Biodiversity Enhancement in Cape Flats Urban Habitats

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

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Summary

Biodiversity is under enormous pressure from an increasing human population. Urbanisation, agriculture, and mining are just some of the factors responsible for the continuous degradation of the natural environment. Of these, urbanisation is one of the leading factors of diversity loss. To address this problem, it is necessary to understand the relationship between biodiversity and urban areas, as well as the relationship between society and biodiversity. This study focuses on these relationships and suggest ways in which urban biodiversity can be maximised without compromising on development. In order to create an urban environment that successfully supports maximised biodiversity, new methods and ideas must be developed to promote the protection of urban ecosystems. The Cape Floristic Region in South Africa is a good example of an area that requires immediate action in order to prevent enormous losses in biodiversity. Data have shown drastic decreases in natural vegetation cover in this area, and with its close to 9000 species, of which approximately 60% occurs nowhere else in the world. This state of affairs should be regarded as a serious crisis.

This study consists of three main parts, the first being a literature review on the current relationships between the urban environment, society, and biodiversity. The second and third parts report on two empirical investigations on the campus of the Faculty of Health Sciences at the University of Stellenbosch in the City of Cape Town. The first of these investigates the possibility of using spirituality connected to nature as a promotional tool for conservation through rehabilitation or restoration of damaged urban vegetation habitats. For this purpose students' and staff members' opinions of the urban nature at the campus were tested. In the second investigation the options of restoring biodiversity to the campus was considered by exploring the best options available for rehabilitation while taking the current biodiversity status on and around the premises into account. This was carried out through three smaller projects that included the physical reintroduction of plant species, vegetation analysis, and bird identification and attraction.

The response of employees and students at the Faculty of Health Sciences was found to be in favour of restoring vegetation and animal life to the campus. This is supported by a belief that their attitude towards their work would improve with improved natural surroundings. Initial rehabilitation attempts highlighted the complexity of rehabilitation practices by bringing forward challenges and problems experienced with the reintroduction of plant species. Despite these problems, increased plant diversity in experimental areas showed the possibility of successfully completing the project. Biodiversity analysis showed that methods of controlling vegetation used by the university are doing more harm than good, as it results in indigenous vegetation being displaced by exotic vegetation.

This study introduces a number of questions regarding the relationship between urbanisation and biodiversity and to what extent the two should be linked. Hopefully it is a step in the direction towards marrying the urban and natural environment, and to create a sustainable urban environment where society no longer sees nature as something outside the city boundaries.

Opsomming

Biodiversiteit word onder enorme druk geplaas deur die groeiende menslike bevolking. Verstedeliking, landbou en die mynwese is maar enkele van die faktore wat bydra tot die aanhoudende degradering van die natuurlike omgewing. Van hierdie faktore is verstedeliking een van dié leidende oorsake van verlies aan diversiteit. Om hierdie probleem aan te pak, is dit nodig om die verhouding tussen biodiversiteit en stedelike gebiede enersyds en biodiversiteit en die samelewing andersyds te verstaan. Hierdie verhoudinge is die fokus van hierdie studie, waarin metodes voorgestel word om biodiversiteit te maksimaliseer sonder om ontwikkeling te kompromitteer. Ten einde 'n stedelike omgewing te skep wat gemaksimaliseerde biodiversiteit suksesvol ondersteun, moet nuwe metodes en idees ontwikkel word om stedelike ekosisteme te beskerm. Die Kaap Floristiese Streek in Suid-Afrika is 'n goeie voorbeeld van 'n gebied wat onmiddellike aandag vra om grootskaalse verlies aan biodiversiteit te verhoed. Kommerwekkende data toon 'n drastiese afname in natuurlike plantegroeibedekking in hierdie area met byna 9000 spesies, waarvan ongeveer 60% nêrens anders in die wêreld voorkom nie. Hierdie stand van sake behoort as 'n ernstige krisis beskou te word.

Hierdie studie bestaan uit drie hoofdele. Die eerste deel verteenwoordig 'n oorsig oor die literatuur wat oor die verhoudinge tussen die stedelike omgewing, die samelewing en biodiversiteit onderling handel. Die tweede en derde dele doen verslag van twee empiriese ondersoeke op die kampus van die Fakulteit Gesondheidswetenskappe aan die Universiteit van Stellenbosch in Kaapstad. Die eerste van hierdie ondersoeke gaan die moontlikheid na om spiritualiteit gekoppel aan die natuur aan te wend om die bewaring van beskadigde stedelike habitatte deur rehabilitasie of restourasie te bevorder. Vir hierdie doel is studente en personeellede se opinies oor die stedelike natuur op die kampus getoets. In die tweede ondersoek word die opsies vir die restourasie van biodiversiteit op die kampus oorweeg deur die geskikste alternatiewe vir rehabilitasie met inagneming van die huidige status van biodiversiteit op en om die kampus te verken. Hierdie

ondersoek is in drie kleiner projekte verdeel, wat die fisiese terugplasing van plantespesies, plantegroei-analise en die identifisering en lok van voëls insluit.

Daar is bevind dat die opinie van werknemers en studente van die Fakulteit Gesondheidswetenskappe ten gunste van die restourasie van plante- en dierelewe op die kampus is. Hierdie opinie word ondersteun deur die respondente se klaarblyklike oortuiging dat 'n verbeterde natuurlike omgewing tot 'n verbeterde houding teenoor hulle werk sou lei. Aanvanklike pogings tot rehabilitasie het die kompleksiteit van sodanige praktyke onderstreep deurdat die uitdagings en probleme wat met die terugplasing van plantespesies ondervind is op die voorgrond getree het. Ten spyte van die probleme het 'n toename in plantediversiteit in die eksperimentele areas gewys op die moontlikheid om die projek suksesvol te voltooi. 'n Analise van die biodiversiteit het getoon dat die metodes wat tans deur die universiteit aangewend word om plantegroei te beheer meer skade aanrig as wat dit goed doen, aangesien dit daartoe lei dat inheemse plantegroei toenemend deur eksotiese plantegroei verdring word.

Hierdie studie bring 'n aantal vrae oor die verhouding tussen verstedeliking en biodiversiteit en in hoeverre die twee verskynsels aan mekaar te koppel is aan bod. Dit is hopelik 'n stap in die regte rigting op die pad na die versoening van die stedelike omgewing met die natuurlike omgewing en die skepping van 'n volhoubare stedelike omgewing waarin die samelewing die natuur nie meer as iets buite die stadsgrense beskou nie.

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Chapter 1: Urban Biodiversity: The Relationship between Man and the Urban Biotic Environment

Summary

Globally, biotic diversity is under enormous pressure from an increasing human population. Urbanisation is one of the main reasons for current unprecedented anthropogenic losses in biodiversity. To address biodiversity loss, an understanding of the relationship between biodiversity and urban areas, as well as the relationship between society and biodiversity is essential. This chapter focuses on these relationships and suggests ways in which urban biodiversity can be maximised without compromising on urban development and expansion. The process of ecological restoration/rehabilitation as a tool to restore biodiversity in the urban setting and the advantages of maximised urban biodiversity are explained and discussed. The conclusion is reached that a framework for biodiversity conservation should be developed on all levels of land management in order to effectively fight biodiversity loss in urbanised areas.

Key words: Urbanisation, Ecological Restoration, Rehabilitation, Sustainable Cities

1.1 Introduction

As co-inhabitants of earth, humans share a variety of resources, such as land, water, air, and minerals with a wide range of diverse living organisms. These organisms form part of what is known as *biodiversity*. From early on conservationists have realised that the terms *nature* and *wilderness* are not adequate in describing what today is known as biodiversity (Takacs, 1996).

Although a wide range of descriptions exists, the definition of biodiversity, as adopted by the Species Survival Commission in 1988, is formulated as follows (Huntley, 1989):

> The variety and variability of all living organisms. This includes the genetic variability within species and their populations, the variety of species and their life forms, the diversity of the complexes of associated species and their life forms, the diversity of the complexes of associated species and of their interactions, and of the ecological processes which they influence or perform.

From this definition it is clear that the concept of biodiversity entails much more than simply referring to all the different species on earth. It includes all biotic and abiotic factors and variables that influence these species on various levels, including the genetic variability within species.

Over the last few decades biodiversity issues have been some of the most prominent international focus areas of research and discussion in all major natural sciences. The relevance of this line of development is clear when the high rate of biodiversity loss resulting from human activities such as deforestation, desertification, increasing human populations, industrialisation, increased waste production, pollution, and over-exploitation of resources is considered. Potentially more significant is the parallel effect of global climatic change caused by these activities, which in turn could cause even greater biodiversity loss, compounding this still relatively manageable problem into a major global crisis.

Currently, the two greatest threats to biodiversity are urbanisation and agriculture (Dobson *et al*., 1997; Garagna *et al*., 2001; Wessels *et al*., 2003). With increasing demands for land to be made available for agriculture, industry, residential and commercial use, mostly due to increasing population sizes, conservationists realise the need to incorporate ecological planning into different sectors of development and industry, such as urbanisation and agriculture. However, it is not only biodiversity in the immediate environment of the developed area that is affected by urbanisation and agriculture. The effects may reach well beyond this area of direct impact and influence the quality of water and air, even at landscape level. This can be seen when an effect on one organism or natural resource within developed areas ripples through the whole food web (which extends beyond the developed areas) and has major effects on other organisms, even those that are not yet described (Primack, 1993). At the current rate of extinction it is quite possible that when these organisms are indeed described, it will be as fossils and not as living organisms.

What role should biodiversity play within the city limits or within the urbanised environment? The answer to this central question is not obvious or clear. To the extreme conservationist the answer could be that urbanised areas should not intrude on biodiversity at all. It may be argued that any further expansion of developed areas should be prevented at all costs. However, this argument does not seem to represent a realistic point of view, since it would probably presuppose the highly unlikely occurrence of zero growth in human population. In contrast, to the economist and businessman the answer might be that biodiversity should be left for the parks and nature reserves in remote areas and that urbanisation should be maximised. This line of argumentation would of course adversely affect biodiversity. As with most environmental issues, this creates a debate that will probably continue for a long time. The best that can be hoped for is to find compromises where urbanisation and biodiversity can each find a niche and co-exist with some degree of mutualism.

To be able to establish co-existence between urbanisation and biodiversity, it is important to understand the relationship between the two phenomena and their impact that they have on society and *vice versa*. Again, this is an extremely complex situation in which different opinions and ideas will surface. In this chapter some of these opinions and ideas on urbanisation and biodiversity will be reviewed in order to attempt to understand the way in which people relate to the urbanised setting and the role biodiversity plays in it.

1.2 The Relationship between Urbanisation and Biodiversity

Issues regarding biodiversity and urbanisation may often seem to be irreconcilable. To maximise conservation, it is however important that the interaction of biodiversity with the urban environment, and the importance of urban biodiversity in ecology, be understood. When considering the impact of urbanisation on biodiversity, as well as on associated ecosystems, the significance of the relationship between the two in terms of conservation applications becomes clear. Equally important is the role and impact of ecology on urban planning and development (Tjallingii, 2000). The United Nations Report (1984) on ecological approaches to urban planning states the following characteristics or results of urbanisation:

1. declining environmental quality in urban areas through air, water, and soil pollution, noise, modifications to microclimate, and loss of natural areas;
2. severe degradation of the surrounding environment and ecological systems of hinterlands, through urban demand for resources;
3. demographic transformations of rural and urban areas through migration with severe social, economic, and environmental consequences;
4. inadequate housing, transportation and public services (water, sanitation, schools and health) resulting in threats to human health and quality of life;
5. an urban poor that is vulnerable to deficiencies in food, good water, fuel, and other basic goods and services;
6. the threat of environmental non-sustainability

From this summary it is clear that the effects of urbanisation on ecology are complicated and interwoven, and represents a variety of problems. On the one hand it is not a viable approach to simply address identifiable symptoms without taking cognisance of their causes, since such an approach would not attend to those causes and therefore fail to deal with the problem in its entirety. On the other hand, the isolation of and dealing with only a single problem (at a time) would similarly yield ineffective results, as such an approach would negate the intricacy of the relationship between urbanisation and biodiversity.

There are various ways in which biodiversity can relate to urban ecosystems (Savard *et al*., 2000). Firstly, the urban environment impacts on adjacent ecosystems by (i) competing for space and water, (ii) polluting the environment through emissions and waste disposal, and (iii) fragmenting habitats. Secondly, biodiversity can be maximised within urban borders and thus impact on the urban environment and people. Thirdly, undesired species can be managed and removed from within the city borders in order to create a healthy ecological environment. These relations imply that nature can not be seen as an object but rather as a process in which a wide range of variables, among others urbanisation, play a role.

Furthermore, there are four main ways in which urbanisation affects biodiversity (McNeely *et al*., 1995):

1. the loss of existing vegetation through land conversion for geographical expansion of settlements and infrastructure;
2. the impact on hydrological and atmospheric systems at local and global levels;
3. the displacement of native vegetation by introducing alien vegetation;
4. the displacement of local vegetation by plantations to meet urban demand for biomass

McNeely *et al*. (1995) further states that the ways in which urbanisation influence biodiversity can be divided into two main categories. They are *direct* and *indirect effects* (Figure 1.1). These effects will lead to biodiversity loss over different time spans. Direct effects, such as habitat loss, leads to declining biodiversity, usually shortly after the onset of urban development, whereas indirect effects will invariably be seen only a considerable time after interference took place.

1.3 Towards Finding a Compromise between Urban Expansion and Urban Greens

In an ideal world animal and plant diversity should relate to urbanisation in a healthy and sustainable way. This desirable relationship can be achieved by applying simple management measures aimed at conserving biodiversity in the highly dynamic urban ecosystem that is characteristic of modern cities (Savard *et al*., 2000). The Global Biodiversity Strategy (WRI/IUCN/UNEP, 1992) suggests that, in order to conserve biodiversity, the defensive attitude of protecting nature from the impacts of development should be replaced by an offensive strategy in which biological resources are utilised in a sustainable manner.

The issue of sustainability is usually closely associated with the sustainability of natural resources and processes (outside the city) only. This view however fails to take the importance of urban ecosystem sustainability into account. According to Hough (1994) the ultimate goal should be the incorporation of biodiversity into urbanisation. This can be achieved by the creation of sustainable cities. According to Hough, sustainability in an urban context implies:

> that the products and energy systems of urban life should be passed on to the larger environment as benefits rather than as costly liabilities.

The concept of sustainable cities marries the urban environment to the ecological landscape outside the city borders and shows the interdependency of people, nature, and places.

Hough further argues that the goal of sustainable landscapes within city boundaries cannot be achieved by exclusively focusing on existing artificial landscapes such as lawns, fountains, and parks, but rather that attention should be paid to obscure wastelands and abandoned areas. This is undeniably true, but does not imply that the role played by established parks and gardens should be ignored. By understanding the ecological processes in both the artificial landscapes, and the obscure wastelands, management strategies can be developed with which to restore both areas. The next step would be to link the fragments into a larger nature reserve or conservation area. By establishing such park systems, a multi-functional role for ecology within the city boundaries is created, which in turn initiates the process of creating sustainable cities.

1.4 The Relationship between Urban Society and Biodiversity

1.4.1 Nature as Separate Entity from the City

Typically the concept of nature is related with the countryside and not with the urban setting. According to Tjallingii (2000) this conceptualisation is reflected in:

> the traditional, and still dominant, discourse on ecology, in which town and country are considered as expressions of the culture-nature polarity.

In this traditional discourse, nature is thus seen as an object or a unique sector that is separated spatially and functionally from the rest of the world and thus also from urbanised areas (Tjallingii, 2000). The city is regarded as a cultural heritage that is remote from nature, and nature is considered synonymous with the countryside, which perpetuates the attitude that one has to travel beyond the boundaries of the city in order to experience "nature". This line of conceptualisation is further manifested in the general perception that "nature" has no place or significance in urban areas. Man-made urban gardens and parks are consequently not regarded as occurrences of biological diversity. Essentially this means that no significant or indeed identifiable relationship between urban society and biodiversity exists.

The advantage of viewing nature as an object is that conserved nature areas can be physically and managerially clearly demarcated, which simplifies the establishment and management of conservation areas (e.g. nature reserves).

The disadvantage is that such a view has a detrimental effect on biodiversity specifically inside urban areas. Only in recent years have some ecologists started to consider urban biodiversity as an increasingly important target of global conservation (cf. Soulé, 1991; Mazzotti and Morgenstern, 1997; Whitmore *et al.,* 2002; Cornelis and Hermy, 2004).

1.4.2 Nature as a Process

According to Tjallingii (2000) the emerging discourse reflects the conceptual development that nature should be regarded as a process. This development implies the integration of nature with all activities and processes in urbanised areas, which would result in the establishment of a positive and active relationship between the urban society and biodiversity.

There are a number of identifiable disadvantages to this approach, of which probably the most important is the financial implications. Aspects such as the acquisition and restoration (where required) of land, affording of labour and expertise, and management expenses would make a conservation programme based on this approach a costly undertaking. Coupled with this is the sheer magnitude which would go into any effort to incorporate such an approach in a conservation programme, which involves, among others, processes like determining the structure and function of ecosystems, the coordination of efforts, and obtaining the support and involvement of all stakeholders. When this is considered, the traditional view of regarding nature as a separate entity seems much simpler and cheaper. Other disadvantages may include the lack of priority that local governments award to biodiversity conservation in urban areas, the limited availability of expertise in among others urban restoration ecology, the time it would take to effect a conservation programme based on this approach, and the perceived aesthetic value that would be attached to the product of such a programme.

This approach, however, represents the ecologically more sound view of nature, as it allows for the inclusion of all factors influencing ecosystem functioning and structure, thereby ensuring the survival and sustainability of the affected ecosystems, both within and outside the city boundaries.

1.5 Managing Biodiversity

Biodiversity management must in the first instance attempt to answer the question as to how nature in the urban environment can be restored and existing biodiversity protected. The solution is not simple. However, by surveying the environment, various possibilities for greening the city environment present themselves: open fields, road edges, river banks, hills, wetlands and privately owned land are all potential green areas. Unfortunately some of these are so degraded that no natural vegetation is left, while others may contain only remnants of natural vegetation (Hough, 1994).

All available land can however not be converted into biodiversity rich areas. The need for appropriate planning and careful decision making is crucial to ensure successful land transformation. There are some determining factors, or ecosystem approaches, that warrant consideration before an urban greening project can be initiated (Dwyer and Stewart, 1995). Planners should take into account the complex interactions between the three main aspects involved with such parks, i.e. the physical, biological, and social aspects. These require input from multidisciplinary fields such as landscape ecology, restoration ecology, landscape architecture, and environmental psychology. It is important to ensure that a balance is achieved between the physical environment, the biological communities, and the social implications.

Golf courses are a good example of areas where the social needs of the human population have damaged large areas of natural habitat. Researchers like Terman (1997) and Gange *et al*. (2003) have shown that the physical, biological, and social aspects of both nature and man can be met in the development of golf courses. Similar strategies can be applied in other sectors of development to create urban green areas with minimal limitations on human development.

Once urban green areas or park systems have been established, they cannot be left to sustain themselves. Management plans are needed with adequately trained personnel being responsible for maintenance and supervision. The type of management structure that can be implemented will depend on the locality of the area.

Areas that have the possibility of being managed green areas, fall into four different management categories (Savard *et al*., 2000): (1) individual lots owned by private individuals or groups of individuals (e.g. home owners, business premises and industrial premises); (2) city sectors, being the areas within a city set aside for commercial, residential, industrial, or recreational purposes that are managed by local authorities; (3) the city itself, being governed by the municipality; (4) landscape adjacent to the city boundaries under regional government or the equivalent thereof.

Savard *et al*. (2000) lists various ways in which these four categories can be designed and managed in order to optimize the green area status. These options can be as simple as the planting of indigenous vegetation and erecting bird nests and feeders. In most instances, however, it may include actions of a much more challenging nature, like the establishment of vegetation corridors and the application of rehabilitation techniques. When a local government (municipality or regional authorities) selects a site to develop as a green area, it is important that a site that maximises public access and species diversity should be chosen in order to allow for maximised cost effectiveness, while conserving as many species as possible (Ruliffson *et al*., 2003).

1.6 Ecological Restoration: The Highest Level of Intervention

There is a variety of areas in the urban setting in which biodiversity and ecological processes conservation can be implemented, ranging from nature reserves and parks to privately owned land. However, due to neglect, many of these areas are degraded to such an extent that little or no biodiversity remains. The most extreme measure to restore nature to these areas is through the process of ecological restoration. This process aims to improve damaged ecosystems with respect to system health and sustainability. There are various definitions for the term *restoration ecology*, of which the simplest is the following:

> the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER, 2002).

Important characteristics of ecological restoration are that (1) it is an intentional, organised activity that (2) initiates or accelerates the recovery of an ecosystem after it has been degraded, damaged or destroyed. The need for human intervention when it comes to the restoration of some degraded areas becomes clear when the time span over which this process would take place naturally is considered: processes involved with natural restoration (e.g. succession) may take from as little as one year but can last up to 10 000 years (Dobson *et al*., 1997).

In order to restore an ecosystem to its historic trajectory, it is necessary to establish the historic conditions at the time prior to disruption (SER, 2002). Unfortunately it is difficult or even impossible to determine this. Therefore, it is nearly impossible to completely restore a damaged ecosystem. However, the historical trajectory can be established as accurately as possible by combining information on the pre-existing structure, composition and functioning with studies on comparable intact ecosystems, environmental conditions, and other ecological, cultural, and historical data (Cairns, 2000; SER, 2002). This forms the basis of ecological restoration processes that can range from the very simple removal of one disturbing factor and allowing the ecosystem to restore to its natural state, to very complex reintroduction processes of indigenous species and the removal of harmful or invasive alien species (SER, 2002). Once the restoration processes is initiated, it is essential that continuous management is exercised to ensure the future well-being of the ecosystem. (Cf. Chapter 3 for a more detailed discussion on restoration ecology.)

1.7 Incentives for Maintaining or Restoring Urban Biodiversity

To conservationists the justification for restoration ecology is obvious. However, to the businessman the advantages of a healthy ecological environment often have to be explained. Apart from the intrinsic value of ecosystem health and biodiversity conservation, it is important that the additional advantages be defined, so that the concept of maximizing urban biodiversity becomes an integral part of businesses, industries, and even home owners.

Jacobs (1999) mentions five advantages of urban green areas: (1) productive value where practises like agriculture, aquaculture, and nurseries continue on the green area and provide a form of income; (2) a cultural value that can include activities like ethno-botany; (3) recreational value, being similar to the value of parks and nature reserves; (4) conservation value; and (5) educational advantages through environmental conservation education. A sixth advantage that can be added to the list is the spiritual value of green areas. The influence of green urban ecosystems on the well-being of societies adds direct value to urban green areas (cf. Chapter 2).

