Spatial Analysis of Open Space in the Quaternary Catchment of the Lourens River

A thesis submitted in partial fulfillment of the requirements for the degree of Magister Scientiae in the Department of Biodiversity and Conservation Biology, University of the Western Cape

By: Gwendolyn Rose Raitt
Supervisor: Dr Richard S. Knight
November 2013
Dedication

To my parents, whose belief in me and support kept me sane.
Keywords
Open Space, Proximity, Human Well-Being, GoogleEarth, Geographical Information Systems, Conservation
Abstract

Spatial Analysis of Open Space in the Quaternary Catchment of the Lourens River
G.R. Raitt
M.Sc. Thesis, Department of Biodiversity and Conservation Biology

This thesis looks at aspects relating to vegetated open space in the quaternary catchment of the Lourens River, Cape Town, South Africa in 2005 and at GoogleEarth as a source of imagery for research. The research questions were: “Is GoogleEarth a suitable source of imagery for spatial analysis of landscapes?”; “What was the potential access (proximity) to vegetated open space of at least 900 m\(^2\) in the Lourens River quaternary catchment in 2005?”; “How many vegetated open spaces with an area of at least 900 m\(^2\) were present in the Lourens River quaternary catchment in 2005?” and “What spaces within the urban edge in the Lourens River quaternary catchment can be said to have some protection from development?”

Open space has multiple benefits for humans in terms of health and social interaction. In urban areas, it is also important for biodiversity conservation. In Cape Town, this is critical since the city has critically endangered national vegetation types that only occur within its boundaries and 319 IUCN Red List species within its boundaries.

Proximity does not reflect use of open space which is affected by the size of the open space, quality of the open space, neighbourhood attributes and individual and collective perceptions of the open space. Quality of vegetated open space is dependent on its facilities and maintenance which are largely determined by its management. In Cape Town, open space management is mainly mowing/brush cutting all spaces which has a negative impact on biodiversity retention. Mowing is continued because of popular demand so action needs to be taken to change popular perceptions.

Google Earth is readily available and widely used. It is used for research in diverse disciplines. Local Internet connection problems complicated this study. Alignment and projection problems were encountered in this study. Thus Google Earth
geospatial issues make it a poor choice of imagery source for large scale spatial analysis of landscapes.

Open space was digitized in Google Earth and transferred to a propriety GIS for editing. Vegetated spaces with a minimum of 900 m$^2$ and a width of at least 15 m were selected from the approximately 1025 digitised spaces. Google Earth imagery was used because it is readily available. Euclidean distances of 300 m, 500 m, 800 m and 900 m (taken from literature) were used to buffer the digitized vegetated open spaces and other data on schools, train stations, bus routes and taxi routes in and within 900 m of the catchment. Buffer analysis was carried out. Data from the City of Cape Town and a schools layer were used to determine the number of cemeteries, community parks, nature reserves and school grounds – space regarded as having some protection from development - within the urban edge of the city and what area they covered.

Within or partially within the Lourens River quaternary catchment, 593 vegetated open spaces of at least 900 m$^2$ were identified. The analysis showed that only two houses were beyond 300 m from a vegetated open space. There was vegetated open space within 300 m of all the schools, stations, bus and taxi routes within the catchment and in close proximity to the catchment. Within the urban edge, only 124 spaces were found to be protected, of which only one was a nature reserve.

Most of the open spaces are not formally designated as open space and are vulnerable to development. Much development has taken place since 2005 in the Lourens River quaternary catchment so action is needed to ensure proximity to vegetated open space remains a positive feature of the area.

Expanding the present research to cover a larger area would provide additional baseline data. Further research could consider the loss of open space over time and the impact of management on the quality of designated open space. November 2013
Declaration

I declare that *Spatial Analysis of Open Space in the Quaternary Catchment of the Lourens River* is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Gwendolyn Rose Raitt

November 2013

Signed:……………………………….
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My family for their support.
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Since GoogleEarth is easily and widely accessible, does it provide a suitable source of imagery for spatial analysis of landscapes without post geospatial rectification?
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Chapter 1 Introduction

Open space is a vastly undervalued resource both for human well-being and for conservation (Roberts et al. 2005, Brueckner 2000) partially because all the values of such space can not be added together and not all values are easily expressed in currency e.g. public goods do not have markets (Lévêque & Mounolou 2001, Fausold & Lilieholm 1999). Open space provides ecosystems services which affect human well-being (Cilliers et al. 2012) and place for indigenous species which need protection (Rebelo et al. 2011). I chose to highlight the importance of open space by doing a desktop study looking at aspects of open space in the quaternary catchment of the Lourens River. The first aspect considered is potential access (proximity) to open space within the catchment. Thereafter the amount of protected open space within the catchment is determined.

A quaternary catchment was chosen because it is a level at which ecological processes function and thus has ecological significance. It also has significance for water management. The 500 m contour cut off was chosen to be higher than any hills in the surrounding area including beyond the Lourens River Quaternary Catchment. This will allow integration with work beyond the bounds of this catchment.

Definition of Open Space

For this study, open space is undeveloped space excluding, as far as possible, ordinary home gardens, rivers in the urban area, tarred space and waterbodies. Fences between adjacent pieces of open space were ignored.

Thesis Style

This thesis has an introductory chapter. The literature review is followed by a technical article and two other articles. A concluding chapter ends the thesis.

Research Questions

Since Google Earth is easily and widely accessible, does it provide a suitable source of imagery for spatial analysis of landscapes without post geospatial rectification?
How many open spaces with an area of at least 900 m$^2$ were present in the Lourens River quaternary catchment in 2005 (the first year with continuous imagery in GoogleEarth)?

What was the potential access (proximity) to vegetated open space of at least 900 m$^2$ in the Lourens River quaternary catchment in 2005?

What spaces within the urban edge in the Lourens River quaternary catchment can be said to have some protection from development?

References


Chapter 2 Literature Review

Introduction
This chapter starts with a look at the study area beginning with a look at the City of Cape Town as a whole to give the context and then shifting to the Lourens River Quaternary Catchment. The rest of the chapter looks at different attitudes/issues (urban sprawl and politics) and disciplines (city planning and conservation) that impact open space before considering open space and then endeavouring to indicate that different disciplines need to work together so that the same space can fulfil its functions for all disciplines and promote human well-being in the long term (holistic view). The city description is followed by the issue of urban sprawl because urban sprawl is an urban phenomenon which is a consideration for the discipline of city planning which follows the urban sprawl section. City planning is affected by politics, the next section. Politics also affects conservation. All terrestrial urban nature reserves are open spaces. Open space is the focal point of this study.

Cape Town

Location
Cape Town is at the southwest tip of Africa (Katzschner et al. 2005, Wilkinson 2000). In 2012, the City of Cape Town Municipality was estimated to cover 2,461 km$^2$ with 294 km of coastline (Strategic Development Information and GIS Department 2012a). Cape Town is a sprawling city that retains the apartheid layout with non-whites on the periphery of the city (Standing 2006, Hiller 2000, Wilkinson 2000).

Demographic Statistics
Cape Town has a population of about 3.75 million (O’Farrell et al. 2012, Strategic Development Information and GIS Department 2012a,b) of which about 42.4% are Coloured; 38.6% Black African; 15.7% White; 1.4% Asian and 1.9% of other races. More than half the population is female (Strategic Development Information and GIS Department 2012b).

Of Cape Town’s population circa 2009, 37% live within 400 m of a park; a further 29% live within 800 m of a park; 14% more live within 1,200 m of a park and 20% live further than 1,200 m from a park (Willemse 2010).
Cape Town has about 1,068,572 households of which 94% use electricity for light; 78% have formal dwellings; 87% have piped water; 88% have access to flush toilets linked to the public sewer system and 94% have at least weekly rubbish removal. Some 47% of households in this city live on R 3,200 or less a month. Employment was at 76% of the labour force (defined as persons aged 15 to 64) in 2011. Adult education levels were at 46% with Grade 12 or higher education for persons aged 20 years or more in 2011 (Strategic Development Information and GIS Department 2012b).

**Public Open Space**

Cape Town City Parks identifies and looks after the following forms of open space: cemeteries, coastal amenities, community parks, district parks, greenbelts, public open spaces, road reserves and undeveloped public open spaces. Ten of the spaces managed by city parks are considered biodiversity areas though in the City Parks data set this category does not exist – at least one of these areas is listed as greenbelt (City Parks 2013, City of Cape Town 2012a). Beaches and public sports facilities are looked after by the Sports and Recreation Department (City of Cape Town 2012b). The Environmental Resource Management Department looks after 16 Nature Reserves and numerous heritage sites including some natural heritage sites (City of Cape Town 2013).

Cape Town had a total of 1,200 parks circa 2009 (Willemse 2010). As of July 2013, there are 11 district parks and 3,339 community parks in the city to which access is free unless otherwise indicated by a notice (City Parks 2013, City of Cape Town 2012a, City of Cape Town 2010).

**History**

The San used and managed the local biota (Davis 2005). Before Europeans arrived (circa 400 – 700 A.D.) the pastoralist Khoi displaced the San from the coastal areas (Wilkinson 2000). The Dutch East India Company founded Cape Town (called De Kaap) as a place for ships to get supplies in 1652 (Western 2002, Wilkinson 2000). The settlement became permanent in 1658 with the gift of land to ex Company
employees. The settlement lay across the existing grazing routes of the Khoi causing conflict (Wilkinson 2000). The Khoi clans started weakening from about 1670 (Newton 2008 citing Theal 1922). The garrison had new quarters by 1674 but the castle in De Kaap was completed in 1677 (Heap 1977). Most of the remaining Khoi in the Cape died of smallpox in the outbreak circa 1712 as did many Europeans (Newton 2008 citing Theal 1922). Slaves were imported (Western 2002, Wilkinson 2000). The slaves were freed in 1834. A municipality was established in 1840 followed by a legislative assembly in 1854. The colony became self-governing in 1872 and Cape Town became its capital. Municipal improvements were carried out in the 1890s (Wilkinson 2000).

Official segregation of races started under British rule in 1901 purportedly to control bubonic plague. The state of South Africa came into being in 1910 by the Act of Union. Cape Town became the seat of parliament, i.e. the legislative capital. Urban planning and control of development gradually formed in the 1930s (Wilkinson 2000). World War II created a large demand for labour which resulted in squatter camps (Western 2002, Wilkinson 2000). After the war, relative affluence led to urban sprawl (Wilkinson 2000). The National Party (the authors of apartheid) won the election in 1948 (Western 2002, Wilkinson 2000). At the time of the 1950 Population Registration Act, Cape Town had a coloured majority of 361 300, a white population of 307 000 and a black population of 74 100 – a total population of 742 400 (Wilkinson 2000). This prepared for the Group Areas Act of the same year which required strict racial segregation and lead to forced removals of non-whites from areas designated as white to the periphery of the city – this was known as apartheid (Willemse 2010, Western 2002, Wilkinson 2000). Apartheid planning resulted in urban sprawl (Holmes et al. 2008) with non-whites on the periphery of the city (Hiller 2000). In the non-white areas, housing was provided but recreational facilities such as parks were overlooked (Willemse 2010). By the end of the removals around 1982 some 200 000 people had been displaced (Western 2002). The Western Cape Regional Services Council was formed in 1986 with the purpose of upgrading service provision to non-white areas (Wilkinson 2000). The end of apartheid saw a mass migration of blacks to the city (Western 2002).
Natural Environment
Cape Town Metropole is within the Cape Floristic Region which is a biodiversity hotspot (Holmes et al. 2008, Myers et al. 2000) with a Mediterranean climate (Fuggle & Ashton 1979). The city’s vegetation type classification and its national equivalents appear in Table 2.1. The city has six endemic national vegetation types. The City of Cape Town also has a detailed breakdown of the Vegetation Types which runs to 65 categories (Holmes et al. 2012) based on Mucina and Rutherford (2006). The city has 319 IUCN Red List species (Critically Endangered, Endangered and Vulnerable) within its bounds (Rebelo et al. 2011) which represent natural capital (Rees 1997). This gives the habitat remnants within the city a high value for conservation globally (Crane & Kinzig 2005).

Tourism
Cape Town is a top tourism destination internationally (Frey & George 2010) possibly because it provides a variety of tourist opportunities. There are ecotourism opportunities (George 2003, O’Farrell et al. 2012), lesbian, gay, bisexual and transgender (LGBT) tourism opportunities (Visser 2003, Visser 2002) and sport tourism opportunities (Kotze 2006, Visser 2002) among others. Some mega-events have involved Cape Town, e.g., the 2010 FIFA World Cup™ (Borchers et al. 2011, Kotze 2006).

In 2002, the estimated number of international tourists visiting Cape Town in a year was 800 000 (Visser 2002). Cape Town had about 1.5 million international tourists in 2010 (the year of the FIFA world cup) and about 2.7 million domestic tourists (Strategic Development Information and GIS Department 2012a).

Fynbos is one of the tourist attractions in Cape Town (O’Farrell et al. 2012, Wilkinson 2000) though this does not mean that tourism can be used to motivate for the preservation of natural remnants as most remnants are not on known tourist routes (O’Farrell et al. 2012). Table Mountain and the National Park that it is part of are a tourist attraction (Davis 2005, George 2003).
Table 2.1.  The status and remaining extent within the city only of Vegetation Types and Subtypes within the City of Cape Town from Holmes et al. (2012) and Rebelo et al. (2011).  Endemic Vegetation Types are marked with an asterisk (*).  City of Cape Town and National Status:  CR = Critically Endangered, EN = Endangered, VU = Vulnerable and LT = Least Threatened.

