State of **Green Infrastructure** in the Gauteng City-Region

GCRO Gauteng City-Region Observatory

UNIVERSITY OF JOHANNESBURG

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VIEW FROM WATERKLOOF RIDGE, TSHWANE, 2013

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Cover image: North east view of Soweto from the Oppenheimer Tower, Oppenheimer Park, Soweto, 2013: In the foreground, Central Western Jabavu, in the middle ground, Mofolo Central, in the background and horizon, Orlando and Diepkloof.

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Foreword

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The State of Green Infrastructure in the Gauteng City-Region (GCR) is a rich, visually powerful output that offers a unique insight into how our city-region is served by various layers of green infrastructure. This is the first study into how various green assets come together to form a network that provides crucial ecosystem services, in the same way as our roads, water pipes, electricity cables and storm water drainage lines provide us with 'basic' services.

The capacity of our infrastructure to cater for a rapidly growing population and economy is a critical challenge for the Gauteng City-Region. Meeting the expanding demand for urban services in a context of resource constraints will prove difficult, especially in the context of historically inequitable, dysfunctional and sprawling urban settlement patterns. Ever larger volumes of domestic and industrial waste, and growing air, water and land pollution, exacerbate the challenge.

Facing up to these pressures, the Gauteng Provincial Government (GPG) has embarked on a number of strategic processes, notably the Gauteng 2055 process – a long-term development vision and plan – as well as a Gauteng Integrated Infrastructure Master Plan and various further policy developments to implement the Gauteng Spatial Development Framework. In this planning the GPG is engaging closely with new ideas for how to build and maintain infrastructure in a way that satisfies the multiple objectives of meeting the needs of our people, especially those without access to services and urban amenities, managing natural resources more efficiently, and reshaping settlements, all within a context of ever present financial constraints.

Within this context, The State of Green Infrastructure in the Gauteng City-Region is both timeous and illuminating, helping to open up a field of new ideas that can be considered in both our long-range strategies, and the short to medium plans that will flow from this in the near future. When we think about infrastructure we are used to thinking about 'big pipes, big culverts, big roads'. This report decisively challenges this common perception of what infrastructure is and should be. It carves out a new conceptual and policy space, helping to show exactly how green assets such as urban trees, parks, wetlands, natural grasslands, and the like, can be – indeed must be! – thought about and planned for as infrastructure. It does this in a number of creative ways.

First, it provides a methodologically rigorous presentation and analysis of available spatial data on various dimensions of Gauteng's diverse green infrastructure networks. Second, through detailed primary research in each of Gauteng's municipalities it interrogates how green infrastructure is being understood, planned for, developed and managed, in the process showing how we have made significant progress as a province, but also where there are areas for improvement in policy and practice. Third, it gives us a glimpse into how green infrastructure can be better appreciated in government finance and management systems through a review of available green infrastructure valuation techniques, as well as an indicative valuation exercise taking one municipality's parks as a case study. Fourth, it presents an intriguing analysis of how citizen's private investments have been a very significant force behind the extension of green infrastructure in the province, and how the kind of green landscapes we have, and might have in future, are very much shaped by cultural preferences and trends. Lastly, its photographic elements provide a visually powerful narrative of the many different kinds of green infrastructure we have in the GCR. The images eloquently capture how our local landscapes and vegetation, which we so often take for granted in our everyday comings and goings around the city-region, are an integral part of our urban form and fabric.

Our shared goal of developing an equitable, efficient and sustainable city-region is greatly advanced by the conceptual and analytical benchmark set by this State of Green Infrastructure in the Gauteng City-Region. The report certainly helps meet our need in government for high quality and policy-relevant data and analysis, and we trust that it will prove to be a resource equally useful and stimulating to business, civil society, communities and the ordinary citizens who ultimately benefit from the services provided by green infrastructure.

Report overview

This report contains a number of sections written by various authors, outlined below.

Green infrastructure: introduction and conceptual underpinnings

(Alexis Schäffler)

The section provides an introduction to the core arguments of the report, and an overview of the concept of green infrastructure as a framework for rethinking infrastructure from an ecosystem services perspective. Through this framework ecological assets can be conceived as an augmentation, or even alternative, to built infrastructure systems. The section highlights the defining features of green infrastructure in terms of the opportunities provided by naturally occurring and manmade ecological systems, that are at once under threat from urban expansion and also undervalued in conventional infrastructure planning. An overview of previous greening paradigms indicates that while ecological investments in urban contexts are not a new phenomenon, there is something unique about viewing and valuing green infrastructure – the interconnected set of natural and constructed ecological systems, green spaces and landscape features – as a network providing services and strategic functions in the same way as traditional 'hard' infrastructure.

Assessing the state of green infrastructure in the Gauteng City-Region

(Alexis Schäffler and Kerry Bobbins)

The 'current state of green infrastructure' identifies the green assets and networks that exist in the Gauteng City-Region (GCR) and assesses the state of digital spatial data publicly available to analyse them. The chapter then provides baseline spatial information on the various components of green infrastructure found in the GCR, examining their extent and coverage, access and connectivity.

Current government plans, visions and capabilities for green infrastructure

(Mduduzi W. Nhlozi, Emmarie Otto, Alexis Schäffler)

This section provides a systematic review of how green infrastructure is being thought about, planned for and implemented in municipalities across the GCR. Mduduzi W. Nhlozi investigates initiatives in various departments and municipal entities in the City of Johannesburg Metropolitan Municipality. Emmarie Otto analyses the Ekurhuleni Metropolitan Municipality (EMM), the City of Tshwane Metropolitan Municipality (CoT), and the Sedibeng District Municipality (SDM), as well as its three local municipalities, Emfuleni, Lesedi and Midvaal. Alexis Schäffler focuses on the West Rand District Municipality and its four locals, Mogale City, Randfontein, Westonaria and Merafong. Each case study assesses how green infrastructure is perceived and valued within the institutional arrangements responsible for it in various ways, and interrogates the policies, programmes and initiatives that are being designed and implemented. The focus is on how government structures and individual officials are interacting with green assets in their planning and management processes, and the resulting opportunities for and blockage points to prioritizing these assets in an infrastructural sense.

Techniques for valuing green infrastructure

(Martin de Wit, Hugo van Zyl, and Douglas J. Crookes)

This is a methodological investigation into ecosystem service valuation techniques that could be applied in the GCR context. A range of potential valuation methods for urban ecosystems and green infrastructure features are profiled. After classifying and comparing the options for valuing relevant ecosystem services, the chapter indicatively demonstrates one methodology for valuing public green spaces in the City of Johannesburg (CoJ). The chapter also considers options for, and limitations to, incorporating green infrastructure valuations into the financial architectures of local government, highlighting the importance of a fine grained understanding of public revenue, expenditure and accounting systems.

Constructed landscapes: community and private sector green infrastructure initiatives

(Alexis Schäffler)

This section presents a more academic reflection on how society invests in landscapes in different parts of the Gauteng City-Region (GCR). Whereas previous chapters focus on government's plans and activities, this section analyses the role of non-government actors, such as local communities and the private sector, in creating green assets. Through a political-ecology lens, it provides an historical overview of the city-region's colonial landscapes, and then reflects on the various economies and cultures currently at work to sustain or transform features of this landscape. In tracing the circuits of investment in green infrastructure, and the cultures behind them, its shows how private garden space emerges as an object of value and importance, but also a highly ambivalent ecological form, with a mixture of introduced and indigenous vegetation, simultaneously existing as natural and unnatural.

Research pathways ahead

(Alexis Schäffler)

This concluding chapter briefly summarises some of the key findings and implications of this report, and looks ahead to map out broad areas of future research that will be pursued by GCRO in the years to come.

Visualizing green landscapes

(Natasha Christopher)

This report is interwoven with six photographic essays by Natasha Christopher, documenting various facets of the green landscapes of the city-region.

CABLE, CABLE, JOHANNESBURG, 2013

Terminology

Infrastructure is the network of systems that conveys resources to communities, households and businesses, connecting them across the city, and allowing for everyday life to function.

Green infrastructure in this report refers to the interconnected set of natural and man-made ecological systems, green spaces and other landscape features. It includes planted and indigenous trees, wetlands, parks, green open spaces and original grassland and woodlands, as well as possible building and street-level design interventions that incorporate vegetation, such as green roofs. Together these assets form an infrastructure network providing services and strategic functions in the same way as traditional 'hard' infrastructure.

Green space and open space are often used interchangeably. This report is primarily concerned with green space as an ecological asset. However a confusion emerges because open spaces can be 'grey' landscapes sealed with impermeable 'hard' surfaces, such as concrete or tarmac, while green space evokes ideas of permeable 'soft' surfaces such as soil, grass, shrubs, trees and water (James *et al*, 2009). At issue are the various references in official policies and databases to open space in a way that includes developed and undeveloped green space. The ambiguity creates a number of difficulties in deciphering the component parts of green infrastructure networks.

Ecosystem services are the benefits to society provided by ecosystems or ecological assets.

Hubs are green assets of varying size that overlap to anchor green infrastructure linkages in the landscape.

Corridors or linkages tie green assets together, allowing for connectivity between hubs and other features of the landscape. This affords pathways for species movement and lays a basis for cumulative effects in the ecosystem services provided by otherwise isolated or segmented green assets.

Multi-functionality refers to the various functions performed by ecological assets, in contrast to traditional 'grey' infrastructure, component parts of which are traditionally geared for one purpose.

SECTION ONE

The section provides an introduction to the core arguments of the report, and an overview of the concept of green infrastructure as a framework for rethinking infrastructure from an ecosystem services perspective.

VIEW FROM LINKSFIELD RIDGE, 2013

Introduction

This State of Green Infrastructure report is both an assessment of the set of natural and manmade landscape features in the Gauteng City-Region (GCR) and an interrogation into how the services provided by these assets are perceived, understood and valued. Inspiration is drawn from the conceptual and planning framework of 'green infrastructure', through which ecological systems, green spaces and other landscape features are regarded as providing services to society in the same way as those offered by traditional 'hard' infrastructure.

The analysis of how green infrastructure serves our society, contained in this report, focuses on both naturally occurring and deliberately planted vegetation within the Gauteng provincial boundary and its surrounding urban nodes, which together constitute the GCR. This city-region is a highly transformed landscape. Although it still contains original savannah grassland and bushveld, it is also now patterned with many constructed green environments, most notably extensive non-indigenous urban forests, large public parks and innumerable landscaped private gardens. This mix is controversial due to the location of the GCR in a watershed context with no major water body. However, the combination of naturally occurring and manmade landscapes is valuable in a region facing worryingly high levels of dirty air, heat island effects, intense storms, polluted and even toxic water systems, and shortages of land for food production, and where people increasingly spend their lives in closed and artificially regulated building environments.

This is not a state of the environment report focusing on the issues of 'conservation' of 'nature'. Rather it is designed to extend our understanding of what we define as 'infrastructure' and thereby open a critical engagement with the relationship between conventional service networks and vegetated dimensions of the urban landscape. Our core argument is that we need a fundamental shift in the way we understand ecological assets within our development paradigm. Trees, public parks, food and community gardens, wetlands and ridges need to be viewed as equivalent to conventional 'hard' or 'grey' infrastructure such as electricity lines, water pipes and drainage networks that allow for the everyday functioning of our settlements, society and economy. The premise of this report is that by better understanding the patterns of green infrastructure imprinted on our landscapes we can provide a starting point for conceptualising these assets as alternative infrastructures and lay a foundation for further work to more effectively value the services they provide. This necessitates deepening what we know about the spatial location, extent and variety of green infrastructure features, about how these are variously accessed and experienced,

VIEW SOUTH OF BRAAMFONTEIN, 2012

and crucially about their role and functioning and how this is currently being (and may potentially be) recognised in service-delivery planning and investment.

To achieve the above, this State of Green Infrastructure report presents a unique visual overview of the form and extent of green infrastructure in the GCR. A series of spatial representations, drawing on all available digital spatial data, identifies relevant green infrastructure features, their extent and how they connect and interact with each other and the wider urban environment. This is coupled with photographic accounts of a landscape that is natural and unnatural at the same time, a construction of human investments that, over time, have created a unique crossbreed of original and designed green assets and spaces. The photographic interpretations in this report are not an aesthetic backdrop to the institutional and technical analyses. They are an integral part of the analytical process of deciphering the extent of public, private and community-driven investment in green infrastructure, and in turn making a case for more dedicated efforts to value the functions provided by this infrastructure in a context of natural resource pressures, service delivery deficits and infrastructure finance and management challenges.

Situating the Gauteng City-Region (GCR)

This study is conducted in relation to a particular site, the Gauteng City-Region (GCR), the polycentric region of towns and cities in and around South Africa's Gauteng province. Gauteng covers an area of 18 179km^2 in central north-east South Africa and, with some 12.3 million people, is the country's smallest and most densely populated province. This is a sprawling region of geographically distinct cities and towns, including the prominent cities of Johannesburg and Pretoria, as well as other significant urban centres. Many urban centres are contained within the provincial boundary; whilst others are found outside the Gauteng administrative space, yet remain intimately connected to form a functional city-region. The wider Gauteng City-Region (GCR) is home to some 13 million people, which is over a quarter of South Africa's population, housed within a 175km radius of central Johannesburg.

The report moves from the premise that the GCR is not just a set of urban settlements in and around a formal administrative boundary. It also needs to be conceived as a spectrum of flows and interactions that constitute the region both as a multi-dimensional 'territory' and a 'political project'.

Accounting for 34% of South Africa's GDP and 11% of Africa's GDP, the GCR makes the largest contribution of Gross Value Added (GVA) nationally and is estimated to be the largest urban economy on the continent (OECD, 2011). The region is a magnet for those seeking better livelihoods. Gauteng's population grew at an average annual rate of 2.7% between 2001 and 2011, outstripping the national average of 1.5%. 52% of this growth was attributable to in-migration with the remainder due to natural births (StatsSA, 2013). The allure of Gauteng is due to its relative success in creating work, in delivering basic services such as water, housing and sanitation – with access levels being much higher than the rest of the country – and in providing greater proximity to urban amenities as well as generally better standards of living (GCRO 2011). The province's average annual population change of over 2% is likely to be sustained into the future. Projecting forward at the current annual average growth rates, Gauteng may have 16 million people by 2025 and 20 million by 2050. This means that current population density is likely to grow from 672 persons per km^2 to 859 per km^2 by 2020, a density on par with current Los Angeles and New York (GCRO, 2012).

Figure 1. Location of the GCR and its municipalities

BOX 1

This map shows the location of Gauteng province, and the municipalities into which it is divided. The Gauteng City-Region (GCR) as an administrative reality does not formally exist. It is a conceptual interpretation of the series of flows and interactions within the cluster of cities, towns and urban nodes that together make up the economic heartland of South Africa.

	2001	2011	Average annual growth 2001-2011
Population (number)	9 388 855	12 272 263	2,71%
Liquid fuels (tons)	15 922 862	21 196 280	2,90%
Electricity provided by Eskom (GwH)	52 007	61 256	1,65%
Waste (tons) in Tshwane	1 992 248	3 573 246	6,02%
Water (ml/day) in Johannesburg	1 107	1 350	2,01%

Table 1. Resource pressures facing the GCR

While population growth of 2% is not unmanageable, it is the growth in households that gives a more accurate perspective on the challenges facing Gauteng, namely how to provide shelter and household infrastructure to those currently without, in a context of mounting resource constraints (GCRO, 2012). In general, the number of households in large cities tends to grow faster than the size of the population. According to the last Census, Gauteng had some 3,9 million households in 2011. It saw a growth of almost 1,2 million households between 2001 and 2011 at an average annual growth rate of 3,6 %. In 2001, Gauteng had 24,4% of the total households nationally and by 2011 this had grown to 27,1%, more than the province's share of the national population. This means that at current growth rates, Gauteng will have some 5,4 million households by 2020, representing a doubling of household numbers over the two decades from 2001.

SOWETO PANORAMA, LOOKING NORTH, JOHANNESBURG, 2013
LEFT: ZONDI AND IKWEZI STATION (OBSCURED)
CENTRE: MOFOLO AND CENTRAL WESTERN JABAVU
RIGHT: CENTRAL WESTERN JABAVU AND MOLAPO

As government provides more formal shelter to those currently living informally, extends water, power and waste networks to cover households currently not connected, and stretches the urban fabric to accommodate a larger population and an expanding economy, there will inevitably be upward pressure on the total quantity of resources used in the city and region, as well as the total waste and pollution generated (see Table 1).

A further and related challenge is the blanketing of natural land with the impervious surfaces associated with housing, roads and other built infrastructure. This has created a situation where a significant portion of Gauteng is in effect 'constructed'. The urban extent of Gauteng is reflected in Figure 2, which shows urban land cover derived from 2009 10 meter resolution satellite imagery supplied by GeoTerraImage (GTI). The map depicts the built environment, which continues to expand through sprawl on the edge of the established parts of the city-region, and along transport corridors between them. This peripheral and ribbon based sprawl raises the question of whether government and private sector housing provision is geared for the type of settlement development needed to accommodate a growing population, especially in light of the fact that economic, residential and transport activity is already highly resource – and land – intensive. This question is further complicated by the nature of the solutions proposed to deal with a sprawling city-region. There has been significant recent government advocacy for density. The Gauteng Spatial Development Framework (GSDF) (2011), for example, takes a policy position for densifying townships and suburbs through advancing compaction, residential densification, in-fill development and the restriction of sprawl (GPG, 2011).

The policy preference for density, through the 'compact city argument', is motivated to achieve sustainability. However, while there is also support for developing green space systems (GPG, 2011), there is a tension between the sustainability gains of increased density and the sustainability imperative of maintaining green areas when it is these spaces that are exploited to increase density, fragmenting currently intact habitat (Uggla, 2012). Already the GCR has seen some investment in high-density developments, which have effectively made incisions into the green areas that previously filtered through the urban fabric. As Uggla (2012) elaborates, the utilisation of available open space is often depicted in urban planning as a necessary precondition for achieving higher density, and justified in terms of the promised compensation of higher quality parks. While this negotiation may reimburse a region the social value of recreating in a park, the danger is the ecological compromise of appropriating the corridors and hubs that hold together green networks. Byrne & Sipe (2010) reflect on what they term the paradox of urban consolidation, which is that it may actually stimulate leisure-based travel, as urban dwellers seek to escape to the countryside or other places for leisure and recreational experiences.

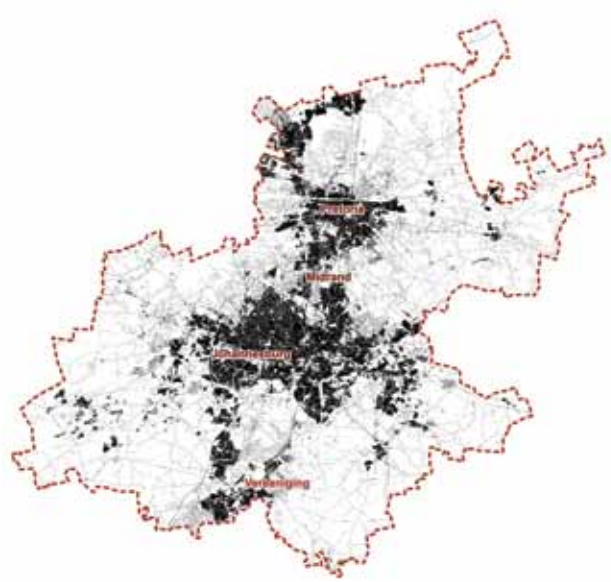


Figure 2. Built-up land in Gauteng

VIEW FROM WATERKLOOF RIDGE, TSHWANE, 2013

The density paradox is made more difficult through the emergence of large residential housing estates around the city-region, especially where green guidelines are incorporated into 'eco-estates' and other lifestyle developments. Many of these developments include ecological buffer zones as well as in-built green infrastructure, which may otherwise have been blanketed over. They also dedicate considerable funding to the upkeep and maintenance of green areas. Yet the issue is of course that these private developments serve only a select group of individuals whose lifestyles are largely the antitheses of inclusive development.

Green infrastructure: conceptual underpinnings

Green infrastructure has emerged as a way of understanding natural and man-made ecological features as components of the infrastructural fabric that supports and sustains society. Yet the idea of establishing more strategic ecological connections in planning is not entirely new. Frederick Law Olmstead's 'parkways' concept in the late 19th Century led to parkway plans that connected parks in major cities of the United States, such as Boston and Chicago, and the Parisian boulevard-style developments (Hosgor & Yigiter, 2011). In early 20th Century Britain, Ebenzer Howard's Garden City movement initiated a global movement of 'garden cities' – highly planned, self-contained and self-sufficient communities – surrounded by greenbelts, in-turn connected into a regional network (Asabere, 2012; Batchelor, 1969). These early visions laid foundations for principles of green space organization and planning, such as those widely adopted in landscape architecture and planning (Jim & Chen, 2003). For instance, the greenways movement of the 1990s saw a surge of multifunctional greenway planning where networks of land were planned, designed and managed for multiple purposes including ecological, recreational, cultural, aesthetic or educational (Kullman, 2012; Ahern in Hosgor *et al*, 2011). Such trends had a major influence on the orientation of current green infrastructure ideas, particularly in terms of the principle of connecting different 'green' assets, such as trees, watercourses, parks, open spaces and agricultural features, into a network (Lockhart, 2009).

While the idea of green infrastructure may seem conceptually akin to earlier paradigms of green space planning and design, the current strategic drive for green infrastructure enters into a broader domain. This was the core message of the seminal report by Benedict & McMahon, Green Infrastructure: Smart Conservation for the 21st Century, which calls for a shift beyond conventional environmental protection and conservation, to a redefinition of green assets and ecological systems as part of the infrastructure that serves society. This movement away from viewing green assets as luxury items or 'nice-to-haves', represents a conceptual break from prior green space frameworks and, crucially, bridges the historical separation between ecological investments and mainline infrastructure planning.

The concept green infrastructure therefore represents a new perspective on how we attach values to green assets as infrastructure. While lineages of conservation planning laid important foundations in this regard, the progression to viewing green landscape features and ecological systems as a network of infrastructure utilities, on par with bulk water and sanitation networks, electricity distribution lines and roads, represents a break from purist notions of environmental protectionism, from narrow aesthetic connotations to nature, as well as from pure traditions of environmental justice. As argued by Thomas & Littlewood (2010), the conscious analogy with hard infrastructure implies something essential for city development, more so than concepts of amenity, and distinguishes green infrastructure from other and earlier notions of green belts and green corridors. The specificity of green infrastructure as a conceptual approach can be found in a number of characteristics qualitatively different from green space or conservation principles applied elsewhere. These characteristics are described below.

Multi-functionality

The defining contribution of planning for green infrastructure is to achieve multi-functionality. In contrast to many grey utilities, which are typically geared towards a single use or purpose, natural systems perform a range of functions to society, and with a remarkable degree of fluidity. The mono-functional design of conventional infrastructure means that utility networks also usually remain dormant unless their specific service is required, in-turn implying that they draw on vast resources to perform a single function (Egyedi & Spirco, 2011, Belanger, 2009). Ecological systems, on the other hand,

VIEW OF SANDTON, 2013

"Green infrastructure is defined as an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations. In our view, green infrastructure is the ecological framework needed for environmental, social and economic sustainability — in short it is our nation's natural life sustaining system. Green infrastructure differs from conventional approaches to open space planning because it looks at conservation values and actions in concert with land development, growth management and built infrastructure planning. Other conservation approaches typically are undertaken in isolation from — or even in opposition to — development."

Benedict & McMahon (2002) in Green Infrastructure: Smart Conservation for the 21st Century

are naturally multi-functional, simultaneously providing a suite of services including flood alleviation, cooling of heat islands, carbon capture, water filtration, local food production and the provision of spaces for people and nature to reconnect – functions otherwise known as ecosystem services (Mell & Roe, 2010). By way of example a park can serve as both recreational and storm water infrastructure if designed to harness sustainable design principles (Sustainable Cities Institute, 2012).

From a strategic planning perspective, green infrastructure can therefore meet multiple municipal goals. In contrast to provision arrangements for water, waste, storm water and energy, usually segregated into disparate departments, green infrastructure invites a strategic approach between different planning functions. This multi-jurisdictional approach calls for connections between land use and ecosystem management functions, and in-turn, the coordination of these functions with the planning of roads, sewer, water and electricity lines and other essential grey infrastructure (Benedict *et al*, 2002). In essence, therefore, green infrastructure is a shift to making investments that provide multiple functions and to valuing these in terms of their ability to simultaneously achieve and integrate ecological, infrastructural and broader development goals. In turn, the multiple services provided by ecological assets can assist government in rethinking how to address critical infrastructure backlogs in development pressure points, especially in tight fiscal circumstances where it simply would not be feasible to build overlapping 'hard' infrastructure networks for various services.

While this reconsideration first involves internalizing the multifunctional services provided by one ecological asset – such as a tree simultaneously functioning to sequester carbon, intercept and regulate storm water and remediate toxic soil and air – it is equally about the interactions between different ecological assets, and how these in turn interact with grey infrastructure. It is both the functioning of different ecological features as part of a living network and the way this network interfaces with the built environment that is important. A key characteristic of green infrastructure is therefore that it starts from the premise that 'green' and 'grey' should not be viewed as separate and competing, even when their relative costs and benefits are compared in planning processes. Rather, it is far more useful to consider how grey infrastructure and ecological systems interface to sustain our communities. This involves recognising that the built and natural environments do already co-exist in many settings, and then calculating how networks of biophysical systems could be purposefully placed to thread through our urban fabric.

Ecosystem services

The premise of green infrastructure planning is that ecosystem services, if valued as equivalent to the services of conventional infrastructure, and systematically planned for as such, can assist society in its everyday functioning, particularly in the face of intersecting climatic, ecological and infrastructural challenges. Ecosystem services are the benefits supplied to humans from nature. They are the naturally occurring functions of ecological processes, ranging from air purification, water flow regulation, reducing erosion and disaster risks associated with environmental change, the provision of green space for growing food and in which people can relax, as well as the provision of habitats and ecosystems that supporting biodiversity. Echoing Norgarrd (2010: 121), the notion 'ecosystem services' is a metaphor that helps elevate the importance of biophysical systems in planning and decision-making priorities and awaken society to think more strategically about nature. Currently, even where development challenges are considered vis-à-vis environmental stresses, there is a tendency to think about green assets only in terms of the aesthetics of human settlements, or in terms of environmental justice concerns. Ecosystems are not recognised as infrastructure systems in their own right. As de Wit *et al* (2012) reflect:

"The key challenge is that information about the value of underlying urban natural assets is not generally included in the financial decision-making processes, leading to weakly informed decisions regarding budget allocations to departments that manage natural assets and the flow of ecosystem goods and services." (de Wit *et al*, 2012)

BRAAMFONTEIN, NORTH VIEW, 2013

The notion of ecosystem services has stimulated a series of experiments with ecosystem valuation techniques. Nuanced quantification of the extent, form and quality of green assets, and the value of each in terms of their infrastructure functionality, is critical if policy-makers are to conclude, with a reasonable degree of confidence, which vegetated forms should receive targeted fiscal support. However, translating quantifications of ecosystem services value into government budgeting and accounting systems confronts challenges in the fiscal architectures behind infrastructure planning. For instance, the delivery of basic services, particularly in larger municipalities, is tied to fiscal architectures predisposed to the consumption of more resources such as energy or water (which municipalities buy in bulk and resell), the sale of more motor fuel (on which a levy is raised), and the continued growth of homes, offices and factories (on which property tax can be charged). Coupled with a structural inclination to spend large capital budgets, for example on extensive storm water systems, there is little fiscal incentive for infrastructural innovations that explicitly link the functions of ecological assets to the provision of basic services. Hence, in spite of an active and growing dialogue around the role of ecosystem services in urban lives and economies, and various advances in measuring these functions (Pittock, Cork & Maynard, 2010), the public sector has been slow to incorporate the benefits of ecological assets into decision-making processes (Chan *et al*, 2006).

Infrastructure that appreciates over time

Valuing the infrastructural benefits of ecosystem services brings a new perspective on the standard set of exigencies that drive public infrastructure valuation. In standard South African municipal accounting practice, time-based depreciation rates are traditionally applied to fixed infrastructure assets (SPAID, 2010). However, by definition as living elements, biophysical systems provide for value that appreciates as the stock, quality, overall health and service productivity of green assets grows over time. There is no way of formally valuing this appreciation of ecological assets in financial systems based fundamentally on the idea of depreciating infrastructure value. Bridging the disjuncture between valuing traditional 'grey' infrastructure, which depreciates over time, and recognising and calculating how ecological assets that grow become innately more valuable over time, with commensurate expansion in the opportunity costs of not investing in it, will require a profound transformation in municipal budget and accounting paradigms.

OPPENHEIMER PARK, SOWETO, 2013

Landscape-scale approach

A last key characteristic of the green infrastructure paradigm is that it involves an understanding of how landscapes serve as the operational ground for infrastructure provision. This landscape-scale focus is distinctive because it provides a basis for understanding the connectivity between ecological and built forms, as well as between ecological capacity and infrastructural opportunity (Yeang, 2008; Benedict *et al*, 2002; Mell, 2008). Incorporating an understanding of landscapes in infrastructure provision is also a progression from conventional conservation planning in that both natural and man-made or constructed landscape features are recognised as valuable in providing for biodiversity enhancement and serving human needs such as air and water quality improvement (McConnell *et al*, 2005). Through a landscape-planning lens, designed green infrastructure is recognised as equally important as naturally occurring vegetation.

Global green infrastructure plans and initiatives

Green infrastructure has therefore emerged as a way of understanding green assets and ecological systems as part of the infrastructural fabric that supports and sustains society. This shift in thinking is evident in the development of various green infrastructure plans and initiatives in other cities and regions across the world. The following examples indicate the growing impulse within statutory planning to invest in green infrastructure. Further, they show that green infrastructure has begun to demonstrate practical success as an alternative service delivery system, bringing tangible local benefits.

The New York Green Infrastructure Plan

In 2009, The New York City government launched the NYC Green Infrastructure Plan. The City identified green infrastructure as "an adaptive approach to a complicated problem that will provide widespread, immediate benefits at a lower cost". Much of NYC is covered by a combined sewer outflow system where rainwater and waste water from homes and properties flow together. The City undertook a cost-benefit analysis of different options for dealing with the need to treat larger volumes of water, and more stringent effluent quality regulations. The analysis found that traditional approaches of constructing large new 'grey' infrastructure would be very costly, relative to an alternative green infrastructure strategy. In addition the conventional approach of expanding tanks, tunnels and water works would have no sustainability benefits beyond treating sewage and storm water, and the extension of the existing system would only begin to deliver water quality benefits at the end of a decade-long design and construction period. The City's preferred Green Infrastructure Plan sets out a number of objectives such as reducing combined sewer outflow volumes by 3,9 billion gallons per year, capturing rainfall from 10% of impervious surfaces, and reaping recreational benefits through the bio-infiltration sites and rain gardens that are core to the strategy. NYC calculated that these solutions, together with some unavoidable grey

infrastructure construction, would cost approximately $5,3 billion over a twenty year period, but this would be a saving to taxpayers of some $1,5 billion when compared to the all grey infrastructure approach. The green infrastructure options would also reduce combined sewer outflows to 17,9 billion gallons a year, compared to 19,9 billion achieved by an all grey strategy. Crucially, the City found that these benefits would accrue immediately and build over time, in contrast to the all grey strategy where benefits would only be seen after long-term construction.

The All London Green Grid

In 2011, the Mayor of London launched The All London Green Grid (ALGG) to promote a shift from grey to green infrastructure. The ALGG expresses green infrastructure as a progression from perceiving London as a city punctuated by parks and green spaces and surrounded by countryside, to an appreciation of this network as part of the city's fundamental infrastructure, as integral to London's metabolism as its roads, rail lines or water pipes. It is significant that the ALGG takes an integrated perspective of the two types of infrastructure, via a multi-layered landscape-wide view that focuses on the need to strategically plan and manage natural and built environments together. In addition to this landscape-scale focus, the ALGG also makes a critical contribution to the global green infrastructure discourse by explicitly recognising the value of man-made green infrastructure and the role of well-designed spaces in urban infrastructure provision. To this end, the ALGG vision is progressive, emphasising principles of connectivity and diversity.

Life: building Europe's green infrastructure

Launched by the European Commission and coordinated by its Environment Directorate-General, LIFE is an effort to build a green infrastructure network across Europe. Its central aim is to combat habitat fragmentation caused by grey infrastructure development, such as roads cutting through natural areas, urbanisation, and the externalities of delivering energy and transport infrastructure, such as electrical overhead cables that are a problem for migrating birds (EU, 2010). Significantly, LIFE articulates its successes – such as the re-routing of major roads to increase the area of favourable habitats for particular species and the installation of natural green bridges to facilitate species movement – as achievements dependent on co-operation between neighbouring countries and multi-stakeholder engagement between government and private land owners (EU, 2010). The promotion of multi-purpose land use, with the aim of harmonising wildlife interests with the economic needs of local populations, has been the guiding principle: "Indeed, financial prosperity was noted as being an important long term factor to prevent further habitat loss through land use abandonment" (EU, 2010). The initiative has been activated by the introduction of 'ecological highways' and 'migration passages' in trans-border planning processes, where the employment and economic opportunities accruing from ecologically sustainable tourism are utilised as incentives to envisage different ways to design and direct cross-border infrastructure development (EU, 2010).

"The vision for the ALGG is to create a well-designed green infrastructure network of interlinked, multi-purpose open and green spaces with good connections to the places where people live and work, public transport, the Green Belt and the Blue Ribbon Network, especially the Thames. This will provide a richly varied landscape that will benefit both people and wildlife providing diverse uses to appeal to, and be accessible by, all."
(The All London Green Grid, 2011)

Conclusion

These and many similar plans show how planning for green assets and ecological systems as an integral part of a city's form and fabric can bring significant economic, social, financial and sustainability rewards. They encapsulate what is possible if government is prepared to shift its consciousness around the definition of infrastructure, encourage broad public acceptance of alternative approaches to service delivery, and innovate in the planning, fiscal and design architectures of infrastructure provision and management.

LANTANA

Natasha Christopher

Lantana Bush, Linksfield Ridge, 2013
Drive, North of the City, 2012









SECTIONTWO

This section identifies the green assets and networks that exist in the GCR and assesses the state of digital spatial data publicly available to analyse them. It then provides baseline spatial information on the various components of green infrastructure found in the region, examining their extent and coverage, access and connectivity.

Assessing the state of green infrastructure in the Gauteng City-Region

This chapter describes the various green assets in the Gauteng City-Region (GCR). This is done using a series of illustrative maps that draw on publicly available spatial data to understand what kind of green infrastructure exists in the city-region, and how various components thereof are distributed, how they are accessed, and how they connect. The datasets reveal a mixed landscape where naturally occurring vegetation is interspersed with planted vegetation, raising questions about the ecological relationships between different green assets and how the functioning thereof is affected by the nature of urban development in the city-region.

This spatial depiction has hinged on the intersection of various datasets to develop an overview of the GCR's diverse portfolio of green assets. Although baseline information on the type, extent and location of green assets is provided, there were significant data challenges, and much more work is needed to collate local data across municipalities and, if feasible, generate new and original data from within government systems or using external sources such as satellite images. This section therefore starts with an interrogation of the available data, and then reviews what the available data shows, following the scheme below:

2.1 data: the state of available digital spatial data for green assets in Gauteng

2.2 landscape transformation: the multiple dimensions of transformed land in Gauteng

2.3 coverage: the physical expanse and spatial extent of natural and vegetated features in the GCR landscape

2.4 access: the proximity and ease of access to different green infrastructure features

2.5 connectivity: the intersections between different landscapes.

MESH, WATERKLOOF, TSHWANE, 2013

Data: The state of available digital spatial data for green assets in Gauteng

A starting point for this report was to assess existing knowledge and data relating to green assets held in public databases. This process involved a two year period of data collection and collation to assemble the most recent publicly available green asset data for Gauteng into an integrated green infrastructure dataset. What follows is an interrogation into the challenges encountered during this data collection process and an overview of how issues, such as data weakness, have been overcome.

A significant amount of digital spatial information is readily available for Gauteng, but is located in various government departments, where it is captured, collated, used and stored according to different operational mandates. At present there is no one repository that houses Geographic Information System (GIS) data in Gauteng and this kind of data for green assets in particular is currently spread between national, provincial and local (district and municipal) government departments, as well as in the offices of independent consultants. Consultants are often contracted to collect GIS data by municipalities for planning purposes. While these datasets often form a large component of the accurate datasets used by municipalities and other GIS users in Gauteng, data is most commonly in the form of environment management frameworks, environmental management plans, land cover and open space frameworks for specific government units, and data has been collected and created to align with their particular mandates.

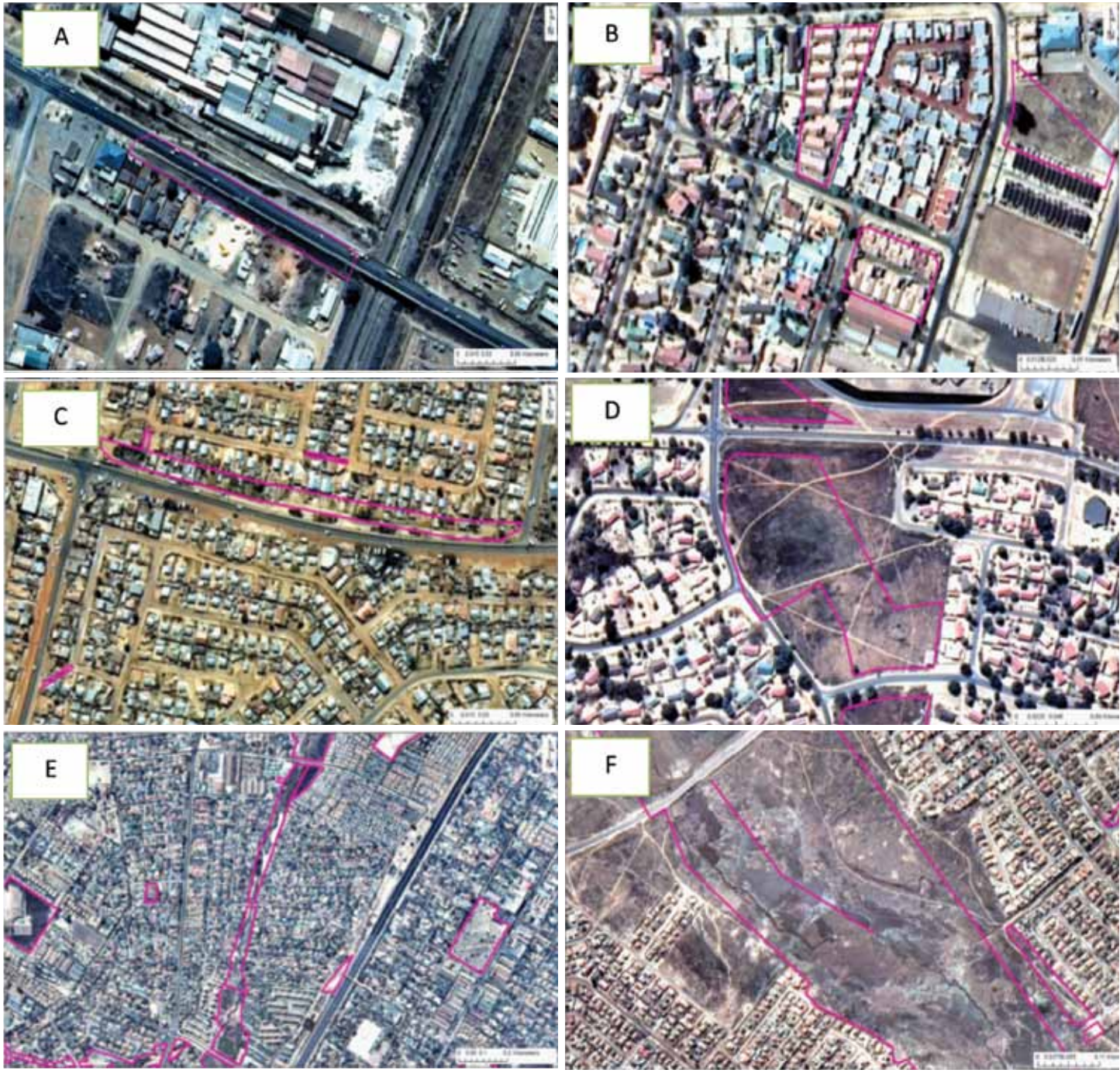


Figure 3. Overview of green asset data errors

The fragmented nature of GIS departments in Gauteng makes the collation of digital green asset data a challenging task. First, some of the municipal GIS departments in Gauteng are not well established. Their data is poorly stored and often of insufficient quality to be used. Well-established departments such as those in the City of Johannesburg (CoJ) and the City of Tshwane (CoT) provide good quality datasets, but this data often cannot be compared with offerings from other municipalities due to incompatibility with poorer quality data. Some departments are also not always aware of the GIS data they house in their departmental repositories.

Second, data is sometimes not stored in a format that can be used by a GIS, such as that in hard copy or CAD formats, limiting its applicability.

Third, spatial datasets are often not compatible due to differences in the way features are defined and classified in different municipalities as well as the way the features are captured and symbolised in a GIS. Issues of incompatibility are also exacerbated by the change of administrative boundaries in municipalities over the last decade, which renders some of the data comparisons invalid.

Fourth, the currency of datasets is an on-going challenge since the date of datasets is often not recorded and multiple data entries with the same classification confuse the mapping process.

Fifth, the status of municipal park datasets in Gauteng highlights the challenges in mapping digital spatial data for green assets such as data inaccuracies and conflicts. Parks data is not compatible at the Gauteng extent as public parks are largely the responsibility of municipalities, which use different approaches to categorise parks. As a result, the definition of parks is recorded differently in various park, open space and park & open space datasets. For example, data secured from the City of Johannesburg (CoJ), categorizes parks as ‘developed parks’, ‘flagship parks’ and ‘undeveloped parks’ (JCP, 2012). The same type of data from Ekurhuleni does not allow for a corresponding categorization because it aggregates all types of parks, which are also defined as ‘passive recreational areas’, into one category. A visual overview of these categorisation differences is provided in Figure 45 in Annexure A. Furthermore, these features are often symbolised by point (representing a single location in space) and / or polygon (representing area shapes) feature classes and do not align around administrative boundaries (ESRI, 2009). Insufficient supporting metadata also often renders these datasets invalid.

Last, inherent weaknesses exist in the parks datasets, including positional and attribute inaccuracies that result from poor data lineage, logical consistency and completeness (Annexure A, Box 1). An overview of GIS data quality issues at a municipal level is presented in Figure 3 A – F:

- Parks in Figures 3 A – C illustrate one of two possible errors that are a result of either a) classification errors inherent in the definition and delineation of parks or b) are an issue of data currency where datasets have not been updated. In both Figures B and C, for example, although parks have been identified, the corresponding land use appears to be residential.
- Park polygons in Figure 3 – D demonstrate positional inaccuracies incorporated in the data digitization process. Data has not been snapped to the boundaries of features that it intends to delineate and may be a result of insufficient cadastre data or inaccuracies in the recording and digitizing of park boundaries in a GIS. Parks therefore do not accurately represent parks on the ground and area values derived for these parks will not be correct.
- Park polygons shown in Figure 3 – E exhibit both positional and attribute inaccuracies through the delineation of multiple park features that together comprise one park on the ground. This may limit the quantification and management of parks in municipalities.
- Topological errors represented in Figure 3 – F illustrate human or GIS errors incorporated in the digitization of green assets that may skew area and measurement calculations based on parks data. This illustrates an error of positional accuracy, which may have arisen during manual digitizing of data during data processing.

It should be noted that these quality issues were not only encountered in the parks dataset, but also in other layers collected during the digital spatial data collation process. It is suspected that compatibility and data quality issues encountered in the parks datasets are illustrative of a broader set of concerns that face GIS departments, such as insufficient funds for the collection of good quality GIS data.

Overcoming concerns – data compilation

A critical step in the production of this report has been the collation of different data to deliver a homogenous information resource from which to grasp the coverage, access, variance and connectivity of green infrastructure in the city-region. To overcome the data quality concerns outlined here, this report draws on a range of data sources to establish a baseline integrated green asset dataset for Gauteng. This GIS output, which in addition to photographic and satellite imagery also profiled in this report, is an important foundation for developing a spatial perspective of the different components of green infrastructure in the GCR. In confronting the challenges in the state and quality of digital spatial data, and by developing novel ways to merge layers from various sources, this report is able to offer a number of insights into how data gaps and weaknesses can be overcome.

The process involved merging layers from a digital spatial data collation exercise according to data type, scale, attributes and extent of different green assets:

a. GIS data needs to be interrogated for each mapping application as the currency and content of datasets varies between final shapefile categories. In particular, layers in the protected and agricultural categories layers often overlap due to expansion or shrinkage of these assets over time. The report has addressed this by extracted layers from a Gauteng land cover dataset (GTI Land Cover 2,5m, 2012) to provide a current and homogeneous dataset from which maps and spatial analyses could be made.

b. While there are many different datasets detailing municipal trees and tree planting in Gauteng, none of these layers are complete or up to date. It was thus necessary for this report to extract trees from a land cover dataset to create a homogenous and accurate tree layer.

c. To order to overcome attribute inaccuracies apparent in the definition and categorization of parks, open spaces and green spaces in Gauteng these categories were merged into a general ‘open space’ layer during a preliminary data collation process. It was found that different open space data sources classify these features differently and may include or exclude roadside verges, open lots and open areas on the urban periphery that may serve very different functions to a similarly classified public park in the inner city of Johannesburg. Merging all categories into one generic green layer – that may include parks, open green areas in urban areas, roadside verges and any other identifiable green space – results in some loss of specificity, and grey landscape features may exist within this data. But it is more informative than using no green space data at all as a result of these data constraints.

d. It is noted that the categories in the collated datasets do not provide a detailed overview of all green assets in Gauteng. The final green layers provide only a partial reflection of reality in that they do not represent private gardens, trees and peri-urban gardening. In such cases, aerial photography and other visual representations are profiled throughout the report. These vignettes of the city-region’s landscape are equally important interpretations of the state of green infrastructure than what can be rendered through the digital spatial data.