The advantages of maintaining and managing urban green areas or restoring areas that have been degraded could be an ideal tool to convince society to support or even initiate ecological restoration processes in the urban environment. Kellert (1980) has shown that city dwellers generally appreciate nature and wildlife and that they are prepared to pay for an authentic “natural” environment. This appreciation can be capitalised on by ecologists in order to reach their conservation goals.

1.8 Conclusion

It is difficult to predict the future of biodiversity in the modern, urbanised environment. However, scientists have to a large degree been able to compare the present status of biodiversity and nature with historical data. Human related extinction rates have reached unprecedented levels (cf. Primack, 1993), and it can only be hoped that this trend will not continue. The effects of human activities, such as urban expansion and intensive and widespread agriculture are well known. Society must therefore take full responsibility for the ecological consequences of its actions.

As the relationship between society, urban areas, and biodiversity is established, ways can be developed to find a suitable and effective compromise between them. From this review it is clear that there are different ways in which the relationship of nature with the urban environment is perceived. The urban society tends to disregard the fact that nature is part of its everyday life. If this perception is not significantly changed, society will not realise the critical role it has to play in the context of global conservation. It is impossible to achieve acceptable global conservation levels if the human population cannot manage its own urban ecological footprint.

It is clear from this review that conservation authorities from all levels of land management must start to develop urban biodiversity strategies through which land management will maximise biodiversity. Only then will effective tools be available with which the destruction of biodiversity, its structures, and functions can be averted.

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Chapter 2: Using Spirituality and a Sense of Place to Promote Conservation in an Urban Setting: A Case Study

Summary

During the past century urban biodiversity has come under increasing pressure due to urban expansion. A good example of this is the Cape Floristic Region, where research has shown alarming decreases in natural vegetation cover. This is mainly due to natural habitats being replaced by urban developments and agricultural activities. Incentives therefore have to be put forward to promote the protection of urban ecosystems. The aim of this chapter is to investigate the possibility of using the spiritual feeling experienced by people when surrounded by nature as a tool for conservation promotion, either through rehabilitation or through restoration of damaged urban natural habitats. For this purpose students' and staff members' opinions of the quality of urban nature at the Faculty of Health Sciences of the University of Stellenbosch in the city of Cape Town was tested. A survey, covering issues such as spare time utilisation on campus as well as opinions and expectations regarding respondents' study and working environment, were conducted. Respondents' ideas on specific areas that need improvement were also tested. Results of the survey showed that the overwhelming majority of respondents feel that their study and working environment needs improvement, with specific emphasis on the natural environment. Furthermore, they feel that, should the natural environment be improved, their attitudes towards their work and studies would improve. From the results of this study it seems plausible to assume that the concept of spirituality can be applied as a conservation tool to promote biodiversity conservation in densely populated areas. However, further studies need to be conducted to accurately determine the influence that a restored urban habitat has on its inhabitants.

Key words: Urbanisation, Spirituality, Urban Biodiversity, Restoration Ecology

2. 1 Introduction

Abram (1996) is of the opinion that "[n]ature, it would seem, has become simply a stock of resources for human civilisation." Thus, humans have evolved from beings that coexist in a symbiotic relationship with nature to beings that consume nature. The general perception of nature is no longer one in which its beauty and magnificence is absorbed and appreciated. On the contrary, large parts of it have been destroyed in man's quest to make life more comfortable. It is therefore no wonder that one of the main problems associated with conservation and the general protection of biodiversity is the lack of support received from individuals, institutions, and organisations.

To many potential key role players, from the individual land owner to highly structured government departments, conservation does not represent any priority and is in fact regarded as of little or no importance. This seems to be especially true in the urban setting, where development and urban growth takes place at an increasing rate. As the human population increases, so does the demand for land and resources. The productive, cultural, recreational, educational, and conservation value of pristine land (cf. Jacobs, 1999) may no longer be reason enough to conserve the associated biodiversity. Conservationists constantly have to introduce new ideas and concepts in order to convince decision makers to take the conservation of biodiversity into consideration when new areas are developed (Primack, 2000).

Any person experiences his/her surroundings continuously, whether at home, on the way to work, at work, on holiday or any other place. This sensory experience (i.e. hearing, seeing, smelling, and feeling) of one's immediate environment takes place unconsciously and/or deliberately, and it plays an important part in shaping a person's being and future. Even the way in which a person performs normal tasks is influenced by his/her physical and sensory surroundings (Schoeman, 1955; Hiss, 1990). This is exemplified in cases where poor working conditions causes low morale among workers, contrasted to cases where optimum working conditions result in higher productivity and a more positive attitude toward the work. These determining conditions include elements like temperature, light, smell, noise, and natural surroundings. However, it seems that individuals' responses to the natural environment can vary (Hartig *et al*., 1999). An individual's response depends on his/her personal experience and perception of the surroundings.

The field of ergonomics aims to find the optimum conditions under which to achieve maximum productivity and work satisfaction (Bridger, 2003). However, until recently the main factors to be investigated and improved on were limited to the immediate environment, for example optimum temperature, light conditions, and noise levels within the office environment. Even though natural surroundings influence an individual's work efficiency and performance in the same way as ergonomic factors, literature on research in this field is very scarce. Studies that partially relate to this line of research include Fredrickson and Anderson (1999), Hartig *et al*. (1999), Herzog and Barnes (1999), Kerr and Tacon (1999). The significance of experiencing unspoilt, well managed natural surroundings in urban areas has seldom been given consideration. By convincing decision makers of the positive effect that well protected and managed elements of natural surroundings (e.g. trees, birds, insects, and plants) can have on their moods and that of their employees, students or colleagues, they may be more inclined to invest in conservation within the urban context (Schoeman, 1955; Abram, 1996). In doing so, a dual result can be achieved: Productivity and work satisfaction is maximised while higher levels of conservation are reached simultaneously.

In this study the term *spirituality* will be used to denote an experience of "a feeling, ambience, essence, aura, harmony and charm or a place's essential spirit or quality of life" when in contact with nature and the wilderness (Hiss, 1990). This experience is reason enough to regard the natural environment found in suburbs, along roads, and outside buildings, as equally important to ergonomic factors taken into account during urban development. In the same way as ergonomics, related to the work or home environment, aims to improve human effectiveness and enhance the quality of life (Sanders and McCormick, 1987), so unspoiled, well managed natural surroundings result in a positive perception of place or heightened spirituality (Hartig *et al*., 1991; Hartig *et al*., 1996; Hartig *et al*., 1999). Heightened spirituality could then directly influence the level of effectiveness in the work place (Figure 2.1).

In this study the possibility to promote biodiversity conservation in an urban setting, using spirituality to promote efficiency, was investigated. For this purpose a survey was conducted among students and employees of the Faculty of Health Sciences of the University of Stellenbosch, which is located on the TMC in the City of Cape Town, South Africa. The aim of the survey was to gather information about respondents' ideas and expectations regarding their immediate environment on the campus. The outcome of the survey points to the probability of achieving success with an attempt to promote biodiversity enhancement. It is assumed that the success of the project is partly dependent on the level of support it receives from all stakeholders on the campus.

Data gathered through the survey will be utilised to develop and establish a rehabilitation and biodiversity enhancement project, complemented by a functional management plan. In this way higher levels of biodiversity can be achieved and maintained while taking into account the expectations of all stakeholders on the campus.

2.2 The Study Site

The Faculty of Health Sciences of the University of Stellenbosch is situated in the City of Cape Town, lying in the Cape Floral Kingdom, one of the richest floral kingdoms in the world (Bond and Goldblatt, 1984). With just under 1000 administrative and academic staff and more than 2000 students, this faculty's population represents a broad demographic spectrum. Members of this population have different needs and expectations, and are active in their interpretations and evaluation of the environment (cf. Churchman, 2002). Thus, given the different backgrounds and roles within the Faculty of Health Sciences, it is obvious that there will be a wide range of ideas, opinions and expectations about global conservation issues, their immediate environment and the appearance of the campus.

The site was selected following an expression of interest by the management of the Faculty to improve or enhance the vegetation and overall biodiversity of the campus. Its participation in this project, although not purely motivated by conservation, provides an opportunity for conservationists to educate a section of the urban population about the importance of urban biodiversity even within the city limits.

The campus of approximately 26 ha is situated next to the Tygerberg State Hospital and together they cover a large area in the form of concrete buildings, parking lots and tarred roads. The main vegetation on the campus consists of lawns and trees, of which a large proportion is alien. Very little other vegetation occurs on the campus, and where remnants of natural vegetation do occur it is controlled through regular mowing. In addition to the above mentioned constructions, sports grounds cover a significant area of the campus grounds. The campus is neighbored by the hospital to the south and a small stream and railway line to the immediate north. To the east the railway company possesses a large area of land that is not developed and is heavily encroached by the alien species, *Acacia salignum*. A densely populated residential area forms the western border of the campus.

2.3 Methods and Materials

Although the campus is green when compared to nearby industries and office complexes, students and personnel perceives the TMC as dull in comparison to the main campus of the University situated in Stellenbosch. This study aims to establish (1) whether this perception represents the general attitude among students and personnel, and (2) whether the need exists to see an improvement in this respect. Information will also be gathered on what the respective stakeholders represented on the campus expect with regard to the improvement of the premises. Furthermore, respondents will be given an opportunity chance to state whether they think that an improved working environment will have a positive effect on their work efficiency and attitude.

To establish the current opinions and expectations of personnel and students on the campus, a survey was conducted. Two questionnaires were designed: one for personnel and one for students. The questionnaires were compiled to be specific to the TMC and were approved by the management of the Faculty. Prior to finalising the questionnaires, they were handed out to 10 students and 10 personnel members to complete. Any problems or errors in question structure were corrected. The questionnaire was printed in both English and Afrikaans, the two main languages spoken on the campus. The questionnaire designed for personnel (cf. Annexure B) were handed out to 750 administrative and academic staff members on 15 October 2003 with the request that completed questionnaires be returned to a specific office.

The questionnaire designed for students (cf. Annexure C) were handed out to 600 students in all the different disciplines (medicine, physiotherapy, dentistry, etc.), ranging from the second to the final (sixth) academic year, during the registration period on 16 and 19 January 2004. By combining the completion of the questionnaires with the registration process, a significant proportion of student population was reached and a large return percentage was expected.

2.3.1 Contents of the Questionnaires

The two questionnaires contained mostly the same questions, but in certain categories questions were changed to be relevant to the respective groups (e.g. student questionnaires included an extra section regarding their residency).

The questionnaires consisted of the following sections:

2.3.1.1 Section A: Demographic Information.

This section was included to obtain the relevant demographic information of the respondents, as this allows for comparison between the different groups. For students the requested information included gender, age, academic year, home language, and whether the respondent was born and raised in the Western Cape. In the personnel questionnaire academic year was replaced with the number of years working on the campus.

2.3.1.2 Residency

This section, which was not included in the personnel questionnaire, was used to determine the respondents' residency status during the time of his/her studies. Student residency can fall into one of three categories: (1) university residency, denoting students who have lived in a university residence on the campus for their entire academic career; (2) private residency, denoting students who live off the campus and (3) previous use of a university residence, but living in a private residence at the time of completing the questionnaire.

2.3.1.3 Opinion on Nature

This section was included to determine the respondents' general opinion about nature and its global conservation status. For this purpose respondents were presented with four incomplete statements, which they had to complete by selecting one of the offered alternatives.

2.3.1.4 Spare Time Utilisation on the Campus

This section was included to determine the respondents' preferences regarding spare time utilisation, e.g. whether they preferred spending their time off the campus, on the campus but indoors, or on the campus but outdoors. Questions for students differed slightly from those for personnel in this section.

2.3.1.5 Campus Appearance

Closed questions regarding the respondents' opinions on the appearance of the campus were included. Respondents had to select their answer to each question from a set of provided answers which were categorised to range from "very good" to "very bad" or "strongly agree" to "strongly disagree". One open question was included, which requested respondents to express what aspect of the appearance of the campus they would like to see improved.

2.3.1.6 Campus Improvements

This section tested the respondents' opinions on improving the natural environment on the campus and the effect it would have on them. Respondents were also presented with a list of possible aspects that could be improved and asked to prioritise these. Furthermore, respondents who were interested and willing to help with a campus improvement project were requested to provide contact details.

2.3.2 Analysis

All answers were allocated coded values (see annexure B and C for coding) and these values were entered into a Microsoft Excel spreadsheet (Microsoft Corporation, 2001). The following sections were specifically coded to get a collective value indicating the respondents' opinion on that section or part thereof:

2.3.2.1 Opinion on nature

Answers in this section were coded in such a way that a negative answer was represented by the lowest coded value (i.e. 1), while the most positive answer was represented by the highest coded value (i.e. 3 or higher, depending on the extent of the range of possible answers). Consequently, the coded values allocated to each of the selected complements to the four half statements were added together, resulting in a value ranging from four to thirteen. This value was then adjusted to a final score out of ten. The final score value represents an indication of each respondent's opinion value on nature, where the value 1 represents the lowest possible opinion on nature, and 10 the highest possible opinion on nature. In the valuation of the respondents' opinion on nature, the secondary question in question 1 of this section, to which respondents had to state whether they view nature as important or crucial, was not taken into account as too few respondents answered the question.

2.3.2.2 Campus Appearance

The same method as for "Opinion on nature" was applied to the first three questions of this section. The answers were coded so that the most negative answer was allocated the lowest value and the most positive answer the highest value. The coded values were then added to get an impression value ranging from 3 to 14, which was consequently adjusted to range from 1 to 12, with 1 showing a very negative impression value on the campus and 12 representing the most positive impression value.

All questions were tested for statistically significant differences between the possible answers by performing a chi-square test in Microsoft Excel. Furthermore, answers were tested for any significant differences between similar questions in personnel and student questionnaires. In cases where a respondent did not answer the question at all, resulting in a zero value in the chi-square test (i.e. a divided by 0 error occurred in the analysis), the 0 were replaced by 0.5.

2.4 Results

A very good response by personnel was achieved, with a return of 196 (28%) completed questionnaires out of 750 questionnaires issued. Of these, 55 (28%) were completed by male respondents and 141 (72%) by female respondents. Distributing questionnaires amongst students during registration resulted in the exceptionally high return of 568 (97%) out of the 600 questionnaires issued. Of these, 158 (28%) were completed by male respondents and 410 (72%) by female respondents. The following results for students and personnel and comparisons between students and personnel were generated:

2.4.1 Opinion on Nature

The opinion value of students and personnel, regarding nature, shows that both groups show a highly significant tendency in the value that they place on nature (students: χ^2 = 1118.55, df =9, p <0.05; personnel: χ^2 = 549, df = 9, p <0.05), with both groups showing very high opinion values (Figure 2.2). The difference in values placed on nature is statistically significant between students and personnel (χ^2 20.75, df = 9, p < 0.05), with personnel placing a higher value on nature than students.

2.4.2 Spare Time Utilisation

During a normal weekday, 82% of students prefer spending spare time off the campus (χ^2 = 233.09, df = 1, p < 0.05). When they do spend spare time on the campus, 22.7% will remain indoors or visit a residence, while the majority (38.8%) visits the Tygerberg Student Centre (TSS) and the second largest proportion (25.6%) partake in some form of sport. Only 12.7% indicated that they would go out and enjoy nature on the campus (χ^2 = 54.41, df= 3, p < 0.05)(Figure 2.3a).

In figure 2.3b it is clear that during lunch time, the majority of personnel on the campus (66%) prefer spending their time indoors (χ^2 = 167.11, df = 3, p < 0.05), with the remaining 34% either leaving the campus, staying outdoors or engaging in other activities. Only 10.4% of the personnel indicated that when they do have additional spare time on the campus, they will regularly take walks, while 48.4% indicated that they will seldom take walks on campus and 41% indicated that they never take walks (χ^2 = 46.91, df = 2, p < 0.05).

Figure 2.3c shows that a significant difference exists between the reasons of students and those of personnel for taking walks on the campus (χ^2 = 92.81, df =4, p < 0.05). Apart from walking to and from class, students would walk on the campus mainly while in conversation with friends or other students, while the smallest group would walk to enjoy nature (χ^2 = 213.27, df =4, p < 0.05). Personnel, on the other hand, would walk on campus mainly in order to enjoy nature and are the least likely to walk while taking time for private contemplation (χ^2 = 14.70, df =4, p < 0.05).

The main reasons why students and personnel do not walk on campus is the lack of features to enjoy while walking, as well as the lack of time to take walks (students: χ^2 = 188.90, df = 3, p < 0.05; personnel: χ^2 = 73.91, df = 3, p < 0.05) (Figure 2.3d).

2.4.3 Campus Appearance

The impression value of students and personnel is a representation of their thoughts and attitudes regarding the physical appearance of the campus. Data for both students and personnel suggests a statistically significant average impression value for both groups (students: χ^2 = 399.4, df = 11, p < 0.05; Personnel: χ^2 = 205.13, df = 11, p < 0.05) (Figure 2.4a). There is also a significant difference between the impression values of students and that of personnel (χ^2 = 25.37, df = 11, p < 0.05), with students showing a slightly lower impression value than personnel.

Students and personnel have specific areas or features on the campus that they would like to see improved with respect to their appearance. Gardens and natural vegetation are the two areas that they feel need the most improvement (students: χ^2 = 380.24, df = 3, p < 0.05; personnel: χ^2 = 123.65, df = 3, p < 0.05) (Figure 2.4b). There was no significant difference between student and personnel data for this question.

2.4.4 Campus Improvements

In figure 2.5a it is evident that both students and personnel agreed that should the natural vegetation, bird, and animal life be improved on campus, they would spend more of their spare time on the campus than in the past (students: χ^2 = 446.76, df = 3, p < 0.05; personnel: χ^2 = 173.84, df = 3, p < 0.05). Both groups felt that their attitude towards the campus and their work would improve, should the natural vegetation, bird, and animal life be improved (students: χ^2 = 536.45, df = 3, p < 0.05; personnel: χ^2 = 101.05, df = 3, p < 0.05) (Figure 2.5b). Furthermore, a larger proportion of students, when compared to personnel, felt this way (χ^2 = 20.58, df = 3, p < 0.05).

The majority of students (94%) and personnel (97%) support the idea of creating natural vegetation corridors between the campus and other natural vegetation areas (Students: χ^2 = 432.99, df = 3, p < 0.05; Personnel: χ^2 = 173.52, df = 3, p < 0.05). In figure 2.5c the extent of support students and personnel give to suggested improvements on campus are plotted. There is statistical significant differences between the options they support (Students: χ^2 = 331.19, df = 5, p < 0.05; Personnel: χ^2 = 92.39, df = 5, p < 0.05) as well as significant differences between the options supported by students as opposed to those supported by personnel (χ^2 = 55.42, df = 3, p < 0.05).

2.4.5 Additional Commentary

In addition to the answers to the questions, some of the respondents wrote additional commentary on the questionnaires. A total of 123 students and 65 staff members gave additional commentary and ideas. The most frequent suggestions can be listed as follows, with the numbers in brackets indicating the number of respondents whom made these suggestions:

Plant more trees. (31)

Add benches and tables. (18)

Plant more indigenous vegetation. (14)

Create animal and bird refuges. (10)

Create a water feature. (11)

2.5 Discussion

"Species management is an admission of failure" (Sutherland, 2000). It is important that these failures should be admitted and the problem not ignored in the hope that it will disappear. Cities and urban areas have reached levels of development and sizes that were probably not predicted a few decades ago. With urban development, increasing pressure was simultaneously placed on the urban natural environment. The continuous pressure of urbanisation on the ecological environment proves man's failure to successfully maintain sustainable biodiversity while promoting human development.

The lack of insight into the future of biodiversity in urban areas has resulted in the need for the implementation of drastic measures, like ecological restoration, that attempts to restore biodiversity to its historical trajectory. This is by no means an easy task and it requires efforts from all sectors of society. However, in spite of overwhelming evidence of global environmental degradation, there are still individuals, companies, and industries that choose to ignore the destruction of their natural surroundings.

It has now become the task of conservationists to convince society to make investments in the protection of earth's remaining natural habitats and to promote the restoration and management thereof. One way in which this can be achieved is to propose the benefits resulting from a positive experience associated with a biodiversity rich area within one's immediate surroundings, which has been shown to strongly affect emotions, attitude, and mental abilities (Fredrickson and Anderson, 1999; Hartig *et al*., 1999; Herzog and Barnes, 1999; Kerr and Tacon, 1999). By capitalizing on this, society can be motivated to put more effort into habitat restoration and management.

This study tested the general perceptions and ideas of a diverse group of people regarding their immediate surroundings during their daily routine on the campus where they work and study. The groups targeted were chosen so that the respondents represented all levels within existing hierarchies on the campus, ranging from junior to senior level students as well as personnel.

2.5.1 Questionnaire Return

The high return of completed questionnaires by personnel and students could be an indication of the level of priority with which they regard the issue at hand. According to the Faculty administration the return by personnel was much higher than their usual return on matters concerning their direct position at the University (e.g. financial and administration). The very high return by students was a result of the timing of the distribution of the questionnaires. As this took place at the beginning of the academic year, students were subjected to fewer time constraints and as they were asked to complete the questionnaires during the registration process, all students were easily targeted. Students were given the option to complete the questionnaires at a later time; nevertheless, most of them, when informed of the nature of the questionnaire, were more than willing to complete it immediately. The significantly higher return by female respondents could most likely be related to the proportion female : male personnel and students employed by and enrolled at the University.

2.5.2 Questionnaire Results

2.5.2.1 Opinion of Nature

The general opinion of respondents regarding the environment is very positive. They see it as an important, if not integral, part of life that has to be protected. One would therefore predict that the outcome of the questionnaire will generally be in favour of environmentally positive propositions on the campus. It is possible that, given the academic nature of the institution, the importance respondents attach to nature is related to their level of academic development. If this is true, further studies should be conducted to distinguish between the diverse views respondents with different academic backgrounds will express regarding nature. This will also determine the approach to be used when dealing with other sectors of society in terms of conservation issues.

A higher opinion value among personnel, when compared to that of students, may be an indication of the level of responsibility exhibited by each of the groups. In general it is assumed that students act less responsible than people who have responsibilities to answer to, e.g. careers and families. It may therefore follow that students in general will act less responsible towards issues regarding nature. Kaiser and Shimoda (1999) have shown that moral and conventional responsibility does play a role in a person's ecological behaviour. However, the opinion value of the students is still high and does therefore not represent a group with a reduced feeling of responsibility towards nature.