<table>
<thead>
<tr>
<th>City Vegetation Types/Subtypes</th>
<th>National Vegetation Types</th>
<th>Percentage of Original Extent Remaining</th>
<th>City of Cape Town Status</th>
<th>National Status 2008</th>
<th>SANBI conservation status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantis Sand Fynbos</td>
<td>Atlantis Sand Fynbos</td>
<td>61.46%</td>
<td>LT</td>
<td>CR</td>
<td>Hardly Protected</td>
</tr>
<tr>
<td>Boland Granite Fynbos</td>
<td>Boland Granite Fynbos</td>
<td>60.23%</td>
<td>LT</td>
<td>VU</td>
<td>Poorly Protected</td>
</tr>
<tr>
<td>Cape Estuarine Salt Marshes</td>
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<td>75.79%</td>
<td>LT</td>
<td>Not given</td>
<td>Well Protected</td>
</tr>
<tr>
<td>Cape Flats Dune Strandveld – False Bay subtype*</td>
<td>Cape Flats Dune Strandveld</td>
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<td>EN</td>
<td>EN</td>
<td>Poorly Protected</td>
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<td>Cape Flats Dune Strandveld – West Coast subtype*</td>
<td>Cape Flats Dune Strandveld</td>
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<td>LT</td>
<td>EN</td>
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<td>Cape Flats Sand Fynbos*</td>
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<td>14.52%</td>
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<td>CR</td>
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<td>Cape Lowland Freshwater Wetlands</td>
<td>51.4%</td>
<td>VU</td>
<td>LT</td>
<td>Well Protected</td>
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<td>Cape Winelands Shale Fynbos (subtype)</td>
<td>Cape Winelands Shale Fynbos</td>
<td>56.89%</td>
<td>VU</td>
<td>VU</td>
<td>Well Protected</td>
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<td>Elgin Shale Fynbos</td>
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<td>EN</td>
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<td>Hangklip Sand Fynbos</td>
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<td>VU</td>
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</tr>
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<td>Kogelberg Sandstone Fynbos</td>
<td>Kogelberg Sandstone Fynbos</td>
<td>97.47%</td>
<td>LT</td>
<td>CR</td>
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<tr>
<td>Lourensford Alluvium Fynbos*</td>
<td>Lourensford Alluvium Fynbos</td>
<td>8.46%</td>
<td>CR</td>
<td>CR</td>
<td>Hardly Protected</td>
</tr>
<tr>
<td>Peninsula Granite Fynbos – North subtype*</td>
<td>Peninsula Granite Fynbos</td>
<td>69.51%</td>
<td>LT</td>
<td>EN</td>
<td>Well Protected</td>
</tr>
<tr>
<td>Peninsula Granite Fynbos – South subtype*</td>
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</tr>
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<td>Peninsula Shale Fynbos (Cape Winelands subtype)</td>
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<td>VU</td>
<td>VU</td>
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<td>12.28%</td>
<td>CR</td>
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<tr>
<td>Southern Afrotemperate Forest</td>
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<td>99.53%</td>
<td>LT</td>
<td>LT</td>
<td>Well Protected</td>
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<td>CR</td>
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</tr>
<tr>
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<td>25.73%</td>
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<td>CR</td>
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<tr>
<td>Swartland Shale Renosterveld</td>
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<td>8.29%</td>
<td>CR</td>
<td>CR</td>
<td>Hardly Protected</td>
</tr>
<tr>
<td>Swartland Silcrete Renosterveld</td>
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<td>16.28%</td>
<td>CR</td>
<td>CR</td>
<td>Hardly Protected</td>
</tr>
<tr>
<td>Western Shaleband Vegetation</td>
<td>Western Shaleband Vegetation</td>
<td>99.78%</td>
<td>LT</td>
<td>LT</td>
<td>Well Protected</td>
</tr>
</tbody>
</table>
An estimated ten percent of the international tourists visiting Cape Town in 2002 were LGBT (Visser 2002). The South African Constitution protects same sex relationships which allows marketing tourism aimed at LGBT communities. Cape Town is regarded as Africa’s LGBT tourism capital (Visser 2003, Visser 2002).

Cape Town has a number of sporting events that draw tourists (Kotze 2006). These include the Cape Argus cycle race and the Old Mutual Two Oceans Marathon (Kotze 2006, Visser 2002).

Tourists are concerned about safety in Cape Town (George 2003). Concern about crime was part of the reason for the failure of Cape Town’s bid to host the 2004 Olympic Games (Ferreira & Harmse 2000).

The tourism industry in Cape Town has low levels of responsible tourism management because the implementation costs are believed to outweigh the expected benefits and local businesses see little government support (Frey & George 2010).

Lourens River Quaternary Catchment (Study Area in Cape Town)
As an ecological boundary, the Lourens River Quaternary Catchment does not match political boundaries (see Figure 2.1). It contains parts of Subcouncils 8 and 22 including parts of Wards 15, 83, 84 and 100 (See Table 2.2, City Maps 2013). The communities mostly have an annual income over R38 400. They are distributed between the middle and high income brackets (Willemse 2010).

This catchment was first reached by Europeans in September 1652 when some deserters tried to go along the coast to Mozambique. A bartering expedition camped on the banks of the Lourens River (first known as Tweede River) in 1655 (Heap 1977). The catchment was explored by Europeans in 1657 and the area was named Hottentots Holland (Newton 2008, Heap 1977). The commander inspected the area in 1668. It was inspected in February and December of 1671. The leader of the December expedition, Lieutenant Coenraad van Breitenbach, named the river Breitenbach River after himself but the name did not stick – most early maps label it Tweede River (Heap 1977). Land in the Hottentots Holland was bought from the
Figure 2.1. Location of the Lourens River quaternary catchment: a) within South Africa as shown by the box and b) within the City of Cape Town

Khoi on 15 May 1672. The Khoi retained movement rights and the right to use land the company was not using (Heap 1977). The first settlement at the foot of the Hottentots Holland took place in 1672 (Newton 2008 citing Theal 1922). It would appear to have been on the banks of the Lourens River between present Main Road, Somerset West and the railway line but nothing remains (Heap 1977). Vergelegen was illegally granted to Willem Adriaan van der Stel, then governor of the Cape, in
1700 (Heap 1977). Francois (Frans) van der Stel owned Parel Vallei and Paardevlei. The river became known as the Laurens River (spelling later changed to Lourens) after someone who drowned in it. This name was used in 1705 by Adam Tas (Heap 1977). The first farmer in what became the Strand, David du Buisson married in 1707 and brought his bride to his loan farm, Vlooibaai, which had the sea and the Lourens River as boundaries on two sides and the farm Onverwacht as the eastern boundary. Willem Adriaan van der Stel left the Cape on 23 April 1708. Vergelegen was then divided into: Vergelegen, Morgenster, Lourensford and Cloeteburg (Heap 1977). In 1817, part of Cloeteburg was bought to build a church and permission to build a settlement was applied for. The church was finished in 1820 and Lord Charles Somerset gave permission for the settlement to have his name in the same year (Heap 1977). The Strand was variously known as Mosterd’s Bay, Hottentots Holland Strand, Somerset West Strand before it became known as the Strand. Some sort of settlement existed by 1835. Sea bathing was an attraction and there were some fishing boats based there. The De Beer’s Dynamite Factory opened in 1902 and a branch railway line to the Strand was opened in 1906 (Heap 1977).

The Lourens River Quaternary Catchment has no district parks but it has 111 community parks (City Parks 2013). Two cemeteries (Goedehoop and Somerset West) lie within the catchment boundaries. Dick Dent Bird Sanctuary is next to the Lourens River on the other side from the edge of Strand. Dick Dent is classified as a biodiversity area on the City Parks website (City of Cape Town 2012a) but as a greenbelt in the City Parks’ Data (City Parks 2013). The status of Dick Dent is thus a little unclear. The Silwerboom Kloof Natural Heritage Site and the Helderberg Nature Reserve are within the catchment (City of Cape Town 2013, Holmes et al. 2012). The Sport and Recreation Department manage Strand Beach within this catchment (City of Cape Town 2012b).

The total population of the wards that make up this catchment is about 117 048 in about 38 979 households (Strategic Development Information and GIS Department 2013a,b,c,d). The portion of Ward 100 within the catchment is mostly outside the urban edge (mentioned in Holmes et al. 2012) and as such is unlikely to contribute much to the catchment’s population or household numbers. Not counting Ward 100,
the population of the other three wards is about 72 742 in about 25 795 households (Strategic Development Information and GIS Department 2013a,b,c). The actual population of the catchment is thus likely to be between 72 742 and 117 048 living in between 25 795 and 38 979 households though probably nearer the lower number because Ward 100 does contribute to the population and number of households in the catchment but not a great deal.

Table 2.2. Characteristics of the wards that make up the Lourens River Quaternary Catchment based on 2011 census data from Strategic Development Information and GIS Department (2013a,b,c,d). Percentages are of the total number of households unless otherwise stated

<table>
<thead>
<tr>
<th>Trait</th>
<th>Ward 15</th>
<th>Ward 83</th>
<th>Ward 84</th>
<th>Ward 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment (% of labour force (ages 15 – 64) in 2011)</td>
<td>94</td>
<td>80</td>
<td>94</td>
<td>83</td>
</tr>
<tr>
<td>Educated adults (% of persons aged 20 years or more in 2011)</td>
<td>84</td>
<td>58</td>
<td>76</td>
<td>49</td>
</tr>
<tr>
<td>Number of households in 2011</td>
<td>8 164</td>
<td>8 862</td>
<td>8 769</td>
<td>13 184</td>
</tr>
<tr>
<td>Formal dwellings (%)</td>
<td>99</td>
<td>83</td>
<td>97</td>
<td>89</td>
</tr>
<tr>
<td>Income R3 200 or less a month</td>
<td>19</td>
<td>51</td>
<td>20</td>
<td>38</td>
</tr>
<tr>
<td>Use electricity for light (%)</td>
<td>99.7</td>
<td>99</td>
<td>99</td>
<td>97</td>
</tr>
<tr>
<td>Piped water (%)</td>
<td>99</td>
<td>99</td>
<td>99</td>
<td>93</td>
</tr>
<tr>
<td>Flush toilets linked to sewage system (%)</td>
<td>98</td>
<td>99</td>
<td>98</td>
<td>91</td>
</tr>
<tr>
<td>At least weekly rubbish collection (%)</td>
<td>99</td>
<td>99.5</td>
<td>98</td>
<td>94</td>
</tr>
</tbody>
</table>

**Urban Sprawl**

**Definition**

Urban sprawl (hereafter sprawl) does not have a commonly accepted definition (Yue et al. 2013, Wolman et al. 2005) as the term has different meanings to different people (Chorianpoulos et al. 2010, Brueckner 2000). It is, therefore, frequently loosely defined (Lopez 2004).
Differing perceptions of density render definitions of sprawl based on density criteria site-specific (Chorianpoulos et al. 2010). One of the problems with density calculations is the choice of geographic area to measure. Metropolitan areas in the U.S.A. include rural land (as do the South African Municipal boundaries, pers. obs.) and urbanized areas in the U.S.A. do not include peri-urban development which some feel epitomizes sprawl (Wolman et al. 2005). Density is not the only element of sprawl, it is also linked to the distribution of density (Lopez 2004).

Various authors have attempted a definition of urban sprawl. Sprawl may be defined low density development of any type that is discontinuous (Bengston et al. 2005, Lopez 2004). Urban change that is not controlled may be defined as sprawl (Chorianpoulos et al. 2010). Van Metre et al. (2000) define sprawl with a citation from the Office of Technology Assessment (1995) stating that residential growth has outstripped population growth in the United States to which Schmidt (2004) adds the specification of low density development (which raises the issue of what low density is, as mentioned above). An analogous definition is excessive investment in new suburban properties (Brueckner & Helsley 2011). Brueckner (2000) defines sprawl as ‘excessive spatial growth of cities’. This is in itself ambiguous as the definition of excessive depends on a person’s perspective.

Causes of Urban Sprawl
Government policies and taxes affect urban form (Lopez 2004, Schmidt 2004, Nivola 1998). The United States system of urban development, put in place after World War II because the citizens wanted it, results in sprawling cities versus the more compact cities that result from the European systems (Leinberger 1998, Nivola 1998). For example, fuel is subsidised so it is cheaper in the United States than in Europe and Europe subsidises its farmers and small businesses where the States do not (Schmidt 2004, Nivola 1998). Failure to implement policies, for example on retaining farmland, may be one of the causes of sprawl in China (Yue et al. 2013). The structural form of city government may also contribute to sprawl – cities in the United States are made up of many autonomous municipalities which act in their own interests (Downs 1998).
A growing population with rising incomes and investment in roads are felt to contribute to urban sprawl in the U.S.A. though these criteria are only considered to be relevant by economists if externalities (i.e. costs/benefits that affect a person or persons not responsible for the activity that caused the costs/benefits) are involved (Brueckner & Helsley 2011). Competition between developers with regard to timing results in lower density development and is one cause of sprawl in the U.S.A. (Heubeck 2009, 2002). Sprawl in China includes a significant amount of industrial development (Yue et al. 2013). Sprawl may in part be caused by wealth because it enables the purchase of larger plots (Lopez 2004). Post World War II affluence contributed to sprawl in Cape Town (Wilkinson 2000). Other contributory causes include cultural values favouring non-urban living and cars and inexpensive land values (Lopez 2004). In South Africa, the racism of apartheid planning for racial segregation contributed to urban sprawl (Holmes et al. 2008, Standing 2006) with non-whites on the periphery of the city (Standing 2006, Hiller 2000). Ironically, the pattern of sprawl contributed to by racism in the United States is the exact opposite with the black minority in the city and the whites in the surrounding suburbs (Powell 1998). Cultural preferences may result in sprawl – an Englishman’s house is his castle making densification difficult (Thomas 2001).

Three market failures play a role in causing urban sprawl (Brueckner 2000). Firstly, the value of open space socially is ignored (Pitt & Boulle 2010, Arefi & Meyers 2003, Brueckner 2000). Secondly, congestion has a social cost which is not recognized by commuters. Lastly, development projects may be artificially cheap because they do not have to pay for all of the accompanying infrastructure (Brueckner 2000).

Advantages of Urban Sprawl
Some people support urban sprawl because of factors such as consumer sovereignty and private property rights. Sprawl is the result of consumers’ desire for land ownership and thus considered good because it meets the consumer demand (Bengston et al. 2005, Gordon & Richardson 1998). Sprawl can provide access to open space and ownership of space, more choice in terms of where to live and work and spatial separation from the problems caused by poverty and these are all factors which consumers’ desire (Downs 1998).
Negative Impacts of Urban Sprawl

Despite those who favour urban sprawl, it is not universally desired because it has negative impacts. These impacts may be divided into environmental, economic and social impacts (Chorianpoulos et al. 2010, Bengston et al. 2005, Leinberger 1998).

**Environmental Impacts**

Sprawl results in environmental degradation (Lopez 2004). It increases loss of agricultural land – though this is not always considered a valid argument against sprawl (Brueckner 2000, Gordon & Richardson 1998) – and natural habitat loss (i.e. loss of open space with natural vegetation) and thus habitat fragmentation with all their associated consequences to biodiversity of which the most extreme is loss of biodiversity (Vimal et al. 2012, Pitt & Boulle 2010, Schmidt 2004, McKinney 2002). The impacts of sprawl on biodiversity extend well beyond the boundaries of the urbanization (Vimal et al. 2012).

Sprawl results in increased per capita consumption and increases the reliance on cars for transport and decreases the possibility of walking where one wants to go. This results in an increased risk of people becoming overweight or obese (Chorianpoulos et al. 2010, Bengston et al. 2005, Lopez 2004, Schmidt 2004). Urban sprawl means people live further from clinics, hospitals and fire departments. This means emergencies carry increased risks as the necessary service has further to travel to reach the emergency (Jackson 2003).