Landscape transformation: the multiple dimensions of transformed land in Gauteng

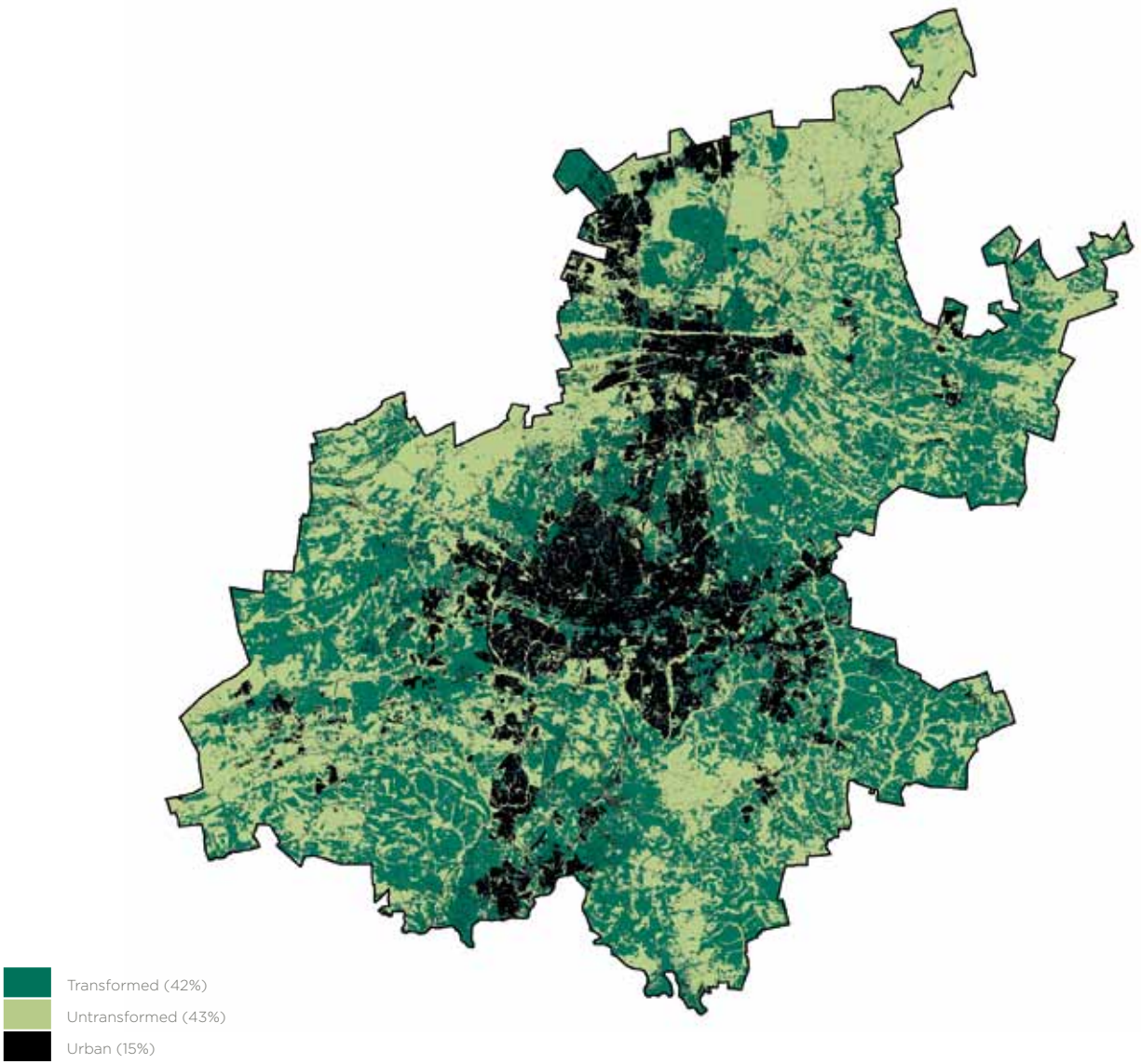


Figure 4. Landscape transformation status in Gauteng

In attempting to understand the extent and nature of green infrastructure in the GCR, this report undertook various attempts at a landscape change analysis. However, this was challenged by the unavailability of time-series data on change in green assets. For instance, GTI Open Space data, based on official cadastre data, was sourced for Johannesburg for both 2001 and 2010. However, the two years of data could not be compared due to ambiguities between the years in the definition of classes such as 'undefined open spaces'. For 2001 this category included various grey infrastructures, such as road networks, and some clearly visible parks which ought to have been categorised under 'parks'. It was impossible to find or generate consistently categorised time-series data for green assets at the Gauteng extent.

While strict change data could not be found, Figure 4 provides some insight into the complexities of land transformation in the GCR. The Figure represents GTI 10m Land Cover data (2009), which is coded into the following three classes, 'urban', 'transformed' and 'untransformed'. This coding approach reveals that both built-up 'urban' land and a series of ecological classes, such as 'urban trees', 'urban grass', and 'cultivated' areas' are categorised as 'transformed' land, while features such as 'dense trees', 'woodland' and 'grassland' are 'untransformed' (GTI Land Cover, 2009). Using this approach, it can be determined that 'urban' land cover constitutes 15% of land cover, transformed land 42%, and features collectively coded as 'untransformed', 43% of Gauteng. However, this does not fully reflect the extent to which urban activities have encroached on or modified native vegetation and whether the large share of green space, increasingly on the periphery, has been degraded. Note that the resolution of the data presented in Figure 4 is such that only land cover features greater than $10m^2$ are identified.

A municipal green asset typology indicates how green infrastructure components further break down per municipality in the GCR. This overview is provided in Table 2 which dissects GTI 2,5m Urban Land Cover for 2012 classes per municipality to represent the distribution of green assets across Gauteng. The graph (Figure 5) indicates that 'Planted and natural grassland' is a dominant feature across Gauteng's ten municipal areas, with larger shares of grassland land cover classes in outlying, less urbanised municipalities, such as Mogale City and Merafong. These municipalities are 59% and 57% grassland respectively.

The data illustrates that while some municipalities are more urbanised than others, the 'urban' land cover classes are not exclusively transformed vis-à-vis the rest of the landscape. There are significant vegetative features 'within' the urban expanse. Furthermore, other land cover classes that are not traditionally viewed as 'transformed' may represent a changeover from one land cover class to another. For example in Lesedi, 41% of the landscape is categorised as planted and natural grassland, but cultivated commercial agriculture also holds a considerable share, constituting 38% of the landscape of this agricultural-based economy.

In understanding the status of landscape transformation in Gauteng, a distinction is therefore required between definitions of 'urban' land that is 'built-up' and land that has been transformed into new green assets, which while suggestive of a natural environment, are landscapes constructed as people have made investments in green assets. An overview of how these investments are driven by communities and the private sector is provided in Section 5. The tendency to view landscape transformation exclusively in terms of built-up or grey urban form is problematized in the inter-municipal green asset typology shown in Table 2 and Figure 5, which highlights the importance of a more nuanced picture rather than conflating vegetation as 'green', 'open', or 'non-urban' land cover. This is particularly the case where the changeover to another land cover type is felt through the construction of new vegetation, such as non-natural and planted trees, which in Ekurhuleni and Johannesburg, for instance, represent 8% and 14% of the respective landscapes according to GTI 2,5m Urban Land Cover data (2012). From this vantage point, 'non-urban' also includes more than 'open' space and calls for a deeper interrogation into the typology of green assets in the GCR.

SQUARE KILOMETRES	EKURHULENI	EMFULENI	MIDVAAL	LESEDI	MOGALE CITY	RANDFONTEIN	WESTONARIA	MERAFONG CITY	JOHANNESBURG	TSHWANE	GAUTENG
Buildings	12	3	1	0	1	1	1	1	23	17	60
Building (School)	3	1	0	0	0	0	0	0	3	2	10
Building (Campuses)	0	0	0	0	0	0	0	0	0	0	1
Sport Stadiums (Buildings)	0	0	0	0	0	0	0	0	0	0	0
School grounds	16	5	1	1	3	1	0	2	18	17	64
Sports and Recreation	7	1	0	0	1	0	0	0	7	5	22
Golf Courses	8	1	2	0	0	1	1	1	9	9	33
Industrial	31	3	2	1	6	1	1	1	21	17	84
Heavy industrial	4	3	0	0	0	0	0	1	1	2	11
Residential (Cluster)	11	1	0	0	1	0	0	0	30	17	62
Residential (Residential and planned)	81	21	5	3	8	2	3	4	113	115	356
Township (Formal)	67	21	1	3	7	3	1	1	66	38	209
Township (Informal)	20	1	0	0	1	1	1	1	12	56	94
Small holdings	87	82	112	21	81	42	19	7	89	362	902
Roads	117	32	20	13	19	8	8	17	132	149	516
Rail	3	1	0	1	0	0	0	1	1	3	11
Thicket, Bushland and Bush clumps	6	4	91	27	28	3	8	59	2	842	1 071
Forest (Indigenous)	7	13	18	5	66	2	2	9	43	206	370
Trees (Non-natural and planted)	161	30	41	24	39	14	14	42	226	188	779
Grassland (Natural and planted)	557	350	821	606	795	200	354	928	508	2 693	7 811
Wetlands	149	36	40	124	17	11	28	56	51	202	716
Degraded natural vegetation	7	6	11	14	3	1	2	3	5	38	91
Cultivated Commercial (Irrigated)	30	11	32	20	21	26	9	15	9	64	236
Cultivated Commercial (Dryland/rainfed)	297	249	440	566	179	130	145	394	50	865	3 314
Mines & quarries	75	13	9	9	13	10	19	34	34	46	261
Open (Little or no vegetation, parking lots, bare sand)	178	60	24	14	26	13	12	25	173	196	720
Water	25	11	44	13	2	1	1	8	7	37	150
Bare rock & soil (Natural surfaces)	17	5	7	17	22	3	9	21	11	105	217
New development	2	0	1	0	0	0	0	0	1	4	10
Total	1 976	966	1 723	1 484	1 343	475	640	1 632	1 645	6 298	18 182

Table 2. Number of square kilometres of each land cover class in each municipality in Gauteng (source: GTI 2,5m Urban Land Cover, 2012)

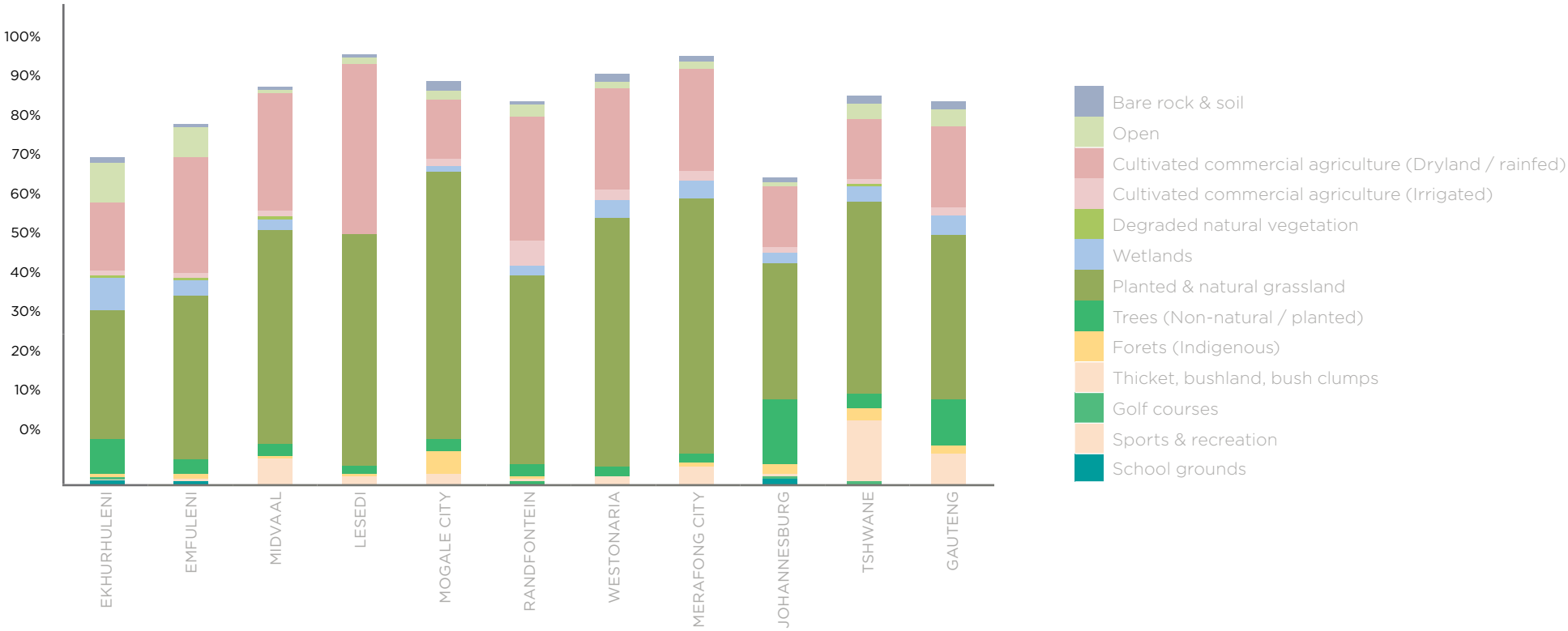


Figure 5. Percentage of selected land cover classes in each municipality in Gauteng (source: GTI 2,5m Urban Land Cover, 2012)

Coverage: The physical expanse and spatial extent of natural and vegetated features in the GCR landscape

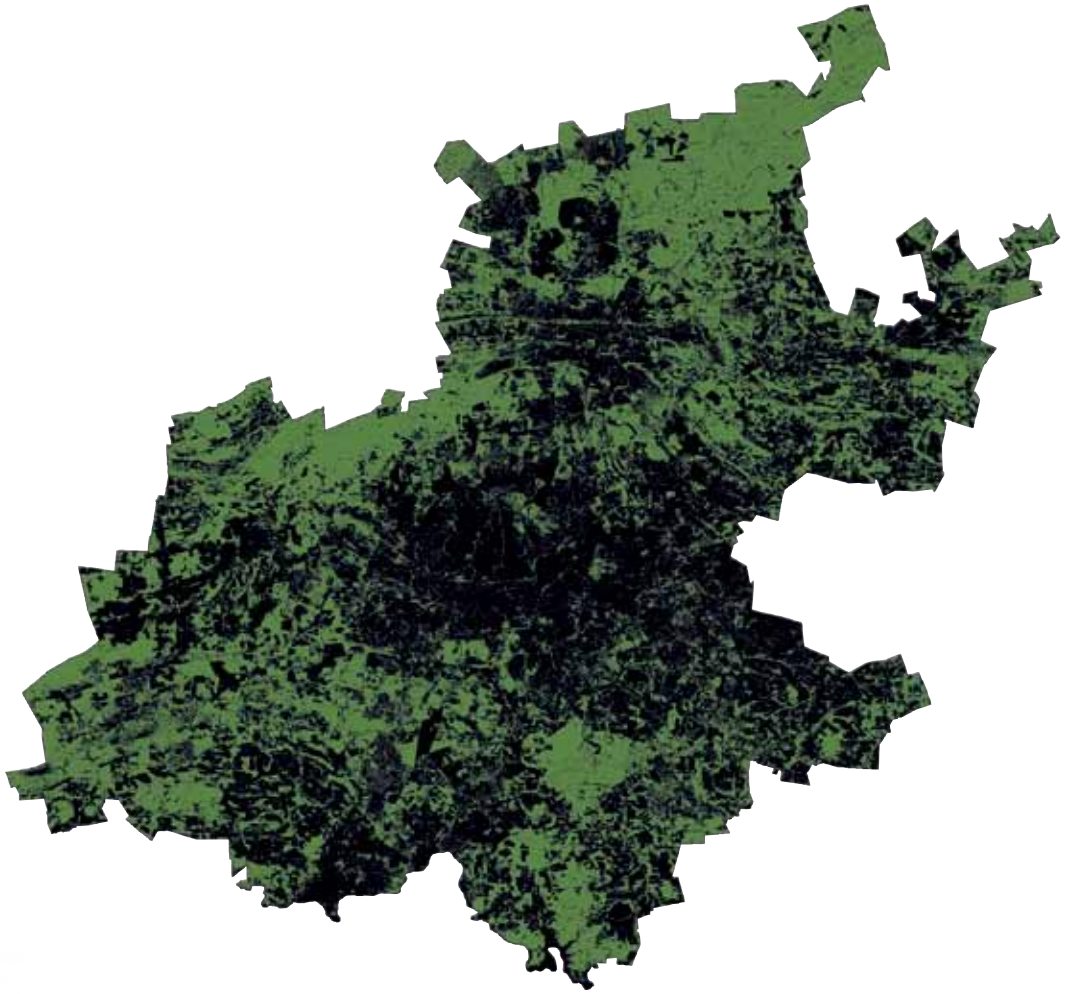


Figure 6. Natural vegetation: thicket, bush land, bush clumps, indigenous forests, shrub land, planted and natural vegetation, degraded natural vegetation

The GCR hosts a variety of naturally occurring vegetation types, including indigenous grassland and forest areas, as well as an array of 'planted' vegetation. The latter includes agricultural land largely on the outer urban edges of the region, through to planted trees, public and private gardens and golf courses. Layers of this natural and planted green infrastructure connect across administrative boundaries and thread through the built form. An in-depth analysis into the distribution of green assets, supported by a comprehensive inventory of different vegetation types, is a complex undertaking in light of these assets' diversity.

Natural vegetation

Natural vegetation in Gauteng corresponds to the grassland biome, the second largest biome in South Africa that spans the central interior of the country. Within this biome, temperate inland grasslands, and Highveld grassland in particular, are naturally occurring. In addition to grasslands, Gauteng hosts various other indigenous vegetation types, in the form of thicket, bush land, bush clumps, indigenous forests and shrub land. These features are shown in combination in Figure 6, which draws on GTI 2,5m Urban Land Cover 2012 data to show natural vegetation in Gauteng. Within this coverage, planted and natural grasslands are taken as components of the grassland biome and degraded natural vegetation is also seen as a relevant facet of the canopy of natural vegetation, albeit being degraded (GTI 2,5m Urban Land Cover, 2012).

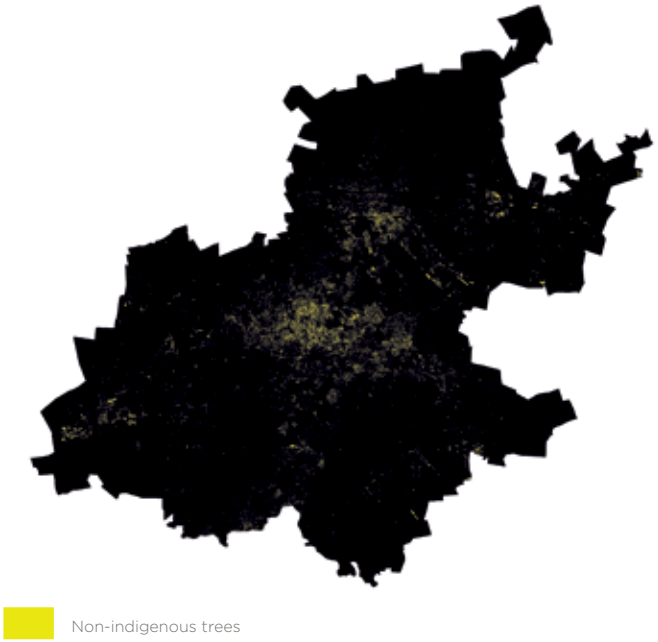


Figure 7. Non-natural trees in Gauteng

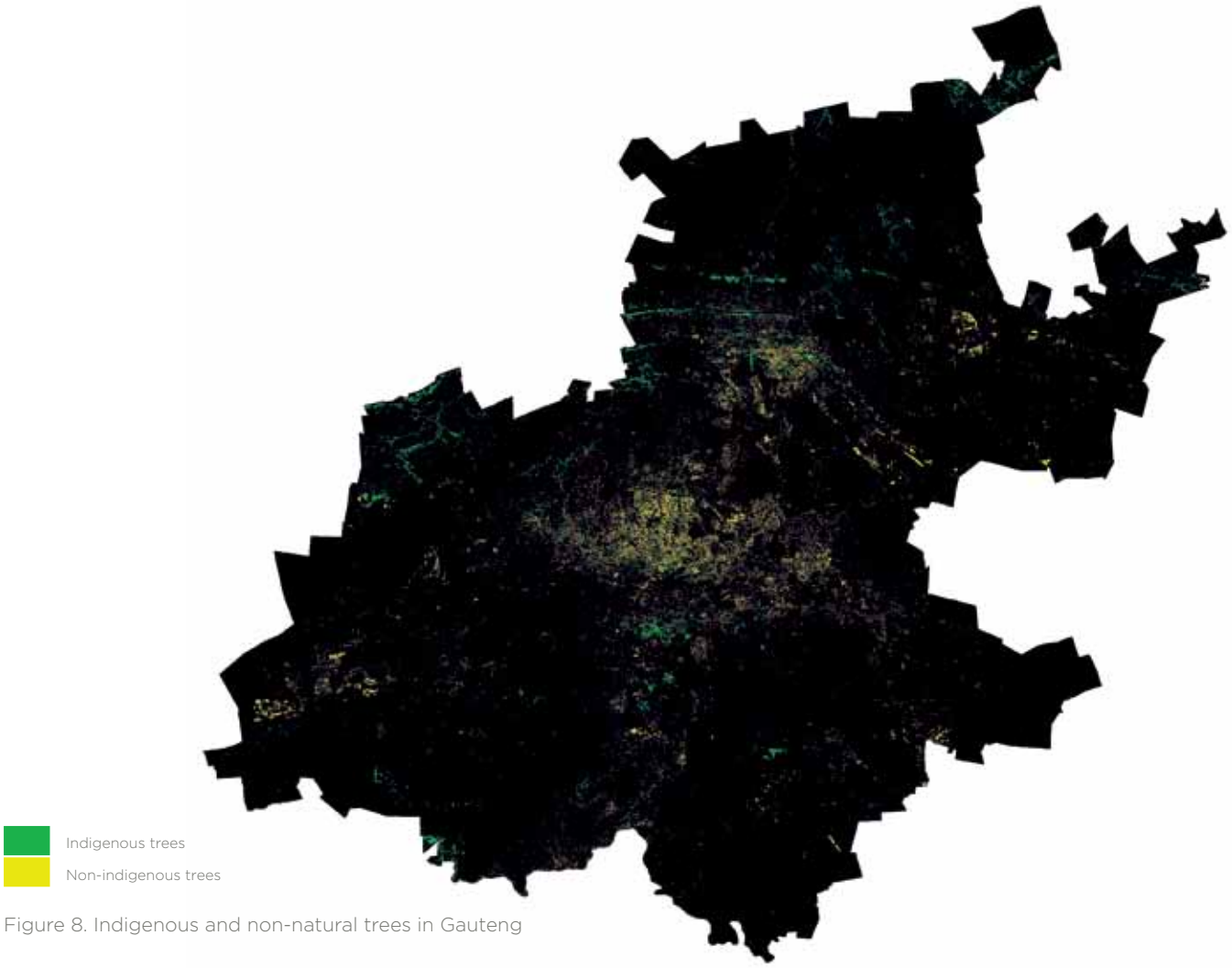


Figure 8. Indigenous and non-natural trees in Gauteng

Planted vegetation: non-natural trees

A prominent ecological feature within the GCR is the large forested expanse that extends across the urban core. There is no verifiable statistic on the exact number of trees in Gauteng, though there are various public claims that the forest in Johannesburg stands at approximately ten million trees (CoJ, 2008; CoJ, 2004). While this may be true, perhaps even an underestimate, the challenge is that tree records are municipal functions, so information resources of municipalities need to be pooled for an integrated assessment of tree coverage. This situation is further complicated because of the substantial numbers of trees that exist in private gardens across the city-region, a complex and fascinating landscape feature explored in more detail in section 5 of this report. Outside of municipal jurisdiction, trees remain invisible to public data inventories. Therefore, aside from aerial imagery that generically represents an overview of trees, information on species, genus, age and quality of planted trees is yet to be captured in empirical datasets harmonized across the GCR.

Figure 7 and 8 is an attempt to address this tree data vacuum by utilizing aerial imagery converted into a 2,5m Urban Land Cover dataset (GTI 2,5m Urban Land Cover, 2012). In this mapping, each pixel on the image represents 2,5m^2 on the ground, so individual trees with a canopy of less than this will not be represented, although dense clusters of trees with individual canopies less than this area may be classified through their joint area of 2,5m^2 or larger. Figure 7 shows non-natural trees and Figure 8 indigenous and non-natural trees together.

Depicted is an urban core where tree coverage is more concentrated than on the outer edges of the province, and where in overall terms non-indigenous trees are dominant. These trends may be related to urban forms that have encroached on natural vegetation, but at the same time, new forms of vegetation have been planted in the urban fabric.

The maps illustrate a greater density of trees in Johannesburg than in other parts of the province, although Ekurhuleni in the east and Tshwane in the north also show concentrations. A substantial portion of Johannesburg's trees are mature trees – many between 50 and 100 years old – which as a result of their maturity and consequent size are visible to aerial imagery. A biography of the urban forest explains the age of many of Johannesburg's trees. The existence of trees in Johannesburg is tied to tree-planting schemes that accompanied the mining boom beginning in the late 19th century, and the subsequent tree growing culture that developed. To supplement indigenous supply, and to settle the dust, large plantations of exotic trees, such as Eucalyptus, Black Wattle and Jacaranda, which tended to be quick-growing and suitable for mine props and excavation, were set up in Johannesburg and surrounding areas (Turton *et al*. 2006). The species types associated with en-masse tree planting also partially explains the occurrence of an almost non-indigenous urban forest in Johannesburg.

However, Johannesburg's urban forest is also not uniformly distributed and there are distinct differences in coverage between the north and south of the city. Based on the GTI 2012 Urban Land Cover dataset, trees cover approximately 24,2 % of the total area of Johannesburg's historically wealthy northern suburbs while tree coverage in the poorer southern quadrant is approximately 6,7% (GTI 2,5m Urban Land Cover, 2012) (See Figure 15).

The striking socio-spatial differences of tree-coverage across Gauteng are depicted in Figures 9 to 14. These figures represent GTI 2,5m Urban Land Cover data (2012) to show that in contrast to the high concentrations of trees in historically wealthy areas, tree coverage is sparse, almost non-existent, in the informal settlements of Daveyton, Mamelodi and Alexandra.

Figure 9. Tree coverage in Bryanston, Johannesburg

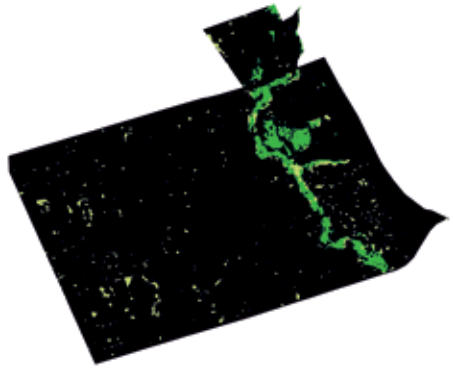


Figure 10. Tree coverage in Alexandra, Johannesburg

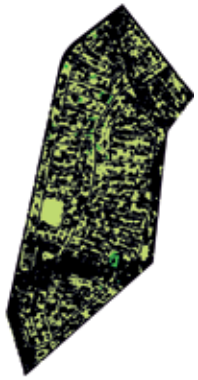


Figure 11. Tree coverage in Atlasville, Ekurhuleni

Figure 12. Tree coverage in Daveyton, Ekurhuleni

Figure 13. Tree coverage in Waterkloof, Tshwane

Figure 14. Tree coverage in Mamelodi, Tshwane

Tree planting projects

An uneven share of green space in Gauteng has galvanised an active justice-packaged drive to redress ecological disparities inherited from apartheid. Figure 17 provides an overview of Johannesburg City Parks (JCP) data on tree-planting projects, initiated in Johannesburg as part of city greening drives. The figure is shown next to two other maps: Figure 15, which is a zoomed in version of the GTI 2,5m Urban Land Cover capturing indigenous and non-natural trees; and Figure 16, which merges this data with tree points captured by Johannesburg's parks management entity City Parks. Comparing figure 15 and 16 reveals that there may have been earlier tree planting programmes, especially in the south of the city, where the size of the young trees means they are not yet large enough to be picked up in aerial imagery, even at a 2,5m resolution. Figure 17 shows recent tree planting programmes with new trees marked in purple (JCP, 2012). Figure 16 is based on tree point data, which means it does not show actual tree coverage. This detail is visible in Figure 15, which reflects GTI's 2,5m Urban Land Cover data (2012), based on aerial imagery that shows a skewed distribution of mature trees in Johannesburg, i.e. those visible to the imagery. The tree points data captured by City Parks (Figure 16) may imply that a substantial portion of tree planting was undertaken in Soweto during 2006-2010, and this data has been aggregated into a generic 'tree points' dataset, although this is not visible to the aerial imagery presented in Figure 15. This results in tree coverage in Soweto depicted in a similar way as that of the northern suburbs, a reality very different to mature-tree imagery in Figure 15.

Of the various greening programmes geared to equalize the distribution of public green space, intensive tree-planting schemes are both prominent municipal capital projects and public media campaigns. In Johannesburg, for instance, capital projects geared towards greening include *2010 Greening Legacy, Soweto Greening 2006-2009*, and *Braamfischerville Tree Planting*, in addition to more general public tree campaigns such as *Arbour Month Tree Planting* and *67 Minute Contribution to Madiba*. To balance out the concentration of mature trees in Johannesburg's historically wealthy northern suburbs, tree planting schemes are primarily located in previously disadvantaged areas, such as Soweto and Orange Farm in the southern quadrant of the city.

Tree planting projects also alert us to the nature of public investments in landscapes previously excluded from public greening. It is clear that there has been an extremely positive roll out of equity-based greening programmes, with heightened momentum particularly in the build-up to the 2010 Soccer World Cup. However, many of these greening projects received attention as short-term, high-pressure commitments to reduce 'ecological disparity' (CoJ JCP, 2008), raising questions about the commitment to sustain these assets over

the long term. For instance, the bulk of Greening Soweto, declared a 2010 World Cup legacy project, took place in winter, when the Highveld frosts hit the hardest, and particularly in Soweto, resulting in many of the trees not surviving the cold (CoJ JCP, 2010). A future version of Figure 15, once the full effect of tree planting is evident, may therefore represent a greater tree extent across Johannesburg, but it is also likely that low tree survival rates in certain areas may mean a scenario not as different as one would expect.

Figure 15. Mature tree coverage captured by GTI 2,5m Urban Land Cover (2012)

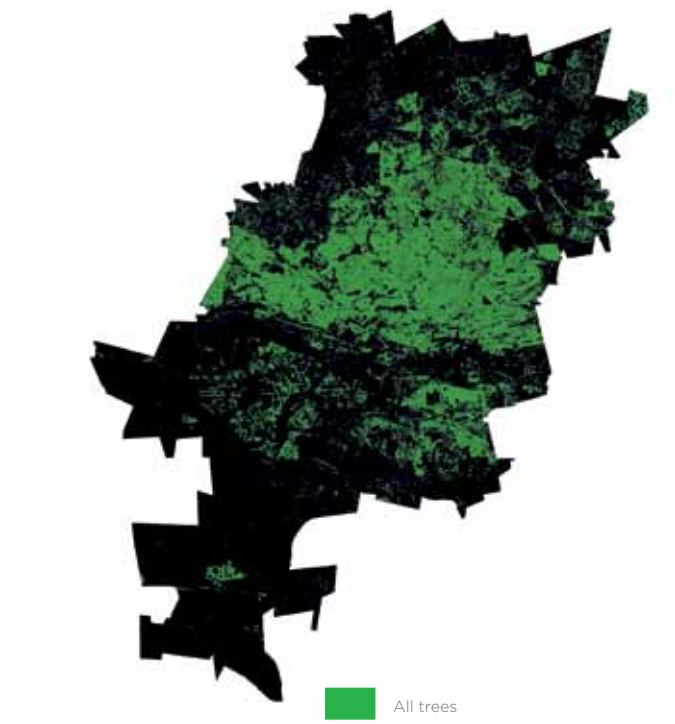


Figure 16: Mature tree coverage (GTI 2,5m Urban Land Cover, 2012) with Johannesburg City Parks tree point data (JCP, 2012)

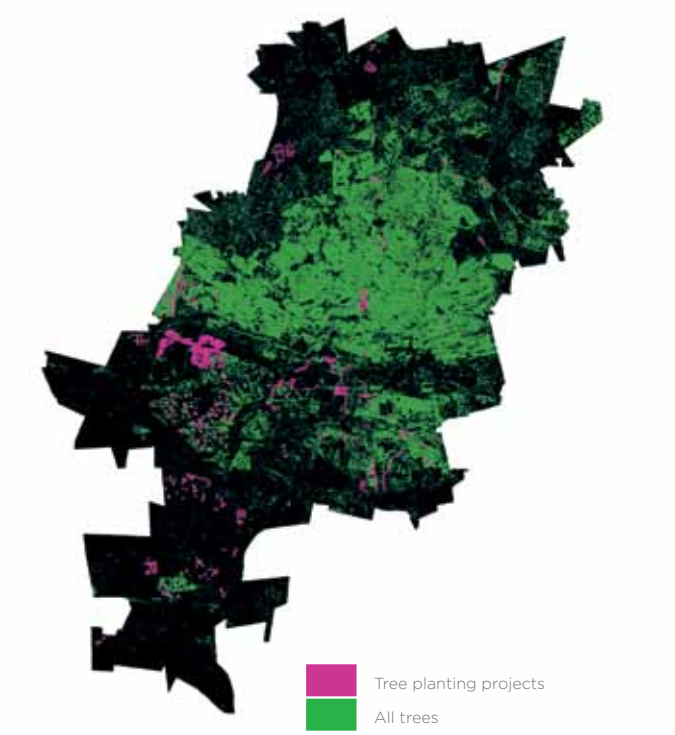


Figure 17. Tree planting projects versus mature trees and Johannesburg City Parks tree point data (GTI 2,5m, 2012, and JCP, 2012)

Figure 18. Commercial agriculture in Gauteng

Figure 19. Overview of agricultural gardens, agricultural hubs, agricultural lands and lands used for livestock

Figure 20. Green space per building including agriculture

Food infrastructure

Although Gauteng is a net importer of food, relying mostly on external supply chains to sustain food consumption, the province does have extensive agricultural assets. Utilising GTI 2,5m Urban Land Cover (2012) data, Figure 18 indicates that these assets are generally located on Gauteng's periphery, surrounding the urban core. This particular dataset also indicates most of Gauteng's 'food infrastructure' is in the form of commercial agriculture, including irrigated cropland and dry land or rain fed cropland. Additional data sources, GDARD's Agricultural Census (2009) and GTI's Land use per building (2009), provide further insights into the different types of land uses associated with agricultural activity in Gauteng. For instance, in addition to large-scale commercial agriculture, agricultural gardens, agricultural hubs, agricultural lands and land used for livestock are also located on the outer edges of the province. An overview of these agricultural areas in relation to commercial agriculture is provided in Figure 19, which reaffirms a regional food infrastructure that surrounds Gauteng's urban core. Figure 20, on the other hand, presents GTI Land use per building (GTI, 2009) to map agricultural green space associated with buildings in Gauteng, revealing a situation where many of the open spaces associated with buildings on the peri-urban edge of the province are used for agricultural production. Some detail on cultivated agricultural land in Gauteng is provided in the Gauteng Agricultural Potential Atlas (GAPA) (2013), which estimates that the total area of cultivated land in the province is 386 244 hectares. According to the GAPA (2013), the majority of this land is used as pastures (53,8%), followed by maize (31,4%), in addition to a number of less prominent produce, such as vegetables (3,4%) and soya beans (4,5%), while 1,9% in 2012/2013 lay fallow.

School grounds, golf courses and sports and recreations spaces

For many people in Gauteng, green assets are green spaces, designed not for ecological reasons but as sites for recreational activity. A substantial portion of these green assets planned as social spaces are school grounds, such as sports fields and other associated open spaces within school boundaries (GTI 2,5m Urban Land Cover, 2012). Spaces used by society for sports and recreational activities, such as public sports facilities and private golf courses, are also prominent features in Gauteng's green asset matrix. At a Gauteng scale, these social green spaces can be aggregated into a group of similar green assets, bound by a common characteristic of recreational use. An aggregated picture of schools grounds, sports and recreational areas, and golf courses is presented in Figure 21, which draws on GTI 2,5 Urban Land Cover (2012) data to plot 'recreational' green space across Gauteng.

Figure 21. Recreational green space across Gauteng

Upon closer interrogation, Gauteng's recreational green spaces are associated with particular users and specific functions within more localized, micro-landscapes. For instance, golf courses generally feature as prominent irrigated areas (see Figure 22). They also project particular socio-economic dynamics in light of them being not readily accessible to all citizens due to membership fees and playing costs. These factors, coupled with often high water requirements in a water stressed context such as Gauteng, have subjected golf courses to various critiques. Yet, in light of land being cleared to accommodate development, the large areas that exist outside of formal protected areas may provide important reprieve in an increasingly built-up landscape. Indeed, various international studies indicate that golf courses have significant ecological value by creating habitats for urban wildlife and otherwise threatened species, as well as providing opportunities for collaborative ecosystem management between public and private stakeholders (Colding & Folke, 2008).

School grounds and sites used for sports and recreation are similar to golf courses in terms of being 'constructed' or 'developed' green spaces. The share of school grounds in relation to settlement and population densities varies across Gauteng. For instance, in contrast to a Westonaria settlement (Figure 23), Soweto in Johannesburg (Figure 24) is relatively well-served by school grounds, which also constitute a large share of 'managed' green space in immediate proximity to surrounding residential settlements. While both examples also include large tracts of land surrounding the respective settlements, there is ambiguity in terms of the exact use of these 'open spaces' by local users and the functions provided by these spaces. In both these examples, the safety and attractiveness of unmanaged open spaces may be cause for concern, and in relation to Westonaria, open space is often deemed dangerous due to the occurrence of dolomitic land in the West Rand, as further explained in the Section 3 case study. A possible corollary, however, is that vegetated open areas left untouched by human influence may house important populations of plants and animals while also purifying the air and regulating water flows (Bolund & Hunhammar, 1999).

Figure 22. Golf course, Ekurhuleni (CSIR Spot 5 Imagery, 2010)

Figure 23. School grounds, Westonaria (CSIR Spot 5 Imagery, 2010)

Figure 24. School grounds and sports facilities, Soweto (CSIR Spot 5 imagery, 2010)

Protected areas

The share of the GCR designated as formally protected areas is represented in Figure 25. This overview of protected areas integrates a number of green asset layers, including botanical gardens, provincial nature reserves and conservancies and various municipal reserves. At a city-regional scale, these formally protected areas come together as a system that has important ecological value as well as being significant heritage sites. The Tswaing Crater, for instance, is an area of 1 981 hectares housing one of the only examples of a lake occupying a meteorite impact crater in South Africa (Swanepoel *et al*, 2004). This has garnered significant scientific interest, and a number of educational and eco-tourism opportunities

While many of the administrative requirements for protected areas are already in place across Gauteng, the quality and functioning of these assets at their local scales reveals a more complicated reality. The Abe Bailey Provincial Nature Reserve in the West\ Rand, for example, faces a number of challenges due to its location within a human-dominated landscape of urban development, agriculture and mining activities (Taylor & Atkinson, 2012). The reserve is also cited by the Merafong IDP (2011) as "an impediment to the northwards expansion of urban Khutsong and Wielverdiend" (Ibid, 2012). In contrast to this, Suikerbosrand Nature Reserve was extended between 2008 and 2009, with the goal of acquiring new reserve lands that currently constitute one complete unit instead of the separate units of two individual parts (GDARD, 2011).

An aggregated overview of Gauteng's protected green spaces is therefore useful to plot the spatial distribution of these assets within the province and beyond. Yet a closer inspection into whether the conservation status of these protected areas is in fact being upheld exposes a series of localized challenges, often omitted from a physical overview, and which need to be incorporated into a more nuanced understanding of the functionality of protected areas.

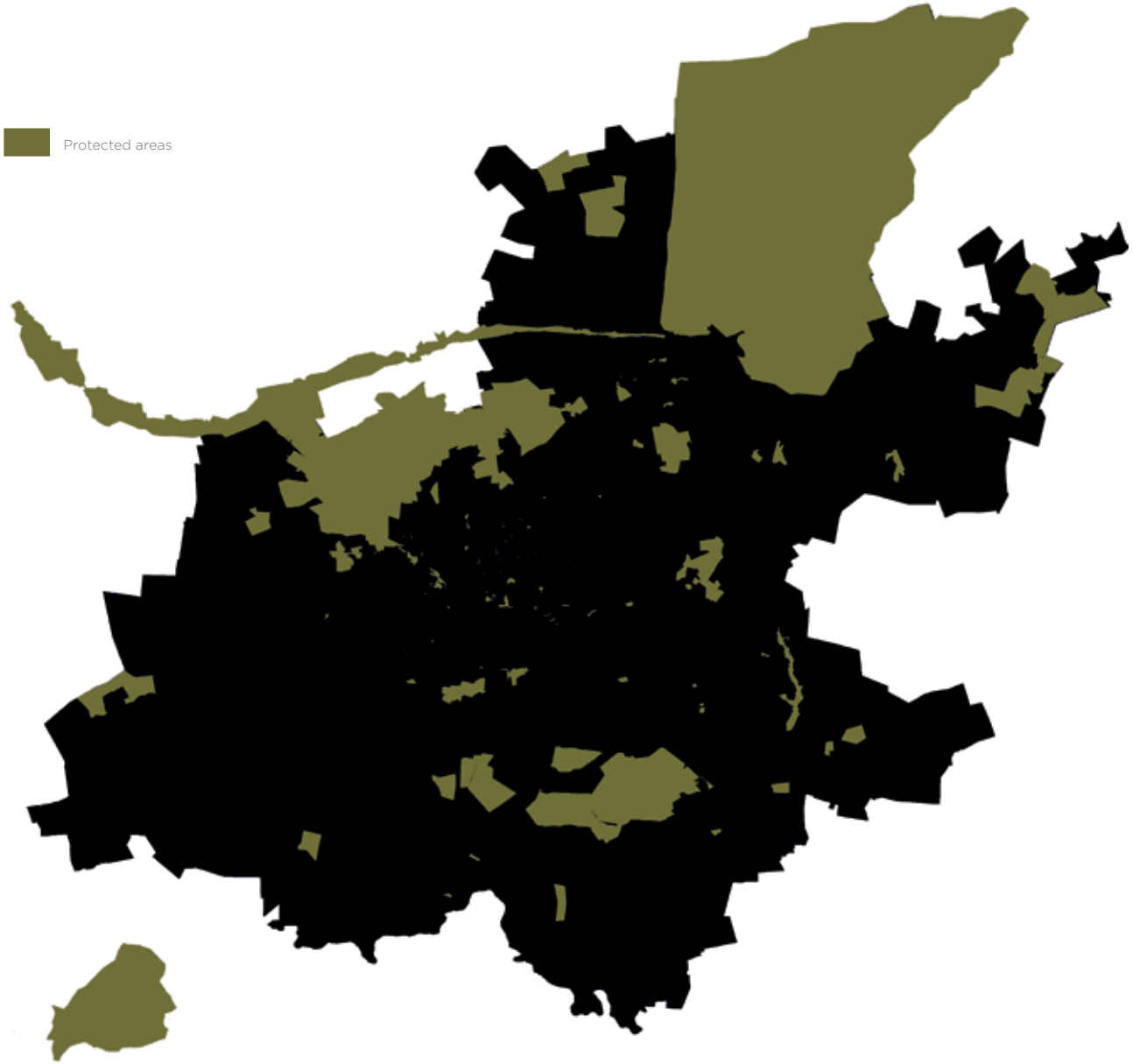


Figure 25. Protected areas in Gauteng

Hydrological networks

Hydrological networks play a critical role in the functioning of broader ecological processes that benefit both humans and the environment. The GCR supports a number of hydrological features that together make up the integrated hydrological network of Gauteng. These features are represented in Figure 26, which shows regional rivers, including perennial and non-perennial rivers, manmade water infrastructure such as reservoirs, various other water bodies such as dams, and a RAMSAR site, namely the Blekbospruit in the eastern quadrant of the province.

While South African water policies are said to be some of the most progressive in the world, the GCR's hydrological network is beset by various challenges brought about by the poor management of natural and man-made hydrological systems and poor implementation and enforcement of water legislation. Of these challenges, supply and quality are some of the most acute since the city-region and its main development nodes are located far from a large, sustainable water source, a challenge compounded by the blanketing of hydrological networks with built form, which significantly alters natural flow regimes. The degradation of water bodies, wetlands and various aquatic ecosystems through short-sighted development activities and cynical abuse of water legislation also compromises the water quality and availability. Examples of these problems in the GCR include acid mine drainage (AMD), pollution of feeder stream and water bodies by mine residue areas (MRAs), and waste water contamination as a result of poorly managed man-made water infrastructure. To the extent that these environmental problems affect downstream water users and inhibit the functions of hydrological systems, green assets in the GCR play an interesting role in the provision of ecosystem services. For instance, certain plant and tree species are phytoremediating, which means they naturally help to cleanse the soil by removing toxic substances, while wetlands naturally filter and regulate water flows, services that can be better grasped if valued more explicitly in infrastructural planning.