2.5.2.2 Spare Time Utilisation

The high number of students who prefer spending spare time either off the campus or indoors, coupled with the small percentage that spend time outdoors, is an indication of the impression that they seem to have of the campus environment. Individuals will be less likely to spend time outdoors if no stimulating experience occurs there. Personnel also spend most of their spare time indoors during a normal working day, with only 10% taking regular walks on the campus. This tendency to stay indoors or to leave the campus whenever respondents have spare time is consistent with a lack of stimulation (in the form of activities, scenery, or recreational areas) on the campus. This is supported by the respondents' impression values regarding the appearance of the campus (Figure 2.4a).

In cases where students do walk on the campus, they will do so mainly while in conversation with friends or other students. They are least likely to walk while enjoying the natural aspects of the campus. Personnel, on the other hand, will walk mainly to enjoy the natural aspects of the campus. As the respondents are from an academic institution where work requires a lot of their time, it is not surprising that the main reason for both students and personnel for not taking walks on campus is a lack of spare time. Furthermore, there are more spare time activities for students than for personnel. On campus students can participate in sport, visit friends, stay in their residence, or go to the Tygerberg Student Centre. Personnel, on the other hand, can only stay in their offices or take walks on the campus. This explains why personnel are more likely to walk on the campus in spare time. However, this does not suggest that personnel find the natural aspects to be adequately entertaining while walking.

2.5.2.3 Campus Appearance

The physical conditions of any work environment play an important role in employee happiness and work satisfaction. Physical conditions can include aspects such as office ergonomics, and physical and natural appearances. Respondents on the TMC rate the impression value of the campus as slightly below average, with students rating it generally lower than personnel. A possible reason for this phenomenon could be found in the fact that 59% of the student respondents reside on the campus, coupled with the assumption that individuals seem to place a higher premium on and therefore show higher expectations of their living environment than their working environment. Both students and personnel feel that gardens and natural vegetation are the two areas that most need improvement. Should these areas be improved, it is expected that the impression value of both students and personnel will increase significantly.

2.5.2.4 Campus Improvements

Respondents agree that they would spend more of their spare time on campus if the natural vegetation, bird, and animal life of the campus are improved. They also feel that should this happen, their attitude towards the campus and their work would improve. Again, this opinion is stronger among students than among personnel, which could again be explained by the fact that students reside on campus. The general opinion of respondents, i.e. that their attitude towards the campus and their work would improve and that they would spend more time on the campus should the campus environment be improved, supports findings that one's mood is affected by the qualities of the surroundings and that entering different environments can alter your mental state or mode (Apter, 1982, 1989; Russell and Snodgrass, 1987). This was shown by experiments using photographic environmental simulations, in which natural settings have been found to alter emotions positively, while urban settings seem to create negative emotions (Hartig *et al*., 1991; Hartig *et al*., 1996; Hartig *et al.*, 1999). These findings can be used as leverage in attempts to convince other institutions to improve and manage their natural surroundings. The argument would be that in return for their investment, they are likely to employ staff with higher levels of work satisfaction and higher efficiency.

An overwhelming proportion of respondents (94% of students and 97% of personnel) support the proposal for the establishment of natural vegetation corridors between the TMC and other natural vegetation areas. Their support for the proposed enhancements on campus (e.g. the establishment of footpaths, benches, rest areas, water features and the reintroduction of fynbos) can be utilised in the development of a management plan for the enhancement of biodiversity on the campus.

2.5.3 Future Considerations

It is clear from this study that the individuals and groups working and studying on the campus have specific expectations regarding their living and working environment. They also seem to be very particular about what exactly they would like to see improved on the campus. This finding is unequivocally supported by the respondents' additional comments on the questionnaires. The general sentiment among respondents is that an improvement in the natural surroundings would improve their attitude towards the campus and their environment. This would probably lead to a heightened sense of spirituality, which is very likely to improve their work efficiency and willingness to perform their tasks to the best of their abilities. One would expect that this tendency existing on the TMC would also be present in other sectors of society. To verify this, similar studies should be performed in the industrial and business sectors. Should results show that the public in general is of the opinion that improved natural surroundings increases one's sense of well-being and therefore work efficiency, these findings could present a convincing tool with which to promote conservation.

Arrow *et al*. (1993) suggest that when the value a person places on nature is determined, one should ask what monetary value he/she is willing to attach to access to a natural environment, and not merely what he/she is willing to accept without committing his/her own financial or material resources. This would reflect a more accurate expression of a person's willingness to use his/her own resources to conserve and protect nature. Within this framework, the results of the survey in this study cannot necessarily be regarded as a true reflection of the willingness of respondents to actually contribute to environmental conservation. Respondents were seemingly eager to suggest improvements to their immediate environment, but whether they will actively participate in a project to effect the suggested improvements, remains to be seen.

The results of the survey can however not simply be ignored and the assumption made that no actual support would be found for a project of this nature. By conducting a biodiversity enhancement project at the TMC, the foundation for similar projects in other sectors can be laid down. Opportunities and challenges can be identified, and by eliminating the problem areas and establishing and increasing the positive perception society has regarding nature in their work and living environment, a tool for urban restoration ecology can be developed.

2.6 Conclusion

Although this study only encompasses a small subset of modern global biodiversity problems it can play an important part in changing the perception of society regarding the importance of urban nature. It is clear from the outcome of the survey that people seek increased interaction with nature in their everyday environment. Conservationists should utilise this need in order to convince authorities to spend more time and effort in ensuring the natural wellbeing of the urban environment, even within the most densely developed cities. However, further investigations need to be carried out in order to truly understand the influence that urban nature has on society. The effect of nature on the productivity and general wellbeing of employees in the work environment need to be tested and the influence of restored environments on humans determined. By implementing a biodiversity enhancement project in order to re-establish the natural biodiversity, the Faculty of Health Sciences at the University of Stellenbosch sets an example to other urban organisations.

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Chapter 3: Biodiversity Enhancement and Ecological Restoration in a Cape Flats Urban Area

Summary

Urban biodiversity is under constant threat from increased urbanisation and alien species invasion. Over the last few decades almost all urban natural areas have been lost to development. This has resulted in conservationists turning to drastic measures of restoring biodiversity through a process of urban restoration ecology. The Faculty of Health Sciences of the University of Stellenbosch is in the process of planning a biodiversity restoration project on its campus. This study investigates the most feasible options available for the area and evaluates current biodiversity levels on and around the premises. The project is comprised of three smaller but interconnecting projects that include the physical reintroduction of plant species, vegetation analysis (using the Shannon diversity index), and bird species identification. The results of the projects show that, with limited effort, biodiversity can be increased by applying the correct irrigation and management options. Of the four reintroduced species (*Protea repens, Leucadendron salignum, Agapanthus praecox* and *Agathosma ovata*), *P. repens* struggled most to re-establish itself. It was also found that areas that were mowed regularly to control plant growth were the least diverse and showed significantly higher degrees of alien species invasion when compared to areas that had very little direct human influence. The low bird diversity of the campus is typical of an urban habitat, but with proper restoration techniques animal diversity in the form of birds, insects, reptiles, and small mammals can be increased without difficulty. The study emphasises the need for further investigation into proper urban management and restoration techniques with specific reference to the Cape Floristic Region.

Key words: Urban Restoration Ecology, Urban Biodiversity, Cape Floristic Region, Urbanisation, Fynbos

3.1 Introduction

One of the greatest threats to biodiversity in the modern era is urbanisation. The only factor that has a greater impact on the environment is expanding agricultural areas (Dobson *et al.,* 1997; Garagna *et al.,* 2001; Wessels *et al.,* 2003). A third factor threatening biodiversity is the encroachment of alien vegetation in fragile ecosystems (Richardson *et al.,* 1996). These factors, being mostly anthropogenic, deprive ecosystems of significant areas of natural habitats, leaving mere fragments of natural vegetation and a severely reduced biodiversity. Comparing present day cities with those of a few decades ago clearly shows that buildings and other artificial constructions have replaced most of the natural vegetation within urban boundaries. Previously areas of lush vegetation, wetlands, or rivers have made way to a concentrated assemblage of buildings and structures. Despite this negative impact on biodiversity even more land continues to be cleared for development as demand increases with growing populations. In the few areas where remnants of natural vegetation survive, it is most likely to be heavily infested with alien vegetation and consequently its capacity to support indigenous plant and animal life is drastically reduced.

Since it is not possible to prevent further urban development, strategies of biodiversity conservation specific to the urban environment must be implemented. One of these is to ecologically restore open areas within the city. The scientific discipline of restoration ecology has only gained proper recognition in the last decade, but its principles and methods are already being applied by various institutions and organisations (Meffe and Carroll, 1997). Ecological restoration aims to improve damaged ecosystems with respect to their health and sustainability (cf. Chapter 1). These ecosystems will typically represent areas that have been degraded to such an extent that they can no longer sustain indigenous vegetation and animal life without external intervention. This does not imply that ecological restoration is reserved for these extreme situations; it can also be successfully applied to areas that have been degraded to a lesser extent.

At this point the relevant concepts and terms used in the field of restoration ecology should be explained. Two components of an ecosystem should be intact for that ecosystem to be regarded as healthy, i.e. its function (biomass and nutrient cycling) and its structure (species and complexity) (Bradshaw, 2002). It follows that a habitat will be regarded as degraded if one or both of these components have sustained damage.

Apart from *restoration*, terms like *rehabilitation* and *reclamation* are used by ecologists to describe various restoration processes. According to Bradshaw (2002) a difference exists between the end results of each of these processes. *Restoration* can be defined as the process of restoring a habitat to its perfect condition, but in order to achieve this, all information of the condition prior to degradation should be known. Thus, the end result of restoration would be the establishment of an exact copy of the original ecosystem. Re-establishing only certain aspects of the ecosystem is known as *rehabilitation.* As this process does not result in the perfect condition being re-established it cannot be regarded as restoration. Rehabilitation does however apply to both ecosystem structure and function. In contrast, the process of *reclamation* (replacement) mainly aims at improving the function of the ecosystem while not considering the structure. Reclamation of an ecosystem is therefore also not equal to its restoration. An alternative to restoration, rehabilitation and reclamation is to allow natural succession to take place at its own rate. Unfortunately it can be a very slow ecological process and in worst case scenarios it could ultimately result in increased degradation (Koehler, 2000, Bradshaw, 2002).

As was pointed out, restoring a damaged habitat to its perfect condition or historic trajectory is extremely difficult due to the difficulty in determining the exact historical and natural state. Even if it is possible to determine the natural state, it remains difficult to restore the damaged habitat and to subsequently manage it, so that it would follow its historic trajectory. The only way to ensure successful restoration is to choose goals that are both technically feasible and scientifically sound, while taking social expectations into consideration (Cairns, 2000). Thus, in instances where restoration is not an option, rehabilitating some of the components of the habitat or creating a series of favorable traits that improve the area with respect to its damaged state (Meffe and Carroll, 1997; SER, 2002) might be the more suitable option.

Intentional activities towards recovering or restoring biodiversity in the urban context can be applied by all sectors of society, such as home owners, and the various institutions, industries and government organisations. The ultimate result of successfully applied urban ecological restoration projects together with normal conservation methods would be a sustainable city where the net products of urban life is beneficial to the environment rather than costly liabilities (Hough, 1994). In return society will want to gain in terms of the value associated with urban nature (cf. Chapter 2).

The Cape Floristic Region (CFR) is an area where extremely extensive fynbos diversity is under enormous pressure due to urbanisation, agriculture, and alien species invasion (Rebelo, 1992; Rouget *et al.,* 2003). Previous attempts at restoring fynbos in degraded areas have achieved varying levels of success. Examples of previous restoration projects include the Camps Bay Reservoir Vegetation Re-establishment Project in the Table Mountain Nature Reserve in 1985 (Peterson, 1988), the Cape Flats Nature Reserve, and various mining sites in the Western Cape.

The City of Cape Town (CCT) lies in the heart of the CFR. One institution in the CCT that showed interest in improving the natural condition of its premises is the Faculty of Health Sciences, University of Stellenbosch. Members of the Faculty's management approached the Department of Conservation Ecology of the same university for assistance with the planning and execution of the project. The main aim of the project was to return natural elements to the campus through a process of the reintroduction of indigenous vegetation, the removal of unwanted species and effecting a general increase in biodiversity. When considering the aims of the project and the limited availability of information regarding local historic ecosystem conditions, the faculty's management cannot execute a true restoration project. This project should rather be a rehabilitation project which aims to reintroduce elements in an attempt to increase indigenous biodiversity, while creating an aesthetically improved environment for personnel and students on campus.

This chapter focuses on the reintroduction of natural occurring plant species in open spaces on the campus and increasing overall diversity mainly in the form of insect and bird life. The study focuses on the reintroduction of selected indigenous plant species and an investigation of some of the basic factors that influence the results of the process. Existing plant diversity is investigated on and around the campus, with the main focus being the influence of open area management strategies on biodiversity.

3.2 The Study Site

The Tygerberg Medical Campus (TMC) of the Faculty of Health Sciences, University of Stellenbosch, is situated in the CCT, which lies within the Cape Floral Kingdom (CFK), one of the richest floral kingdoms in the world (Bond and Goldblatt, 1984). The extraordinary richness and exceptionally high percentage of endemic plant species presents the main reason why the Cape region was recognised as the CFK, making it the smallest of six existing floral kingdoms in the world (Takhtajan, 1969; Good, 1974). Despite its relatively limited size (covering only 89 000 km^2) the CFK boasts close to 9000 species in approximately 960 genera, accounting for 42% of Southern African flora (Bond and Goldblatt, 1984; Gibbs Russell, 1985; Goldblatt and Manning, 2000). Even more remarkable is that more than 60% of these species (i.e. more than 6000 species) are endemic to the region (Goldblatt and Manning, 2000).

With its wet winters and dry summers (Figure 3.1), this kingdom has a distinct Mediterranean climate (Taylor, 1980), and its species/area ratio for vascular plants is the highest for any temperate or sub-tropical region (Bond and Goldblatt, 1984). A sclerophyll type vegetation, commonly known as the Cape Fynbos vegetation, forms the bulk of the Cape Floral Kingdom flora (Levyns, 1964; Oliver, 1977; Taylor, 1978), while Restioid, Ericoid and Proteoid elements make up its distinguishing characteristics (Oliver *et al.,* 1983).

It is clear to the conservationist that a biodiversely rich area such as the CFR must be conserved and protected at all costs. However, alarming results regarding the conservation status of fynbos are shown in a study conducted by Boucher (1983) on the western Cape foreland south of the Berg River in the Western Cape Province. Dividing the fynbos vegetation of this area into three main types, West Coast Strandveld, Coastal Renosterveld and Coastal Fynbos, Boucher showed that in 1972 only 41% of West Coast Strandveld, 14% of Coastal Fynbos and 6% of Coastal Renosterveld remained. By 1998 the State of the Environment Report of the Cape Metropolitan Area (CMA) (City of Cape Town, 1998) showed that of the lowland vegetation types, less than 1% sand plain fynbos and 32% strandveld fynbos remained in the CMA, and only 3% of the total West Coast Renosterveld remained. The main reasons for this drastic loss in fynbos are, as already pointed out, mainly human activity such as urbanisation, agriculture, mining and the introduction of alien species (Rebelo, 1992; Rouget *et al.,* 2003).

3.3 The Physical and Biotic Environment on the Campus

The physical environment of the TMC is typical of an urban developed area. Buildings and other constructions dominate the area with well maintained and trimmed gardens, consisting of a mixture of alien and indigenous vegetation, attempting to bring some natural aspects to the TMC. Areas that are out of sight and not visited on a regular basis are mowed to reduce the labour and related costs of maintaining vegetation.

To the north the TMC is bordered by a small stream flowing in an east to west direction. Although it lies just outside the northern fence of the campus it is still part of the university's property. To the east lies a large area of vacant and unmanaged land belonging to the local railway company. On the southern side the campus is bordered by the Tygerberg State Hospital, and to the west by a residential area (Figure 3.2).

The exact composition and structure of the vegetation in the area prior to the construction of the TMC and the Tygerberg Hospital is not known. However, from interviews with local residents it can be assumed that the vegetation was in a near pristine condition. Only a few footpaths or small dirt gravel roads crossed the area, and today these are still in use on the remaining open area on the eastern side of the campus (Aerial photograph, Chief Directorate: Surveys and Mapping, 1960). The building of the medical campus commenced in the early 1960s, and over the last 40 years buildings, infrastructure, and sports grounds were gradually added and expanded. Today the approximate size of the campus is 260000 m^2, with the largest portion covered by physical constructions (Figure 3.3).

The TMC falls in the Coastal Fynbos Area (Kruger, 1979; Boucher, 1983), which is dominated by a uniform composition of Proteaceae, Restionaceae and Ericoid-leaved shrubs (Boucher, 1983). Today, only remnants of the natural vegetation and animal life are found in open areas on and around the campus.

3.4 Methods and Materials

To investigate the options and methods available to achieve an end-result of enriched biodiversity on campus, this study has been divided into three smaller but interconnecting projects. These include investigations to determine the current state of the natural environment of the campus.

3.4.1 Reintroduction of Plant Species

Provisional investigations on the TMC have lead to the establishment of a core area where rehabilitation of the land can take place. Financial implications, future developments, and water availability were factors that were taken into consideration when deciding on the area. The first step in the rehabilitation process was the experimental reintroduction of indigenous vegetation in the open spaces on the campus.

Four fynbos species, Sugarbush (*Protea repens*), Sunshine Conebush (*Leucadendron salignum*), Common Agapanther (*Agapanthus praecox*) and False Buchu (*Agathosma ovata*), were used for the experiment. They were chosen mainly due to the presence of flowers, availability, and their occurrence in the nearby Cape Flats Nature Reserve, which can be used as a reference nature ecosystem for rehabilitation processes on the TMC. The main aim of the experiment was to determine the level of successful reintroduction of the species, both with and without irrigation. The specific area for the experiment was chosen for two reasons: (1) it was the only area that would not be influenced by the existing irrigation system of the sports fields; (2) it was the area closest to a water source. Twenty plots of 10 m x 3.75 m (37.5 m^2) were laid out in a corner along the campus border, forming two blocks with 10 plots along each side (Figure 3.2).

Ten cuttings of each species were planted on 20 August 2003 in each of the plots in the two blocks. Plants were obtained from a local nursery and were approximately six months old. Plots were prepared by manually removing all vegetation prior to planting. Holes approximately 25 cm deep were made for each plant. *Protea repens* species were planted one meter apart and the remaining species were planted 0.75 m apart.

For the first month all plots were watered every seven days. For the remaining five months alternate plots were watered every seven days with sprayers for 45 minute periods. Water was supplied at 40 litres per minute, resulting in approximately 48 mm of water per watering period.

Keeping the block effect in mind there were thus a total of four experimental groups or treatments (labelled “wet 1” and “dry 1” in block 1, and “wet 2” and “dry 2” in block 2) with five plots for each group. The soil in block 1 is more compact and filled with rocks and stones. The soil in block 2 is very sandy with no rocks and stones. The following measurements were taken during the six month period at monthly intervals: for *P. repens* and *L. salignum*: height, number of branches and survival of each plant; for *A. praecox*: average leaf length of the four longest leafs of each plant and survival; for *A. ovata*: height and survival.

To prevent plants that received less water due to an edge effect from influencing the data, the first and last individual species in each row were omitted in measurements and calculations. In order to compensate for the differences in plant size at the time of planting, the difference between the last and first measurements, divided by the first, was used for all measurements to standardise the results. The resulting number (-1 and larger) is a representation of plant growth, where -1 represents a plant that died, a value between 0 and -1 a plant that showed negative growth, and a value greater than 0 a plant that showed positive growth.

For each species all the measurements were pooled according to treatment type (i.e. "wet 1", "wet 2", etc.) and type of measurement (i.e. *P. repens* height change, *L. salignum* height change, etc.). Thus, one treatment consisted out of 40 measurements (5 plots with 8 individuals per plot). The analysis of variance (ANOVA), followed by the Scheffe Test as *post hoc* analysis, were performed to test for significant differences in plant growth between each of the groups (StatSoft, Inc., 2003). Due to the block effect, as pointed out, all four groups were compared with each other.

3.4.2 Vegetation Analysis and Change in Open Area Management

A convenient method of managing open areas in the city is by physically reducing or removing plant cover by processes such as mowing. In this way, vegetation is controlled with very little effort and surroundings are kept neat and tidy without the need to water and trim plant cover. The same method is applied on certain areas of the TMC. Towards the eastern border of the campus and along the stream, vegetation has been kept low by regular mowing. To gain insight into the effects of this management strategy on plant biodiversity, a vegetation analysis has been performed on three areas on and around the campus. The three areas are: (1) the railway grounds, which is a fragmented habitat that has had no specific human influence over the last few decades; (2) open areas, i.e. areas on campus that have had intensive human influence in the form of mowing; (3) experimental plots, which is previously mowed areas on which the reintroduction of plant species experiment was undertaken. The Shannon diversity index was used to compare the open areas, the railway grounds, and the experimental plots. Data was gathered in each area by using 1 m^2 quadrants divided into a grid of 100 cm^2 squares. Each species occurring in the quadrant is noted with the number of 100 cm^2 squares it occurs in. The details on the three areas are as follows:

Open area: The gardening services company was requested to cease mowing approximately 20 000 m^2 of the open area at the end of 2002. The area was left to recover without any human intervention, and in winter/spring 2004 the vegetation biodiversity of the area was determined by randomly choosing five 1 m^2 quadrants.

Railway grounds: This vacant area has not been utilised or managed previously. A total of 10 quadrants were chosen at 10 m intervals covering the ground in a v-shaped line.

Experimental plots: This area consists of the twenty 37.5 m^2 plots on which fynbos species were introduced, and the open areas between the plots. It represents an area that had some human influence in the form of soil disturbance and watering over the last year. Again, five 1 m^2 quadrants were laid out on and between the experimental plots for species diversity calculation.

For the purpose of comparing plant biodiversity in the three areas, species occurrence in each quadrant were identified and used with the Shannon diversity index to establish diversity (H’) and evenness (J’) (Kent and Coker, 1992). All plants were identified to genus level, with some not being identified to species level due to a lack of time and resources. An ANOVA was performed to test for statistical significance between the three areas (StatSoft, Inc., 2003).

3.4.3 Attracting Birds

Most of the bird species occurring on and around the TMC during the summer months were identified. This was carried out by walking along a fixed transect on the campus. The areas covered included buildings, lawns, open areas, the stream, the railway grounds, areas with trees and gardens. The transect was walked at a steady pace alternating between mornings at 08:00 and afternoons at 16:00. All spotted bird species were recorded. The survey was performed during the period October 2002 to March 2003 over a total of 24 days.