Air and water quality decrease with urban sprawl which results in health problems (Bengston et al. 2005, Lopez 2004, Schmidt 2004, Van Metre et al. 2000). Sprawl has increased the levels of polycyclic aromatic hydrocarbons (PAHs - suspected carcinogens) in reservoir sediments in the United States. The reason for the increase in PAHs is increased vehicle use (Van Metre et al. 2000). Car emissions are responsible for both increasing the severity of asthma and, in some cases, causing it. Exposure of pregnant women to high levels of vehicle emissions increases the risk of the infant having heart defects (Jackson 2003).
**Economic Impacts**

The costs of public infrastructure development and maintenance increase. Service provision can be problematic (Chorianpoulos et al. 2010, Bengston et al. 2005). New infrastructure may be financed at the cost of maintaining existing infrastructure (Downs 1998). In the U.S.A., policies favouring sprawl are linked to urban blight in the city centres (Brueckner & Helsley 2011). Sprawling cities that rely on car transport are poor economic performers (Chorianpoulos et al. 2010).

**Social Impacts**

Sprawl leads to loss of historic and/or culturally significant sites and destroys a sense of place - all of which have emotional impacts (Bengston et al. 2005). It weakens community bonds (Chorianpoulos et al. 2010, Bengston et al. 2005, Lopez 2004, Brueckner 2000).


In the U.S.A, sprawl has lead to the concentration of poor people in the city centres. Racial segregation is a consequence of sprawl (Downs 1998). In South Africa, including in Cape Town, sprawl means the poor on the city periphery are often far from work imposing significant travel costs (Standing 2006).

**Overview**

Sprawl is a contentious issue, in part because of the lack of an accepted definition. Perceptions of it may be positive or negative but concern about it appears to be the dominant view.

**City Planning**

More humans live in cities than outside of cities. In developed countries this has been true since at least the middle of last century and this became true globally between 2005 and 2010 – by 2010 urban dwellers made up 51.6% of the global population (United Nations, Department of Economic and Social Affairs, Population Division
City planning started because of health concerns and is still a public health issue though health is not the present driver of urban design (Jackson 2003). City planning is sometimes perceived as being anti-poor but it is a tool that can be used in different ways (Watson 2009) and has the power to improve human well-being (Jackson 2003).

City planning should be focused on people and building communities (Boarnet 2006, Miller 2002). Policies and plans providing for a mythical average person are not good enough. The diversity of the population must be considered in the development of policies. It is particularly important to consider children since they have no political say and limited mobility (Chiesura 2004, Chawla 2002, Lawrence 1996). The importance of considering children in planning is emphasized by the UN Convention on the Rights of Children which requires countries to provide an environment that maximizes the child’s well-being and potential (Chawla 2002).

Citizens should be included in the city planning process and particularly in open space design, especially since such inclusion has benefits for their health and happiness (Garau & Sclar 2004, Jackson 2003, Abu-Ghazzeh 1996, Amankwah-Ayeh 1995). Identifying and clarifying the values of different stakeholders can reduce conflict and lead to negotiation. Consensus is unlikely without a clear understanding of participants’ values and interests. Interests may change as a result of information. Consensus building techniques should be adjusted to fit the requirements of the situation. Rigid legal time frames can hamper consensus building (Baldwin & Ross 2012). City planning is not a one size fits all solution (Watson 2009, Jackson 2003).

City planning is based on values and there are tensions between different values. For example, tensions exist between valuing order (control) and spontaneity (or freedom) (Jacob & Hellström 2010, Dixon et al. 2006, Mitchell 1995). According to Jacob & Hellström (2010) and Dixon et al. (2006), values include play and leisure, unity and identity, change and unruliness, power and organization.

Planners have to reconcile three conflicting (though not always) fundamental aims: economic development, environmental protection and social equity. The successful
balancing of these three aims could be considered sustainable development. Planners may need to decide whether to argue a given position or act as a neutral mediator between the three different groups (Campbell 1996). One conceptualization attempting to balance these aims for planners is the ‘humane metropolis’ which presents a set of five environmental and social goals for focusing planning. The goals are: the restoration and maintenance of ecological services; health and safety, both physical and mental, of locals; efficient use of resources (energy, matter, time and water); social and environmental justice and to maintain the importance of community and place (Pickett et al. 2011).

Local geography is also important for planning new buildings. Planning a new building near existing urban open space needs to take into account the impact of the new building on the microclimate of the space. The microclimate of a given urban space affects the use of the space as it affects people’s comfort (Mertens 1999).

Cities are central to achieving global sustainability (O’Farrell et al. 2012, Bulkeley et al. 2011). Different ideas exist as to how cities can become sustainable. Masdar city, a prototype zero Carbon city, is a high density development that has narrow streets and tall buildings (Bulkeley et al. 2011, Mezher 2011). Another approach to achieving sustainable cities is the transition town community movement which started with Totnes in England and has become a network (Transition Network 2013, Bulkeley et al. 2011). The transition town movement focuses on energy use – what sources of energy are used and how much is used and what can be done to use less energy and less harmful energy sources. The core principles the movement strives to attain are resilience and self-sufficiency (Transition Network 2013, Bulkeley et al. 2011).

A city is a system. Ecological processes occur throughout the city, not just in green space. This needs to be remembered in planning so that a holistic approach is used (Pickett et al. 2011). Four environmental goals are important for cities. They need to: decrease energy use, decrease and get rid of pollutants, create a desirable environment and assist in biological conservation (Botkin & Beveridge 1997). Pickett et al. (2004)
suggest using the metaphor of resilient cities to link urban planning/design with ecology and social science as a means towards achieving these goals.

Cultural context (including gender roles and user preferences) needs to be considered as well as local geography and economic context in planning open space both in terms of spatial distribution and design of the space (Wendel et al. 2012). The location and distribution of open space affects the impact the space has on the surrounding community (Walsh 2007). Private open space does not substitute for public open space with local ownership (Bates and Santerre 2001).

Probably the most successful park planning strategy is to plan the parks with new development (BenDor et al. 2013). Planning needs to consider not only urban green space but also peri-urban open space. Farmland also needs protection (Koomen et al. 2008). Jim and Chen (2003) suggest planning open space at the level of the metropolis (built up area and suburbs), city and neighbourhood scales. The linearity of a greenway network suits a compact urban form. At a city level, a greenway network can use land that is not suitable for development. It can also allow the planning of new greenspaces and help to preserve existing greenspaces. Having a planned greenway network reduces developmental conflicts. Using a network can improve accessibility to greenspace. Urban renewal can allow the incorporation of greenspace in old cities (Jim & Chen 2003).

Small isolated greenspaces are the most common type of greenspace in Chinese cities. In China, such spaces tend to be lost (Jim & Chen 2003). Given the perception that open space is unused space (Pitt & Boulle 2010), the loss of such spaces is also likely to occur in South Africa (Roberts et al. 2005).

Politics

Natural spaces within cities are necessary for the maintenance of public will to conserve (Pitt & Boulle 2010). Conservation and sustainability can only be achieved by changing global perceptions of economics and nature (Pitt & Boulle 2010, Adolphson 2004). Especially since politics acts in the short term and biodiversity planning is long term (Roberts et al. 2005).
Public perceptions and political agendas are shaped by urban institutions (Crane & Kinzig 2005). Political and economic leaders are not usually people who have much contact with concepts of biodiversity (Davis 2005). Government and business decisions are usually based on economics (Raitt 2011, Roberts et al. 2005) but all decisions have an impact on the environment. Under the business paradigm, everything must pay for itself (Raitt 2011) thus economic considerations tend to outweigh environmental considerations in decision making.

The foundation of economic theory determines political and cultural development rather than reflecting it (Fricker 1998). The neoclassical perspective of economics is unable to perceive ethical questions (Adolphson 2004) which explains why multinational companies are able to ignore legislation that they do not like (Oskamp 2000). The World Trade Organisation and multinational corporations, not governments, control policies that negatively impact the environment and justice (Raitt 2011).

Politicians do not wish to be the messengers of bad news so they do not pass on bad news (Oskamp 2000). This attitude also influences how they delegate. Risky policies are delegated so that any blame accruing can be placed on others. Policies that do not benefit the politician are also delegated – i.e politicians delegate for maximum personal advantage rather than social well-being (Alesina & Tabellini 2005). Bureaucrats need to look competent to boost benefits while in office and to ensure their future. Policymakers (both bureaucrats and politicians) are likely to act for maximum personal benefit (Alesina & Tabellini 2005).

Neighbourhood crime rates are affected by the socioeconomic characteristics of the neighbourhood and by the crime rates of surrounding neighbourhoods (Wolfe & Mennis 2012). The design of the landscape affects human behaviour (Matsuoka & Kaplan 2008) this has implications for dealing with crime and political unrest. What people consider a comfortable living environment is subjective and may be based on intangible factors (Takano et al. 2002).
Part of the city resident’s well-being is his/her own responsibility (Jackson 2003). Grassroots opinion does not match that of profit orientated big companies and constant monitoring is needed to avoid business driven watering down of environmental legislation (Oskamp 2000) especially since, in many countries, corporations own the media (Raitt 2011). Corporate interests are seeking control of open/public space (Mitchell 1995). It is important to remember that alternatives to corporate control exist. Common pool resources can be effectively managed by their users if the users take part in setting the rules and have some government support in managing compliance. Contributing to decisions affecting resource use results in a better probability of users complying and self-regulation than rules imposed from outside (Baldwin & Ross 2012).

While city residents’ have responsibility for their own well-being, government also has responsibility for citizens’ well-being and the conservation of other species. Conservation is not assigned to a particular governmental level in the South African Constitution. In Cape Town, environmental responsibilities are fragmented within the municipal government. Responsibilities are also split between the national, provincial and city governments (Katzschner et al. 2005).

Conservation
The main reason for having protected areas is to retain global biodiversity (Robinson & Ginsberg 2004). The fifth World Parks Congress (Durban 2003) “recognised … that the contribution of parks to human well-being is pervasive, poorly quantified and underappreciated” (p. 607 Robinson & Ginsberg 2004). Parks here seems to refer to conservation areas. People from all socio-economic backgrounds have some awareness of the need for conservation though other needs may take priority (Ferketic et al. 2010).

Humans build cities and are the keystone species in them (Rees 1997) so conservationists must consider the issues of urbanization (Miller & Hobbs 2002). Conservation has to consider the needs and wishes of the surrounding communities if it is to be successful. Interaction with the local communities is necessary to determine their needs and wishes (Ferketic et al. 2010, Pitt & Boulle 2010, Davis 2005, Niemelä
This does not mean that the surrounding communities should set the priorities as socio-economic issues would take priority and there would be no ensuing conservation (Ferketic et al. 2010). To achieve conservation, one needs to identify what prevents it and then seek solutions. Identifying environmental problems in a community and seeking solutions facilitates the development of action plans. Meetings with the locals must be followed by appropriate action to generate more action. Ongoing activity may also leverage funding that can help to sustain it. Locals can help to focus conservation action (Davis 2005).

The impacts of urbanization on biodiversity extend well beyond the urban edge due to factors such as pollution (Vimal et al. 2012, Crane & Kinzig 2005). In the Netherlands and Germany, conservationists recognize that adapting agricultural management can provide habitat for many native species (Koomen et al. 2008).

Urban conservation is necessary (Rebelo et al. 2011, Pitt & Boule 2010, Crane & Kinzig 2005, Niemelä 1999). Cities located in environmentally sensitive biodiversity hotspots have natural habitat within them that may be of global significance as it is in São Paolo in Brazil and Cape Town in South Africa, for example (Crane & Kinzig 2005). Urban open space can thus be critical for the conservation of rare and endangered species (Niemelä 1999) and this is true for Cape Town which contains 319 IUCN Red List species (Rebelo et al. 2011). Natural spaces within cities are also necessary for the maintenance of public will to conserve (Pitt & Boulle 2010) since environmental knowledge is correlated with exposure to the natural environment. It is not correlated to education (McDaniel & Alley 2005). With increasing urbanization, contact with nature will take place in an urban setting for the majority of people (Crane & Kinzig 2005). People-centred conservation along with community-based resource management are needed for communities to learn to value their natural heritage (Rebelo et al. 2011). People use their memories of the natural environment they experienced as children as a baseline to judge environmental degradation which means each generation’s view is less realistic than the previous generation’s view – called the shifting baseline (Lindenmayer et al. 2008, Miller 2006) so urban nature is critical for the formation of realistic baselines. The shifting baseline is also known as environmental generational amnesia (Miller 2006).
Conservation in urban areas is complicated (Pitt & Boule 2010). Reasons for this include that development tends to leave odd patches and corridors which are impacted by pollution and nonnative species from the surrounding built environment which is persistent and expanding (Vimal et al. 2012, Pitt & Boule 2010, McKinney 2002, Baschak & Brown 1995 citing Cook 1991). Development may separate ecosystems from supporting structures. Patches may be overused for cultural/traditional medical harvesting or subsistence or recreation or even formally developed into parks that suit humans rather than the native species (Petersen et al. 2012, Pitt & Boule 2010, Baschak & Brown 1995 citing Cook 1991). The fact that remnants are not ecologically pristine gives rise to perceptions that these remnants are not worth conserving (Pitt & Boule 2010, Baschak & Brown 1995). Urbanization leads to biotic homogenization and the spread of alien species (Miller 2006, McKinney 2002). People-wildlife conflicts have to be dealt with (Savard et al. 2000) which requires community and other stakeholder engagement which can only be achieved if negative perceptions of conservation are overcome (Gallo & Goodchild 2012, Rebelo et al. 2011, Pitt & Boule 2010, Ancrenaz et al. 2007). Botanical conservation in Cape Town is hampered by the perception that natural veld poses security and fire risks (Rebelo et al. 2011, Van Zyl & Leiman 2002).

Human landscape change (direct and indirect) is accelerating (Lindenmayer et al. 2008, Thomas et al. 2004). Increasing urbanization means that natural areas with significant ecological value are disappearing from cities (Baschak & Brown 1995). This may lead to the inaccurate perception that existing remnants are not valuable to conservation (Pitt & Boule 2010). In reality, the value of such sites goes beyond the immediate habitat value because they allow urbanites to experience nature which can improve their education and quality of life and thus promote conservation (Miller 2006, Savard et al. 2000). Urban conservation can be used for community upliftment (Pitt & Boulle 2010).