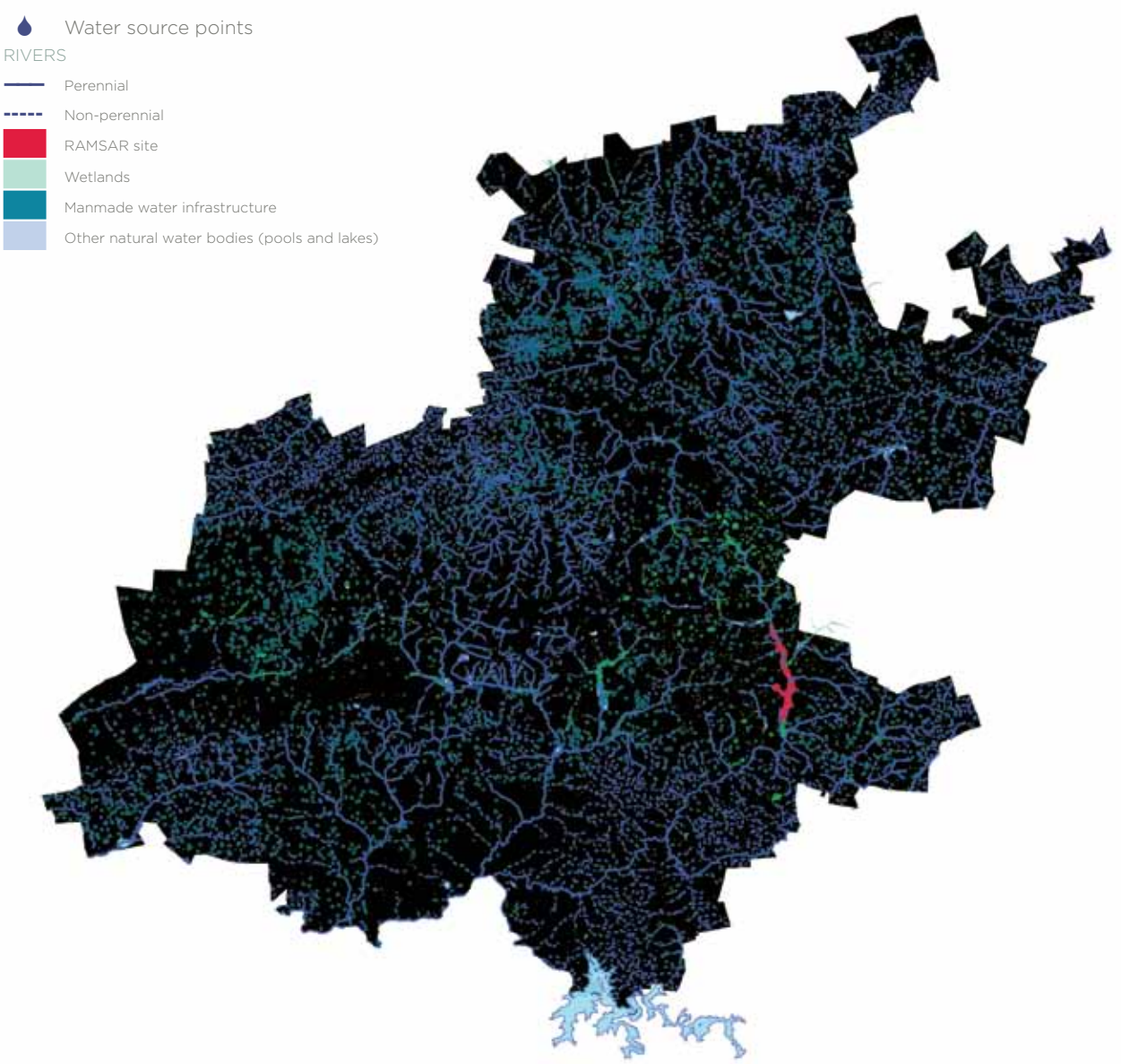


Figure 26. Hydrological networks in Gauteng

Access: The proximity and ease of access to green assets

The functions of green assets assume an infrastructural role through the idea of ecosystem services, and the promotion of these as the equivalent of traditional services such as electricity, potable water and sanitation. Green assets therefore enter into the debate about the rights to services and the asymmetries in infrastructure coverage. The obligation to improve access to green space has activated strategic dialogues about relative shares of green space for a particular population group as well as various standards for maximising the access thereto. For instance, the Guidelines for Human Settlement Planning and Design, known as the 'Red Book' (CSIR, 2000), includes an assortment of recommendations about how public open spaces should be planned according to users' frequency and access needs:

- Larger parks should be located in areas with no or limited access to natural amenities (in the form of mountains or coastlines). They should be fairly evenly distributed throughout a settlement, and where possible, connected by parkways.
- Smaller parks can be located within easy walking distance (i.e. ± 300m) of workers situated within busy commercial and industrial centres in order to create contrasting spaces of relief within predominantly residential areas, so as to create easily surveilled child-play spaces, and within school clusters, which create safe, shared playtime spaces.
- As larger parks serve sub-metropolitan as well as local users, maximum distances will sometimes be greater than maximum walking distances (i.e. ± 500m or 10 min). The implication of this is that parks will often need to be accessed by bicycles or public transport
- As smaller parks are likely to be used on a daily basis by children, elderly people and workers, and are accessed by foot, they should be located within 300m to 700m of users. The maximum time spent walking to a smaller park should therefore be approximately 10 min.
- The area and dimensions of a park vary according to the functions the park is intended to perform, and to proximity to the natural environment. Larger parks should be able to accommodate a variety of collective events like carnivals, fairs and concerts. Parks that are between 6 ha and 10 ha in size, with widths of between 200m and 300m, and lengths of between 300m and 500m, are generally flexible enough to accommodate these events.
- The area and dimensions of smaller parks also vary according to the functions they are intended to perform. Smaller parks should, however, be small enough to maintain a sense of intimacy, and enable easy visibility and recognition (i.e. ± 25m maximum). Such parks should therefore be between 450m^2 and 1 000m^2 in size, with widths of between 15m and 25m, and lengths of between 30m and 40m. (CSIR, 2000)

While these guidelines are valuable benchmarks, the reality is that the comparative basis for measuring success against generic standards differs in every context and also over time. In the case of Gauteng, the influx of people into urban areas is changing demographic profiles, and hence access needs, while shifting population densities and urban forms affect the way public green spaces are located within different areas. In light of these trends, it is interesting to see how municipalities frame access to public green spaces. In general, municipalities frame dimensions of access according to generic international standards. For instance, the City of Johannesburg (CoJ) highlights an international benchmark of 2 hectares of quality public open space per 1000 residents in dense urban settings as a relevant measure of the City's ability to cater for green space (City of Johannesburg, 2012), while the City's greening agent has also publicized providing 4 hectares of open space for every 1000 people (JCP, 2012). The City of Tshwane's (CoT) Environmental Management Department, on the other hand, uses 1 hectare of open space per 1000 residents to determine the need for public open spaces in relation to population density (CoT, 2007).

The different points of emphasis in target definitions of accessible public green space raise questions about the varied outcomes that may emerge over time as a result of how physical measures are interpreted in planning processes. The complexities of utilising standard measures to determine

and guide access are evident in an analysis of how CoJ's 2 hectares of quality public open space per 1000 people, versus 4 hectares of open space, plays out in reality. Firstly, the term 'quality public open space' can variously be applied to a range of green features falling under the management of Johannesburg City Parks (JCP), the assets of which range from nature reserves and bird sanctuaries to various types of parks. For the purposes of this report, a selection from JCP 2013 asset data indicates that parks in Johannesburg are broken down into three broad categories, namely developed parks, flagship parks, and undeveloped parks. If we accept that these assets are of a generally acceptable quality – possibly high quality in the case of developed or flagship parks, or, in the case of undeveloped parks, of a quality fit for future development or to be improved – we can engage in an indicative analysis of how the Johannesburg target for quality public open space plays out in practice, acknowledging that there is a substantial amount of public green space that exists in addition to assets defined as parks. In addition to the fundamental conceptual questions about which green assets are defined as high quality on the one hand, and public open spaces on the other, the debate is further about how access is measured in relation to the City using two simultaneous benchmarks of 2 and 4 hectares for public open space.

While green asset data from Johannesburg City Parks (JCP, 2013) is organised into both regions and municipal wards, wards are commonly used as the smallest administrative area for community-based planning and according to which green assets are also categorized in JCP datasets. Figure 27 represents wards in Johannesburg that are above and below the 2 hectare target of quality parks per 1000, while Figure 28 shows how the City is faring in relation to the more ambitious 4 hectare target. What emerges from this analysis is a scenario where the majority of wards in Johannesburg are below the lower 2 hectare target and those wards that are either meeting or exceeding the target are concentrated in historically wealthy parts of Johannesburg. However, what this situation fails to reveal is that those wards under the 2 hectare quota are not necessarily underserved in terms of public parks, since there are wards in Johannesburg where there are 1.6 hectares or 1.9 hectares of public parks per 1000 people, but which, by implication of the 2 hectare target, remain excluded from those wards deemed as having sufficient access. While a more detailed analysis may seem viable, using StatSA's Small Area Layer (SAL) (2013) for instance, the challenge is that CoJ uses a ward-based planning approach, which does not necessarily represent the way people see their access being determined. By way of example, a park on the edge of a ward boundary in a large-sized ward X, where most of the population may concentrate on the far side away from the park, may be more accessible to the population in the adjacent small-ward Y, while ward Y itself has no park in its boundaries.

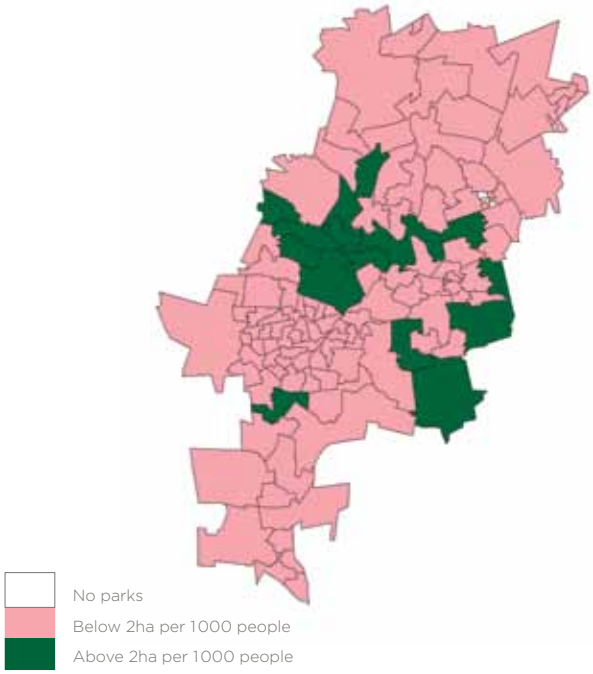


Figure 27. Wards above or below 2ha parks per 1000 individuals

The debate about access is therefore also about the appropriateness of wards as areas for community based planning, and of 2 or 4 hectares of quality public open space per 1000 people in dense urban settings as related to ward boundary-based planning. This question hinges on whether the current ways of measuring access to public parks are realistic and appropriate in light of the boundaries provided by community-based ward-level planning.

A more detailed understanding of access to public open spaces can be obtained utilising StatsSA's Small Area Layer (SAL) data on population. Figure 29 draws on SAL data for Johannesburg, intersected with JCP public parks data using a 750m buffer. 750m to a park is used as a benchmark of walking distance based on an average walking time of 15 minutes. Although the Red Book suggests 500m as a guideline for maximum walking distance from a park, and would change our analysis, we have used 750m as a more appropriate measure, based on a constant walking speed of three to four km/h, so that 15 minutes would represent 750m to 1km.

This alternative measure of access indicates the total population per SAL that falls within and outside of the 750m buffer, and yields a more localised analysis of whether people are within walking distance to public parks, regardless of whether parks feature at a ward level. Figures 29 and 30 indicate the range of population numbers within and outside of the 750m park buffer, represented using a green to red colour ramp. The range of the population that falls within this 750m buffer is indicated by the green colour ramp, from light to dark, and those people falling outside of the buffer are represented by lighter to darker shades of red. Based on this analysis, 4 112 681 people (7% of Johannesburg's population) in SALs fall within a 750m buffer of parks, and 322 062 people fall outside of the 750m buffer. This presents a more localised view in that while ward based maps suggests certain people are well-served by parks, the SAL analysis shows that many concentrations of people are actually without immediate access to parks. Figure 30 also shows a clear deficit of parks in the far north of Johannesburg, where there has been a large growth of population, often in estates. The deficit is significant since one might imagine that the largest gaps in access would be in the poorer southern parts of the city, such as in Soweto and Orange Farm. Although the focus on proportion of a population within a particular boundary is a different framing to a hectare-based measure of available public open space, it is a therefore more localised measure that illustrates the complexities of measuring access using a ward-based target.

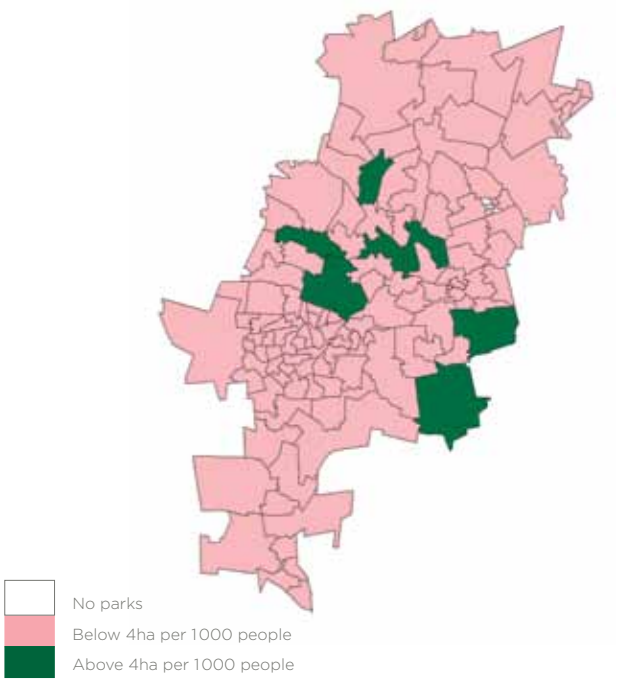


Figure 28. Wards above or below 4ha parks per 1000 individua

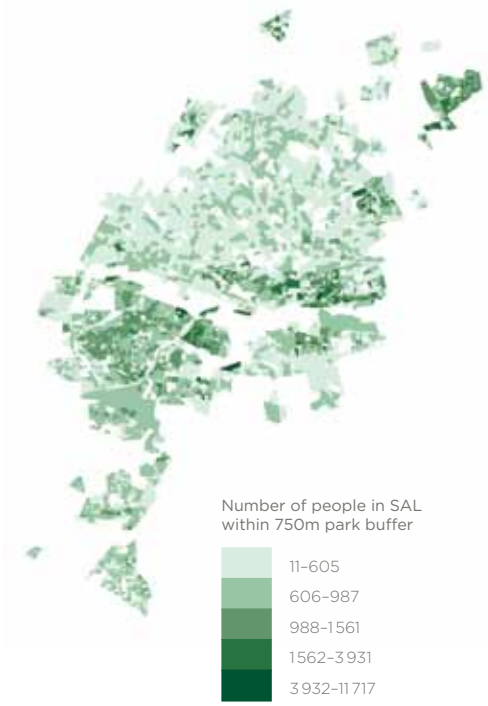


Figure 29. Population in all SALs within a 750m buffer of parks

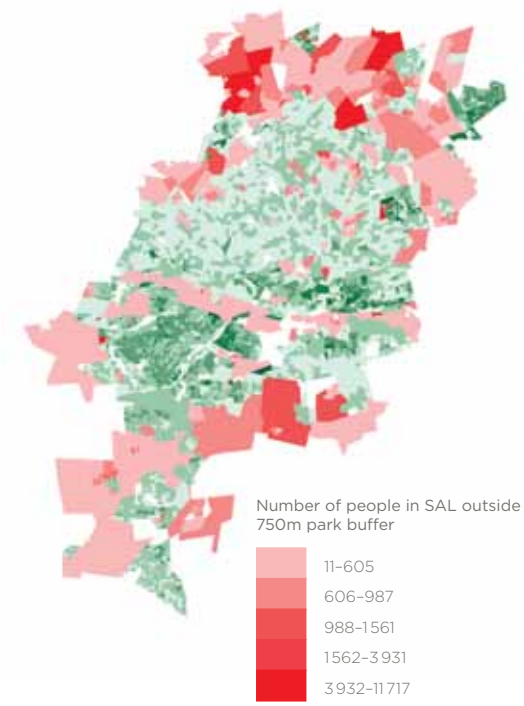


Figure 30. Population in all SALs within and outside 750m buffer of parks

Private green

In Gauteng, older, wealthier suburbs tend to have significant concentrations of green space in private gardens. Regardless of the share of public green space available in difference parts of Gauteng, there is a noticeable disparity in the amount of green space behind the walls of private space in different parts of the city-region. These variances are strikingly captured by CSIR Spot 5 aerial imagery (CSIR, 2010) in Figures 31 and 32, showing Houghton and Soweto in Johannesburg respectively. In addition to the fact that the large green spaces visible in each figure differ substantially – golf courses in Houghton versus large tracts of land dividing parts of Soweto – vegetation in Houghton is also far denser inside and outside of private properties, such as on tree-lined streets adjoining these properties.

Privately zoned green areas play a provocative role in patterns of access to green infrastructure. A substantial portion of residential and corporate properties in the GCR houses large shares of vegetation, yet the fragmented nature thereof, which is commonly the product of exclusive estates or private residences, affects access for different socio-economic groups.

Using data from AfriGIS Gated Communities (2012) and GTI 2,5m Land Cover (2012), Figure 33 represents the share of green space in gated communities, drawing out Waterfall in Tshwane and Aspen Hills in the south of Johannesburg as examples. At the same time as these gated communities fragment land – giving the landscape a parcel-like character - they also incorporate vegetation within their zoning structures, which may have otherwise been blanketed with built-up land. This raises a debate about the allegedly damaging spatial forms of estate – and gated – communities, particularly since a number of 'eco' estates, such as Waterfall Estate in northern Johannesburg, are also designed as developments that both shelter natural assets and include landscaping provisions in development guidelines.

Figure 31. Aerial image of Houghton (CSIR Spot 5 Imagery, 2010)

Figure 32. Aerial image of Soweto (CSIR Spot 5 Imagery, 2010)

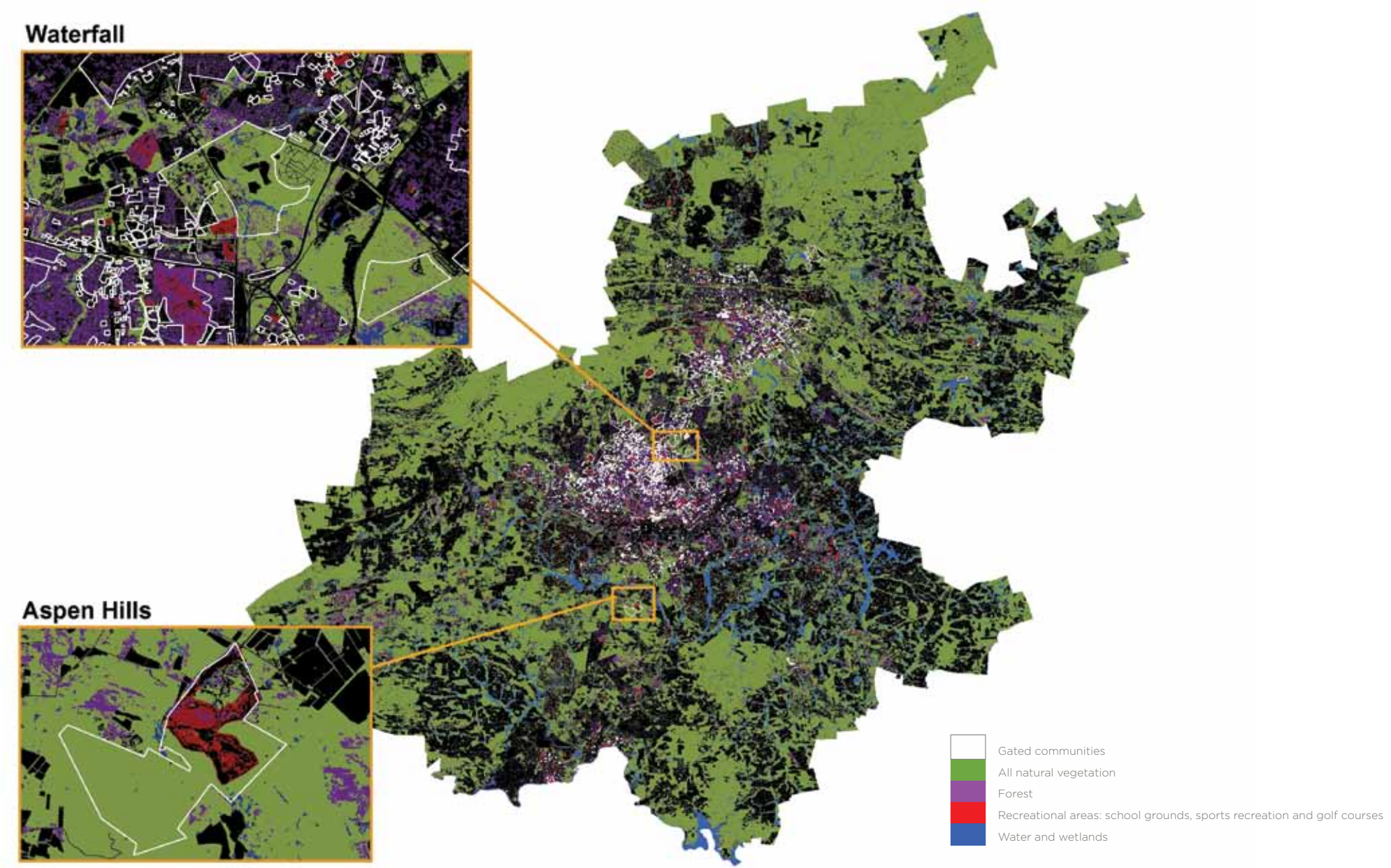


Figure 33. Private green space in gated communities

Connectivity:
The intersections between different landscapes

"There is a corridor of open land cutting across the north-south growth of Johannesburg; it runs from beyond Gillooly's Farm to the east, through golf courses, parks and public gardens, to the Zoo Lake, and on to Emmarentia and the west rand. Parts of the corridor have different formal uses: some public, some private. Together they make up a green belt providing a natural reservoir of plant and bird life, a buffer against urban sprawl, and a breathing space for the city..." (Smith, 1988).

This excerpt from The Brenthurst Gardens implies a context where a prominent green corridor threads together a series of green assets, converging as a green network in an expanding Johannesburg. Although green passages exist within the current landscape of the GCR, these are to be discerned amongst extensive built form, as more grey infrastructure has been added to the landscape. This transformation is evident in the highly urbanised central spine of Gauteng, expanding outward to encroach on natural vegetation, large portions of which have either been intersected or surrounded by built form. The results are a striking set of green fingers engulfed by rapidly spreading residential development and accompanying transport networks. In light of the effects on ecological integrity, discerning green passageways within the GCR underscores the importance of a fine-grained analysis of where portions of the landscape remain connected amidst a mass of grey infrastructure. A series of these analyses are presented in Figures 34 to 36, which utilise ESRI World Imagery (2010) to uncover the extent of green corridors across parts of the city-region. In Figure 34, for example, there are a number of a green extensions that stretch from the northern quadrant of Johannesburg south, such as via the Braamfontein spruit, yet largely exist as thin spines of green in an otherwise grey landscape.

While the landscapes of Orange Farm (Figure 35) and Hammanskraal (Figure 36) may seem to present a more favourable scenario, one where vegetation is less pressured by encroaching urban form, the configuration of these expanding informal settlements may change in years to come. These examples show that In spite of urban form, there are ribbons of green that have been kept intact. The implication is, however, whether these corridors and other current green assets can be retained in the same way as densification in the Figure 34 example has allowed.

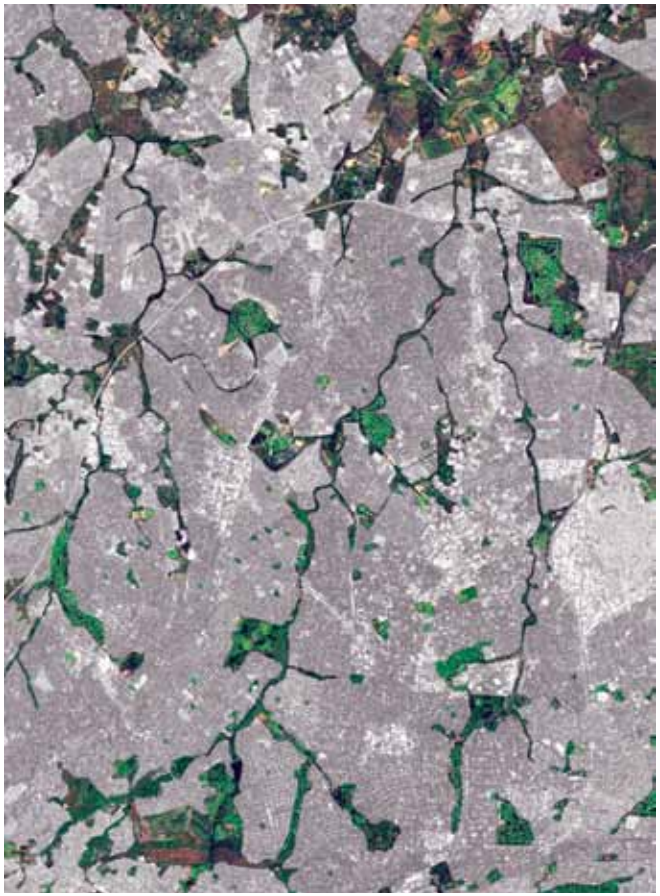


Figure 34. Green passages including the Braamfontein Spruit, Johannesburg

Figure 35. Orange Farm, Johannesburg

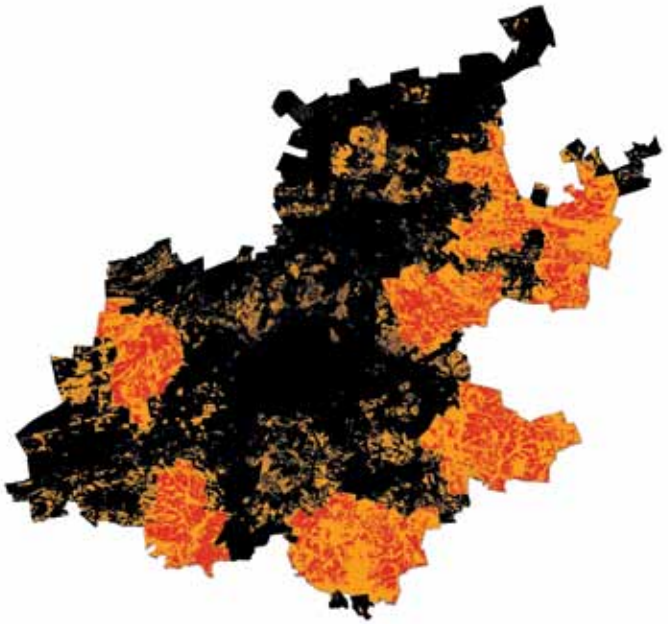
Figure 36. Hammanskraal, Tshwane

However, micro-scale linkages in the landscape are not always clear at a city-region scale where different green assets are aggregated into similar features typologies. Figures 37 to 42 assist in deciphering these landscape connections and identifying where green corridors are still intact or where these have been interrupted or fragmented by the layering on of more grey infrastructure, buildings and utility networks to the landscape. Relating this to a wider regional picture of green infrastructure therefore involves conceptual extractions of the different green asset networks that cover the city-region. These different networks have been identified as different forms of natural and planted vegetation, agricultural land, constructed recreational spaces, protected areas and hydrological networks, and are summarized below in Figures 37 to 41. Viewed together, these green assets present a view of the GCR constituted as a multi-layered green infrastructure network (Figure 42).

Figure 42 also presents a scenario of the maximum degree of spatial overlap between Gauteng's different green assets. This representation of green infrastructure differs from conventional protection approaches as it focuses on interlacing concepts from conservation, land development and crucially, man-made infrastructure planning (Benedict & McMahon, 2006). This moves beyond strict conservation applications by identifying how natural and constructed green assets in an area work together, and allow for a more sophisticated understanding of how this green infrastructure works in relation to built-form. This scenario is akin to a connectivity analysis, which refers to "the degree to which a landscape facilitates or impedes the flow of energy, materials, nutrients, species, and people across a landscape" (Ahern, 2007). While connecting different green assets using aerial imagery and digitised land use or land cover data provides an indication of the degree of green asset overlap, the reality is that this connectivity has been affected by a range of factors. These include landscape transformation, including both the expansion of built-form and the creation of new types of constructed landscapes, and a number of externalities

Multi-layered open space, trees, ridges, bare natural landscapes and vegetation

Figure 37. Natural and planted vegetation



Multi-layered agricultural lands, commercial agriculture and agricultural hubs

Figure 38. Agricultural land

Multi-layered recreational areas

Figure 39. Recreational green spaces

arising from the way development has proceeded in different parts of the province. This affects both the physical linkages between landscapes, i.e. their spatial configuration, as well as the degree of functional connectivity in terms of the ability of a landscape to continue to provide services to society. For instance, while the inner city of Johannesburg is more densely grey than green, it is connected to near inner city suburbs by networks of street trees, which interestingly follow the grey corridors of roads. In contrast, large green segments of land between Johannesburg and Ekurhuleni may seem to represent an uninterrupted green asset, but are intersected by a major transport route.

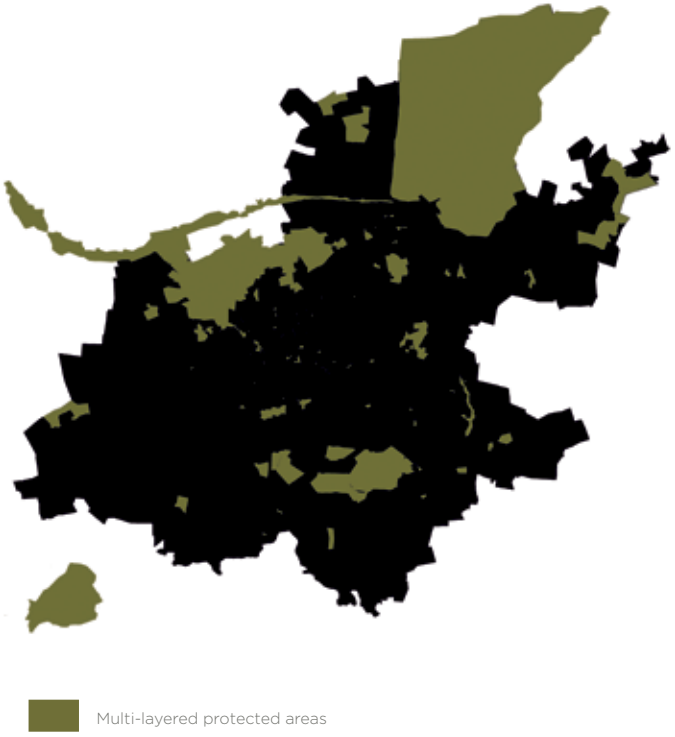


Figure 40. Protected areas

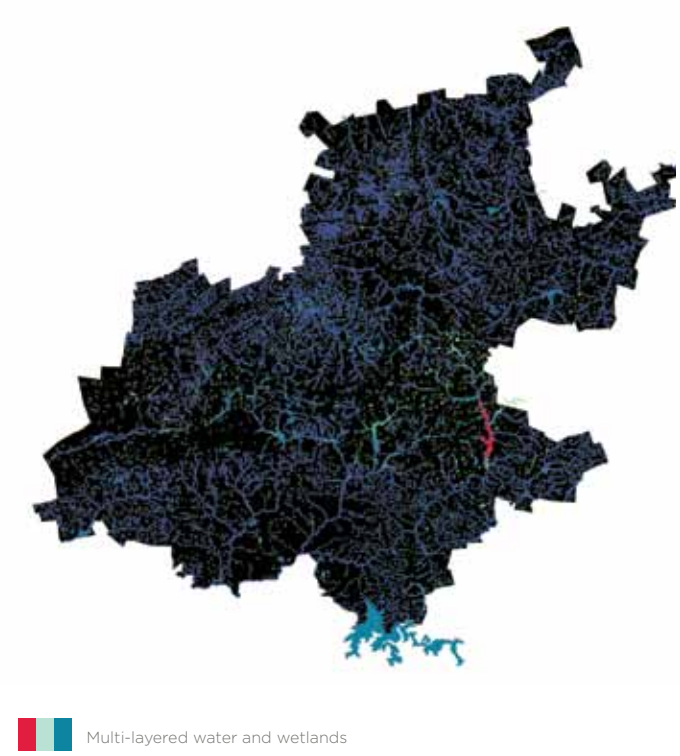


Figure 41. Hydrological networks

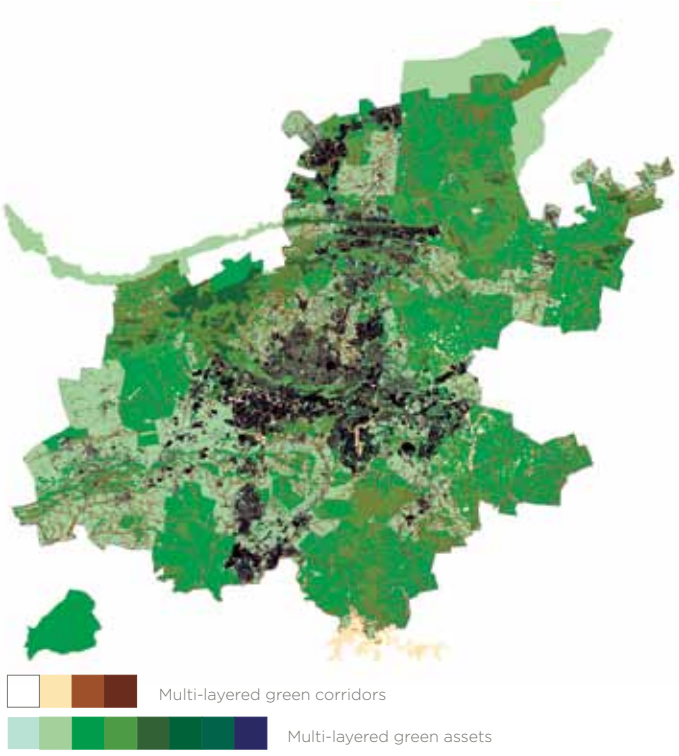


Figure 42. The GCR as a multi-layered green infrastructure network

WATER

Natasha Christopher

Acid, West Rand, 2012
Water, Springbok Park, Tshwane, 2013

SECTIONTHREE

This section provides a systematic review of how green infrastructure is being thought about, planned for and implemented in municipalities across the GCR. Each case study assesses how government structures and individual officials are interacting with green assets in their planning and management processes, and the resulting opportunities for and blockage points to prioritizing these assets as infrastructure

Current government plans, visions and capabilities for green infrastructure

In the Gauteng City-Region (GCR), a number of foundations have been laid for investment in the region's ecological assets. There is a strong promotion of natural resource protection, with various policies focusing on conservation targets to preserve indigenous or naturally occurring vegetation. Many of these targets are motivated in light of the eco-tourism benefits of conservation programmes, through which there is a connection into economic development. Strategic dialogues are also recognising that investments in ecological assets, specifically trees and certain plants and shrubs, can assist in mitigating the adverse consequences of inter alia, heavy winds, airborne dust and various forms of pollution. Where planning processes are incorporating ecosystems services into mainstream planning, there is an explicit focus on community benefits of greening investments which are often articulated as initiatives that both reduce peoples' vulnerability to environmental stress and redress ecological disparities inherited from apartheid. Despite an institutional openness to such investments, new strategic commitments in trees, community gardens and landscaping to accompany new developments are challenged by fiscal priorities which often favour short-term economic multipliers such as large residential developments from which municipalities can accrue tax benefits.

It is encouraging, however, that municipalities are seeing development pressures as opportunities to incorporate landscaping and greening and it is significant to observe collaborative efforts between private developers and government, which reflect a broader political space to think differently about how investments in ecological assets can be financed and sustained through creative service delivery arrangements.

This chapter reflects upon the production and recreation of landscapes in local municipalities of the GCR through interrogating the processes by which government plans, invests and values ecological and green assets as part of the operations and objects of municipal service delivery.

A series of case studies provide an overview of relevant institutional structures, frameworks and programme in Gauteng's three metropolitan municipalities, two district municipalities and their respective local municipalities. This review of institutional and policy processes focuses on how public entities interact with green assets and examines whether a conscious effort is being made to value these assets as infrastructure. In doing so, the case studies highlight where in the institutional architecture of local government green assets are supported and discuss some of the blockage points within municipal operations to mainstreaming a green infrastructure mind set.

FLOWER BOX, BENTLEY STREET, ROBERTSHAM, JOHANNESBURG, 2013

City of Johannesburg

This case study discusses the institutional and policy landscape through which ecological assets are planned and budgeted for in the City of Johannesburg, focusing on whether such assets are understood and planned for as infrastructure. The following analysis provides an account of how ecological assets feature in Johannesburg's planning consciousness, the nature of recent green investments by the City as alternatives to grey infrastructure and the implications for municipal innovation in green infrastructure. Johannesburg appears to be making some headway in terms of more integrated landscape planning, but there is still a room to expand the City's definitions of 'green space' and to develop the skills and resources devoted to valuing ecological assets in an infrastructural sense.

Johannesburg's urban landscape

Johannesburg has an interesting, yet controversial ecological profile. Prior to the gold-mining boom of the 1880s, the Witwatersrand had no trees, no gardens, no parks, and the natural landscape was characterized by savannah grassland, scattered bushveld, and some native woodland areas (CoJ, 2012; CoJ JCP, 2012). Today however, Johannesburg is home to an extraordinary ecological asset, what is claimed to be the world's largest urban forest, which according to the City is said to have grown to 10 million trees (CoJ, 2008). Now interspersed with public and private green spaces, the urban forest is a significant ecological feature that needs to be understood as a product of the city's intersecting industrial and ecological histories.

In the late 19th century, a tree-planting boom began as an attempt to both settle the dust, and cleanse the air, as a result of intense mining activity during the Gold Rush, and to supply poles to support mine shafts and excavations (Turton *et al*., 2006). Quick-growing species such as Eucalyptus, Black Wattle and Jacaranda, and varieties with which the colonials were familiar such as London Planes, Oaks and Pepper trees, were introduced during a massive tree-planting scheme that paralleled the expansion of mining activities (Turton *et al*., 2006; CoJ, 2003; CoJ JCP, 2012; Mawson 2004). While indigenous trees initially met the demand for mining timber, these became denuded with the expansion of mining and led to both private landowners and mining companies investing in large scale non-indigenous timber plantations. These fundamentally transformed the landscape in and surrounding Johannesburg (Christopher, 1982). It is important to note that mining companies imported a substantial number of trees preferred for supporting mining activity, such as the quick-growing Eucalyptus, familiarly known as Blum Gum from Australia, which with a tall, branchless appearance and growing period of 8-12 years, was seen as bringing the quickest commercial return; ideal for use in mine shafts (Christopher, 1982; Mawson, 2004).

The establishment of nurseries and the current Horticultural Training Centre at Zoo Lake (CoJ, 2012) were some of the social structures that helped coordinate the transformation of Johannesburg's natural landscape. Experiments conducted to test the suitability of various tree species for mine props were further drivers of en-masse tree planting in present day Saxonwold, Parktown, Langlaagte, Craighall and Fairland. Residents were also given trees to plant in their gardens and trees for domestic horticultural use (CoJ, 2012; Christopher, 1982; Mawson, 2004).

The result was that coupled with mining-driven tree planting processes, a mosaic of green spaces began to emerge in Johannesburg, consisting of features indigenous to the Highveld landscape, such as savannah grassland, interspersed with suburban-style green spaces that were sustained through household level tree-planting and garden beautification (Turton *et al*., 2006; Mawson, 2004). The naming of Johannesburg's early suburbs, such as Forest Town, Parkview and Parktown (Turton *et al*., 2006) is reflective of the wider ecological constructions that took place through individual investments in ornamental greening and horticulture. Over time, there has also been a significant increase of private green spaces in Johannesburg and the pervasive presence of suburban gardens embodies interesting socio-spatial dynamics where enclosed, private grounds are outcomes of unequal social realities, but also representations of the substantial investments of citizens in formulating a sense of belonging and spatial identity (Wylie, 2011). That is, while the uneven distribution of tree coverage and private green spaces is a physical manifestation of unequal access to services across the city (Schaffler and Swilling, 2013), there are citizen greening investments that play a fundamental role in the form of Johannesburg's landscape.

The mix of different land cover classes in Johannesburg is illustrated in Figure 43, a map based on GTI 2,5m Land Cover from 2010, which represents the share of urban areas (buildings, industrial, residential, small holdings, new developments, streets and roads) relative to both manmade and natural green space. The data shows that the significant share of manmade or planted green space (gardens, golf courses, non-natural trees) in Johannesburg versus natural green space (thicket, bush veld, bush clumps, indigenous forest, shrub lands, degraded natural vegetation and natural land surface), so that although there is a high overall share of green space, a large portion of this is not necessarily naturally occurring.

GARDEN COURT, MILPARK, JOHANNESBURG, 2013


Garden Court

Relevant institutional processes

Green space management is the formal mandate of the City's conservation and greening agent, Johannesburg City Parks (JCP), colloquially known as 'City Parks'. City Parks is a municipal-owned entity (MoE) that manages a number of ecological assets such as parks, cemeteries, street verges, nature reserves and street trees (CoJ JCP, 2008/9). Because City Parks is formally designated as a section-21 company in South Africa, its existence is non-profit, with the mandate to provide and manage designated green spaces for and on behalf of the City of Johannesburg (CoJ JCP, 2008/9).

City Parks receives its mandate via the Department of Environment and Infrastructure Services at the City of Johannesburg. The Department's operations are divided between a branch called 'Environmental Planning and Management' – which oversees City Parks and the Johannesburg Zoo – and an infrastructure and services portfolio with directorates responsible for energy, waste and waste (CoJ, 2012).

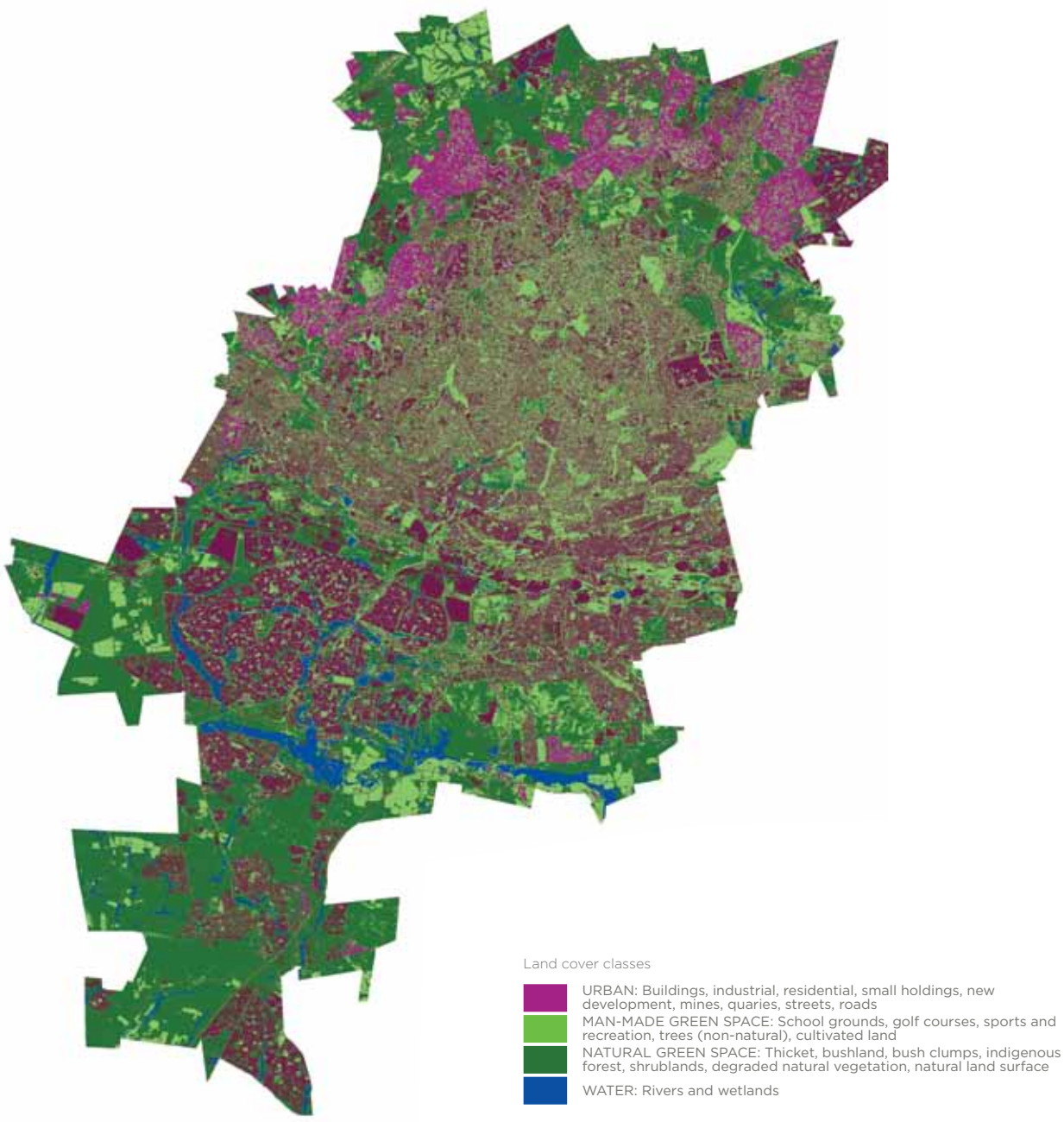


Figure 43. Overview of land cover classes in Johannesburg

As a MoE, City Parks has a certain degree of independence in its daily operations which focus more specifically on the following:

- Planning, design and landscaping
- Park utilisation management
- Environmental conservation, including biodiversity management and awareness
- Park, open space and cemetery maintenance
- Horticultural and arboriculture projects
- Bio-aquatic management
- Botanic research, monitoring and information sharing
- Conservation, rehabilitation and enhancement of ecosystems
- Invader species control
- Infrastructural maintenance.