In previous attempts, Rock Kestrels were successfully lured to nest in artificial nest boxes mounted to the Tygerberg Hospital buildings (Van Heerden *et al.,* 1994). For the current study the same was attempted by mounting artificial Rock Kestrel and Barn Owl boxes to the campus buildings. The two rock kestrel boxes were constructed and placed on the seventh floor of the administration building of the Faculty of Health Sciences in June 2004 in such a way that one faced southwards and the other eastwards. The two barn owl boxes were delivered to the maintenance department for installation on the second floor of one of the buildings facing east. Together with the nest boxes, reintroduced plant species should be the motivation for various bird species to gradually return to the campus.

3.5 Results

3.5.1 Reintroduction of Plants

In general the re-establishment of plant species showed a positive response to irrigation. A highly significant difference exists between irrigated and non-irrigated plots. The following differences were noted for the different species:

Protea repens showed statistically significant differences in plant height increase between irrigated and dry plots. Plants from plot “wet 2” had a significantly greater height increase than both “dry 1” and “dry 2” ($F = 7.72$, $df = 3$, $p < 0.001$ for all comparisons) (Figure 3.4a). “Wet 2” also had a significantly greater height change than “Wet 1” ($F = 7.72$, $df = 3$, $p < 0.022$). Regarding survival, plants from plot “wet 2” had a higher survival rate than plots “wet 1”, “dry 1”, and “dry 2” ($F = 9.40$, $df = 3$, $p < 0.006$ for all comparisons). A significant difference was also found between all four plots for the change in the number of branches ($F = 7.13$, $df = 3$, $p < 0.022$) (Figure 3.4b).

Leucadendron salignum showed highly significant changes in plant growth between irrigated and dry plots. Changes in height was evident, with a significantly greater height increase in “wet 1” and “wet 2” when compared with “dry 1” and “dry 2” ($F = 26.37$, $df = 3$, $p < 0.00001$ for all comparisons) (Figure 3.4c). The change in number of branches showed significant differences between the same groups, with irrigated plots showing a greater increase in number of branches than dry plots ($F = 15.32$, $df = 3$, $p < 0.008$ for all comparisons) (Figure 3.4d).Differences in survival between irrigated plots and dry plots were highly significant with for comparisons between “wet 1” and “wet 2”, and “dry 1” and “dry 2” ($F = 31.2$, $df = 3$, $p < 0.00001$).

Agapanthus praecox Comparing average leaf length of plants between the different plots showed a significant difference between “wet 1” and “wet 2”, compared with “dry 1” and “dry 2” ($F = 71.27$, $df = 3$, $p < 0.00001$) (Figure 3.4e). Wet plots also had a much higher survival rate than dry plots ($F = 26.61$, $df = 3$, $p < 0.00005$ for all comparison).

Agathosma ovata Height increases in irrigated plots were significantly greater than in dry plots ($F = 36.3$, $df = 3$, $p < 0.00001$ for all comparisons) (Figure 3.4f). Survival rates were significantly different between “wet 1” and “wet 2”, compared with “dry 1” and “dry 2”, with dry plots showing very low survival success ($F = 41.18$, $df = 3$, $p < 0.0002$ for all comparisons).

3.5.2 Vegetation Analysis and Change in Open Area Management

Vegetation, although heavily encroached with alien species, re-emerged in the largest part of the open areas. Nests of Crowned Plovers (*Vanellus coronatus* that had been destroyed by mowing in the past were kept intact, and the birds were now successfully raising chicks.

During the vegetation diversity analysis, 63 plant species were identified on the open areas, the railway grounds, and on and in between the experimental plots (Table 3.1). However, 19 of these species (30%) are exotic to the CFR. The Shannon diversity index showed significant differences for plant diversity (H') only between the experimental plot area (H' = 2.01) and railway grounds (F = 5.14, df = 2, p < 0.03). No significant difference was found between the evenness values (J') of the three different areas (F = 0.268, df = 2, p > 0.05).

When considering the occurrence of exotic species, it becomes clear that only four exotic species occur on the railway area as opposed to the seven on the experimental plots and 14 on the open areas. Furthermore, the exotic species cover 15.7% of the railway sample plots, 29.79% of the rehabilitated areas, and 35.38% of the open areas (Table 3.2).

3.5.3 Attracting Birds

The diversity of birds on or flying over the campus was determined through observation. A total of 46 different bird species were identified (Table 3.3). Two artificial Rock Kestrel boxes were successfully installed on the buildings of the Faculty of Health Sciences. By September 2004 the nest boxes had not been inhabited.

3.6 Discussion

3.6.1 The Value of Biodiversity

Connecting a monetary value to nature can prove to be very difficult (Ryan *et al.,* 1995; Turpie, 2003). This is mainly due to the different views local communities have on the uses and benefits of nature. The same applies when it comes to valuing fynbos in the CFR. According to Le Maitre *et al.* (1997) the value placed on natural resources like fynbos by an individual is directly related to his/her knowledge thereof. This could include knowledge about its productive, cultural, recreational, scenic, conservation, educational, and spiritual value (cf. Chapter 2). Furthermore, the general perception is that the need to protect nature becomes increasingly important with increasing productive value, cultural value, etc. Similarly, the perceived value of biodiversity also rises with an increase in knowledge about its vulnerability or decline (Turpie, 2003).

It has been shown by Turpie *et al.* (2003) that the economic value of the CFR is estimated at approximately US$1 700 million per year. A degraded natural area is however more likely to be regarded as less valuable and would therefore be disregarded as a potential conservation or natural site. Ironically, it is these areas that require extra care in the form of restoration and rehabilitation ecology in order to restore their value and in this way aid in the biodiversity conservation process.

The open areas on the TMC are a good example of an area that will increase in value through some rehabilitation processes. The current open area management strategy consists of keeping vegetation short through regular mowing. In this way alien vegetation is controlled and the area is kept neat and tidy. Unfortunately, the effect of mowing has negative consequences on biodiversity. Together with removing alien vegetation, indigenous vegetation is removed and with decreasing natural vegetation, animal diversity, mainly in the form of insect and bird life, is reduced. The ultimate result is typical of the urban setting, with limited indigenous biodiversity and increased occurrences of alien species.

3.6.2 Plant Reintroduction on the Tygerberg Medical Campus

Considering the results of the project to re-establish species on campus, it is clear that biodiversity enhancement in the form of the reintroduction of indigenous species is a feasible option despite the problems that may arise. Looking at the growth and survival of the four species, there is no doubt that re-established plants will have to be irrigated initially as almost all of the plants form the dry plots died. Furthermore, it seems that *P. repens* was the most vulnerable species planted, as it showed the clearest signs of struggle. Even in the irrigated plots *R. repens* showed negative growth (Figure 3.4a). One of the possible reasons for this is that the CFR is a winter rainfall area, whereas the plants were only planted towards the end of the rainy season. In the initial planning the project would have been started in the early winter, but due to logistical problems this was not possible. Had the project been started earlier, more non-irrigated plants could have survived and plant growth in the form of number of branches, height increase, and leaf length might have been more positive. Nevertheless, should re-establishment be commenced early in the rainy season, it would still be recommended that irrigation be applied at least for the duration of the first dry season.

An additional factor that possibly caused lower survival and growth rates might be the fact that the CFR experienced a warmer and dryer summer season (Figure 3.5). The average monthly maximum temperatures for the six month period were up to 2°C higher than the 30 year average (1961-1990). In addition, lower average rainfall figures resulted in harsh conditions for young plants in which to get established. Furthermore, plants were damaged or completely destroyed by animals such as guinea fowl (*Numida meleagris*), that trampled plants while foraging for food, and Cape dune molerats (*Bathyergus suillus*), burrowing in the experimental plots, consequently damaging root systems or entire plants.

3.6.3 Vegetation Diversity on the Tygerberg Medical Campus

With 30% of plant species on and around the campus being exotic, the area should be regarded as a degraded natural habitat. However, from the results of the vegetation analysis it is clear that previously degraded areas that have undergone some level of rehabilitation shows a positive reaction, as the number of exotic species decreased in as little as a year's time when compared to other open areas on campus. Calculating the Shannon diversity index for parts of the campus showed that the diversity in the experimental plots increased considerably, when compared with the railway grounds, over a relatively short time-span. Apart from the additional introduced species, this is probably due to the disturbance in the soil when the plots were prepared, which included manually removing weeds, thus allowing dormant fynbos species to emerge in the absence of competitors.

Comparing the presence of exotic species on the railway grounds with the open areas and experimental plots, it is evident that the railway grounds has the lowest number of exotic species compared to the open areas, which have the most. It is clear from the study that removing or managing vegetation through regular mowing is not an option when it comes to biodiversity conservation. Thirty five percent of the total area that had undergone this treatment is covered with alien species, compared to 30% on the experimental plots and only 16% on the railway grounds. Thus, the area with the least human influence had the least number and surface cover of exotic species, and *vice versa*. The experimental plots (previously part of the open areas) showed a slight decline in the number of exotic species present and with proper management this number should decrease even more. It should be noted that the total domination of the railway grounds by *Acacia salignum* is not evident in the results. Nevertheless, removing *A. salignum* from this area would be a very good start to a rehabilitation process.

3.6.4 Bird Diversity on the Tygerberg Medical Campus

Bird diversity on the campus is typical of the urban habitat, with pigeons, starlings, and doves being the most common. When compared with the Cape Flats Nature Reserve, where more than 82 different species occur, the 46 of the TMC could be symptomatic of the degraded habitat. However, it should be mentioned that the bird survey was not carried out throughout the year, thus more species will most likely be added to the list should the survey be extended. Building artificial nest sites is one possible way of attracting more birds to the campus. The effect of this strategy is limited, however. The largest number of species will be attracted through an improvement of the habitat. Still, the nest sites remain a viable option for attracting rarely occurring species, like Rock Kestrels, to the site.

3.6.5 Biodiversity Enhancement Options on the Tygerberg Medical Campus

Short and long term goals for the ecological rehabilitation of the TMC should be identified, while taking the expectations of employees and students into account. A list of the best suitable plants must be compiled in conjunction with the Cape Flats Nature Reserve and its nursery. These should include plants that have a good survival rate and are aesthetically valuable. Further studies could be done to determine the success rate of re-establishing species using seeds or cuttings, as well as different methods of weed control (i.e. chemical, physical, fire, etc.). The optimum irrigation strategy should be determined and the possibility of using fire as method of exotic species control should be explored.

The possibility of interconnecting nature reserves and areas with natural vegetation through vegetation corridors must be kept in mind. The railway grounds on the eastern side of the campus have an open area that reaches over the complete distance to the Cape Flats Nature Reserve. Should all parties involved agree, this can form the starting point for interconnecting these three areas and thereby creating one of the largest natural areas in the urban environment of the CCT.

3.7 Conclusion

The TMC biodiversity enhancement project is a good example of what the future of conservation in the urban environment is likely to be. This study shows that it is possible to use limited resources to enhance biodiversity over a short time. Attempting to restore fynbos vegetation on the TMC could have very positive results if managed correctly. These results can be direct, in the form of increased biodiversity and a more attractive environment, or indirect, by setting an example for others to follow. As with any large project, however, this type of project also poses several problems. Working within the city boundaries, the ideas and opinions of all stakeholders should be taken into account, even more so on the TMC, where more than 2000 employees and students work on a daily basis. All their needs and expectations should be taken into consideration and a compromise should be reached so that the end-result will desirable to al.

Once the vegetation structure is being restored, other parts of the urban ecosystem will be restored automatically. Initially, insects and birds will start to return, followed to a lesser extent by reptiles. With some relocation activities, small mammals and other reptiles can be reintroduced as well. Once this process is complete, the urban ecosystem can function independently with very little external management needed.

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Chapter 4: Management Recommendations for a Biodiversity Enhancement Project of the Tygerberg Medical Campus, Faculty of Health Science, University of Stellenbosch

4.1 Introduction

The TMC of the Faculty of Health Sciences, University of Stellenbosch, is home and workplace to a diverse group of students and personnel. Creating and maintaining a positive attitude among them in order to continue the intellectual dynamics and creativity of the institution is of crucial importance to the faculty's management. Sustaining a feeling of *genius loci* (spirit of place) among personnel and students will not only motivate them, but also increase work efficiency and job satisfaction (cf. Chapter 2).

Apart from the health services provided to society, the faculty also shows interest in promoting environmental health on and around its premises. A survey, conducted among to personnel and students on the campus, showed that they would support actions of enhancing the natural environment on campus, specifically by focussing on indigenous vegetation. The TMC has a very low indigenous plant and animal diversity, with remnants of natural vegetation largely dominated by alien species (cf. Chapter 3).

To create an ecologically sound environment on the TMC, careful planning is essential in order to ensure the success of such a project. The aim of this chapter is to highlight the main results of both the survey and biodiversity enhancement research conducted on the campus. Suggestions and recommendations are listed regarding biodiversity enhancement options while taking into account the expectations of the students and personnel.

4.2 Factors to be Considered when planning the Implementation of a Biodiversity Enhancement Project

4.2.1 Social Factors

The project could have a significant social impact on of the TMC by altering the existing environment in which personnel and students live and work. It will attempt to create a spirit of place on the campus through improved surroundings. The different stakeholders' expectations and opinions regarding such changes should be identified and carefully considered. Personal communication with staff and students will in all probability show that the expectations of these two groups may differ significantly. Thus, in order to ensure the success of the project, all stakeholders must be involved, and where opinions differ, compromises should be negotiated.

4.2.2 Environmental Factors

Due to the complexity of a sustainable ecosystem, it is necessary to develop the correct methods of biodiversity enhancement in order to ensure its future sustainability. The specific species to be reintroduced, method, and timing of reintroduction are just some of the variables that could determine the success or failure of the project. Ignoring these variables may result in failed attempts to rehabilitate degraded environments and can as a result cause even more damage.

4.2.3 Financial Factors

The implementation and execution of rehabilitation projects require a degree of financial input that do not always seem justifiable due to the difficulty of expressing the end product of rehabilitation in monetary terms (Ryan *et al.,* 1995; Turpie, 2003). However, the advantages in terms of enriched biodiversity could be enough to validate its place in urban environments. These include:

4.2.3.1 In Spiritual Terms

The positive effect of green, diversity rich surroundings on an individual's spirituality may result in positive attitudes and a sense of belonging (cf. Chapter 2).

4.2.3.2 In Conservation Terms

Focusing on the upkeep of indigenous biodiversity helps to ensure the future existence of the rich diversity of the Cape Floristic Region (CFR). Simultaneously, the conservation value attached to rehabilitation creates a positive image within the business or institute, as well as among members of the public, other businesses and government institutions.

4.2.3.3 In Monetary Terms

In contrast to most exotic species, a direct financial gain is associated with the use of indigenous plants in gardens. In the long term they require less water, as they are better adapted to the specific climate of the area. Levels of maintenance are also lower, as the vegetation is less susceptible to stresses like pests, drought, and frost.

4.3 Biophysical Environment on the Tygerberg Medical Campus

The CFR is one of the richest floral kingdoms in the world, with Restioid, Ericoid and Proteoid elements forming the distinguishing characteristics of Cape fynbos (Oliver *et al.,* 1983; Bond and Goldblatt, 1984). This complexity arose despite relatively severe Mediterranean type climate conditions and poor soil quality where dry and windy summers can easily desiccate fragile vegetation (Cowling *et* al., 1992; Le Maitre and Midgley, 1992; Meadows, 2000).

The Tygerberg Medical Campus (TMC) falls in the Coastal Fynbos Area (Kruger, 1979; Boucher, 1983) which is dominated by a uniform composition of proteaceae, restionaceae and ericoid-leaved shrubs (Boucher, 1983). As with most urban areas, almost all of the natural vegetation has been replaced by man-made structures and gardens with open areas largely invaded by alien species. Conditions are made even harsher by deep, sandy, and acidic soils (Boucher, 1983) in which remaining species have to compete.

4.4 Suggested Focus Areas for Biodiversity Enhancement on the Tygerberg Medical Campus

4.4.1 Core Area

In this study, two core areas have been identified for fynbos re-establishment. The first of these are the open (previously mowed) areas on the eastern side of the campus directly behind the sports fields, consisting of relatively large areas where little or no human activity takes place. Current vegetation consists of a mixture of alien and indigenous species with approximately half the species being exotic (cf. Chapter 3). The second core area is the area immediately surrounding the small perennial river on the northern border of the campus which is ideal to establish plant species dependent on a continuous water supply. Vegetation can be established both in the river and on its banks.

4.4.2 Secondary Areas

Small open areas where little or no human activity takes place are scattered all over the campus. These include areas along the perimeter fence, on and around parking lots, and between student residences and buildings. These areas are currently mostly covered with kikuyu grass and a few trees, of which a large proportion are exotic.

4.4.3 Linkages

In order to maximise biodiversity it is important to link the core and secondary areas using vegetation corridors in order to create a flow of genetic diversity on the campus. Long term planning could also include linking the TMC with natural areas in other parts of the city (e.g. the Cape Flats Nature Reserve). This will prevent the formation of a genetically isolated island on the campus where no gene flow can take place between it and nearby but similar areas.

4.5 Materials and Methods

4.5.1 Choosing and Placement of Vegetation

The aim of this project is not to recreate fynbos on the TMC and its vicinity, but rather to reintroduce some plant elements from the proteaceae, restionaceae, ericoid and geophyte groups so that over the next 10 to 15 years the vegetation structure on the campus resembles that of fynbos. Furthermore, with the correct placement of carefully selected species in strategic locations, the inherent value of biodiversity will increase the overall values (spiritual, financial, aesthetic, etc.) of existing elements on campus without significant financial implications. These measures could include host plants attracting birds, butterflies, and other insects, placed in areas of contact (but not conflict) with personnel and students (outside windows, along footpaths, next to benches, etc.).

4.5.2 Sourcing Vegetation for Reintroduction

When plant species are acquired for reintroduction, it is important to ensure that site genetically adapted species are selected (Holmes and Richardson, 1999). The first option is to collect species from the nearby Cape Flats Nature Reserve that should be genetically similar to natural occurring species in the TMC area. Secondly, with the help of botanists, it is possible to collect seeds from locally occurring indigenous species (mostly on the railway grounds, cf. Table 3.1) on a monthly basis. Through a process of mulching and smoke treatment species can be reintroduced and increased until a good cover is achieved (Holmes and Richardson, 1999). Smoke treatment enhances germination and growth and consists of a process of soaking the seeds in water that have been aerated with smoke filled air obtained from burning fynbos.

It is also very important to ensure that plant associations with mycorrhizae, a symbiotic relationship between plant roots and fungi, exist (Van Rooyen, 2004). This will help to ensure optimum conditions for plants to establish themselves in and can be achieved through inoculations on plant roots in nurseries.

4.5.3 *In Situ* Nursery

Long term commitments could include the creation of an *in situ* nursery where genetically site adapted seedlings and cuttings can be cultivated. These can then be reintroduced to the campus or be supplied to nearby home owners, businesses or institutions to be established in neighbouring areas. Inoculation processes with complementary mycorrhizae as well as smoke treatment of seeds can be performed in the nursery to ensure the success of re-establishment projects. The nursery should be managed in cooperation with nearby nature reserves or fynbos nurseries.

4.6 Alien Species Control

One of the major causes of biodiversity loss in the CFR is the large scale of invasion by alien species (Richardson *et al.,* 1996). A total of 19 alien species have been identified in open areas and around the TMC. This process is a continuing threat that will require ongoing management. Seed dormancy and seed dispersal from nearby areas will continuously reintroduce alien species to the campus. Cooperation with the Working for Water Programme (led by the Ministry of Water Affairs and Tourism) to eradicate alien vegetation will not only decrease competitor species of fynbos, but also increase the availability of water in the Western Cape.

4.7 Long Term Management

Initially, biodiversity enhancement projects on the campus would require a relatively significant financial and labour input. However, once established, they will require less input than traditional exotic gardens. One of the most important long term management strategies should be the periodical burning of fynbos in late summer or early autumn (Holmes and Richardson, 1999). This is essential to control exotic species as well as to ensure the survival of indigenous species. The planning of controlled burning and the intervals and number of blocks that should be burned alternately is a critical element of fynbos management. It is essential that an even distribution of age and size classes for fynbos be established and maintained. For example, controlled burning on the core areas can take place in a 10 to 15 year cycle in three different blocks on a rotational basis.

4.8 Suggestions for Enhancing Biodiversity and Increasing the Value of the Project

From the survey and the initial biodiversity enhancement experiments the following suggestions could be considered to enhance biodiversity and to create an aesthetically improved environment on the TMC:

1. A committee consisting of representatives from stakeholders on the campus who can lead a biodiversity enhancement project should be established. This group should be responsible for the dissemination of information to all the stakeholders on campus.
2. Clean-up days on the campus should be organised, as littering remain a continuing problem in open areas on the campus. This should be complemented with a recycling programme for glass, paper, metal, and

organic litter, with recycling bins at easily accessible and convenient locations on the campus.

3. The open area management strategy of indiscriminately mowing all vegetation should be replaced by a process of identifying and removing exotic species and managing indigenous vegetation.

4. Once exotic species are under control and remnants of fynbos vegetation has returned through natural succession, new species of fynbos should be reintroduced to the open areas on the campus. This should take place at the beginning of the winter season. Reintroduced species would require irrigation twice weekly during the summer months and weekly during dryer periods in the winter months. During this time exotic species should be removed manually until the fynbos species are of such a size that exotic species would not pose a significant threat to their survival. Irrigation should be ceased once the plants have adequately established themselves.

5. A natural fence consisting of Kei-apple, *Dovyalis caffra* and Num Num, *Carissa macrocarpa* species could be planted on the inside of the existing fence at half meter intervals to form an impenetrable fence that would eventually reach an approximate height of two meters. Its flowers and edible fruits would also attract more bird species to the campus.

6. Exotic trees should be gradually replaced with indigenous ones. From the results of the survey and in personal interviews with personnel and students on campus it became evident that most of them do not wish to see any existing trees removed. However, taking this action is necessary, as many exotic species displace indigenous vegetation and are heavy consumers of water. Their ability to spread fast is also a cause for concern. What is suggested is that initially only every second tree be removed and replaced with a suitable indigenous species. Once these trees are larger, the remaining exotic species could be replaced.

