

**THE CRITICAL NATURAL CAPITAL OF THE BUFFALO CITY  
MUNICIPALITY, SOUTH AFRICA: HARNESSING LOCAL  
ACTION FOR BIODIVERSITY CONSERVATION**

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“Man is a singular creature. He has a set of gifts, which make him unique among the animals, so that unlike them, he is not a figure in the landscape – He is a shaper of the landscape.” Jacob Brondowski.

## ABSTRACT

Globally, ecosystems provide services of almost twice the value of global gross national product (Costanza *et al.*, 2006). The Buffalo City Municipality (BCM), South Africa contains biodiversity of national and international importance (Pierce, 2003; Pierce *et al.*, 2005). Despite this, the municipality continues to experience loss of both urban and rural biodiversity (Buffalo City Municipality, 2006a). This study sought to determine the status of biodiversity, and the potential for ecosystem services to contribute to conservation, within the BCM.

Biodiversity features, including ecosystem type, species of special concern and biodiversity processes, were identified and mapped using a GIS to produce a biodiversity priority index for the BCM. Current transformation status was then mapped to determine the level of ecosystem degradation within the BCM. Priority biodiversity areas as well as individual biodiversity features were spatially overlain against current transformation status and protected areas and analysed using a GIS to determine the level of degradation and protection of BCM biodiversity. In total 3.5% of total BCM biodiversity was protected. Of the 24 ecosystem types, 11 (45%) had less than 1% under protection, while 16 (67%) had less than five percent protected. Not restorable areas, thus completely lost to biodiversity conservation, comprised just less than a quarter of the total BCM area while un-impacted areas comprised just 12.3%.

Twenty five ecosystem services were identified as being provided by intact natural ecosystems within the BCM. The natural capital providing these services was identified and mapped to produce an ecosystem service index (ESI) using a GIS. This ecosystem service index and the biodiversity priority index were overlain to determine their level of correlation. Overall ESI correlation with priority biodiversity was weak although several individual ecosystem services, including carbon sequestration, showed correlation.

Using the above data layers an implementation plan and conservation framework was proposed to assist the coordination of local conservation action within the BCM. It is

concluded that ecosystem services are a potentially useful tool for conservationists at the local level seeking to ensure that biodiversity has relevance to and receives protection from broader society.



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This thesis is dedicated firstly to both my fathers, Gavin Hagen and Craig Walsh, whose own passion and love for Africa's wild places ignited my own passion for the environment, and to my mother, Mandy Walsh, whom in her own caring way has always provided me guidance and support throughout my career.

Secondly, it is dedicated to all those brave young men and woman who, in this region of the Eastern Cape, lived and died in the name of the freedoms we now take for granted everyday. Protecting the earth and the battle for sustainability will require the same level of selflessness from us in our own lives today in minimising our impact on the planet. So that one day our children may reflect how selflessly we gave to ensure they inherited an earth worth living in.

## ACRONYMS AND ABBREVIATIONS

AR	Actively restorable
BCM	Buffalo City Municipality
BCMOSS	Buffalo City Municipal Open Space System
BI	Biodiversity intactness
BPI	Biodiversity priority index
CAPE	Cape Action Plan for People and the Environment
CBNRM	Community-based natural resource management
CDM	Cleaner Development Mechanism
CNC	Critical natural capital
CTS	Current transformation status
DWAF	Department of Water Affairs and Forestry
EIA	Environmental impact assessment
ESI	Ecosystem service index
GIS	Geographic information system
ISI	Information services index
MEA	Millennium Ecosystem Assessment
MOSS	Metropolitan open space system
MSL	Mean sea level
NR	Not restorable
NSBA	National Spatial Biodiversity Assessment
PCSI	Productive and cultural services index
PES	Payment for ecosystems services
PR	Passively restorable
RDB	Red Data Book
RSI	Regulation services index
RUPRU	Rhodes University Population Research Unit
SDF	Spatial Development Framework
SSC	Species of special concern
STEP	Subtropical Thicket Ecosystem Planning

UI            Un-impacted  
WfW        Working for Water

## CHAPTER 1: INTRODUCTION

On the 29 August 2005 Hurricane Katrina slammed into the US coastal city of New Orleans, with the human-engineered storm protection infrastructure catastrophically failing, causing more than US\$ 100 billion in physical damage and immeasurable loss to human well-being (Costanza *et al.*, 2006). The real tragedy however is that such damage was predictable and that for an estimated US\$ 14 billion required for the restoration of New Orleans' coastal wetlands, which previously provided a natural, long-term buffer against hurricanes, most of this damage and suffering could have been averted (Costanza *et al.*, 2006). Costanza *et al.* (1997) estimated the total non-market value of services provided by natural ecosystems globally to be approximately US\$ 33 trillion while the total global gross national product was only US\$ 18 trillion. Natural ecosystems therefore play a critical role in the world's economies and in improving human well-being.

The Millennium Ecosystem Assessment (2005) has recently played a significant role in highlighting both the role of biodiversity in ensuring human well-being and its continued decline globally. Critically the Millennium Ecosystem Assessment highlights that the health of a nation's biodiversity and its human well-being are intrinsically linked (Millennium Ecosystem Assessment, 2005). The Millennium Ecosystem Assessment (2005) contains the following two key messages: "The most important direct drivers of biodiversity loss and ecosystem service changes are: habitat change; climate change; invasive alien species; overexploitation; and pollution"; and that "science can help ensure that decisions are made with the best available information, but ultimately the future of biodiversity will be determined by society". A major conclusion of significant concern is that an unprecedented effort would be necessary to achieve a significant reduction of the current rate of biodiversity loss at global and national level by 2010, a goal set by the Convention on Biological Diversity (Balmford *et al.*, 2005).

The rate of biodiversity loss in South Africa is little different and with its massive demands for economic development to achieve the government's primary goal of poverty alleviation, the pressure for biodiversity loss in the country are only likely to significantly

increase. Despite these challenges, South Africa is one of the world's mega-diverse countries and is ranked third globally in terms of species richness (Driver *et al.*, 2005). For this reason alone, it is critical to find rapid and effective means to ensure the continued conservation of the indigenous biodiversity of South Africa.

The Eastern Cape Province of South Africa contains six of the country's seven biomes, two global centres of plant endemism and a global biodiversity hotspot (Pierce *et al.*, 2005). The Buffalo City Municipality (BCM), covering an area of 2 515 km<sup>2</sup>, has an estimated population of 1 110 685 people at an overall density of 442 persons per km<sup>2</sup>, and is a major commercial and industrial centre at the geographical heart of the Eastern Cape Province (Buffalo City Municipality, 2004). The BCM, containing approximately 15% of the Eastern Cape Province's population (Buffalo City Municipality, 2004), therefore has a significant influence on the current and future state of the province's biodiversity. Locally, the BCM Integrated Development Plan (Buffalo City Municipality, 2006b) and BCM Integrated Environmental Management Plan (Buffalo City Municipality, 2006a) have highlighted the rapid loss of biodiversity within the municipality as a significant concern. There is therefore a need for its protection.

The conservation paradigm for most of the previous century has been the creation of formally protected areas, firstly for the conservation of specific species of plants and animals, and in more recent times to conserve specific ecosystems and landscapes (Edwards & Abivardi, 1998). However, given that much of the world's biodiversity exists outside of formally protected areas in productive landscapes important to humans, this means of preserving indigenous biodiversity is now recognised as being limited for meeting the targets necessary to ensure the long-term persistence of much of the world's biodiversity (Pressey, 1994; Edwards & Abivardi, 1998; Margules & Pressey, 2000). Thus increasingly the international and local conservation community has seen the need to focus on conserving biodiversity outside formally protected areas (Kerley *et al.*, 2003). Despite this, biodiversity conservation still remains a relative non-priority amongst policy makers and decision makers around the world and particularly within developing countries such as South Africa.

Traditionally, conservation planning in South Africa as well as elsewhere, has focused mainly on biodiversity (Margules & Pressey, 2000; Cowling *et al.*, 2003; Pearce *et al.*, 2005; Stewart *et al.*, 2005). Although conservation of biodiversity is frequently justified through its provision of ecosystem services, most conservation effort has been towards the conservation of biodiversity rather than the continued provision of ecosystem services (Balvanera *et al.*, 2001). It has, however, recently been put forward that conservation planners need to incorporate social and economic concerns into conservation plans through the incorporation of ecosystem services (Egoh *et al.*, 2007) to make these plans, and thus the conservation of biodiversity, more relevant to society at large. Nevertheless, while a wide range of criteria for defining biodiversity priority have been proposed, no such criteria have been defined for safeguarding ecosystem services (Balvanera *et al.*, 2001).

The concept of critical natural capital (CNC; Ekins *et al.*, 2003) is a useful one to determine why it may be important to conserve a given ecosystem. Ekins *et al.* (2003) define CNC as “natural capital that provides „important“ or critical ecosystem functions that cannot be substituted for by any other function, whether environmental or not; the loss of which would be irreversible; and the loss of which would risk, or actually entail, immoderate loss”. Ecosystem services can be defined as the set of ecosystem functions useful to humans, many of which are critical to our survival (Kreman, 2005). Importantly, however, to maintain the flows of goods and services from natural capital which benefit human well-being we must also ensure that the health of the ecosystem itself and its various processes are maintained as well (Ekins *et al.*, 2003). This may potentially be one of the most compelling means for motivating for the maintenance of indigenous biodiversity.

Increasingly the South African conservation sector is recognising the important role of local government in conservation planning (Driver *et al.*, 2005; Pierce *et al.*, 2005). Ultimately, motivation and support for biodiversity conservation will have to come from civil society at large in order to make a real and more lasting impact (Balmford & Cowling, 2006) as conservation is an activity best undertaken at the local level (Bryant,

2006). The ecosystem goods and services literature has already established many of the important functions that ecosystems play for humanity (Edwards & Abivardi, 1998; de Groot *et al.*, 2002; Chiesura & de Groot, 2003) and thus the concept of CNC provides an opportunity to link local people to the role played by natural capital and thus provide them with the means for making informed decisions regarding its sustainable use. In this way their impassioned pleas and lobbying will provide the basis for ensuring the protection of natural capital and the biodiversity required to sustain it (Pierce *et al.*, 2005).

Currently, however, little work has been done on determining what services ecosystems provide for local government and its citizens within South Africa, and elsewhere, and what natural capital provides these services (but see: Ekins, 2003). However, if the identification of natural capital is to be relevant to local government and its citizens, then its identification needs to be mainstreamed into local landuse planning (Pierce *et al.*, 2005). The field of conservation planning has already made major strides in the effort to mainstream biodiversity conservation into local landuse planning through stakeholder involvement (Driver *et al.*, 2003; Knight *et al.*, 2006).

Pierce *et al.* (2005) propose that stakeholders be involved in identifying and mapping different forms of natural capital which provide important ecosystem services (Ekins *et al.*, 2003), communicating its importance to local government and motivating for its incorporation into land-use planning. The extent to which the natural capital mapped overlaps with biodiversity-based conservation targets can also be assessed (Pierce *et al.*, 2005). Assuming that: a) there is significant overlap between these natural capital features and biodiversity, and b) the general citizenry can be marshalled to protect this natural capital; this approach would allow the responsibilities of the conservation sector to shrink significantly (Pierce *et al.*, 2005).

Balvanera *et al.* (2001) maintain that mapping these ecosystem services will allow for assessment of: the levels and types of services supplied by alternative landuses; the degree of spatial overlap of different types of services; and forecast changes in ecosystem

services provision under alternative future scenarios. With regard to the degree of overlap between biodiversity priority approaches and ecosystem service provision approaches, Balvanera *et al.* (2001) postulate that the degree of congruence, including spatial, is likely to increase as: an increasing number of services is considered; functional redundancy is valued as a buffer against random natural events (e.g. drought, flooding) and anthropogenic change; and the relative weight of biodiversity intensive services is increased.

## CHAPTER 2: LITERATURE REVIEW

### 2.1 Conservation planning

Conservation planning seeks to identify priority areas for conservation action with the goal of minimising the loss of biodiversity (Meyers *et al.*, 2000; Pressey & Cowling, 2001). Internationally, conservation planning has been adopted by a large number of governmental agencies and non-governmental organisations to prioritise their conservation actions (Meyers *et al.*, 2000; Valutis & Mullen, 2000; Cowling *et al.*, 2003; Driver *et al.*, 2005).

Recent calls have been made that conservation planning has been ad-hoc rather than systematic (Pressey, 1994; Margules & Pressey, 2000) which has led to the emergence of systematic conservation planning (Margules & Pressey, 2000). Systematic conservation planning incorporates three basic principles (Driver *et al.*, 2005) including:

1. The principle of representation;
2. The principle of persistence; and
3. The principle of qualitative target setting.

#### 2.1.1 Conservation planning in South Africa

South Africa is at the forefront of conservation planning, also known as biodiversity planning, internationally and has adopted an ecosystem approach to systematic conservation planning through a focus on ecosystems rather than purely on individual species (Driver *et al.*, 2005). Examples of systematic conservation planning within South Africa include the National Spatial Biodiversity Assessment (NSBA; Driver *et al.*, 2005), the Cape Action Plan for People and the Environment (CAPE; Cowling *et al.*, 2003) and the Subtropical Thicket Ecosystem Planning programme (STEP; Pressey & Cowling, 2001). As well as these national and bioregional scale assessments, a number of fine-scale systematic conservation assessments have been undertaken within South Africa such as the fine-scale conservation assessment for the Nelson Mandela Metropolitan Municipality (Stewart *et al.*, 2005).

The NSBA (Driver *et al.*, 2005) highlights the need to incorporate both economically valuable and culturally important ecosystems and species, and indicates that they are currently important information gaps within the NSBA assessment. It also indicates that these components may be better suited for inclusion within more fine-scale, regional or local scale biodiversity assessments.