In parallel to this basket of activities, Johannesburg undertakes a number of environmental education and community participation programmes, such as Arbour Week, 200 000 Tree Planting Campaign, Extreme Park Makeover, Greening Soweto and Outdoor Gyms. City Parks has a vision to be Africa's leading green environment and cemetery management company. This vision is further informed by targets to reduce ecological disparity and ideas of environmental justice, with an explicit emphasis on 'bridging the green divide' and a 'legacy of inequality separating the wealthy north from the dusty south west':

"... City Parks is committed to bridging the green divide between disadvantaged townships and the suburbs. It is responsible for providing inclusive open spaces and serves all the people of Joburg."

To the extent that City Parks is strongly inclined to the creation, protection, maintenance and development of green open spaces in previously disadvantages areas, it appears that public investments in Johannesburg's landscape are largely driven as rights-based green space interventions. Indeed, the provision of green space within Johannesburg's broader umbrella of 'environmental management' is very much a matter of 'redressing ecological deficiencies' and 'improving access to recreational space'. The provision of green space for these particular purposes is largely linked to whether communities were previously disadvantaged and the trend towards 'Eco-recreation' within City Parks' public parks-style investments. These are manifesting in projects such as the development of a park at Cosmo City (a multi-racial, multi-income housing development) and park development at Ivory Park and Zola Eco Park, two communities identified in terms of their previous disadvantaged status. The following 2013 press release is also suggestive of an enlarged budget for parks development in marginal areas.

"CITY Parks and Zoo receives an operational budget of R693 million. The R373.9 million capital budget of City Parks and the Zoo will go towards projects such as new parks in Leratong, Poortjie, Orange Farm, Northern Farms – Diepsloot, Chiawelo and Road Islands; the development of the Olifantsvlei cemetery, and R10 million for the establishment of new parking facilities at the Zoo."

(JCP, 2013)

While principally coordinated by City Parks, greening initiatives in Johannesburg have also incorporated a number of other agencies, brought on board to contribute both financially and from an operational perspective:

"JCP works closely with various other agencies in ensuring the greening mandate is carried forward. Due to JCP's reputation for innovative parks and beautification development, over the passt year JCP has been contracted to work with other government departments to aid and assist in developments outside of the CoJ. This includes the National Department of Water, Agriculture and Environment for the park development in Mthatha and the Provincial Department of Transport for the beautification of the R24 Albertina Sisulu Road from OR Tambo airport." (CoJ JPC, 2009/10)

Such alliances also extend to private – and non-governmental partnerships, which play a strong role in City Parks' active tree planting campaigns. For instance, despite internal budgets for tree planting, a substantial number of City Parks projects rely on conjoined efforts between the MoE and external partners, such as the tree planting initiative with Citi Bank at Orlando West Park, where 100 trees were planted to "address disparities and for beautification purposes, and improving the state of the environment" (CoJ JCP, 2009/10). Such projects gained momentum in the run up to the 2010 Soccer World Cup, which initiated a major drive to redress ecological disparity in historically treeless areas through tree-planting schemes, but with a definite intention of preparing Johannesburg to host the international sporting event (CoJ JCP, 2009/10). In these cases, a number of partnerships were formed between City Parks, as a municipal agency, and private nurseries or growers who contribute in kind by donating trees and seedlings, with civil society or non-governmental organisations (NGOs) also taking up 'brokering' role in these arrangements. It is encouraging that these tree planting programmes also aim to increase both the size and quality of indigenous habitats, coupled with the conscious prioritisation for indigenous planting in previously disadvantaged areas such as Mofolo South, Orlando West, Orange Farm, Mapetla, Diepkloof, Dlamini, Zola and Dobsonville (CoJ JCP, 2012).

Johannesburg's efforts to conserve green spaces and biodiversity are therefore underpinned by an explicit equity rationale, with access appearing to be a key precondition and determinant for green space planning generally. While goals for the 'protection of river eco-systems, water conservation and protection of ecological reserves' indicate a positive ecological consciousness, there is a perhaps a stronger campaign to improve access and beautify green spaces in communities historically excluded from such investments. For example, City Park's suggested goal of "four hectares of open space for every 1 000 people" (CoJ JCP, 2012) and to meet international benchmarks of 2 hectares of quality public open space per 1000 residents in dense urban settings is an explicit social and aesthetic commitment in light of the somewhat ambiguous reference to 'open space', which could be any form of open, partly vegetated land.

The underlying orientation towards community-driven planning is also supported through the City's Capital Investment Management System (CIMS), which prioritises investment decisions and tracks the progress of projects that have been approved for implementation. The variables embedded in CIMs are based on the requirements of a given population, particularly new developments to accommodate for population growth, and the services and infrastructure these developments require (CoJ JCP Official, *pers. comm*, 2013). Officials at City Parks reflect that CIMS is used to determine priority greening projects for capital expenditure with high priority projects being in previously disadvantages communities (CoJ JCP Official, *pers. comm*, 2013). Officials also reflect that this inclination is supported by mayoral priorities and the City's long-term development paradigm through visions such as the Growth and Development Strategy (GDS) and the Spatial Development Framework (SDF).

SOCCER CITY, NASREC, SOWETO, 2013

Relevant strategic processes

The City of Johannesburg has interpreted a greening mandate through a number of ecologically progressive policies and frameworks. Some of these are required in terms of national legislation, such as the Biodiversity Act, 2004 (Act 10 of 2004), which stipulates that local and district municipalities are mandatory users of Bioregional Plans, which much align to Integrated Development Plans (IDP)s and SDFs. In addition to these mandatory obligations, Johannesburg has developed some specific policies and frameworks that encapsulate the framing of its greening mandate. The Joburg Metropolitan Open Space System (JMOSS) was developed in 2002 with the view to address loss of green spaces, in response to the lack of a policy framework to guide green space planning and management in the City (CoJ, 2002; CoJ Eagle, *pers. comm,* 2012). JMOSS is articulated as providing a comprehensive policy framework and / or guidelines for the protection, management and optimisation of open space areas within the City (CoJ, 2002). Significantly, JMOSS calls for the following:

"planning, development and management of green spaces can no longer be regarded as secondary to other local council functions." (CoJ, 2002)

"[green space] requires recognition as an asset that requires careful management, and needs to be afforded a status by all citizens of Joburg that will lead to continued and productive use." (CoJ, 2002)

JMOSS specifies three categories for green spaces in the city, namely primary, secondary and tertiary open spaces. Within these categories sub-categories detail the features of different green spaces such as botanical gardens, water-bodies, nature reserves and other related spaces (CoJ, 2002). However, a number of city officials have raised concerns about the accuracy and details of this information, primarily due to deficient or irregular ground-truthing that took place during the development of JMOSS, which was essentially a desktop study (CoJ JCP Official, *pers comm,* 2012; CoJ Eagle, *pers. comm,* 2012). Similar concerns emerge in terms of the JMOSS policy objectives, which give overarching guidelines and principles but not the "specific criteria to be applied to primary open space in order to determine the most appropriate management strategy and policy to give effect to MOSS and its management" (CoJ JCP Official, *pers. comm,* 2013). This has resulted in numerous challenges where areas were determined via the three-tiered categorisation process, yet with no specific criteria about how these should be developed, supported or maintained (CoJ Eagle, *pers. comm*, 2012; CoJ JCP Letsoko, *pers. comm,* 2012).

Following these concerns, the City of Johannesburg convened a second JMOSS policy in 2004, questioning the process and methodologies followed for the initial JMOSS. The second JMOSS policy sought to provide "more robust criteria and principles for the identification of high value primary open space, in line with broader legislative and policy frameworks, and creating further proactive and reactive mechanisms for the protection and management of open space" (CoJ, 2004b). The focus of the policy was the management of the existing and desired primary open spaces through setting out guidelines for how these spaces should be managed both in terms of biodiversity conservation and ecological sensitivity (CoJ, 2004b). However, the application of JMOSS II needs to be treated with caution, since its policy proposals were based on the same data – which lacked ground-truthing – that informed JMOSS I (CoJ, 2004; CoJ Eagle, *pers. comm*, 2012; CoJ JCP Letsoko, *pers. comm*, 2012; CoJ JCP Njingolo, *pers. comm,* 2012).

The troubled JMOSS processes saw the City of Johannesburg develop a Bioregional Plan (BRP) in 2011 with an expectation that the plan will feed into broader planning and development frameworks, and be streamlined with other planning tools such as the Environmental Management Framework (EMF) and Spatial Development Framework (CoJ, 2011). The plan is seen as critical for informing "land-use planning, environmental assessment and authorisations, and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity" (CoJ, 2011). In theory, the plan should provide guidelines for the conservation of biodiversity and support for ecological areas in Johannesburg given the high demand for "mining activity, industry, commercial enterprise activities" in the City. Reporting that approximately 36% of the City is in a natural or near natural state and 48% of the city is reported to be built-up or transformed for various urban functions (CoJ, 2011), the Bioregional Plan set a mandate of mitigating further depletion of natural environment and urbanisation pressures through prioritising Critical Biodiversity Areas (CBAs) and Support Ecological Areas (SEAs).

Current initiatives

While not explicitly articulated as green infrastructure initiatives, various greening projects driven or facilitated by City Parks are seeing investments in ecological assets. In terms of City Park's key performance areas, for instance, the following targets were cited for 2009/10 regarding protection of river eco-systems, water conservation and protections of ecological reserves:

1) The actual of 8 wetlands rehabilitated and improved exceeded the target of 5
2) The actual of 7 clean ups in terms of maintenance and control of reeds exceeded the target of 4
3) The actual of 383 ha of river trails cleaned / rehabilitated / maintained exceeded the target of 216 ha
4) The actual of 1 912 ha cleaned from alien vegetation exceeded the target of 1 402 ha
5) The actual of 96% of compliance with Environmental Management Standards (EMS) exceeded the target of 95% for the 2009/10 financial year.

Within these areas, the reference to the EMS indicates that City Parks takes cognizance of benchmarking, in addition to Johannesburg-specific targets relating to wetlands and rivers. The EMS is the set of processes and practices developed by the International Standard Organization (ISO) to guide control and improvement of an organization's environment performance, the current form of which is the ISO 14001 EMS (EMS, 2013).

While such targets represent a clear goal to address ecological degradation, a major thrust within City Parks is a set of aesthetic greening initiatives prioritised for communities without access to 'green space'. Current initiatives ranging from 'park beautification, maintenance and upgrades and tree planting' have clear socio-spatial patterns, which is understandable in light of the uneven spatial distribution of service delivery inherited from apartheid. For instance, many trees planted as part of greening programmes are generally concentrated in Orange Farm, Soweto, Diepsloot, Vlakfontein and Jabavu as areas excluded during historical en-masse tree-planting. For similar reasons, City Parks is undertaking a substantial number of new park developments with the aim of offering public space opportunities in communities where these have been historically absent.

There are also beautification projects that are part of greening spaces adjacent to highways and main roads as well as the areas surrounding large infrastructure projects such as Orlando Stadium. In effect, these projects work to beautify existing or newly

ELECTRIC, RED, ELECTRIC – NORWOOD, JABAVU, JABAVU, 2013

laid grey infrastructure through landscape design and installation. They are very much determined by the requirements for new roads, stadia or utility networks rather than an explicit mandate to invest in a green infrastructure network for its own inherent value. While the inclusion of landscaping plans and designs within City Park's project specifications is valuable, these will not necessarily amount to infrastructural connections if they occur in isolated cases, without clear plans to connect initiatives through planned ecological corridors and linkages.

Outside of the greening activities undertaken by City Parks under the environmental portfolio of the Department of Environment and Infrastructure Services, there has been some receptiveness to green infrastructure as an alternative strategy for storm water management. For instance, the Johannesburg Roads Agency (JRA), which is responsible for roads and storm water management in the City, received pilot training from SWITCH, an action-research programme, implemented and co-funded by the European Union with a cross-disciplinary team of 33 partners from around the world, to instigate a shift from the logic of "getting rid of storm water as quickly as possible" to "maintaining natural water balance" (SWITCH, 2010). This is through innovations relating to Sustainable Urban Drainage Systems (SUDS), which embrace integrated water cycle management through harvesting and or treatment of storm water and wastewater to supplement potable water supplies. Green infrastructure technologies that utilize, enhance and/or mimic the natural hydrological cycle are key in this approach (Beecham & Fallahzadeh, 2011; Environment Protection Agency (EPA), 2008). In this context, green infrastructure approaches are generally decentralized, small to medium-scale infrastructures, including green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, porous and permeable pavements, vegetated median strips and reforestation/re-vegetation, as well as the protection and enhancement of riparian buffers and floodplains (Younos, 2011).

However, it is yet to be seen whether the interventions facilitated through the SWITCH training have taken hold in Johannesburg since most current projects, such as storm water infrastructure plans for Orange Farm, are premised on an engineering logic of large, once-off investments in concrete conduits and channels that only have seasonal use (Schaffler, forthcoming). As a JRA official reflects, "...although we know SUDs is the preferred approach, these still need to be verified in terms of budget and if it incurs additional costs, we will continue to convert open channels and use underground pipes" (CoJ JRA Official, *pers. comm,* 2012). So while alternative ways of managing storm water are being considered, and in fact are the only explicit conceptualisations of green infrastructure, there are various challenges regarding the effective take-up of decentralised green infrastructure practices. This is clear in further reflections from City officials:

"...on the other hand, the problem is that you have engineers who, in most cases, do not want to change and adapt to new ways of thinking about the engineering and design of for example, pavements." (CoJ Official, pers. comm, 2012)

"Most traditional engineers think that if you use, for example, street swales or buffer strips for drainage, you then have a situation where you constantly have to maintain these and as a result incur more cost you would have avoided if you provided concrete paving." (CoJ Official, pers. comm, 2012)

"...even the notion of implementing green roofs or gardens raises a lot of concerns. For those trees to grow, tons of soil will have to be loaded on the building roofs that were not initially designed for such mass. With rainfall, this mass will be even doubled. Now you can imagine the effect this will have on the building. So, to have such initiatives will require that more money is spent to ensure that we do not have buildings collapsing in the next few years." (CoJ JRA Official, pers. comm, 2012)

"...our role is to ensure that the surface of the road gets dry as quickly as possible after rainfall. Now, I am not sure if having green servitudes will appropriately serve this purpose." (CoJ JRA Official, pers. comm, 2012)

Perceptions of ecological assets

Just like any other rapidly growing city, Johannesburg is faced with numerous development pressures, ranging from housing, road infrastructure, employment, and the provision of other basic services. A key challenge for Johannesburg appears to be the processes and decision-making structures that underpin development priorities. The redevelopment of Huddle Park golf courses into a mixed-use facility captures some of the challenge in land use decisions. Huddle Park was originally envisaged as a housing development, and the 2002/03 proposal for development of low cost housing in the eastern quadrant of the City sparked substantial frustration by local communities. Critique came from communities who used the area for recreational purposes and because of the location of wetlands in the park:

"I still do not understand how they came to this decision. We personally had to fight them, the City, for this proposed development. It just seems as if they do not care about the environment, but collecting rates." (Ward 73 Committee Member, pers. comm, 2012)

In 2007, the housing plans for Huddle Park were cancelled and the area was reconceived as a mixed-use facility, incorporating the existing golf course and an upmarket retail centre (CoJ, 2007). The current development, promoted as the "much anticipated revival of Huddle Park" is called "New Huddle Park Golf & Recreation" (Huddle Park, 2013) and is promoted in terms of the various outdoor facilities offered, including three golf course types, walking running and cycling, amongst others. The morphing of Huddle Park into an upmarket development highlights the tensions experienced in the initial development application processes, and the extent to which public interests are truly incorporated in developments that may, in reality, not be readily accessible to a broader public.

Another key challenge relates to the mixing and/or overlapping of responsibilities for the drafting of policies. In the development of the Johannesburg Open Space Framework (JOSF), City Parks assumed a leading role rather than a supporting one. Interestingly, it is the department of Environmental Planning and Management that assumed a supportive role. As noted by one of the JCP officials "*we are the ones who developed the Johannesburg Open Space Framework that guides planning and management of our green assets today*" (CoJ JCP Official, *pers. comm*, 2012). In this instance, it is unclear how the responsibilities and functions are shared between the city departments and MoEs. It is also difficult to understand how City departments have evolved to exercise their oversight functions. The JMOSS, for example, was initially developed within an Environmental Planning directorate that was part of a much larger department that also included strategic planning and transport directorates. This institutional organisation has undergone various modifications, namely, a separate Environmental Planning and Management unit, which has subsequently been merged with an infrastructure directorate.

Concluding remarks

In Johannesburg, greening initiatives are often seen as means to facilitate recreational opportunities and assist in redressing historical ecological disparities. While these initiatives come in a variety of forms, investments in tree planting, park developments, maintenance and upgrades, and beautification initiatives such as road islands, appear to be the most common. In this respect, 'greening' seems to serve social development objectives and it is not clear whether Johannesburg is making a conscious synthesis of these ecological functions of greening projects within the broader landscape. There are, however, investments that embrace the role of indigenous vegetation and the maintenance of natural ecological processes, but are largely approached as conservation strategies rather than broader infrastructure planning.

While there are progressive officials who promote green infrastructure as an alternative strategy, these officials are often challenged by a set of perceptions, planning cultures and standard daily operations that stunt innovation. Obstacles exist for officials and managers to articulate the benefits of green infrastructure solutions when everyday operations continue to provide for traditional concrete canals, gabions and steel reinforcing to "deal with urban flooding". At a daily operational level, these practices, coupled with a cognitive and cultural reluctance to abandon business as usual, is creating a situation where officials are either sceptical or reluctant to entertain alternative infrastructure options, with various officials reflecting, without detailed evidence, that "green infrastructure methods are expensive" (CoJ JRA Official, *pers. comm*, 2012). The possibility of transforming current infrastructure practice, in the case of storm water management, through a green infrastructure philosophy is therefore met with a number of difficulties when decision-makers are faced with shifting out of a particular infrastructural trajectory.

In terms of what has already been done from a strategic perspective, there are a number of policies and frameworks that suggest substantial work has been undertaken under the ambit of 'green space planning'. There is a strong theoretical foundation for green space planning, but it appears that the City understands green assets in various ways as a conservation mandate, as a means to address spatial disparity and as beautification to accompany grey infrastructure. While there are some indications that green infrastructure in the true sense is understood, there has been limited realisation of the concept in plans and practice.

Ekurhuleni Metropolitan Municipality

Ekurhuleni Metropolitan Municipality (EMM) represents the fourth most populous of South Africa's eight metropolitan municipalities. The metro was established following the amalgamation of nine cities and two other councils in 2000, from what was historically known as the "East Rand". EMM is now home to 25,9% of Gauteng's total population in an area of 1 976 km^2, and with 1 609 people per km^2 is one of the most densely populated areas in the country. Ekurhuleni is a centre of heavy industry and manufacturing, and is often referred to as "Africa's workshop", encompassing the largest concentration of industrial activity in South Africa and sub-Saharan Africa (Machaka and Roberts, 2004). It is also regarded as the national transport hub, housing OR Tambo International airport and links to extensive national and cross-border roads and rail networks, converging with factories and production facilities to fuel a strong manufacturing and industrial sector that accounts for just less than 26% of provincial GDP (National Treasury, 2009).

Ekurhuleni's industrial base was created on the back of South Africa's mining industry, the legacy of which is now being felt through a number of externalities. Degradation of natural vegetation and vulnerable hydrological systems are posing challenges in light of development pressures and an urge to upscale industrial activities, such as future plans to become an Aerotropolis ('a new urban form placing airports in the centre with cities growing around them, connecting workers, suppliers, executives, and goods to the global marketplace'). In light of these trends, it is encouraging to see various progressive policies and frameworks supporting green assets as well as a number of greening projects, although questions remain regarding the coherence and integration thereof. Many initiatives seem distinct in that they are isolated from critical ecological and hydrological networks. What follows is a review of how the value of ecological assets is being internalised within EMM's strategic processes and how these have come to matter politically.

The landscape

While EMM is situated within a naturally occurring Grassland Biome, transformation of the landscape has meant that only a few areas of high quality grassland remain (EMM, 2009). In EMM, there are 10 threatened ecosystems and at least 16 threatened plant species while a large portion of the metro's wetlands and freshwater ecosystems are also critically endangered (EMM, 2011a). According to the EMM Environmental Policy (EMM, 2012a), development pressures have meant that just over 36% of EMM remains in natural or near natural state while 64% of the metro has been transformed for agricultural, urban and mining activities. In terms of future land uses, EMM is viewed as an important agricultural resource with 41% of the metro identified by the Gauteng Agricultural Potential Atlas as important for protection of agricultural resources (EMM, 2012a).

EMM is also situated on a continental divide and local watershed, which serves as the origin for various rivers and hydrological systems. The EMM Environmental Policy of 2012 views the intricate network of rivers, wetlands and pans as the single most important natural feature of the EMM, providing the overall backbone for an open space system and the system of biodiversity resources (EMM, 2012a). These resources include a number of untransformed grasslands, such as the Moist Cool Highveld and the Rocky Highveld; the proposed Meyersdal Nature Area; and hydrological resources such as the Natalspruit and wetlands, Swartspruit and Blesbokspruit Ramsar Wetland, one of seventeen internationally significant wetlands in South Africa, as well as various dams and pans (EMM, 2012a, EMM, 2004).

Relevant strategic and policy processes

EMM has a number of policies, frameworks and plans which reflect the importance of ecological assets in development outcomes. These commitments range from conservation-style support, such as alien-clearing and protection of wetland, to objectives of linking natural elements within open space frameworks and the promotion of ecosystem services for their potential socio-economic value. This signals progress with regard to integrating the services of ecosystems into development outcomes and it is significant that Ekurhuleni is also undertaking a number of 'greening' processes in local communities that are sometimes not publicised in high-level development and spatial planning frameworks.

At a generic level, the 2055 Draft Growth and Development Strategy (GDS) describes the future vision for Ekurhuleni, to *Grow and Sustain a Sustainable City.* This vision is underpinned by a number of sound ideas such as "sustainable natural resource use; continuous improvement in air, water and soil quality; decreased consumption of limited natural resources; integrated sustainable agriculture; stable and protected ecosystems; and; biodiversity and ecosystem protection in light of current ecosystems degradation" (EMM 2012b). These are supported by a number of strategic processes and policy documents within EMM (Table 3), through which appeals are made to:

- Avoid fragmentation of natural systems
- Protect the integrity of the primary open space network
- Enhance access to open spaces
- Endorse densification within the urban fabric
- Recognise ecological function when assessing environmental impacts
- Quantify environmental goods and services in terms of their economic value
- Integrate the open space system and conserve biodiversity as an integral land use
- Use the open space network as a planning tool to contain development, and in doing so, protecting the natural environment and agricultural potential.

Ekurhuleni Biodiversity and Open Space Strategy (EBOSS) (2009)	Meet open space needs of the population of Ekurhuleni in a way that will ensure adequate access to a variety of types of open spaces in Ekurhuleni that will fulfil the physical and psychological needs of the community; Meet the national biodiversity targets for vegetation types in the area in an appropriate manner that focuses on attainable on attainable priorities; Consider and integrate the conservation plan needs of the province in a practical way Consider and take land needed for development into account in an objective and equitable manner Contribute as an integrated elements in the proper functioning of Ekurhuleni as a city
EMM Environmental Policy (2012)	Key natural resources are protected and conserved EMM employees are aware of environmental matters and environmental education initiatives are implemented Environmental principles are embedded in Infrastructure and development activities in EMM Land, water and air pollution is prevented and reduced Catchments are managed in an integrated manner EMM is energy efficient and has adapted to climate change impacts Sound environmental governance
Ekurhuleni Environmental Management Framework (EMF) (2011)	The protection and conservation of areas that are sensitive from an ecological and hydrological perspective Protection and conservation of areas that have a high potential or value for agriculture Management of urban sprawl Management of urban open space
Ekurhuleni Bioregional Plan (2011)	Inform land-use planning, environmental assessment and authorisations, and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity. This through providing a map of biodiversity priority areas, referred to as Critical Biodiversity Areas and Ecological Support Areas, with accompanying land use planning and decision-making guidelines.

Table 3. Relevant green space provisions and guidelines in EMM strategic processes

Ekurhuleni's articulation of ecological priorities is in relation to matters such as 'natural resources and system', 'open space networks', 'biodiversity' and 'environmental goods and services'. These priorities represent positive ambitions for landscape-scale approaches to spatial planning. Indeed, references within various documents to *corridors* and *connectivity* (Box 2) show a conceptual recognition of the need to create linkages between ecological features through "linking primary and secondary open space networks" (EMM, 2012a) and "maintaining ecological support areas in functional states" (EMM, 2011a). The main channel through which practical provisions are made for these ideas to be implemented is the Ekurhuleni Metropolitan Spatial Development Framework (MSDF) (2011), the primary spatial planning tool through which land use guidelines are applied. Significantly, the MSDF (2011) stipulates the following terms for natural open space to be integrated into the urban context:

"Protection of Open Space: The primary open space network, as identified and classified in EBOSS represents the minimum open space areas that needs to be retained from a biodiversity and ecological services perspective. The primary open space system must be included in the Ekurhuleni Spatial Development Framework as well as the detailed Local Spatial Development Frameworks. The primary open space network can in certain areas provide a natural barrier to contain urban development and can be used as a planning tool in determining the Urban Edge, especially in the Northern and Southern areas of Ekurhuleni. Further, the primary open space network further assists urban development in providing areas which are able to protect developed areas, by offering natural buffer zones for problems associated with natural disasters e.g. flooding." (EMM, 2011b)

Encouragingly, these MSDF land use guidelines, which are based on the principles endorsed by the metro's Bioregional Plan (2011) and the "fine scale planning" undertaken prior to this for the Ekurhuleni Biodiversity and Open Space Strategy (EBOSS) in 2009, are associated with targets in the metro's Integrated Development Plan (IDP) for 2011-2014. According to the Ekurhuleni IDP, Budget & SDBIP for 2011/12 – 2013/14, there is a 49 607 backlog of hectares to be protected and conserved in the metro, with a 5 year target of 13 588 hectares to be conserved. However, in the revised 2013-2106 IDP, the total hectares of land with ecological value to be formally protected has been revised down to 1000 hectares of land with actual performance for the year 2012 reported as 100 hectares (EMM, 2013). The focus here is understandably municipal protected and conserved land, the closest association to which is the notion of 'natural open space', prioritised and defined by the EBOSS in 2009 as "open areas that still have a natural vegetation cover where there is little human intervention and which is currently not utilised intensively by humans" (EMM, 2009). It is important to note that the connection of this idea into IDP processes does not represent the total ambit of work the metro undertakes to both conceptualise and invest in relevant ecological assets.

Those who work within EMM, such as Environmental Resource Management officials, are also involved in more specific activities that might not be captured in the high-level IDP planning processes, but are still part of public investments in the metro's green landscape. By way of example, through the Trees for Homes programme, the *Greening of Ekurhuleni* project (2009) was initiated as an environmental programme through a growing political conversation about the role of greening for social outcomes:

BOX 2

Corridors and connectivity: The high levels of development in Gauteng have created very limited connectivity of ecosystems. Gauteng is a key bottleneck to west-east connectivity of ecosystems, which can impact on the long-term survival of a range of species and ecosystems in the context of on-going climate change. Maintaining connectivity is critical for long-term persistence of biodiversity in the face of on-going climate change, and represents the major contribution to facilitating climate change adaptation within the Gauteng Province and South Africa as a whole. (EMM, 2011a)

Ecological Corridors: Ecological Corridors are passages of natural habitats providing connectivity of different spaces of habitats along or through which species may travel without any impediments. (EMM, 2012a)

"The Greening of Ekurhuleni Project 2009 aimed to deliver 7 860 trees to low cost housing units in Ekurhuleni. These trees will result in 2954 tons of carbon dioxide being sequestrated over the next 15 years. This also contributed to urban greening. The average low cost house is sited on 250m². One hectare is equal to 10 000m. There are therefore 40 houses per hectare with one tree per household. 7 860 households x 250m² = 1 965 000m². It can therefore be said that through this project 196,5 hectares of urban forest have been planted. The delivery of trees and increased environmental awareness for beneficiaries is the primary output of the project." (FTFA, 2009)

In many respects then, the EMM institutional landscape is animated with progressive ideas about sustainable investment in 'land', 'open space' and 'natural systems', and a number of principles and guidelines are identified in planning documents in support thereof. From a traditional 'conservationist' or 'protectionist' stance, it is encouraging that these guidelines have found purchase within key development planning targets.

EMMARENTIA, JOHANNESBURG, 2013

Current initiatives

Trees and tree-planting

In EMM, there is a growing commitment to tree-planting, with various initiatives signalling strong municipal investment in trees as key activities for greening outputs. To an extent, the emerging tree-planting movement has been steered by a cognizance of the function and value of trees, and of their value in providing services in light of Ekurhuleni's industrial and environmental context:

"Trees absorb the carbon dioxide released by industries and release oxygen, which is vital for human beings to breathe... Trees also prevent soil erosion by holding water during heavy rainstorms, thus keeping the land arable. Trees are regarded as windbreaks and rows were planted along the streets in an effort to guard against damage in the event of strong winds. We are not just pushing to be a city with the largest forest; in the interest of generations to come we want to save the environment from the effects of climate change by promoting the preservation of trees and better understanding of the value of trees, especially indigenous trees," she explained, adding that trees serve as a source of food, medicine, scenic beauty, building material and also play a vital role in the well-being of our communities." (EMM, 2012d)

A local newspaper, the Bedfordview Edenvale News (6 September 2012) reflected on this change in thinking, reporting that *"The Ekurhuleni Metropolitan Municipalities (EMM) area's status as the manufacturing hub of the country is one of the reasons that residents should take tree planting seriously"*. For instance, after the 2011 tornado in Duduza informal settlement, which devastated over 150 homes and fatally injured a child, EMM collaborated with two other agencies, the Gauteng Department of Agriculture and Rural Development (GDARD) and Rand Water, in planting 733 trees (both fruit and ornamental) and donating a further 477 trees to schools and clinics in the area (GLGH, 2012). Although Ekurhuleni does not have data available on how many trees there are in the municipal area, it is estimated that between 2008/09 – 2012/13 (1st Quarter) 71 851 trees were planted which is an average of 14 000 trees a year. It is also telling of a growing public tree-planting culture that the EMM developed a 2007 by-law for the Planting, Pruning, Removal and Treatment of Street Trees within the municipal area, on council owned land such as sidewalks (EMM, 2007).

Within EMM's greening activities, a number of tree planting schemes seem to depend on collaborative efforts between the metro itself, local communities, interest groups and in some cases, supported by funding from donor organisations. For instance, the *Greening of Ekurhuleni* project is organized and facilitated through Food & Trees for Africa's (FTFA), *Trees for Homes programm*e, a public greening initiative in low-income communities. FTFA is a non-profit civil society organisation and conducted the greening initiative in Ekurhuleni through sponsorship from EMM which funded 21 569 trees since 2006. A further 7860 trees (both fruit and ornamental) were planted since 2009 as part of a fruit tree project called *Carbon Offset Intervention,* funded by the Royal Danish Embassy and the South African national Urban Environmental Management Program (UEMP). FTFA estimated that the planting of 7 860 trees will result in 2 966 tons of carbon dioxide sequestered over a 15 year period. It is also significant that Community Based Educators (CBE) feature strongly in the collaboration efforts of such programmes, through assisting with tree distribution to community homeowners, planting and education campaigns.

According to the *''Greening of Ekurhuleni, Trees for Homes, Final report''* (2009), the EMM is the first municipality in South Africa to set aside a significant budget for a greening strategy through Food & Trees for Africa's (FTFA) *Trees for Homes programme.* The Trees for Homes Programme's focus is on low cost housing developments with the following objectives:

- To contribute to greening, sustainable natural resource management and food security
- To create an awareness of the benefits of environmental upliftment activities amongst all communities of Southern Africa
- To work in partnership with government, the private sector and civil society
- To contribute to the design, implementation and management of sustainable greening projects
- To alleviate poverty, develop skills and contribute food security for the numerous communities that apply for assistance.

Coupled recreation and rehabilitation?

There are a number of activities relating to EMM's Open Space Planning, Provisioning and Maintenance mandate that channel investments into the metro's ecological assets. Under this mandate, R 60,3 million was allocated to develop new and upgrade existing recreational parks in Ekurhuleni for the 2012/13 financial year (EMM, 2012d). It is significant however, that park development is also regarded as an opportunity for land rehabilitation. In 2012, EMM launched the Cleaner and Green Ekurhuleni campaign which encourages communities to refrain from illegal dumping in open spaces through the promotion of these as playgrounds or parks, and spaces to plant trees, and supported by up-scaling waste removal initiatives in informal settlements.

As part of what appears to be a rehabilitation initiative, an EMM-Mayoral flagship project titled the *Rehabilitation and beautification of lakes and dams* has been launched to "elevate dams and lakes to a flagship status … and expedite the development of such water resources for eco-recreational purposes" (EMM, 2012d). In this regard, EMM has entered into a Memorandum of Understanding (MOU) with the South African Maritime Safety Authority (SMSA) with the view to encourage and facilitate the development of inland waterways in the metro and to provide leadership and strategic direction to the boating and tourism industries. According to SMSA (2012), Marine Tourism includes boating and cruising clusters (such as yachting, cruising, ferrying and hospitality and entertainment) and encompasses recreation that includes marine activities such as diving, swimming and sailing, leisure activities such as eco-marine tourism, real estate, adventure and viewing. SMSA also views inland regions as having a high potential for marine-based tourism with inland dams and major rivers providing ecosystem services of considerable economic benefit to communities.

The articulation of 'hydrological rehabilitation and beautification' through a marine tourism agenda is provocative given that the Ekurhuleni State of Environment Report (2004) highlights widespread degradation of water resources as a key priority for the metro (EMM, 2004). For instance, following a ground truthing exercise of data generated in 2005 through the Environmental Management Framework (EMF), the EMM Wetlands Inventory Report (2007) reports that 13% of the wetlands captured on this baseline data were destroyed or no longer exist. The EMM wetlands form part of an interconnected hydrological system which includes lakes and the dams, with wetlands providing regulating ecosystem services such as flood attenuation, trapping of sediments, and filtering of nutrients and toxins from the water. The health of the wetlands will affect the lakes and the dams and the activities and developments of the lakes and the dams will also have an effect on the wetlands' regulatory function. The investment in ecosystem services as economic contributors may incentivise investment in protecting the urban hydrological system, although this will also depend on whether marine tourism is managed effectively and sustainably. It is telling that Ekurhuleni's Environmental Policy (2012) expresses concern about the water resources (rivers, lakes and wetlands) which have been severely affected by development. The increase in built-up and hard surfaces is causing pollution into water courses and acute stormwater issues, aggravated by an inadequate storm water control system (such as retention ponds and pollution control litter traps) to deal with these challenges.

In contrast to the marine tourism scheme, EMM undertakes various activities to 'manage and protect valuable water resources' (Ekurhuleni Environmental Policy, 2012). Priority wetlands have been selected as part of the national *Working for Wetlands* programme, which is active in several quaternary catchments in EMM (SANBI, 2004). According to the EMM's Department: Environmental Resource Management, wetlands are the largest natural asset in the metro and form part of the hydrological and open space system. Priority wetlands have been selected as part of the Wetland Rehabilitation Plan completed in June 2011, which prioritises wetlands for rehabilitation purposes. This plan is based on the Wetland Inventory Report Identification,

CUT GRASS, SOUTHERN SUBURBS, JOHANNESBURG, 2013

Classification, Assessment and Delineation of Wetlands within the Ekurhuleni Metropolitan Municipality (EMM) compiled in 2007 which mapped the extent, distribution and diversity of wetlands within the area and assessed their functions and values. According to the South African State of Cities Report (SoCR) 2011: ''The two-year project cost just over R2.3 million, and employed 45 previously unskilled workers in the construction of gabions and concrete structures to stabilise banks, block erosion channels and retain sediment.'' These projects, as stipulated by the SOCR (2011), were done to restore the wetlands so as to purify the water for the municipality and encourage better flood protection. According to the council there is also a threat of acid mine drainage which will have long term effects on the natural systems of the metro. This is addressed with *ad hoc* interventions from the Department of Water Affairs, with special concern for the areas of Grootvlei and Germiston.

EMM identified several biodiversity projects as part of the EBOSS (2009) under the International Council for Local Environmental Initiative (ICLEI)'s Local Action for Biodiversity (LAB) initiative. These projects are regarded as catalyst projects that promote a variety of issues with regards to biodiversity, which can be implemented in the EMM. Due to a lack of capacity (human and financial), these projects cannot all be implemented at the same time. The current focus, according to the Department of Environmental Resource Management, is on the implementation of the Leeupan Regional Park Project. This involves rehabilitation of a wetland back to a functional ecosystem, and the establishment of an environmental centre that will provide environmental and recreation activities for the surrounding communities including a cultural heritage precinct commemorating the life of OR Tambo.

According to the State of the City Address (EMM, 2012e), nine parks were upgraded as part of the clean and green campaign and 8 387 trees planted across Ekurhuleni. Through the planning of the Directorate of Parks and Cemeteries, most of the major parks in the EMM are projected on master plans, designed to accommodate implementation in phases over several years, drawing from their annual capital budget which could be in the region of R 50 – R 70 million. Parks development focuses on new parks and the upgrading of existing parks into more creative spaces, as well as encouraging physical activity, such as in Trim Parks, which are parks that include outdoor exercise apparatus. More provision is also made to accommodate disabled people. Constraints in terms of parks are that there is lack of proactive planning and many departments still operate in silos. Parks are often allocated on the left over land in town planning developments, and where priority is given to parks, it is often through other flagship initiavies, such as the 'Rehabiliation and beautification of lakes and dams', a Mayoral flagship project.

Perceptions of ecological assets within EMM

Although there is no overarching green infrastructure strategy in place, there are various initiatives that promote investment in Ekurhuleni's ecological assets and indicate a supportive conceptual environment for the role of these in municipal planning and operations. From a biodiversity and conservation perspective, there is a robust body of conceptual work that outlines guidelines and principles for the management of natural spaces and systems. This work has been transmitted into the metro's spatial planning frameworks, such as the MSDF (2011), which seem to be founded on thorough ecological principles, such as notions of 'corridors' and 'connectivity'. These concepts indicate a progressive conversation within EMM's planning circles about the importance of linked-up natural system and emphasis is placed on the importance of not fragmenting open space, but rather promoting it as a continuous functional extent.

While there is a well-articulated conceptual architecture relating to ecological issues, there is a more select focus within integrated development planning. The reporting indicator in the IDP relates specifically to protecting open space under municipal jurisdiction. Yet once we are aware of the full basket of activities under EMM's operations, we see that investments extend to a range of ecosystem services such as air and microclimate regulation. Importantly, a range of actors, including public officials, volunteers and interest groups, jointly owns the visions underlying these investments.

CUT GRASS, SOUTHERN SUBURBS, JOHANNESBURG, 2013

This does not dilute the political importance of many greening initiatives – indeed various media briefings publicise this work – but there is limited follow-through of localised projects, such as tree-planting initiatives, into mainstream performance reporting.

An emerging trend within EMM is also the allocation of value to natural systems in light of their potential for eco-tourism and investment spin-offs. A view to capitalise on this 'economic value-add' may present a contrary perspective to the principles endorsed by the planning documents of increasing conservation areas and using natural assets as buffers to guard development against natural disasters. Although the policy and strategy arena within EMM appears to be progressive and drive an admirable agenda, the strategic integration across different institutional mandates is not entirely clear. The main repository of support appears to be spatial planning frameworks but these are somewhat disconnected from the articulation of wetlands and trees as contributing to broader socio-economic values.

EUCALYPT, WATERKLOOF RIDGE, TSHWANE, 2013

City of Tshwane

In terms of landmass, the City of Tshwane (CoT) is the single largest metropolitan municipality in the country and the third largest city in the world, after New York and Tokyo. Following the merger of Tshwane with district municipality Metsweding (which included Nokeng tsa Temane Local Municipality and Kungwini Local Municipality), Tshwane covers an area of 629 844 hectares or 6 298.4 km^2, approximately 39% of the Gauteng province (CoT, 2012a). As boundary extensions present Tshwane with choices regarding type of future development to facilitate, the recognition given to "open"and "green" spaces and various conservation priorities as city mandates in multiple strategic processes signals a degree of commitment to protecting land in light of development pressures and to investing in new green assets.

Our review of green infrastructure planning in Tshwane indicates that green asset priorities in the City extend from traditional 'environmental' protection initiatives, focusing on open space planning and nature conservation-style activities, to an active interest in ornamental landscapes and horticultural projects. These different strategic aspirations are reflected in a diverse institutional architecture, where a complex, multiform basket of functions is managed by various structures. To the extent that this makes for a holistic view of green assets, Tshwane's institutional schema may be reflective of the diversity of green infrastructure, yet the critical question is whether sufficient connections are being made between green assets as components of an integrated network across the City.

The landscape

Tshwane is located between bushveld to the north of the City and Highveld grassland to the south, with the Magalies mountain range forming a natural boundary between the two biomes (CoT, 2012a). According to the City's Bioregional Plan (2011), Tshwane has 15 ecosystems listed as threatened and 83% of wetlands and 58% of rivers also categorized as threatened (CoT, 2011).

In the 2005 Tshwane Open Space Framework (TOSF), land degradation is articulated as something related to the nature of urban development in the metro, including sprawling low-density built form, fragmentation of land uses and encroachment of informal settlements onto 'sensitive open space resources' (CoT, 2005a). The TOSF (2005) also describes Tshwane's landscape as one that is facing increasing pressure from urban development, but one that also contains substantial 'open space' in relation to built-up municipal area and "exceptional natural features" such as ridges, wetlands, water source systems, a meteoritic crater and ecological areas" (CoT, 2005a). These features have come under pressure from Tshwane's growth as a metropolitan municipality, often fragmenting natural assets. In the metro, land used for commercial, residential and infrastructural purposes often intersects large segments of open space, although there have also been new investments in land that makes provision for parks, golf courses, eco-estates and conservation areas.

NURSERY, DIE WILGERS, TSHWANE, 2013

VIEW FROM WATERKLOOF RIDGE LOOKING NORTH, TSHWANE, 2013

According to the TOSF (2005), Tshwane's landscape has been greatly transformed by middle-income, sprawl-like suburban development which in some parts of the metro, such as the south-eastern periphery, has blanketed natural ridges, canalised rivers and streams and carpeted expanses of natural open grassland. The nature of this suburban development is such that walled and 'lifestyle' estates have privatised and fragmented many green spaces (TOSF, 2055), with implications for how accessible these are to the broader public. At the same, time, however, many private developments are adjoined to large open spaces, some branding themselves as green developments, while various residential settlements are positioned in large open areas that intersect roads and buildings.

Relevant institutional arrangements

Oversight of natural and open space resources in Tshwane falls under the Environmental Management Division, which is grouped together with Agriculture and Waste Management divisions as part of the metro's Environmental Management Department. The responsibility of the Environmental Management Division is to promote ecological integrity through the protection, utilization and enhancement of natural and open space resources by integrating environmental considerations into the sustained management and development of the City. The Environmental Management Division comprises four strategic branches:

i. *Open Space Planning* which includes the following subsections: Strategic Open Space Planning; Open Space Design and Management; and Open Space Development Impact Management

ii. *Environmental Policy and Resource Management* of which the subsections are Environmental Policy, Programme and Information Management; Environmental Audit, Risk and Management Systems Development Facilitation; Environmental Education and Awareness Management; Air Quality; Climate Change and Sustainable Energy

iii. *Parks, Horticulture and Cemetery Provision* including Parks and Horticulture Services Provision Management; Cemetery Services Provision Management; Urban Forestry, Nursery and Training Provision Management; and Parks, Horticulture and Cemetery Services Technical Support

iv. *Nature Conservation and Resorts Management* which is broken down into Nature Conservation Management; Resorts Operations Management; Swimming Pools Operations Management; and Nature Conservation, Resorts and Swimming Pool Technical Support.

These four operational divisions reflect different departmental aspirations regarding how green assets are managed in Tshwane, ranging from spatial planning directives to recreational and cosmetic investments in green spaces. While the convergence of different objectives is via the overarching Environmental Management vision of promoting ecological integrity, the components that constitute 'natural and open space' infrastructure are the direct responsibility of individual divisions and the officials working therein. This unbundling of duties means that the status of green assets is determined by departmental interactions since funding and implementation capacity spans a number of decision-making processes geared, in one way or another, to oversee natural assets, ecological systems and greening initiatives.