7. An artificial water feature could be created on one of the open areas on campus. This could be in the form of a pond with the water source either being runoff water from the roofs of buildings, or from the cooling systems of buildings, or water from the nearby stream. Such a feature will attract more bird species and would create an aesthetically positive element on the campus. The proposed site is between the sports fields and the eastern border of the campus.
8. Indigenous water plants should be introduced to the pond.
9. A footpath leading through reintroduced fynbos vegetation in open areas on the campus should be established. Value can be added to this by creating picnic areas and benches shaded by vegetation, bird hides, and information signs on plants and animals occurring on campus (e.g. identification tags on trees). These features should be accessible to disabled persons.
10. A sand patch in the open areas for guinea fowl and other birds should be created.
11. Small mammals and reptiles could be relocated to the campus with the cooperation of Western Cape Nature Conservation.
12. The eradication of alien species in neighbouring open areas and the expansion of natural vegetation to these areas can be accomplished by working together with the Working for Water Programme of the Department of Water Affairs and Forestry, other nearby nature reserves and the railway company. The establishment of vegetation corridors from the TMC to other open areas, especially the open areas of the neighbouring railway grounds that lead through to the Cape Flats Nature Reserve, could be investigated.

4.9 Conclusion

The process of maximising indigenous biodiversity on the TMC would require long term commitment from role players in the Faculty of Health Sciences community, as well as sufficient support from the entire University management. However, as stated in this chapter, the advantages of the project outweigh the effort, time, and money required by it. With careful planning and by appointing dedicated and knowledgeable staff (with regard to indigenous biodiversity), changes on the campus could be seen in as little as a year's time. By following the guidelines proposed in this chapter, the expectations of personnel and students are taken into account while considering optimum conservational practices.

4.10 List of Useful Books, Nurseries, and Organisations for the Re-establishment of Fynbos on the Tygerberg Medical Campus and Surroundings

Books

Botha, C., Botha, J., 2000. *Bring Nature back to your Garden*, Western Edition. Interpak Books, Pietermaritzburg.

Joffe, P., 2001. *Creative Gardening with Indigenous Plants: A South African Guide*. Briza Publications, Pretoria.

Reid, J. 2000. *Butterfly gardening in South Africa*. Briza Publications, Pretoria.

Van Jaarsveld, E., 2000. *Wonderful Waterwise Gardening*. Tafelberg Publishers, Cape Town.

Nurseries

Kirstebosch Production Nursery, National Botanical Institute, Private Bag x7, Claremont 7735, South Africa.

Cape Flats Nature Reserve and Nursery, University of the Western Cape

Organisations

Western Cape Nature Conservation Board, Private Bag X100, Cape Town, 8000

Working for Water Programme, Private Bag 4390, 3rd Floor Murray & Roberts Building, 73 Hertzog Boulevard, Cape Town, 8000

4.11 References

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Boucher, C. 1983. Floristic and structural features of the coastal foreland vegetation south of the Berg River, western Cape Province, South Africa. *Bothalia* 14, 669-674.

Cowling, R.M., Holmes, P.M., Rebelo, A.G. 1992. Plant diversity and endemism. In *The Ecology of Fynbos: Nutrients, Fire and Diversity* Ed R. Cowling pp 62-110, Oxford University Press, Cape Town.

Holmes, P.M., Richardson, D.M., 1999. Protocols for restoration based on recruitment dynamics, community structure, and ecosystem function: perspectives from South African fynbos. *Restoration Ecology* 7 (3), 215-230.

Kruger, F.J. 1979. South African Heathlands. In *Ecosystems of the World. Vol 9*. Heathlands and Related Shrublands, ed R.L. Specht, pp19-80, Elsevier, Amsterdam.

Le Maitre D.C., Midgley, J.J. 1992. Plant reproductive ecology. In *The Ecology of Fynbos: Nutrients, Fire and Diversity* Ed R. Cowling pp135-174, Oxford University Press, Cape Town.

Meadows, M.E. 2000. The ecological resource base: biodiversity and conservation. In *The Geography of South Africa in a Changing World*, ed R. Fox, K. Rowntree, pp 361-389, Oxford University Press, Cape Town.

Oliver, E.G.H., Linder, H.P., Rourke, J.P., 1983. Geographical distribution of present-day Cape taxa and their phytogeographical significance. *Bothalia* 14, 427-440.

Richardson, D.M., Macdonald, I.A.W., Holmes, P.M., Cowling, R.M. 1996. Plant and animal invasions. In *The Ecology of Fynbos: Nutrients, Fire and Diversity*, ed. R.M. Cowling, pp 271-308. Oxford University Press, Cape Town.

Ryan, P.G., Cowling, R.M., Costanza, R. 1995., Valuing ecosystems: is the fynbos worth conserving? *South African Journal of Science* 91, 572-573.

Turpie, J.K., 2003. The existence value of biodiversity in South Africa: how interest, experience, knowledge, income and perceived level of threat influence local willingness to pay. *Ecological Economics* 46, 199-216.

Van Rooyen, M. 2004. *The use of natural processes to ensure sustainable rehabilitation of degraded soils*. Unpublished M.Phill.

Chapter 5: Conclusion

Preserving biodiversity within the urban context is just as important as it is in nature reserves and other conservation areas. Failure to preserve urban biodiversity will result in the destruction of a large part of what should be a heritage left to future generations. However, until recently the main concern in the city was to maximise development. Where space was available, attractive gardens have been created by using indigenous or exotic species indiscriminately. As a result, conservationists are now facing invasion by exotic species that not only compete for resources with indigenous vegetation, but often completely destroy natural ecosystems. From this study the following main conclusions can be highlighted:

The conclusions reached in chapter 1 show that one of the major reasons for degraded habitats in the urban environment is the existing perception often have about natural areas and biodiversity in the city. Instead of regarding urban nature as equally important to rural nature, the general conviction seems to be that there is no place for nature within the city and that remaining natural areas can be destroyed for the sake of development. The advantages linked to preserved urban biodiversity are not realised. These include conservational, recreational, cultural, educational, productive, and spiritual advantages.

In order to preserve or re-establish biodiversity in the city, the existing perception of urban nature has to be addressed. Nature should no longer be seen as something distant, but rather as an integral part of daily city life. Once this is achieved, individuals and groups will be more willing to invest time and money in conservational projects practices within urbanised areas. Simultaneously, existing biodiversity in the city would become noticeable, which would further change the perception of urban nature in favour of the preservation thereof. Finally, when role players in the urban environment realise the importance and benefits of urban biodiversity, processes can be put in place to either preserve remnant natural habitats or to effect some form of restoration or rehabilitation ecology.

The spiritual connection with nature can often be a very positive experience. Emphasising nature within the city can therefore create a heightened spirituality among city dwellers. A heightened spirituality refers to anything from a more positive attitude towards life and work to a feeling of being content and satisfied with one's surroundings. From chapter 2 it is clear that a definite need exists for the preservation or re-establishment of biodiversity rich areas around the urban workplace and home. However, even more important is the interest that exists in a large part of society to become actively involved with biodiversity enhancement projects.

From the survey conducted it is clear that the respondents have very specific ideas about their immediate environment and to what extent it should be changed for conservational purposes. For instance, most respondents agreed that exotic vegetation should be replaced with indigenous species; however, they feel strongly that exotic trees should not be removed. This illustrates that the difference between the opinions of the general public and those of conservationists can be in conflict. Only by providing adequate information based on research and literature, a compromise can be negotiated to benefit conservational processes.

The spiritual advantage linked to natural habitats in the urban environment is motivation for city residents to work towards greener cities. However, it would seem that not much research has been done on the positive spiritual effect that specifically urban nature could have. With sufficient evidence linking increased productivity and work satisfaction with well managed or preserved natural surroundings, conservationists will be able to put more pressure on all levels of management to invest more time and effort in conservation.

Once role players are convinced of the benefits of urban nature, the best methods of preserving or re-establishing biodiversity in the city should be decided on. The methods could include protecting pristine habitats, expensive restoration projects, or relatively simple biodiversity enhancement projects. Of these, the latter is probably the more feasible option for most institutions and private individuals. In the short term it entails the reintroduction of key species that have been lost from an ecosystem, together with alien species control and subsequent management. However, in the long term, through processes of natural succession, the ecosystem structure and function could be restored and thus the conservational goals could be met.

Looking specifically at fynbos, it is clear that lost fynbos vegetation can be re-established with relatively low financial input. A simple change in open area management could already show positive effects in terms of biodiversity richness and a decrease in the numbers of exotic species. The long term financial benefits linked to natural vegetation gardens, as well as the aesthetic value thereof, should be worth the initial time and effort spent to return natural vegetation and its associated animal life.

In chapter 4 recommendations for the enhancement of biodiversity on the Tygerberg Medical Campus of the Faculty of Health Sciences at the University of Stellenbosch are put forward. The suggestions are specifically related to the TMC but could mutatis mutandis also be applied by the individual in his/her own garden and by institutions and organisations much larger than the Faculty of Health Sciences.

By launching this project, the Faculty of Health Sciences sets a very important example, not only to similar organisations and institutions, but also to individuals and government institutions. By establishing and linking a network of these urban green areas throughout a city, a so-called “green city” can become a reality. It is of the utmost importance that urban biodiversity conservation should be actively promoted and applied without delay in order to save as much biodiversity as possible. To wait may prove to be a mistake, either in the sense that conservation might be much more costly in the future or that it may simply be impossible. This is especially true in areas such as the extremely rich Cape Floral Region.

The three main aspects of this study call for a change in urban societies' perception of nature, and that the importance of a healthy natural urban environment, followed by the realisation of the benefits this could have on human spirituality and productivity be recognised. Finally, it asks for the implementation of similar projects in other sectors of society and for the management of existing areas within the city.

Annexure A: Figures and Tables

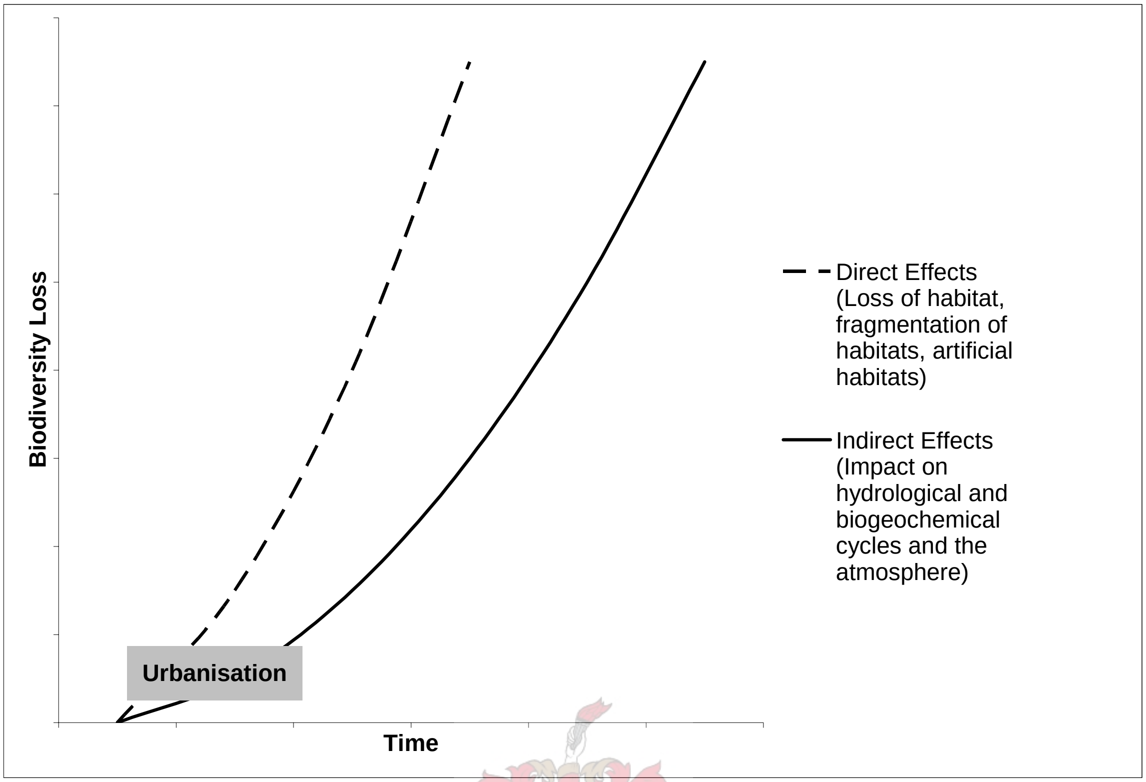

Figure 1.1 Graphical representation of the two main categories into which Mcneely *et al*. (1995) divide the effects of urbanisation on biodiversity. Direct effects such as loss of habitat and fragmentation of habitats will affect biodiversity shortly after onset. The effects of indirect actions such as impacts on hydrological systems will only appear after a longer period.

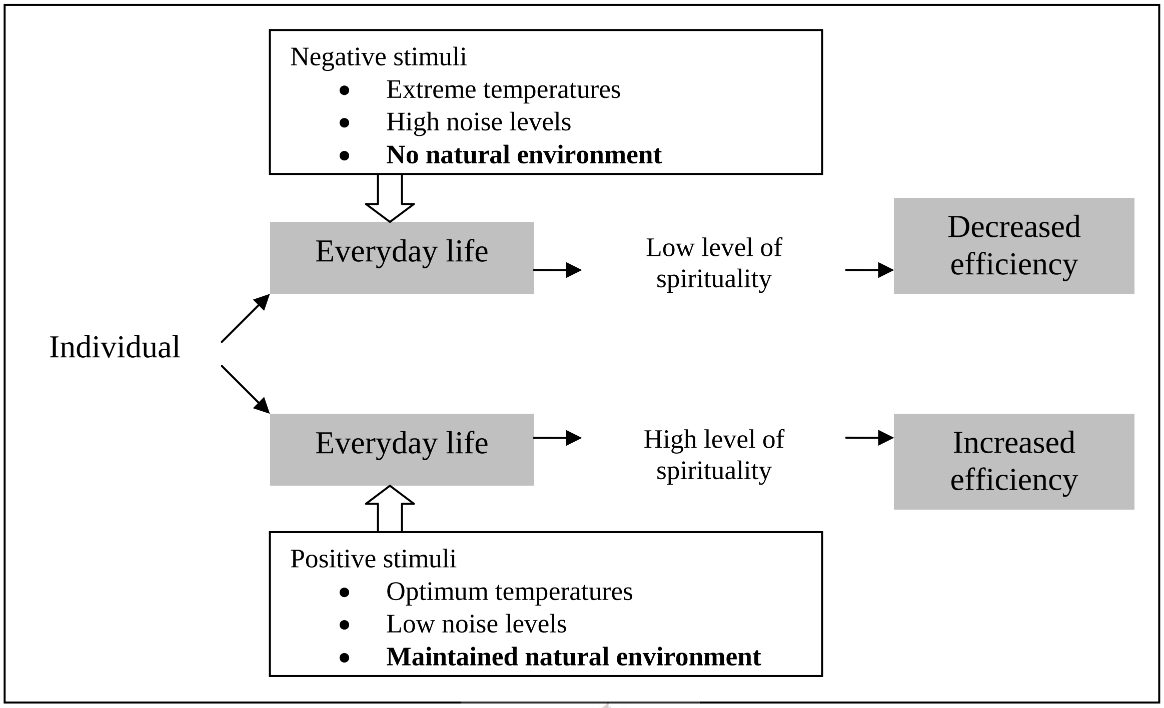

Figure 2.1 The effect of an individual's surroundings on spirituality and the consequences on work efficiency. The diagram shows that negative stimuli result in a negative attitude or lack of spirituality, and positive stimuli result in a positive attitude or heightened spirituality.

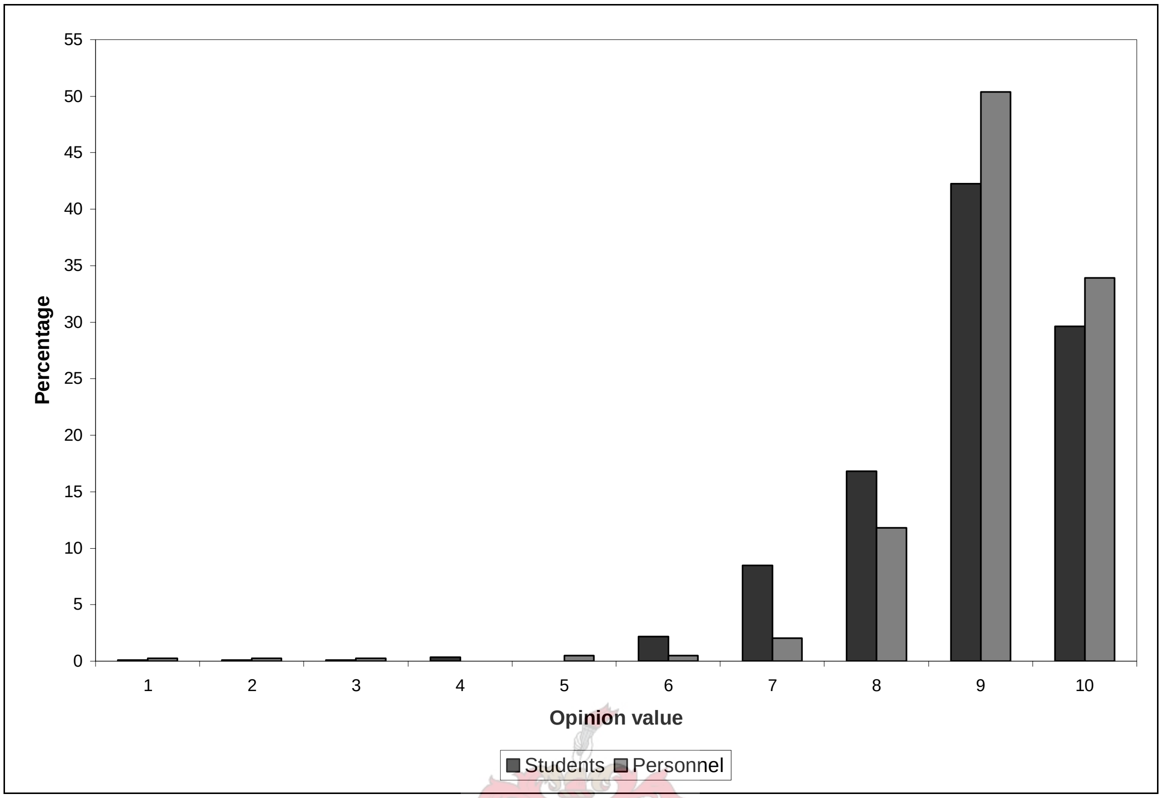

Figure 2.2 Graph representing the opinion value of respondents regarding nature as a percentage. Both students and personnel show a significant positive that averages 9 (students: χ^2 = 1118.55, *df* =9, p < 0.05), personnel: χ^2 = 549, *df* = 9, p < 0.05). Personnel places a significantly higher value on nature than students (χ^2 20.75, *df* = 9, p < 0.05).

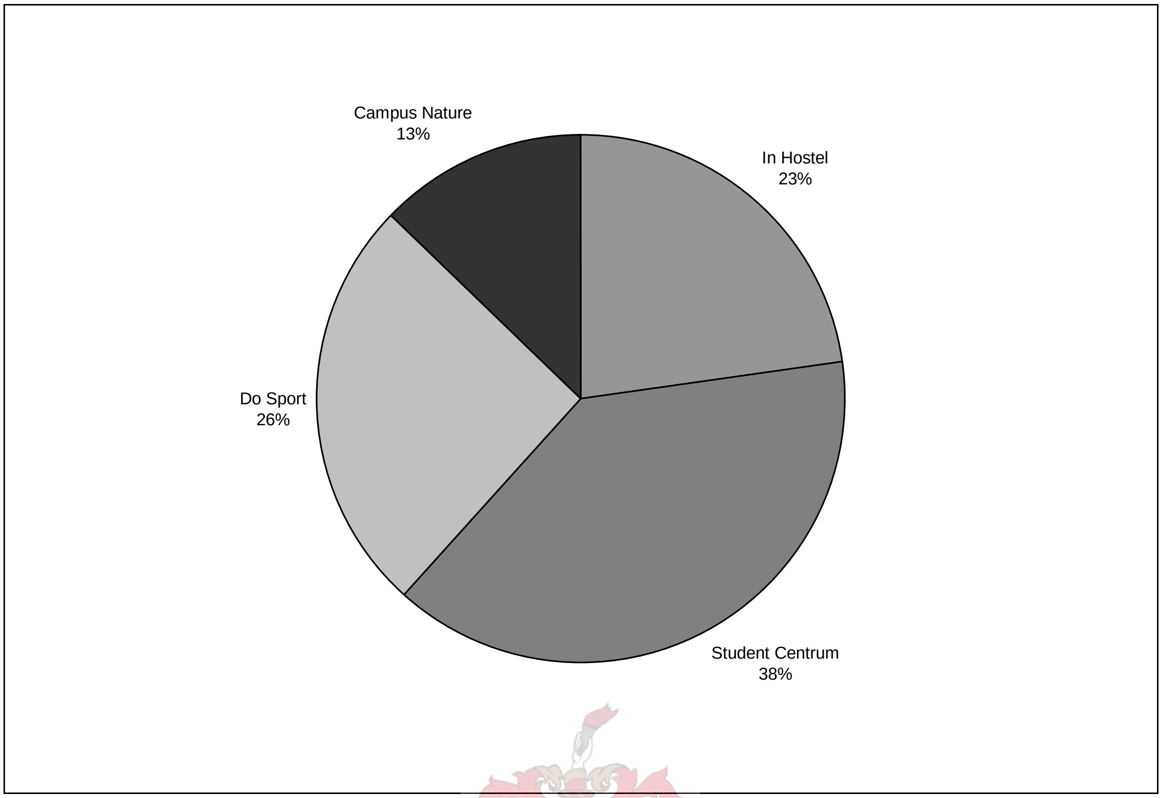

Figure 2.3a Figure representing, as a percentage, student choice of place for spending any available spare time while on campus. The most significant proportion prefer spending time in the Student Centrum (χ^2 = 54.41, df= 3, $p < 0.05$)

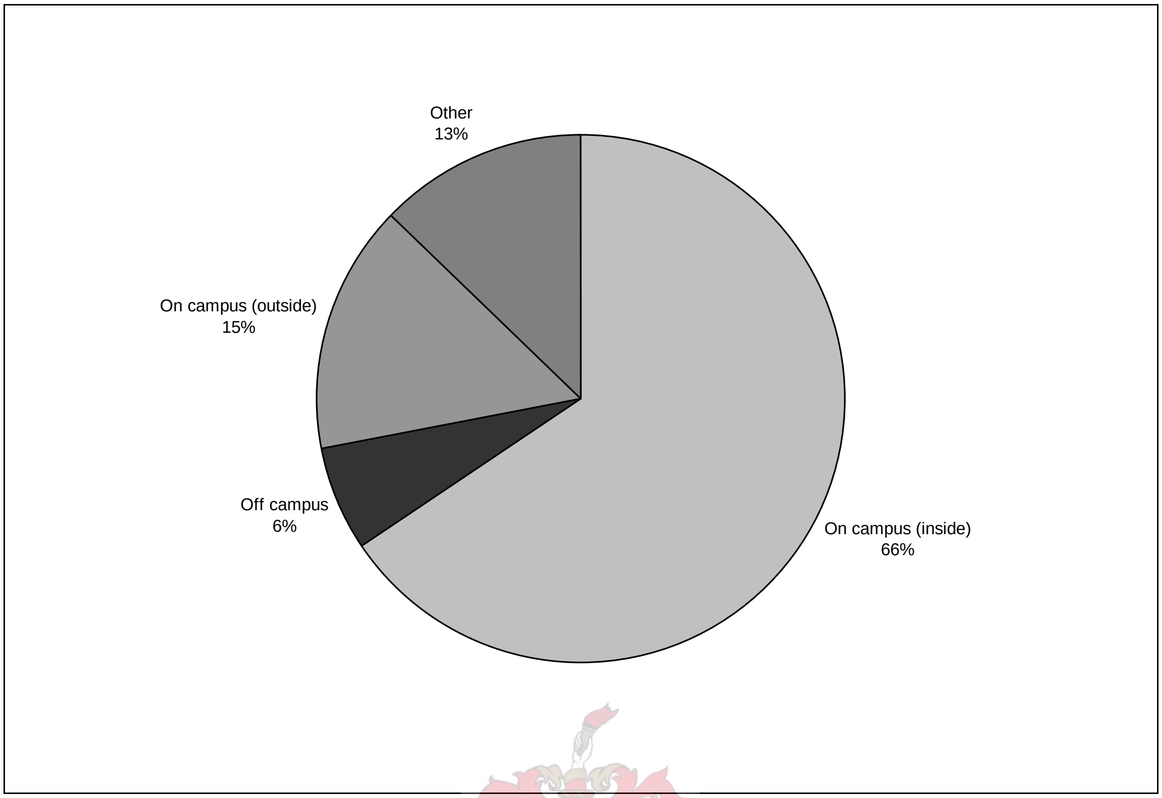

Figure 2.3b Figure representing, as a percentage, personnel choice of place for spending lunch time. The majority of personnel (66%) prefer spending their time indoors on campus ($\chi^2 = 167.11$, $df = 3$, $p < 0.05$), with the remaining 34% either going off campus, staying outdoors or doing something else.