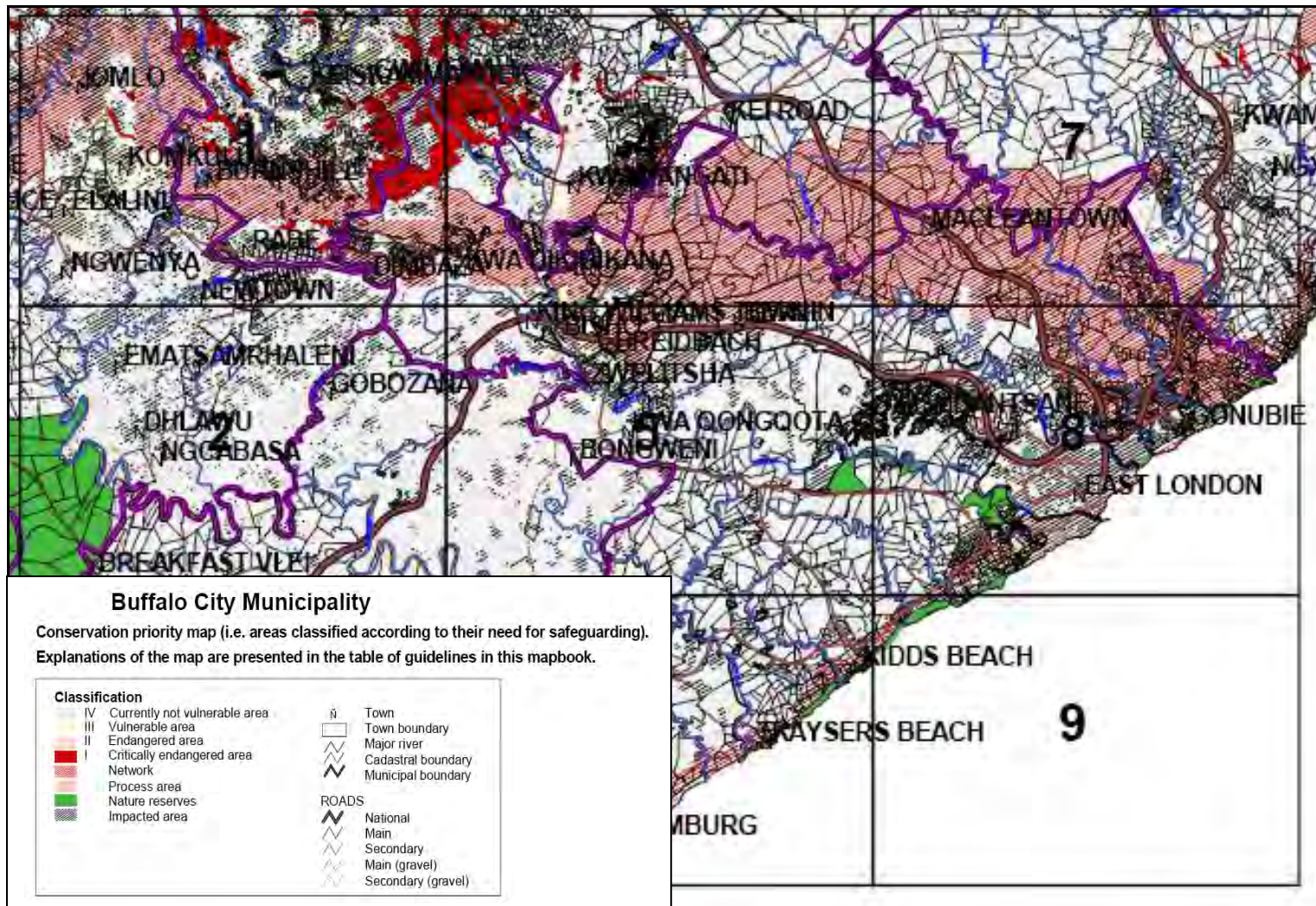
#### 2.1.2 The Subtropical Thicket Ecosystem Planning programme

The STEP programme is a bioregional biodiversity planning initiative developed to help ensure the long-term survival of the Subtropical Thicket biome (Pierce *et al.*, 2005). This biome covers a major portion of the Eastern Cape Province. The STEP programme advocates the need to conserve biodiversity to ensure the continuous provision of ecosystem goods and services critical to human well-being and provides a tool in the form of a conservation plan to achieve this (Pierce *et al.*, 2005). However, if this and other conservation plans are to be successful in practice then policymakers, landuse planners and decision makers, land owners, and the general public at large need to understand the tangible and intangible links between biodiversity, natural capital and the provision of ecosystem goods and services.

The STEP conservation assessment, undertaken at a scale of 1:100 000, identifies biodiversity features (Table 2.1; Figure 2.1), in the form of vegetation types, within the BCM (Pierce, 2003). Table 2.1 provides a conservation status for each vegetation type, the total hectares of each vegetation type found within the BCM, as well as what percentage this is of the total hectares found within the entire STEP planning domain (Pierce, 2003) which provides a useful measure of endemism for each vegetation type.

**Table 2.1.** Information on the vegetation types identified within the BCM through the Subtropical Thicket Ecosystem Planning (STEP) programme (Pierce, 2003)

STEP vegetation types	STEP description	Conservation status	Total ha in BCM	% Total in BCM
Albany Coastal Thornveld	Non-thicket vegetation type	Currently not vulnerable	3732.24	3.98
Amatole Afromontane Forest	Non-thicket vegetation type	Critically endangered	6517.04	21.03
Bedford Savanna Thicket	Fish Valley Thicket mosaic with Savanna	Currently not vulnerable	0.44	0.00
Berlin Savanna Thicket	Buffels Thicket mosaic with Savanna	Currently not vulnerable	131189.67	52.17
Buffels Thicket	Solid Thicket with no spekboom	Currently not vulnerable	24194.97	65.84
Buffels Valley Thicket	Solid Thicket with no spekboom	Vulnerable	9414.44	43.69
Cintsa Dune Thicket	Transfish Dune Thicket mosaic with Grassland	Currently not vulnerable	3428.97	20.32
Doubledrift Karroid Thicket	Fish Valley Thicket mosaic with Succulent Karoo and Grassland	Currently not vulnerable	3025.74	2.26
Floodplain / Estuary	Wetland	Critically endangered	701.26	N/A
Hamburg Dune Thicket	Transfish Dune Thicket mosaic with Savanna	Currently not vulnerable	11232.71	31.19
Inland Thornveld	Non-thicket vegetation type	Currently not vulnerable	8989.85	6.88
Kiwane Dune Thicket	Transfish Dune Thicket mosaic with Fynbos	Currently not vulnerable	12522.63	97.63
Moist Mountain Grassland	Non-thicket vegetation type	Currently not vulnerable	3384.50	1.32
Mountcoke Grassland Thicket	Buffels Thicket mosaic with Grassland and Fynbos	Currently not vulnerable	26466.26	52.05
Mountvale Grassland Thicket	Fish Thicket mosaic with Succulent Karoo and Grassland	Currently not vulnerable	321.12	7.53
South East Coastal Vegetation	Non-thicket vegetation type	Currently not vulnerable	401.18	N/A
Transfish Dune Thicket	Solid Dune Thicket	Currently not vulnerable	2834.07	48.34
Umtiza Forest Thicket	Buffels Thicket mosaic with Forest	Vulnerable	3186.06	100.00



**Figure 2.1.** Subtropical Thicket Ecosystem Planning (STEP) programme conservation priority map for the BCM showing conservation network areas and conservation status for vegetation types within the BCM (Pierce, 2003)

The conservation assessment also identifies six ecological networks, one of which is within the BCM, to guide the implementation of the STEP mega-conservancy network concept (Knight & Cowling, 2003), as well as a coastal network (Figure 2.1). These corridors are designed to efficiently and effectively ensure the long-term survival of the Subtropical Thicket biome as well as other biomes within the STEP domain (Knight & Cowling, 2003; Pierce, 2003).

### 2.1.3 Local landuse planning in South Africa

Since the advent of democracy and change in government regime in 1994, South Africa has seen a move away from the previous more autocratic and centralised style of governance towards a more participatory and local form of governance. This has led to a corresponding shift in both the mechanisms for dealing with biodiversity conservation and the authorities and stakeholders that are responsible for biodiversity management (Pierce *et al.*, 2005). Thus while previously conservation was seen purely as the role of national and provincial government agencies in South Africa, it is now considered a function of local government as well. A fact which is reflected in the passing of recent legislation in South Africa in particular the Local Government Municipal Systems Act 32 of 2000 and the National Environmental Management: Biodiversity Act 10 of 2004 (Pierce *et al.*, 2005).

Municipalities within South Africa are lawfully mandated with the responsibility of landuse management within their jurisdiction. The Local Government Municipal System Act requires that every South African municipality develop a Spatial Development Framework (SDF) that incorporates social, economic and environmental concerns. The National Environmental Management Biodiversity Act lays out the requirements for the incorporation of biodiversity, particularly threatened ecosystems and species requiring protection, into SDFs. Together these two pieces of legislation provide the basis for local conservation planning in South Africa. The conservation sector has increasingly recognised that proactive planning such as SDFs as opposed to reactive planning such as Environmental Impact Assessments (EIA), are an effective and important tool for ensuring the protection of indigenous biodiversity (Pierce *et al.*, 2005).

#### 2.1.4 Open space planning globally and locally

Traditionally conservation planning has primarily addressed biodiversity conservation in rural, albeit productive landscapes, generally treating urban areas as having little or no biodiversity value (Pressey & Cowling, 2001; Cowling *et al.*, 2003; but see: Stewart *et al.*, 2005). However, the discipline of urban open space planning has busied itself specifically with the conservation of urban biodiversity. Historically open space planning was mainly occupied with the concerns of providing public amenities and aesthetic improvements. However, given the current unprecedented rates of urbanisation around the world, the protection and maintenance of biodiversity has recently also become a major consideration for urban open space planners (Cilliers *et al.*, 2004; Haight *et al.*, 2005; Bryant, 2006).

In South Africa the concern of conserving urban biodiversity has led to the concept of Metropolitan Open Space Systems (MOSS; Poynton & Roberts, 1985). MOSS have been designed for a number of South African cities which, in line with their international counterparts, are experiencing unprecedented rates of growth as more and more South Africans are drawn to cities for the economic opportunities they offer (Cilliers *et al.*, 2004). Urban nature conservation in South African cities thus needs to compete with the increased need for space, development and job opportunities and urban open space is thus under significant pressure to make meaningful social, economic and cultural contributions to human well-being in order for urban planners to justify its continued existence (Cilliers *et al.*, 2004).

#### 2.1.5 Background to the Buffalo City municipal open space system assessment

The BCM has undertaken a MOSS, hereafter referred to as the BCMOSS assessment, in order to respond to the high levels of biodiversity loss within the area under its jurisdiction (Buffalo City Municipality, 2007). A major objective of this MOSS is to ensure that the municipality is able to meet its goals for the conservation of indigenous biodiversity, as well as to incorporate important social and economic services provided by ecosystems within the Municipality (Buffalo City Municipality, 2007). Understanding the current state of biodiversity within the BCM's jurisdiction is crucial to ensuring its

proper protection. As such, an important aspect of the BCMOSS assessment project was to undertake a fine-scale conservation assessment building on the products of the STEP programme (Buffalo City Municipality, 2007). Table 2.2 indicates the data sources used to generate an ecosystem type data layer for the BCMOSS assessment project (Buffalo City Municipality, 2007).

**Table 2.2.** Data layers used to create the BCM ecosystem type data layer for the BCMOSS assessment project (Source: Buffalo City Municipality, 2007)

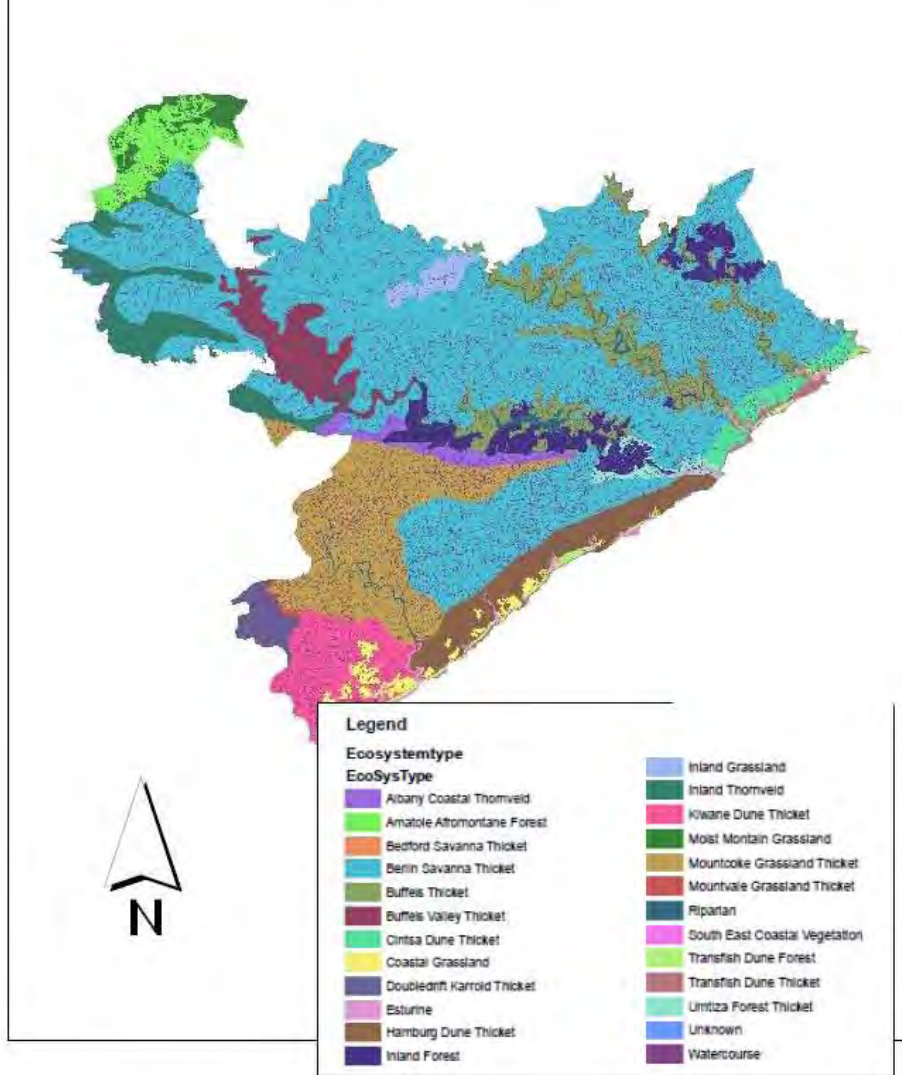
Ecosystem type data layers	Description and data source
STEP vegetation type	STEP data layer mapped as part of the STEP project indicating pre-transformation extent of vegetation types of all biomes but mainly focused on the Sub-tropical Thicket biome.
BCM forest type	Indigenous forests mapped as part of the BCMOSS assessment project using aerial photography and local expert knowledge.
BCM grassland type	Indigenous grasslands mapped as part of the BCMOSS assessment project using aerial photography and local expert knowledge.
DWAF watercourse	The Department of Water Affairs and Forestry (DWAF) watercourses layer with a buffer of 20m on either side.
BCM estuarine	BCM data layer indicating estuarine systems within BCM.
BCM riparian	BCM data layer indicating major rivers systems within BCM.

The layers in Table 2.2 were merged to provide the ecosystem type data layer for the BCM indicated in Table 2.3. In total the BCM contains 24 known ecosystem types which include four azonal (i.e. their distribution is determined by specific physical rather than biological factors); eleven solid (i.e. they are comprised of a single biome) vegetation types; and nine mosaic vegetation types (Vlok & Euston-Brown, 2002) comprised of two or more biomes in a matrix with one another. A 25<sup>th</sup> classification includes areas for which the ecosystem type was unknown. These BCM ecosystem types are spatially represented in Figure 2.2.