Views of nature were found to increase residents’ sense of well-being (Kearney 2006) though this may depend on the type of environment. Manicured gardens are considered beautiful by many who see unmanaged vegetation as ugly (Barrett &
Odum 2000). This appears to be the case with many of the City of Cape Town’s residents since open space gets mowed regularly including during the reproductive phase of indigenous species (Maneveldt 2011, Pitt & Boulle 2010, Marais & Maneveldt 2006) which encourages weeds (Marais & Maneveldt 2006) – a fact of which City Parks is aware and are working towards rectifying (pers. comm. Mr George Frost and Mr Gregory Benskin 3.07.2013). The impetus for mowing comes from the residents of Cape Town since city parks area managers have horticultural training and are not automatically against logical practices (pers. comm. Mr George Frost 3.07.2013). This attitude needs changing for the good of both humans and nature.

For protected areas to survive, they must be considered in the context of the landscape around them (Robinson & Ginsberg 2004, Golley 1989). Natural patches are part of a terrestrial matrix in which migrants may find temporary resources (Litteral & Wu 2012, Golley 1989). Conservation must include interfaces between the freshwater, marine and terrestrial realms (Beger et al. 2010). Having continuous greenspace does not guarantee a habitat connection (Jim & Chen 2003) but greenspace may provide habitat connections (Milanovich et al. 2012). A city is a system (Pickett et al. 2011). Urban ecosystems are very dynamic (Savard et al. 2000). Ecological processes occur throughout the city, not just in green space (Pickett et al. 2011). Focusing solely on patches may not achieve the planned conservation goals (Fischer et al. 2005). Species react uniquely to landscape change. Behavioural studies may be the best way to determine connectivity (Shreeve & Dennis 2011). Brady et al. (2011) found that the properties of the matrix determined isolation more than the distance to the nearest patch did. The nature (extent, degree and permanence) of changes to the matrix impact the area and isolation effects of patches. It is necessary to move from a patch focus to a landscape mosaic focus (Kupfer et al. 2006).

Ecosystem services, defined as ecosystem functions that benefit humanity (Egoh et al. 2007), are not suitable for motivating for conservation for all natural remnants in Cape Town. National and global conservation targets are better motivators in these cases (O’Farrell et al. 2012). Selecting conservation areas based on ecosystem services may present problems in terms of biodiversity retention. For Cape Town, as
part of a biodiversity hotspot, biodiversity must take precedence over ecosystem services for conservation (O’Farrell et al. 2012).

Privately owned land of all sizes in Cape Town is critical for the preservation of biodiversity. The Biodiversity Stewardship programme is a mechanism used in Cape Town to bring private land owners into conservation. Private landowners participating in this programme enter into agreements with authorities to protect the natural areas they own (Norval 2012).

Open Spaces
Definitions and Terminology
Open space means different things to different people. Ordinary citizens of the United States use ‘open’ for space with a clear view so woodland is considered less open. This is not how the word ‘open’ is used to refer to open space by developers, land use practitioners, planners and resource managers (Kaplan et al. 2004). One definition of open space is any and all forms of undeveloped land (Bengston et al. 2005). Urban green space is a subset of open space being space with permeable surfaces which may be natural or modified by humans (Wendel et al. 2012, Willemse 2010). Another definition of urban green space is any piece of land covered by vegetation (Rasidi et al. 2012).

Open space is not necessarily public space. It may be pseudo-public space, i.e. space that is open to the public but not publicly owned. Even public space may be rendered exclusive by the definition of ‘the public’ (Mitchell 1995). The boundary between private and public is not always clear (Dixon et al. 2006).

Types of Open Space
There are different ways of classifying urban space. Some categories may overlap. Some categories may have subdivisions. What follows is a selection of examples found in literature and municipal data: allotments, church yards, cemeteries, coastal amenities, community gardens, drainage lines, greenbelts, heritage sites, parks, nature reserves, outdoor sports facilities, road verges, school grounds and urban agriculture.
Access to Open Spaces

Without policy intervention, a public good such as open space is inadequately provided (Brander & Koetse 2011, Kotchen & Powers 2006). China’s policies have led to an increase in the green space cover of most Chinese cities (Zhao et al. 2013). Management is needed in order for there to be any common access. While open space is a public good, it is usually managed by the city authorities (Jacob & Hellström 2010). Access to public open space may depend on the definition of the word ‘public’ (Mitchell 1995).

There are recommendations from some organisations concerning how close people should live to open space. English Nature recommended a maximum distance of 300 m to live from open space and the European Environment Agency recommended a 900 m maximum distance (Barbosa et al. 2007). In South Africa, a preliminary recommendation by the CSIR is that people should be within 750 m of a park with a capacity of 0.5 ha per 1 000 people (Willemse 2010 citing Green & Argue 2007). There are also recommendations concerning the amount of park space per person – Willemse (2010) cites Barton et al. (2003), an English study, as recommending 6—8 m² per person. In Cape Town, only the high income bracket meets this recommendation with 7.1 m². The middle income areas have 2.6 m² per person and the low income areas have 2.2 m² per person (Willemse 2010). In Tokyo, the per capita park space was 5.18 m² in 1997 (Takano et al. 2002). It should be noted that parks are only one form of open space. Willemse (2010) covers only designated parks, not protected natural areas or other forms of open space.

Proximity (or potential access), used as a proxy for access, does not equate to use of open space because of barriers to access. Barriers to access and use include lack of safety, distance from green space, neighbourhood walkability, lack of desirable space nearby, no time to visit open space (Wendel et al. 2012, Wolch et al. 2011) and social factors (Ball 2006). In Santa Cruz, Bolivia, women and the poor have more barriers
to access to urban green space (Wendel et al. 2012). Walkability is more important for girls than for boys (Wolch et al. 2011).

Typically people are willing to walk about five minutes to reach open space (Wendel et al. 2012) but the estimate of how much distance is covered varies (not surprising given differences in pace) – for English Nature, 300 m is an estimated five minute walk (Barbosa et al. 2007) while Wendel et al. (2012) and Willemse (2010) consider 400 m to be about five minutes walking. Other studies consider fifteen minutes the maximum time people are willing to walk to a park (Willemse 2010 citing CSIR 2000). The amount of time people are willing to spend walking to an open space may depend on the country they live in. In New Zealand, only 23% of trips to recreational open space are taken on foot while about 72% are by car (Witten et al. 2008).

More open spaces mean more potential access and more likelihood of use if the spaces are perceived as safe (Wendel et al. 2012). This is also true for the other mobile species that use open space (Campbell 2006).

Access to open space is equal in all socio-economic sectors in Melbourne, Australia (Timperio et al. 2007) but wealthy Australian neighbourhoods are likely to have more amenities available in open space than poorer neighbourhoods (Crawford et al. 2008). Most New Zealanders have good access to a park (Witten et al. 2008). This is not true in Georgia, U.S.A.: poorer communities are more likely to have undesirable land use near them and less likely to have desirable land near them (Zhang et al. 2008). The City of Cape Town, South Africa is more like Georgia, U.S.A. than Melbourne, Australia or New Zealand with regard to open space access – the provision of parks for low income groups is poor. There is a park for every 7 102 people in the low income bracket where the middle income bracket has a park for every 2 368 and the high income bracket has a park per 1 430 people (Willemse 2010).

**Perceptions of Open Space**

Perceptions of open space depend on the quality of the environment in terms of cleanliness, peace and health. People see pollution through the lens of its impacts on their own health rather than as a cause of environmental destruction (Arefi & Meyers
Badly maintained, unsafe or congested open spaces may lead to negative perceptions of the space (Wendel et al. 2012).

In Visakhapatnam, a crowded city in India, access to public space was not perceived to be a problem but the quality of the space was a concern (Arefi & Meyers 2003). This concern with the quality of public space rather than access is also reflected in Melbourne, Australia (Crawford et al. 2008). Income does not affect the perception of value of open space but population density does – open space is more highly valued in densely populated areas (Brander & Koetse 2011).

Some perceptions of open space reflect class, cultural and/or religious value, economic use and the physical traits of the space (Arefi & Meyers 2003). Some perceive green space as a luxury for the elite (Wendel et al. 2012, Roberts et al. 2005). This is true in South Africa’s past (Roberts et al. 2005) and possibly is still true for some South Africans.

Natural open space in South Africa may be perceived as unused land available for plundering (Pitt & Boulle 2010 and pers. com. Mr N. Braaf of Ithokazi Mining at a public meeting at Mfuleni Primary School, 25.11.2011). Open space in South Africa is often perceived as unsafe (Cilliers et al. 2012, Van Zyl & Leiman 2002). It is also clear that many fail to see the need for open space (Pitt & Boulle 2010) to the extent that no income group in Cape Town feels that parks and recreation provision is a service that requires improvement despite unequal provision of this service (Willemse 2010).

Quality
Good management in the form of ensuring safety, maintaining the space and ensuring diverse amenities results in quality open spaces and ensures more user diversity and more total use which may lead to a sense of community ownership and thus better care of the space by the community (Wendel et al. 2012, Chiesura 2004). Co-management is a successful way to deal with public goods (Jacob & Hellström 2010).
The size and quality of open space may affect how much it is used (Giles-Corti et al. 2005). A variety of tools to assess the quality of open spaces exist. The Public Open Space Tool (POST) has been adapted for use with GoogleEarth (Taylor et al. 2011).

Kaplan et al. (2004) note that conventional landscaping (lawns) leads to environmental degradation and does not provide the sense of well-being generated by more natural landscapes. Like South Africa, the U.S.A. has lawns or mowed areas for open space (Kaplan et al. 2004). Lawn care chemicals are also harmful to human health (Jackson 2003).

The Value of Open Space
Open space in cities is significantly undervalued. One cause of this is that the benefits of open space are not being accounted for (Roberts et al. 2005, Brueckner 2000) or, sometimes, even recognised (Roberts et al. 2005). Society generally fails to value resources that cannot be owned or do not have a monetary value attached to them (Roberts et al. 2005).

The type of open space affects the value of the space (Brander & Koetse 2011). Open space is usually multifunctional (Fausold & Lilieholm 1999). A comprehensive valuation is difficult as all the values can not be added together and not all values are easily expressed in currency e.g. public goods do not have markets (Lévêque & Mounolou 2001, Fausold & Lilieholm 1999). To complicate matters of valuation further, benefits may be experienced without direct use of the open space (Willemse 2010).

Open space provides place for different ethnic groups to meet and mingle. It provides opportunities for contact with others (Rasidi et al. 2012) which is one reason why open space is regarded as critical for the development of a sense of community (Willemse 2010, Pitt & Boulle 2010, Arefi & Meyers 2003) though this development will only happen if the community has a sense of ownership of the open space (Pitt & Boulle 2010).
In urban and urbanising areas, open spaces provide ecosystem services (Fausold & Lilieholm 1999). Ecosystem services may be defined as ecosystem functions that benefit humanity (Egoh et al. 2007). Ecosystem services can be placed in four groups: cultural services, provisioning services, regulating services and supporting services (Cilliers et al. 2012). Ecosystem services and their values are site specific (Ciliers et al. 2012, Bolund & Hunhammar 1999). Different types of open space vary in their ability to provide ecosystem services so it makes sense to prioritise keeping those that provide more ecosystems services such as wetlands (Roberts et al. 2005). Urban agriculture contributes to food security (Barthel & Isendahl 2013). Ecosystem services such as pollination rely on native fauna (Andersson et al. 2007) thereby benefiting conservation.

While conservation is not an economic use of open space (Fausold & Lilieholm 1999), native species represent natural capital (Rees 1997). Open space may provide connectivity between different habitat patches (Milanovich et al. 2012) which is valuable for conservation. Natural habitats in urban areas are vastly important and may have global significance as in the case of São Paolo in Brazil and Cape Town in South Africa (Crane & Kinzig 2005).

Open space provides city inhabitants with an opportunity for contact with ‘nature’ (Crane & Kinzig 2005). Such contact is essential for developing awareness of the environment which is necessary for conservation (Pitt & Boulle 2010) and for sustainability. Contact with nature also fills a spiritual need (Chiesura 2004).

Open space may provide enhancement value to adjacent properties (Fausold & Lilieholm 1999). The density of residential area may affect the amount of enhancement value provided by open space (Dehring & Dunse 2006). In Africa, the value of properties next to open space was found lower than those away from the space in some places (Cilliers et al. 2012) so in Claremont (Cape Town), a park reduces property value but in Kuilsriver (Cape Town) there is a premium for being near a park (Van Zyl & Leiman 2002). This may have to do with a perception that being near the open space poses safety hazards (Cilliers et al. 2012, Van Zyl & Leiman 2002). Heavily used open spaces may reduce property values because of
noise and congestion (Bates & Santerre 2001) so the prices of Lakeside houses (Cape Town, South Africa) near the braai sites at Zandvlei are negatively affected because of weekend noise (Van Zyl & Leiman 2002). Questions of future development and the enforcement of zoning policies may discount the price of houses near open space (Van Zyl & Leiman 2002).


Open space can contribute to achieving national and international goals. Part of meeting the requirements of the UN Convention on the Rights of Children for quality living environments for children involves providing quality open space (Chawla 2002). Open space with natural vegetation can assist in achieving national and international conservation targets (O’Farrell et al. 2012).

Urban open space was initially provided for its health benefits to the urban population (Botkin & Beveridge 1997) and is still a major determinant of quality of life for city dwellers (BenDor et al. 2013). A study of the users of Vondelpark in Amsterdam in the Netherlands showed that the majority of users considered the feelings generated by park use important to their well-being (Chiesura 2004). Access to walkable green space has been shown to improve longevity regardless of socio-economic status in a megacity environment (Takano et al. 2002).

Exposure to vegetated open spaces has been shown to increase self-discipline in children and thereby to facilitate academic progress and to reduce antisocial behaviour (Taylor et al. 2002). Exposure to ‘natural’ (my quotes) areas is known to facilitate recovery from directed attention fatigue and stress (Kaplan 1995) which may be why the presence of vegetation that does not obstruct visibility decreases crime in city neighbourhoods in the U.S.A. (Kuo & Sullivan 2001) and why attractive places are known to produce more innovation and vegetation is known to contribute to
attractiveness (Botkin & Beveridge 1997). The psychophysical restorative benefits of visiting parks are valued by the users of Vondelpark in Amsterdam (Chiesura 2004).

Proximity to parks/green space reduces the likelihood of obesity in children (Wolch et al. 2011) and is associated with leisure time physical activity (Witten et al. 2012, Giles-Corti et al. 2005, Owen et al. 2004) though Witten et al. (2008) found that vehicular access to open space was not correlated to physical activity.

Use of Open Space
Most of the literature focuses on park use rather than use of all forms of open space.

Socio-demographic and socio-economic factors play a role in determining park use (Schipperijn et al. 2010, Willemse 2010). Parks must be positively perceived by potential users for them to become park users (Willemse 2010). A park will not be used by those groups whose preferences are not catered for (Wendel et al. 2012). Thus, increasing the diversity of amenities is likely to increase use provided safety is ensured (Wendel et al. 2012, Willemse 2010).