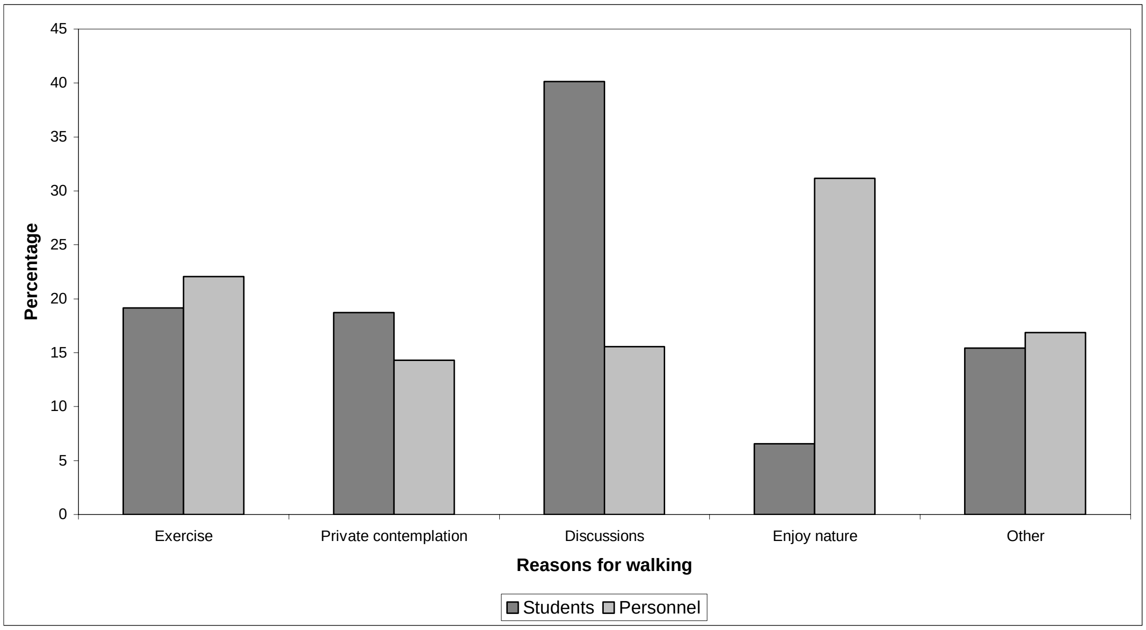

Figure 2.3c Graph representing as a percentage the reasons why respondents take walks on campus. A significant difference exists between the reasons of students and those of personnel for walking on campus (χ^2 = 92.81, *df* =4, $p < 0.05$). Apart from walking to class and back, students will walk on campus mainly while having discussions with friends or other students while the smallest group will walk to enjoy nature (χ^2 = 213.27, *df* =4, $p < 0.05$). Personnel on the other hand will mainly walk on campus in order to enjoy nature and are the least likely to walk while taking time for private contemplation (χ^2 = 14.70, *df* =4, $p < 0.05$).

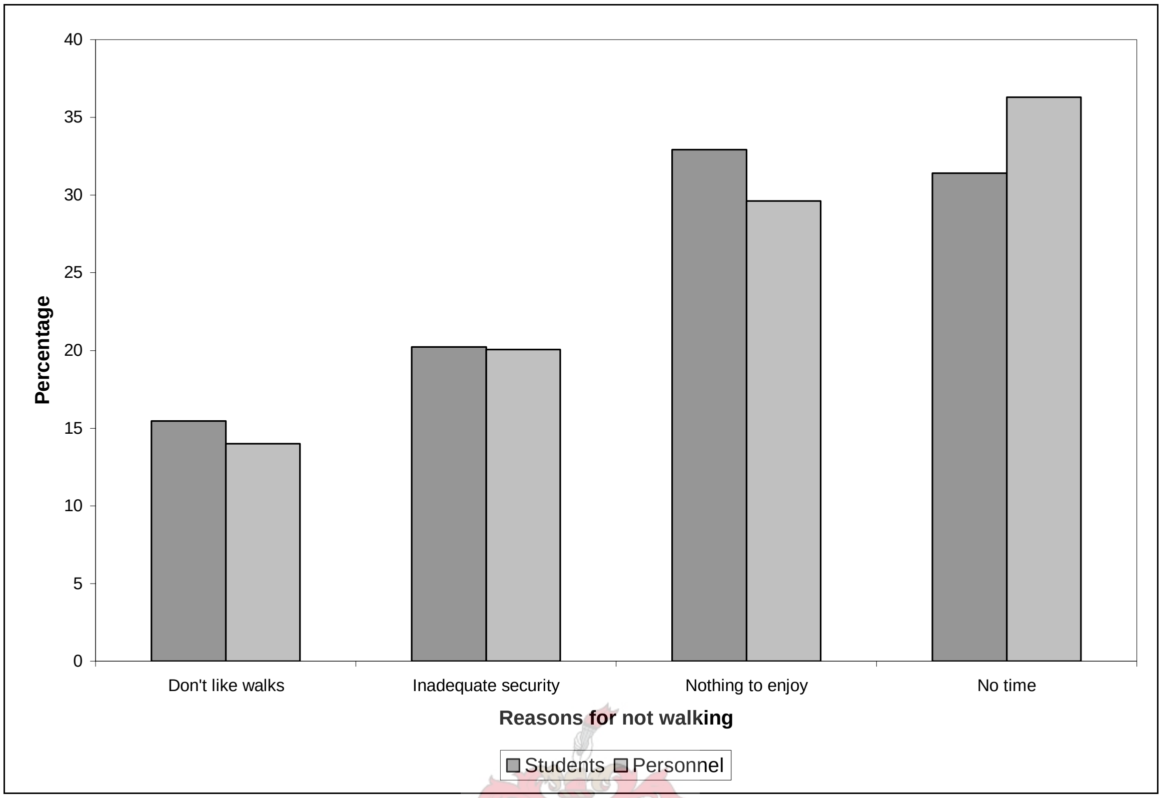

Figure 2.3d Graph representing as a percentage the reasons why respondents are reluctant to take walks on campus. The main reasons why students and personnel don't walk on campus is the lack of things to enjoy while walking as well as the lack of time to take walks (students: χ^2 = 188.90, *df* = 3, *p* < 0.05, personnel: χ^2 = 73.91, *df* = 3, *p* < 0.05,).

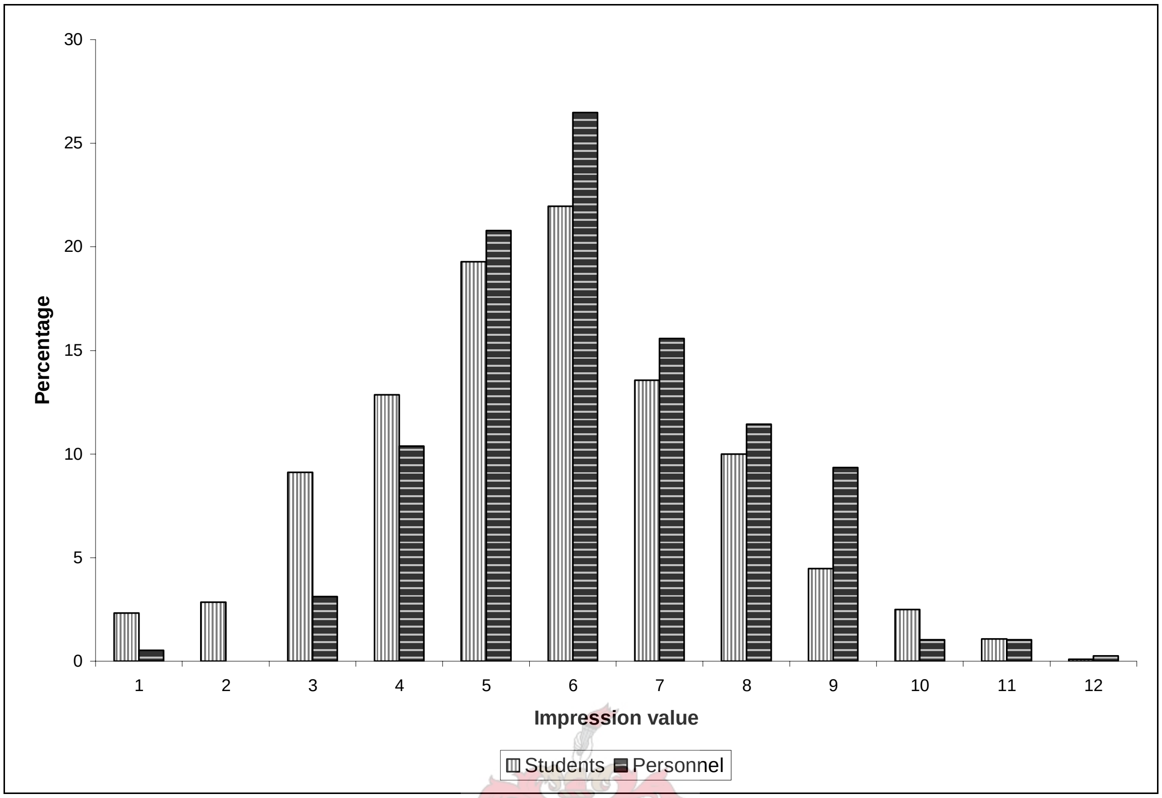

Figure 2.4a The impression value of students and personnel regarding the Tygerberg Medical Campus appearance. Data for both students and personnel suggests a statistically significant tendency for respondents to have an average impression value (students: $\chi^2 = 399.4$, $df = 11$, $p < 0.05$; Personnel $\chi^2 = 205.13$, $df = 11$, $p < 0.05$). There is also a significant difference between the impression values of students and personnel ($\chi^2 = 25.37$, $df = 11$, $p < 0.05$) with students having a slightly lower impression value than personnel.

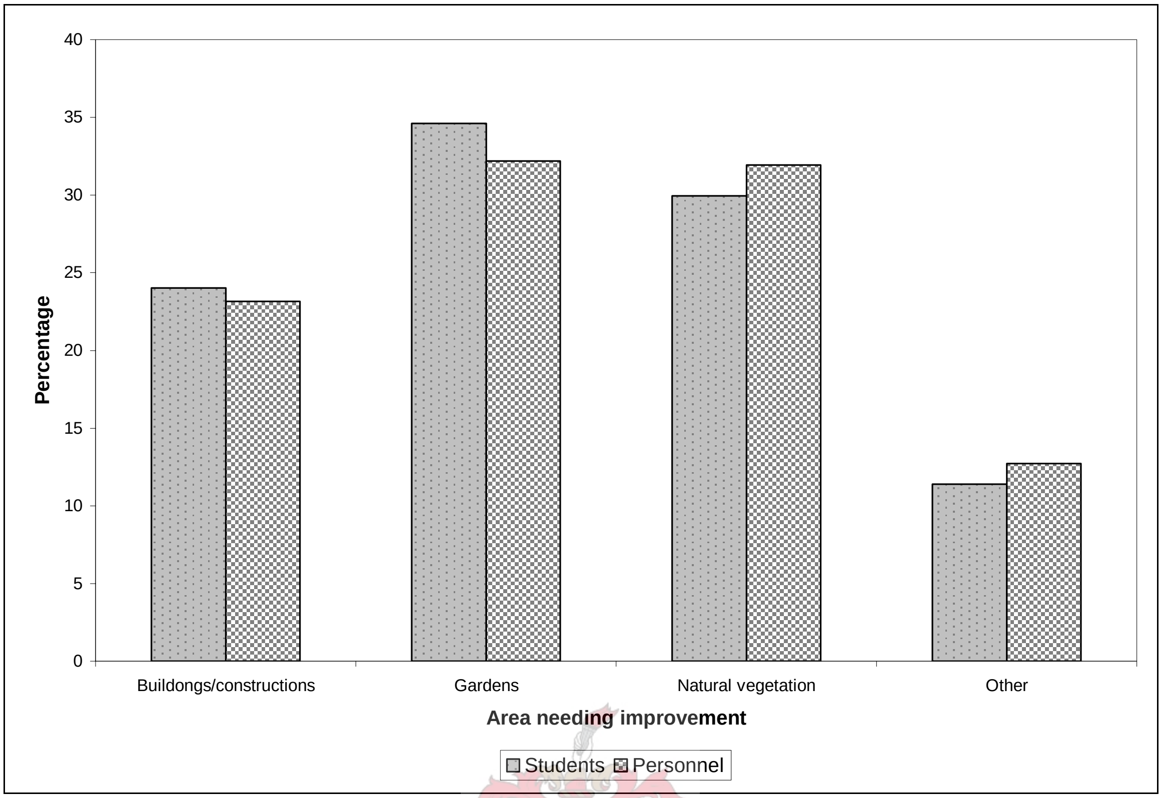

Figure 2.4b The areas or items on the campus that respondents would like to see improved with respect to its appearance. Gardens and natural vegetation are the two areas that they feel need the most improvement (students: $\chi^2 = 380.24$, $df = 3$, $p < 0.05$; personnel: $\chi^2 = 123.65$, $df = 3$, $p < 0.05$). There was no significant difference between student and personnel data.

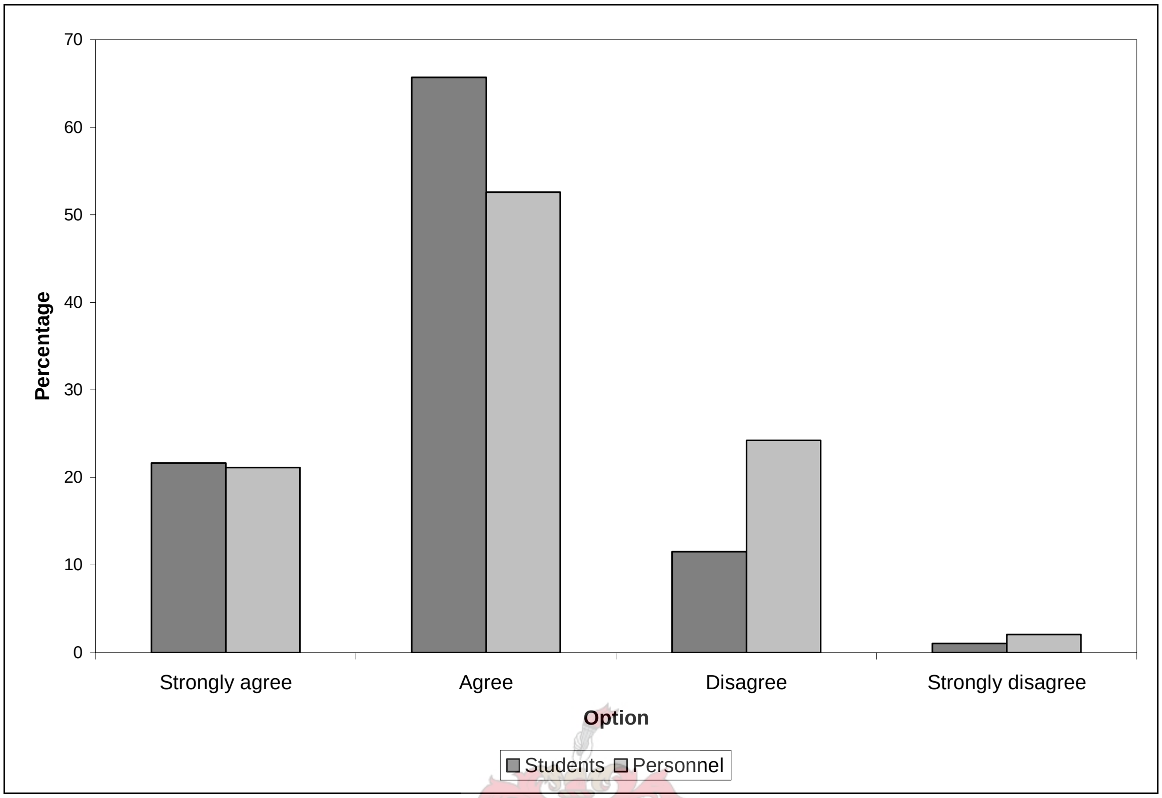

Figure 2.5a Respondents level of agreement to the statement that should the natural vegetation, bird, and animal life be improved on campus, they will spend more of their spare time on campus than in the past. A significant proportion agreed to this (students: $\chi^2 = 446.76$, $df = 3$, $p < 0.05$; personnel: $\chi^2 = 173.84$, $df = 3$, $p < 0.05$).

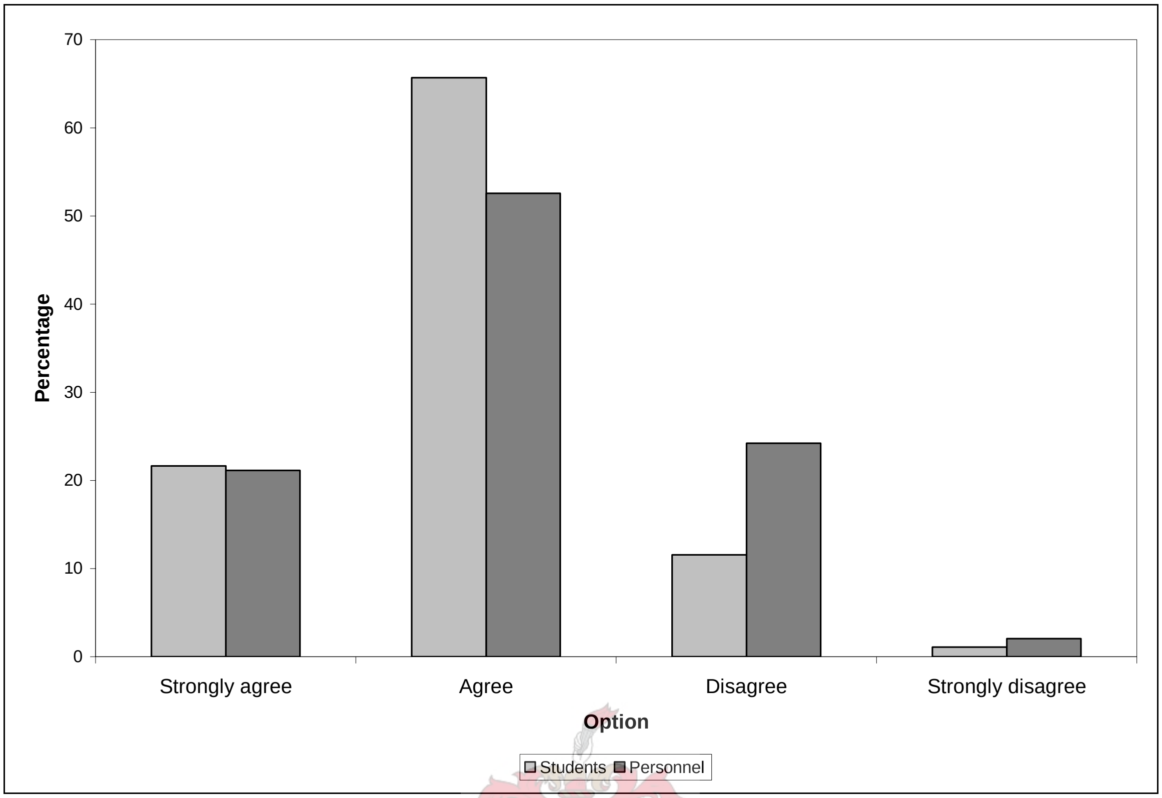

Figure 2.5b Student and personnel attitude towards the campus. A larger proportion of students, when compared with personnel, felt that their attitude towards the campus and their work will improve should the natural vegetation, bird and animal life be improved (χ^2 = 20.58, *df* = 3, $p < 0.05$).