**Table 2.3.** Information on the BCM ecosystem types, including the total, and proportion of total, area covered by each ecosystem type within the BCM

Biome	BCM ecosystem type	Total area (ha)	Proportion of total (%)
<i>Azonal ecosystem types</i>			
Wetland	Riparian	4358.77	1.73
Wetland	Watercourse	22719.82	9.00
Wetland	Estuarine	1324.61	0.52
Dune Vegetation	South East Coastal Vegetation	366.05	0.15
<i>Solid vegetation types</i>			
Subtropical Thicket	Buffels Thicket	14240.51	5.64
Subtropical Thicket	Buffels Valley Thicket	7811.49	3.10
Dune Thicket	Transfish Dune Thicket	1477.18	0.59
Dune Forest	Transfish Dune Forest	1418.90	0.56
Forest	Amatole Afromontane Forest	6572.33	2.60
Forest	Inland Forest	8542.16	3.39
Savanna	Albany Coastal Thornveld	3042.30	1.21
Savanna	Inland Thornveld	9169.36	3.63
Grassland	Coastal Grassland	2552.99	1.01
Grassland	Moist Mountain Grassland	2863.25	1.13
Grassland	Inland Grassland	2129.32	0.84
<i>Mosaic vegetation types</i>			
Subtropical Thicket/ Succulent Karoo/ Grassland	Double Drift Karroid Thicket	2497.33	0.99
Subtropical Thicket/ Grassland/ Fynbos	Mountcoke Grassland Thicket	22834.34	9.05
Subtropical Thicket/ Succulent Karoo/ Grassland	Mountvale Grassland Thicket	288.31	0.11
Subtropical Thicket/ Savanna	Bedford Savanna Thicket	0.39	0.00
Subtropical Thicket/ Savanna	Berlin Savanna Thicket	113920.19	45.15
Subtropical Thicket/ Forest	Umtiza Forest Thicket	1542.44	0.61
Dune Forest/ Grassland	Cintsa Dune Thicket	3169.93	1.26
Dune Forest/ Savanna	Hamburg Dune Thicket	9284.14	3.68
Dune Forest/ Fynbos	Kiwane Dune Thicket	9687.62	3.84
	Unknown	520.35	0.21
	<b>Total</b>	<b>252334.06</b>	<b>100.00</b>

## BC'MOSS Conservation Plan: Ecosystem Type



**Figure 2.2.** Spatial distribution of the BCM ecosystem types (Source: Buffalo City, 2007)

## 2.2 Natural capital and ecosystem functions

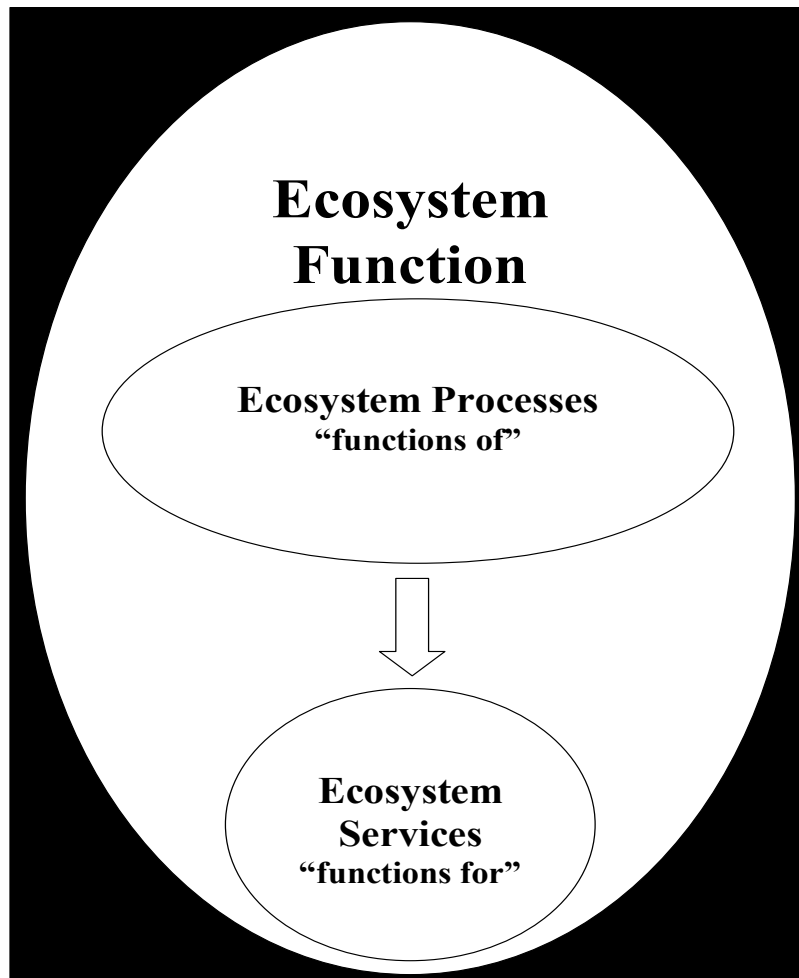
If maintenance of a non-declining natural capital stock can be considered a criterion for sustainable development (MacDonald *et al.*, 1999) then it is important to establish which stocks of natural capital provide important ecosystem services. Ekins & Simon (2003) maintain that taking the anthropocentric view, it is not the particular stocks of natural capital that are of importance but rather the ability of the capital stock as a whole to continuously provide the ecosystem functions which make an important contribution to human well-being.

### 2.2.1 Ecosystem functions, services and processes

Ekins *et al.* (2003) define two basic groups of ecosystem functions, the first being the „functions for“, which are those functions which provide direct benefits for humans. These are the functions which are generally most easily perceived and appreciated and, the maintenance of which, most environmental policy is directed (Ekins, 2003). These „functions for“ result in the provision of ecosystem services.

The second group, being the „functions of“ the environment, are those which “maintain the basic integrity of natural systems in general and ecosystems in particular” (Ekins, 2003), which are also referred to as ecosystem processes. These functions are not easily perceived, and scientific knowledge about them is still uncertain and incomplete. However their continued operation is critical for the continued provision of many of the „functions for“ humans (Ekins, 2003).

While humans are generally aware of the goods and services that ecosystems provide directly for them, or the „functions for“ ecosystems, such as the provision of clean air and water, food crops and recreational activities, they often fail to see the importance of the „functions of“ ecosystems or the functions that ensure that the ecosystems themselves continue to provide the goods and services that are essential to human well-being (Ekins *et al.*, 2003), most notably biodiversity itself. Figure 2.3 graphically depicts the relationship between ecosystem functions, services and processes.



**Figure 2.3.** Overview of the relationship between ecosystem functions, ecosystem processes and ecosystem services

### 2.2.2 Categories of ecosystem functions

de Groot *et al.* (2000) define four categories of ecosystem functions, these being:

1. Regulation functions: this group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through bio-geochemical cycles and other biospheric processes. In addition to maintaining ecosystem (and biosphere) health, these regulation functions provide many services that have direct and indirect benefits to humans (such as clean air, water and soil, and biological control services).

2. Habitat functions: natural ecosystems provide refuge and reproductive habitat to wild plants and animals and thereby contribute to the (*in situ*) conservation of biological and genetic diversity and evolutionary processes.
3. Production functions: photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures which are then used by secondary producers to create an even larger variety of living biomass. This broad diversity of carbohydrate structures provides many ecosystem goods for human consumption, ranging from food and raw materials to energy and genetic materials.
4. Information functions: because most human evolution took place within the context of undomesticated habitat, natural ecosystems provide an essential „reference function“ and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, recreation and aesthetic experience.

de Groot *et al.* (2002) provide a systematic and comprehensive classification of these ecosystem functions as well as examples of the goods and services that these functions provide (Appendix 1). These functions are of value to human society through the ecosystem services they provide. Once these functions are known their criticality can be assessed and the natural capital or components of natural capital that provide the functions can be identified (de Groot *et al.*, 2002).

The Millennium Ecosystem Assessment (MEA; 2005) also defines four categories of ecosystem services, these being provisioning services (e.g. food, fresh water, wood and fibre and fuel); regulating services (e.g. climate regulation, water purification, flood regulation and disease regulation); cultural services (e.g. spiritual, aesthetic, recreational and educational); and supporting services (e.g. nutrient cycling, primary production and soil formation). The relationship between de Groot *et al.*'s (2000) classification system and the MEA classification system is expressed in Table 2.4.

**Table 2.4.** Relationship between de Groot *et al.*'s (2000) and the Millennium Ecosystem Assessment (2005) classification of ecosystem services

de Groot <i>et al.</i> 's (2000)	Millennium Ecosystem Assessment (2005)
Productive functions	Provisioning services
Regulation functions	Regulating services
	Supporting services
Information functions	Cultural services
Habitat functions	None

The MEA however erroneously refers to certain ecosystem services (e.g. nutrient cycling and primary production) whereas they are in fact ecosystem processes based on the definition set out in Boyd & Banzhaf (2007). Many of the MEA examples of ecosystem services could equally be ecosystem processes and therefore, as per Boyd & Banzhaf (2007), these MEA “ecosystem services” should be referred to as ecosystem functions until they have delivered a specific benefit to human well-being in which case they should then be referred to as an ecosystem service.

### 2.2.3 Determining ecosystem service provision

To standardise environmental accounting of ecosystem services Boyd & Banzhaf (2007) propose a focus on the *final* ecosystem service, where *final* refers to the last contribution of the ecosystem. Boyd & Banzhaf (2007) further define *final* ecosystem services as components of nature, directly enjoyed, consumed, or used to yield human well-being. The focus on final, rather than intermediate, services prevents double counting of services (Boyd & Banzhaf, 2007).

Drawing from Boyd & Banzhaf (2007) it is important to distinguish between the benefit provided by nature (i.e. the *final* ecosystem service); the ecosystem service associated with the provision of the benefit; and the ecosystem processes and functions, associated with the provision of the ecosystem services. As well as this, it is important to note that generally ecosystem services are spatially explicit and therefore reference to a particular ecosystem service refers to a spatially explicit location (Boyd & Banzhaf, 2007).

de Groot *et al.*'s (2000) four categories of ecosystem functions are utilised to discuss ecosystem services potentially supplied by intact natural capital in the BCM below. Intact natural capital is defined as natural capital that has maintained its biodiversity intactness as discussed in section 2.2.6. Using the rationale for determining *final* ecosystem services by Boyd & Banzhaf (2007) means that the habitat function category in its entirety contains only ecosystem processes and no ecosystem services. The remaining three categories of ecosystem functions contain both ecosystem processes as well as services.

## 2.2.4 Regulation functions

### 2.2.4.1 Carbon sequestration and storage

Natural ecosystems provide a valuable service in mitigating against global climate change through the sequestration and storage of carbon dioxide (Mills *et al.*, 2005; Glenday, 2007). Boyd & Banzhaf (2007) argue that carbon sequestration is not a *final* ecosystem service but rather a supporting service for a number of other *final* ecosystem services. However, given the establishment of the international carbon market it is counter-argued that there is a direct economic benefit provided by this service.

Glenday (2007) undertook a study into the carbon sequestration and storage capacities of various ecosystem types within the eThekweni Municipality, South Africa to determine the effects of landuse planning and resultant landuse changes on local climate change impacts. The eThekweni Municipality is located approximately 500 km north of the BCM, also on the east coast of South Africa. Glenday's (2007) study thus provides a useful reference, at least on a comparative basis, for similar ecosystem types found in the BCM (Table 2.5).

**Table 2.5.** Carbon sequestration potential for different vegetation types (Glenday, 2007), and their BCM equivalent

Glenday (2007) ecosystem type	BCMOSS equivalent ecosystem types	Mean carbon density (tC/ha)
Coastal scarp forest	Amathole afromontane; inland forest	199
Dune forest	Dune forest	133
Swamp forest	Riparian	197
Dry valley thicket	Subtropical thicket	121
Bushclump grassland mosaic	Thicket/ grassland matrix	82
Wooded grassland	Savanna	66
Primary grassland	Grassland	62
Estuarine wetland	Estuarine	244
Freshwater wetland	Watercourse	149

#### 2.2.4.2 Flood protection and stormwater discharge

Natural, intact ecosystems provide structural buffers against flooding as well as providing for subsequent discharge of stormwater after flood events (Braga, 1999; Baron *et al.*, 2002; Postel & Thompson, 2005). Increased impacts from flooding and lack of stormwater discharge will result in damage to human well-being, through the loss and damage of infrastructure and livelihoods affected by flooding and stormwater discharge.

Fischer & Fischenich (2000) found that a riparian vegetation buffer width of 20 to 150m would provide for flood protection, resulting in reduced flood peaks, as well as providing a physical barrier against flood waters. Wetland ecosystems, in general, provide increased flood protection, and slower discharge (Anon., 2005; Greenfell *et al.*, 2005) although the role of vegetation within the general catchment area is also important (Greenfell *et al.*, 2005; Postel & Thompson, 2005). The BCM spatial development framework plan, as part of its disaster management policy, regards the 1:100 flood-line of any watercourse and river as not developable in order to protect the riparian zone and minimise flood risk (Buffalo City Municipality, 2003). The above information is summarised in Table 2.6.

**Table 2.6.** Ranking of relative importance of regulation services (excluding carbon sequestration and storage; pollination; and biological control)

Ecosystem service	Natural Capital elements important for ecosystem service provision	Reference	Relative importance
Flood protection and stormwater discharge	Riparian vegetation	Fischer & Fischenich (2000)	Highest
	Wetlands (general)	Anon. (2005); Greenfell <i>et al.</i> (2005)	Highest
	Catchment vegetation	Greenfell <i>et al.</i> (2005); Postel & Thompson (2005)	Medium
Water provision	Riparian vegetation	Verhoeven <i>et al.</i> (2006); Fischer & Fischenich (2000)	Highest
	Freshwater wetlands (general)	Verhoeven <i>et al.</i> (2006); Greenfell <i>et al.</i> (2005)	Highest
	Catchment vegetation	Postel & Thompson (2005); Postel & Thompson (2005)	Medium
Erosion prevention	Riparian vegetation	Fischer & Fischenich (2000); Braga (1999)	Highest
	Wetlands (general)	van der Perk <i>et al.</i> (2000)	Highest
	Vegetation on steep slopes (>1:5)	Buffalo City Municipality (2003); Rodriguez <i>et al.</i> (2006)	Highest
Sand dune stabilisation	Coastal dune forest	Lubke & de Moor (1998)	Highest
	South east coastal vegetation	Lubke & de Moor (1998)	Highest

#### 2.2.4.3 Fresh water provision

Natural, intact ecosystems play a major role in water purification and supply (Baron *et al.*, 2002; Greenfell *et al.*, 2005; Verhoeven *et al.*, 2006) which, due to their interrelatedness are jointly referred to here as water provision. The impact of decreased water purification results in lowered water quality, requiring either increased water purification costs, or resulting in increased incidence of water borne diseases and healthcare costs. Postel & Thompson (2005) calculated the average savings on water purification costs in 27 US water supply systems, indicating a 211% increase in purification costs when natural forest cover was reduced from 60% to 10%. Water supply efficiency is also lost, with increased wet season supply and lower dry season supply, resulting in decreased agricultural productivity (Postel & Thompson, 2005).

Postel & Thompson (2005) indicate that the entire watershed, or catchment, is important for water provision. Riparian vegetation and freshwater wetlands within catchments play

a particularly important role in water provision (Verhoeven *et al.*, 2006; Fischer & Fischenich, 2000; Greenfell *et al.*, 2005). Fischer & Fischenich (2000) provide evidence that a riparian vegetation buffer width of 5 to 10m would provide for water quality protection.

Within the BCM the Buffalo, Nahoon and Keiskamma river catchments are utilised for domestic and industrial purposes whilst the Keiskamma, Chulumna, Buffalo, Nahoon, Gonubie, Ncera, Gulu, Igoda, and Kwelera river catchments are utilised for agriculture. A number of catchments are utilised for subsistence purposes (Buffalo City Municipality, 2002; Buffalo City Municipality, 2006c). The above information is summarised in Table 2.6.

#### 2.2.4.4 Erosion prevention and sand dune stabilisation

Natural intact ecosystems prevent soil erosion (Braga, 1999; Fischer & Fischenich, 2000; Ananda & Herath, 2003; Postel & Thompson, 2005) and stabilise coastal sand dune systems ensuring stable sand movement along the coastline (Lubke & de Moor, 1998). Although erosion affects ecosystem functioning and the provision of other services such as water quality, its prevention is also a direct service. Erosion results in a loss of valuable topsoil for agriculture (Ananda & Herath, 2003) as well as physical loss of land resulting in damage to property and human well-being (e.g. through landslides). Sand dune stabilisation however, ensures more controlled and predictable sand movement along the coastline the loss of which would affect human property, agriculture and livelihoods.