SPRINGBOK PARK, TSHWANE, 2013

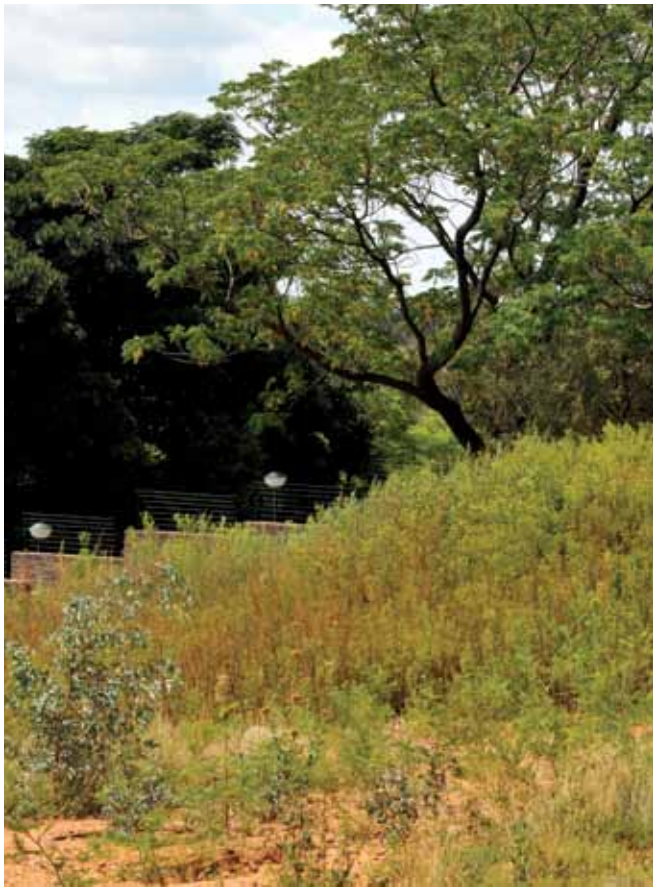
WATERKLOOF RIDGE, TSHWANE, 2013

In what seems a proactive move, Tshwane's Strategy for Environmental Education and Training for Employees (2005) identifies "green infrastructure" as part of the metro's employee training content and something that is also articulated as an environmental management tool for Environmental Resource Management. Yet there is no standard definition of what green infrastructure means for Tshwane in available policy documents, creating some ambiguity regarding how green infrastructure is actually conceived at an operational level. The most prominent framing appears to be within the Tshwane Integrated Environmental Plan (2005), which regards open spaces as areas with "ecological, infrastructural (servitude) and recreational value" (CoT, 2005a). It is telling, however, that an official within the Environmental Management Department reflects that:

"Conservation in Tshwane is largely seen as biodiversity management, retaining natural areas in the City to be used as sustainably as possible and to avoid the degradation and fragmentation of nature areas." (CoT Official, pers. comm, 2012)

Indeed, the proclamation of nature reserves in Tshwane, for purposes of nature protection, restoration and conservation, is a major thrust within the City's 'services' profile. At the time of writing, Tshwane has a total of thirteen nature reserves, ten bird sanctuaries and thirteen nature-worthy conservation areas, which include the Magaliesberg ridge and the rivers within open space. Of this mix of nature areas, there are five proclaimed nature reserved and a further three, Fairy Glen Nature Reserve, Colbyn Valley Wetland and the Klapperkop Nature Reserve are in the process of being proclaimed under the *National Environmental Management: Protected areas Act 57 of 2003.* Perhaps as a result of the priority given to conservation, there appears to be a substantial amount of media attention branding natural reserves as tourism opportunities and in terms of their recreational benefits, such as trail running and various outdoor activities. Further, in terms of the Conservation of Agricultural Resources Act (CARA), 1983 (Act No 43 of 1983), Tshwane received funding via the Department of Water Affairs (DWA) to remove alien vegetation.

It seems that a critical challenge for Tshwane is the fiscal capacity to sustain investments in green assets. For instance, although there is an increase in the area under conservation management, due to the inclusion of Cullinan and the Bronkhorstspruit in the Tshwane area, additional responsibilities have not been accommodated through an increase in the available budget (Tshwane Nature Conservation and Resorts Management Official, *pers. comm*, 2013). This flat budget presents an incredibly tight fiscal environment to expand facilities in green and landscaped spaces, deliver public education programmes and sustain maintenance of tourism facilities in conservation areas. The repercussions for Tshwane include massive skill deficits to mainstream natural and green space investment since the City's conservation department is operating on skeleton staff with an insufficient operational budget (Tshwane Nature Conservation and Resorts Management Official, *pers. comm*, 2013). Within this environment, it is significant that nature reserves are seen as key financial contributions to the City – R 6,5 million in revenue for the 2011/12 financial year, through providing for tourism and recreational activities. According to the Nature Conservation and Resorts Management Division, Groenkloof nature reserve generated the single largest income in this regard during 2011/2012 with the most popular use being daily hiking and mountain biking.



WATERKLOOF RIDGE, TSHWANE, 2013

BOX 3

"A single tree can remove as much heat from the air as five average-sized air conditioners. Trees and vegetation also break the wind, moderating temperature in the winter." (CoT, 2005a)

''Due to the ecological (environmental goods and service) and place making value of trees, trees and engineering services must be regarded as service delivery imperatives.'' (CoT, 2005a)

Relevant strategic processes

The most cogent recognition within Tshwane of the need to plan for green assets appears to be the Proposed Tshwane Open Space Framework (TOSF) (CoT, 2005a). The framework takes its cue from the externalities associated with the City's development thus far, focusing on the fact that because open spaces are undervalued, they often become the target for development and are sold off at low prices. The TOSF (2005) recommends that:

"...Open Space value should rather be based on the cost of restoring such space back to its natural state once it has been developed and/or based on cost-benefit analysis studies that consider and quantify not only Open Space's development value, but also its social and ecological (environmental goods and services) functioning value..." (CoT, 2005a)

While there is no explicit articulation or definition of green infrastructure within the TOSF, there are a number of interesting proposals for how open spaces can be rethought in terms of the functions they provide to society:

"Trees and other plants also play a critical role in improving air quality and ameliorating the increased heat created by urban development. They not only absorb ozone, carbon dioxide, sulphur dioxide, nitrogen dioxide and other noxious air pollutants, but remove dust and particles from the air and release oxygen. The transpiration of water by plants helps control and regulate humidity and temperature. A single tree can remove as much heat from the air as five average-sized air conditioners. Trees and vegetation also break the wind, moderating temperature in winter. The result is a decrease in energy consumption, along with its costs and associated pollution.

Parks in stream valleys or urban wetlands absorb storm water much more cheaply than in artificial systems. Large Open Spaces allow rainwater to be absorbed slowly and to percolate into underground aquifers – reducing the danger of flash flooding or erosion due to rapid runoff." (CoT, 2005)

The link between ecological benefits to social and economic functions is a further theme within the proposed TOSF (2005), which regards certain features, such as "healthy aquatic food chains" as "indispensable for economies such as the recreation, fishing and tourist industries" (CoT, 2005). It is significant then that the proposed TOSF (2005), a conceptual framing document, has as a key policy statement the recommendation that open space must be viewed as a land use and service of equal importance to any other land use and service, and that the value of open space should not only reflect market value, but should ultimately be an expression of the benefit to present and future communities and not just to those who buy property.

While the proposed TOSF (2005) reflects an alignment between ecological and socio-economic issues in Tshwane's strategic discourse, the operational contribution is the spatially-explicit Bioregional Plan for the City of Tshwane (2011). Here a landscape-scale approach is related to strategic planning. This plan sets out to:

".... inform land-use planning, environmental assessment and authorisations and natural resource management, by a range of sectors whose policies and decisions impact on biodiversity. This is done by providing a map of biodiversity priority areas, referred to as Critical Biodiversity Areas and Ecological Support Areas, with accompanying land-use planning and decision-making guidelines.'' (CoT, 2011)

The Bioregional Plan provides valuable spatial data on ecosystems such as critical biodiversity hotspots, irreplaceable areas and ecological support areas to accompany urban development as well as options for biodiversity offsets

where development takes place. It is also encouraging that the Bioregional Plan has been buttressed by data collection studies such as the Report on Flooding in Tshwane (2006), which captures wetlands in Tshwane, including those that existed prior to boundary extensions and the exact position of wetlands to establish conditions for current development (CoT, 2011).

Tshwane has also begun strategizing for alternative approaches to infrastructure provision and service delivery through utilising various ecological principles and systems. For instance, the Green Building Development Policy (November, 2012) includes "mandatory" (must be complied with) and "promoted" (may be complied with) green building development standards and green infrastructure techniques such as swales are framed as recommendations for on-site storm water retention through sustainable urban drainage systems (SUDS). However, other strategic initiatives investigating ecological assets within Tshwane's operations have been less successful. The 2008 Strategy for Sustainable Management of Plants for Traditional Medicinal Purposes in Tshwane failed to receive management approval and, as a result, is yet to be implemented, while the Integrated Water Resource Protection Framework, dated 2006, has been halted due to a lack of funds (CoT Van den Berg, *pers. comm*, 2012). Such challenges reflect a broader challenge confronting municipal decision-making and budgeting processes where despite institutional enthusiasm for progressive ideas, the financial and procedural demands of implementation may complicate take-up.

Reading across Tshwane's strategic processes, a common theme in various frameworks and policies is the role of trees in providing a number of functions to the City. The Proposed Tshwane Open Space Framework (TOSF) (2005), views trees as important carbon sinks which absorb ozone, sulphur dioxide, nitrogen dioxide and other toxic air pollutants, and remove dust and particles from the air, in turn releasing oxygen, which improves air quality. Similar sentiments are expressed through the City's approach to challenges such as climate change and air pollution, in relation to which the planting of trees is suggested as a means to reduce greenhouse gas emissions (CoT, 2012c). While such views provide a sound conceptual base regarding the multifunctional role of the City's trees, the most tangible articulation thereof is through Tshwane's Urban Forestry Policy (2003) which aims to encourage the planting of more trees in Tshwane and provides guidelines for the planting, maintenance and protection of trees (CoT, 2003). The policy's focus on tree planting on road reserves and within the whole Metropolitan areas is motivated through the following:

- Trees are planted for the beautification of the city and environmental upgrading of suburbia
- Trees are an asset in that they break and soften the hard city landscape environment
- Trees play a very important role in giving life to the city be revitalizing the air and reducing city noise levels
- Trees on road reserves influence both our biological and physical urban environments and contribute to more liveable urban spaces
- Trees reduce annual heating, supply city environments with oxygen, reduce smog levels, absorb small particles and gases of air pollution, absorb rain and thereby reducing the amount of water to be removed by storm-water drainage and increase property values.

Tshwane's Urban Forestry Policy also includes detailed guidelines that inform tree planting and maintenance in the

JACARANDA, TSHWANE, 2013

BOX 4

JACARANDA POLICY:

Until further notice no new Jacarandas will be planted to comply with the Conservation of Agricultural Resources Act (Act No. 43 of 1983)

If permission is granted by the National Department of Agriculture, Jacarandas that have been lost due to natural death, accidents, road widening etc. will be replaced with Jacarandas to maintain the Jacaranda character of the City. Preference will be given to the inner city and main arterials leading into the city.

WATERKLOOD RIDGE, JOHANNESBURG, 2013

city and which represent a multi-dimensional conceptual landscape that affects tree-related matters. On the one hand, the policy stipulates that all new suburbs will be planted with suitable indigenous species but that exotics will only be used for replacement where necessary (CoT, 2003). The planting of exotics for replacement purposes is motivated as an attempt to maintain the character of the city (see Box 4) and in terms of street trees, the policy specifies that the "same species will be used per street as far as possible, to ensure a uniform character per street [while] [i]t is however important to not simplify biomes by decreasing species diversity" (CoT, 2003). This is underpinned by the idea that Tshwane's urban character has been defined by Jacarandas and a modification of this may be at odds with the identity of the City. The propensity to focus on both indigenous afforestation and alien removal has seen Tshwane develop a priority-based approach to urban forestry operations, with tree planting prioritised in previously disadvantaged areas and removal of undesirable aliens based on a selection of priority species and removal periods for each selection.

Additionally, the Urban Forestry Policy specifies how Tshwane's trees should be valued:

"...tree evaluation will be done in accordance with the internationally approved formula devised by the British Tree Council in 1975, known as the Helliwell system." (CoT, 2003)

"A qualified urban forester or horticulturalist will determine the value of the tree following seven parameters and formula plus the costs of removing and replanting the tree with a similar tree if practical." (CoT, 2003)

Tshwane has expanded on these ideas through facilitating a study titled, *The Growth and carbon sequestration by street trees in the City of Tshwane,* conducted by Professor G.H Stoffberg (2006). The research, which was financed by the City, set out to determine the monetary value of the *Jacaranda mimosifolia* street tree population of the City of Tshwane based on the quantity of the carbon stored in the trees (Stoffberg, 2006). Although this work lays an important conceptual foundation for understanding the role of trees in metropolitan contexts, the research insights are yet to find practical application at a city-scale. For instance, while the City undertakes tree maintenance and planting reports, which give inventories for afforestation programmes, little is recorded estimating the future value of these programmes beyond what was done by Stoffberg in 2006. While valuation analyses have not been done at scale, the foundations have been laid in Tshwane's strategy discourse. The study indicates public sector recognition of the services provided by Tshwane's trees and which, together with reducing ecological disparity, provides conceptual support for tree planting in the metro by the Urban Forestry Division (CoT Dry, *pers. comm*, 2012).

Current initiatives

In Tshwane, there are various initiatives that may not be explicitly articulated as "green infrastructure", but are nevertheless investments in the urban landscape. These range from investigation into the workings of natural systems with a view to informing later programmatic work through to active tree planting and park development initiatives. This range reflects the four different parts of Tshwane's Environmental Management Division.

The development and conservation of greenbelts and natural assets in new and existing residential settlements is an initiative of Tshwane's Parks, Horticulture and Cemetery branch. The initiative generally focuses on previously disadvantaged areas, including Atteridgeville, Soshanguve and Ga Rankuwa and includes the development of nurseries for seedling production, forested nature areas, conservation areas and bird sanctuaries and the rehabilitation of wetlands and bushveld. Many of these projects are focused on school greening with the goals of environmental education and to create environments within schools that are conducive for learners, staff and residents around the area (CoT, 2012c). Similar motivations drive Tshwane's *Two Parks per Ward Programme* which, in addition to ensuring sufficient park infrastructure in all communities to address backlogs thereof, is framed as an initiative with environmental and social spin-offs such as reducing illegal waste dumping on unmanaged land and improving human health conditions (CoT, 2012c). This reflects that the social benefits of trees, parks and conservation areas are filtering into strategic processes within the City. It is also positive to see conscious efforts to align greening programmes with community needs through awareness-raising initiatives and environmental education in schools.

Expansion of the urban forest is another major thrust within the operations of *Cemeteries, Parks and Horticultural Services* and the City has a goal of 11 000 trees to be planted every year, which includes 5000 fruit trees donated to needy communities and 80% of trees to be planted in previously disadvantaged areas (CoT Cemeteries, Parks and Horticultural Services Official, *pers. comm*, 2012). In addition to the contribution of tree planting programmes to previously disadvantaged areas, the expansion of the urban forest is also developing Tshwane's information and knowledge bases about trees across the City. According to an official within *Urban Forestry, Nursery and Training Services*, there are currently 100 000 trees growing in the City Nursery, which Tshwane utilises to propagate its own trees (CoT Dry, *pers. comm,* 2012). Tree propagation also happens according to a seven year cycle, which is based on the experience of officials within *Urban Forestry, Nursery and Training Services* that it takes seven years for an indigenous tree to be mature enough to be planted on a road reserve (CoT Dry, *pers. comm,* 2012). Therefore, while tree planting activities in Tshwane are incentivised through broader goals and motivations, such as the United Nation's Environment Program (UNEP)'s global Billion Tree Campaign, there is important, more localised knowledge that informs the actual process of urban forestry expansion, such as the suitability of indigenous thorn trees for road islands and parks but not for road reserves (CoT Cemeteries, Parks and Horticultural Services Official, *pers. comm*, 2012).

In Tshwane, there are a range of activities articulated within the format of Open Space Plans that exhibit a growing awareness of different types of open spaces and the status of these in terms of accessibility, connectivity, character, development / ecological status and public perception of different spaces (CoT, 2007). These plans are completed for a specific area or suburb, such as the Local Open Space Plan for Soshanguve, and represent engagement with open space typologies at a very local level. The Local Open Space Plan for Soshanguve (CoT, 2007) makes an important contribution by identifying five typologies in Soshanguve including a green network (such as ecological nodes as green nodes and ridge systems as green-ways); a blue network (including wetlands as blue nodes and natural watercourses as blue-ways); a grey network (which include cemeteries and reservoirs as grey

nodes and railway lines as grey-ways); a brown network (including local parks as brown nodes and urban core streets as brown-ways); and red networks (including recreational space as red nodes and local boulevards as red-ways). This categorisation is a schema that Tshwane has developed to classify typologies of open space networks in local areas, or 'zones', in different areas of the city (CoT, 2007). While the Soshanguve plan provides thorough scoping work to understand the nature of each open space typology as well as details on implementing the local open space plan, it is essentially a planning document, undertaken by an external contractor, to assist future implementation through guidelines and priority activities. It still requires official approval.

Furthermore, at general planning level, the Tshwane Growth and Development Strategy (GDS) 2055 (CoT, 2012b) articulates sustainable agricultural development as an opportunity to unlock the full potential of land available in the City. A similar focus came through the 2012 State of the City Address, which reported that:

"... the City has deployed four tractors and equipment in the two regions to cultivate maize on 150 hectares. Seeds and fertilisers were provided to the farmers through the Comprehensive Agricultural Support Programme. By the end of the second quarter of the 2011/12 financial year the City provided 1 454 agricultural starter packs to indigent households."

Urban agriculture investments are principally taking the form of food gardens on council owned land and, according to the Director of Agricultural Development Programmes, also on land around power lines and road reserves in order to preserve land against encroachment and to turn them into productive open spaces (CoT Maine, *pers. comm*, 2012). There are also investments by the City in rural agriculture development, through the sustainable agricultural village (SAV) programme, which are framed as "a participatory approach to a sustainable rural development by providing an anchoring agricultural platform through provision and transfer of infrastructure, technology and skills" (CoT, 2007). It is significant that the articulation of these programmes is through the value-added benefits of agricultural investments and that, in addition to infrastructural investments, the SAV methodology has a major focus on the incubation of new entrepreneurs and commercialization of enterprises for interface with the agro-processing markets (CoT, 2007).

Finally, Tshwane is investing in sustainable urban drainage systems (SUDS) in specific areas around the City such as the Menlyn Maine Precinct that has been modelled on the principles of water sensitive urban design (WSUD). Infrastructural solutions include a bioswale on the median island in Aramist Road, which collects storm water runoff from the carriage way for infiltration back into the soil to recharge groundwater; a stormwater attenuation point; rainwater harvesting tanks; and a green roof that reduces the impact of stormwater runoff.

Perceptions of green infrastructure

A number of positive foundations have been laid within Tshwane's strategic thinking about the role of natural systems for broader economic and social development. There is a particularly strong spatial planning foundation in this regard, through the City's Bioregional Plan which in turn feeds information into the Environmental Management Framework (EMF) and the Metropolitan Spatial Development Framework (MSDF). There is however, room for improvement since the EMF currently excludes region 5 and the newly incorporated region 7, while some strategic documents, such as the State of Environment Report (SOER) that was completed in 2001/2002, may be due for revision. According to officials, the key determinant affecting policy formulation and development is the availability of budget. A number of officials feel that the prioritisation of conservation policies and strategies is hindered by limited budgets, which affects the pace at which existing processes can be updated, in turn congesting the operational activities across the City. One official also noted that where funds are generated by certain projects, such as nature reserves and other tourist-related initiatives, these funds are not necessarily re-invested in the development of reserves or other nature areas and are often rather redirected to the coffers of City administration (CoT Dry, *pers. comm*, 2012).

Yet there are also a number of strategic processes that have been part of Tshwane's institutional system for at least a decade that remain relevant insofar as programmatic details on greening activities may still be applicable for the foreseeable future. The Tshwane Urban Forestry Policy (2003), for instance, specifies details on tree afforestation, maintenance and evaluation, a mechanism which also importantly draws

on local knowledge and experience regarding what is locally appropriate.

A key thrust of Tshwane's greening work continues to be a focus on previously disadvantaged areas with the social benefits of parks, trees and nature areas featuring strongly in City communications. The framing of such projects is through an association between greening and wider social objectives, such as the health benefits of converting illegal dumping sites to parks, but this association appears to be more notional and hypothetical rather being based on empirical work to quantify these and similar publicised benefits. The propensity of Tshwane to undertake such work may depend on the coming together of key interests, such as the facilitation of research by the City, to provide a more definitive basis for investments in greening.

In light of pressures from urban development and perceptions that open spaces are inexpensive and undervalued potential vacant lots to be developed, it is encouraging that Tshwane is investing in nature reserves and conservation areas, bird sanctuaries and botanical gardens. Indeed, there is a clear effort by the City to market such areas in terms of their contribution to Tshwane as a recreational destination and a number of nature reserves, such as Groenkloof Nature Reserve, are advertised through City-run media platforms as offering hiking trails, horse and biking trails and picnic areas while parks, botanical and zoological gardens are promoted as popular recreational venues for citizens (CoT, 2010).

Finally, in a revealing reflection, officials within Tshwane's Nature Conservation division describe their everyday duties marred by ignorance and unwillingness by communities and other government departments to acknowledge that to work with nature is the most effective way to build our cities (CoT Nature Conservation and Resorts Management Official, *pers. comm*, 2012). Officials reflect that although it may be cheaper for the City to maintain existing nature areas than to develop new ones, few professionals, politicians and members of the general public actually listen, with the result that the important social and health benefits of maintaining existing green assets are largely undervalued.

Conclusions

Although there are initiatives supporting green assets in Tshwane, questions remain as to whether these are being sufficiently understood as an integrated network and mainstreamed into economic development visions. Where connections to social and economic values are made vis-à-vis green assets, these seem to be linked to tourism and the economic multipliers of recreational activities. Therefore, while there may be strong planning foundations for managing Tshwane's green assets, through the EMF, the Open Space Framework and Bioregional Plan, these remain largely planning tools. The connection to broader development is mainly through isolated projects, such as the growth and carbon sequestration by street trees in the City of Tshwane study (Stoffberg, 2006) and alternative storm water projects. Valuable lessons emerge from this empirical work about what it might take to value green assets more explicitly and embed these assets in Tshwane's infrastructure fabric.

IN BETWEEN WATERKLOOF AND WATERKLOOF RIDGE 2013

BOX 5

"Sedibeng is facing serious water pollution challenges in river systems and water bodies, notably the Kliprivier and Blesbokspruit which are polluted from runoffs from industrial areas, townships and waste water treatment works. The Kliprivier is one of the most polluted rivers in the Sedibeng District as a result of mining and industrial activities in the upper catchments, outside the borders of Sedibeng." (Sedibeng, 2009)

Sedibeng District Municipality

Sedibeng District Municipality (SDM) is located on the southern edge of Gauteng (Sedibeng 2012a) and includes the local municipalities of Emfuleni, Lesedi and Midvaal. While the following evaluation focuses on the ecological investments by each local municipality, the individual green strategies and operations undertaken by Emfuleni, Lesedi and Midvaal need to be seen within the overall Sedibeng context, for two reasons. First, the three municipalities together make up a largely continuous and uniform ecological extent, with transversal common features and challenges. Second, while each local municipality's plans and investments are unique, and need to be examined separately, planning for District level functions does bind local processes together to some degree. The Sedibeng Department of Transport, Infrastructure and Environment carries a set of functions broadly associated with what could be understood to be an environmental management remit. Its responsibilities range from sustainable energy to air quality under the broad umbrella objective of "A Clean and Green Sedibeng". This framing provides district-wide guidance for municipalities to invest in green assets, albeit along lines that assume greening to be a largely aesthetic or cosmetic investment. Within this, local municipal plans provide a more focused articulation of the types of green assets to be invested in such as urban agriculture, veld, community gardens, street trees, and landscape design in commercial developments, amongst others. In addition an array of district-wide collaborative arrangements, organised through a dynamic institutional architecture specific to the Sedibeng context, support various cross-municipality greening programmes.

Sedibeng: overall landscape

Sedibeng covers an area of 4 185 km^2 that extends along a 120km axis on the entire southern area of the Gauteng Province, (Sedibeng, 2009). The Spatial Devellopment Framework states that:

"The area can be described as mostly agricultural/rural, especially in the eastern parts. The main urban areas are concentrated in the western part of the district, consisting of Vereeniging and Vanderbijlpark as well as the Evaton/ Sebokeng residential complex to the north of it in Emfuleni. Lesser urban concentrations are found in Meyerton in Midvaal, and in Heidelberg/Ratanda in Lesedi."

The largely rural character of Sedibeng is associated with low population densities and a landscape characterised by towns that are "far apart". According to the municipality, this increases the costs of delivering infrastructure to rural areas and is why the bulk of municipal service provision is concentrated in the urban parts of the district (Sedibeng, 2012a). The structure of the landscape has been fundamentally shaped by the district's economy, with economic activity concentrated in urban nodes, such as Vanderbijlpark and Vereengening, and which are generally heavy / noxious industries associated with steel and petro-chemicals (Sedibeng, 2012a). This has created a landscape of rural areas connected into urban nodes via highways and long transport routes and interspersed by vast expanses of agricultural areas. Despite a largely rural nature, 48% of the District has been identified as transformed, categorised as agriculture (37%), urban (8%) and mining (3%) (Sedibeng, 2012b), and indicates the extent to which agricultural development has altered natural habitats. While

mining only represents 3% of Sedibeng as a whole, mining and related industrial activity have had serious effects on the landscape, particularly on the district's hydrological systems. The Draft Sedibeng Bioregional Plan (2012) states that the district is seeing changes in water quality, through inter alia, acid mine drainage and mining effluents, waste water from treatment plants, fertilizer and pesticide runoff, while catchment hardening and increased storm water flows are affecting natural water flow regimes. This is a particularly concerning in light of the 36 unique wetlands and 8 rivers identified in Sedibeng by the National Freshwater Ecosystem Priority Areas (NFEPA) (Nel, 2011). 94% of wetlands and 25% of rivers in the District are listed as threatened (Sedibeng, 2012b). In addition to pressures on aquatic systems:

"There are at least 10 threatened plant species and 14 threatened animal species in the Sedibeng District, and 10 vegetation types are listed as threatened under the provisions of National Environmental Management Biodiversity Act (NEMBA), 2008." (Sedibeng, 2012b)

Therefore, although Sedibeng contains significant green spaces, such as rural and agricultural land, the quality of the overall landscape is increasingly affected by agricultural, industrial and mining-related activities. The critical challenges of poor air quality and acute air pollution, particularly within the Emfuleni and Midvaal Municipalities are illustrated by the fact that the Vaal Triangle Airshed was declared as as a first national priority area in terms section 18(1) of the Air Quality Act (Act No. 39 of 2004) (Sedibeng, 2012a) indicates the severity of the externalities associated with mining and industry. While there are indirect links to the role of Sedibeng's ecological assets in mitigating this crisis – such as references within the Gauteng Air Quality Management plan to indigenous hedges and trees as pollutant absorbents – many pollutants eventually return to ecosystems, entering soil and water bodies, reducing plants' ability to perform critical functions, such as air purification, with serious implications for the quality of the District's landscape.

In light of the above, Sedibeng's nature reserves and conservation-related areas represent critical spaces of untransformed land. For instance, the Suikerbosrand Nature Reserve, on the north-eastern edge of Midvaal Local Municipality, in the Suikerbosrand hills, is seen by the municipality as a critical ecosystem but one that is under threat from uncontrolled low cost informal housing (Sedibeng, 2012a).

Relevant institutional arrangements and strategic processes

As a District Municipality, Sedibeng provides an overarching foundation for service delivery in local municipalities. District municipalities coordinate district development strategies, partially supply services to end users, and support local municipalities in providing services. The municipality is structured so that the Transport, Infrastructure and Environment department facilitates general 'environmental' mandates, such as air quality, green energy, climate change, and waste exchanges, and on-the-ground activities and implementation generally happening through the local municipalities. Within this double-tiered system, the overarching strategic processes administered by the District are the key procedural channels through which Sedibeng coordinates district-wide planning. As such, while implementation of services, such as the provision of parks, may not necessarily happen as a direct action of Sedibeng as a District Municipality, the District plans and visioning strategies are crucial institutional corridors for implementation, requiring coordination and a reflection of local priorities.

Within Sedibeng, foundations have been laid within various district level strategic processes to invest in the region's ecological assets. At a general level, the District's Integrated Development Plan (IDP) (2012/13 – 2016/17), promotes sustainable environmental management in various ways. These include restoration of degraded ecosystems; ensuring sustainable land use management through the rehabilitation of land to contribute to ecosystem resilience; improving management to prevent deforestation; and protection of indigenous forests to transfer these assets to appropriate conservation agencies. Within the 2012/13 – 2016/17 IDP, progressive calls are also made to promote the protection of biodiversity through "valuing ecosystem services" and for the "quantification of the value of ecosystems" as well as "mechanism to reflect the value of biodiversity in national resource accounts and facilitate the identification and protection of high potential agricultural land" (Sedibeng, 2012a). Similar sentiments are expressed in the District's Growth and Development Strategy (GDS) (Sedibeng, 2011) which sets out visions of:

"Reviving a sustainable environment from waste dumps to a green region, by increasing the focus on improving air, water, and soil quality and moving from being a producer and receiver of waste to a green city."

"A region which makes the most of, and extends its wealth of open and green spaces, natural environments and waterways, realising their potential for improving the health, welfare and development of the people of Sedibeng."

Within the overarching visions provided by the GDS and IDPs, there are more specific green programme commitments such as the Environmental Programme of Action (EPoA). This makes explicit reference to the environmental services provided by Sedibeng's ecosystems and proposes a number of objectives, targets and projects within following key focus areas:

- Air quality
- Protection and Maintenance of the Region's Natural Assets and Ecosystems
- A Clean and Green Sedibeng
- Environmental Management in the Private Sector
- Waste Management
- Water Resource Management.

Through the above focus areas, the EPoA laid the foundation for the Sedibeng's GDS to take form and be implemented, via "focus areas that can have large-scale impacts at district level" (Sedibeng, 2007). Yet, in spite of positive propositions within the EPoA (2007) (see Box 6), the extent to which these are translated into action is unclear since there is little by way of reporting and monitoring to assess the success of the

BOX 6

For A Clean and Green Sedibeng, the following targets exist:

- A co-ordinated approach towards cleaniness and greening related initiatives exists in the Sedibeng region by end 2009
- Trees planted for every citizen living in Sedibeng by 2012
- All alien vegetation to be cleared from riverine and protected areas in the Sedibeng Region by 2012
- Three projects in the Sedibeng Region to be used as best practice examples for the "A Clean and Green Sedibeng" focus area

WEST RAND WATER, 2013

EPoA approach. Furthermore, the EPoA fails to feature in the Draft Bioregional Plan for Sedibeng (2012), which although in consultation phase, is set up as guideline for informing a range of policies and sectors whose decisions impact on biodiversity and natural resources. This raises concerns regarding the coordination between strategic processes and while the Draft Bioregional Plan (2012) is a primary informant – through identifying Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESA) – the connection between biodiversity-related information and the District's greening initiatives is unclear. District-level planning processes are, however, structured as feeders into local municipalities, so that for instance the Draft Bioregional Plan guidelines and recommendations should be integrated into Environmental Management Frameworks (EMFs) which are administered locally.

District level perceptions

Beyond the formulation of key plans, the District seems to carry few direct responsibilities towards greening, in spite of there being a Transport, Infrastructure and Environment Department. Asked about the role of this department in sustaining ecological assets, one official responded:

"Yes, there is an environmental division, but I am struggling myself to understand my mandate. My role is not clearly defined and the role and functions of the District as a whole are not clearly defined either" (Sedibeng Official, pers. comm,2012)

The lack of clarity is compounded by financial constraints. These include a limited operational budget and budget allocations mainly in support of salaries of a large and overstaffed organisation, as a department official reflects:

"Greening is generally perceived as a "nice to have" and as a beautification effort not directly linked to infrastructural issues and while the IDP lists greening initiatives these are not necessarily high on the list when the IDP budget priorities are allocated for projects to be implemented." (Sedibeng Official, pers. comm, 2012)

PEDESTRIAN CROSSING, TELEPHONE CABLE, JOHANNESBURG, 2013

Emfuleni Local Municipality (ELM)

Of the three local municipalities in Sedibeng, Emfuleni has the largest population but covers the smallest area, approximately 987km^2. Although Emfuleni also has a significant urban component, which concentrates residential, business and industrial land uses, the municipality retains a largely rural character of which agricultural holdings and farmland represent the dominant share (Emfuleni, 2012a). While the Vaal River is a defining feature within the municipality – Emfuleni in Sesotho, means "by the water" and the Vaal forms the southern boundary of the municipality as well as the boundary between the Gauteng Province and the Free State Province – Emfuleni has another dominant feature which has shaped the form of the landscape. This is the N1 freeway which divides Emfuleni into mostly rural, agricultural land to the west and mostly urban areas to the east of the freeway, including areas such as Vanderbijlpark, Sebokeng and Sharpeville (Emfuleni, 2012a).

The landscape

Emfuleni's relatively flat topography forms a number of watersheds which in turn feed into the Klip River, the Rietspruit and the Leeuspruit as well as the Vaal River (Emfuleni, 2012a), which is the largest river running through Gauteng. Emfuleni also features a number of "important sites", such as the Falcon Ridge, which contains a tributary of the Vaal River and a mountain, and "irreplaceable sites" such as the Sharpeville and Sedibeng Dams that provide habitats for animals and serve as important recreational areas (Emfuleni, 2012a). Yet, in the same way as water is an emblematic feature of Emfuleni's history, hydrological challenges are some of the most acute ecological dilemmas facing the municipality. Challenges include the pollution of water bodies by nearby sewer works, development encroachment onto wetlands and flood lines, and illegal excavations for storm water management that result in wetland degradation (Emfuleni, 2012b). Hydrological challenges are summarised in the SDF as follows:

"The conservation of the Emfuleni river system is also necessary for hazard avoidance. To this end, it is imperative that the natural drainage channels and banks of all the rivers within Emfuleni, as well as their tributaries, be protected up to the 100-year flood line. This will protect Emfuleni communities from flooding; while at the same time ensure the protection of the ecological status of the river embankments, which is necessary for flood management." (Emfuleni, 2012a)

The clusters of wetlands and tributaries that run through Emfuleni intersect various other naturally-occurring assets, such as ridges and grasslands, which are in turn defined by river courses and affected by any hydrological degradation. The de-proclamation of certain sites, such as the Leeukuil dam, raises concerns regarding the success of Emfuleni's administrative apparatus to manage issues such as illegal dumping and ecological degradation. Indeed, according to the Emfuleni's Department of Environmental Management, Health and Social Development (Emfuleni Official, *pers comm*, 2012),

there are no existing conservation areas in the municipality, except for a section of land at the North West University Vaal Triangle Campus and the Mount Ridge Conservancy, a privately owned farming area, which is in the process of being proclaimed as a conversancy. Therefore, since water appears to occupy a central position in Emfuleni's municipal identity and because negative environmental externalities from industrial or economic activities are impacting on various ecological networks, whether institutional and strategic processes have been able to chart a coherent vision for ecological investments is a critical question for making sense of the municipality's future outlook.

Relevant institutional arrangements

Emfuleni's Environmental Management Department started as an ad hoc section of the Department of Health and consists of an Environmental Management section with five environmental inspectors and a section dealing with Environmental Health that employs twenty officers. Only one person in this department is responsible for strategic planning of the environment in the municipality. The department's current focus is on industrial impact management and the regulation of pollution by industries. The Environmental Programme of Action (EPoA) of the ELM, "Reviving Our Environment" (2007), stipulates a key focus area as the ''Protection and Maintenance of the Region's Natural Assets and Ecosystems''. This is a large responsibility facing this fairly young Environment Management Department.

Environmental management in Emfuleni is divided into the Department of Waste and the Department of Parks and Cemeteries, the latter occupying itself with tree planting and the planning and maintenance of open spaces. The most direct investment in ecological assets appears to be through Parks and Cemeteries, via the *Parks, Open Spaces and Grass Cutting* division, the mandate of which is:

- Provision of public open space
- Development and maintenance of the landscape
- Urban renewal of the Central Business District (CBD)
- Control of alien vegetation
- Conservation of environmentally sensitive areas
- Veld management
- Urban agriculture
- Environmental awareness raising
- Provision of outdoor adventure facilities and urban greening (Emfuleni, 2012c).

The delivery of these mandates is faced with some pressing fiscal difficulties. The operational budget for Parks, Open Spaces and Grass Cutting, for instance, showed a decline of 24% between 2011/2 and 2012/3 (Emfuleni, 2012c), posing both implementation and maintenance constraints in the municipality. However, this does not appear to be a "parks-specific" problem and a recent publication by the Parliamentary Monitoring Group (2012) reported the following:

"Emfuleni said that the major challenge for the municipality was cash flow problems. Its budget had been exponentially increasing to four times the budget of ten years ago, due to increased service delivery demands. The budget for 2011/12 was R3.7bn and for 2012/13 was R4.5bn ... There were challenges around the functionality of the billing of services ... The deficit of 2010/11 was a result of the unbundling of fixed assets, depreciation, and interest payments on debt impairments. 76.29% of capital expenditure for 2011/12 had been spent, and council funded projects had been under-spent by R37.7m because funding had been impacted by the low revenue income. National grant expenditure stood at 96%, but an R18m restructuring grant had been withheld by Treasury. The municipality did not have a robust enough tariff model and therefore some services had been delivered at below cost. There were vacancies in critical areas because of the precarious cash flow problems..." (PMG, 2012)

It is telling of municipal budget pressures that a number of private organisations, willing to fund the development of parks and sidewalks, have entered into Pubic Private Partnerships (PPP) with Emfuleni to achieve these ends. In 2011, a shopping complex entered into a voluntary partnership with the Department of Parks and Cemeteries to undertake horticultural development and maintenance of street islands along Louis Trichardt Boulevard and in 2012 a local church in the municipality offered assistance to Emfuleni to maintain various parks in Vanderbijlpark, at no cost to the municipality. While these agreements signal a degree of boldness on the part of private institutions to address service delivery, there remain institutional challenges that underlie Emfuleni's 'environmental politics'. As two municipal officials reflect:

''There is no political commitment towards the environment, priorities are bulk infrastructure such as road, storm water, waste water, electricity and water and the environment is not yet integrated with these.'' (Emfuleni Official, pers. comm, 2012)

"There are institutional coordination problems mainly due to the failure of a "green" committee to provide a platform for coordination between departments to lessen the impact on, and improve the management of, natural assets and secondly, because the Environmental Department is not seen as one with authority and thirdly, there is no integrated Environmental Management Strategy to incorporate all departments such as Waste and Air Quality Management." (Emfuleni Official, pers. comm, 2012)

Grappling with institutional coordination and the priority of social and economic concerns, seen as the core business of the municipality, Emfuleni is faced with a situation where the "environment" often struggles to be mainstreamed into strategic decisions, which in turn often lack the necessary environmental considerations and context. For instance, while the termination by the Gauteng Department of Agriculture and Rural Development (GDARD) of a municipal proposal to build 54 RDP houses in a wetland is a positive intervention, the initial proposal disregarded national environmental legislation and has been a costly and time-consuming process for the municipality (Emfuleni Official, *pers. comm*, 2012). This is exacerbated by a lack of human resources and capacity to stimulate proactive environmental planning and, critically, the collection of up to date environmental data for decision-making. It appears these factors result in disincentives to mainstream environmental planning into strategic decisions, which often lack the necessary environmental considerations to protect the natural assets in the area.

Relevant strategic processes

Emfuleni has various policies and strategic documents, which provide support for the municipality's ecosystems. These include the District-level Sedibeng Bioregional Plan (2012), the Sebokeng and Evaton Open Space Plan (2012) and the Environmental Management Framework (EMF) (2002). At a local level, the EMF does exist for the Local Vaal area but not for the entire ELM. At the time of writing, the municipality was in a process to approve the development of an EMF for the entire municipal area, which will be funded from the Municipal Infrastructure Grant (MIG).

According to the municipality, the open space network needs to be incorporated into the EMF, which will eventually form part of the Spatial Development Framework of the council. Emfuleni does not have a State of Environment Report (SOER) and therefore relies on the provincial SOER. The Sebokeng and Evaton Open Space Plan (2012), which is set up to be incorporated into the Integrated Development Planning (IDP) and the local Spatial Development Framework (SDF), aims to ensure that the resources that are contained in the open spaces as well as the biodiversity and associated ecosystem services, are protected and managed in a sustainable manner. This plan is significant in that it is a localised proposal, i.e. in the Sebokeng and Evaton areas, and contains a master plan identifying different types of green, brown and grey networks, as well as general management guidelines which address issues such as requirements for wetlands rehabilitation, food lots, and access to sensitive ecosystems, fencing, alien vegetation, control access and tree lists.

The strategic commitment to ecological assets within Emfuleni emerges in these and other planning and environmental documents of the municipality such as the IDP and the SDF. These documents describe the importance of ecosystem goods and services as providers of life-giving functions and the importance of maintaining, conserving, reviving and rehabilitating these systems to protect their functions. Furthermore, the Climate Change Toolkit for Emfuleni (SALGA & GIZ, 2011) describes the value of the ecosystem functions to the local community, such as recreational and social function, and to the surrounding area in terms of attenuation, carbon sequestration, reducing the heat island effect, purification of water and air, provision of water and providing a connection with nature. The Climate Change Toolkit offers a number of

normative proposals in light of these ecosystem functions including inter alia:

- The rehabilitation of wetlands to preserve their function of trapping sediments, controlling of floods and filtering out toxins and excess nutrients and acting as carbon stores, reducing greenhouse gases in the atmosphere
- The planting of more trees in the municipality to increase the carbon sink capacity of the area, reduce a wide range of pollutants in the air and provide an improved microclimate through convection and evaporation
- Conservation and management of the natural drainage channels and ecological system on the river banks for managing flooding and storm water.

Additionally, there are offers to develop an inventory of all wetlands in Emfuleni in collaboration with GDARD and to specify how environmentally sensitive areas should be conserved and incorporated into planning. In particular, the SDF states that ecologically 'Irreplaceable Sites' and 'Important Sites' as stipulated by the GDARD C-Plan2 need to be incorporated into the proposed open space network of Emfuleni, through rivers and tributaries as corridors that assist species migration within Emfuleni (Emfuleni, 2012a).

The IDP (2011/12) also proposes measures for addressing environmentally sensitive areas through inter alia:

- conserving natural areas and to avoid developments near riverfronts and floodplains
- combating dam and river pollution
- correcting conflicting land use by not allowing industries in rural areas
- protecting red data species
- implementing a connected network of Open Spaces throughout the area
- linking the natural areas (such as the Vaal River, other wetlands and hills) (Emfuleni, 2011).

The current SDF for Emfuleni, which is based on data from GDARD, indicates that green areas form a strong well connected continuous open space network with little fragmentation, and also indicates the position of parks and areas of dolomite as a guide for development. The biggest threat to open spaces is development encroachment as there is no municipal-wide environmental data for proactive decision making to manage this effectively and to motivate against development. The other threats to open spaces and wetlands are dumping and old sewer infrastructure as well as poor storm water management which pollute and degrade ecological systems.

Current initiatives

There are a number of initiatives administered by Emfuleni to invest in local green assets, including the development of parks, tree planting initiatives, urban agriculture, identification of parks based on an open space plan, eradication of alien vegetation, audit and verification of the open spaces and wetland rehabilitation. Although Emfuleni currently has 95 developed parks covering 470 hectares, 460 hectares have been identified as requiring upgrading, which in addition to 1070 hectares of undeveloped open space, indicates a large portion of municipal-owned land exists as open space but which is either not formally managed as parks or requires further investment (Emfuleni, 2012c).

In terms of tree planting, Emfuleni has sets a benchmark of 10 000 to be planted, 5 000 of which have been planted in the Sebokeng township (ELM, 2012). This is part of a municipal objective to plant trees in every township street and extends to fruit trees in private gardens, initiatives that are supported by widespread alien tree eradication in the municipality. Of the 32 hectares of alien vegetation earmarked for clearing in Emfuleni, 24 hectares are already cleared near the Klipriver, an area anticipated to be developed into a bird sanctuary in collaboration with GDARD.

Other initiatives coordinated by Emfuleni's Parks, Open Space and Grass Cutting division include a feasibility study to develop open space in an environmentally sensitive area around the Sharpeville Dam; an Open Space Master Plan for Sebokeng and Evaton; development of eleven parks (Bophelong, Beverley Hills, Adams Road, Evaton, Sebokeng Zone 6, Sebokeng Zone 11, Three Rivers, Roshnee, Vereeniging Extension 1 and Sharpville); the rehabilitation of wetlands and the establishment of various food gardens. The Parks, Open Space and Grass Cutting division also contributes towards addressing unemployed matriculated youth of the Vaal by converting general worker vacancies into Student / Intern Horticulturists positions. Furthermore, the national Buyisela (Eco-town) initiative, articulated as a project investing in ecological infrastructure, is being implemented in Emfuleni and is seeing municipal-wide street cleaning, the creation of landscaped gateways as well as tree planting around the municipality. Buyisela means giving back or restoring, and is part of a Greening and Cleaning Pilot Project, launched in October 2009, as an initiative by the Department of Environmental Affairs, the Department of Water Affairs, and other programmes to create ten eco-towns based on sustainability principles.