In Santa Cruz, Bolivia, women, the elderly and the less educated make use of green space less frequently than other groups. Men make more use of sports facilities than women. Larger parks (known as urban parks) are used at night (Wendel et al. 2012). Children are the age group with the most park use. Children in developed countries are usually accompanied by an adult for safety reasons. Most people do not visit parks alone for safety reasons (Willemse 2010).

Frequency of Use
Frequency of use decreases with increasing travel distance above 300 m. Subjective estimation of distance to a space is a better guide to use than an objective measurement (Schipperijn et al. 2010).

Reasons For Use/Used For...
People use parks for many reasons of which some are listed here in no particular order. People use parks: to get fresh air, to exercise either individually or as a group,
to walk the dog, to get some peace and quiet, to socialize with family and/or friends, to relax, to observe and experience nature, as a shortcut to get somewhere, for artistic inspiration, to meditate, to get away from the urban environment, to observe other people, to sit, for a date, to feed birds, to eat lunch, to play, for photography, to sunbathe (Rasidi et al. 2012, Schipperijn et al. 2010, Willemse 2010, Chiesura 2004, Abu-Ghazzeh 1996). Willemse (2010) also notes some antisocial uses such as drug taking, sexual gratification (mostly through attacks) and voyeurism.

Chiesura (2004) did not pick up gender differences in motives for use but did pick up age differences in the study of Vondelpark users in Amsterdam. The youngest favoured sport and meeting people while adults and seniors preferred relaxing, being with children and contemplating nature (Chiesura 2004).

**Why Open Space Is Not Used**

Barriers to use may be reasons for not using parks. Distance is a one such barrier that is a factor in not using open space. People over 80 are less likely to use green space so age is another barrier. Lack of time and both physical and social safety concerns may affect the use of open space. Thus, individuals may not use parks because they lack someone to go with. Undesireable open space will be avoided (Wendel et al. 2012, Wolch et al. 2011, Schipperijn et al. 2010, Willemse 2010, Abu-Ghazzeh 1996). Personal factors may also be barriers to using parks. Poor self-efficacy (in this case, self-efficacy is the self-perceived ability to be physically active in difficult situations) is another possible reason limiting the use of space when access is perceived as poor (Deforche et al. 2010).

Some people are not interested in using parks (Rasidi et al. 2012). Daily routine leads others to forget that it is possible to visit green space during the week. For those who remember that green space is available to visit during the week, the benefits of visiting the open space may seem to be contrary to the mindset needed for work and so be avoided during the working week (Hitchings 2012).
**Holistic View**

**Information**

Western thought separates humans and nature – this perception needs to be changed (Ingold 2000, Rees 1997). The values individuals hold need to change for sustainability to be possible (Dahl 2012).

Contextual considerations are needed for appropriate interpretation of information (Banzhaf 2010) thus, city planning ideas taken directly from the northern hemisphere do not work as is in the southern hemisphere due to the contextual differences between the cities (Watson 2009). Perspective determines what ethical questions can be answered (Adolphson 2004). Perspective also affects the understanding of words (Kaplan et al. 2004, Niemelä 1999).

Bombarding people with facts about how serious environmental problems are may cause action paralysis and decrease their commitment to solving these problems (Jensen 2004) but ecological knowledge needs to be integrated into urban planning if urban biodiversity is to be maintained (Niemelä 1999).

Using a stakeholder participation approach in planning and management of the environment facilitates the flow of information (Matsuoka & Kaplan 2008, Pitt & Boulle 2010). Norms are created by social dialogue. Information from ecology is linked to values in public debate. Using ecology to evaluate social phenomena will provide information but what is done with the information is normative (Pickett et al. 2011, Raitt 2011).

Academic articles are for academics and tend not to have much impact on planning and management. Effort needs to be made to spread the information to communities and the relevant officialdom (Banzhaf 2010). Participatory action research offers a model for improving communication but is expensive to implement (Pickett et al. 2004).

Literature searches turn up low numbers of articles from certain geographical areas. This may be because the said areas do not publish in international English medium.
journals. More published research may exist in the local language of such geographical areas (Francis 2012).

**Transdisciplinarity**

Open space is of importance in several fields of study including conservation and economics (Banzhaf 2010). Several disciplines contain the concept of ecology (Pickett et al. 2011). Multidisciplinary input is needed to achieve a holistic approach to integrate ecology into urban planning (Tzoulas et al. 2007, Pickett et al. 2004, Niemelä 1999). Linking ecosystem health, human health and open spaces might help to achieve this (Tzoulas et al. 2007), as could the fact that open space is usually multifunctional (Fausold & Lilieholm 1999) so for example cultural/historical sites can also serve as greenspace (Jim & Chen 2003).

Transdisciplinary collaboration is necessary for preventive health care (Jackson 2003). Evidence that living where there are walkable green spaces increases longevity can be used for policy making and promote collaboration regarding urban planning (Takano et al. 2002).

Various scientific disciplines can provide information on the scope and nature of environmental problems but the identification of the causes of and solutions to these problems usually lies outside the boundaries of these disciplines in the social sciences (Raitt 2011, Jensen 2004)

**Synergy**

Long term conservation requires a solid institutional basis (Davis 2005). Taking a systems approach enables the connection of models developed by different disciplines and players in city management (Pickett et al. 2011). Information that creates the political will to conserve needs to be backed up with the resources to conserve or conservation will not happen (Banzhaf 2010).

**Sustainability**

All civilization is based on the functioning ecosphere supporting life and being productive (Carlman 2005, Rees 1997). To live sustainably requires using less than
or up to the amount of natural resources that can be replenished by the ecosphere without degradation (i.e. loss of natural capital) (Miller 2002). Sustainability is considered to be a balance between economic, environmental and social health so indicators tend to be a blend of these three elements but the concept extends beyond these categories to the internal and existential dimensions. Examples of sustainability involve equity, justice and social cohesion and not affluence (Fricker 1998). Sustainable development is a goal that may be reached by increments. It will not be achieved overnight (Campbell 1996). For example, the different aspects of parks (economic, environmental and social) need to be balanced to achieve sustainability (Willemse 2010). Everyone is anthropocentric. Our choice of values and priorities to apply to both nature and society determines our world view. Utopian views may impede progress toward sustainability (Campbell 1996). The challenge of sustainability is to change attitudes and behaviour concerning the way people live and use space. This requires social discourse (Fricker 1998).

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**Articles Cited By Other Authors But Not Found**


**Personal Communications**

Mr Gregory Benskin, Principal GIS Technician, City Parks North, Community Services, City of Cape Town at his office in Millpark Office Block, Ixia Road, Milnerton on 3 July 2013.

Mr N. Braaf, Director of Ithokazi Mining at a public meeting held as part of an EIA process at Mfuleni Primary School, 25 November 2011.

Mr George Frost, Head of Administrative Support, City Parks North, Community Services, City of Cape Town at his office in Millpark Office Block, Ixia Road, Milnerton on 3 July 2013.
Chapter 3 Analysing Google Earth as a Source of Imagery for Research

What is Google Earth?
Google Earth is a readily available (see Appendix 3.1) and successful freeware virtual globe (Sheppard & Cizek 2009, Blamont 2008). Kingsbury and Jones (2009) show a wide range of non-academic uses of Google Earth. It is promoted as a tool for those who do not know any GIS e.g. by the MAPA project (MAPA Team Undated) which also promotes it as a communication tool. Does Google Earth provide a suitable source of imagery for spatial analysis of landscapes without post geospatial rectification?

Use of Google Earth for Research
Google Earth has been useful for research in a variety of disciplines. In spatial research, Google Earth can be used to identify areas of a given landuse/landcover to use for supervised classification of satellite imagery (Githiora 2008) or to ground truth classifications based on satellite imagery (Magidi 2010, Mallick 2008). It was successfully used for assessing park quality in Australia (Taylor et al. 2011). Prof. Lee Berger uses Google Earth to identify potential sites for archaeological investigation (Berger 2010). Google Earth is used for presenting issues, planning and research both two and three dimensionally which raises ethical issues concerning the manner of presenting (Sheppard & Cizek 2009). Google Earth can be used to teach spatial concepts (Patterson 2007).

Using Google Earth to Collect Open Space Data in the Lourens River Quaternary Catchment
The earliest continuous coverage of the study area in Google Earth was compiled for 2005, thus this was chosen for this study.

Data Collection
Preparation
Possibly the first issue with Google Earth is that its files are not directly compatible with different GIS systems so conversion tools are needed. This is changing. Google Earth Pro is capable of importing .shp files and GIS systems are developing and
refining their own conversion tools. This step requires knowledge of the projections of the files to be converted.

The boundaries of the study area and the 500 m contour were obtained from the Biodiversity GIS web portal (Willoughby et al. 2007) and National Geospatial Information respectively as .shp files and converted from .shp files to .kml (keyhole markup language) files using Shp2kml (see Appendix 3.2).

**Digitising**

Google Earth provides point, line and polygon digitizing options which can be used on the imagery from a selected date. The default form for a polygon is solid colour which may make seeing where one wants to place the next node difficult. This is easily overcome by changing the style and can be done without ‘finishing’ the polygon. A point icon is confusing as during placement there are crosshairs showing a centre of the icon which presumably matches the coordinates but the centre does not match the point of the pin on the default icon which one would expect to mark the spot. Editing is done by right clicking on the digitized object in the sidebar on the left and selecting properties.

**Problems Encountered**

Google Earth imagery is subject to the normal problems of high definition digitizing such as boundaries obscured by trees or shade and precision not guaranteeing accuracy.

A single Google Earth coverage may consist of images from multiple dates prior and up to the selected date. For the Lourens River quaternary catchment, the 23 March 2005 coverage has two dates: the bulk of the urban part of the catchment is 23 March 2005 imagery but the upper end of the catchment is 15 February 2005 imagery. This difference in dates was not deemed large enough to be of consequence in this study but it is potentially problematic. The digitizing was finished early in 2012. When the 2005 imagery in the Lourens River quaternary catchment was viewed on 15 May 2013, the boundaries between the 15 February 2005 and 23 March 2005 imagery had
Figure 3.1. Polygon digitised over 23 March 2005 Google Earth imagery shown a) displayed in Google Earth over 23 March 2005 imagery and b) displayed with appropriate projection over a georeferenced 2005 aerial photograph supplied by the City of Cape Town.
Figure 3.2. Polygon digitised over 23 March 2005 Google Earth imagery shown a) displayed over 23 March 2005 Google Earth imagery and b) displayed over 12 February 2009 Google Earth imagery.

changed so as with other material referenced from the web, access dates are important.
What was not a problem for this study, but is worth mentioning is that imagery quality is not consistent between years as is true for high definition aerial photographs. The Lourens River quaternary catchment imagery for 2006 is of a lower quality than 23 March 2005 or more recent images.

The biggest problem was alignment. Google Earth imagery is not aligned to latitude and longitude (Figure 3.1) which means adjustments are required to enable the use of data captured from it in a GIS. This wastes time. Images from different dates are also not aligned to each other (Figure 3.2) making Google Earth impractical for change detection or time series analysis without post-processing. Post-processing would involve ground control points and rubber sheeting the image then doing accuracy assessment – a time consuming procedure. The alignment errors appear to be less than ten metres so the error should be negligible for 30 m x 30 m pixel raster modeling.

Problems Discovered Post Data Collection
After converting the Google Earth .kml files to files for a GIS, the data was projected over aerial photographs acquired from the City of Cape Town Municipality. This showed that even within the 23 March 2005 imagery, the different sections were not all aligned to each other. This may have been a stitching problem.

Discussion
The problems encountered in this study demonstrate that Google Earth is not suitable as a source of data and imagery for spatial research without post geospatial correction. There are, as indicated in the literature, other ways in which it can be used in spatial research. It is thus a matter of the appropriate use of this resource for research (See Table 3.2.).

In South Africa, aerial photos, orthophotos and topocadastral maps can be obtained with little or no cost (discounting travel) from National Geospatial Information for which the main base is in Mowbray, Cape Town. Google Earth’s easy access may
### Google Earth Versus Alternatives

Table 3.1. Comparison of available globe/map services. Data from: Mr Martin Cocks (Pers Comm.), Google Team (2013), Kim & Hogan (2004), Maxwell et al. (2004), Sheppard & Cizek 2009, Willoughby et al. (2007)

<table>
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<tr>
<th>Service → Attribute ↓</th>
<th>Google Earth</th>
<th>Google Maps</th>
<th>NASA World Wind</th>
<th>ArcGIS Server</th>
<th>Bing Maps/ Microsoft Virtual Earth</th>
<th>BGIS/ Biodiversity GIS¹</th>
<th>ArcGIS Explorer</th>
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<td>*</td>
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<td>Resolution</td>
<td>Not consistent</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>Not Applicable</td>
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<td>Digitising Possible</td>
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<td>Yes – under ‘My Places’ Create Map or My Maps</td>
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<td>Yes – under ‘My Places’</td>
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<td>Yes</td>
<td>Yes</td>
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</tr>
</tbody>
</table>

¹ BGIS is the institutionalised form of what started as the Conservation Planning Unit in Cape Action Plan for People and the Environment.
² LRQC – Lourens River Quaternary Catchment
* Information not found. The author was unable to persuade NASA World Wind to work.
Table 3.2. Suitability of Google Earth for various uses from literature and this study

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<td>Yes</td>
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<td>Identifying specific sites e.g. for archeology or for supervised</td>
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<td>This study: 4—5 m is not a large error</td>
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<tr>
<td>Small scale planning</td>
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<td>Site specific mapping on a large scale</td>
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</tbody>
</table>
make it more viable than getting data from National Geospatial Information since aerial photographs acquired there also require processing.

The ready availability provides a wide audience potentially making Google Earth an effective communications tool. The MAPA project is presenting conservation research to the public by attaching information to each study’s research location on Google Earth. It provides a quick and easy way to see what is happening (MAPA Team Undated).

**Conclusion and Recommendation**
Google Earth is a useful toy and learning tool. It is a useful tool for communication and can be useful for many kinds of research but does Google Earth provide a suitable source of imagery for spatial analysis of landscapes without post geospatial rectification? No, it is not currently suitable as a source of data and imagery for spatial research without post-processing. Google Earth images should be treated like aerial photographs which require post geospatial corrections.

**References**


Appendix 3.1 Local Problems
Saying Google Earth is readily available is perhaps overstating the case. Google Earth requires a stable Internet connection of reasonable speed (Patterson 2007). In 2011 through to June 2012, there were a number of incidences of trouble with the Seacom cable so the Internet was not reliable in South Africa.