Riparian vegetation is important in preventing erosion (Braga, 1999; Fischer & Fischenich, 2000). Fischer & Fischenich (2000) provide evidence that a riparian vegetation buffer width of 10 to 20m would provide for bank stabilisation and thus erosion control. Van der Perk *et al.* (2000) indicate the value of wetlands in the prevention of erosion from the physical movement of water through these ecosystems. Vegetation on steep slopes also reduces erosion (Buffalo City Municipality, 2003; Rodriguez *et al.*, 2006). The BCM spatial development framework plan regards slopes

with a vertical: horizontal ratio of greater than 1m: 5m as presenting a high erosion risk which should not be developed unless artificial erosion control measures can be engineered (Buffalo City Municipality, 2003).

Dune stabilisation is provided by specialised coastal ecosystems, specifically adapted to the high sand movement environment (Lubke & de Moor, 1998). These include coastal dune forest and foredune vegetation (Lubke & de Moor, 1998). Table 2.6 provides a summary of the above information.

#### 2.2.4.5 Pollination and biological control

Pollinator species provide a vital service in the form of pollination of commercially and culturally utilised crop and plant species (de Groot *et al.*, 2002; Kremen *et al.*, 2002; Kremen *et al.*, 2004). Biological control, also referred to as pest control, species are involved in population control of other species, either through increasing mortality, or suppressing the reproductive potential of the prey species (e.g., predation or parasitism). This can be regarded as a *final* ecosystem service when the biological control is carried out on species regarded as being pests or parasites (Daily, 1997; Kremen & Ostfeld, 2005) that either directly affect humans or else affect species beneficial to humans (i.e. crops or livestock).

While natural ecosystems are also reliant on pollination and biological control to maintain ecosystem intactness, this is an ecosystem process rather than a service. These services refer specifically to pollination and biological control for non-native or cultivated species, introduced by humans but important to human well-being. Native or indigenous species harvested directly from the wild are regarded as a production service, discussed below, and pollination and biological control in these species are rather ecosystem processes involved in the delivering of the *final* ecosystem service.

Pollinator and biological control species in turn rely on patches of natural habitat of sufficient size to ensure their survival and completion of their lifecycles (Kremen *et al.*, 2004; Pauw, 2004; Swift *et al.*, 2004). In the case of pollination, Kremen *et al.*'s (2004)

study on native bee communities in California, USA determined that successful crop pollination was strongly related to the proportion of patches of natural habitat within 1-2.5km of the farm site. These elements of natural habitat can thus be regarded as the natural capital required for the undertaking of the pollination ecosystem service.

The Integrated Agricultural and Rural Development Strategy for the BCM (Buffalo City Municipality, 2006c) identifies a number of agricultural activities which would require pollination and one that would benefit from biological control (Table 2.7). Suitable pollination and biological control agents were identified that provided these services. For these agricultural ventures to be viable, patches of natural habitat are required to maintain viable populations of the required pollinators and biological control agents. Rodent species, particularly the introduced invasive Black Rat (*Rattus rattus*) and Brown Rat (*Rattus norvegicus*) are pest species in the BCM and require control (Galbraith, 2008). Table 2.7 summarises the above information.

**Table 2.7.** Pollination and biological control services provided within the BCM and the natural capital required to ensure the continued provision of these services

Ecosystem service category	Ecosystem service specific to BCM	Potential pollinator/ biological control agents	References	Natural capital
Pollination	Olive oil; pomegranate; fig; essential oils (e.g. Buchu; Wilde als; Kakiebos); macadamia nuts; citrus; and pineapple production	Arthropods: Bees; wasps	Buffalo City Municipality (2006c); Kremen <i>et al.</i> (2004)	All habitat of pollinators within total potential range (as per Buffalo City Municipality, 2006c) of crops requiring pollination and foraging range buffer distance (1- 2.5 km)
Biological control	Livestock ecoto-parasites (e.g. ticks, flees) control	Bird: Cattle Egret	Buffalo City Municipality (2006c)	All habitat [grasslands, open savanna, shorelines of inland waters] of cattle egret within total potential livestock farming range and foraging range buffer distance

Biological control	Rodent control	Bird: Owl spp	Galbraith (2008)	All habitat [Woodland, forest, coastal forest, riparian, grassland] of Owl spp. within buffer around settlements/ urban areas equalling the foraging range of owl spp
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## 2.2.5 Productive and information functions

### 2.2.5.1 Production and cultural services

Natural intact ecosystems provide a number of productive and cultural uses (Cocks, 2006; Pote *et al.*, 2006; Rodriguez *et al.*, 2006; Shackleton & Shackleton, 2006). Shackleton *et al.* (2001) found that the average economic value of wild resources consumed in seven independent studies conducted throughout rural areas in southern Africa was R3 522 in 2001 and that a large number of rural households were reliant on these natural resources for their well-being. Cocks (2006) found similar reliance on harvested natural resources for rural as well as urban centres in and around the BCM. Cocks (2006) also highlights the interrelated nature of productive and cultural resources, with many of the uses indicated in Table 2.8 having both productive and cultural elements to their use. Igoqo, a cultural artefact constructed of wild plants where female ancestors are believed to reside; kraals, where male ancestors are believed to reside; and grass brooms, all perform a productive function as well as a cultural and spiritual function. A loss of these harvested resources would entail a decline in well-being for those relying on them within the BCM. Appendix 2 provides a summary of the species most commonly utilised, the habitat within which these species are found, and the BCM equivalent ecosystem type or biome.

**Table 2.8.** Productive and cultural ecosystem services provided within the BCM and their classification according to de Groot *et al.* (2002)

de Groot <i>et al.</i> (2002) ecosystem service functions category	BCM ecosystem service (Pote <i>et al.</i> , 2006; Cocks, 2006; Shackleton <i>et al.</i> , 2001; Shackleton & Shackleton. 2006)
Food resources	Wild fruit; wild vegetables; fish
Raw materials	Building and manufacturing material: Fencing; construction timber Fuel and energy: Fuelwood Fodder and fertilizer: Livestock production (commercial and subsistence)
Medicinal resources	Medicinal species
Cultural information	Ritual slaughtering, Igoqo, kraal, grass brooms

#### 2.2.5.2 Information services

According to Chiesura & de Groot (2003) natural capital does not only provide the biogeochemical context for species and habitat preservation but also the socio-cultural context for human society. Human well-being requires the fulfilment of personal needs, such as freedom, self-development, recreation, psycho-physical health, and collective needs, such as social contacts, norms and values, ideals, cultural identity, as well as the basic physiological needs such as clean air and water (Chiesura & de Groot, 2003).

Certain historical, educational and scientific information resides in and relies on surrounding natural, intact ecosystems and landscapes for its interpretation (Chiesura & de Groot, 2003). Natural intact ecosystems and landscapes also provide aesthetic and recreational opportunities, ecosystem services which improve the physiological well-being of local residents as well as increasing and attracting tourists (Braga, 1999; Akbar *et al.*, 2003; Chiesura & de Groot, 2003; Brady, 2006). The BCM Tourism Master Plan (Buffalo City Municipality, 2004) reveals the following aesthetically pleasing; recreationally important; historical; and educational and scientifically important, natural elements in the BCM and the natural capital responsible for maintaining these landscapes (Table 2.9). Natural capital in this instance is interpreted as being the surrounding natural environments within which the aesthetic; historical; or scientific and educational information resides or recreational opportunity occurs.

#### 2.2.6 Classifying the impacts of humans on natural capital and biodiversity

The role of biodiversity in the provision of ecosystem services for human benefit can be understood as a „function for“ natural capital (Ekins *et al.*, 2003). As well as playing a direct role in the provision of ecosystem services (Lorueau *et al.*, 2002; Hooper *et al.*, 2005; Kremen, 2005), biodiversity plays an important role in ensuring the resilience and productivity of an ecosystem and its ability to adapt to change (Duffy, 2002; Ekins *et al.*, 2003; Kremen, 2005).

**Table 2.9.** Classification of information services provided within the BCM and the natural capital required to ensure the continued provision of these services

de Groot <i>et al.</i> (2002) ecosystem service functions category	BCM information services reliant on natural elements for its interpretation (Buffalo City Municipality, 2004)	BCM natural capital
Aesthetic information	Scenically and aesthetically pleasing natural elements	Valley Thicket comprising <i>Euphorbia</i> and <i>Acacia</i> spp; coastal dunes and beaches; estuaries; rivers
Recreation	Recreational fishing Recreational walking/ relaxing	Estuaries Nature trails: Umtiza NR trails; Nahoon Estuary (Dassie) trail; Cove Rock trail; Abbotsford trail; Amathole hiking trail
Historical information	Historical information	Public nature reserves Fossilised archaic <i>Homo sapien</i> footprints at NPNR Xhosa historical: Gompo Rock; Ndlambe's Great Place; Mngqesha's Great Place (Mngqesha location, King Williams Town)
Science and education	Educationally and scientifically information reliant on natural elements for its interpretation	Public nature reserves

Maintaining the intactness of indigenous biodiversity, hereafter referred to as biodiversity intactness, of natural ecosystems is therefore required to ensure the continued flow of ecosystem services they provide that are beneficial to human well-being.

Potschin & Haines-Young (2006) suggest that landscapes and the ecosystems associated with them should be viewed as a resource that provides a range of goods and services for human well-being. Potschin & Haines-Young (2006) thus define a sustainable landscape as one in which the output of goods and services provided by the ecosystems within the landscape are maintained, and the capacity of these systems to deliver benefits for future generations is not undermined.

It is suggested by van der Perk *et al.* (2000) that the global environment is now so heavily utilised that natural capital has become the limiting factor for much economic development, more so than human-made capital, which has given rise to the need for cultivated capital (van der Perk *et al.*, 2000). While natural capital takes up more ecological space than cultivated capital, it provides a greater number of services and requires little management (van der Perk *et al.*, 2000). Cultivating or domesticating

natural capital results in the multifunctional character deriving from its naturalness being narrowed down towards enhancement of only one or a few services. The result is a loss of biodiversity and other essential ecosystem services being compromised (van der Perk *et al.*, 2000).

Urbanisation, in particular, significantly influences the functioning of ecosystems and the services they provide for human well-being. Urban development fragments, isolates, and degrades natural habitats; simplifies and homogenises species composition; disrupts hydrological systems; and modifies energy flow and nutrient cycling (Alberti, 2005). Since humans depend on ecosystems for food, water, and other important products and services, changes in ecological conditions that result from human actions in urban areas ultimately affect human health and well-being (Alberti, 2005).

To determine the impact of humans on natural capital and the ecosystem services they provide it is necessary to classify ecosystems according to the extent of human interference they have received. van der Perk *et al.* (2000) provide the following classification of natural capital:

**Unique natural systems** – ecosystems where since the industrial revolution (circa 1750) human impact has been no greater than that of any other native species, and has not affected the ecosystem's structure. Climate change is excluded from the definition, because human-caused climate change is likely to affect all ecosystems and eliminate all natural ecosystems as defined here.

**Semi-natural or modified systems** – ecosystems where human impact is greater than that of any other species, but whose structural components are not cultivated. Cultivated in this context refers to deliberate human manipulation of ecosystems. Most of the planet is now modified, including land and sea areas usually considered „natural“. Such systems include, for example, naturally regenerating forest used for timber production or naturally regenerating rangeland used for livestock production.

**Sustainably cultivated systems** - ecosystems where human impact is greater than that of any other species, and many of whose structural components are cultivated in a sustainable way, meaning without the input of human-made capital. These include, for example, organic and bio-dynamic agriculture, agroforestry and sustainable forestry.

**Unsustainably cultivated systems** – ecosystems where human impact is greater than that of any other species, and most of whose structural components are cultivated, with inputs of human-made capital: farmland, sown pasture, plantations, and aquaculture ponds.

**Urban systems** – ecosystems dominated by buildings, roads, railways, dams, mines and other human structures, consisting of for example: parks, green belts, botanical gardens, lawns and horticultural greenhouses. Most of the environmental factors in these systems (drainage, irrigation, nutrition, temperature) are controlled by human-made capital.

Alternatively, Scholes & Biggs (2005) describe the following landuse classes for the southern African Millennium Ecosystem Assessment:

**Protected** – minimal recent human impact on structure, composition or function of the ecosystem and biotic populations inferred to be near their potential.

**Moderate use** – extractive use of populations and associated disturbance, but not enough to cause continuing or irreversible declines in populations. Processes, communities and populations are largely intact.

**Degraded** – extractive use at a rate exceeding replenishment and widespread disturbance. Often associated with high human population densities and poverty in rural areas. Productive capacity reduced to approximately 60% of „natural“ state.

**Cultivated** – natural land cover replaced by planted crops. Most processes persist, but are significantly disrupted by ploughing and harvesting activities. Residual biodiversity

persists in the landscape, mainly in set-asides and in strips between fields (matrix), assumed to constitute approximately 25% of landuse class.

**Plantation** – natural land cover permanently replaced by dense plantations of trees. Unplanted areas assumed to constitute approximately 25% of landuse class.

**Urban** – land cover replaced by hard surfaces such as roads and buildings and which include dense populations of people. Most ecological processes are highly modified and remnant semi-natural cover is assumed to constitute 10% of landuse class.

It should be noted that the Scholes & Biggs (2005) study was carried out at a sub-regional scale and thus the reference to the natural elements within the cultivated, plantation and urban landuses reflect the coarse scale of their assessment. More fine-scale assessments should identify the patches of „natural“ cover referred to and as such should not be considered part of the cultivated, plantation or urban, nor the degraded or modified landuses. Table 2.10 combines and provides a comparison of the two classification systems and assigns an approximate Biodiversity Intactness (BI) score based on Scholes & Biggs (2005).

**Table 2.10.** Comparison of the classification systems of van der Perk *et al.* (2002) and Scholes & Biggs (2005) indicating an approximate Biodiversity Intactness score based on Scholes & Biggs (2005)

van der Perk <i>et al.</i> (2000) (types of environmental capital)	Scholes & Biggs (2005) (types of landuses)	Approximate BI (based on Scholes & Biggs, 2005)
Unique natural systems	Protected	>90% (Protected ecosystems)
Semi-natural or modified systems	Moderate use	90-75% (Ecosystem integrity maintained)
Sustainably cultivated systems		75-50% (Ecologically sustainable landuses areas)
Intensive (non-sustainably) cultivated systems	Degraded	>50% (Impacted ecosystems – degraded)
	Cultivated	
	Plantation	
Urban systems	Urban	>20% (Impacted ecosystems - urban)

Rouget *et al.* (2006b) however argue that the index developed by Scholes & Biggs (2005) is undermined by the coarseness of landuse degradation available. It is therefore important to utilise finer-scaled landuse data to ensure the accuracy in determining a biodiversity intactness index for a given area using the methodology developed by Scholes & Biggs (2005).

## **2.3 Implementing conservation action at the local level**

### **2.3.1 Biodiversity at the local level**

For many local people the concept of biodiversity is tied up with conservation, particularly with „global public good“ conservation priorities such as protecting globally rare species or habitats (Vermeulen, 2004). Locally relevant biodiversity issues get much less attention to the extent that biodiversity planners may not even know how to ask the right questions at the local level (Vermeulen, 2004). However, “giving lay people the possibility to express their opinions about the environment is a powerful tool not only to disclose human immaterial needs, but also to articulate the underlying values and beliefs” (Chiesura & de Groot, 2003).