Future greening plans

The planning department of the ELM sees the potential for scenic mapping and tourism for the area but a bigger plan for this is lacking and would like to see that explored. Emphasis is placed on cleanliness and greening related initiatives in Emfuleni which encompass proposed initiatives such as the development of an open space system for the region, greening standards for new developments, waste management and management of illegal dumping and alien vegetation eradication. There are also targets set in the EPoA for planting a tree for every citizen in Emfuleni by 2016. This implies the planting of 721 663 trees if the population statistics of 2011 are considered (Emfuleni, 2009; StatsSA, 2012). There is also a target set in the EPoA to clear alien vegetation from all riverine and protected areas by 2016 and promote Sharpeville Dam regeneration. The Open Space and Parks Division aims to develop as many parks as possible and promote urban agriculture and the growing of vineyards in support of the Vaal River Wine Route (Emfuleni, 2012a). The SDF also supports the potential for urban agriculture and recognises that there are pockets of high-potential agricultural soils present throughout Emfuleni, which forms part of the bigger Emfuleni Agricultural Hub and should be maintained within township layouts for urban agricultural purposes (Emfuleni, 2012a). The SDF also highlights that communities generally practice urban agriculture for income-earning or food-producing activities. This local production of food allows savings in transportation costs and storage and it improves the quality of the urban environment through greening and therefore reduces pollution.

KLIPRIVIER, SOWETO, 2013

Perceptions of and commitment toward ecological assets

In Emfuleni, the commitment towards investing in ecological assets happens via a number of platforms, including tree-planting, climate change and green economy initiatives, and projects that recognise the recreation and social potential of areas, such as the Vaal River. However, while these initiatives might exist and endorse investment in natural assets, they are not always selected as priorities in planning agendas and consultations with municipal officials indicate that priority support is often given to services relating to bulk infrastructure, such as roads, storm water management, waste water, electricity and water supply.

According to an Emfuleni Town Planning official, there is also a lack of understanding and appreciation of how natural assets function. The official gives examples of wetlands stripped of reeds for development purposes, undermining their natural water purification and flood attenuation functions, and open spaces used as illegal dumping sites. A major challenge appears to be the fiscal capacity to maintain these assets, which in turn creates incentives for the municipality to "sell off" land for development. In this respect, while ecological assets appear to be valued, they are valued according to the development they facilitate, instead of the ecosystem functions they provide:

"Due to a lack of education and awareness, undeveloped open spaces are not valued according to the services that they provide to the community and the entire ecosystem and are often seen as potential for development" (ELM official, *pers. comm,* 2012)

The same official also explains that because unemployment is so high in Emfuleni, there is often conflict between conservation and development and particularly in terms of relatively short term social priorities and long term ecological functions the outcomes of which sometimes only materialise over the long term. These challenges signal that education and awareness about ecosystem functions is critical, but also more practical matters of reconciling budget priorities within a limited political term of five years and the possible replacement of councillors. Green infrastructure is often understood as renewable energy, public transport and green buildings (ELM official, *pers. comm*, 2012), and not necessarily as assets of the natural system in and around the city.

Lesedi Local Municipality (LLM)

According to its 2006 Environmental Management Framework (2006), Lesedi Local Municipality (LLM) spans an area of ±1430km^2 with open grassland plains, hills and outcrops (Lesedi, 2010). The natural character of the area has mainly been transformed by human settlement and agricultural activities (Lesedi, 2006). Lesedi is mainly rural, dominated by agricultural land of which 94% comprises large-scale commercial farms (Lesedi, 2006).

The landscape

Lesedi's natural environment is characterised by a flat topography causing poor drainage and results in various pans, vleis and wetlands (Lesedi, 2006). This natural character of the area contains valuable biodiversity-rich features including natural primary grasslands, koppies, ridge and wooded savannah areas, that contribute to a rich combination of ecosystems and are valuable as potential outdoor recreation and tourism opportunities (Lesedi, 2006). Other significant environmental features in Lesedi include the Blesbokspruit wetland, a RAMSAR site, the Alice Glöckner Reserve and the Suikerbosrand natural reserve (Lesedi, 2006). The Suikerbosrand Nature Reserve has been classified as a biodiversity hotspot and the Alice Glöckner Nature Reserve, a smaller nature reserve, has recently been rehabilitated (Lesedi, 2006). The Alice Glöckner Nature Reserve contains red data species, and various other noteworthy flora and geological features. Both the Suikerbosrand Nature Reserve and the Alice Glöckner Nature are managed by the province through GDARD and are promoted in light of their eco-tourism potential.

"...due to budget constraints, the Parks Section is not able to effectively maintain all parks and green open spaces, and with the mushrooming of low cost housing developments, green open spaces, except for those under power lines, are under pressure. So in order to save costs, we are making an effort to phase out intensive high maintenance gardens and develop more low maintenance gardening..."

(LLM Parks Section Official, 2012)

The integrity of this landscape is challenged by various urban, industrial and mining-related activities. In particular, the Blesbokspruit catchment's hydrological functions are being undermined by industrial and mining developments upstream as well as riparian irrigation that affects the catchment's base flow and with implications downstream, in the Suikerbosrand River and the Vaal River (Lesedi, 2006). Various strategic documents also indicate that pressures on biodiversity and ecosystem services are related to population pressures and challenges arising from urban expansion challenges such as increased sewage, water pollution, dumping of building materials in natural areas and the externalities associated with mining activities. Development has also taken place in many grassland plains, reducing species diversity in the area, while the extraction of sand along rivers and spruits is destroying river and wetland habitats.

Relevant institutional arrangements

In Lesedi Environmental Management is a unit within the Department of Planning and Development that operates alongside the Department of Service Delivery, which manages waste and sanitation, and the Department of Community Services through which Environmental Health operations take place. Community Services also houses Lesedi's "Parks Section" that is responsible for the maintenance of parks and open spaces, sidewalks, street trees, playgrounds, cemeteries and municipal gardens, as well the eradication of alien vegetation, weed control and locating and protecting "Red Data Species" in collaboration with GDARD. At the time of writing, Lesedi was without a strategic environmental manager and there were various operational and budgetary challenges that appeared to affect environmental management.

Relevant strategic policy processes

Several strategic documents integrate ecological assets into Lesedi's strategic vision as a municipality. Reading across the Lesedi Local Municipality (LLM) IDP 2012/2016, the Lesedi Environmental Management Framework (EMF) 2006, and the Lesedi Local Municipality Spatial Development Framework (SDF) 2010, the following emerge as positive visions for the municipality:

- The importance of protecting the natural resource in future planning to promote recreation and tourism development
- Addressing the development of ecological corridors connecting both natural (rivers, pans, dams, ridges) and recreation activities with each other, forming a municipal wide connected open space network) also linking up with urban open spaces within the urban nodes) to enhance specie protection
- The importance of providing open space throughout urban areas to provide "green lungs"
- There should be no development taking place in ecologically sensitive areas
- Self-sustaining development promoted in communities
- Raising awareness to inform farmers of the high value of biodiversity habitats.

Of the strategic documents administered by Lesedi, the Environmental Management Framework (Lesedi, 2006) is the

primary tool guiding the management of ecological assets as it informs the management of environmentally sensitive areas and provides information on environmental analyses (LLM Official, *pers. comm*, 2012). Lesedi does not have a Bioregional Plan and the municipality takes its cue from the overarching vision provided in the district-level Sedibeng Bioregional Plan of 2012. Although this approach allows for structure within district level operations, there may be room for ecological planning that is more nuanced and localised, and revisions of information contained within the 2006 EMF. According to a council official, for instance, "the council would value a more locally specific bioregional plan drafted through consultation and interaction with the various municipalities and which should include ground truthing and not just be a desktop study" (LLM Official, *pers. comm*, 2012).

Current and future initiatives

Roll-out of "green" initiatives in Lesedi is closely aligned to local economic support and a large portion of these are articulated as "green economy projects". Green economy projects are however diverse, ranging from energy interventions and sustainable manufacturing, to actual investments in ecological assets such as food security and sustainable agriculture projects (Lesedi, 2012). It is significant that many of Lesedi's green economy initiatives are collaborative projects between the local municipality and provincial and national government, which either provide fiscal support or assist in the operational processes of project development. For instance, Lesedi's wetland rehabilitation project is a joint Expanded Public Works Program (EPWP), SANBI and LLM initiative that aims to create 35 jobs (LLM Official, *pers. comm*, 2012). While projects removing alien vegetation are collaborations between GDARD, LLM, Department of Environmental Affairs (DEA), Department of Water Affairs (DWA) and the Department of Public Works (DoPW), setting out to create 112 jobs (LLM Official, *pers. comm*, 2012).

Various greening initiatives exist outside of Lesedi's green economy framing, such as the investments by LLM's Parks Division in tree planting projects and in the development of parks and open spaces for beautification purposes. According to Lesedi's Parks Department, there are approximately 12 000 public trees in the municipality and Lesedi's Parks Section has planted 7 500 trees, including 6 000 in Heidelberg and 1500 in Ratanda, Impumelelo and Kwazenzele. In the 2011/12 financial year, the municipality also planted approximately 300 trees in Impumelelo & Kwazenzele, initiatives which were supported through Lesedi's municipal nursery where trees are propagated, maintained and then distributed to schools and other institutions.

The impressions of Lesedi officials is that the LLM Parks Section operates within a limited budget and is largely dependent on GDARD for most projects that have taken place thus far (LLM Official, *pers. comm*, 2012). Lesedi relies on funds from GDARD's Bontle ke Botho or *Clean and Green Campaign* to unlock potential new park developments in the municipality, while most tree planting initiatives in the municipality rely on donations from both provincial and district governments. In 2011/12, for instance, GDARD donated 250 indigenous trees to Lesedi, and Sedibeng District Municipality supplied 300 indigenous and 50 fruit trees, which, together with other external funding from provincial government to develop community parks, provides the majority of support for Lesedi's greening initiatives.

Furthermore, various actions listed in LLM's strategic documents indicate a willingness to improve the management of ecological assets in the municipality. For instance, the IDP 2012/2016 states that a comprehensive Environmental Management Plan (EMP) will be drawn up, with guidelines and procedures for implementation, and the district-level SDF indicates that Lesedi would have to upgrade infrastructure such as waterborne sewerage systems to avoid raw sewerage being released into natural watercourses and wetlands, which is currently causing environmental and health challenges. There are also initiatives planned within Lesedi's green economy projects, such as Beautification of Entrances for Lesedi through planting trees and grass with an project budget of R9 350 00, but which is yet to secure funding and will depend on the lobbying efforts of the municipality to raise funds (LLM Official, *pers. comm*, 2012).

Perceptions of ecological assets

''Trees have also always been planted for aesthetical value as well as for shade and windbreak. Next to streams trees form greenbelts connecting various networks." (LLM Official, pers. comm, 2012)

In Lesedi, while assets such as the Blesbokspruit Wetlands are seen as "important environmental resources", the outcomes of ecological investments are generally articulated in terms of broader social and economic objectives such as the cosmetic, tourism and local economic development spin-offs that result from investing in "the environment" (LLM Official, *pers. comm,* 2012). However, according to the Lesedi Parks officials, greening initiatives are significantly challenged by community perceptions of the value of ecological investments. There have been many cases of tree vandalism in communities and many trees have been obstructed and destroyed, prohibiting trees from maturing. In their experience, Lesedi officials also note that young trees also get eaten by sheep, cows and goats that roam freely and unattended, while some homeowners believe that trees create concealed areas for criminals and that tree leaves create untidy spaces that attracts insects (LLM Official, *pers. comm*, 2012). As a result, Lesedi no longer plants trees in front of households without residents' approval and careful consultation is now undertaken to determine the suitability of each tree and to establish residents' willingness to contribute to tree maintenance (LLM Official, *pers. comm,* 2012).

In addition, there are institutional challenges that undermine a progressive ecological mandate within Lesedi, with limited funds and human resources being the major obstacles:

"It would require leadership to provide administrative and political direction in terms of a sustainable environment, which will enable human and budget resources to be allocated accordingly. In order to ensure successful investment in ecosystems services, knowledge and data on green infrastructure is required for officials and decision makers, and awareness is crucial for the general public. Green infrastructure would have to be valued in the same manner as other important services provided by the Council such as roads, water and electricity." (LLM official, pers. comm, 2013)

Midvaal Local Municipality (MLM)

Midvaal is the southernmost municipality in Gauteng and is predominantly rural in character comprising largely agricultural land (Midvaal, 2007). Midvaal constitutes 10,3% of the total Sedibeng population and 0,8% of the Gauteng population (Midvaal, 2007). In addition to extensive farming, representing approximately 50% of Midvaal's land use, the municipality includes significant natural features, notably the Suikerbosrand Nature Reserve and the Vaal River, as well as the Suikerbosrand River and the Klip River (Midvaal, 2011: Midvaal, May 2012). Being largely rural, urban land use in Midvaal is concentrated in agricultural and farming areas such as Meyerton, Walkerville, De Deur and Henley-on-Klip, and aside from industrial and commercial industries clustered along main transport routes, agricultural holdings occupy large parts of the Midvaal area (Midvaal, 2007).

Midvaal's landscape is confronted by a number of development pressures, particularly along the R59 freeway and along main river areas, where uncontrolled sprawl of low cost informal housing is endangering grasslands and is fast approaching protected areas such as the Suikerbosrand Nature Reserve (Midvaal, 2012). In addition, the absence of formal waste disposal and the occurrence of illegal dumping in informal settlements are resulting in ground and surface water pollution, which together with pollutants from agricultural production, is impacting on the quality of land available in Midvaal (Midvaal, 2012).

Relevant institutional arrangements and strategic processes

While many of Midvaal's planning processes take their cue from various district and provincial processes, such as the Sedibeng State of Environment Report (SoER) and the GDARD C-Plan, environmental management in Midvaal is a unique assembly of officials in the Department of Development and Planning and the Department of Social Services, the latter of which is primarily responsible for ecological investments. The Department of Social Services undertakes the following activities:

- implement pollution control strategies
- conservation of natural resources
- environmental awareness
- contribute towards sustainable urban and rural development
- grass and tree cutting

Supporting these functions, there are a number of strategic documents that govern environmental management in Midvaal. These documents include the Environmental Management Framework (Midvaal, 2007), the Midvaal Integrated Development Plan (IDP) (2012-2016) for 2012-2013, Midvaal Density Policy (2011), Midvaal Local Municipality Public Open Spaces By-Laws and Strategic Environmental Plan (SEMP) included in the IDP (Midvaal, 2012). While these frameworks, plans and policies guide land use management and planning and provide a legislative context for public open spaces and conservation mandates, there are also contradictory articulations of the role of ecological assets in relation to broader development, with natural features seen as both development constraints and part of the Municipal Open Space System to be protected. According to Midvaal's 2012/13 IDP:

"The most significant constraints for development identified in the Midvaal area in terms of the Midvaal SEMP (Strategic Environmental Management Plan) include the following:

- *The occurrence of Nature Reserves, specifically the Suikerbosrand Nature Reserve;*
- *Significant natural open space connectors;*
- *Several established conservancies in the area;*
- *The occurrence of Category I and Category II Ridges;*
- *Occurrence of large areas of medium and high potential agricultural land;*
- *Potential pollution sources from local and regional industrial activities, waste facilities, mining*
- *Activities and irrigation agriculture;*
- *Constraints to development due to the position of the urban edge; and*
- *Development activities in the Vaal Dam Area.*

There are clear indications from all sectors in the study area that there is a significant demand for development land, especially along the R59 freeway and the southern part of the study area, at the Vaal Dam, lying in an area bound by the R54 and R549." (Midvaal, 2012)

To an extent, this ambiguity is addressed in Midvaal's Environmental Management Framework (Midvaal, 2008), which was developed to provide information on environmental features and natural resources and guidelines on the Municipal Open Space System in relation to proposed developments. The framing of natural resources as constraints to development pressures may therefore indicate a deeper set of issues faced by Midvaal where residential development may address short term housing needs but at the expense of existing natural resources so that a critical consideration is the nature of future development paths. Indeed, the focus on higher density urban land use, as articulated in Midvaal's SDF may curb sprawling settlements and retain the "lungs of the city" identified in the IDP as elements that improve the quality of life of residents (Midvaal, 2012). Generally, the IDP lays a sound foundation for strategic ecological investments, through calls for the establishment of a Midvaal Biosphere to protect and enhance natural assets, and to promote landscaping in new developments to combat soil erosion and airborne dust (Midvaal, 2012). Such calls intimate the beginnings of a strategic vision that speaks to both natural asset conservation and the functional benefits of greening investments, a key motivation of which is to ensure that poor communities are less vulnerable to ecological disturbances.

Current Initiatives

In Midvaal, investments in ecological assets straddle a continuum of greening ranging from cosmetic or beautification initiatives to projects that address community services and safety. For instance, Midvaal undertook major tree planting initiatives in line with national greening efforts that accompanied the FIFA Soccer World Cup and in response to various national projects such as *The Adopt a Tree Campaign*. According to media reports, this campaign saw 500 trees planted during 2012 and 300 trees were planted for Arbour day 2012 in Sicelo Primary School, Lakeside park, Meyerton sports grounds and Verwoerd Street. The Midvaal Parks Departments also made 1000 indigenous trees available for collection by residents for planting during 2012. While these investments have a definite aesthetic character, tree planting schemes are also motivated to "promote a greener environment", as investments in cleaning the air and environment:

''When we look at the sky here it is brown and dirty, so we need to plant trees that can suck in the dirt and make oxygen so that you and I can breathe in cleaner air'.'

''There are four trees required per person to combat their or his/her impact on the environment.'' (Executive Mayor, Timothy Nast, Triangle Courier, 2012)

Recipients of Midvaal's tree planting schemes are generally previously disadvantaged schools and communities, to whom the Department of Safety, Heath and Environment and the Midvaal Mayoral Office donate trees, with a particular focus on indigenous and fruit-bearing trees, the latter used in supporting community vegetable gardens (Triangle Courier, 2012). To garner financial support for community greening, Midvaal is also experimenting with innovative institutional arrangements such as those created via the A*dopt a Park* initiative whereby large firms can fund parks in return for tax deductions (Midvaal official, *pers. comm*, 2012). This kind of collaboration is an indication of institutional openness to overcome obstacles to community greening.

In addition to greening initiatives through tree planting and park developments, Midvaal promotes natural asset *protection* as a foundation for tourism and related economic spin-offs. Municipal support for the tourism opportunities offered by the topography and vegetation of Midvaal focus on the area's four major tourism features: the Vaal Marina precinct located around the Vaal Dam, the Suikerbosrand Nature Reserve, Klip River and specifically the Henley-on-Klip area and it's extensive ridges. These assets are viewed as potential opportunities to expand the range of tourism facilities to include the mountain biking routes, hiking trails, game farming, and other adventure sports (Midvaal, 2012). The Midvaal EMF (2007) also proposes protecting the Suikerbosrand Nature Reserve from negative external drivers of change via a one kilometre wide buffer zone of low intensity and compatible land use.

Midvaal is also the base of the Gauteng Conservancy Association (GCA) formed in 2003 to promote conservation on private property in Gauteng and to give "teeth" to efforts to protect Gauteng's fast-disappearing greenbelt areas (Midvaal, 2012). The GCA is another example of independent organizations assisting government to manage illegal mining activities, dumping of refuse, overgrazing, veldfires, game poaching, ill-planned golfing estates, theft of plants and rocks, tree-cutting, alien vegetation, amongst others (Midvaal, 2012). It is significant that this community-driven initiative received the Mail and Guardian Greening the Future Merit Award for Environmental Best Practice in the Not-for-Profit Organization Category in 2005 and received the NACSA Aardvark Gold Award for best environmental practice in a province in South Africa in 2006.

Finally, according to the Midvaal Town Planning Department (Midvaal Official, *pers. comm*, 2012), the municipality's large expanse of land is viewed as an opportunity for attracting large scale investments to the area such as Savanna City. This is a development of 18 000 houses, which although designed

according to green building or sustainable housing principles, and to facilitate developers to obtain carbon credits, may undermine policy talk to conserve natural assets and retain 'natural open space connectors'. The Sicelo RDP housing project, for example, is based on green building principles, which includes rainwater harvesting and landscaping design sponsored by GDARD. Also proposed is a pre-proclamation Urban Management Framework (UMF) for the management of open space management and wetlands and 1000 trees to be donated by the Social Services Department and various fruit tree donations from the Mayor.

Perceptions of ecological assets

Midvaal's ecological assets benefit from strong political commitment through the Mayor who personally takes an interest in greening. This is coupled with a supportive policy landscape, which provides incentives to align development with ecological investments, and institutional receptiveness to overcome budget difficulties through collaborative partnerships. Positive examples of these include developments in the north-west of Midvaal such as Walkerville and Henley-on-Klip where developments are not in favour of any tourism-related activities and exhibit strong sentiments to retain pristine natural assets (Midvaal Official, *pers. comm*, 2012).

Midvaal's strategic discussions are also beginning to emphasise the important of ecological assets in providing services such as carbon sequestration values and noise and airborne dust buffering. However, according to Midvaal's Department of Health, there remain challenges in terms of sustaining trees:

"Trees are distributed as part of the upliftment of the environment and communities are excited about getting a tree for free. Fruit trees is more practical, but also more expensive and complex to maintain." (Midvaal Official, pers. comm, 2012)

With municipal initiatives supporting ecological assets, it is important not to lose sight of the social and cultural dynamics that have an important role to play in the productivity of a landscape. To the extent that Midvaal is seeking assistance from private firms for greening initiatives, the municipality is beginning to internalise the social practicalities of ecological investments, which may actually benefit from development application of the inclusion of landscaping guidelines and green building principles. Midvaal is still beset by development pressures but there are signs that the perception of what constitutes traditional development is beginning to change, with various strategic documents catering for landscaping, trees, gardens and ecological open space. There are also various articulations of the benefits of certain green assets, such as the claim by the Midvaal Department of Health officials that ''1 ton of carbon is being sequestrated by a tree over its lifetime" (Midvaal Official, *pers. comm*, 2012), but it is unclear as to whether this assertion is promoted outside of media platforms and connected into mainstream development planning.

Sedibeng: overall conclusions

Amongst the local municipalities within Sedibeng there are a number of commonalities in terms of how ecological assets are managed and perceived. In general, deficits in operational budgets and human resources compromise the capacity to coordinate and manage assets that are not key social or economic priorities. While there is an appreciation of the value of "the environment" within the departments directly responsible for inter alia trees, open spaces or parks, this understanding does not always filter down to the community level and is not necessarily a priority at top management level. The drive to "green" municipal operations often occurs through green economy or climate change-related mandates, which although inherently diverse are still opportunities for furthering investments in ecological assets. There is also a strong association between natural assets in the district and the economic benefits that accrue through eco-tourism.

The local municipalities depend on the coordination function of the Sedibeng District, but there are a number of concerns regarding local applicability of district-level planning. The District's Bioregional Plan is often perceived as merely a desktop study and according to some officials, does not represent the local municipal contexts effectively. Provincial support from GDARD plays an important role in supporting District initiatives, particularly the funding of alien vegetation removal as well as local municipal tree planting and park development projects, which may not have been possible without provincial support.

It is concerning that some of the local municipalities are without environmental managers, barring Emfuleni, and it is often not clear which departments or officials in each municipality are responsible for different streams of greening operations. Out-dated data and gaps in policies are also starting to show across the local municipalities. Midvaal is the only municipality that has a municipal-wide EMF. While Lesedi has an EMF, it is yet to be endorsed by DEA and Emfuleni's EMF covers only a section of the municipality, although there are plans to expand this. Various officials interviewed expressed concern that environmental management sections are often seen as not being a priority in the council with no authority and often have to revert to provincial or national departments to manage environmentally related issues. It is interesting, however, that while both Lesedi and Midvaal do not have an environmental management department, strictly speaking, their Departments of Social Services undertake trees and parks operations, which may be an indication of the conceptual coupling of greening projects and social services.

West Rand District Municipality (WRDM)

As a district municipality, West Rand District Municipality (WRDM) encompasses the four local municipalities of Mogale City, Merafong, Westonaria and Randfontein. It carries some district municipality functions of its own and also works to align strategies across the four locals. Visions to merge the four municipalities into a single metropolitan municipality are proposed in WRDM's *Vision 2016* (WRDM, 2012a). This merger is, in part, articulated as a holistic approach to environmental concerns and one which will develop economies from climate change mitigation strategies and the growth of green and sustainable industries (WRDM, 2012). This single metro vision hinges on approval by the Demarcation Board of South Africa, a decision scheduled for July or August 2013.

Regardless of whether the West Rand municipalities will be merged into a metro, the co-ordination of the greening operations of each local municipality is a key concern. The WRDM has developed a *Green IQ Strategy* through which it commits to becoming the greenest district in South Africa (WRDM, 2013). Alongside this district level strategic focus, the four local municipalities are making explicit investments in the greening of existing and new developments, infused with explicit mandates to green disadvantaged communities, in the process embedding ecological assets in the realm of community services. Subject to possible institutional shifts, ecological assets in the West Rand enter squarely into the sphere of municipal competencies and operational purview. Their active investments in greening initiatives play a critical role in creating and sustaining green landscapes.

WEST RAND ROUTE, 2013

The landscape

The West Rand is located on the South Western edge of Gauteng and covers approximately 4,095 km^2, of which a majority consists of natural open spaces and agricultural lands (WRDM, 2011). The district contains a world heritage site, the Cradle of Humankind, that forms part of the ecologically sensitive Magaliesberg range of ridges (WRDM, 2011). According to the WRDM Bioregional Plan, the West Rand has a high percentage of rare and threatened species and ecosystems as a result of the region's unique topographic and geological diversity and high levels of habitat transformation (WRDM, 2012b). Therefore, although overall land transformation levels in Gauteng are higher than in the West Rand, which is 6% urbanised and predominately rural, the municipality has been greatly impacted by agricultural, mining and industrial activities the effects of which include acid mine drainage, waste water treatment plants, fertilizer and pesticide runoff, overgrazing and catchment hardening, amongst others (WRDM, 2012b, WRDM, 2009). These pressures have created a landscape in which 55% of ecosystems are identified as threatened while 83% of wetlands and 33% of river types are also threatened (WRDM, 2012b).

Relevant institutional arrangements and strategic processes

The structure of WRDM is such that the investment and management of ecological assets does not happen via one 'environmental' unit per se, but through the interactions of various district officials and planners in relation to local municipal operations. The most important area of institutional activism by the District are visioning frameworks, plans and strategies that by themselves appear to hold together the institutional space for managing and investing in green assets. For instance, the WRDM Green IQ Strategy (2013) defines seven key priorities that focus the District on operations such as intensive tree planting schemes, removal of alien vegetation and regenerating degraded lands. These represent an explicit strategic process in which ecological priorities for the district are strongly embedded.

To the extent that the WRDM Green IQ Strategy (2013) is a vision for the future, additional support for future investments in ecological assets is provided via the district's IDP for 2011/12 to 2015/16. Under the strategic goal 'Environmental Management', WRDM undertakes a district environmental management framework, environmental management programmes, district environmental management project resource mobilisation and district environmental management performance monitoring. While these strategic goals are connected into broad sustainability objectives, such as air quality and waste management, specific priorities are also earmarked in the WRDM IDP (2012/13) to invest in ecological assets including a biodiversity management strategy and an open space and greening master plan. These strategies are bolstered by other project ideas such as the acknowledgement within the IDP of the need to "create a district wide GIS based system that will operate in accordance with the newly formulated Land Use Management Scheme for the district… created on a regional level of all existing and future developments, transportation data, subdivision applications, geological / environmental sensitive areas etc." (WRDM, 2012a).

Alongside the IDP, the WRDM Bioregional Plan (BRP) (2012) and the WRDM State of Environment Report (SOER) (2011) serve as information tools informing land use planning and reporting on the state of the environment in the district, including pressures facing the district. Both the WRDM BRP (2012) and the WRDM SOER (2011) relate provincial planning information, predominately via GDARD and the Gauteng Conservation C Plan, to West Rand specificities. Provincial data is the primary feeder into these processes, which as reporting and information tools are understandably generic so that while they elucidate the West Rand situation, such as endemic invertebrates occurring in the district, they are processes that inevitably cover a broad spectrum of issues and themes. Such information tools therefore need to be considered alongside processes that are more programmatic and strategic, such as the IDP, supported through the Vision 2016 and the Green IQ strategy, as the primary channels for district-wide plans for ecological assets and supporting projects. Together, these processes signal a shift in the consciousness of the District towards a green identity, but the capacity to implement this vision remains a question. Many '2016' projects are still to be established and while projects are allocated budgets, these allocations, at the time of writing, are yet to be approved and officially paired to projects. The actualisation of strategic

objectives becomes clearer through tracking the programmes and project implementation for local municipalities, a process that also elucidates the institutional circuits through which capital investments are directed.

A significant geological feature of the West Rand is the occurrence of dolomite which while performing important hydrological functions, through holding substantial ground water and controlling the water table, also dissolves in response to water table fluctuations, in turn increasing the risk of sinkholes and restricting land use and settlement patterns (DWA, 2009; WRDM, 2011b). The risk of developing on dolomitic land has been a major determinant of the nature of the West Rand landscape. Although there are large expanses of land, much of this land is deemed unsuitable for development due to the risk of sinkholes, which according to municipal officials have created an excess of open spaces. From a management perspective, much of this land is deemed a burden so that both developments and greening work by local municipalities have distinct spatial characteristics that emerge from the location of dolomite. This also means that new ecological assets, such as trees and community gardens, funded by municipalities, are concentrated in areas deemed safe. This creates a landscape of specifically located ecological investments.

Local greening implementation – reflections from the locals

The four local municipalities within the West Rand are engaged in various aspects of greening. There are projects that serve cosmetic purposes, often aligned to ideas of 'community recreation', while other initiatives focus on transforming degraded land with an explicit coupling of service delivery objectives and landscaping principles. There is a clear municipal recognition of the functions of ecological assets, yet it is unclear if this is work is informed by detailed scientific studies on the functions of specific ecological processes. These mandates are variously influenced by community needs, settlement design guidelines and by space constraints posed by dolomitic land amongst others, with the result being a number of institutional engagements with the meaning of 'ecological investment'.

Of the explicit landscape investments made by local municipalities, Mogale City's greening work appears to be the most technical, specifying various requirements for developments vis-à-vis ecological features such as open spaces adjoining buildings, trees and gardens. For instance, the Mogale City By-Law relating to Urban Greening and Biodiversity (2005) stipulates a number of edicts, which together represent a progressive vehicle for investment (Box 7):

BOX 7

2. SUBMISSION OF LANDSCAPE DEVELOPMENT PLANS
   - 2.1 Targeted property developments
     - 2.1.1 "The submission of Landscape Development Plans to the Directorate Integrated Environmental Management will be compulsory for any residential and business development whether developed as a single unit or sub-divided portions, except for individual residential 1 erven smaller than 2000m2 in extent"

3. PROVISION & PRESERVATION OF TREES ON PRIVATE PROPERTY DEVELOPMENTS
   - 3.1 Provision of trees on parking lots and pedestrian walkways
     - i) Any property developer providing more than four parking bays per property, will plant trees at a density of one tree for every four parking bays
     - v) Property owners within private residential estates will only plant suitable indigenous tree species on their sidewalks, which will be determined by the Sub-Directorate of Parks Management. The estate manager will distribute a list of such suitable trees species to every new property owner within such residential estate. The estate manager will instruct property owners to remove tree species other than those specified on the prescribed list and upon failure to do so remove such trees at the cost of the property owner

4. ALLOCATION OF PRIVATE OPEN SPACE
   - 4.1 All residential property developments or townships in excess of 1Ha in extent, will allocate a minimum of 15% of the property towards zoned private open space. Such zoned private open spaces will individually not be less than 1500m2 in extent.
   - 4.2 All business estates including office parks and industrial parks in excess of 1Ha in extent, will allocate a minimum of 10% of the property towards private open space. Such private open spaces will individually not be less than 1000m2 in extent.
   - 4.3 A minimum of 75% of the allocated private open spaces will be interconnected, forming a functional network of green spaces. Such open space connectivity may only be intersected by road infrastructure

These by-laws guide Mogale's Urban Greening, which is articulated as "a wide range of urban development actions that aim to facilitate a sustainable relationship between urban dwellers and their environment" (Mogale City, 2005). Alluding to a policy landscape in which notions of urban greening circulate and while backed by technical guidelines, are not necessarily rooted in considerations of the effects of different species choices or arrangements in the landscape, a Mogale City official reflects:

"There is a focus on how open spaces can ameliorate climate change-related issues, but there is no supporting scientific detail for this, which comes more from an educational perspective." (Mogale City Official, pers. comm, 2013)

In the West Rand, the state of 'ecological' or 'green space' knowledge is tied to the history of municipal planning, which before the amalgamation of locals into the West Rand in early 2000s, existed without an overarching 'open space framework' of the entire region. In part, this has been addressed by the development of the WRDM BRP (2012) but the place of scientific expertise across planning circuitries is still wanting since much of the work following amalgamation has been about setting an agenda for ecological investments. In doing so, a number of versions of 'urban greening' have focused strongly on the cosmetic connotations of greening, with conscious attempts to create green spaces and 'green' existing and new developments. By way of example, the Randfontein Local Municipality's programme of *Greening and Beautification* (Randfontein, 2010), significantly articulated through visual impressions of a beautification programme, focuses on main arterials, parks, and areas of illegal dumping to achieve the following:

- To provide residents and visitors with flower gardens, streetscaping, cleanliness, and public art in order to promote the aesthetic appeal of the area
- To maintain and continuously improve image route streetscaping to contribute to the beautification of our area
- To continue to enhance the general cleanliness of Randfontein and associated green initiatives
- To create employment, thus contribute to Randfontein's economic growth
- Greening of RLM
- To provide dramatic colourful landscape enhancements.

This programme is not entirely different from what Mogale is undertaking and signals the aesthetic approach embedded in much of the West Rand's greening work. Similar sentiments are expressed in the other local municipalities' programmes, coupled with ideas of how greening can assist both communities and the environment. Through its Greening and Beautification project Westonaria Local Municipality frames tree planting as an initiative that "comes with significant benefits" such as mitigating climate change, beautifying the area, serving medicinal functions, the provision of fruit and contribution to economic opportunities (Westonaria, 2013). Such logics are tantalising, but the corollary that planting trees, gardens and investing in other greening initiatives is socially and ecologically beneficial, is largely based on standard explanations such as "improvement of aesthetic appeal" and "greening to contribute to the environment". These motives have required little empirical valuation to find purchase within municipal planning, which appears to draw on the perceived value of and connection to social and environmental well-being. While this may mean that government stakeholders need little to be convinced of the need to invest in greening, as this underpinning philosophy already appears to exist, the suite of services provided by ecological assets varies considerably, depending on relationships between ecological processes and different landscape choices.

It is telling that in Merafong, 'Parks' are measured through *developed* parks, opens spaces and sidewalks, with a key focus on 'Park development' as a reporting tool (Merafong, 2011a, Merafong, 2010). Municipal officials reflect that the persuasive policy argument for this work is generally the number of parks developed for communities, and previously disadvantaged communities in particular. This mandate is largely incentivised by the Guidelines for Human Settlements, Planning and Design which stipulates a number of general guidelines in relation to access to public green spaces (CSIR, 2000). These guidelines are largely motivated as a community recreation opportunity, and it is significant that various local municipalities in the West Rand house the design of green spaces under an institutional arm dealing with *community services*, motivated by "the needs of people in informal settlements" and to achieve "the correct ratio of parks to people" (Randfontein Official, *pers. comm*, 2013).

A further trend is cemeteries as of key focus of the West Rand's greening investments, with a number of the locals exhibiting an institutional coupling of parks and cemeteries, usually under community services mandates. This is the case in Westonaria, and in Mogale City, where cemeteries are managed alongside parks, trees, urban greening and environmental protection, operations collectively labelled as 'Parks Management'. The demand for cemeteries is a major consideration across the West Rand where the rising demand for cemeteries is complicated by the unavailability of suitable land, due to dolomite. In Merafong for instance, of the municipality's 11 cemetries, 5 are full to capacity and 6 are in operation, while in Randfontein, municipal officials have begun selling the idea of 'second burials', using the same grave twice, to preserve space (Merafong, 2011b; Randfontein Official, *pers. comm*, 2013).

Municipalities in the West Rand have also invested in greening in interesting ways to overcome particular land use challenges. Of the three parks established by WRDM, namely Bekkersdal (Westonaria), Maglakeng (Randfontein) and Fedela (Merafong), two were established to convert informal dumping sites into managed park areas so to curb illegal dumping. Parks are seen as instruments to change public perceptions of open spaces, which in the absence of sufficient waste collection services as well as community education about the effects of pollution, become the subjects of illegal dumping activities. However, WRDM officials, reflecting on park projects, explain that despite park investments, illegal dumping still takes place in areas adjacent to parks (*WRDM Officials, pers. comm, 2013).* Officials also noted that compared to Soweto in Johannesburg, where community buy-in for parks is strong, there is a slow take-up by communities of appreciating parks in the West Rand (*WRDM Officials, pers. comm, 2013)*.

WEST RAND ROUTE, 2013

Perceptions of ecological assets

In the West Rand, a range of motives supports greening initiatives. On the one hand, there is a political decisiveness to enhance community recreation opportunities, via developing parks for previously disadvantaged communities, while aesthetic motives, tied to unique land use issues, drive strategic endorsements of landscaping and greening guidelines. The diverse policy landscape in which these ideas are embedded reflects a planning perception that ecological investment is broader than traditional conservation or preservation mandates. While the correlation between specific ecological processes and wider social benefits is largely based on generic targets rather than empirical research, the strategic choice to include parks, trees and landscaping guidelines in municipal operations is still a positive move, as reflected by a Mogale City official:

"Historically open spaces have been seen as 'social spaces' but there is now more of a focus on ecological services and how much open spaces can be used to sustain these." (Mogale City Official, pers. comm, 2013)

The sustainability of this shift is determined by financial support to carry out greening but also, crucially, a working relationship between municipalities and local communities. Municipal experience with tree initiatives, for instance, has demonstrated to officials the reasons behind unsuccessful tree planting. Officials reflect that small trees are often broken by school children or vandalised by community members, and by implication, officials now ensure trees procured are at least between 1,5 metres and 2 metres in height and avoid saplings in planting schemes (WRDM Official, *pers. comm*, 2013). Importantly, this speaks to the value of officials' experience in assessing the success of various ecological investments and although not necessarily captured in detailed scientific reports, also indicates that local government knowledge retained over time is a critical source of ecological know-how. In this respect, many officials engaged with parks, open spaces and other forms of greening emphasise experience has taught them that community awareness is critical, and there is consequently a strong emphasis on "educating communities to avoid vandalism once we establish a project" (Mogale City Official *pers. comm*, 2013).

Although 'community values' feature as a primary motivation in most West Rand greening schemes, little detailed work has been done to study the relationship between ecological investments and social value, and in particular, how the specific attitudes of residents affect the success of projects such as vegetable gardens or tree planting. There is a general acceptance that these initiatives are socially beneficial, but officials' experience with greening schemes is that these schemes depend on "levels of interaction between communities and trees and gardens, and whether people actually use green features " (WRDM Official, *pers. comm*, 2013).

Yet while local municipal parks departments are largely responsible for park maintenance, the actual design and establishment of parks is often outsourced to landscape consultants and private sector partners. One municipal official reflects that "we just don't have the capacity here to develop a park, and more often than not, the private sector can do it better than we can" (West Rand official, *pers. comm*, 2013). Furthermore:

"If we want to plant trees, we ask for donations from nurseries or NGOs. We mainly get support from nurseries. Our executive mayor set out to plant 10 000 trees with no budget and we rely mainly on donations from nurseries or mines." (WRDM Official pers. comm, 2013)

The fact that the 10 000 tree planting target is one of the strategies promoted in WRDM's *Vision 2016* to create a holistic approach to environmental concerns (WRDM, 2012a) underscores some notable trends in the way ecological investments are made in the face of acute budget challenges. At a district level, WRDM has established key partnerships with industries to support greening initiatives through donations from companies operating in and around the region. While the horticultural industry is an obvious contributor to greening initiatives, the role of mining companies is a more complex one given the controversial ecological impact of mines operating in the West Rand. A number of municipal officials also comment on the "positive" and "incredibly helpful" role of mining companies in greening settlements through *pro bono* tree planting schemes (Westonaria Official, *pers. comm*, 2013). While by no means uncommon, the intention of the mining sector to incorporate social and environmental priorities in their operations underscores the institutional configurations that determine the ability of government to manage and restore its assets. Whether these subtleties will be affected in the long-term by vulnerabilities felt by the mining sector may be an important consideration, in terms of the fiscal and organizational capacities to invest in landscapes, but perhaps more critical is whether mining companies' investments are backed by information on the benefits of specific species and planting configurations. It appears many mining-supported investments are also driven as 'social' or 'community' investment projects, with very little data collection on the benefits of particular projects, making it difficult to comprehensively assess the overall value project actions.

Conclusions

In the West Rand, it could be said that tree planting, park development and landscaping projects are aligned with the idea of green infrastructure through the various municipal references to the broader social and environmental benefits that flow from these projects. Yet the value of these projects is generally unaccounted for, with projects largely being motivated as simplified "community" or "environmental" initiatives. It is telling that local officials' experience indicates the importance of public acceptance and active engagement in greening projects, particularly in terms of maintenance and keeping sites free of pollution and vandalism, and uncovering the details behind the relationships between greening projects and community value may indeed provide critical information on the value of investing in such projects. More detailed reflections on the investments in ecological assets, whether this be through collaborative partnerships between government and other sectors, and in turn through local communities, is a critical consideration in terms of enhancing joint responsibility for landscape investments and to decide on the best fit of potential investments in a wider landscape setting.

Overall conclusions

A number of solid foundations exist in the public domain for planning and future investment in the GCR's green assets. Some progressive institutional structures and ambitious greening targets make for a productive and active policy landscape. Much of this agenda takes place via tree-planting, park upgrades and extensions, and various attempts to address uneven shares of green space acorss the city-region. While this work is positive, the connection into mainstream infrastructure planning is still wanting. This signals a need for activism from government to embrace alternative infrastructure styles and research into the kinds of green infrastructure appropriate for different municipal contexts. The set of solutions that may fit a dolomitic context in the West Rand, for example, may not be as relevant for more forested areas such as Tshwane and Johannesburg, where the services of green infrastructure already in place are to be capitalized upon. This work presents a major opportunity for municipalities in the GCR, which are situated in diverse institutional and ecological settings. The integration of the different knowledges that exist, about different green assets and challenges faced in managing them, is a critical step in developing a city-region approach to green infrastructure.

BOUGAINVILLIA

Natasha Christopher

Bougainvillia, Johannesburg, 2011 - 2013





















SECTION FOUR

This section explores ecosystem service valuation techniques that could be applied in the GCR context. After classifying and comparing the options for valuing relevant ecosystem services, the chapter indicatively demonstrates one method for valuing public green spaces in the City of Johannesburg.

Techniques for valuing green infrastructure

Background and introduction to ecosystem valuation

Background

Planning for green infrastructure involves understanding its functions and how these benefit society. This report has already established the principle that the GCR's green assets ought to be appreciated as infrastructure, but more detail is needed on how to value the multiple benefits of green infrastructure and how to incorporate ecosystem services valuations into public budgeting and planning processes. This chapter provides a preliminary investigation into options for valuing multi-dimensional and multi-functional green assets. Its argument is strongly influenced by a study by the City of Cape Town: *Investing in Natural Assets. A Business Case*, where the case for investment in and maintenance of ecological assets was made through applying economic valuation techniques to the sustained flows of ecosystem good and services (De Wit *et al*., 2009a; De Wit *et al*., 2009b; De Wit *et al*., 2012). In line with this foundational work, this chapter assesses ecosystem valuation work undertaken thus far and lays the basis for future GCRO research pathways to value ecosystem services more explicitly in the GCR.

The chapter is structured as follows:

- A desktop review of methodologies for valuing ecosystems services in economic terms, illustrated via examples of how this is currently conducted in urban settings with a focus on, but not limited to, South African case studies
- A case study demonstrating ecosystems valuation in the GCR's urban context, using data on parks from the City of Johannesburg
- A summary discussion on the importance of, and opportunities for, including ecosystem valuation in policy frameworks and planning and budgeting processes in the GCR.

WATERFALL ESTATE, MIDRAND, 2013

Introducing ecosystem valuation

The importance for ecosystem valuation has been emphasized in the development of a business case to invest in green infrastructure by the City of Cape Town (De Wit *et al*., 2009b). In a subsequent unpublished report on ecosystem finance mechanisms, De Wit and Van Zyl (2010) argue as follows:

"As everyone benefits from ecosystem goods and services, the relevant authorities who have the mandate of being custodians to the public good, have a role in investing and maintaining such services. Where such services do benefit private agents as well, it will only be fair for private agents to contribute to the maintenance of such services. This is not very different from the investment and maintenance of other utilities – municipalities invest in infrastructure and the provision of services and those who benefit (households, industries, tourists) pay through mechanisms such as tariffs, property rates and charges. Where social objectives, such as the rollout of services to the poor need to be achieved, national and/or provincial government also contributes. The logic therefore, from a municipalities' perspective, would be to outsource investment and maintenance of natural capital only where clear, private benefits can be achieved, and work with an approach of either a full service provision model by the municipality in certain cases, or with shared arrangements with the private agents in other cases."

Incorporating green infrastructure into public planning and budgeting requires an understanding of the potential role of monetary valuation of ecosystem goods and services (EGS). Through monetary valuation, the economic multipliers of investing in ecosystems become evident. The ecosystem value-added relative to the return on public expenditure on green infrastructure highlights the need to use public funds for sustaining ecological assets (De Wit *et al*., 2012). Monetary valuation contributes to public budgeting and planning of green infrastructure in at least four areas:

1. Valuation tools offer a framework for providing a common currency through which information may be shared with relevant decision-makers across a range of inter – and intra – departmental functions
2. Environmental valuation provides a framework for valuing the benefits that accrue to future generations
3. Environmental resource economics (ERE) valuation tools can address sectoral issues such as environmental governance, biodiversity resources and cultural heritage, thereby contributing towards a holistic approach to environmental management
4. Valuation can be used to assess the benefits derived from services of the natural resources and ecological systems in the urban contexts, as well as how these benefits are distributed.