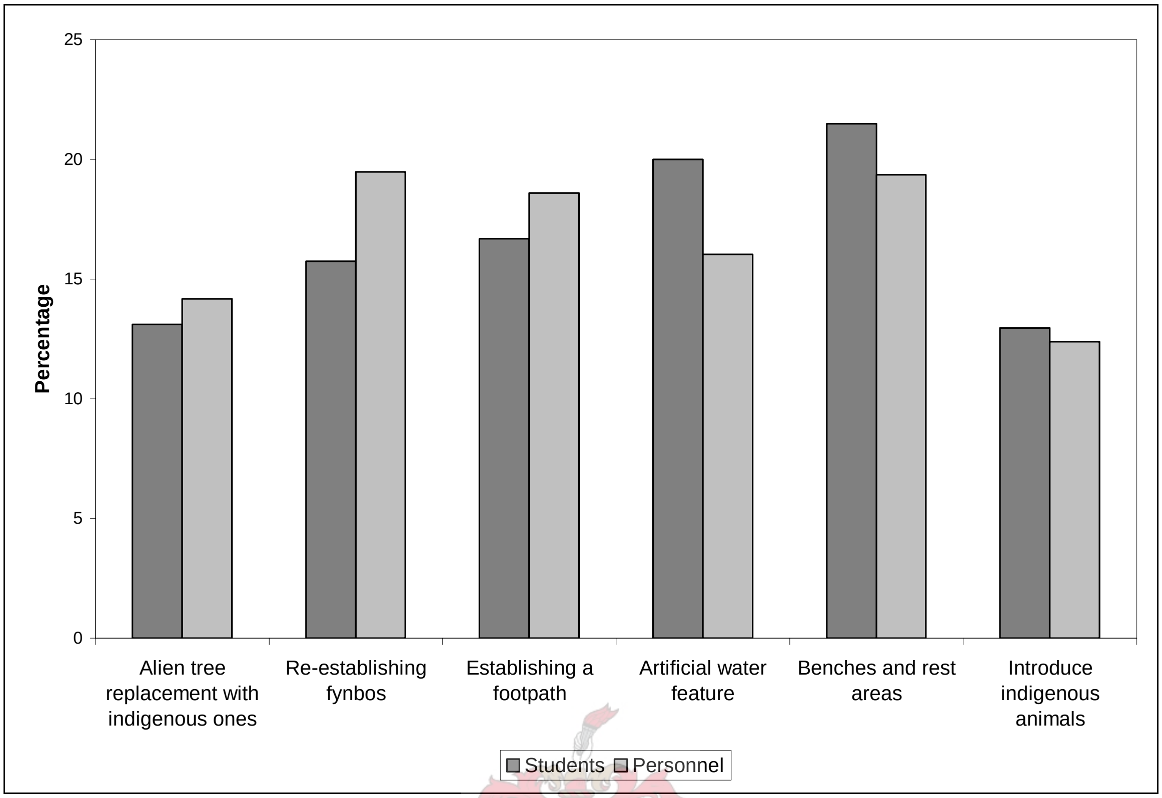

Figure 2.5c The percentage support students and personnel give to suggested improvements on campus are plotted. There is statistical significant differences between the options they support (Students: $\chi^2 = 331.19$, $df = 5$, $p < 0.05$; Personnel $\chi^2 = 92.39$, $df = 5$, $p < 0.05$) as well as significant difference between the options supported by students as opposed to the options supported by personnel ($\chi^2 = 55.42$, $df = 3$, $p < 0.05$).

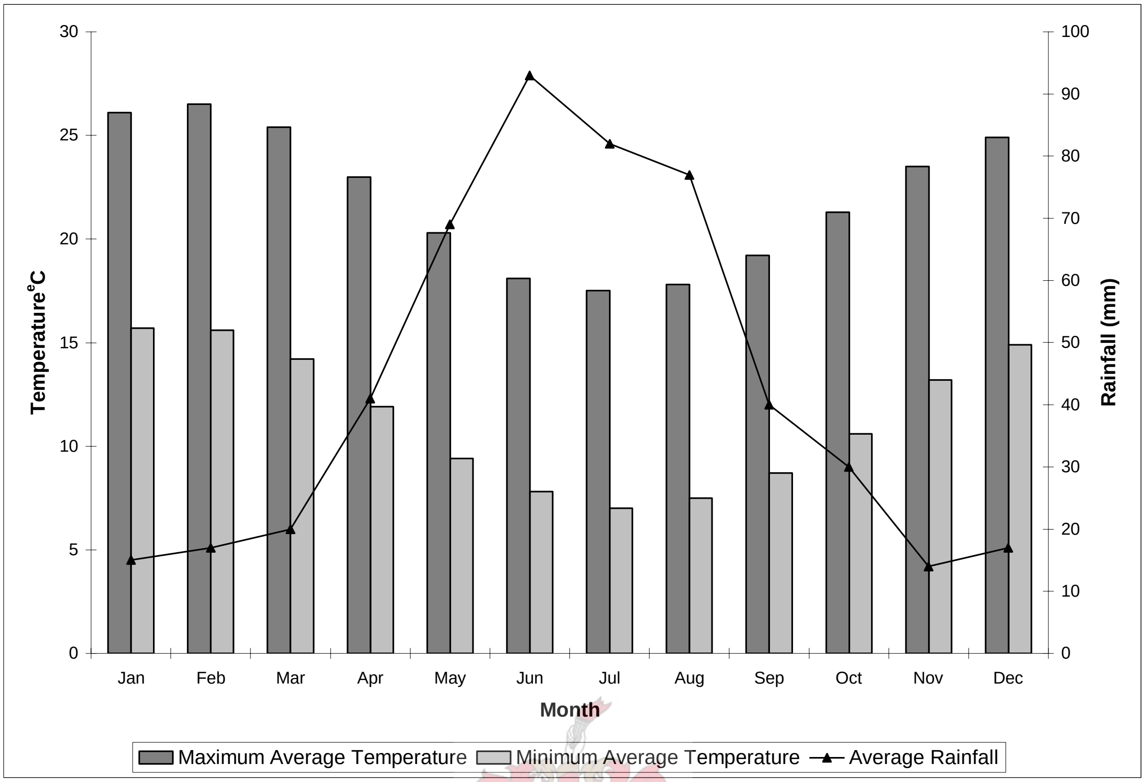

Figure 3.1 Average maximum and minimum temperature with average rainfall for the period 1961-1990 as measured at the Cape Town International Airport close to the Tygerberg Medical Campus (Cape Town Weather Bureau, Climate Section).

Figure 3.2 Satellite image of the Tygerberg Medical Campus showing the layout of the premises and other areas of concern to the project (Chief Directorate: Surveys and Mapping South Africa).

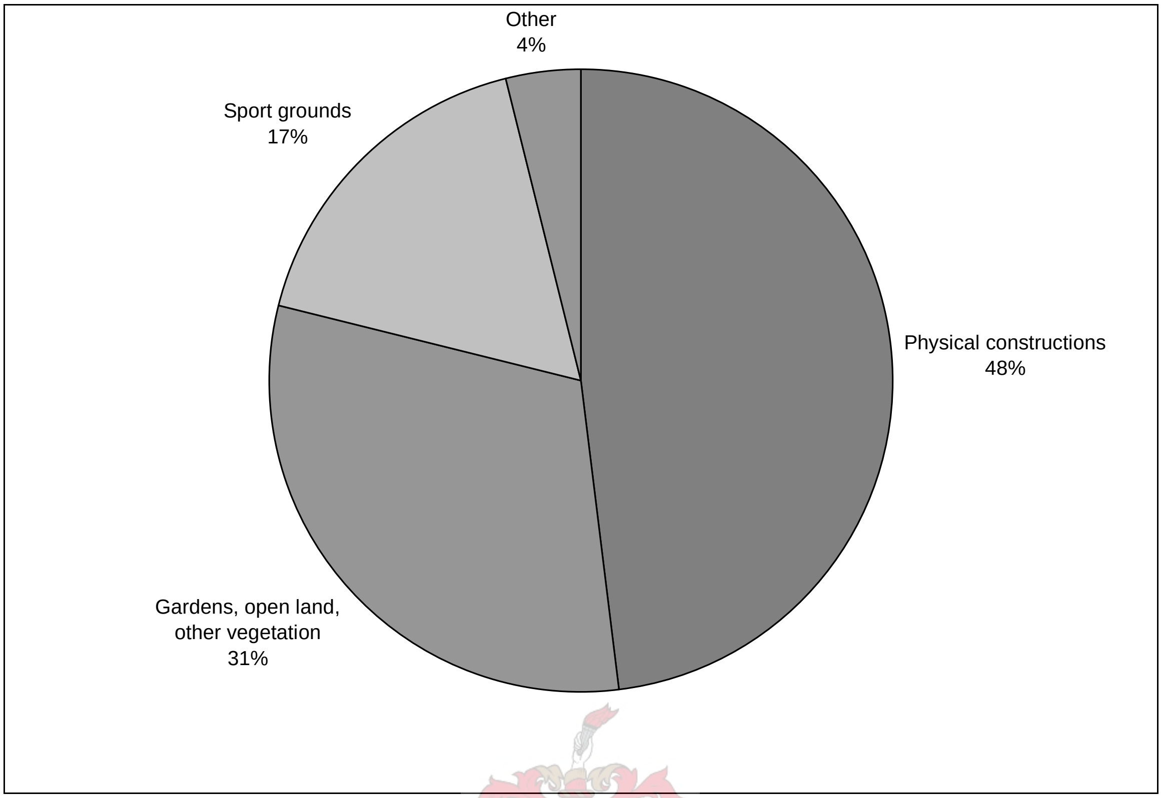

Figure 3.3 Chart showing the area composition of the Tygerberg Medical Campus. Physical constructions form the bulk of the campus followed by gardens, open areas and other vegetation.

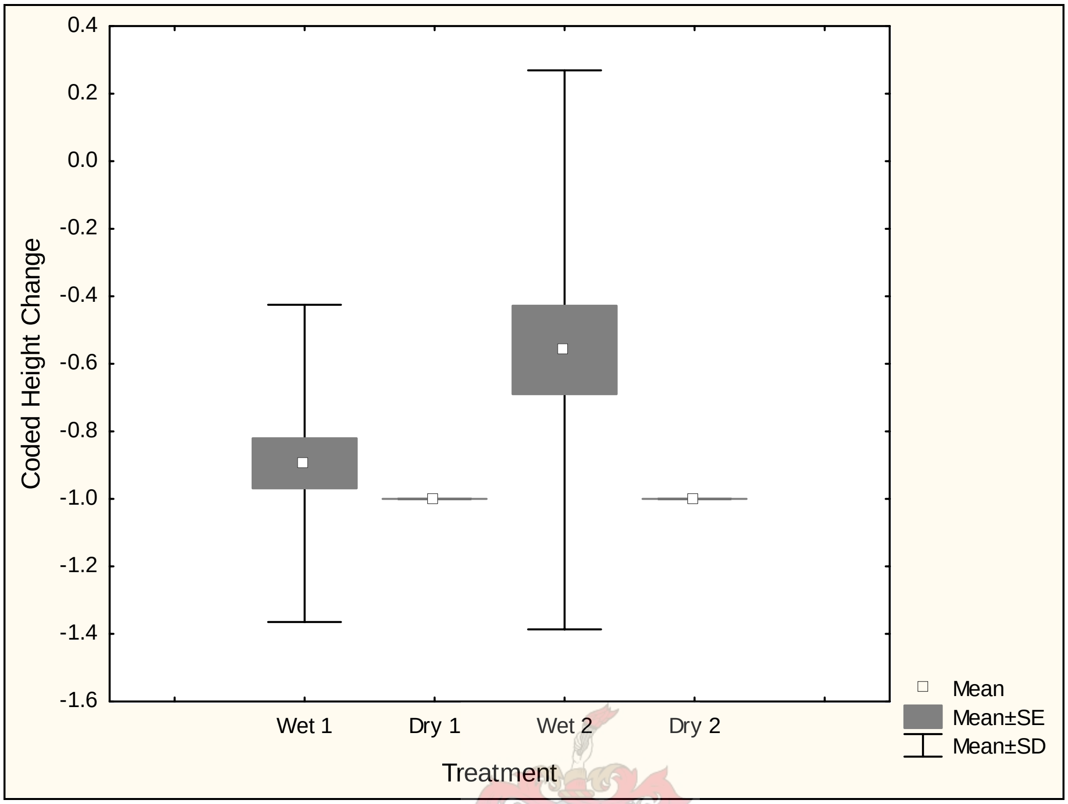

Figure 3.4a Graph showing the coded change in height for *P. repens*. Significant differences exist between “wet 2 and dry 1” as well as “wet 2” and “dry 2” (F = 7.72, df = 3, p < 0.001).

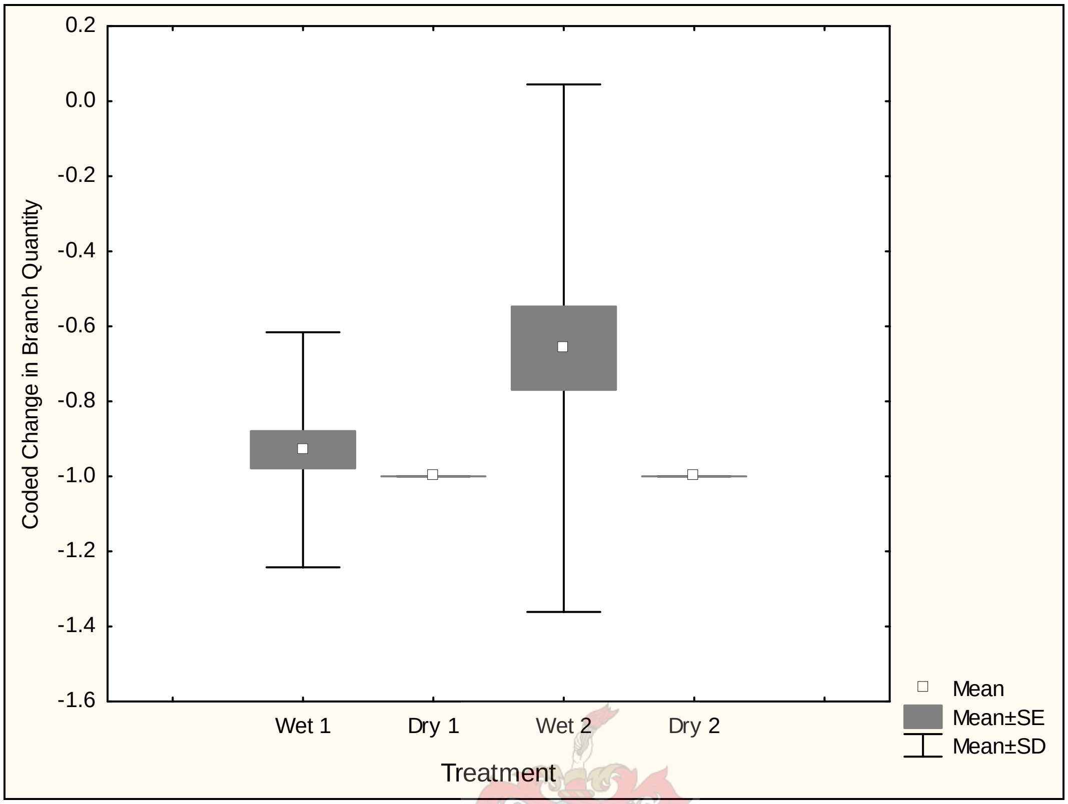

Figure 3.4b Graph showing the coded change in number of branches for *P. repens*. Significant differences exist between “wet 1” and “wet 2” compared to “dry 1” and “dry 2” (F = 7.13, df = 3, p < 0.022).

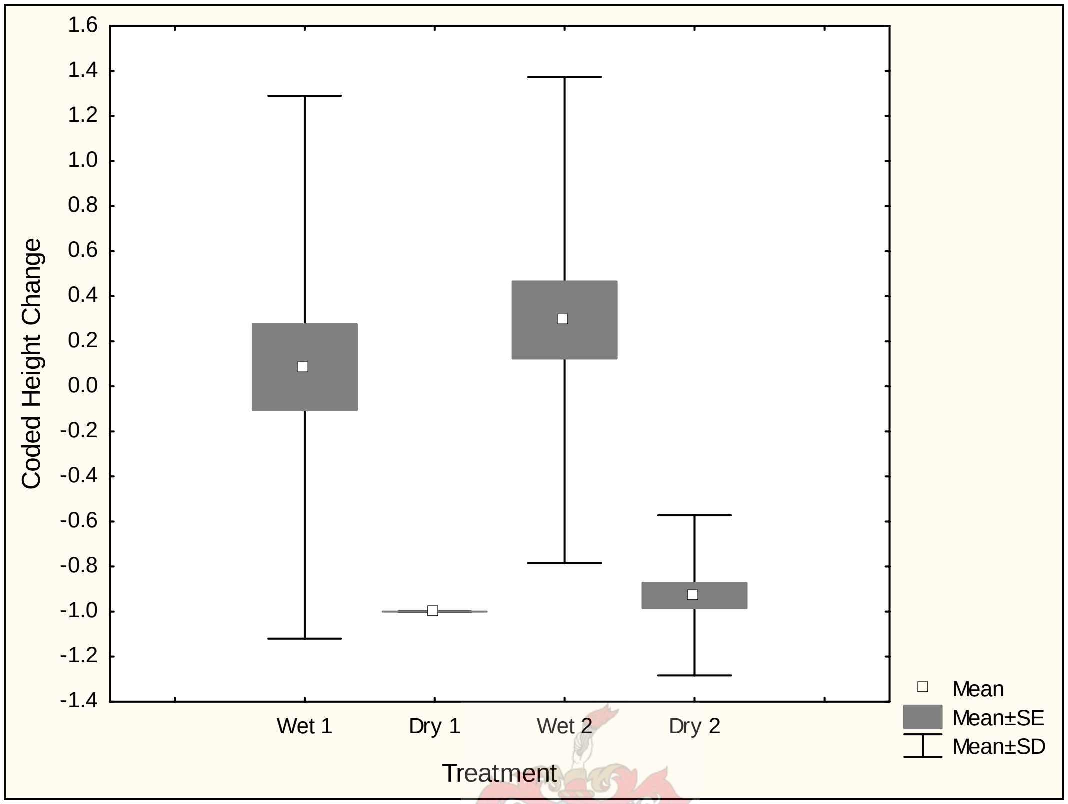

Figure 3.4c Graph showing the coded change in height for *L. salignum*. Strongly significant differences exist between "wet 1" and "wet 2" compared to "dry 1" and "dry 2" (F = 26.37, df = 3, p < 0.00001).

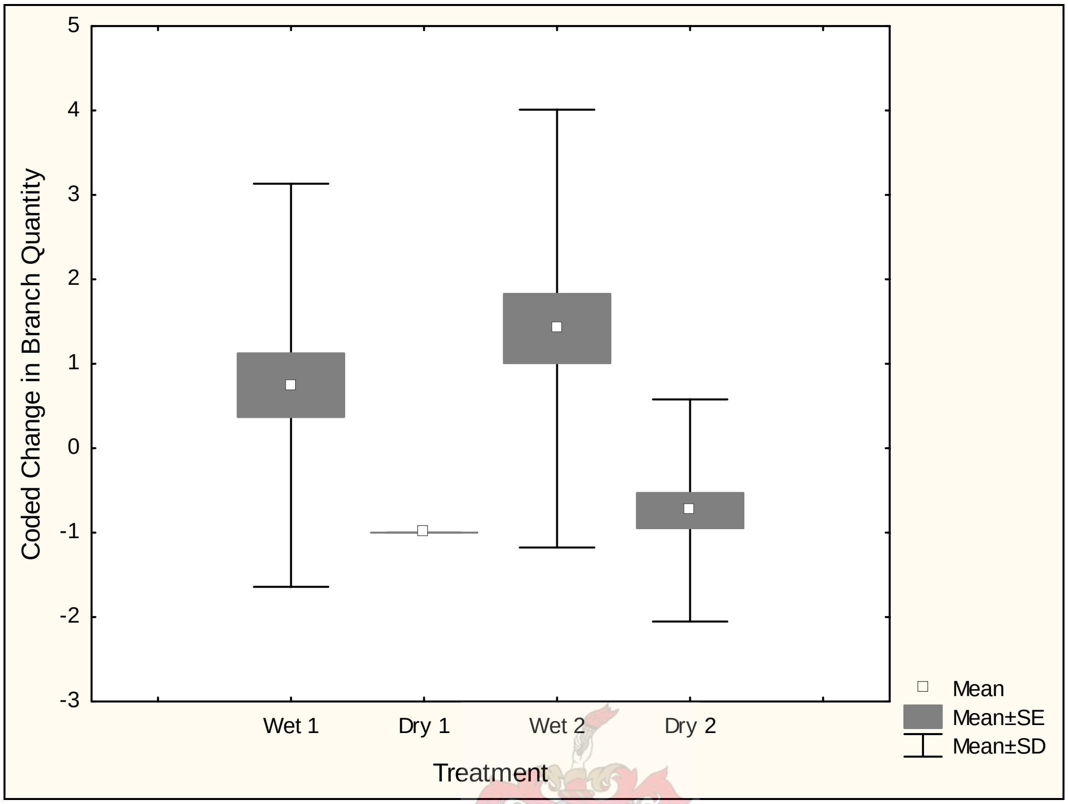

Figure 3.4d Graph showing the coded change in number of branches for *L. salignum*. Significant differences exist between "wet 1" and "wet 2" compared to "dry 1" and "dry 2" (F = 15.32, df = 3, p < 0.008).