Added to that, the proxy servers at the University of the Western Cape do not always appear able to cope with Google Earth. This was particularly the case when proxy servers with authentication were implemented. One got multiple authentication requests and ultimately no access. Courses held using Google Earth required special prior arrangements or ad hoc arrangements on the day with ICS to alleviate this problem. Google Earth does mitigate these problems to some extent by having a very useful caching facility – as long as one able to work within the cached data. The University of the Western Cape has since stopped using authentication in part because of the issues with Google Earth.

Local use of proxy servers may also affect NASA World Wind.

Appendix 3.2 Online Programme Sources

DNR Garmin Application 5.4.1 (Minnesota Department of Natural Resources) is available at http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html.
Chapter 4 Proximity to vegetated open space in the Lourens River quaternary catchment, Cape Town, South Africa

Abstract
The functioning ecosphere is the basis for all civilization. Most humans live in cities (51.6% in 2010) and the percentage of humans in cities continues to grow. Urban open space is a major determinant of urban quality of life. As a public good, policy intervention is necessary to ensure adequate provision of open space since it is undervalued. Management (usually a municipal responsibility) is needed to ensure common access. Proximity to open space has benefits for society. The study looked at the proximity to vegetated open space of 900 or more square metres in the Lourens River quaternary catchment, Cape Town, South Africa in 2005 for homes, schools and for public transport (busses, taxis and trains). Vegetated open space was digitized in Google Earth and transferred to a GIS. Euclidean distances of 300 m, 500 m, 800 m and 900 m (taken from literature) were used to buffer the digitized vegetated open spaces and other data on schools, train stations, bus routes and taxi routes in and within 900 m of the catchment. Buffer analysis was carried out. The analysis showed that only two residences were beyond 300 m from a vegetated open space. There was vegetated open space within 300 m of all the schools, stations, bus and taxi routes within the catchment and in close proximity to it. Most of the open spaces are not formally designated as open space and are vulnerable to development. Proximity does not reflect use of open space which is affected by the size of the open space, quality of the open space, neighbourhood attributes and individual and collective perceptions of the open space. Further research could consider loss of open space over time and the impact of management on the quality of designated open space.

Introduction
All civilization is based on the functioning ecosphere supporting life and being productive. Humans build cities and are the keystone species in them (Rees 1997). More humans live in cities than outside of cities. In developed countries this has been true since at least the middle of last century and this became true globally between 2005 and 2010 – by 2010 urban dwellers made up 51.6% of the global population (United Nations, Department of Economic and Social Affairs, Population Division 2012) and the percentage of the population in cities is growing (Wendel et al. 2012).
Four environmental goals are important for cities, they should aim to: decrease energy use, decrease and dispose of pollutants, create a desirable environment and assist in biological conservation (Botkin & Beveridge 1997). Vegetated open space is critical for the achievement of these goals as it provides ecosystem services, defined as ecosystem functions that benefit humanity (Egoh et al. 2007, Fausold & Lilieholm 1999).

Urban open space was initially provided for its health benefits to the urban population (Botkin & Beveridge 1997) and is still a major determinant of quality of life for city dwellers (BenDor et al. 2013, Wendel et al. 2012). Awareness of the impact of the built environment on both physical and mental health (Francis et al. 2012a, Jackson 2003a) has led to some countries including the U.S.A. (Huston et al. 2003, Jackson 2003b) and Australia (Francis et al. 2012a) looking at managing the local environment in cities to promote public health.

Open space is usually multifunctional (Fausold & Lilieholm 1999). A comprehensive valuation is difficult as all the values cannot be added together and not all values are easily expressed in currency e.g. public goods do not have markets and economics ignores social value (Lévêque & Mounolou 2001, Brueckner 2000, Fausold & Lilieholm 1999).

Open space is a public good (Jacob & Hellström 2010) and as such is inadequately provided without policy intervention (Brander & Koetse 2011, Kotchen & Powers 2006). In cities, open space is significantly undervalued (Roberts et al. 2005, Brueckner 2000). Open space planning will always be under threat from political expediency (Roberts et al. 2005). Particularly in places like South Africa in which natural open space may be perceived as unused land available for plundering (Pitt & Boulle 2010). Private space is not a substitute for public open space that is locally owned (Bates and Santerre 2001). Having said which, the boundary between public and private is not set in stone (Dixon et al. 2006).

Management is needed in order for there to be any common access. The municipality is usually tasked with management. Co-management is a successful form of
management for public goods (Jacob & Hellström 2010) that has the advantage of uplifting the community and building a sense of community (Pitt & Boulle 2010).

Proximity to open space increases the chances of contact with nature. This has mental and physical health benefits (Frumkin 2003, Taylor et al. 2002, Kaplan 1995) and benefits for society by reducing violence and, if the field of view is not obstructed, crime (Matsuoko & Kaplan 2008, Kuo & Sullivan 2001). It is important for the formation of a ‘sense of community’ (Pitt & Boulle 2010, Arefi & Meyers 2003, Frumkin 2003), though this is conditional to the community feeling ownership of the space (Pitt & Boulle 2010). Proximity to open space is a predictor of exercise which is important for health (Frumkin 2003). Proximity does not equate to access or use because places like nature reserves and sports facilities have controlled access.

Some organisations have made recommendations concerning how close people should live to open space. English Nature recommended a maximum distance of 300 m to live from open space and the European Environment Agency recommended a 900 m maximum distance (Barbosa et al. 2007). People are willing to walk about five minutes to reach open space (Wendel et al. 2012) but the estimate how much distance is covered varies (not surprising given differences in pace) – English Nature’s 300 m is their estimate of five minutes walking (Barbosa et al. 2007) while Wendel et al. (2012) and Willemse (2010) consider 400 m to be about five minutes walking.

Proximity to open space is a first step to some of the benefits of such space hence the focus of this paper on proximity to open space that is 900 m² or larger in the Lourens River Quarternary Catchment. Larger spaces are more likely to be used (Giles-Corti et al. 2005) though the author has observed the use of very small bits of lawn in Cape Town. The research question asked is, ‘What was the potential access (proximity) to vegetated open space of at least 900 m² in the Lourens River quaternary catchment in 2005?’ It is answered by looking at the proximity to open space of homes, schools and public transport (busses, minibus taxis – hereafter taxis – and trains).

The Lourens River Quarternary Catchment falls within the City of Cape Town Municipality, Western Cape, South Africa (Figure 4.1). It includes parts of the
erstwhile municipalities of Somerset West and Strand. The households mostly have an annual income over R38 400. They are distributed between the middle and high income brackets (Willemse 2010). The national land use/land cover types found in the catchment in 2009 are: cultivated land, mines, natural land, plantations, urban built up and waterbodies (SANBI 2009). From the national land use/land cover types, the major categories are the natural land, cultivated land, plantations and urban built
up. Most of the natural vegetation is in the higher altitude portions of the catchment to the north east and east. Below the natural vegetation in the eastern part of the catchment are cultivated lands and plantations. The central and southern portions of the catchment are dominated by the urban built up landuse/landcover category which reaches the coast in the southern part of the catchment (SANBI 2009). The catchment is part of the Cape Floristic Region which is a biodiversity hotspot (Myers et al. 2000) so all natural remnants in the city boundary are critical for the conservation of biodiversity (O’Farrell et al. 2012).

Materials and Methods

Data Collection

Preparation

The boundaries of the study area and the 500 m contour were obtained from Biodiversity GIS (Willoughby et al. 2007) and National Geospatial Information respectively as .shp files and converted from .shp files to .kml files using Shp2kml (see Appendix 4.1). Google Earth was chosen as a source of imagery because of its ready availability.

Digitizing

The open spaces below the 500 m contour were digitized in Google Earth for the quaternary catchment of the Lourens River. It was assumed that the images had the same resolution (~0.75 m) or resolution similar enough not to compromise the analyses.

Space on the catchment boundary that went over it was included. An attempt has been made to avoid/exclude water bodies and rivers in the urban areas and water bodies in the non-urban areas but it is not always possible to see the course of a river because of trees on its banks. Narrow sidewalks have been left out because of the difficulty of identifying them and because they usually are not vegetated. Water bodies and structures in what is otherwise open space were also digitized so that they could be removed from the open space area at a later stage. Private gardens have been left out as far as possible but not gardens opened to the public such as Vergelegen. Tarred tracks were mostly not digitized. Open spaces extending a long
way beyond the boundaries of the catchment were stopped at visually convenient points such as tracks or bridges.

The digitizing started with the section of the Lourens River quaternary catchment for which the earliest Google Earth coverage was 23 March 2005. At any listed date on Google Earth, the coverage is a composite of images that do not necessarily match the listed date (pers. obs.). Some open spaces come from images from 15 February 2005. The two dates were digitized separately. Approximately 1450 separate spaces, structures and waterbodies were digitised. The digitized spaces were saved as .kml files.

Google Earth coverages for different dates are not aligned either with each other or with actual geographical coordinates. Google Earth files were saved by date so that spaces that overlapped different dates were split and saved separately as .kml files and joined later after realignment.

**Acquisition of other data**

Digital photographs and information layers (stations, bus routes, taxi routes) were acquired from the City of Cape Town Municipality. The City Parks Department supplied a layer of spaces that fall under their care. Mr Martin Cocks of UWC, Bellville and SANBI, Kirstenbosch supplied a point format schools layer.

**File Preparation for Analysis**

The .kml files were converted to .shp files using DNR Garmin Application 5.4.1 (Minnesota Department of Natural Resources – see Appendix 4.1). The files were in a latlong projection.

Where necessary, water bodies and buildings were removed from the open space. All spaces were then checked in Google Earth by Dr R.R. Raitt and checked by the digitizer using imprecisely dated 2005 imagery from the City of Cape Town in a GIS. This resulted in the identification of some missed spaces, cut outs and inconsistencies which were then dealt with.
The open spaces digitized from 15 February 2005 imagery have a different alignment in Google Earth to those digitized from 23 March 2005 imagery. This was manually shifted four to five metres for an approximate match to 23 March using control points. After realignment, the 500 m contour borders were corrected and continuous space, that was separated because of different dates and alignments, was joined. All of the about 1025 spaces were combined into one file with a latlong projection. Further realignment was not undertaken so as to allow the final product to be displayed in Google Earth as part of the MAPA project (MAPA Team Undated). The combined file was reprojected to Gauss-Kruger LO 19 Haartebeeshoek 1994.

The area of each space was calculated in square meters. Unvegetated spaces were excluded. Space greater than or equal to 900 m² (the area of a 30 m x 30 m pixel) with a cross section of at least 15 m (half of a side of a 30 m x 30 m pixel) was selected for analysis. This was done to allow the option of raster modeling. A set of 593 spaces met these criteria.

Train stations in or within 900 m of the study area were identified from data from the City of Cape Town. These were Firgrove Station (about 500 m outside of the catchment), Somerset West Station and Van der Stel Station. Probable access points (stations have limited access) were identified and marked in Google Earth on the 23 March 2005 imagery so as to match the alignment of the open space. The points were converted from .kml to .shp using the same program as was used for the open space. The points were combined.

Bus and taxi routes within the catchment were identified. Points were put at junctions in Google Earth on the 23 March 2005 imagery. The .kml files were converted to .shp files and combined. Copies of the bus and taxi route data were then moved to align with the points so as to approximate the Google Earth alignment.

It should be noted that the minibus taxis which are dealt with here function in a manner similar to buses travelling on fixed routes rather than taking a passenger from door to door. This means that the buses and taxis are in competition with each other as they fulfil the same role.
Schools within the Lourens quaternary catchment and within 900 m of the said catchment were identified from a schools layer. Polygons were created in Google Earth on the 23 March 2005 imagery for all identified schools as access points were not clear. The polygons were converted .kml to .shp using the same program as with the spaces and combined.

From the literature, 300, 500, 800 and 900 m distances were found. English Nature recommended a maximum distance to live from open space of 300 m (Barbosa et al. 2007). A California study by Wolch et al. (2011) used 500 m. People with their children were prepared to walk 800 m to reach open space in Australia (Crawford et al. 2008) and a New Zealand study by Witten et al. (2012) used the same distance. The European Environment Agency recommended 900 m as a maximum distance to live from open space (Barbosa et al. 2007). These distances were selected to analyse proximity (Euclidean distance) to open space in the Lourens quaternary catchment.

Analysis
All the 900 m² vegetated spaces were buffered by the selected distances starting with a radius of 300 m to determine walking proximity. Buffers were then placed around schools to determine walking proximity. The proximity of ≥ 900 m² vegetated spaces from public transport (bus routes, taxi routes and train stations) was determined by buffering the aforementioned public transport. The application of the buffer was followed by buffer analysis.

Results
In 2005, there were only two houses (on Goedehoop Road where it connects to Firmount Road at 34.0692445°S, 18.843864°E and 34.0691760°S, 18.844172°E) in the Lourens quaternary catchment that were further than 300 m from a ≥ 900 m² vegetated open space though the middle of a dam was also beyond 300 m from such space and no place in the Lourens quaternary catchment that was further than 500 m from such a space (Figure 4.2). All the schools in this study had ≥ 900 m² vegetated open spaces within 300 m of them excluding their own grounds (Figure 4.3).
Figure 4.2. Vegetated open space in the Lourens River quaternary catchment, Cape Town in 2005 digitized from Google Earth and converted for use in a GIS with a distance of 300 m all around (single buffer for all open spaces) to show proximity to the vegetated open space. The river within the catchment boundary is the Lourens River.

Firgrove Station is within 300 m of open space contiguous with open space in the Lourens quaternary catchment. Both stations within the catchment are within 300 m of ≥ 900 m$^2$ vegetated open spaces (Figure 4.4). Open space could be reached within 300 m of both bus and taxi routes (Figures 4.5 & 4.6).

Discussion
The Lourens quaternary catchment was well provided for in terms of open space in 2005. This is in keeping with the upmarket part of Cape Town that falls within it - middle to high income areas (Willemse 2010). Unfortunately, most of this space is not formally designated as open space (City Parks 2013, Willemse 2010) or is privately owned and as such is not ‘protected’ from development. Only 111 community parks are found in the Lourens River quaternary catchment of which 11 had an area of less than 900 m$^2$ (City Parks 2013).
Figure 4.3. Schools with concentric distances of 300 m, 500 m, 800 m and 900 m to show the proximity of the schools to various vegetated open spaces within the Lourens River quaternary catchment, Cape Town. In a), individual buffers are used and in b), one buffer per distance is used for all schools.