Review of methodologies and examples of existing ecosystem valuation work in urban contexts

Total Economic Value approach

The Total Economic Value (TEV) approach is widely used as a framework for incorporating complex and interrelated interactions between the physical attributes of the environment and the associated value flows. The framework is used to value both market and non-market benefits, as well as future use, along with values totally unrelated to future consumption. A comparison between market, non-market and proxy market values is given in Table 4.

	MARKET VALUES	NON-MARKET VALUES	PROXY MARKET VALUES
Definition	The value of environmental goods is directly inferred by looking at the value they are traded on markets. An example is the direct or shadow price of timber sold on the market	Most environmental goods, such as clean air and water, and healthy fish and wildlife populations, are not traded in markets. Their economic value – how much people would be willing to pay for them in Rands or Dollars – is not revealed in market prices. Non-market valuation techniques are then employed.	The value of environmental goods is inferred indirectly through proxy (surrogate) markets. An example would be to infer the value of a wetland by comparing property prices in close proximity to the wetland compared with property prices further afield.
Examples of valuation techniques	Market price Replacement cost Opportunity cost	Contingent valuation Conjoint analysis	Travel cost Aversive behaviour Defensive expenditure Hedonic pricing

Table 4. A comparison between market, non-market and proxy market values (Source: Own Analysis)

There is no universally accepted framework for total economic value. Usually a distinction is drawn between use and non-use values, the former being those values that involve some interaction with the environment, and the latter being those values derived from the knowledge that a resource exists. However, this categorisation creates a problem for the so-called option values, which involve preservation of a resource so that it may be used in the future. Some would classify these as use values, while others classify these as non-use values. In addition, there are so-called quasi option values that involve delaying decisions until technology is developed to such an extent that an optimal decision might be made concerning the environmental resource.

Using the use value / non-use value categorisation, a distinction can be drawn between direct use values and indirect use values. Direct use values are those associated either with the consumptive use of the resource (e.g. food, fuel, water, timber) or non-consumptive use (e.g. tourism). Indirect use values are associated with the benefit derived from the ecosystem, without directly consuming it (e.g. climate regulation, carbon sequestration and erosion control). Non-use values are usually divided into existence and bequest values, although altruistic values are sometimes also included in this category. Existence values are those values associated with knowing that a resource is available, irrespective of whether the individual will ever benefit (directly or indirectly) from it. This value is highest for charismatic species such as the Big Five, or Asian Pandas. Bequest values measure the willingness of current generations to pay to ensure that the environment is preserved for future generations. Altruistic values are similar to existence values, except that a value is placed on contemporaries deriving a benefit from the resource.

Ecosystem services and valuation techniques

The Millennium Ecosystem Assessment (2005) distinguishes four categories of goods and services:

- provisioning services that relate to the products derived from an ecosystem, including food, fibre and fuel, genetic resources, medicines and pharmaceuticals
- regulating services that involve the benefits derived from the regulation of ecosystem processes, such as air quality regulation, climate regulation, water regulation, erosion regulation, disease regulation, pest regulation and natural hazard regulation
- cultural services are the benefits people obtain from ecosystems such as reflection, recreation, inspiration, and aesthetic enjoyment, and include cultural diversity and educational values, and
- supporting services are those necessary for the production of all other ecosystem services, such as soil formation, photosynthesis, primary production, nutrient cycling and water cycling.

In terms of the total economic value framework, provisioning services fall largely within the direct use category, regulating services are largely indirect use values, cultural services comprise both a direct use component for values such as recreation, and an existence value component for most of the remainder (Table 5). Supporting services on the whole do not form part of TEV, but are valued indirectly through the services they provide to other ecosystem goods and services.

CATEGORY	TYPE OF GOODS AND SERVICES	TYPE OF ECONOMIC VALUE	MONETARY VALUATION TECHNIQUE
Provisioning services	Fresh water provision	Direct use value	Effects on production,cost of alternative sources, benefits transfer technique
	Materials for crafts	Direct use value	
	Fish resources (e.g. from dams)	Direct use value	
	Small scale urban farming	Direct use value	
	Fuel wood	Direct use value	
Cultural services	Recreation and ecotourism	Direct use value	Travel cost, property price/ hedonics, contingent valuation & conjoint analysis, benefits transfer technique
	Educational values (e.g. school excursions and scientific research)	Direct use value	
	Aesthetic values and sense of place	Existence value	
	Provision of inspirational beauty	Existence value	
Regulating services	Water purification & waste treatment	Indirect use value	Replacement cost, preventative costs, costs of disaster, system failure, benefits transfer technique
	Air quality regulation (local)	Indirect use value	
	Climate regulation (global)	Indirect use value	
	Erosion regulation	Indirect use value	
	Flood attenuation	Indirect use value	

Table 5. Ecosystem goods and services and monetary valuation techniques (Source: Adapted from De Wit *et al*. (2009b))

Case studies

The value of green infrastructure can typically be conceptualised through five categories, namely natural areas, landscapes, water, soil and air. This is based on a review of a number of local case studies, which apply monetary valuation techniques to the five categories, with the exception of soil, for which no sufficiently representative set of local urban valuation studies was available. The relationship between these categories and the case study values is discussed below and represented in Table 6.

CATEGORY	VALUATION
Natural areas	Recreational values from urban open spaces, recreational value of protected areas
Landscapes	Geological and cultural features
Water	Wetland values
Air	Air pollution, carbon sequestration

Table 6. Relationship between categories and case study values (Source: Own analysis)

Recreational values from green open spaces

There are a variety of green open spaces in the GCR, including protected areas, ridges, recreation parks, sports facilities, traffic islands, cemeteries and natural areas on privately owned land (Bouwer, 2008). In addition to small pockets of natural open spaces either owned privately or belonging to government, there are other green open spaces including nature reserves designated as protected areas in terms of relevant municipal, provincial or national legislation. Green open spaces play an important role in metropolitan and urban areas through providing recreational benefits and potentially increasing property values. A detailed study of green open spaces in the Cape Metropolitan area (Turpie *et al*., 2001) provides an indication of the value of undeveloped land. Contingent valuation was used to estimate the value of use, option and existence values of open spaces, while hedonic pricing determined the impact of open spaces on property values. Not all open spaces produce a positive value. Using the hedonic pricing method, vacant lots are shown to provide a dis-amenity of R7 840 per hectare in metro SE (2011 values). Close proximity to parks, on the other hand, provides a premium of R134 365 per hectare (annualised) in 2011 prices (see Table 7).

	CONTINGENT VALUATION		HEDONIC PRICING
	METRO S	METRO SE	METRO SE
Parks	5 220	4 100	134 365
Sports fields	26 288	47 139	25 217
Natural vegetation	9 128	1 501	
Vacant land	1 316	408	-7 840
Agricultural fields	74 355	1 207	

Notes: All values are in 2011 Rands. Values are inflated to 2011 values using the CPI index for urban areas (South African Reserve Bank). Values are based on City of Cape Town Metropolitan Open Spaces Study (CMOSS). Source: Based on Turpie *et al*. (2001)

Table 7. Open space values (R/ha) from CV and hedonic pricing, 2011

Geological and cultural values

In an ecosystem valuation study assessing the relationship between ecological features and property values, Turpie (1998) used the hedonic pricing method to assess whether property prices were affected by proximity to Table Mountain, in the City of Cape Town. The study concludes that proximity to the City centre is a factor influencing property prices in the City bowl, and this has confounded the influence of the Table Mountain views. Gauteng has a number of geologically and culturally significant areas, including the Tswaing Meteor Crater and Cradle of Humankind World Heritage Site. No known monetary valuation studies have been conducted on these areas. Such studies are complex and require non-market approaches to valuation using survey techniques.

Wetland values

Wetlands may have either a positive or negative impact on the prices of properties in close proximity to the wetlands. A number of hedonic pricing studies in the City of Cape Town have indicated a premium associated with properties situated close to wetlands. In Zandvlei in Cape Town, for example, property price premiums were approximately R 92,2 million in 2001 (Van Zyl, 2007). In Zeekoevlei, also in Cape Town, property values associated with houses on the vlei are between 14 and 29 percent higher, and this diminishes rapidly with increasing distance from the wetland (Van Zyl & Leiman, 2001).

Wetlands also provide a number of benefits, including recreational opportunities and water regulation, amongst others. Both Joubert and Turpie (2001) and Turpie and Joubert (2001) used the expressed preference (Contingent Valuation Method (CVM), specifically) and revealed preference methods (the Travel Cost Method (TCM) specifically), to estimate the recreational value of Zandvlei and Kuilsriver in the Western Cape. In terms of water purification services, Harding (2001) used the replacement cost method to estimate the costs of constructing an artificial wetland, as well as water purification and storage functions. The benefits provided by wetlands for agricultural production, through irrigation and water for

livestock, have been assessed by Lannas and Turpie (2009), who elicited direct use values from agricultural production for the Mfuleni peri-urban wetland. Finally, wetlands and other natural assets provide important benefits in terms of flood attenuation. De Wit *et al*. (2009b) use the damage cost method to estimate the value of flood buffering provided by natural assets. Results are summarised in Table 8.

TYPE OF VALUE	TECHNIQUE	METRO S	METRO SE	ALL AREAS	REFERENCE
Recreational option	CVM	7 226	36 856	22 041	Joubert and Turpie (2001)
Recreational use	TCM	7 903	-	7 903	Turpie and Joubert (2001)
Property value	HPM	96 881	72 302	84 591	van Zyl and Leiman (2001)
Water quality	RCM	31 918	35 617	33 768	Harding (2001)
Direct use value	HHS	-	15 874	15 874	Lannas and Turpie (2009)
Flood attenuation	DCM			387	De Wit *et al*. (2009)
Total economic value				387	

Notes: Values from individual studies are inflated to 2011 values using the CPI index for urban areas (SARB Quarterly Bulletin). CVM=contingent valuation method; TCM= travel cost method; HPM= hedonic pricing method; RCM=replacement cost method HHS= household survey (direct use value); DCM= Damage cost method.

Table 8. Urban and peri-urban wetland values (R/ha/yr), South Afrca (2011 prices)

Table 8 indicates that property values are potentially the highest contributors to total economic value in peri-urban wetlands. However, wetlands in poor ecological health may also adversely affect property prices. For example, property values adjacent to Cape Town's Lotus River were on average lower by between 10 and 14 percent than comparative properties not adjacent to wetlands (Van Zyl & Leiman, 2001). The Kuils River in the Western Cape is an example of how rehabilitation of ecological assets can affect prices positively. Before rehabilitation, property prices adjacent to the river were on average 10 to 12 percent lower than the surrounding areas. After rehabilitation this discount disappeared. According to the City of Johannesburg (2011), 302 hectare of freshwater wetlands in Johannesburg and 1 654 hectares of wetlands in Gauteng are classified as vulnerable. This suggests an urgent need to better understand the monetary value of these increasingly pressured assets.

Air pollution and carbon sequestration

Urban trees perform an important role in carbon sequestration and reduction in the effects of air pollution. Schäffler and Swilling (2013) use the cost of carbon method to estimate that the standing stock value of carbon sequestration in Johannesburg's urban forests is US$64,2 million, which equates to an annual value of R49,04 million over a 20-year period assuming an exchange rate of R7,5 = US$1, but excluding growth of the standing stock. Relating this value to the total City of Johannesburg (CoJ) area, i.e. 164 458 hectares (Schäffler & Swilling, 2013), the annual value of carbon sequestration of City of Johannesburg's urban trees is estimated to be R298,20 per hectare per year.

De Wit and Blignaut (2006) report carbon sequestration also benefits from grasslands at 0,19tC/ha, which at a carbon price of US$12,10/tC (Schäffler & Swilling, 2013) or R90,75/tC, assuming an exchange rate of R7,5/US$, equates to a carbon sequestration value of grasslands of R17,24/ha/yr. Apart from the air and climate regulation benefits, grasslands perform a number of other important ecological functions such as medicinal products and grazing services, particularly on the Highveld in a grassland biome. However, the CoJ (2011) warns that 34 percent of bush veld and grasslands within Gauteng is either critically endangered or endangered due to urban encroachment (CoJ, 2011). The situation is far worse in the City of Johannesburg, where 67 percent of ecosystems is either critically endangered or endangered (CoJ, 2011).

Demonstrating ecosystem valuation in practice

There are a number of possible options available to practically demonstrate the valuation of ecosystem services, including:

1. The value of well-maintained natural areas in flood attenuation
2. The water purification and flood attenuation values associated with wetlands
3. The recreational and aesthetic values associated with green open spaces
4. The value of air quality improvements associated with natural areas
5. The value of urban agriculture focused on communal open spaces.

Data availability and related practicalities were considered as factors in choosing which technique to use to illustrate ecosystem valuation within the GCR. The assessment of these factors indicated that it would be best to proceed with a case study primarily focused on recreational and aesthetic values associated with green open spaces, which is the subject of the following section.

Valuation of green open spaces focusing on recreational and aesthetic benefits

Recreational and aesthetic benefits of green open spaces tend to have relatively high magnitudes particularly in largely urban settings with large populations. The following valuation techniques are most commonly applied in order to estimate the value of these benefits

- Contingent valuation or conjoint analysis using a survey to illicit values from respondents
- Hedonic or property value technique which analyses real estate values in order to isolate the portion of these values that relate to the availability and proximity of green open spaces
- Travel cost technique in which the costs associated with travel to a green open space are estimated based on a survey of users.

Unless verifiable and consistently updated data is readily available, each of these techniques requires significant primary data collection and analysis in order to produce reliable results for the entire city-region. While data for the GCR is available, there remain challenges in the way provincial and municipal government collate data across administrative boundaries, and a number of inconsistencies emerge when looking across publicly available datasets. Consequently, the benefits transfer technique was used to generate preliminary indicative values. This relied on the findings of valuation studies from elsewhere with values from those analyses appropriately adjusted (see Box 8 for an explanation of the benefits transfer technique). The valuation exercise also focused on a select area, the CoJ to pilot the benefits transfer technique in Gauteng. The exercise comprised the following steps:

1. Source maps of all green open spaces under the control of City Parks within the City of Johannesburg
2. Estimate the total size of these areas per open space land use type and for each of the City of Johannesburg's regions
3. Source data on the value of green open spaces estimated elsewhere on a per hectare basis
4. Apply appropriate adjustment factors to per area values from elsewhere in order to make them as locally applicable as possible
5. Multiply green open space area sizes in the City of Johannesburg by estimated per area values appropriately adjusted.

BOX 8 THE BENEFITS TRANSFER METHOD EXPLAINED

The benefit transfer method is used to estimate economic values for ecosystem services by transferring available information from studies already completed in another location and/or context. For example, values for recreational fishing in a particular state may be estimated by applying measures of recreational fishing values from a study conducted in another state. Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context. Benefit transfer is often used when it is too expensive and/or there is too little time/data available to conduct an original valuation study, yet some measure of benefits is needed.

– Ecosystemvaluation.org.

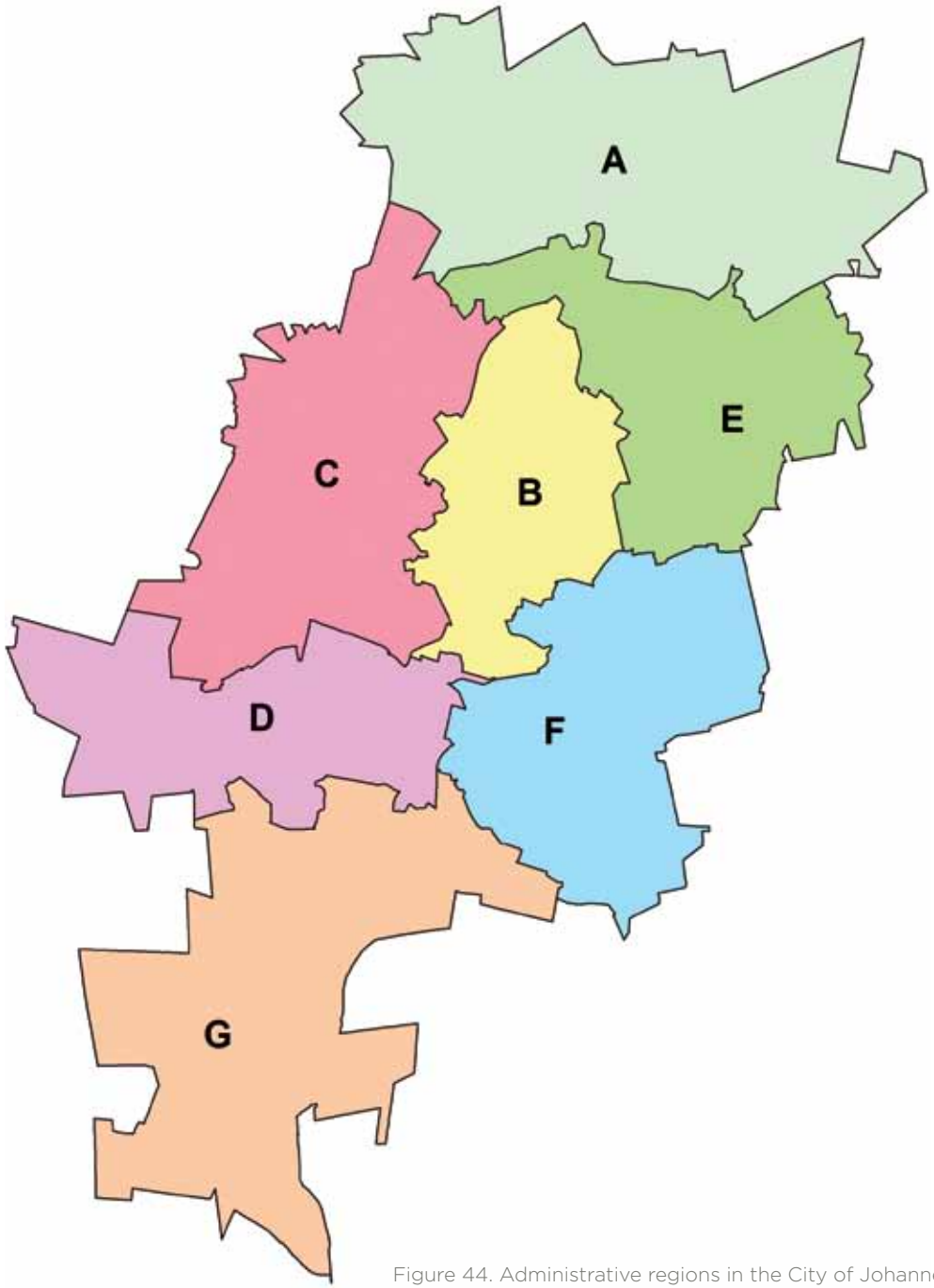


Figure 44. Administrative regions in the City of Johannesburg

Current open space types and land areas in Johannesburg

Figure 44 provides a map of the City of Johannesburg with its seven regions (Regions A to G). In order to ease presentation, data focused on these seven regions separately and on the City of Johannesburg area as a whole. Data was also available at a ward level but was considered not appropriate for the purposes of this coarse level study given the inconsistent sizes and generally small land areas of wards, which hinders comparisons. Data was sourced from Johannesburg City Parks (JCP) to estimate green asset / green open space land areas per open space land use type. Comparisons were also made with total land area data in order to show relative abundance of green assets per region.

As can be seen in Table 9, Johannesburg has a variety of land use types that have been broadly classified as 'green open space'. This includes 23 open space types such as parks, nature reserves, riverine areas, and road verges, summing to a total land area of approximately 15 970 ha and equal to roughly 9,7% of the total land area in the CoJ. Regions with a greater proportion of Johannesburg's open space include Region G (21,3%), Region C (16,3%) and Region F (16%), while those with lower portions include Region E (10,2%), Region A (11,1%) and Region B (11,7%).

In terms of the overall availability of open space per region, Region B has the greatest proportion of open space relative to its own overall land area (12,5%) followed by Regions D and F (both 11,6%). Region A has the lowest proportion of open space relative to its own overall land area (5,5%) followed by Region E (8,4%). Regions C and G both have average proportions of open space relative to their overall land area (10,2% and 10,6% respectively) when compared with the other regions in the City.

	REGION A	REGION B	REGION C	REGION D	REGION E	REGION F	REGION G	TOTAL – ALL REGIONS	
Total land area (in ha)	32 093.2	14 911.3	25 572.8	18 511.4	19 323.4	22 011.5	32 118.8	164 542.4	
Land area as a % of total land area in CoJ	19.5%	9.1%	15.5%	11.3%	11.7%	13.4%	19.5%	100.0%	
Land area per green open space category (in ha)									% of total OpenSpace
BIRD SANCTUARY	16.2	55.8	17.0	–	31.7	–	–	120.6	0.8%
CEMETERY	68.8	189.7	63.9	307.2	274.8	57.8	185.9	1 148.1	7.2%
DEPOT	7.0	4.0	4.2	2.3	8.9	7.9	5.5	39.8	0.2%
FLAGSHIP ROAD ISLAND	20.4	107.9	0.6	6.6	–	–	–	135.5	0.8%
ENVIRONMENTAL CONSERVATION DEVELOPMENT	7.2	1.1	20.6	344.9	–	3.5	112.9	490.0	3.1%
IN ESTATE	45.1	4.7	6.3	–	–	1.3	–	57.3	0.4%
INFORMAL SETTLEMENT	290.3	14.5	127.8	91.4	–	17.1	324.4	865.4	5.4%
MAIN ARTERIAL	5.5	130.3	91.1	257.0	168.3	295.1	374.5	1 321.9	8.3%
MAIN ROAD	195.7	25.6	314.3	–	55.5	27.5	18.3	636.8	4.0%
NATURE RESERVE	17.0	117.3	547.9	14.3	83.2	770.5	–	1 550.2	9.7%
NURSERY	–	–	–	5.3	17.2	–	–	22.5	0.1%
PARK – DEVELOPED SMALLER PARKS	30.3	293.0	168.6	112.3	153.3	268.7	64.5	1 090.6	6.8%
PARK – FLAGSHIP	15.8	210.9	169.7	127.9	89.4	57.5	61.3	732.4	4.6%
PARK – AS YET UNDEVELOPED	118.6	45.4	159.4	29.1	39.6	92.9	82.8	567.8	3.6%
PARK – AS YET UNDEVELOPED (Not actively managed)	83.9	145.2	557.4	355.7	93.2	509.4	611.5	2 356.2	14.8%
RIVER	443.2	39.0	34.3	80.7	196.8	25.8	1 215.1	2 035.0	12.7%
ROAD ISLAND	–	3.0	1.0	–	1.4	13.9	1.6	20.9	0.1%
SIDEWALK	136.4	15.5	–	–	0.7	51.0	13.0	216.5	1.4%
SIDEWALK (Not actively maintained)	267.5	374.8	287.0	260.3	383.6	291.4	321.9	2 186.4	13.7%
SPORT	–	0.8	–	55.5	4.7	5.7	10.9	77.5	0.5%
TOWN ENTRANCE	–	–	–	6.6	–	0.5	1.6	8.8	0.1%
WATER BODY	–	25.5	36.5	84.1	24.0	62.2	–	232.4	1.5%
ZOO	–	57.4	–	–	–	–	–	57.4	0.4%
TOTAL	1 768.9	1 861.0	2 607.4	2 141.2	1 626.1	2 559.7	3 405.8	15 970.1	100.0%
Open space area as a % of total open space area in CoJ	11.1%	11.7%	16.3%	13.4%	10.2%	16.0%	21.3%	100.0%	
Open space area as a % total land area in the region	5.5%	12.5%	10.2%	11.6%	8.4%	11.6%	10.6%	9.7%	

Table 9. Hectares per open space types in the City of Johannesburg

Having estimated hectares of open space type in Johannesburg, broadly reasonable estimates were needed for the per hectare value of these spaces. These estimates were generated by applying the benefits transfer technique, which is based on the use of existing value estimates for green open spaces found elsewhere. These existing value estimates are to be found in the literature on the value of green open spaces reviewed in the next section.

Value estimates from other studies of green open spaces

The international environmental economics literature contains a number of studies that have focused on attaching values to green open spaces. The findings of this body of work on recreational and aesthetic values have been collated and reviewed by McConnell and Walls (2005), Brander and Koetse (2007) and Kroeger (2008). While Kroeger focused exclusively on hedonic analysis studies of property value premiums, McConnell and Walls (2005) and Brander and Koetse (2007) covered both hedonic studies and the application of contingent valuation techniques[1]. For the purposes of this valuation exercise, the results of contingent valuation studies are most relevant. This is because such studies focus on the overall values that a cross-section of society attribute to open spaces. While useful in other settings, hedonic studies only focus on the portion of open space values that are reflected in nearby private property values. These studies also tend to measure the relative increase in values as an individual moves closer to open spaces, and not the overall value enhancement associated with the presence of open spaces. For example, the review of hedonic studies in Brander and Koetse (2007) indicates that house prices increase by an average of approximately 1,9% for every 100 meters that one moves closer to open spaces, but the study does not provide an overall value for open space as such.

A general finding in reviews of ecosystem service values is that these values are often highly situation specific, but that general patterns are observable and that values attributed to green spaces in particular feature prominently. With regard to contingent valuation studies, the most recent review by Brander and Koetse (2007) was based on 38 contingent valuation studies, 20 of which provided sufficient information for them to be included in a statistical meta-analysis of their results. The majority of these studies estimated open space values in terms of unit area (e.g. value per hectare) covering a wider variety of open space types (i.e. forests, parks, general green space, agricultural areas and undeveloped land). The average value for green open space across all studies and open space types was found to be US$13 210 per hectare per year in 2003 terms while the median value was US$1 124/ha/yr, which implies that half of the studies reviewed had values below US$1 124/ha/yr).

In order to augment value estimates presented in their study, Brander and Koetse (2007) also use meta-analysis to test some of the common hypotheses regarding the nature of the value of open spaces. With regard to the hypothesis that the value of open space increases with population density, they found that the population density variables in both of their meta-analysis models of open space values were significant and had positive relationships to open space values. This is probably owing to higher demand for open space driven by its relative scarcity and suggests that remaining open spaces in densely populated urban areas are likely to be highly valued.

[1] Note that the studies reviewed by McConnell & Walls in 2005 are included in Brander & Koetse's later review in 2007.

Somewhat against their expectations, Brander and Koetse (2007) did not find a statistically insignificant link between income levels and open space values. They hypothesise that people might prefer to consume private open space (e.g. private gardens) rather than public open space as their incomes rise. If so, this is a preference that is likely to play a significant role in determining the value of open space in Johannesburg's middle to higher income areas due to the relative abundance of privately owned green space in these areas (i.e. many homes is these areas have large gardens). The high incidence of crime in Johannesburg relative to other cities around the world may also push preferences towards private open spaces.

Within South Africa, the only study to generate primary values on green open spaces was the one done by Turpie *et al*. (2001) in Cape Town as discussed above. Applying contingent valuation, this study derived per hectare values for parks, sports fields, natural areas, vacant land and wetlands. In the case of parks, for example, Turpie *et al*. found that values for open spaces averaged R2 663/ha/year in 2001 Rand values. These per hectare value estimates were based on willingness-to-pay estimates per household surveyed. Note that there was a medium level of availability of green open space within the areas where those responding to the contingent valuation survey resided. From a policy and management implications point of view, Turpie *et al*. found that increased management effort by the municipality (and private citizens' initiatives) was a highly significant driver of higher values particularly for recreational areas such as parks. The other prominent driver was security perceptions with low or even negative values attached to those open space areas perceived as unsafe or providing hiding places for criminals.

Appropriate green open space values for the City of Johannesburg

Having reviewed the relevant literature above it was possible to generate appropriate values for application in the City of Johannesburg. In this regard the following steps were followed:

1. **Adjust all values in the literature to 2013 terms.** For international estimates this required adjustments to reflect exchange rate difference (at purchasing power parity rates) as well as differences in national income levels. For South African estimates, only inflationary adjustments were needed.

2. **Choose preferred values per hectare.** The open space values generated in South Africa (i.e. those from Turpie *et al*., 2001) were found to be preferable. Aside from the obvious reasons to strongly prefer locally relevant data over that generated in other countries, the South African study also had the advantage of containing values for different types of open spaces. In addition, the majority of the studies included in the international review focused on urban forests and very few on urban parks. The higher values in the international literature did, however, provide a useful comparison or 'reality check' for the South African estimates. In broad terms, the international estimates were higher even after making standard adjustments for relative purchasing power and incomes differences. This indicates that the South African estimates may be artificially low, if anything. The adjusted South African values from Turpie *et al*. (2001) were therefore assumed to be low estimates and were consequently used for the Low Estimate scenario in the overall valuation exercise (see Table 10). Two other scenarios, the Medium and High Estimate scenarios, were also included in the valuation exercise in order to present a range of likely estimates. The values applicable to these scenarios were assumed to be 50% and 100% higher respectively relative to the Low Estimate scenario. These percentages were chosen based on what seemed most reasonable.

3. **Adjust preferred values as needed to reflect differences in open space types.** This involved broadly matching the five open space types used in Turpie *et al*. with the 23 type classifications found in the CoJ JCP data for 2013. In some cases, matches were obvious for common land use types such as established parks. In others, it was more difficult to find matches and reasonable averages had to be used. For example, values applied to road islands were derived based on an average between parks and vacant land values to be found in Turpie *et al*. (2001)

Table 10 shows the results of the calculations described above used to derive indicative estimates of per hectare values for the City of Johannesburg open spaces. It also provides notes on how values from the City of Cape Town in Turpie *et al.* (2001). were adjusted in order to achieve the best possible match with open space types in Johannesburg.

	2013 VALUE IN R/HA/YR			
	LOW ESTIMATE	MEDIUM ESTIMATE	HIGH ESTIMATE	
Values from the Cape Town Open Space Values Study				
Parks	R 3 926	R 4 462	R 4 999	
Sportsfields	R 25 173	R 35 156	R 45 139	
Natural vegetation	R 1 438	R 5 089	R 8 741	
Vacant lands	R 390	R 825	R 1 260	
Wetlands	R 3 127	R 5 166	R 7 206	
Values applied to Joburg City Parks land				Explanation of values used from Cape Town Open Space study to generate comparable low estimate for application to Johannesburg:
BIRD SANCTUARY	R 4 776	R 7 164	R 9 552	Ave between parks and natural vegetation medium value
CEMETERY	R 914	R 1 371	R 1 828	Ave between natural vegetation and vacant land low value
DEPOT	R 390	R 586	R 781	Vacant land low value
FLAGSHIP ROAD ISLAND	R 914	R 1 371	R 1 828	Ave between natural vegetation and vacant land low value
ENVIRONMENTAL CONSERVATION DEVEOPMENT	R 4 508	R 6 762	R 9 015	Ave between parks low and natural vegetation medium value
IN ESTATE	R 3 926	R 5 889	R 7 852	Parks low value
INFORMAL SETTLEMENT	R 825	R 1 238	R 1 651	Vacant land medium value
MAIN ARTERIAL	R 914	R 1 371	R 1 828	Ave between natural vegetation and vacant land low value
MAIN ROAD	R 914	R 1 371	R 1 828	Ave between natural vegetation and vacant land low value
NATURE RESERVE	R 4 462	R 6 694	R 8 925	Parks medium value
NURSERY	R 2 957	R 4 436	R 5 914	Ave between natural vegetation and vacant land medium value
PARK – DEVELOPED SMALLER PARKS	R 4 462	R 6 694	R 8 925	Parks medium value
PARK – FLAGSHIP	R 4 462	R 6 694	R 8 925	Parks medium value
PARK – AS YET UNDEVELOPED	R 2 957	R 4 436	R 5 914	Ave between natural vegetation and vacant land medium value
PARK – AS YET UNDEVELOPED (Not actively managed)	R 1 132	R 1 697	R 2 263	Ave between natural vegetation low and vacant land medium value
RIVER	R 3 302	R 4 953	R 6 604	Ave between medium wetlands and low natural veg value
ROAD ISLAND	R 2 957	R 4 436	R 5 914	Ave between natural vegetation and vacant land value
SIDEWALK	R 2 957	R 4 436	R 5 914	Ave between natural vegetation and vacant land value
SIDEWALK (Not actively maintained)	R 390	R 586	R 781	Vacant land low value
SPORT	R 35 156	R 52 734	R 70 312	Sportsfields medium value
TOWN ENTRANCE	R 2 957	R 4 436	R 5 914	Ave between natural vegetation and vacant land medium value
WATER BODY	R 5 128	R 7 692	R 10 255	Ave between wetlands and natural vegetation medium value
ZOO	R 4 462	R 6 694	R 8 925	Parks medium value

EXPLANATORY NOTES: Low estimates for values applied to Joburg City Parks land are based on values from the Cape Town Open Space study, some of which are used directly and others adjusted. An explanation is provided for how each low estimate value for Joburg was derived in this way
Medium estimates for Joburg City Parks land were derived by increasing low estimates by 50%. High estimates for Joburg City Parks land were derived by increasing Low estimates by 100%

Table 10. Indicative values per hectare per year for open space types in the City of Johannesburg

Table 11 shows the results of detailed calculations of indicative values per open space type to estimate value per hectare for open spaces in Johannesburg. As can be seen from, total values for this scenario were estimated at roughly R58 million/yr for all open spaces under City Parks' management.

	ESTIMATED VALUE IN RANDS / HA / YR – MEDIUM SCENARIO								% OF TOTAL
LAND USE CATEGROY	REGION A	REGION B	REGION C	REGION D	REGION E	REGION F	REGION G	TOTAL	
BIRD SANCTUARY	R 115 779	R 399 431	R 121 922	R 0	R 227 044	R 0	R 0	R 864 176	1.5%
CEMETERY	R 94 365	R 260 075	R 87 666	R 421 202	R 376 843	R 79 187	R 254 944	R 1 574 282	2.7%
DEPOT	R 4 092	R 2 356	R 2 436	R 1 360	R 5 185	R 4 630	R 3 240	R 23 298	0.0%
FLAGSHIP ROAD ISLAND	R 28 033	R 147 903	R 795	R 9 081	R 0	R 0	R 0	R 185 812	0.3%
ENVIRONMENTAL CONSERVATION DEVEOPMENT	R 48 567	R 7 144	R 139 023	R 2 331 946	R 0	R 23 536	R 763 079	R 3 313 295	5.7%
IN ESTATE	R 265 897	R 27 465	R 36 857	R 0	R 0	R 7 400	R 0	R 337 619	0.6%
INFORMAL SETTLEMENT	R 359 383	R 17 904	R 158 191	R 113 097	R 0	R 21 205	R 401 583	R 1 071 364	1.8%
MAIN ARTERIAL	R 7 551	R 178 690	R 124 971	R 352 416	R 230 829	R 404 647	R 513 479	R 1 812 583	3.1%
MAIN ROAD	R 268 323	R 35 091	R 430 890	R 0	R 76 061	R 37 665	R 25 096	R 873 125	1.5%
NATURE RESERVE	R 113 721	R 785 260	R 3 667 480	R 95 640	R 556 776	R 5 157 460	R 0	R 10 376 336	17.9%
NURSERY	R 0	R 0	R 0	R 23 493	R 76 245	R 0	R 0	R 99 738	0.2%
PARK – DEVELOPED SMALLER PARKS	R 202 629	R 1 961 086	R 1 128 422	R 751 602	R 1 026 045	R 1 798 606	R 431 862	R 7 300 253	12.6%
PARK – FLAGSHIP	R 105 481	R 1 411 447	R 1 135 965	R 855 908	R 598 382	R 384 798	R 410 572	R 4 902 552	8.5%
PARK – AS YET UNDEVELOPED	R 526 300	R 201 304	R 706 928	R 129 205	R 175 568	R 412 205	R 367 074	R 2 518 583	4.3%
PARK – AS YET UNDEVELOPED (Not actively managed)	R 142 385	R 246 393	R 946 027	R 603 700	R 158 152	R 864 588	R 1 037 895	R 3 999 140	6.9%
RIVER	R 2 195 368	R 193 062	R 169 909	R 399 848	R 974 891	R 127 872	R 6 018 520	R 10 079 470	17.4%
ROAD ISLAND	R 0	R 13 149	R 4 348	R 0	R 6 101	R 61 841	R 7 281	R 92 720	0.2%
SIDEWALK	R 604 906	R 68 743	R 0	R 0	R 2 955	R 226 306	R 57 567	R 960 476	1.7%
SIDEWALK (Not actively maintained)	R 156 666	R 219 506	R 168 076	R 152 453	R 224 652	R 170 643	R 188 528	R 1 280 524	2.2%
SPORT	R 0	R 39 687	R 0	R 2 926 369	R 245 976	R 301 852	R 574 042	R 4 087 926	7.1%
TOWN ENTRANCE	R 0	R 0	R 0	R 29 382	R 0	R 2 161	R 7 295	R 38 838	0.1%
WATER BODY	R 0	R 196 455	R 280 928	R 646 787	R 184 430	R 478 782	R 0	R 1 787 382	3.1%
ZOO	R 0	R 383 909	R 0	R 0	R 0	R 0	R 0	R 383 909	0.7%
TOTAL	R 5 239 445	R 6 796 059	R 9 310 833	R 9 843 488	R 5 146 134	R 10 565 386	R 11 062 057	R 57 963 403	100%
% of total	9.0%	11.7%	16.1%	17.0%	8.9%	18.2%	19.1%	100.0%	

Table 11. Indicative values per year for individual open space types in the City of Johannesburg – Medium Estimate Scenario

At a more aggregated level, Table 12 provides a summary of values per year per region for all open space types, across values scenarios. It shows that the Low and High Estimate scenarios resulted in values of R38 million/year and R77 million/year, respectively. It also shows the percentage of total values per region and compares these to open space as a percentage of total open space area, as a percentage of the total land area per region, and as a percentage of total land area for the City (taken from Table 9). For example, these comparisons show that Region A's relatively low share of total open space values relates to the relatively low percentage of open space areas as a percentage of total land area (5,5%) even though total land area is large (19,5% of the

BARK HARVEST, JOHANNESBURG, 2013

total land area of Johannesburg). On the whole, open space value amounts are broadly commensurate with total open space areas. There are some relatively minor exceptions such as Region D where the percentage of value exceeds that of total area (17% versus 13,4%) indicating a greater proportion of higher value open space types in Region D when compared with other regions. A closer inspection of Table 11 reveals that the main reason for this higher value is the presence of extensive municipal sports fields in Region D, which have very high values per hectare.

REGION	ESTIMATED VALUE IN RANDS / HA / YR			% OF TOTAL VALUE	VS	% OF TOTAL OPEN SPACE AREA IN COJ
	LOW	MEDIUM	HIGH			
Region A	R 3 492 964	R 5 239 445	R 6 985 927	9.0%		11.1%
Region B	R 4 530 706	R 6 796 059	R 9 061 412	11.7%		11.7%
Region C	R 6 207 222	R 9 310 833	R 12 414 444	16.1%		16.3%
Region D	R 6 562 326	R 9 843 488	R 13 124 651	17.0%		13.4%
Region E	R 3 430 756	R 5 146 134	R 6 861 513	8.9%		10.2%
Region F	R 7 043 591	R 10 565 386	R 14 087 181	18.2%		16.0%
Region G	R 7 374 704	R 11 062 057	R 14 749 409	19.1%		21.3%
Total	R 38 642 269	R 57 963 403	R 77 284 538	100.0%		100.0%

Table 12. Indicative values per year for all open space types in the City of Johannesburg across Estimate Scenarios

In order to convert per year values into total present value totals it was necessary to apply discounting to these values. Discounting is the process of reducing future benefits and costs to their present time equivalent (Ecosystem Valuation, 2000). The discounting period chosen was effectively perpetuity (i.e. discounting was applied until the point at which discounting no longer made any difference to present value results). A base rate of 4% was chosen as most suitable in this regard and the sensitivity of results to a higher (6%) and a lower (2%) rate were also tested. This base rate and associated higher and lower rates were selected after a review of the rates recommended in some of the more recent debates surrounding discount rate choice particularly as they relate to longer-term environmental issues such as climate change (see for example, Stern (2007), Weitzman (2007) and Cole (2008). The base rate chosen essentially reflects the middle ground while the lower and higher rates reflect the lower and higher estimates recommended in these debates.

The results of the discounting exercise are captured in Table 13 and show that at a 4% discount rate, the total present value of open spaces in the City of Johannesburg ranges between R966 million and R1,9 billion. Under a lower discount rate of 2% these values increase to between R1,9 billion and R3,9 billion. Under a higher discount rate of 6% they decrease to between R644 million and R1,3 billion.

REGION	DISCOUNT RATE	ESTIMATED PRESENT VALUE IN RANDS		
		LOW	MEDIUM	HIGH
Region A	2%	R 174 648 182	R 261 972 273	R 349 296 365
	4%	R 87 324 091	R 130 986 137	R 174 648 183
	6%	R 58 216 061	R 87 324 091	R 116 432 122
Region B	2%	R 226 535 307	R 339 802 961	R 453 070 614
	4%	R 113 267 654	R 169 901 481	R 226 535 308
	6%	R 75 511 769	R 113 267 654	R 151 023 539
Region C	2%	R 310 361 107	R 465 541 660	R 620 722 213
	4%	R 155 180 554	R 232 770 831	R 310 361 107
	6%	R 103 453 702	R 155 180 554	R 206 907 405
Region D	2%	R 328 116 280	R 492 174 421	R 656 232 561
	4%	R 164 058 141	R 246 087 211	R 328 116 281
	6%	R 109 372 094	R 164 058 141	R 218 744 188
Region E	2%	R 171 537 813	R 257 306 720	R 343 075 626
	4%	R 85 768 907	R 128 653 360	R 171 537 814
	6%	R 57 179 271	R 85 768 907	R 114 358 542
Region F	2%	R 352 179 532	R 528 269 298	R 704 359 064
	4%	R 176 089 766	R 264 134 650	R 352 179 533
	6%	R 117 393 178	R 176 089 766	R 234 786 355
Region G	2%	R 368 735 217	R 553 102 826	R 737 470 434
	4%	R 184 367 609	R 276 551 413	R 368 735 218
	6%	R 122 911 739	R 184 367 609	R 245 823 479
Total for all Regions	2%	R 1 932 113 439	R 2 898 170 158	R 3 864 226 878
	4%	R 966 056 722	R 1 449 085 083	R 1 932 113 444
	6%	R 644 037 815	R 966 056 722	R 1 288 075 629

Table 13. Indicative present values for all open space types in the City of Johannesburg across Estimate Scenarios

Summary discussion

Investment in green infrastructure, like any other investment in infrastructure, requires a proposition of value. The economic valuation of such investments is one approach that can be fruitfully utilised to make a case for investing in green infrastructure. However, monetary valuation studies of green infrastructure in South Africa are sparse and the paucity of valuation work is particularly prevalent for urban ecosystem services. There are various valuation applications, such as Dodds' (2010) hedonic pricing study of residential property in the West Rand, but these largely exclude environmental variables and very few studies undertake ecosystem valuation as an explicit objective. The City of Tshwane's Metropolitan Open Spaces Framework sets out to investigate monetary valuation techniques, but stops short of conducting a monetary valuation study for the City's open spaces. What progress there is appears to be in the valuing of assets in selected areas, such as the study by Stoffberg (2006) in valuing carbon sequestration of street trees in the City of Tshwane. This work found that the greatest monetary benefit (US$2m) would be derived from planting 115 000 indigenous street trees mainly in poorer, previously disadvantaged communities, while the existing 33 630 Jacaranda mimosifolia street trees in Tshwane were valued at US$419 786. It is clear that the economic valuation of urban environmental goods and services has started to attract some interesting case studies, but as a discipline it is still in its infancy both in South Africa and the GCR.

The valuation case study in this report shows how indicative values can be generated for public parks as a component of green infrastructure in the City of Johannesburg. These values are admittedly approximations and are based on a benefits transfer that relies primarily on adjusted values data originally generated in Cape Town in the early 2000s. However, these figures provide a useful demonstration of valuation while also highlighting the significance of values for green assets in an urban setting. At a 4% discount rate, the total present value of public parks in the City of Johannesburg is estimated to range between R966 million and R1,9 billion. This illustrative exercise is one of many such studies that could be conducted in the GCR in order to better understand the value of green infrastructure for more informed decision-making and management processes. Such research efforts should be strongly encouraged, preferably as part of a longer-term integrated programme of research with clear objectives that moves beyond ad-hoc efforts.

Having demonstrated value, a further challenge is to incorporate green infrastructure in government budgeting and planning processes. The benefits of doing so are tied to the value of investments in urban ecosystems to our society such as saving on costs of engineering infrastructure, enhancing quality of life and property values, and in increasing the appreciation within our urban consciousness about our connections to ecological processes. There is increasing evidence that investment in green infrastructure will predominantly save on costs to municipalities, and 'green infrastructure' as a framework is gaining momentum worldwide in various urban and regional strategies, plans, policies and projects. Buttressed by innovative financing arrangements, such as public-private partnerships, tax-increment financing, development charges, value-capture taxes, and carbon finance, the opportunities for investing in green infrastructure – on the basis of a more accurate estimation of the value of ecosystem services they provide – are ripe.

FIREPLACE / STORAGE SPACE, GREENSIDE, 2013

SYMBIOSIS

Natasha Christopher

Sumbios, Johannesburg, 2012-2013


SPAR

SECTION FIVE

This section analyses the role of non-government actors, such as local communities and the private sector, in creating green assets. Through a political-ecology lens, it provides an historical overview of the city-region's colonial landscapes, and then reflects on the various economies and cultures currently at work to sustain or transform features of this landscape.