Vermeulen (2004) identifies four broad groups of stakeholders that at any given location could have an interest in biodiversity:

- Government: legislative and policymaking bodies and implementing agencies
- Environment: conservation organisations
- Community: local residents and representative bodies
- Private sector: resource use or extraction businesses

It is important that any assessment of biodiversity takes into account these stakeholders to have relevance to the general citizenry. Assuming these elements of the general citizenry can be shown the benefits and value of protecting the natural capital that provides them ecosystem services critical to their wellbeing. Then this could have great potential for ensuring the protection of indigenous biodiversity. Conservation planning as an emerging discipline has the potential to bring together ecosystem services and biodiversity conservation and with its emphasis on stakeholder engagement, could also bring together

the divergent view points of diverse stakeholder groups. However, the underlying premise in the above is that biodiversity priority and ecosystem service provision show a high degree of overlap. It is therefore important to determine this.

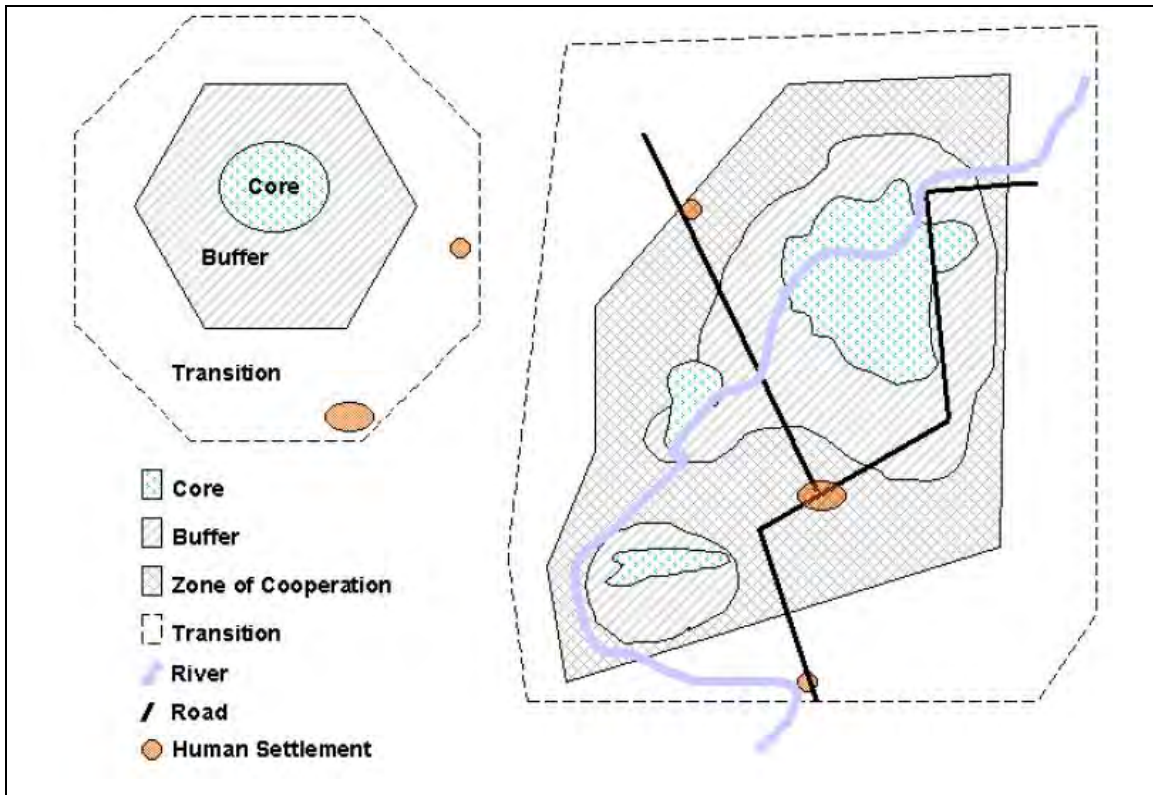
### 2.3.2 The role of biosphere reserves in local biodiversity conservation

By definition, biosphere reserves contain core protected areas surrounded by sustainably utilised buffer and/or transition zones (Brunckhorst, 2001; Nations, 2001). The core protected area is managed primarily to maintain its biodiversity intactness and any species of special concern it may harbour (Figure 2.4). While the outer buffer and transition areas may contain human settlements and be utilised for a number of extractive and generally traditional landuses including agriculture, grazing and timber extraction. There is generally a gradient of increasing intensity of landuse as one moves from the buffer to the transition zones (Brunckhorst, 2001; Nations, 2001). The emphasis is on sustainable landuse at the landscape level and in many cases biosphere reserves provide ideal opportunities to undertake research, as well as gain a practical understanding, of the anthropogenic influence on a given ecological system (Nations, 2001).

For the biosphere concept to work in practice it is crucial that people and their activities are incorporated within the design and functioning of the reserve and that they actively take ownership of the programme (Brunckhorst, 2001).

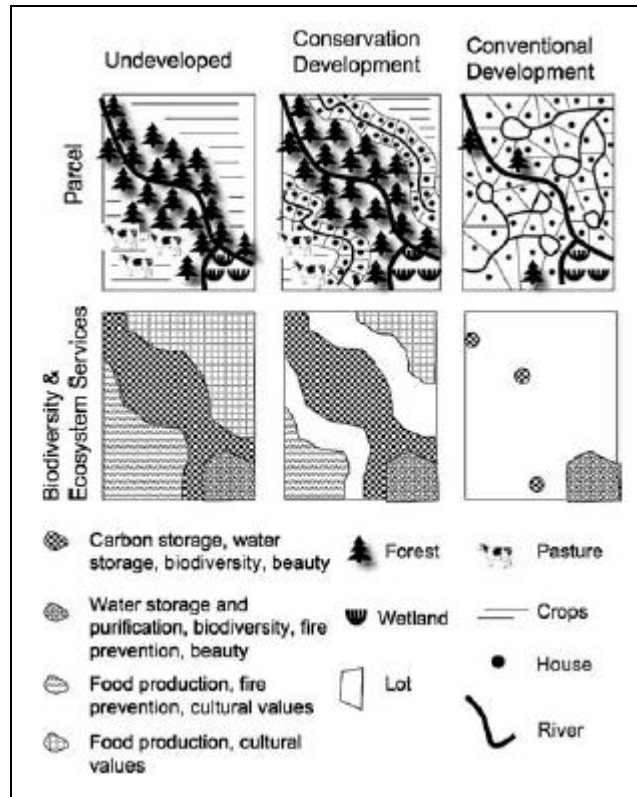
### 2.3.3 The role of conservation development in local biodiversity conservation

Pejchar *et al.* (2006) define conservation development as “a form of development that relies on scientific assessments of the ecological importance of a property’s assets to identify what parts of a property should be protected and restored and how the remainder should be developed in a manner compatible with the protection of these assets” and should “provide ongoing stewardship of the protected portion of the development” (Figure 2.5). This is in contrast with conventional development approaches which seek to carve up the landscape into plots of land, with general disregard for most environmental features.



**Figure 2.4.** Illustration of the biosphere reserve concept, showing both theoretical (left) and practical (right) examples (Source: Brunckhorst, 2001)

Through the protection, or restoration, of natural capital conservation development provides a number of advantages over conventional development which disregards these assets, including: relatively higher property values for example due to increase in amenity value; lower development costs due to more compact development; and flows of the ecosystem services provided by the protected or restored natural capital (Pejchar *et al.*, 2006). It is proposed that through carefully considered and planned conservation development the protection of natural capital on a site can be secured or even enhanced, which may not be the case if the site remained undeveloped (Pejchar *et al.*, 2006).



**Figure 2.5.** Illustrative comparison of conservation development and conventional development (source: Pejchar *et al.*, 2006)

### 2.3.4 The role of policy measures for land owners in local biodiversity conservation

For private land owners in general there are four main policy actions that can be utilised to increase biodiversity conservation, including educational programmes; acquisition of land or resource rights; direct incentives; market creation and improvement; and regulatory prohibitions and requirements (Doremus, 2003). Pence *et al.* (2003) in their analysis of suitable off-reserve instruments for achieving biodiversity conservation on private land within the South African context identified four such potential instruments (Table 2.11). These instruments fell into two categories, these being property rights instruments and financial mechanisms. Property rights instruments could include management agreements and conservation easements, while financial mechanisms could include management assistance and tax relief (Pence *et al.*, 2003).

**Table 2.11.** Conservation mechanisms for off-reserve conservation on private lands in South Africa  
(Source: adapted from Pence *et al.* (2003))

Functional category	Specific types	Examples	Timeframe
Property-rights instruments	Management agreements	Contractual nature reserve Management plan	30-99 years 5-30 years
	Conservation easements	Title deed restriction on landuse	99-perpetuity
Financial instruments (incentives)	Management assistance	Alien clearing subsidies	Variable
	Tax relief	Tax rebates on land managed for improving biodiversity Differential tax rates (e.g. taxing natural, high biodiversity areas at lower tax rates than cultivated areas)	Annual Annual

### 2.3.5 The role of restoration ecology in local biodiversity conservation

Clewell & Aronson (2006) define five main rationales for restoring ecosystems, including: technocratic; biotic; heuristic; idealistic; and pragmatic. The technocratic rationale is generally undertaken to fulfil the mandates of large institutions, the biotic for restoring local biodiversity and the heuristic and idealistic rationales to fulfil certain human or cultural values attached to nature such as recreating a spiritual connection to nature or for research and understanding of ecosystem functioning (Clewell & Aronson, 2006). The pragmatic approach serves to restore natural capital and the flows of ecosystem services that exist, or previously existed, before the ecosystem was degraded (Clewell & Aronson, 2006).

Clewell & Aronson (2006) argue that previous rationales for restoration have been too narrow in their focus and call for a blending of the technocratic and idealistic rationales with the newly emerging pragmatic rationale. They argue that this will combine the benefits of large institutional support of technocratic rationale with the more locally relevant and supported idealistic rationale. Melding these into the pragmatic, or ecosystem services oriented approach, will provide a “goal orientated” framework around which these two, as well as the biotic and heuristic, approaches can all be achieved. The goal in this sense will be the achievement of specific ecosystem services which by

extension will require the restoration of the ecosystem, or ecosystems, which provide them.

### 2.3.6 The role of payment for ecosystem services in local biodiversity conservation

Payment for ecosystems services (PES) programmes have grown rapidly over the last three decades and a number of successful examples currently exist around the world whereby users of ecosystems services are making payments to those responsible for managing the ecosystems responsible for providing the services (e.g. Gutman, 2003; Kremen & Ostfeld, 2005). A number of case studies have been developed and the means for implementing PES has grown ever more sophisticated. One of the most well known PES programmes is that of New York's Catskill Catchment (Kremen & Ostfeld, 2005). At a cost far less than the cost of constructing a newly required water treatment plant, New York City administrators invested in rehabilitating the highly degraded catchment so that it would produce water of the required quality. Numerous other PES examples exist globally for a broad array of projects investing in a number of ecosystem services types (Gutman, 2003; Kremen & Ostfeld, 2005).

The objective of this study was to identify what ecosystem services are provided by intact, natural ecosystems within the BCM and to incorporate them into local conservation and landuse planning initiatives to protect this natural capital and the biodiversity on which it relies on for its continued functioning.

This study thus attempted to answer the following key questions:

1. What is the current status of biodiversity within the BCM and to what degree is it currently protected?
2. What ecosystem services are critical to the BCM and the well-being of its citizens and what natural capital provides these services?
3. To what degree does natural capital identified as priority for biodiversity conservation overlap with natural capital identified as being critical for ecosystem services?

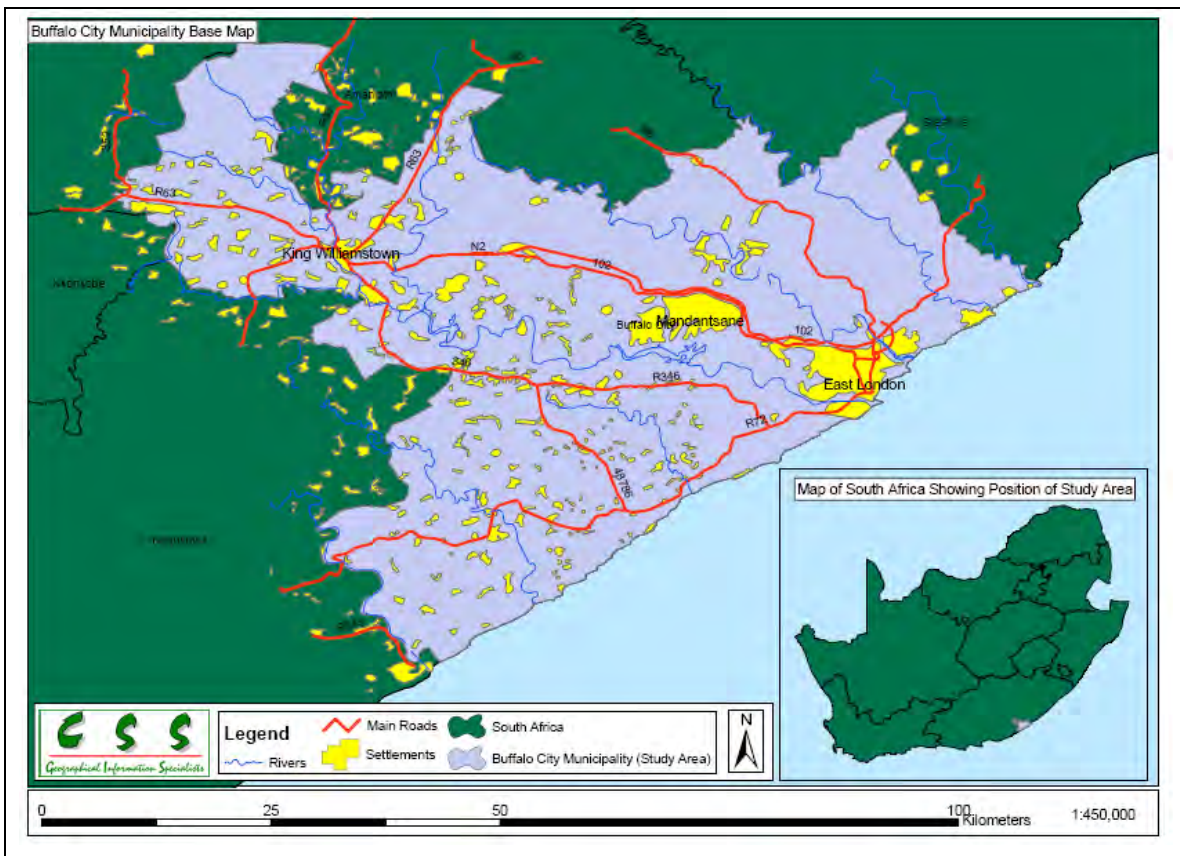
4. Can priority focus areas and suitable conservation actions be identified to harness local action for biodiversity conservation and maintenance of ecosystem services?

This thesis is structured in the following manner. Chapter 1 introduces the topic of research. Chapter 2 gives an overview of the literature relevant to the subject being researched. Chapter 3 provides details of the methods used in undertaking the research, including the study area, data gathering and data analysis. Chapter 4 presents the results of the research. Chapter 5 discusses the results of the research and provides recommendations and conclusions resulting from the research.