Both availability and access to open space are important but do not indicate use of such space (Cilliers et al. 2012, Wendel et al. 2012). This article considers proximity to open space but not the factors affecting the use thereof such as size of the space,
Figure 4.4. Stations with concentric distances of 300 m, 500 m, 800 m and 900 m to show the proximity of the stations to various vegetated open spaces within the Lourens River quaternary catchment, Cape Town. In a), individual buffers are used and in b), one buffer per distance is used for all stations.
Figure 4.5. Bus routes with concentric distances of 300 m, 500 m, 800 m and 900 m to show the proximity of the routes to various vegetated open spaces within the Lourens River quaternary catchment, Cape Town.

Figure 4.6. Taxi routes with concentric distances of 300 m, 500 m, 800 m and 900 m to show the proximity of the routes to various vegetated open spaces within the Lourens River quaternary catchment, Cape Town.
quality of the space, neighbourhood attributes and individual and collective perceptions of the open space (Cilliers et al. 2012, Giles-Corti et al. 2005). Some factors may act as barriers to use including lack of safety, distance from green space, neighbourhood walkability, lack of desirable space nearby, no time to visit open space (Wendel et al. 2012, Wolch et al. 2011) and social factors (Ball 2006).

The quality of open space affects its use (Giles-Corti et al. 2005). The importance of this factor is such that tools (e.g. POST and C-POST) have been developed and used to judge the quality of open space (Taylor et al. 2011, Crawford et al. 2008, Giles-Corti et al. 2005). Tools (e.g. NEWS and NDAI) have also been developed and used to assess neighbourhood qualities affecting outdoor activity (Witten et al. 2012, Gebel et al. 2011). Quality might be a cultural perception or even a personal one. It is likely that such tools would need to be calibrated for use in countries other than where they were created. The author would not be pleased to see lights in any neighbourhood public space for two reasons. The first is a reduction in the perception of personal safety as opposed to the usual feeling of increased safety. The second is the harm that artificial light does to nocturnal biodiversity (see Hölker et al. 2010). The author finds endless mowed lawns dull. Kaplan et al. (2004) note that conventional landscaping (lawns) leads to environmental degradation and does not provide the sense of well-being generated by more natural landscapes. Lawn care chemicals are also harmful to human health (Jackson 2003a).

Larger parks are generally preferred (Wendel et al. 2012, Giles-Corti et al. 2005) contributing to the choice of larger spaces for analysis but this does not mean small spaces are not used. The author has seen people using very small pieces of lawn near a local shopping centre.

The safety of the neighbourhood also affects the use of open space. In South Africa, open space is often perceived as unsafe (Cilliers et al. 2012, Van Zyl & Leiman 2002). It is also clear that many fail to see the need for open space (Pitt & Boulle 2010) to the extent that no income group feels that open space provision is a service that requires improvement (Willemse 2010). This may be due to lack of personal experience of such space.
However, lack of use does not make the vegetated open space useless; people still benefit from open space without using it (Francis et al. 2012b, Kearney 2006) via the psychological benefits provided by the sight of vegetation (Taylor et al. 2002, Kuo & Sullivan 2001), the employment required for the maintenance of these spaces (Fausold & Lilieholm 1999) and ecosystem services vegetated open space provides (Cilliers et al. 2012).

While the digitizing was painstakingly done, it is not accurate. The digitizer was relatively inexperienced (as can be seen by the varying distance between points on polygons indicating varying degrees of zoom) and trees obscure whatever is under them. However, this approximation still shows a broad overview which is unlikely to change significantly due to more precise work.

Buffering gives absolute distance but not actual access distance as walking access is usually via the road network. The bus and taxi data were in the form of polylines (with no area) so the buffering provides an inaccurate estimate of the distance. The data did not include specific stopping points on these routes making proximity to the route an unreliable guide to potential access.

This paper looks at physical proximity to open space but there are also socio-political factors that affect access to open space. How ‘the public’ is defined is one of these factors (Mitchell 1995). Another is the fluid nature of the boundary between public and private space (Dixon et al. 2006).

This study considered proximity to space in the Lourens quaternary catchment in 2005. Since then there has been considerable development in the area. There is a lack of research looking at the changes in open space over time. In the light of the literature on the importance of the quality of open space, research on the management of such space and its impacts would provide useful information.

**Conclusion**

What was the potential access (proximity) to vegetated open space of at least 900 m$^2$ in the Lourens River quaternary catchment in 2005? The Lourens River quaternary
catchment was well provided with open space with an area of more than 900 m$^2$ in 2005. All but two houses met the most stringent suggestion for proximity to space found in the literature – that of English Nature of 300 m – as did all the schools and forms of public transport considered in this study (Barbosa et al. 2007).

However, most of this space was not formally designated as open space and may be lost to development. Thus this positive picture is partially an illusion. Formal action is needed to ensure that proximity to open space remains a positive feature of living in the Lourens River quaternary catchment.

Acknowledgements
The author thanks Mr Erin Laubscher and Mr Eben van Dyke of the Mapping Section of the City of Cape Town Municipality for providing data, Mr Gregory Benskin of City Parks Department for providing data, Mr Martin Cocks of UWC, Bellville and SANBI, Kirstenbosch for data and Dr Rosemary Raitt for checking the data and proofreading.

References


City Parks. 2013. City Parks Geodatabase. GIS data, City Parks Department, City of Cape Town Municipality.


**Appendix 4.1 Online Programme Sources**

DNR Garmin Application 5.4.1 (Minnesota Department of Natural Resources) is available at
http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmi
n.html).
Chapter 5 Open Space and Conservation in the Lourens River Quaternary Catchment

Abstract
Urban conservation is necessary to retain biodiversity and to retain the will to conserve. Environmental knowledge is correlated with exposure which, for most people, will take place in an urban setting. Urban conservation is complicated by impacts from the surrounding environment and perceptions that remnants are not worth saving and pose safety hazards. The value of urban remnants goes beyond habitat value because of their role in education. Protected areas need to be considered in the context of their surroundings. Concentrating on patches may fail to achieve conservation goals. The focus needs to be on the landscape mosaic. This study looks at the occurrence of open space in the urban matrix in the Lourens River quaternary catchment, Cape Town, South Africa. Vegetated open space in 2005 was digitized in Google Earth and transferred to a GIS to use as a baseline. Data on protected open space was then compared to this in terms of number of spaces and area. Of 124 protected spaces, only one was a nature reserve. The western part of the catchment lacked protected space. The Lourens River quaternary catchment’s urban matrix includes more disturbed open space than natural open space. This space could still be of conservation value. The challenge is to work with schools and City Parks to achieve management that is sympathetic to biodiversity.

Introduction
Urban conservation is necessary (Rebelo et al. 2011, Pitt & Boule 2010, Crane & Kinzig 2005, Niemelä 1999). Cities located in environmentally sensitive biodiversity hotspots have natural habitat within them that may be of global significance as it is in São Paolo in Brazil and Cape Town in South Africa, for example (Crane & Kinzig 2005). Urban open space can thus be critical for the conservation of rare and endangered species (Niemelä 1999) and this is true for Cape Town which contains 319 IUCN Red List species (Rebelo et al. 2011). Natural spaces within cities are also necessary for the maintenance of public will to conserve (Pitt & Boulle 2010) since environmental knowledge is correlated with exposure to the natural environment. It is not correlated to education (McDaniel & Alley 2005). With increasing urbanization, contact with nature will take place in an urban setting for the majority of people.
People-centred conservation along with community-based resource management are needed for communities to learn to value their natural heritage (Rebelo et al. 2011). People use their memories of the natural environment they experienced as children as a baseline to judge environmental degradation which means each generation’s view is less realistic than the previous generation’s view – called the shifting baseline (Lindenmayer et al. 2008, Miller 2006) so urban nature is critical for the formation of realistic baselines. The shifting baseline is also known as environmental generational amnesia (Miller 2006).

Conservation in urban areas is complicated (Pitt & Boule 2010). Reasons for this include that development tends to leave odd patches and corridors which are impacted by pollution and nonnative species from the surrounding built environment which is persistent and expanding (Vimal et al. 2012, Pitt & Boule 2010, McKinney 2002, Baschak & Brown 1995 citing Cook 1991). Development may separate ecosystems from supporting structures. Patches may be overused for subsistence or recreation or even formally developed into parks that suit humans rather than the native species (Pitt & Boule 2010, Baschak & Brown 1995 citing Cook 1991). The fact that remnants are not ecologically pristine gives rise to perceptions that these remnants are not worth conserving (Pitt & Boule 2010, Baschak & Brown 1995). Urbanization leads to biotic homogenization and the spread of alien species (Miller 2006, McKinney 2002). People-wildlife conflicts have to be dealt with (Savard et al. 2000) which requires community and other stakeholder engagement which can only be achieved if negative perceptions of conservation are overcome (Gallo & Goodchild 2012, Rebelo et al. 2011, Pitt & Boule 2010, Ancrenaz et al. 2007). Botanical conservation in Cape Town is hampered by the perception that natural veld poses security and fire risks (Rebelo et al. 2011, Van Zyl & Leiman 2002).

Human landscape change (direct and indirect) is accelerating (Lindenmayer et al. 2008, Thomas et al. 2004). Increasing urbanization means that natural areas with significant ecological value are disappearing from cities (Baschak & Brown 1995). This may lead to the inaccurate perception that existing remnants are not valuable to conservation (Pitt & Boule 2010). In reality, the value of such sites goes beyond the immediate habitat value because they allow urbanites to experience nature which can
improve their education and quality of life and thus promote conservation (Miller 2006, Savard et al. 2000).

For protected areas to survive, they must be considered in the context of the landscape around them (the matrix) (Robinson & Ginsberg 2004, Golley 1989). Natural patches are part of a terrestrial matrix in which migrants may find temporary resources (Golley 1989). Conservation must include interfaces between the freshwater, marine and terrestrial realms (Beger et al. 2010). Having continuous greenspace does not guarantee a habitat connection (Jim & Chen 2003) but greenspace may provide habitat connections (Milanovich et al. 2012). A city is a system (Pickett et al. 2011). Urban ecosystems are very dynamic (Savard et al. 2000). Ecological processes occur throughout the city, not just in green space (Pickett et al. 2011). Focusing solely on patches may not achieve the planned conservation goals (Fischer et al. 2005). Species react uniquely to landscape change. Behavioural studies may be the best way to determine connectivity (Shreeve & Dennis 2011). Brady et al. (2011) found that the properties of the matrix determined isolation more than the distance to the nearest patch did. The nature (extent, degree and permanence) of changes to the matrix impact the area and isolation effects of patches. It is necessary to move from a patch focus to a landscape mosaic focus (Kupfer et al. 2006).

This article looks at one aspect of the urban matrix that can benefit conservation— the occurrence of protected open space – within the urban edge in the Lourens River quaternary catchment. The Lourens River quaternary catchment is in the City of Cape Town Municipality, South Africa (Figure 5.1). The research question is, ‘What spaces within the urban edge in the Lourens River quaternary catchment can be said to have some protection from development?’

Methods
The data for this article were drawn from a larger study.
Figure 5.1. Location of the Lourens River quaternary catchment: a) within South Africa as shown by the box and b) within the City of Cape Town.

Data Collection

Preparation

The .shp file of the boundaries of the Lourens River quaternary catchment was obtained from Biodiversity GIS (Willoughby et al. 2007) and the .shp file of the 500 m contour was obtained from National Geospatial Information. The .shp files were
converted to .kml files using Shp2kml (see Appendix 5.1). Google Earth was the chosen source of imagery because of easy access.

**Digitizing**

The open spaces in the Lourens River quaternary catchment below the 500 m contour were digitized in GoogleEarth. The resolution of the different images was assumed to be the same (~0.75 m) or similar enough not to compromise the analyses.

Peripheral spaces that went over the catchment boundary were included. As far as possible, rivers and water bodies in the urban areas and water bodies in the non-urban areas have been avoided/excluded but the course of a river may be hidden by the trees on its banks. Narrow sidewalks are difficult to identify and are seldom vegetated so they have consequently been excluded. Structures and water bodies within otherwise open space were also digitized to allow their removal from the open space area prior to analysis. Private gardens have been excluded as far as possible but not gardens that are opened to the public such as Vergelegen. Tarred tracks have mostly not been digitized. Open spaces that continue a long way beyond the catchment boundaries were ended at visually convenient points such as tracks or bridges.

The digitizing started at the coast of the Lourens River quaternary catchment. The earliest Google Earth coverage for this section was 23 March 2005. A Google Earth coverage at any listed date is a composite of images which may not all match the listed date (pers. obs.). So, for the Lourens River quaternary catchment, some of the open spaces were digitized from images dated 15 February 2005. The different dates were digitized separately. Approximately 1450 separate spaces, structures and waterbodies were digitised. All digitized spaces were stored as .kml files.

Google Earth coverages from different dates do not align either with each other or with actual geographical coordinates. Google Earth files were saved by date so spaces that overlapped different dates were split and saved separately as .kml files and joined later after realignment.
**Acquisition of Other Data**

Digital photographs were acquired from the City of Cape Town Municipality. The Municipal Parks Department supplied data on spaces that fall under their care. Mr Martin Cocks of UWC, Bellville and SANBI, Kirstenbosch supplied a point format schools layer. The City of Cape Town’s Biodiversity Network, which identifies spaces regarded as important for conservation, was downloaded from Biodiversity GIS (Willoughby et al. 2007).

**File Preparation for Analysis**

DNR Garmin Application 5.4.1 (Minnesota Department of Natural Resources – see Appendix 1) was used to convert the .kml files to .shp files. The files were in a latlong projection.

Where necessary, structures and water bodies were removed from open space. All spaces were then checked in Google Earth by Dr R.R. Raitt. The spaces were also checked by the digitizer using imprecisely dated 2005 imagery from the City of Cape Town in a GIS. Some missed spaces, cut outs and inconsistencies were identified and dealt with.

The open spaces digitized from 15 February 2005 imagery have a different alignment in Google Earth to those digitized from 23 March 2005 imagery. Realignment was done manually (a shift of four to five metres) using control points to get an approximate match to 23 March. The 500 m contour borders were corrected after realignment and continuous space that was separated because of different dates and alignments was joined. All of the about 1025 spaces were combined into one file with a latlong projection. Further realignment was not undertaken so as to allow the final product to be displayed in Google Earth as part of the MAPA project (MAPA Team Undated). The combined file was reprojected to Gauss-Kruger LO 19 Haartebeeshoek 1994 which is the projection favoured by the City of Cape Town Municipality.

The area of each space was calculated in square meters. Unvegetated spaces were excluded. Space greater than or equal to 900 m² (the area of a 30 m x 30 m pixel)
with a cross section of at least 15 m (half the side of a 30 m x 30 m pixel) was
selected for analysis. This was done to allow the option of raster modeling. A set of
593 spaces met these criteria. From this set, a further set falling mainly within the
urban edge was selected for analysis.