Constructed landscapes: community and private sector green infrastructure initiatives

Urbanization is often associated with the modification of natural landscapes. The development of built-up areas and laying down of infrastructure is a major threat to local ecosystems in and around urban regions. However, as people urbanize, they also partake in gardening and horticulture, creating private landscapes that exist outside of the public domain. These landscapes often expose processes of colonial city-building that have produced striking divisions in spatial form. The 'home and garden' archetype is often contested as "the entitlement of white South Africans, while reproducing generations of black people in relation to the land premised on labour migrancy and domestic / garden work" (Murray, 2006). These local struggles related to space are some of the condemned products of an unequal neoliberalism:

"...Johannesburg...is at once a city of monumental architecture and abysmal slums; a city of luxurious playgrounds for the rich and empty wastelands for the poor: a city of utopian fantasy and dystopian anxiety: and a city of collective memory and intentional forgetting...[where]...magnificent mansions and their luscious greenery contrasted with corrugated iron shacks forlornly sited on treeless, barren ground; spotlessly clean shopping malls in the northern suburbs contrasted with chicken feet grilled on open fires at taxi ranks in Soweto; expensive BMWs speeding past old black women trudging along the road after a hard day's work; and homeless street kids begging handouts from insouciant middle-class urbanites in a hurry to get to a restaurant appointment in some trendy new hot spot. Johannesburg has always been, and remains so today, a city of spectacle and a city of ruin, where the jarring mismatch between extreme wealth and abject poverty has contributed to an enduring sense of unease and discomfort." (Murray, 2008)

WATERFALL ESTATE, MIDRAND, 2013

NORTHWARDS HOUSE, PARKTOWN, JOHANNESBURG, 2013

In these terms, the prejudices of an engineered aesthetic cater for a wealthy elite, through the construction and partitioning of landscapes (Murray, 2004; Chipkin, 2005). While useful, this also presents an all too conventional account of the archetypal colonial space, dichotomously expressed as "nothing but the spatial embodiment of unequal economic relations and coercive segregationist policies" (Mbembe & Nuttal in Chipkin, 2005). However, there are questions to be asked about how, within these divided landscapes, various cultures and economies have emerged to create new forms of green infrastructure. Notwithstanding their discontents, the intriguing circuits of investments in private garden spaces, and the gardening cultures that exist in much more varied ways than we might think, provide an alternative lens than that which focuses only on the nature of socio-economic divides. A deeper understanding of private green space alerts us to a political-ecology of the GCR's landscapes, where indigenous vegetation has been transformed but often replaced with new vegetation and species, morphing into a strange ecological form. This is not to dismiss the struggles associated with private green space, but to provoke an interrogation into the political-ecology of society's investments in landscapes and how this investment is not necessarily contained in the wealthy 'northern suburbs' of the GCR, but activated across cultures of place and consumption.

Colonial gardening cultures

"From our sister country of Australia, sharing the same variety of climatic conditions as South Africa, has come a treasure-store of shade and flowering trees epitomized by the eucalypts which since they were first introduced by Sir Lowry Cole in 1828, have become ubiquitous in our land ... The increasing popularity of the ornamental Chamaecy-paris, Cryptomeria, Cupressus, Juniperas, Taxodium, Taxus, and Thuya, lies in their effectiveness in creating an instant sense of grace, elegance and stateliness in a garden." (Lighton, 1972)

The transformation of South Africa's landscape is tied to various political, socio-economic and ideological forces that explain the widespread occurrence of exotic trees and forested areas, garden landscapes, golf courses and large privately managed green spaces. The establishment of tree plantations,

to supplement timber supply, has roots in the country's colonial and apartheid history, where the exploitation of indigenous forests for timber production saw the introduction of exotic forests that have become such notorious features of landscape of South Africa. Mirroring these trends, much of the vegetation in Gauteng has to do with processes of colonization and territorialisation, political manipulations of space, coupled with state-driven tree planting schemes, and attempts to beautify a seemingly 'barren' landscape. These processes have manifested in an abundance of established gardens, often designed around the periphery of a lawn, and plantations of trees and shrubbery and flowerbeds, accumulated over time into a suburban green space matrix, of leafy, middle class neighbours. Implicated in a colonial and bourgeois ecology, these landscapes represent an ecological biography, predicated on movements of species for industrial and commercial purposes and reproduced behind the walls of private homes and properties:

Gardens of South Africa (Dorothea Fairbridge, 1924)

"For Johannesburg has been blest in many ways: it has been built in an era in which the planning of the garden is reckoned only second in importance to the planning of the house...it is not easy to make a garden in that part of Johannesburg, for the natural structure of the land is rock and kopje, and the rock must be blasted out and the soil carted in if you want to plant trees, and to ensure them long life and prosperity. In planning the garden of Arcadia, Lady Phillips wisely left the kopjes as she found the, crowned with their native plants and queer edible berries, supplementing these in time with Aloes and other native plants and trees ..."

SPRINGBOK PARK, TSHWANE, 2013

Switzerland and Savoy advert (South African Gardening and Country Life, 1934)

"In many lands it is increasingly difficult to find real country. There are endless dusty roads with hedges cut back in the interests of those who use motor cars. Flowers by the wayside have been destroyed and the hedges are no longer the resting place of song-birds. In many places low fences have displaced the hedges, disfigured by horrible advertisements. Common land is trodden bare and littered with paper. Broken bottles and dirty paper markets mark the spot where picnic parties have gathered."

PARKWOOD, JOHANNESBURG, 2013

The Brenthurst Gardens (Alan Huw Smith, 1988)

"'The site favoured the design of a beautiful garden with terraces, pergolas, water-pools, and a natural rock-garden in the lichened rocks on which the house stood', Baker noted... It was a scheme of studied informality, typical of Baker, but one which did not survive for long. The ladies of Parktown vied with each other to recreate showcase gardens in an earlier and grander English tradition, and it was not long before the slopes of Marienhof were filled with row upon of geometrically clipped formal hedgework."

Remarkable Gardens of South Africa (Nini Bairnsfather Cloete, 2012)

"The Khatlampi Private Reserve lies in the heart of the vast area known as the Cradle of Humankind – a World Heritage site where the world's most important human fossils have been found. Lying to the northwest of Johannesburg and covering 1 000 hectares, the reserve comprises five adjoining farms in the area. The landowners agreed to drop the fences between their properties, and the result was the creation of a unique environment of biodiversity that incorporates pristine grasslands, indigenous forests, caves and dolomite valleys, all of which have ben set aside to enable animals to roam free in their natural habitats ... The wonderful trees on the property were mostly already in situ and they are 'unashamedly not indigenous'. Lofty English and pin oaks thrive here, along with combretums, various acacias and Cape willows, which are underplanted with grasses so as to blend into the veld."

"Brenthurst – In an era of environmental awareness, dedicated plantswoman and passionate environmentalist Strilli Oppenheimer emphatically embraced the challenge of 'blurring the boundaries between garden and nature'... One of South Africa's premier residences, the famous Brenthurst estate also encapsulates the country's gardening history. Once open veld, then planted to forestry in 1890 for building material for the town that was springing up across the treeless Highveld, today it's the only estate of the Randlords of yesteryear that survives with its setting intact. A 16-hectare green lung in the centre of the City of Gold, it is being allowed to grow and breathe at will, secure from the ever-growing demands of expanding humanity."

JAN SMUTS AVENUE, 2013
CENTRAL AVENUE, HOUGHTON, 2013
JABAVU, SOWETO, 2013

These excerpts make for an intriguing enquiry into the political-ecology of urbanized landscapes. In terms of the transformation of a grassland and bushveld biome to mixed-patch forested areas, gardens and managed parks, Gauteng's landscape invokes notions of spatial and ecological engineering. Indeed, the dual occurrence of water challenges in Gauteng and a largely introduced landscape, comprising water-sapping exotics and equally problematic lawn-based gardens, is an acute contradiction for naturally occurring grassland. Socially punctuated critiques, on the other hand, lambaste private green spaces as the products of apartheid, the mark of white middle-class suburbia:

"A journey through Johannesburg traverses extreme models of housing and urban neighbourhoods. From enormous houses with vast landscaped gardens in tree lined avenues, to shacks sitting shoulder to shoulder separated by muddy paths." (Poulsen, 2010)

"From the air, the pleasing bright green quilt of well-watered English-style gardens and thick alien trees that shade traditionally white – now slightly desegregated-suburbs, is pocked with ubiquitous sky-blue swimming pools." (Bond, 2007)

"Seeking to escape what they perceive as the miasmal city, affluent residents have partitioned the urban landscape into a patchwork assemblage of bunkered enclaves that provide the fanciful illusion of sanitized, first-world cosmopolitanism in the midst of third-world impoverishment." (Murray, 2008)

These descriptions conjure up images of men in green overalls holding parts of a manicured scene together. Landscaping and garden service 'bakkies', lawnmowers and leaf blowers reinstate a landscape of leafy green suburbs, trees and private gardens. Behind what may come across as a natural landscape is a web of gardeners, private homeowners, landscapers, garden services, plant growers and sellers that sustain vast garden expanses. This is often viewed as a testimony to an imperial aesthetic that has weaved "interior gardens, landscape atriums, sequestered gathering places" (Murray, 2008) into the physique of Johannesburg's northern suburbs and other similar spaces in Gauteng. These connotations focus on the struggles of the excluded versus the privileged, and how this divide is reproduced in a neoliberal political-economy and uneven urban form. However, this overlooks citizen mobilization around different forms of green infrastructure, the day-to-day operations of retail and wholesale nurseries and the important knowledge base of gardeners and homeowners, which are also not always different people.

Aside from mass media celebrating garden design and some superficial accounts of the boom in garden services, landscaping businesses and nurseries that accompanied the construction of Johannesburg's urban forest (Davie, 2002), the gardening supply chain and its added value has been studied in little empirical detail:

ORANGE GROVE, JOHANNESBURG, 2013

HILLBROW, JOHANNESBURG, 2013

OBSERVATORY, JOHANNESBURG, 2013

"How economically important (and ecologically influential), exactly, are the mini-industries of nurseries, seed distribution, garden tools, hedge-cutters and lawnmowers, paving stones, concrete gnomes, hosepipes, custom-made trellises, paid family-specific gardeners and garden-service teams, the advertising and the transportation expenditures required for all of these? I have found no studies which tell us; suffice it to speculate that it is substantial." (Wylie, 2011)

The activities of the South African Green Industries Council (SAGIC), the umbrella organization that represents the consumer green industry in South Africa, does contribute in both 'jobs' terms and in terms of the investment made by citizens in landscapes. This happens through SAGIC's subsidiary organisations, such as the South African Nurserymen's' Association (SANA), the South African Landscaping Institute (SALI), the Landscape Irrigation Association of South Africa (LIA), the Lawnmower Association of South Africa (LMA), the South African Arboricultural Association, the Interior Plantscapers Association (IPSA), the South African Flower Growers Association (SAFGA), the Institute of Environment and Recreation Management (IERM) and the International Plant Propagators Society (IPPS) (Life is a Garden, 2010). This supply chain, together with more local networks, such as the Johannesburg Garden Club (JSC) and Gardens of the Golden City, maintain a significant portion of Johannesburg's green infrastructure that exists outside of public green space. While these networks may be seen as extensions of an unequal political economy, it is a misconception that the value chains investing in private green infrastructure are only those colonial cultures of greening. There are multiple dimensions of the GCR's horticultural scene, some of which have indeed spun off colonial gardening, but are now activated in more varied ways that deserve attention in terms of their ecological value. Although these activities may not be as blatant or extravagant as a northern suburbs bourgeois ecology, which some experts have also argued is still intact, they represent the novelty and complexity of private green infrastructure in the city-region.

‘Sustainable’ gardening

The trend towards sustainable gardening has seen a proliferation of trends variously packaged and promoted as ‘eco-friendly gardening’, ‘gardening for climate change’, ‘water-wise gardening’, amongst others. Within these movements, people seem to be increasingly patriotic about indigenous vegetation (Geldenhuys, 2010). This is inspiring landscapes purified of exotic and introduced species, largely motivated as a shift towards holistic gardening, that works in harmony with nature, and also to ease water stress by ‘becoming a water smart and water-wise gardener’ (Life is a Garden, 2010; 2011). This changeover is apparent in large-scale corporate and residential developments in Gauteng for which the guidelines and specifications are increasingly inclined towards ‘ecological restoration’, ‘indigenous’ ‘and ‘native’ land use. Ballard & Jones (2008) see the relatively recent suburban fad for indigenous as a break from the conventional suburban gardening aesthetic of using global horticultural plants through concerted efforts to bring nature appreciation into the domestic sphere.

While these notions of sustainable gardening are admirable and relevant, the context of indigenous plants is highly specific. A number of professionals within the horticultural industry have warned against the blanket application of indigenous planting that ignores the specificity of a particular habitat. When asked to comment on the growing interest in indigenous gardening, an indigenous plant specialist in Gauteng is hesitant to generalize about the nature of indigenous planting:

“As a specialist indigenous grower, I can reflect on the upward trend in indigenous gardening, and indeed there is a big trend, but the specificity of indigenous gardening in my nursery and in my local context is very different to what is broadly indigenous in South African terms. I can see the new species of butterflies and birds that have hitchhiked to my property on the outer edges of Gauteng from Kwa-Zulu Natal, but our weather conditions and landscape structure, being a more rural area, are different to what is found in more metropolitan landscapes. Because our landscape is more natural and non-urban, it makes sense to promote indigenous planning, since there have been fewer disturbances, but in the more urban landscapes, where things have been significantly disturbed, landscapes are constructed, re-developed, and when under pressure from environmental managers, destroyed and re-created to become indigenous again…” (Indigenous plant specialist, pers. comm, 2013)

An indigenous movement of growing popularity is marked by practical complexities that may not feature on the face of branding strategies geared to shift gardening preferences. A Johannesburg-based landscape consultant, contemplating the process of the design, installation and final utilisation of a large-scale retirement garden, reflects on this retrospectively:

ROCK, MAELOLA STREET, JABAVU, 2013

"The brief was for a strictly indigenous landscape, which was previously a blue gum plantation, where we even found Blue Vervet monkeys living in the trees, and this is in Joburg. We removed the Blue Gum, and planted over 3000 trees, and a dam with indigenous fish, which has drawn bird life and animals that were not there before, and all non-native gardening, such as rose gardening, was not permitted. But now, once our contract has ended, many of retired folk have started planted rose beds, because they were so used to growing up with roses in their gardens. So as much as the powers that be motivated an indigenously-strung landscape, people started planted on their own accord, surreptiously because it was what they wanted." (Johannesburg landscape consultant, pers. comm, 2013)

Some of the negative kickbacks that ensued in this case of a Blue Gum plantation remade into an indigenous landscape may have been avoided through a more collaborative process that assessed resident perceptions vis-a-vis landscaping guidelines. A number of questions have also been raised about whether the horticultural industry as a whole has evolved from its colonial gardening history:

"Nurseries and landscapers aren't doing enough to educate consumers about the role of particular indigenous plants in lieu of one of their most critical function, attracting pollinators. Although locally indigenous plants attract local pollinators, many exotics also do this, and have an ecological value in that regard." (Environmental journalist, pers. comm, 2013)

"Although edible plant consumption comprises 80% of sales, the horticultural market as a whole has not really developed to cater for new demands, and is still catering for a 1960s Houghton lady. There are no wholesale, let alone, retail, nurseries in Soweto or Alexandra and but the market is there, although it may be different for different and more localized." (Unnamed owner of a wholesale herb nursery in Gauteng, pers. comm, 2013)

Without diluting the significance of a sustainable transition in gardening, it is important to recognise the variables that influence an urban ecosystem. These include local conditions such as the micro-climate, fertility of the land, and cultural and economic variables, such as average income of the citizens, which all need to be related to a set of conclusions about what kind of landscape to invest in (Collins *et al.*, 2000).

An organic servitude garden: a guerrilla gardening case study

CASE BRIEF:

Client A approaches landscape consultant to reclaim a barren servitude between Client A and neighbour. The servitude measures 70 m x 3 m = 210 m2, and servitude was previously ridden with rats and a severe fire hazard, and prior to fencing off, used as an illegal dumping site, now secured by means of a locked palisade fence at either end. Client A requested in project brief the design and installation of an organic vegetable garden. The existing servitude area, although not barren, is overrun with weeds of 2m in height, refuse, rubble and debris, which require cleaning and eradication. The site is on an extreme slope and erosion will need to be controlled. Client A does not foresee that the produce from the organic servitude garden being for his own use, (Client A has a family of five), but the produce is to be donated to a community school in Alexandra. The project brief also stipulates that the area is to be demarcated into an accessible space, to include a pedestrian pathway or walkway, and that the site is a working space or a 'work in progress garden'. Within the limits of a Client A's budget, the consultant requires initial preparation where garden borders and beds are defined to plant a range of vegetables, herbs, citrus trees, and berry vines. The methodology for installing the garden includes the terracing of an area, using CCA-treated / approved timber and retaining blocks, organic compost and fertilizer. Borehole water from Client A's premises will also be introduced and an irrigation system installed. The consultant plans to use this project for raising awareness and to encourage fellow neighbours and the community at large to adopt the principles encompassed by the garden.

The above case represents another distinctive trend emerging in Gauteng and the world over towards edible gardens, sometimes labelled as 'urban agriculture' or 'food gardens' or 'community gardens'. The motivation underlying this movement is often for 'self-sustaining gardening', from which people can produce and harvest food (Herb gardening specialist in Gauteng, *pers. comm*, 2013). Additionally, non-governmental organisations (NGOs), school-feeding programmes and Corporate Social Investment (CSI) initiatives are also driving a large part of the edible gardening trend. In these instances, edible gardening is an interesting form of change and social movement through urban agriculture at more localized and often neighbourhood scales. Edible garden initiatives are often identified for previously disadvantaged communities and there is also a major focus on addressing food insecurity in these contexts. For instance, the Siyakhana Initiative for Ecological and Food Security operates urban agriculture sites in Johannesburg to improve food security, increase access to nutritious and sustainably grown foods, and raise awareness of the impact of ecological health promotion (Siyakhana, 2013). In light of these goals, the case of municipal property appropriated by residents of a neighbourhood represents similar activist notions to enhance the productivity of landscapes for local food production. While Client A sought municipal approval of the property, the organic servitude project commenced without legal rights gained. Client A also had the option of installing any kind of garden, a monocultural lawn area or impermeable 'hard-scaping' for example, and a significant choice was made at a citizen level to develop an organic vegetable garden and engage local communities.

SLOPE WITH HERB GARDEN, 10TH STREET KILLARNEY, JOHANNESBURG, 2013

COMPOST AND HERBS AT TOP OF SLOPE, 10TH STREET, KILLARNEY, JOHANNESBURG, 2013

Medicinal gardening

South Africa's annual local trade in medical plants amounts to 20 000t, representing 574 species (Water Wheel, 2013). However, many medicinal plants are currently harvested at unsustainable rates in the wild, and instead of being used for 'muthi', are fed into export markets for big pharmaceutical companies (Indigenous horticulturist in Gauteng, *pers. comm*, 2013):

"The true traditional healer understands ecology and will never over harvest. Unfortunately, many people now harvest plants indiscriminately as a source of income. While, legally many of these plants are protected and may not be removed from the wild, the spatial extent on which this activity is taking place makes it impossible to enforce legislation in this regard." (Dr Wentzel, Water Research Commission, in Water Wheel, 2013)

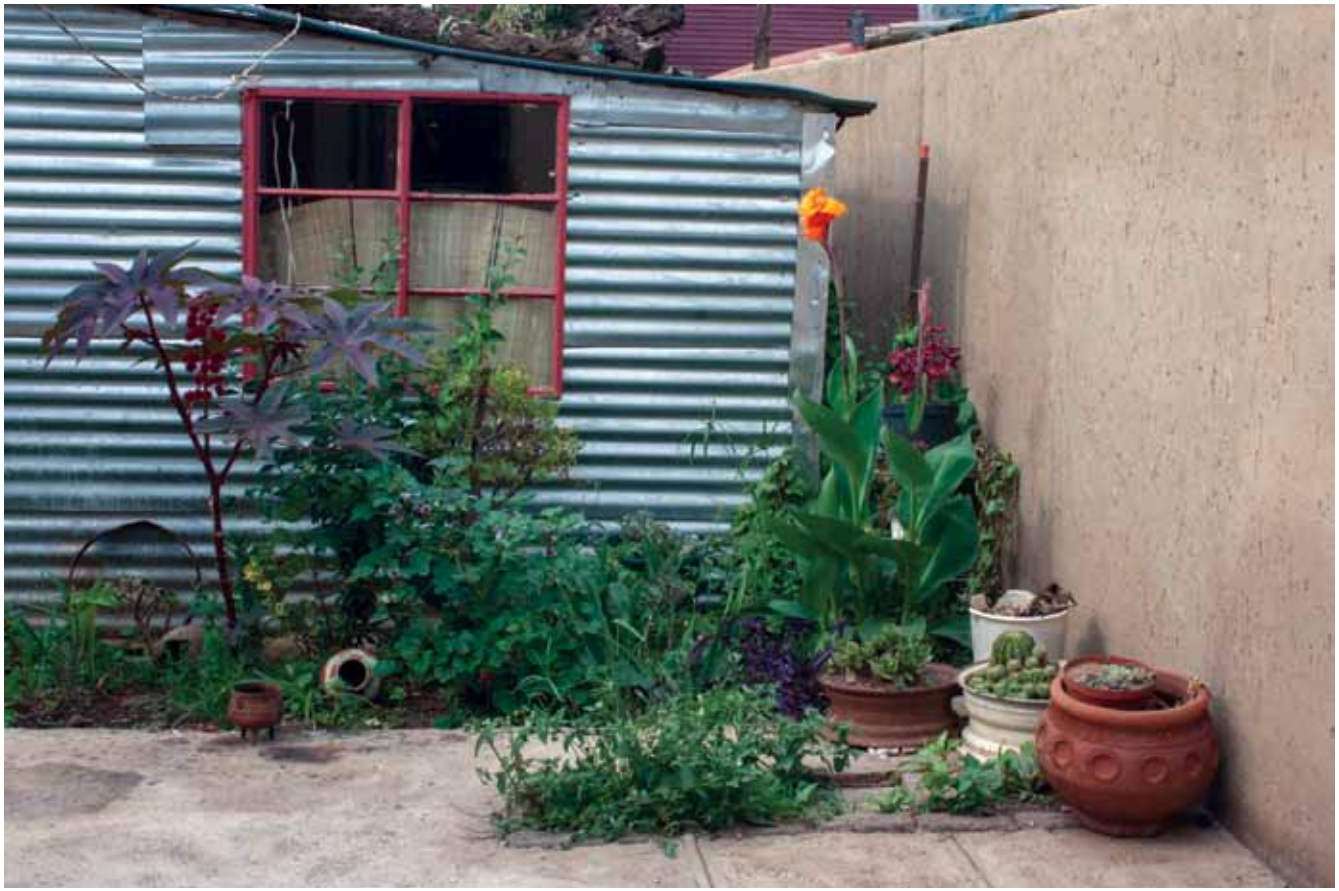
The dispersal of medicinal plants through informal markets increases the vulnerability of wild plant populations to exploitation (Garden Africa, 2013). This trend has occurred as medicinal plant collection has shifted from being almost solely an activity of traditional specialists, to involve commercial harvesters that supply plant material through formal sector traders and, increasingly, through greater numbers of informal sector businesses to supply large demand (Cunningham, 1993). In the GCR, an example of medicinal over-harvesting is the trade of Drimia sanguinea, a "Near Threatened" (NT) species according to SANBI's threatened species or 'Red List' (SANBI, 2012). Drimia sanguinea is the most common species sold in the Faraday market, central Johannesburg, and present at more stalls and in bigger volumes than any other species (Brueton in SANBI, 2012). According to Williams (in SANBI, 2012), the population of Drimia sanguinea has declined by 20-25% in the last 60 years due to mass harvesting for medicinal trade in Gauteng's 'muthi' shops and via street traders in Faraday market in particular. The Faraday Street Market 'hawkers of health' are Gauteng's largest vendors of indigenous traditional medicine, described as a 'hidden' economy due to the difficulties in quantifying the subsistence activities associated with medicinal plant trade that are often extensions of household and domestic activities' (Williams, 2003). Williams (2003) further notes that as with other informal sector activities, there is a disproportionately large number of females within the medicinal plant trade in Gauteng with low education levels, and clustered in a poorly paid, narrow income range.

For a market such as Faraday, primary customers are generally self-employed traditional healers, who either cannot or do not harvest their own medicine (Williams, 2003). Williams (2003) captures these supply-related reasons from a survey of customers at Faraday market:

NEPROLEPSIS FERN, CUSSONIA AND ROSMARINUS OFFICINALIS, 2013

- The market has a wide variety of plants
- The market sells muthi that works
- The plants are always available and fresh
- Faraday is closer to home
- Faraday is familiar to the respondents and some don't know other markets to buy plants from
- There are no places in Gauteng to 'dig' the plants known to the respondents.

In light of these reasons, it is significant that Williams (2003) found only 18,3% of traders at Faraday market harvest their own plants; the remainder either buy plants from commercial harvesters (36,6%) or gather small quantities and buy the rest (45,2%). Therefore, despite a general shift from localized, specialist medicinal plant harvesting towards commercial activity, there are harvesting localities that are "difficult to ascertain", which, according to Williams, is because "some traders do not know where plants are harvested or [are] reluctant to offer this information" (Williams, 2003). These invisible plant sources may not be easily accessed or viewed, and in the event that harvesting does not take place in large commercial plantations, are likely to be domestically harvested on private properties. The image on the following page depicts such a scene, a domestic medicinal garden in Soweto, the owner of which describes her space as a "garden used to grow plants and to help people with illnesses like colds and flu or tummy problems" (Soweto medicinal garden owner, *pers. comm*, 2013). The owner also mentioned she uses the plants mostly for making teas (Soweto medicinal garden owner, *pers. comm*, 2013). The planting and harvesting of plants in such a localised manner highlights the varied nature of domestic gardens which, although "private gardens", are clearly different from a typical English-style garden of the 'northern suburbs'.



HERB GARDEN, MAELOLA STREET, JABAVU, 2013

As Lubbe *et al* (2010) note, although domestic gardens are part of a wider green infrastructure, the layout and species of these gardens are often unique constructions of people choosing to use "useful plants" and plant "vegetable gardens, fruit trees and herb / medicinal gardens". The authors reflect that the functional nature of many domestic gardens is often such that a much higher proportion of alien species is found in these privately-managed spaces, as gardeners choose hardier alien species for cultivation purposes (Lubbe *et al.*, 2010). These insights present domestic medicinal gardens as a fascinating component of private green infrastructure. These kinds of gardens expose untapped information on the form and species composition of private green spaces to help us understand the nature of green infrastructure currently managed privately and the underlying ecological value. The special skills and knowledge of traditional medicinal gardeners also shed light on the fact that private gardens are associated with a gradient of cultural and socio-economic preferences and are not just objects of a wealthy, middle class manicured landscape.

SOWETO, JOHANNESBURG, 2013
SOWETO, JOHANNESBURG, 2013
HOUGHTON, JOHANNESBURG, 2013

The instant gardener

"In the last 3 years, we have seen a changeover as the average person starts to get garden designers in to do 'a new gardening'. People are much more open to indigenous gardening and as landscapers, we also know more about how to work with indigenous gardening. This is because people know how good indigenous looks and it, 'indigenous', was previously seen as messy. People are now internalizing this; through the value that indigenous is 'low maintenance' and because of various trends, such as both parents working, so gardens have to be low maintenance. It is very much the older generations for whom high maintenance makes sense. Unlike younger generations, however, many older generations have actually seen trees grow old, but younger people might not be able to experience this relation to nature. The result is that retailers, in meeting demands of customers, draw on instant trees grown in containers, transplanted into a garden as if it was always there… so while there is a definite decrease in annuals, there is still a perception that gardens suddenly happen." (Gauteng-based landscaper, pers. comm, 2013)

The openness to indigenous gardening in Gauteng is a positive gardening investment if more people are actually investing and becoming involved in their own gardens. However, according to an indigenous nursery owner on the outskirts of Johannesburg, although there seems to be greater appreciation and understanding of the value of gardening, people are not generally making daily investments in their gardens (Indigenous nursery owner, *pers. comm*, 2013). Another nursery owner reflects:

"Daily gardening is not part of the lifestyle of younger generations, and in the case of townhouses or smaller developments, which are part of the "instant age", people want a landscaper to make a garden look good and pretty. This is about clipped and trimmed vs. scruffy, wild and bushy. The problem is gardening is not a necessity, it's last on our hierarchy of needs." (Nursery owner, pers. comm, 2013)

This should not detract from a 'changeover' from the "established gardener trend" where ornamentals and exotic annual species have dominated for years (Herb Nursery owner, *pers. comm*, 2013), but highlights the impacts of preconceived ideas of what a garden should look like and how long it takes to look a certain way. These social and psychological dynamics situate gardening within aesthetic preferences and individual choices that affect the nature of horticultural markets and value chains. Reflecting on how this has happened in the United States, for instance, Robbins has documented how the aesthetic practices of consumer culture, coupled with various trends in the agricultural sector, drive the use of lawn and lawn chemicals that effectively cater for sprawl-based, low-density suburban development (Robbins *et al.*, 2001; Robbins *et al.*, 2003). While these "classed aesthetics" (Robbins *et al.*, 2003) may play out differently in Gauteng, particularly as younger generations move into townhouse complexes or subdivided plots, there is a definite interplay between 'low maintenance', 'indigenous and 'a pretty garden' conceptions, all of which are part of a consumption geography of affecting the construction of landscapes. A final reflection on how social preference continuously reproduces and transforms landscapes:

ALOE SP. AND PORTULACCA OLERACEAE (PURSLANE), 2013
TWO SPECIES OF BRYOPHYLLUM AND GALANSONGA PARVIFOLIA, 2013

"I've just completed a garden that was once a typical English garden, that floated into something that resembled a French Rivera garden, where the scope was to take everything out and create a new indigenous garden. The only exotic I left in was a Magnolia and Plectranthus. I've also just been asked to re-design a small townhouse complex, built in the 90s when palms were in fashion. Now we've taken all the big palms and made the pool smaller..." (Gauteng-based landscaper, pers. comm, 2013)

"In its ecological aspect (which is not securely divisible from its cultural aspect) the garden also lies in a troubled but creative interzone between "nature" and "culture"; between wilderness and the tamed; between agriculture and aesthetics, utilising, blending, critiquing and redefining all these categories." (Wylie, 2011)

Ambivalent landscapes

While the landscapes of the GCR have altered naturally occurring environments, they are also novel spaces of animals, plants and microorganisms interacting with and sustained by humans. The construction of novel landscapes has been described as a process of "ecologies becoming urban and cities becoming ecological" (Hinchliffe & Whatmore, 2006), creating 'urban ecologies', 'urban nature' or 'urban ecosystems. These entities have ignited global interest in the convergence of human and ecological systems and stimulated redefinitions of 'traditional' ecological values, construed as the 'pristine' and 'untouched' (Rees, 2003).

Indeed, urban ecology as a concept, often embodying introduced species, is far removed from what we find in national parks, reserves and conservation areas (Braun, 2005). Urban ecosystems, and various subsidiary ideas about horticulture and designed landscapes, are often deemed anomalies from a strict conservationist perspective (Cilliers *et al.*, 2004). The potency of the urban ecological controversy is such that attention tends to be on ecosystems of the 'wild' or 'rural' pristine habitats (Pickett & Cadenasso, 2006). In this vein, private urban green spaces are often viewed as an aberration of what is natural, being constructed and planted version of nature. The enigma of urban greenery in the city-region becomes apparent through reflecting on the ordinary ways in which people produce and utilize landscapes in a natural grassland biome to create unique spaces and landscapes. Further, what happens when landscapes are left unattended? There is leftover vegetation that appears in the transects of buildings and walls and the crevices of streets, remnants of spaces once managed. Once discharged of human oversight, vegetation is also often left to manoeuvre its own paths and configuration, and represents a counter anecdote to what is a manicured suburban garden. Understanding how these landscapes are reinstated into the city-region, in ways that are simultaneously intentional and incidental, reveals a network of green infrastructure that is both natural and planted, ordinary and introduced.

HERB GARDEN, MAELOLA STREET, JABAVU, 2013

Conclusion

In exploring the full ambit of green infrastructure, we need to consider how landscapes come to be and are changed. Various forms of horticulture, urban agriculture, medicinal gardening, and iterations of 'sustainable' planting movements, by and large exist because of a human choice to plant something. Overcoming a preconceived idea of what a garden is in the GCR uncovers landscapes that are constructed by citizens and transcribed in local knowledge. This is about appreciating the interaction between a gardener, who may or may not be the owner of a garden, and a wider landscape, and how this relationship is valuable, not only a product of society's divisions.

XENIA

Natasha Christopher

Tradescantia pallida, Johannesburg, 2013











SECTION SIX

This concluding chapter briefly summarizes the report's key findings and its implications for future research pathways to be pursued by GCRO.

Research pathways ahead

This report is a first step towards developing a Green Infrastructure Plan for the GCR. A basis has been provided for understanding the composition, extent, distribution and connectivity of green infrastructure. This has shown how the services of green infrastructure are valued and understood by government and citizens, and the different ways that these stakeholders invest in landscapes.

A number of key areas have emerged where further research and engagement is necessary. These include robust and integrated data in terms of how information about green assets is recorded and collated. Without more sophisticated understandings of the nature and diversity of green infrastructure across the GCR, financial resources and political mandates may struggle to relate to the services provided by green assets. This is critical so that the currently undervalued green infrastructure of the city-region can be connected into the architectures of public and private decision-making. There are interesting paths to be carved out in developing a future research agenda on the GCR's green infrastructure:

Integrated data inventories

The journey of this report was about how best to understand the current nature and condition of green infrastructure in the GCR. Visual and digital spatial data resources have proved critical in this quest and it seems that more progressive research and planning trajectories that value the services of green infrastructure will need to look to green asset information that is more accurate and consistent. This will depend on the creation of synergies between government departments and a more nuanced understanding of how green infrastructure provides services to the city-region.

Critically, this depends on the way individual municipalities record green asset data, since there is currently no standardized method of doing so. Addressing a series of inconsistencies in the way green infrastructure is understood, perceived and represented across the city-region's public custodians is also critical. A future look into how municipalities can consolidate knowledge may therefore benefit a research agenda looking to public green asset data as an important vehicle for valuing ecosystem services. This highlights the importance of a shared

PALM TREES ON JAN SMUTS, JOHANNESBURG, 2013

facility for integrating data across municipalities since ecosystem valuation for the GCR requires data in a more robust and consistent format than what is currently available at municipal level. Additionally, many green assets, such as trees on private properties, fall outside of municipal jurisdiction. The possibility of improving the use of spatial data to grasp the full extent of green infrastructure in the city-region is therefore an important strategic conversation with and between municipalities.

Prioritising ecosystem services

Questions remain about how best to use green asset data to identify and prioritise ecosystem services in the city-region. An exercise that looks to the kind of ecosystem services provided by different green assets, and which functions are relevant in light of current challenges facing the GCR, may assist in according green infrastructure an economic or financial 'Rand value'. This is based on the underlying principle that by effectively valuing ecosystem services, green assets can be understood in the same way as engineered systems, and similarly accounted for in municipal budgeting, planning and infrastructure asset management. A key issue here is how to link accurate spatial data to primary data on the services flowing from ecological systems.

Government expenditure, revenue and accounting systems

Extending our understanding of infrastructure requires a fine-grained understanding of public revenue, expenditure and accounting procedures. In terms of expenditure, local government administrations are often driven by the imperative to spend large capital budgets, on big pipes and culverts, so that even with fiscal pressures there is little incentive within the engineering domain to innovate for green infrastructure. Government revenue and accounting procedures are also driven by a standard set of exigencies, such as completeness of revenue, no under – or over – expenditure within the parameters of a budget, and asset deprecation. Within these, there is little space for understanding a set of undervalued ecosystem services and how green infrastructure, such as trees, parks, wetlands and food gardens, can appreciate over time. Our future research will look more closely at this.

Conclusion

A Green Infrastructure Plan for the GCR stands to benefit from an improved and deeper grasp on the city-region's green assets. How these can be understood as infrastructure will depend on strategic conversations between different stakeholders so we can identify where in the infrastructure planning process there is room for alternatives. This involves paying close attention to the need for urban services and how investments in green infrastructure can help us extend and maintain access to these services in more sustainable ways than what is currently delivered.

KILLARNEY, JOHANNESBURG, 2013

BODY

Natasha Christopher

Bag, Nest, Johannesburg, 2013
Cicatrix, Johannesburg, 2013
Home, Johannesburg, 2013

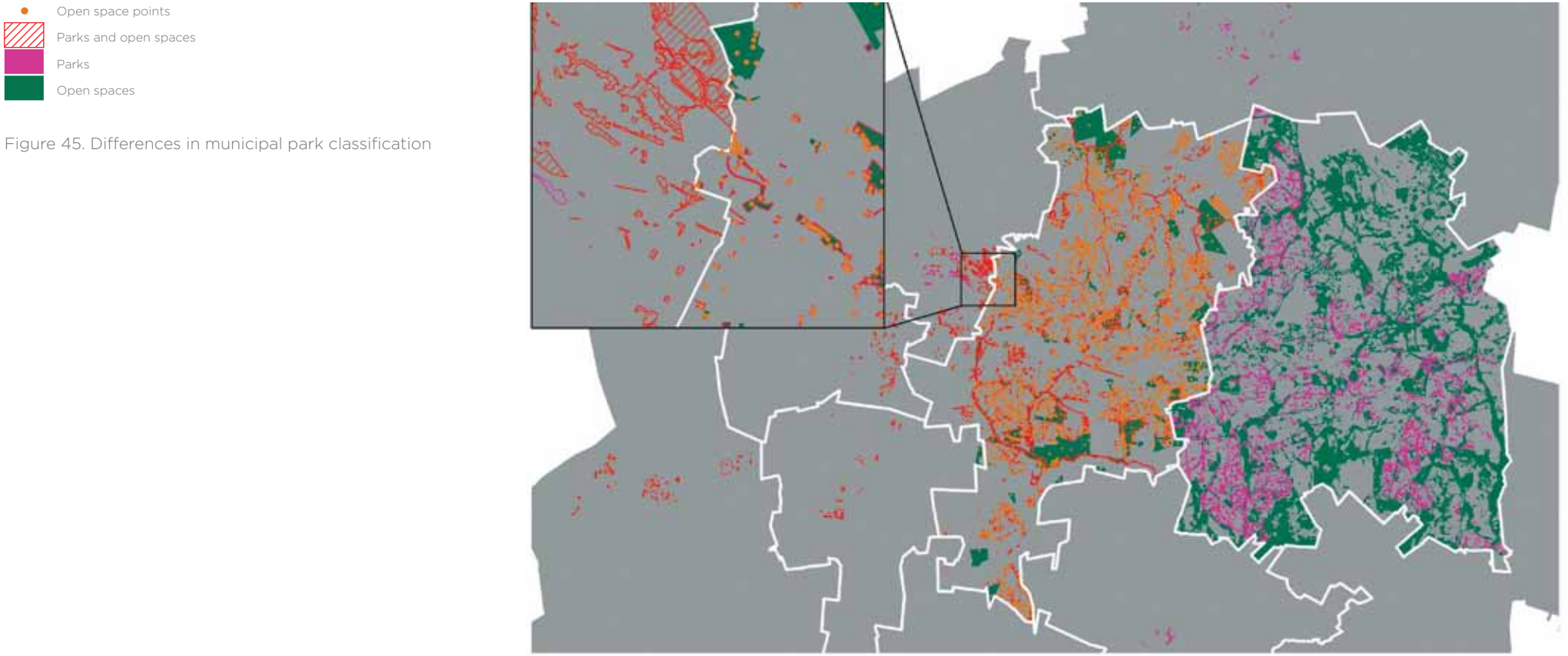


Figure 45. Differences in municipal park classification

Annexure A

Differences in municipal park classification

Parks are differently categorised across municipalities. Figure 45 shows that parks are classified in the West Rand District Municipality as 'open space' points, in Ekurhuleni as 'parks and open spaces', and in Johannesburg as both 'open spaces' and 'parks'. The inconsistencies may indicate differences in park conceptualisation and definitions. The different features, i.e. 'points' used versus polygons, also indicate different formats in the way spatial data is digitized.

Overview of data quality issues at a municipal level

Data inaccuracies can be incorporated in both the positional and attribute information of a dataset (Bolstad and Smith, nd) and can occur as result of data lineage, logical consistency, completeness and currency (Buckley, nd). Positional accuracy gauges how well the location, size and shape of the real world translates into GIS data and attribute accuracy reflects how well tabular characteristics represent reality (Bolstad and Smith, nd). Data lineage, logical consistency, completeness and currency refer to inaccuracies that can be incorporated into the datasets through determining the data source, the faithfulness of the dataset and topological errors (Table 14).

Error is defined as a deviation from the observed reality and the fitted value (Siska & Hung, 2001). Miranda (2001) argues that the need for obtaining and utilizing quality spatial information free of error is imperative to perform any analysis involving the use of GIS as a tool for data manipulation and evaluation. Error can be introduced unintentionally and imprecisions in the data can be compounded in a GIS project when more than one data source is being used.

The use of metadata should always include necessary information around the co-ordinate system, date of data, data origin, extent, scale, projection, accuracy and format (Pascual, 2011). There are many international metadata standards on the market, but these are often costly to purchase and use.

DATA QUALITY	DESCRIPTION
Positional accuracy	Manual digitizing of data, field surveys, drafting or map production, distortion on the map paper, in the digitization equipment itself or the activities of the operator and can also be added in the data processing steps.
Attribute accuracy	Remote sensing of data in the model, field inventories, photointerpretation, digital imagery classification, seasonal data acquisition and category identification.
Lineage	Source of data, content, date of data capture, geographic coverage, data transformation and algorithms.
Logical Consistency	Spatial data inconsistencies resulting from intersections, duplicate features and topological errors.
Completeness	Unclassified areas in data and any procedures that have been followed to eliminate these.

Table 14. Types of accuracy and descriptions of inaccuracy type (Bolstad & Smith, nd, Buckley, nd).

JACARANDA

Natasha Christopher

October, November, Johannesburg, 2007 - 2010

















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Map references

The maps in Section 2 were drawn from various data sources. These were:

- Data generously provided by the GIS departments in various municipalities. The municipalities and the corresponding data provided included:
  - City of Johannesburg (CoJ): Municipal Reserves; Conservancies; Hydrology; Regional Rivers; River Areas; Municipal Wetlands; Water Bodies; Agricultural Areas; Open Spaces; Johannesburg City Parks (JCP) Parks; Open Spaces; Reserves; Protected Areas; Bird Sanctuaries; Botanical Gardens; Municipal Reserves; Nature Reserves; Conservancies; Community Points; Urban Trees; Cemeteries
  - City of Tshwane (CoT): Birding points; Municipal Wetlands; Agricultural Areas; Cemeteries; Properties greater than 2 ha; Community Points; Cemeteries
  - Ekurhuleni Metropolitan Municipality: Bird Sanctuaries; Municipal Wetlands; Hydrology; Water Bodies; Manmade Water Infrastructure; Agricultural Areas; Mining belt; Open Spaces; Parks; Natural Open Space; Cemeteries
  - West Rand District Municipality (WRDM): Land Categories; Protected areas; Wetlands; Parks; Open Spaces; Community points; Cemeteries
  - Mogale City Local Municipality (MCLM): Regional Rivers; Municipal Wetlands; Manmade Water Infrastructure; Agricultural Areas; Properties greater than 2 ha
  - Randfontein Local Municipality (RLM): Bird Sanctuaries; Erven; Agricultural Areas; Properties greater than 2 ha; Golf Courses; Cemeteries
  - Midvaal Local Municipality (MLM): Open Spaces; Vacant Land; Agricultural Gardens; Agricultural Holdings; Agricultural Areas; Golf courses; Cemeteries
  - Merafong Local Municipality (MLM): Municipal Wetlands; Caves; Urban Trees; Properties greater than 2 ha
- Gauteng Department of Agricultural and Rural Development (GDARD) Cplan V3.3: Reserves; Other Reserves; South African National Defence Force (SANDF) land; State Land, National Parks; Protected Natural Environment; Conservancy; Municipal Reserves; Provincial Nature Reserve; Dinokeng; World Heritage Sites; Ridges; Transformed Ridges; Bird sanctuaries; River Areas; Agricultural Gardens; Agricultural Hubs
- Gauteng Department of Agriculture Conservation and Environment (GDACE): Conservancies
- Gauteng Department of Roads and Transport (GPRT): Regional rivers
- South African National Biodiversity Institute (SANBI): Nature Reserves; World Heritage Sites; Protected areas
- National Geo-spatial Information (NGI): Landuse 2006; Water Bodies; Water Source Points; River Lines; Regional Rivers; Inland water areas; Manmade Water Infrastructure; Caves; Golf courses; Urban trees; Cemeteries; Zoos; Properties greater than 2 ha; Open Spaces
- Department of Environmental Affairs: World Heritage Sites; RAMSAR sites (i.e. Wetlands of importance)
- Department of Water Affairs (Previously DWAF): Catchments
- Working for Water: Alien Plants
- Council for Scientific and Industrial Research (CSIR): National Freshwater Ecosystem Priority Area project (NFEPA) wetlands; Spot 5 Aerial imagery
- Statistics South Africa (StatsSA): Small Area Layer (SAL)
- ESRI: World Imagery
- AfriGIS: Gated Communities
- GeoTerraImage (GTI): 2,5m Urban Land Cover; 10m Urban Land Cover.

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