## CHAPTER 3: MATERIALS AND METHODS

### 3.1 Study area

The study area was the BCM (Figure 3.1), a local municipality, as spatially defined by the South African Municipal Demarcation Board. The BCM falls within the Amathole District Municipality which is one of six district municipalities located within the Eastern Cape Province of South Africa, which makes up the southernmost portion of the African continent.



**Figure 3.1.** Location map of the Buffalo City Municipality (Source: Buffalo City Municipality, 2005)

The Eastern Cape is the third most populous province in South Africa and is regarded as one of the two poorest in the country (Buffalo City Municipality, 2006b). The BCM is the key urban centre of the eastern part of the Eastern Cape, consisting of a corridor of urban areas including East London, Mdantsane and King Williams Town (Buffalo City Municipality, 2006b). This urban corridor is flanked in the north and south by extensive

rural landscapes. Within the BCM's rural areas there are a multitude of landuses on land under communal, state-owned and private land tenure. Private landuse includes commercial agriculture, livestock and wildlife farming, and eco-tourism, while communal landuse consists mainly of subsistence pastoralism and agriculture (Buffalo City Municipality, 2003). As well as the above aforementioned landuses, there is a significant area of plantation forestry in the north-western corner of the BCM.

Outside of the urban corridor, the BCM contains a number of smaller towns, villages and coastal resorts as well as numerous informal settlements. The municipality contains several heavy industrial complexes such as East London's West Bank, Berlin, Dimbaza and the East London Industrial Development Zone.

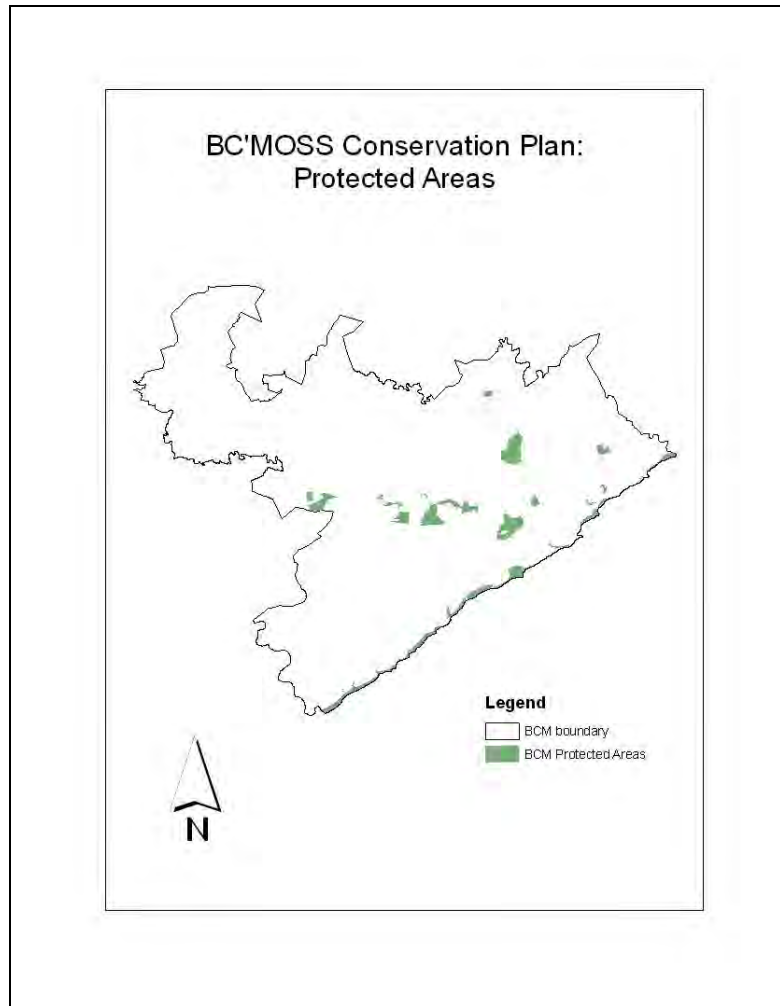
The study area is bordered by the Indian Ocean with a 77 km coastal corridor running from the north-east to the south-west. There are a number of formally and informally protected areas within the BCM including provincial and municipal reserves, state forests and a number of conservancies and private game reserves. Figure 3.2 indicates the spatial distribution of protected areas within the municipality. Extensive conservation worthy areas, zoned under the municipal zoning scheme as open space, exist within urban areas of the BCM (Buffalo City Municipality, 2007).

#### 3.1.1 Climate and rainfall

The climate of the BCM varies considerably between the coastal and inland regions. The coastal region around East London provides for mild and humid conditions with an average yearly minimum of 8°C and maximum of 39°C. This climate can be attributed to the influence of the warm Agulhas ocean current. The inland regions of the BCM have significantly more variable conditions, with King Williams Town having an average yearly minimum of -2°C and maximum of 42°C (Buffalo City Municipality, 2005).

Rainfall in the study area varies from 400 mm to more than 1 000 mm per annum, with an annual mean of about 700 mm (Buffalo City Municipality, 2006a). The highest precipitation occurs in the Amathole Mountains and in the coastal region of the

municipality. Most of the rainfall occurs during summer, except in the coastal area west of East London, where rain falls year-round (Buffalo City Municipality, 2005).



**Figure 3.2.** The spatial distribution of protected areas within the BCM

### 3.1.2 Geology and topology

The study area extends from sea level along the coastal belt increasing in a north-westerly direction to an elevation between 450 m and 850 m above MSL. The elevation in the most north-westerly portion of the study area, the Amathole Mountains, reaches 2 100 m above MSL. The region is characterized by a number of incised river valleys, which run nearly parallel to each other in a south-easterly direction through the municipality and which break it at regular intervals (Buffalo City Municipality, 2002).

The geological strata of the BCM belong to the Beaufort Group which in turn belongs to the Karoo Supergroup (Lubke & de Moor, 1998). The area consists mainly of mudstones and sandstones, with intruding dolerite dykes and sills. These dolerite dykes are generally good aquifers (Lubke & de Moor, 1998). The geology and soils are derived from marine shales and result in the high concentration of salts and salinity of surface and groundwater (O'Keeffe *et al.*, 1996).

### 3.1.3 Biotic environment

The BCM is represented by a diverse range of ecosystems, ranging from coastal dunes to forested hills in the hinterland and including subtropical thicket, wetlands, and riverine ecosystems (Buffalo City Municipality, 2005). Of particular importance, both economically and biophysically, is the approximately 70 km of coastline (Buffalo City Municipality, 2006a). The BCM is situated within the highly species diverse Albany centre of endemism which has been listed, along with the Maputoland and Pondoland centres of endemism further north, as a global biodiversity hotspot (Steenkamp *et al.*, 2005). The major biomes represented within the BCM include subtropical thicket, afro-montane forest and savanna (Buffalo City Municipality, 2005).

As well as its important floral diversity, the BCM also contains a number of important faunal species of conservation concern (Buffalo City Municipality, 2005) namely:

- A number of rare and endemic butterfly species;
- Four Red Data Book (RDB) listed frog species;
- Three RDB listed reptile species;
- Four RDB listed bird species; and
- An endemic mammal species and a number of RDB listed mammals.

Many ecosystems within the BCM are stressed and are in need of conservation and remedial attention (Buffalo City Municipality, 2005). Many terrestrial ecosystems have become infested with invasive alien vegetation, while many freshwater and marine ecosystems are subjected to high levels of pollution (Buffalo City Municipality, 2005). In

addition, development pressure is increasingly placing coastal areas under great threat (Buffalo City Municipality, 2005).

The decline of faunal diversity is closely linked to the decline of floral diversity and thus loss of natural vegetation types within BCM will result in a corresponding decline of faunal diversity (Buffalo City Municipality, 2005). Certain species are, however, in decline due to direct factors such as over-harvesting. Based on the BCM State of Environment Report (Buffalo City Municipality, 2005) the major threats to biodiversity within BCM are categorised in Table 3.1.

**Table 3.1.** Threats to biodiversity in the BCM (Adapted from: Buffalo City Municipality, 2006a)

Biodiversity threat category	Biodiversity threat subcategory
Urbanisation impacts	Low income housing developments Encroachment into public open spaces Illegal dumping Landuse changes Failure to rehabilitate disturbed areas Habitat fragmentation Legal and illegal stone and sand mining Poor water quality
Over-utilisation impacts	Removal of trees for fuel wood Collection of medicinal and culturally important plants
Cultivation and agricultural impacts	Agriculture and forestry Overgrazing by domestic livestock
Spread of alien invasive species	

#### 3.1.4 Socio-economic environment

Approximately 80% of the population is found in the urban nodes of East London and King Williams Town, while only 20% of the population is located in rural areas of the municipality (Buffalo City Municipality, 2004). While Census 2001 estimated a total population of the BCM at 731 000 people, a study commissioned by the BCM and undertaken by the Rhodes University Population Research Unit (RUPRU) estimated the population at 959 975 in 2001 (Buffalo City Municipality, 2004). Based on the RUPRU study, population growth rates are projected to show dramatic declines over the next two decades. The growth rate for the period between 2001 and 2006 was projected at 2.91%,

falling to 1.00% for the period between 2011 and 2016. Despite this declining growth rate, the 2006 population of the BCM is estimated at 1 110 685 and is expected to peak in 2021 at around 1 300 000 people (Buffalo City Municipality, 2004), an increase of more than 30%, or 300 000 people, during the 20 year period between 2001 and 2021. This growth is likely to increase the pressure on natural capital within the study area over the next two decades.

The average monthly household income for the BCM is R2 110 and the unemployment rate is currently about 35%. As can be seen in Table 3.2, about 54% of BCM households live below the poverty line (less than R9 600 per annum in 2001; Census, 2001).

**Table 3.2.** Annual BCM household incomes in 2001 (Source: Census, 2001)

Annual Household Income	No. of households	% of total households
Zero	55 253	28
R1 – 4 800	12 943	7
R4 801 – 9 600	36 684	19
R9 601 – 19 200	29 375	15
R19 201 – 38 400	22 768	12
R38 401 – 76 800	15 836	8
R76 801 – 153 600	12 001	6
R153 601 – 307 200	6 434	3
R307 201 – 614 400	1 593	1
R614 401 – 1 228 800	443	0
R1 228 801 – 2 457 600	564	0
Over R2 457 600	169	0
Total	194 063	100

## 3.2 Data collection and analysis

### 3.2.1 Determining the status of the Buffalo City's biodiversity

A biodiversity priority index (BPI) was developed for the BCM to determine the current status of biodiversity within the municipality. Indices, commonly used for economic as well as ecological data, are used to compare the quantity of related variables with a standard or base value (Ricketts & Imhoff, 2003; Wikipedia, 2008). The BPI was based on the principles of systematic conservation planning (Margules & Pressey, 2000). However, the lack of fine-scale targets for biodiversity conservation necessitated that the BPI could not follow the principle of target setting (Margules & Pressey, 2000). The result of this was that the BPI provided a measure of relative biodiversity value for a given area rather than that of irreplaceability normally associated with systematic conservation planning (Margules & Pressey, 2000). The BPI therefore provided a spatially explicit measure of relative biodiversity value.

The data used for the BPI were gathered through utilising local expert knowledge, readily available datasets or collected in the field and were comprised of five weighted variables (Table 3.3). Each of the variables was measured and digitised into a dataset using ESRI ArcGIS 9.1. Only one dataset, species of special concern, was generated from new, local expert knowledge and then digitised. The five BPI variables fell into two broad categories, biodiversity pattern and ecological process. All spatial data analysis was undertaken using ESRI ArcGIS 9.1 software.

The BPI score was determined as

$$\text{BPI} = \text{ET} \cdot w + \text{SSC} \cdot w + \text{BP}_1 \cdot w + \text{BP}_2 \cdot w + \text{BP}_3 \cdot w$$

where ET was the ecosystem type score (Table 3.4), SSC was the number of species of special concern occurring, BP was the occurrence of one or more of the three biodiversity processes, and  $w$  was the index weighting (Table 3.3).

**Table 3.3.** Categorisation and weighting of the biodiversity variables used to produce the biodiversity priority index (BPI)

BPI variable	BPI category	BPI weighting
Ecosystem type	Pattern	1
Species of special concern	Pattern	3
Major riverine corridor	Process	1
STEP coastal corridor	Process	2
STEP network area	Process	2

The total BPI scores were then divided into four groupings as follows: A total BPI score of zero was labelled as low biodiversity value; a score of one or two as medium biodiversity value; a score of three or four as high biodiversity value; and a score of five or greater as very high biodiversity value. The method used to determine the score for each individual BPI variable is elaborated on below.

#### 3.2.1.1 Determining the ecosystem type component of the biodiversity priority index

The ecosystem types determined as part of the Buffalo City municipal open space system (BCMOSS) assessment (Buffalo City Municipality, 2007) were utilised to spatially represent biodiversity pattern. Ecosystem types which could not withstand any further loss according to the Subtropical Thicket Ecosystem Programme (STEP; Pierce, 2003), those listed as critically endangered, were given the maximum ecosystem type score of four.

All forest and estuarine ecosystems, which were legally protected from any further loss, and regarded by STEP as critically endangered, were also given a score of four. Based on this maximum score of four, ecosystem types regarded by STEP as being endangered, vulnerable and currently not vulnerable were given relative scores of three, two and zero respectively.

Further to this, based on the available literature for the BCM (Buffalo City Municipality, 2005; 2007) and expert opinion (Lubke & Carter, pers. comm.), coastal grasslands and

riparian ecosystem types were regarded as the equivalent of endangered and hence given a score of three. Watercourses were regarded as being the equivalent of vulnerable and thus given a score of two. All other remaining ecosystem types were given a score of zero (Table 3.4).

**Table 3.4.** Biodiversity propriety index (BPI) scores determined for each ecosystem type

Ecosystem type	BPI score
Albany Coastal Thornveld	0
Amatole Afromontane Forest	4
Bedford Savanna Thicket	0
Berlin Savanna Thicket	0
Buffels Thicket	1
Buffels Valley Thicket	2
Cintsa Dune Thicket	0
Coastal Grassland	3
Double Drift Karroid Thicket	0
Estuarine	4
Hamburg Dune Thicket	0
Inland Forest	4
Inland Grassland	0
Inland Thornveld	0
Kiwane Dune Thicket	2
Moist Mountain Grassland	0
Mountcoke Grassland Thicket	0
Mountvale Grassland Thicket	0
Riparian	3
South East Coastal Vegetation	0
Transfish Dune Forest	4
Transfish Dune Thicket	0
Umtiza Forest Thicket	4
Unknown ecosystem type	0
Watercourse	2

Endemic and near endemic STEP vegetation types were also given additional points within the weighting to reflect the importance of their conservation within the boundaries of the BCM, whereas other vegetation types could be conserved elsewhere. Vegetation types for which 90% to 100% of the total area of the vegetation type occurred within the BCM (Table 2.1) were regarded as endemic and given an additional two points within the BPI score. Vegetation types for which 66% to 90% (i.e. more than two thirds) of the total

area occurred within the BCM were regarded as near endemic and given an additional one point.