From the BioNet data, the data within the urban edge in the Lourens River quaternary
catchment were selected and saved as a new file. Areas protected in perpetuity were
selected from the file of the BioNet data within the urban edge in the Lourens River
quaternary catchment and saved in a file as were areas otherwise marked as important
to the biodiversity network though not formally protected and the natural areas not
considered important for the BioNet.

From the City Parks data, the data within the urban edge in the Lourens River
quaternary catchment were selected and saved as a new file. The community parks
and cemetery data were selected from the file of the City Parks data within the urban
data were saved and projected over the City of
edge in the Lourens River quaternary catchment and saved. It should be noted that on
site signage and database designation do not always agree. The community parks data
is the best quality portion of the City Parks data (pers. comm. Mr Gregory Benskin).
Community parks have definite protection against development but the author is
unclear how much protection greenbelt areas and drainage lines would have.

The school layer was in a point format so the layer was projected over the City of
Cape Town aerial photographs which were used to digitize the school grounds and the
open space within the school grounds that met the aforementioned conditions. The
point data were not entirely accurate so, for the Somerset West Met. Primary School,
the site selected may be inaccurate though it matches where the point is located (the
school lacks extensive grounds and is not known to the digitizer).

**Analysis**

The number of units and total area were calculated for cemeteries, community parks,
natural areas protected in perpetuity, school open space, unprotected biodiversity
areas and vegetated open space in 2005 falling mainly within the boundaries of the
Lourens River quaternary catchment (Table 5.1).
Table 5.1. Forms of protected open space in relation to total open space in 2005 within the urban edge in or partially in the Lourens River quaternary catchment. The areas are taken from the boundaries in the GIS data and are consequently estimates of the actual area. Data used from the City of Cape Town and this study.

<table>
<thead>
<tr>
<th>Type of open space</th>
<th>Number</th>
<th>Area (ha)</th>
<th>Minimum Area (ha)</th>
<th>Mean Area (ha)</th>
<th>Maximum Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open space all or mostly inside the urban edge with ≥ 900 m² in 2005¹</td>
<td>583</td>
<td>2 070.33</td>
<td>0.091</td>
<td>3.551</td>
<td>456.635</td>
</tr>
<tr>
<td>Unprotected areas of interest for conservation³</td>
<td>14</td>
<td>414.783</td>
<td>0.425</td>
<td>29.627</td>
<td>265.921</td>
</tr>
<tr>
<td>Natural remnants not selected for the biodiversity network</td>
<td>9</td>
<td>10.83</td>
<td>0.236</td>
<td>1.203</td>
<td>3.355</td>
</tr>
<tr>
<td>Natural areas protected in perpetuity</td>
<td>1</td>
<td>4.967</td>
<td>4.967</td>
<td>4.967</td>
<td>4.967</td>
</tr>
<tr>
<td>Cemeteries⁴</td>
<td></td>
<td>8.21</td>
<td>2.706</td>
<td>4.105</td>
<td>5.504</td>
</tr>
<tr>
<td>Schools⁵</td>
<td></td>
<td>33.58</td>
<td>0.091</td>
<td>1.599</td>
<td>6.097</td>
</tr>
<tr>
<td>Community Parks⁶</td>
<td>111</td>
<td>155.04</td>
<td>0.008</td>
<td>1.259</td>
<td>26.564</td>
</tr>
<tr>
<td>Total ‘Protected’ Space</td>
<td>124</td>
<td>201.8</td>
<td>0.008</td>
<td>1.495</td>
<td>26.564</td>
</tr>
</tbody>
</table>

¹ The vegetated open space and schools open space have a minimum threshold of 900 m² (= 0.09 ha). The community parks do not have this threshold - 11 are less than 900 m² in area. The selection algorithm used to obtain the set of the minimum number of areas needing to be acquired to meet conservation targets for the biodiversity network did not have an area threshold. However, the tenth tie break rule (rule used to choose between otherwise equal value sites) was to take the larger area (Holmes et al. 2012).

² Open spaces with the bulk outside of the urban edge were not included so the area here is even more of an approximation than the rest of the data.

³ Parts of these areas of conservation interest lie outside of the urban edge (Figure 5.5). Further several of these areas are contiguous though treated separately. If joined, the count would change to ten. If formally protected, these areas would help Cape Town to meet its conservation targets and also contribute to national conservation targets (Holmes et al. 2012).

⁴ Not all the cemetery is green space but for convenience the entire area has been used.

⁵ Not all the schools have vegetated open space around them. Some non-vegetated open space is included. The space measured is that which matches the criteria used for open space: more than 900 m² and at least 15 m wide. This means that, while there are ten school grounds, there are twenty-one open spaces.

⁶ This is 2013 data. There were fewer parks in 2005. City Parks is improving its GIS database (pers. comm. Mr Gregory Benskin 3.07.2013).
Results

In 2005, open space was widespread within the urban edge in the Lourens River quaternary catchment (Figure 5.2). Within the urban edge in the Lourens River quaternary catchment there is only one permanently protected natural area (Silwerboom Kloof) (See Table 5.1, Figure 5.3). Helderberg Nature Reserve is outside of the urban edge. Protected open space is less widely distributed with the western portion of the catchment noticeably lacking protected space (Figure 5.4) though the sites of conservation interest would help to fill this gap (Figure 5.5). Most protected spaces have less than one hectare (Figure 5.6). Tie break rule (a rule used to choose between otherwise equal value sites) number ten for selection of sites for
conservation selects for the larger site (Holmes et al. 2012). This means that the fourteen sites of conservation interest do not have the same size distribution but the addition of these sites does not change the profile (Table 5.1, Figure 5.7).

**Discussion**
Conservationists must consider the issues of urbanization (Miller & Hobbs 2002). Protected areas lie within a matrix of other land uses. Conservationists need to think beyond the protected areas to consider how the matrix can be used to promote conservation objectives. Open spaces, while not natural veld, can and do provide habitats for some native plant species (mostly geophytes – pers. obs.) and connectivity for some bird species (see for e.g. Litteral & Wu 2012). Areas that are not ‘natural’ can be used to aid conservation of natural areas e.g. the flower beds at Kenilworth.
Figure 5.4. Protected open space within the urban edge in the Lourens River quaternary catchment, Cape Town. Data from the City of Cape Town and for school open space digitized from 2005 imagery supplied by the City of Cape Town.

Racecourse are planted with flowers that attract sunbirds which are necessary pollinators in the Renosterveld conserved there (pers. comm. Dalton Gibbs).

Areas such as cemeteries, community parks and school grounds enjoy some degree of protection from development and are readily accessible to the urban population. In the urban matrix in the Lourens River quaternary catchment, these spaces provide about 197 ha of green space to humans and other species – far exceeding the amount of protected natural space unless the sites of conservation interest can be protected (Table 5.1, Figures 5.3—5.5). The three largest protected spaces in the catchment are not natural though that would change if the sites of conservation interest were protected (Figures 5.6, 5.7). Protecting the sites that are of conservation interest would also mean more protected open space in the western part of the catchment.
Figure 5.5. Unprotected space with natural vegetation within the urban edge in the Lourens River quaternary catchment, Cape Town. Data from the City of Cape Town.

Figure 5.6. Distribution of protected open space in terms of area. Data from the City of Cape Town.
Figure 5.7. Distribution of protected open space and space of conservation interest in terms of area. Data from the City of Cape Town.

(Figure 5.5) which otherwise has little protected space – probably because of its history as business property (Heap 1977).

The words ‘nature’ and ‘environment’ tend to mean ‘outdoors’ and ‘my surroundings’ to the urbanite – both of which may be exceedingly unnatural. In view of the perception that any green space is natural, it may be a good idea to push to make sure that some native species are present on such spaces however unnatural the open spaces will still be.

Most of the open spaces within the Lourens River Quaternary Catchment are not considered natural as demonstrated by the fact that they are not included or considered in the biodiversity network (Holmes et al. 2012, Figures 5.2, 5.3 & 5.5) and consequently they are not likely to have many native species. The challenge is to reduce the disturbance and use these spaces to promote the preservation of spaces that are remnants or can be restored. Environmental awareness needs to be part of everyone in society not just those who have made conservation their profession. Conservation needs to focus resources on educating the population and working with schools would be a logical place to start. Children have a great capacity for learning (Balmford 2002) but conservationists need to be careful not to overemphasize the problems facing the environment and conservation as doing so may lead to action.
paralysis and a decrease in the commitment to conserve (Jensen 2004). Public education would not only benefit conservation areas but would also potentially enable City Parks Managers to manage parks in a more ecologically sound manor. Regular mowing including during flowering/seedset is known problem in Cape Town (Pitt & Boule 2010). What is perhaps less well known is that the emphasis on mowing at biologically disastrous times is due to public perceptions and consequent demands for mowing. City parks officials have horticultural training but they are constrained by complaints from local residents if their contractors do not mow regularly (pers. comm. George Frost). It is with locals and local rate payers associations, ward councils and other local groups that conservationists need to work to achieve better management of open space in Cape Town. Representatives of such groups could discuss management of public open spaces with the local City Parks area manager and bring about change.

Conservationists are also residents of a particular area. Conservation should start at home. What about local community parks? Action in the local community may be as valuable as formal employment in conservation.

**Conclusion and Recommendations**

What spaces within the urban edge in the Lourens River quaternary catchment can be said to have some protection from development? This paper identified 124 protected open spaces in the form of a nature reserve, two cemeteries, 111 community parks and 10 school grounds within the Lourens River quaternary catchment’s urban matrix but more of these open spaces are disturbed than are natural open spaces. This disturbed space could still be of conservation value. The challenge is to work with schools and City Parks to achieve management that is sympathetic to biodiversity. A resource person for schools is recommended since, as Raitt (2011) pointed out, teachers tend to find it difficult to teach ecology. A liaison with rate payers’ associations and ward councils is advised to promote the acceptance of different management practices to be implemented by City Parks.

**Acknowledgements**

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Personal Communications
Mr Dalton Gibbs, conservationist for City of Cape Town Municipality in 2010.

Mr Gregory Benskin, Principal GIS Technician, City Parks North, Community Services, City of Cape Town at his office in Millpark Office Block, Ixia Road, Milnerton on 3 July 2013.

Mr George Frost, Head of Administrative Support, City Parks North, Community Services, City of Cape Town at his office in Millpark Office Block, Ixia Road, Milnerton on 3 July 2013.

Appendix 5.1 Online Programme Sources

DNR Garmin Application 5.4.1 (Minnesota Department of Natural Resources) is available at http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html).
Chapter 6 Conclusion

Since GoogleEarth is easily and widely accessible, does it provide a suitable source of imagery for spatial analysis of landscapes without post geospatial rectification?

This study made use of Google Earth imagery. The images were not accurately aligned and alignment differs between different dates as with aerial photography. This makes Google Earth a poor choice of image source for spatial research without post geospatial corrections. However, the relative ease of access may make Google Earth a more practical option than the alternatives, e.g. aerial photographs from National Geospatial Information.

How many open spaces with an area of at least 900 m² were present in the Lourens River quaternary catchment in 2005 (the first year with continuous imagery in GoogleEarth)?

The Lourens River Quaternary Catchment was well provided with open spaces with an area of more than 900 m² in 2005. A total of 593 spaces in or partially in the catchment met this criterion.

What was the potential access (proximity) to vegetated open space of at least 900 m² in the Lourens River quaternary catchment in 2005?

All but two houses in the Lourens River Quaternary Catchment met the most stringent suggestion for proximity to space found in the literature – that of English Nature of 300 m (Barbosa et al. 2007). All the schools within the catchment had open space of at least 900 m² within 300 m. Public transport in the form of buses, minibus taxis and trains provided access to open spaces of at least 900 m² within 300 m of their stopping points and routes.

What spaces within the urban edge in the Lourens River quaternary catchment can be said to have some protection from development?

Most of the open space in the Lourens River Quaternary Catchment was not formally designated as open space and may be lost to development. Thus the positive picture provided by the number of open spaces and the proximity to open space is partially an illusion. There has been considerable development in the area since 2005. Action is
needed from both residents and the municipality to ensure that proximity to open space remains a positive feature of living in the Lourens River Quaternary Catchment.

Within the urban matrix, only 124 spaces have some form of protection. Only one of these is a nature reserve. The other spaces that may be said to have some protection were cemeteries (two), community parks (111) and school grounds (10). It is important to use existing open space to promote conservation both through education and through management of the space. The challenge for those concerned about the environment is to act at a local level as concerned citizens.

**Future Research**

Expanding the present research could provide baseline data for change detection research. Promoting more change detection research projects may be a way to stimulate action to protect open space.

The quality of open space is highlighted in the literature (e.g. Crawford et al. 2008 and Giles-Corti et al. 2005) as an important determinant of the use of open space. The quality of open space is dependent on its facilities and maintenance which are largely determined by its management. In Cape Town, the municipality has everything possible mowed flat apparently in the belief that it is more aesthetically pleasing because it is ‘tidy’ (Maneveldt 2011, Pitt & Boulle 2010, Marais & Maneveldt 2006). This has a negative impact on biodiversity retention (Maneveldt 2011, Marais & Maneveldt 2006) – a fact of which City Parks is aware and are working towards rectifying (pers. comm. Mr George Frost and Mr Gregory Benskin 3.07.2013). Research is needed to demonstrate the impacts of mowing on biodiversity. Research could also be done to identify the determinants of park quality in a South African context.

Keurboom Avenue Park, the open space in Westridge between Keurboom Avenue and Nerina Avenue, had many indigenous species in the 1990s when some pupils from Parel Vallei High School surveyed the flora (Pers Comm. Dr R.R. Raitt 28.05.2013). Unfortunately, this area is subjected to regular municipal mowing so it is unlikely to have retained all the species that were then present. Personal
observation suggests that the surviving native species are mostly geophytes. Research could be done to determine which indigenous species persist on open spaces.

Expanding the present research to cover a larger area would provide additional baseline data. There is a lack of research looking at the changes in open space over time. Research on the management of open space and its impacts would provide useful information.

References


**Personal Communications**

Mr Gregory Benskin, Principal GIS Technician, City Parks North, Community Services, City of Cape Town at his office in Millpark Office Block, Ixia Road, Milnerton on 3 July 2013.

Mr George Frost, Head of Administrative Support, City Parks North, Community Services, City of Cape Town at his office in Millpark Office Block, Ixia Road, Milnerton on 3 July 2013.

Dr Rosemary R. Raitt, Retired Science Education Specialist on 28 May 2013.
Appendix 1 Online Programme Sources


DNR Garmin Application 5.4.1 (Minnesota Department of Natural Resources) is available at http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html).