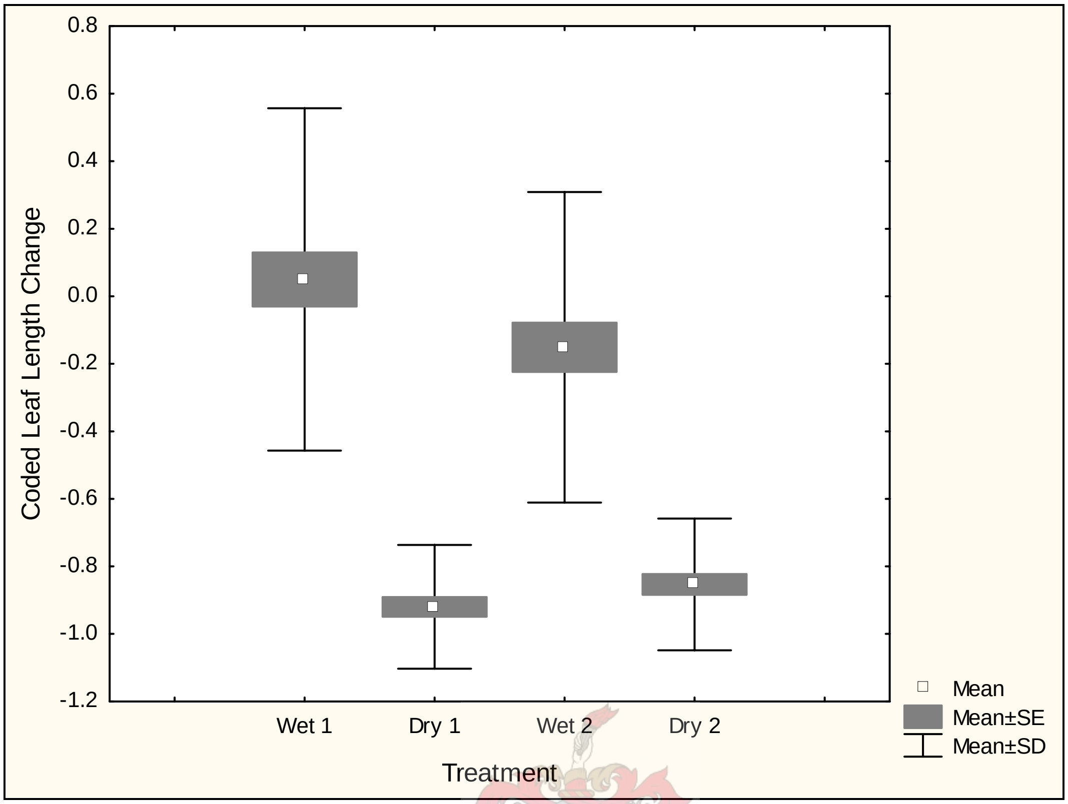

Figure 3.4e Box and whisker plot showing the change in average leaf length for *A. praecox*. Strongly significant differences exist between "wet 1" and "wet 2" compared to "dry 1" and "dry 2" ($F = 71.27$, $df = 3$, $p < 0.00001$).

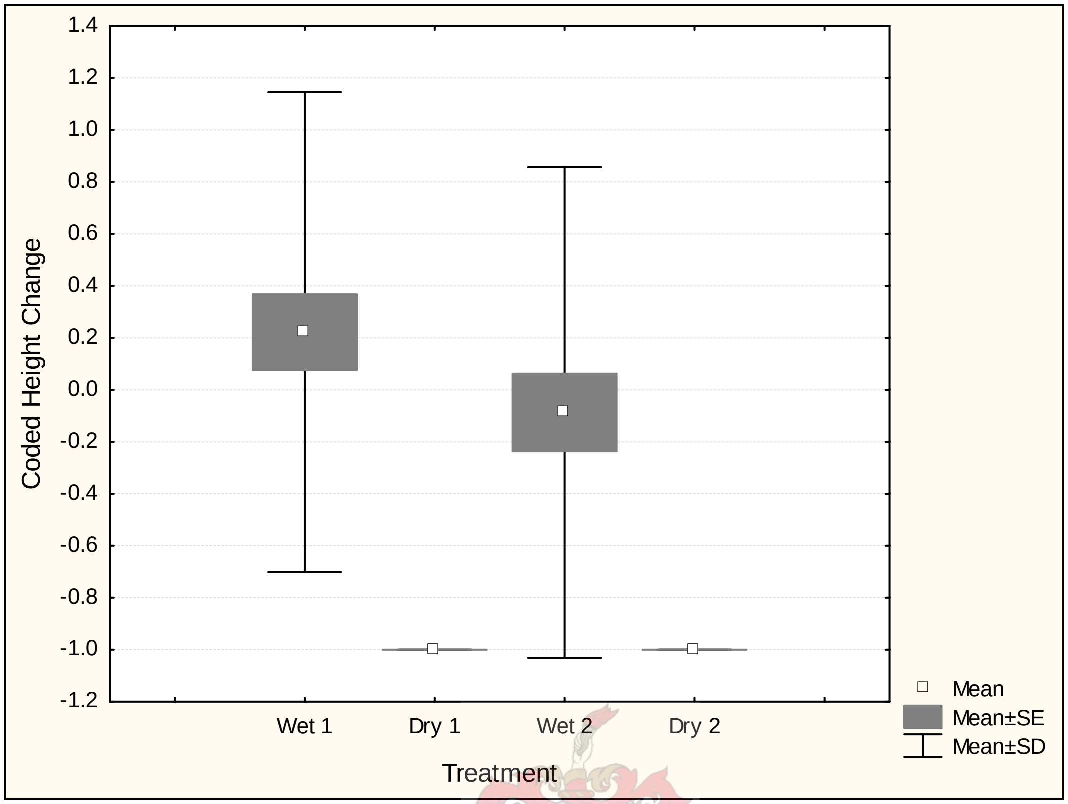

Figure 3.4f Box and whisker plot showing the coded change in height for *A. ovata*. Strongly significant differences exist between “wet 1” and “wet 2” compared to “dry 1” and “dry 2” (F = 36.3, df = 3, p < 0.00001).

Table 3.1 All plant species identified in the open areas, railway grounds, and experimental plots doing a Shannon diversity index using one square meter quadrants with 100 smaller 10cm x 10cm grids inside. Total cover represents the number of 10cm x 10cm grids the specific species occurred in from a total of 20 quadrants. Exotic species are printed in bold.

Species	Total Cover	Species	Total Cover
Cynodon dactylon	533	*Emex australis*	12
Eragrostis curvula	163	***Plantago major***	12
Raphanus species	121	*Carpobrotus edulis*	12
Ursinia anthemoides	100	***Lagurus ovatus***	11
Dischisma species	91	*Passerina species*	9
Hypochaeris radicata	75	*Leucadendron species*	9
Wahlenbergia capensis	70	*Agathosma ovata*	9
Cliffortia juniperina	69	***Polycarpon tetraphyllum***	8
Trifolium species	67	*Lyperia tristis*	8
Acacia saligna	63	*Helichrysum indicum*	6
Cliffortia species	63	***Vulpia bromoides***	6
Helichrysum crispum	53	*Oxalis pes-caprae*	6
Tribolium species	53	***Melilotus species***	6
Briza maxima	45	***Conyza species***	6
Bromus ridgidus	40	***Pennisetum clandestinum***	6
Cyperus species	36	*alien weed yellow flowers*	6
Arctotheca calendula	35	*Aster species*	4
Disa bracteata	34	*Erodium botrys*	4
Dimorphotheca pluvialis	34	*Isolepis species*	3
Elytropappus rhinocerotis	33	*Aristea africana*	3
Trachyandra revoluta	27	*Agapanthus species*	3
Vulpia species	26	*Cotula turbinata*	3
Echium plantagineum	25	*Isolepis antarctica*	2
Anagallis arvensis	19	*Lampranthus species*	2
Conicosia pugioniformis	19	*Pelargonium myrrhifolium*	2
Crassula glomerata	17	***Avena barbata***	2
Holothrix species	15	*Satyrium species*	1
Metalasia species	15	*Wachendorfia species*	1
Lolium perenne	14	*Oxalis purpurea*	1
Andropogon eucomus	13	*Albuca species*	1
Tetragonia fruticosa	13	*Tripteris clandestina*	1
Paspalum dilatatum	12		

Table 3.2 The list of bird species spotted on and around the Tygerberg Medical Campus during the period October 2002 to March 2003 over a total of 24 days.

Common Name	Scientific Name	Number of Days Spotted
Rock pigeon	*Columba guinea*	24
Laughing Dove	*Streptopelia senegalensis*	24
Cape Turtle Dove	*Streptopelia capicola*	24
Redwinged Starling	*Onychognathus morio*	24
Fiscal Shrike	*Lanius collaris*	21
Cape Wagtail	*Motacilla capensis*	21
Cape Sparrow	*Passer melanurus*	21
Cape White-Eye	*Zosterops pallidus*	19
Greater Striped Swallow	*Hirundu cucullata*	19
Wattled Starling	*Creatophora cinerea*	18
Helmeted Guineafowl	*Numida meleagris*	18
Whitethroated Swallow	*Hirundo albigularis*	15
Southern Masked Weaver	*Ploceus velatus*	13
Pied Crow	*Corvus albus*	12
Blacksmith Plover	*Vanellus armatus*	11
Hadeda Ibis	*Bostrychia hagedash*	10
Cape canary	*Serinus canicollis*	9
Spotted Prinia	*Prinia maculosa*	8
Whiterumped Swift	*Apus caffer*	7
Feral Pigeon	*Columba livia*	6
Cape Francolin	*Francolinus capensis*	6
Yellowrumped widow	*Euplectus capensis*	6
Crowned Plover	*Vanellus coronatus*	6
Kittlitz's plover	*Charadrius pecuarius*	6
Cattle egret	*Bubulcus ibis*	5
Little Swift	*Apus affinis*	4
Egyptian Goose	*Alopochen aegyptiacus*	3
Southern Olive Thrush	*Turdus olivaceus*	3
Cape Weaver	*Ploceus capensis*	3
Spotted Dikkop	*Burhinus capensis*	2
Grassveld Pipit	*Anthus cinnamomeus*	2
House Sparrow	*Passer domesticus*	2
Redfaced Mousebird	*Colius indicus*	2
Whitebacked Mousebird	*Colius colius*	2
European Starling	*Sturnus vulgaris*	2
Rock Kestrel	*Falco tinnunculus*	2
Redeyed Dove	*Streptopelia semitorquata*	1

Table 3.2 Continued The list of bird species spotted on and around the Tygerberg Medical Campus during the period October 2002 to March 2003 over a total of 24 days.

African Marsh Warbler	*Acrocephalus baeticatus*	1
Hartlaub's Gull	*Larus hartlaubii*	1
Sacred ibis	*Threskiornis aethiopicus*	1
Lesser Doublecollared Sunbird	*Nectarinia chalybea*	1
European Swallow	*Hirundu rustica*	1
Rock Martin	*Hirundo fuligula*	1
Brownthroated Martin	*Riparia paludicola*	1
LeVaillant's Cisticola	*Cisticola tinniens*	1
Cape Bulbul	*Pycnonotus capensis*	1

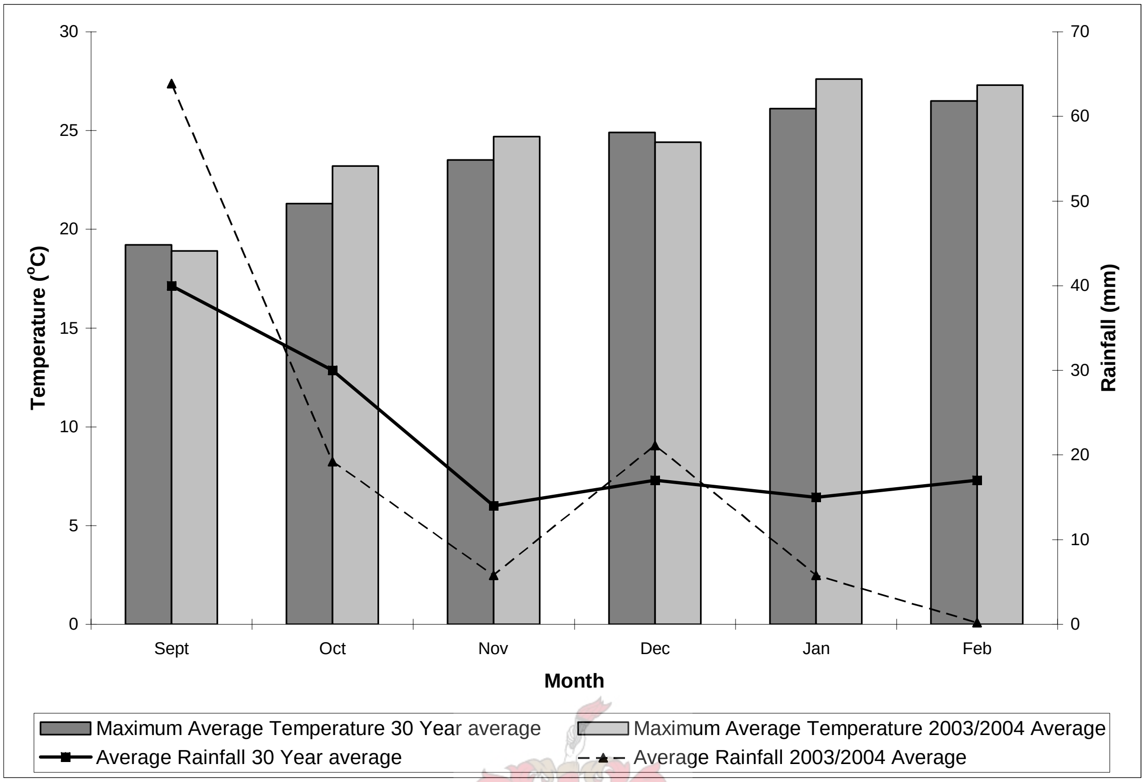

Figure 3.5 Comparison between the average maximum temperatures and average rainfall for the period 1961-1990 with the averages for the months September to October 2003/04 at the Cape Town International Airport close to the Tygerberg Medical Campus (Cape Town Weather Bureau, Climate Section).

Annexure B: Personnel Survey

Stellenbosch University
Faculty of Health Sciences
Personnel Survey

PLEASE READ THE QUESTIONS AND INSTRUCTIONS CAREFULLY

Mark the appropriate box with a X and where written answers are needed please use the appropriate space.

Section A: Demographic Information

1. Date questionnaire is completed (dd/mm/yy) [/ /]
2. Gender
   - [1] Male
   - [2] Female
3. Age ____ Years
4. Number of years working/studying on the Tygerberg Campus ____ Years
5. Home language
   - [1] Afrikaans
   - [2] English
   - [3] Xhosa
   - [4] Other
6. Were you born and raised in the Western Cape?

____

____

____

Section B: Opinion on Nature

1. In my opinion nature (i.e. wild plants and animals) is:
   - [2] Something I don't think about much
   - [3] Something I regard as being an important/crucial **(circle most relevant word)** aspect of life
   - [1] Something standing in the way of development
2. Being surrounded by nature makes me feel:
   - [2] No specific feeling
   - [3] Calm and relaxed
   - [1] Irritated
3. I think the general, global conservation status of nature is:
   - [2] Sufficient
   - [3] Insufficient
   - [1] Over protected

4. Urbanisation and development should have preference over nature conservation:

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

Section C: Spare Time Utilization on the Tygerberg Campus

1. During my lunch time on Campus I usually:

1	Stay on Campus but prefer staying indoors
2	Leave Campus
3	Stay on Campus but prefer staying outdoors
4	Other

2. When I have additional spare time available while on Campus, I usually:

1	Stay on Campus but prefer staying indoors
2	Leave Campus
3	Stay on Campus but prefer staying outdoors
4	Other

3. If I have sparetime, I like to take walks on the Campus grounds:

1	Often
2	Seldom
3	Never (if never skip question 4)

4. I regularly walk on Campus for the following reason(s):
(You may mark more than one answer)

	To get exercise
	To get time for private contemplation/thinking
	While having discussions with colleagues/students
	To enjoy nature
	Other

5. The main reasons why I'm reluctant to take walks on Campus are:
(Rank in order of importance with one (1) being the most important.)

____ I don't like going for walks

____ Security is not adequate

____ There is nothing to see/enjoy while walking

____ I don't have time for walks

Section D: Feeling Towards Tygerberg Campus Appearance

1. My first impression about the appearance of the Campus is:

5	Very good
4	Good
3	Moderate
2	Bad
1	Very bad

2. Regarding the natural environment (plants, birds, other animals) on Campus my impression is:

5	Very good
4	Good
3	Moderate
2	Bad
1	Very bad

3. It is my impression that there is a definite need to improve the appearance of the Campus:

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

4. The Campus can be improved by improving the condition of:
(Rank in order of importance with one (1) being the most important.)

____ Buildings/constructions

____ Gardens

____ Natural vegetation

____ Other (specify) ________________________________

Section E: Possible Tygerberg Campus Improvements

1. Increasing and managing the natural vegetation (e.g. fynbos), bird and animal life on Campus will improve the appearance of the Campus.

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

2. If the appearance of the Campus ground is improved by increasing natural vegetation, bird and animal life, I would spend more of my spare time on Campus than in the past:

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

3. If the appearance of the Campus ground is improved by increasing natural vegetation, bird and animal life, I feel that my overall attitude towards the Campus and my work will improve:

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

4. Would you support the establishment of natural vegetation corridors (strips of natural vegetation) linking the Tygerberg Campus with other natural occurring areas or nature reserves?

1	Yes
2	No

5. From the following list, rank the actions you would like to see done on the Tygerberg Campus:

(Rank in order of importance with one (1) being the most important.)

____ Gradual replacement of most exotic trees and plants with indigenous ones

____ Re-establishing natural occurring fynbos in selected open areas

____ Establishing of a footpath leading through fynbos with information on the different plants, birds and animals occurring on Campus

____ The creation of an artificial stream with cascades (waterfall) and a pond

____ Benches and other rest areas shaded by natural vegetation

____ Introduction of small indigenous animals (tortoises, other reptiles, hares, etc.) on Campus

If you have any other suggestions for improving the quality of the environment on the Campus, please state them here: (Also give your contact details if you would like to be part of a group improving the natural appearance of the Tygerberg Campus)

Annexure C: Student Survey

University of Stellenbosch
Faculty of Health Sciences
Student Survey

PLEASE READ THE QUESTIONS AND INSTRUCTIONS CAREFULLY

Instructions: Mark the appropriate box with a X and where written answers are needed please use the appropriate space.

Section A: Demographic Information

1. Date questionnaire is completed (dd/mm/yy) [/ /]

2. Gender
   - [ ] 1 Male
   - [ ] 2 Female

3. Age ____ Years

4. Current academic year ____ Year

5. Under-graduate or post-graduate
   - [ ] 1 Under-graduate
   - [ ] 2 Post-graduate

6. Home language
   - [ ] 1 Afrikaans
   - [ ] 2 English
   - [ ] 3 Xhosa
   - [ ] 4 Other

7. Were you born and raised in the Western Cape?

____

____

____

Section B: Student Residency on the Tygerberg Campus

1. How many years have you been a full time student on the Tygerberg Campus?
   - [ ] 1 Less than 1 year
   - [ ] 2 Between 1 and 2 years
   - [ ] 3 Between 2 and 3 years
   - [ ] 4 Between 3 and 4 years
   - [ ] 5 Between 4 and 5 years
   - [ ] 6 More than 5 years

2. Do you currently reside on the Tygerberg Campus?
   - [ ] 1 Yes
   - [ ] 2 No

3. Till present, how many years have you resided on the Tygerberg Campus?

1	Never resided on Campus
2	Up to 1 year
3	Up to 2 years
4	Up to 3 years
5	Up to 4 years
6	Up to 5 years
7	More than 5 years

4. If previously residing on the Tygerberg Campus, but privately now, what is the reason for changing to private residency?

1	Not applicable
2	Financially more viable
3	Didn't like living in hostel
4	Didn't like living on the Tygerberg Campus
5	Moved to more beautiful surroundings
6	Other

Section C: Opinion on Nature

1. In my opinion nature (i.e. wild plants and animals) is:

2	Something I don't think about much
3	Something I regard as being an important/crucial **(circle most relevant word)** aspect of life
1	Something standing in the way of development

2. Being surrounded by nature makes me feel:

2	No specific feeling
3	Calm and relaxed
1	Irritated

3. I think the general, global conservation status of nature is:

2	Sufficient
3	Insufficient
1	Over protected

4. Urbanization and development should have preference over nature conservation:

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

Section D: Spare Time Utilization on the Tygerberg Campus

In this section, spare time refers to time between or after class, when you are not doing any academic or academic related activities.

1. When I have spare time during a normal academic day on Campus, I prefer to:

1	Stay on Campus
2	Leave Campus

2. When on Campus, during my spare time, I like to:

1	Remain inside (Hostel, Teelsie, library, etc.)
2	Remain outside (Lawn, rugby field, swimming pool, etc.)
3	Do sport (Gymnasium, rugby, tennis, swim, etc.)
4	Other

3. When on Campus I prefer spending free time doing:
(Rank in order of preference with one (1) being the most preferred.)

	Stay in hostel/visit friends in hostel
	Go to Teelsie
	Do sport (Gymnasium, Rugby, Tennis, Swim, etc.)
	Enjoy nature on Campus

4. When on Campus, and I have spare time, I enjoy walking on Campus and looking at the nature aspects such as plants and birds.

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

5. Apart form walking to class, I regularly walk on Campus for the following reason(s):
(You may mark more than one answer)

	To get exercise
	To get time for private contemplation/thinking
	While having discussions with friends/other students
	To enjoy nature
	Other

6. The main reasons why I'm reluctant to take walks on Campus are:

(Rank in order of importance with one (1) being the most important.)

_____ I don't like going for walks

_____ Security is not adequate

_____ There is nothing to see/enjoy while walking

_____ I don't have time for walks

Section E: Feeling towards Tygerberg Campus Appearance

1. My first impression about the appearance of the Campus is:

5	Very good
4	Good
3	Moderate
2	Bad
1	Very bad

2. Regarding the natural environment (plants, birds, other animals) on Campus my impression is:

5	Very good
4	Good
3	Moderate
2	Bad
1	Very bad

3. It is my impression that there is a definite need to improve the appearance of the Campus:

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

4. The Campus can be improved by improving the condition of:

(Rank in order of importance with one (1) being the most important.)

____ Buildings/constructions

____ Gardens

____ Natural vegetation

____ Other (specify) ________________________________

Section F: Possible Tygerberg Campus Improvements

1. Increasing and managing the natural vegetation (e.g. fynbos), bird and animal life on Campus will improve the appearance of the Campus.

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

2. If the appearance of the Campus ground is improved by increasing natural vegetation, bird and animal life, I would spend more of my spare time on Campus than in the past:

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

3. If the appearance of the Campus ground is improved by increasing natural vegetation, bird and animal life, I feel that my overall attitude towards the Campus and my studies will improve:

1	Strongly agree
2	Agree
3	Disagree
4	Strongly disagree

4. Would you support the establishment of natural vegetation corridors (strips of natural vegetation) linking the Tygerberg Campus with other natural occurring areas or nature reserves?

1	Yes
2	No

5. From the following list, rank the actions you would like to see done on the Tygerberg Campus:
(Rank in order of importance with one (1) being the most important.)

____ Gradual replacement of most exotic trees and plants with indigenous ones

____ Re-establishing natural occurring fynbos in selected open areas

____ Establishing of a footpath leading through fynbos with information on the different plants, birds and animals occurring on Campus

____ The creation of an artificial stream with cascades (waterfall) and a pond

____ Benches and other rest areas shaded by natural vegetation

____ Introduction of small indigenous animals (tortoises, other reptiles, hares, etc.) on Campus

If you have any other suggestions for improving the quality of the environment on the Campus, please state them here: (Also give your contact details if you would like to be part of a group improving the natural aspects on Campus)

____
____
____
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____
____