### 3.2.1.2 Determining the species of special concern component of the biodiversity priority index

Species of special concern (SSC) data were provided by two botanical experts (Table 3.5; Dold & Lubke, pers. comm.) and these data were broadly mapped into hotspots (Table 3.6). SSC refers to species as well as sub-species and variations in the case of some plant species. It was decided to only utilise highly endemic or near endemic Red Data Book SSC. These species, sub-species and variations are totally reliant on protection within the BCM for continued survival in the wild whereas more widespread species could potentially be adequately conserved elsewhere even if their populations within the BCM were destroyed. Given the need for focusing scarce conservation resources, more widely distributed RDB species, such as black rhinoceros (*Diceros bicornus*) and African finfoot (*Podica senegalensis*), were not recorded, as there were opportunities to conserve them in habitats outside of the BCM.

The SSC identified in Table 3.5 were mapped using a Geographic Information System (GIS) into broad SSC “hotspots” within which one or more SSC were located (Table 3.6). In all but one case these broad SSC “hotspots” were further refined by only including the specific habitat types within which these species were known to exist. The exception was hotspot number four for which, due to a lack of data, this was not done. Each SSC “hotspot” was given a BPI score of one for each species it contained. The SSC component was given an index weighting of three to ensure that the minimum BPI score for any given area was high. This was because even a small loss of habitat for these SSC could have critical consequences for the global population due to their highly endemic nature.

**Table 3.5.** The distribution and conservation status of the species of special concern mapped using local expert knowledge as part of the biodiversity priority index

Scientific name	Distribution	RDB status
<i>Acmadenia kiwanensis</i> I. Williams	Kiwane, Chalumna	VU D2
<i>Aspidoglossum flanaganii</i> (Schltr.) Kupicha	Chalumna	VU D2
<i>Bergeranthus leightoniae</i> L. Bolus	King Williams Town, Stutterheim, Komga	Rare
<i>Brachysterlam franksiae</i> N.E. Br. Subsp. <i>grandiflorum</i> . A.P. Dold and Bruyns	Igoda only	VU D2
<i>Brachystelma meyerianum</i> Schltr.	King Williams Town	EN B1+2bcde VU D2
<i>Bulbine frutescens</i> (L.) Willd. Var. <i>Chalumnensis</i> Baijnath ined.	Chalumna – Kiwane	VU D2
<i>Cassipourea flanaganii</i> (Schinz) Alston	Pirie, Komgha	CR A4 acd
<i>Ceropegia radicans</i> Schltr. Subsp. <i>Smithii</i> (M.R. Hend.) R.A. Dyer	Kwelera Bridge	VU D2
<i>Delosperma dunense</i> L. Bolus	Kaysers Beach	Data deficient
<i>Drimia chalumnensis</i> A.P. Dold and E. Brink	Chalumna only	VU
<i>Faucaria subintegra</i> L. Bol.	Kiwane only	VU D2
<i>Haworthia cooperi</i> var. <i>doldii</i> Bayer	Chalumna river bridge	Very rare and localised data deficient
<i>Haworthia cooperi</i> var. <i>leightonii</i> (G.G. Sm) M. B. Bayer	Kaysers Beach	Very rare and localised data deficient
<i>Haworthia reinwardtii</i> (Salm-Dyck) Haw. Var. <i>reinwardtii forma chalumnensis</i> (G.G. Sm.) M.B. Bayer	Chalumna	Localised, data deficient
<i>Kniphofia bruceae</i> (Codd) Codd	Komgha, Isidenge	LC
<i>Metarungia galpinii</i> (Baden) Baden	Nahoon Dam	EN A3c
<i>Monsonia galpinii</i> Schltr. Ex R. Knuth	Igoda	VU D2
<i>Tritonia atrorubens</i> (N.E. Br.) L. Bolus	Komgha to Kei Mouth – possibly around Bisho –Kei Road	VU
<i>Tulbaghia cominsii</i> Vosa	King Williams Town	VU D2
<i>Umtiza Listeriana</i> Sim	Umtiza Reserve	NE
<i>Sandelia bainsii</i>	Gulu and Igoda river systems	

### 3.2.1.3 Determining the biodiversity process component of the biodiversity priority index

Three important biodiversity processes, also referred to as ecological processes, were determined. Spatial surrogates were used to map these processes. The three processes identified were the ecological network and coastal corridors identified by STEP (Pierce, 2003) as well as major riverine corridors. A spatial surrogate for major riverine corridors was determined and mapped using a GIS by placing a 250 m buffer either side of a major rivers dataset for the BCM.

**Table 3.6.** Description of species of special concern “hotspots” used to determine the biodiversity priority index

Hotspot no.	Description of the location of the identified species of special concern
1	Exposed, old dune systems within the coastal grasslands between Kidds Beach and the Kiwane River.
2	Winterstrand grasslands on the steep dune system (at Igoda).
3	Pirie Forest, species mainly found in this patch of forest although it is also found in a very small number of forest patches elsewhere in Eastern Cape.
4	The margins surrounding flat granite rocks (Dwala) in the Montain Grasslands around Dimabza and King Williams Town.
5	Kwelera River Valley Thicket
6	The margins of bush clumps within the vicinity of Nahoon Dam, the species does still occur in the immediate area of the dam but a large percentage of the original population was flooded when the dam was built.
7	Giant Earthworm Castings within the montian grasslands around Pirie forest.
8	Igoda and Gulu River systems
9	Umtiza Nature Reserve

Given the importance of the STEP ecological network and coastal corridors for maintaining both biogeographic as well as local (i.e. BCM) scale ecological processes these were given a score of two. Major riverine corridors, being important on a local rather than biogeographic scale, were given a score of one.

### 3.2.2 Determining the level of biodiversity protection within the Buffalo City Municipality

#### 3.2.2.1 Analysis of the protection status of ecosystem type, species of special concern, ecological processes and biodiversity priority areas

The ecosystem type, species of special concern and ecological processes data layers were each spatially overlain with the protected area data layer (Figure 3.2) and the degree of their overlap determined using a GIS. The same analysis was conducted for the overall BPI.

#### 3.2.2.2 Determining current transformation status of Buffalo City ecosystems

To determine the degree of transformation of BCM ecosystems, a combination of aerial photography, available geospatial data, and local knowledge were used to divide the BCM into four basic land cover types. Aerial photography taken in 2006 was analysed at a scale of 1:20 000 for mapping and to categorise the BCM into the four land cover types.

The accuracy of this classification was later confirmed through a two-day ground-truthing exercise.

These maps were then digitised using a GIS to produce the current transformation data layer. This data layer was then spatially overlapped with the BPI data layer to determine the level of transformation of biodiversity within the BCM. The land cover categorisations used to produce the data layer were determined as described below.

**Not Restorable (NR):** areas that have already been intensively impacted directly through human use and which, for economic or social reasons, it would be unfeasible to restore to a state of ecosystem intactness within the next decade. Such areas included urban areas, rural settlements, roads, actively used cultivated fields and commercial forestry plantations.

**Actively Restorable (AR):** areas that, while being highly impacted, could feasibly be utilised for restoration within the next decade, but which would require active rehabilitation and direct human input to achieve restoration to a state of ecosystem intactness. These areas included, fallow land, highly eroded land, land infested with alien invasive vegetation, and areas heavily overgrazed by domestic livestock.

**Passively Restorable (PR):** areas which showed some signs of impact through human influence, but which would only require passive rehabilitation to restore them to a state of ecosystem intactness. Such passive rehabilitation measures could be achieved through improved natural resource management measures. These measures could include, reducing grazing pressure, the use of controlled fire, and reducing levels of natural resource extraction.

**Un-impacted (UI):** areas that were largely un-impacted by human use and which were still in a state of ecosystem intactness and where no restoration effort would be necessary. Such areas included protected indigenous forests, sustainably grazed and un-grazed areas, protected areas and nature reserves, and undisturbed municipal open space.

The categorisation of land could be compared with the similar categorisations undertaken by van der Perk *et al.* (2000) and Scholes & Biggs (2005; Table 3.7) and an approximated Biodiversity Intactness (BI) score based on Scholes & Biggs (2005) was used in determining a BI score for the BCM by multiplying the percentage coverage for each transformation category by an approximated mean BI score for each category.

**Table 3.7.** Comparison of BCM current transformation status (CTS) against other landuse categorisations

BCM CTS category	van der Perk <i>et al.</i> (2000) (types of environmental capital)	Scholes & Biggs (2005) (landuses classes)	Approximate BI (based on Scholes & Biggs, 2005)
Un-impacted (UI)	Unique natural systems	Protected	>90% (Protected ecosystems)
Passively restorable (PR)	Semi-natural or modified systems	Moderate use	90-75% (Ecosystem integrity maintained)
Actively restorable (AR)	Sustainably cultivated systems		75-50% (Ecologically sustainable landuses areas)
Not restorable (NR)	Intensive (non-sustainably) cultivated systems	Degraded	>50% (Impacted ecosystems – degraded)
		Cultivated Plantation	
	Urban systems	Urban	>20% (Impacted ecosystems - urban)

### 3.2.2.3 Guidance for landuse planning and decision making within the Buffalo City Municipality

From a landuse planning perspective, to further increase the effectiveness of conservation efforts, development should be guided towards lowest biodiversity priority areas that are most transformed. Converse to this, highest biodiversity priority areas that are least transformed should receive the highest level of protection from development and other high impact activities. Areas falling in between these two extremes should receive intermediate levels of protection.

Based on the above, the entire BCM area was categorised, based on biodiversity priority index score and current transformation status as follows: 1 “go”, 2 as “go-but”, 3 as “no-

but”; and 4 as “no go”. Whereby “go” or “no” represents the default position towards development on a given land parcel and “but” represents a set of criteria for ensuring conservation of biodiversity, to be determined on a case-by-case basis, under which a proposed development should proceed.

### 3.2.3 Determining ecosystem service provision within the Buffalo City Municipality

De Groot *et al.*'s (2002) comprehensive classification of ecosystem functions (Appendix 1) was used to identify a specific set of ecosystem services provided throughout the BCM at the municipal scale. Documented information was used to identify this specific set of ecosystem services provided to the BCM.

The set of ecosystem services identified were then linked to the specific sources of natural capital which provided these services using available literature. These services were then worked through and refined during one-on-one interviews with three ecological scientists and a historical and cultural expert. This process is further detailed below for each ecosystem service.

The above process was based broadly on Troy & Wilson's (2006) five core step process for mapping ecosystem services (Table 3.8), although an index rather than an economic value was used for “valuing” ecosystem services. The natural capital supplying the identified ecosystem services was mapped using a GIS. The above assessment was undertaken for the entire municipal area and at a scale of approximately 1: 25 000.

### 3.2.4 Producing an ecosystem service index for the Buffalo City Municipality

The natural capital providing the identified ecosystem services within the BCM was assigned an index value for each ecosystem service to produce an Ecosystem Service Index (ESI). To do this, each ecosystem service was assessed and the natural capital providing these services was assigned an index score between zero and ten. These scores were then spatially assigned using a GIS and represented for the BCM area.

**Table 3.8.** Five core steps for mapping ecosystem services based on Troy & Wilson (2006) and the equivalent used for mapping BCM ecosystem services

Troy & Wilson's (2006) five core steps for mapping ecosystem services	Equivalent steps for mapping of BCM ecosystem services
1. Spatial designation of the study extent	The BCM
2. Establishment of a land cover typology whose classes predict significant differences in the flow and value of ecosystem services	BCMOSS ecosystem types (see Figure 2.2)
3. Meta-analysis of peer-reviewed valuation literature to link per unit area coefficients to available cover types	Detailed in section .2.2
4. Mapping land cover and associated ecosystem service flows	Detailed in section 3.2.5
5. Calculation of total ecosystem service value and break down by cover class	Detailed in section 3.2.5, index based on relative value.

### 3.2.4.1 Generic rules for ecosystem service index scoring

Generic rules were applied for scoring individual ecosystem services comprising the ESI as follows:

1. Services which were provided either by a single ecosystem in its entirety or equally by a group of ecosystems in their entirety were assigned a score of ten while all other ecosystems were assigned a score of zero.
2. Services which were provided by a group of ecosystems but not equally so, were given relative values based on the degree to which they provided the service.

As an illustrative example, carbon sequestration is not provided equally by all ecosystems, as a grassland may sequester only 50% of the carbon that a forest sequesters. In the above example, the forest ecosystem would be assigned an index score of ten while the grassland would be assigned a score of five. Ecosystems not providing the service would be assigned a score of zero. Always, the ecosystem providing the highest value was assigned a score of ten with other ecosystems being assigned a relative value.

Where data were only available for biomes, rather than the specific ecosystem types, then individual ecosystems were given the scores based on their biome categorisation (Table 2.3). Mosaic ecosystem types, comprised of multiple biomes (see Table 2.3), were calculated by adding together the ecosystem service values

for each biome they were comprised of and dividing by the number of biomes making up the mosaic ecosystem type.

3. For non-ecosystem linked services, these services, or components of services, could not be assigned to specific ecosystems but were rather related to specific physical or cultural features within the landscape. This required that these individual natural capital features were assigned an index value of ten whilst other areas were given a value of zero.

Based on the above generic rules the methods for determining an ESI score for each individual ecosystem service are further described below and is summarised in Appendix 3.

### 3.2.5 Determining regulation services index scores

#### 3.2.5.1 Carbon sequestration and storage

An ESI score for carbon sequestration and storage was determined using an approximated measure of total carbon per hectare (tC/ ha; a measure of the carbon storage capacity of a given ecosystem) for each ecosystem type based on Glenday (2007; see Table 2.5). This approximated total carbon per hectare was then used to approximate a relative index score for carbon sequestration for each of the BCM ecosystem types.

The ESI scores for carbon sequestration and storage are shown in Table 3.9. The estuarine ecosystem type had the highest approximated total carbon per hectare of 244, while the south east coastal vegetation ecosystem type had an approximated 0 tC/ ha. Thus these ecosystem types received an index score of ten and zero respectively. All other ecosystem types received a relative ecosystem score in between these values.

**Table 3.9.** Approximated total carbon sequestration per hectare for BCM ecosystem types (based on Glenday, 2007) and a corresponding, relative ESI score

BCM ecosystem type	Approximated tC/ha	ESI score
Albany Coastal Thornveld	66	3
Amatole Afromontane Forest	199	8
Bedford Savanna Thicket	94	4
Berlin Savanna Thicket	94	4
Buffels Thicket	121	5
Buffels Valley Thicket	121	5
Cintsa Dune Thicket	98	4
Coastal Grassland	62	3
Double Drift Karroid Thicket	82	3
Estuarine	244	10
Hamburg Dune Thicket	100	4
Inland Forest	199	8
Inland Grassland	62	3
Inland Thornveld	66	3
Kiwane Dune Thicket	98	4
Moist Mountain Grassland	62	3
Mountcoke Grassland Thicket	82	3
Mountvale Grassland Thicket	82	3
Riparian	197	8
South East Coastal Vegetation	0	0
Transfish Dune Forest	133	6
Transfish Dune Thicket	133	6
Umtiza Forest Thicket	160	7
Watercourse	149	6

### 3.2.5.2 Pollination and biological control

An ESI score for pollination and biological control was determined using the information in Table 2.11. All natural capital identified for pollination and biological control was given an ESI score of ten (Table 3.10).

As a secondary filter, the natural capital shown in Table 3.10 was then further aggregated to provide an index score according to the relative complexity of ecosystem types, with forest ecosystem types receiving a relative score of ten whilst South East Coastal Vegetation received a score of zero (Table 3.11). The relative complexity measure was an approximation, based on the assumption that more complex ecosystems are likely to harbour larger populations of pollinator and biological control species and therefore provide a relatively higher ecosystem service, than less complex ecosystems.

**Table 3.10.** Natural capital required to ensure the continued provision of pollination and biological control services in the BCM (primary filter for pollination and biological control services)

Natural capital	Pollination ESI score	Biological control ESI score
All pollinator habitat within total potential range of crops requiring pollination (as per Buffalo City Municipality, 2006c) and foraging range buffer distance (1- 2.5 km).	10	n/a
All habitat (grasslands, open savanna, shorelines of inland waters) of cattle egret within total potential livestock farming range and foraging range buffer distance	n/a	10
All habitat (Woodland, forest, coastal forest, riparian, grassland) of owl species within buffer around settlements/ urban areas equalling the foraging range of owl spp	n/a	10

**Table 3.11.** Relative index scores for pollination and biological control (secondary filter for pollination and biological control services)

BCM ecosystem type	Pollination and biological control index score
Albany Coastal Thornveld	5
Amatole Afromontane Forest	10
Bedford Savanna Thicket	6
Berlin Savanna Thicket	6
Buffels Thicket	7
Buffels Valley Thicket	7
Cintsa Dune Thicket	7
Coastal Grassland	3
Double Drift Karroid Thicket	4
Estuarine	7
Hamburg Dune Thicket	8
Inland Forest	10
Inland Grassland	3
Inland Thornveld	5
Kiwane Dune Thicket	7
Moist Mountain Grassland	3
Mountcoke Grassland Thicket	4
Mountvale Grassland Thicket	4
Riparian	7
South East Coastal Vegetation	0
Transfish Dune Forest	10
Transfish Dune Thicket	10
Umtiza Forest Thicket	8
Watercourse	5

The index scores from Tables 3.10 and 3.11 were spatially assigned and overlain using a GIS. For any given area, the two index scores were multiplied and divided by 10 to produce a final ESI score for pollination and biological control.

### 3.2.5.3 Flood, water provision, erosion and sand dune stabilisation

The index scores for all other regulation functions including flood protection and stormwater discharge; fresh water provision; erosion prevention; and sand dune stabilisation, were determined using the information in Table 2.6. These ecosystem services were broadly differentiated in terms of relative importance, these being highest; medium; and lowest. Natural capital elements of greatest importance were given a score of ten; lowest a score of zero; and medium a score of 5 (Table 3.12).

**Table 3.12.** Relative index scores for flood protection and stormwater discharge; fresh water provision; erosion prevention; and sand dune stabilisation services

Natural capital element	Flood protection and stormwater discharge index score	Fresh water provision index score	Erosion prevention index score	Sand dune stabilisation index score
Riparian	10	10	10	n/a
Watercourse	10	10	10	n/a
Estuarine	10	0	10	n/a
Coastal dune forest	n/a	n/a	n/a	10
South east coastal vegetation	n/a	0	n/a	10
Vegetation on steep slopes (>1:5)	n/a	n/a	10	n/a
All other ecosystem types within freshwater catchments	5	5	0	0

A secondary filter was applied to the above values. For flood protection and stormwater discharge only natural capital within BCM catchments which contained urban settlements was included. For fresh water provision only natural capital within BCM catchments utilised for domestic, industrial and agricultural water provision was included. For erosion prevention only natural capital within BCM catchments that contained human settlements, both rural and urban, and agriculture was included. For sand dune stabilisation only natural capital within a 1 km buffer zone around coastal settlements was included. The above filter was applied using a BCM settlements layer and a GIS.

### 3.2.6 Determining productive and cultural services index scores

All of the identified productive and cultural services were provided by individual species within the BCM. The habitats within which individual species were found were identified and linked to specific BCM ecosystem types using the data contained in Appendix 2 (Table 3.13).

**Table 3.13.** Productive and cultural ecosystem services within the BCM and the habitat within which these individual species were found

de Groot <i>et al.</i> , (2002) functions category	BCM ecosystem service	Natural capital habitat
Food	Food resources: Wild fruit	Forest, coastal forest, subtropical thicket
	Food resources: Wild vegetables	Forest, watercourses, riparian, grasslands
Raw materials	Food resources: Fish/ fish bait	Estuarine
	Building and manufacturing material: Fencing	Riparian, subtropical thicket, savanna, forest
	Building and manufacturing material: Construction timber	Subtropical thicket, savanna, forest, coastal forest, riparian, watercourse
	Fuel and energy: Fuelwood	Riparian, subtropical thicket, savanna, forest, watercourse, coastal forest
Medicinal resources	Fodder and fertilizer: Livestock production (commercial and subsistence)	Grassland, subtropical thicket/ grassland matrix, savanna, watercourse
	Medicinal resources	Grassland, savanna, subtropical thicket, forest, coastal forest
Cultural and artistic information	Ritual slaughtering	Riparian, subtropical thicket, savanna, forest, watercourse, coastal forest
Cultural and artistic information	Igoqo (Xhosa cultural artefact constructed of wild plants where female ancestors are believed to reside)	Riparian, subtropical thicket, savanna, forest, coastal forest
Cultural and artistic information	Kraal	Riparian, subtropical thicket, savanna, forest, coastal forest, watercourse
Cultural and artistic information	Grass brooms	Watercourses, riparian

If a species was found within a specific ecosystem type it was given a score of ten, if not, a score of zero (Table 3.14). As the available data were biome based, mosaic ecosystem types resulted in some intermediate scores. As a secondary filter, only habitat within a 2 km range of human habitation was mapped as this was determined to be a reasonable distance that people would travel to collect natural resources.

**Table 3.14** Relative productive and cultural ecosystem service index scores for each BCM ecosystem type calculated using the data presented in Table 3.13

BCM ecosystem type	Wild fruit	Wild vegetables	Fish/ fish bait	Fencing	Constructi on timber	Fuelwood	Livestock production	Medicinal resources	Ritual slaughterin	Igoqo	Kraal	Grass brooms
Albany Coastal Thornveld	0	0	0	10	10	10	10	10	10	10	10	0
Amatole Afromontane Forest	10	10	0	10	10	10	0	10	10	10	10	0
Bedford Savanna Thicket	5	0	0	10	10	10	10	10	10	10	10	0
Berlin Savanna Thicket	5	0	0	10	10	10	10	10	10	10	10	0
Buffels Thicket	10	0	0	10	10	10	10	10	10	10	10	0
Buffels Valley Thicket	10	0	0	10	10	10	10	10	10	10	10	0
Cintsa Dune Thicket	5	5	0	0	5	5	5	10	5	5	5	0
Coastal Grassland Double Drift	0	10	0	0	0	0	10	10	0	0	0	0
Karroid Thicket Estuarine	3	3	0	3	3	3	7	7	3	3	3	0
Hamburg Dune Thicket	0	0	10	0	0	0	0	0	0	0	0	0
Hamburg Dune Thicket	5	0	0	5	10	10	5	10	10	10	10	0
Inland Forest	10	10	0	10	10	10	0	10	10	10	10	0
Inland Grassland	0	10	0	0	0	0	10	10	0	0	0	0
Inland Thornveld	0	0	0	10	10	10	10	10	10	10	10	0
Kiwane Dune Thicket	5	0	0	0	5	5	0	5	5	5	5	0
Moist Mountain Grassland	0	10	0	0	0	0	10	10	0	0	0	0
Mountcoke Grassland Thicket	3	3	0	3	3	3	7	7	3	3	3	0
Mountvale Grassland Thicket	3	3	0	3	3	3	7	7	3	3	3	0
Riparian	0	10	0	10	10	10	0	0	10	10	10	10
South East Coastal Vegetation	0	0	0	0	0	0	0	0	0	0	0	0
Transfish Dune Forest	10	0	0	0	10	10	0	10	10	10	10	0
Transfish Dune Thicket	10	0	0	0	10	10	0	10	10	10	10	0
Umtiza Forest Thicket	10	5	0	10	10	10	5	10	10	10	10	0
Watercourse	0	10	0	0	10	10	0	0	10	10	10	10

### 3.2.7 Determining information services index scores

The service provided by aesthetically pleasing, recreationally important, historically important, and educationally and scientifically important, natural elements relying on natural capital were linked to specific ecosystem types or other natural capital elements as per Table 2.9. All natural capital elements identified as important for these services were then given an ESI score of 10 (Table 3.15) which was spatially assigned using a GIS.

**Table 3.15.** Relative index scores for aesthetically pleasing; recreationally important; historically important; and educationally and scientifically important natural elements relying on natural capital

Ecosystem type or information reliant on natural elements for its interpretation	Aesthetic index score	Recreation index score	Historic index score	Educational and scientific index score
Buffels Thicket	10	n/a	n/a	n/a
Buffels Valley Thicket	10	n/a	n/a	n/a
Transfish Dune Forest	10	n/a	n/a	n/a
Transfish Dune Thicket	10	n/a	n/a	n/a
Coastal Grassland	10	n/a	n/a	n/a
South East Coastal Vegetation	10	n/a	n/a	n/a
Riparian	10	n/a	n/a	n/a
Estuarine	10	10	n/a	n/a
Umtiza Nature Reserve trails	n/a	10	n/a	n/a
Nahoon Estuary (Dassie) Trail	n/a	10	n/a	n/a
Cove Rock	n/a	10	n/a	n/a
Amathole hiking trail (Prierie Forest)	n/a	10	n/a	n/a
Public nature reserves	n/a	10	n/a	10
Palaentological: Fossilized archaic Homo sapiens'' footprints at NPNR	n/a	n/a	10	n/a
Xhosa historical: Gompo Rock	n/a	n/a	10	n/a
Xhosa historical: Ndlambe''s Great Place (10-15kms from Macleantown near Xinira River)	n/a	n/a	10	n/a
Xhosa historical: Mngqesha''s Great Place (Mngqesha location, King Williams Town)	n/a	n/a	10	n/a

### 3.2.8 Determining the level of ecosystem services and biodiversity priority overlap

The BPI and the ESI were spatially overlain using a GIS and analysed statistically using the Pearson correlation coefficient to determine the degree of spatial correlation between biodiversity priority and ecosystem service provision within the BCM. This was done for the overall ESI and BPI as well as for each of their respective components in order to

determine whether specific ecosystem services coincided with specific biodiversity priority features.

### 3.2.9 Determining priority areas for implementation of conservation action

To determine areas where local citizen action could be harnessed for biodiversity conservation through ecosystem service provision, the current transformation layer was intersected with the ESI and the BPI using a GIS. The current transformation layer provided a measure of the degree of transformation of the landscape within the BCM and thus also, conversely reflected the rehabilitation potential of the BCM landscape.

These three layers were analysed together to determine „hotspots“ for implementing conservation action, where ecosystem services were highest, biodiversity priority highest, and rehabilitation potential greatest. This was done by identifying overlapping areas which contained an ESI score  $>5$ ; BPI score  $>2$ ; and current transformation status categorisation of either actively or passively restorable.

A matrix to guide the implementation of conservation action, based on the ESI, BPI and current transformation status variables, was also developed. The conservation action matrix also considered land tenure, in the form of private ownership, public ownership and communal land, as a fourth variable. The matrix proposed options for conservation action for any given variation of these four variables.

## CHAPTER 4: RESULTS

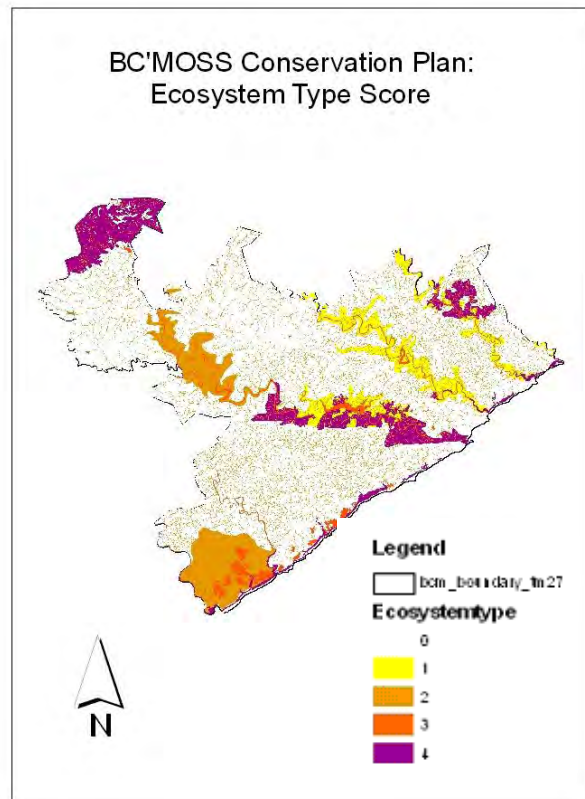
### 4.1 The status of biodiversity within the Buffalo City Municipality

#### 4.1.1 Analysis of protection status for ecosystem type, species of special concern and ecological processes

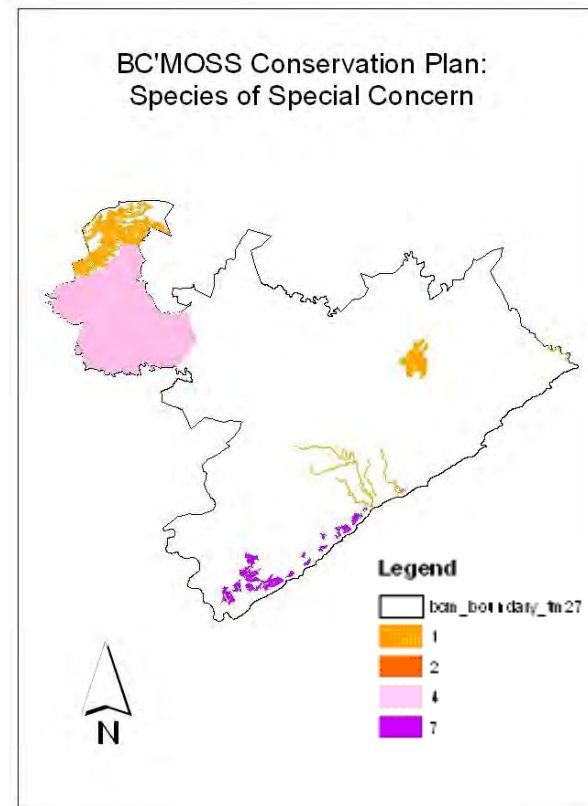
Ecosystem type BPI scores were highest along the three major (Buffalo, Quenera and Gonubie) river valleys; coastal grasslands between the Kiwane and Igoda coastal villages; a band of coastal forest stretching most of the length of the BCM coastline; and the Amathole Mountain area in the far north-west corner of the municipality (Figure 4.1). South East Coastal Vegetation was the most protected (99.7%) ecosystem type followed by Transfish Dune Forest (71.9%), while seven ecosystem types had zero hectares protected (Table 4.1). Of the 24 ecosystem types (unknown is excluded), 11 (45%) had less than 1% under protection, while 16 (67%) had less than five percent protected. Eight ecosystem types had received more than 10% protection.

The 21 species of special concern (SSC) identified included 20 plant species and one vertebrate species of which 15 were full species, three were subspecies, and three were varieties. The 21 SSC were contained within a total of nine SSC “hotspots” with “hotspot” number one, coastal grasslands between the Kiwane and Igoda coastal villages, containing the largest number of SSC (Figure 4.2). In total SSC hotspots covered 42 977 ha or 17% of the total BCM area while the total for SSC “hotspots” under protection was 1 256 ha or 2.92%.

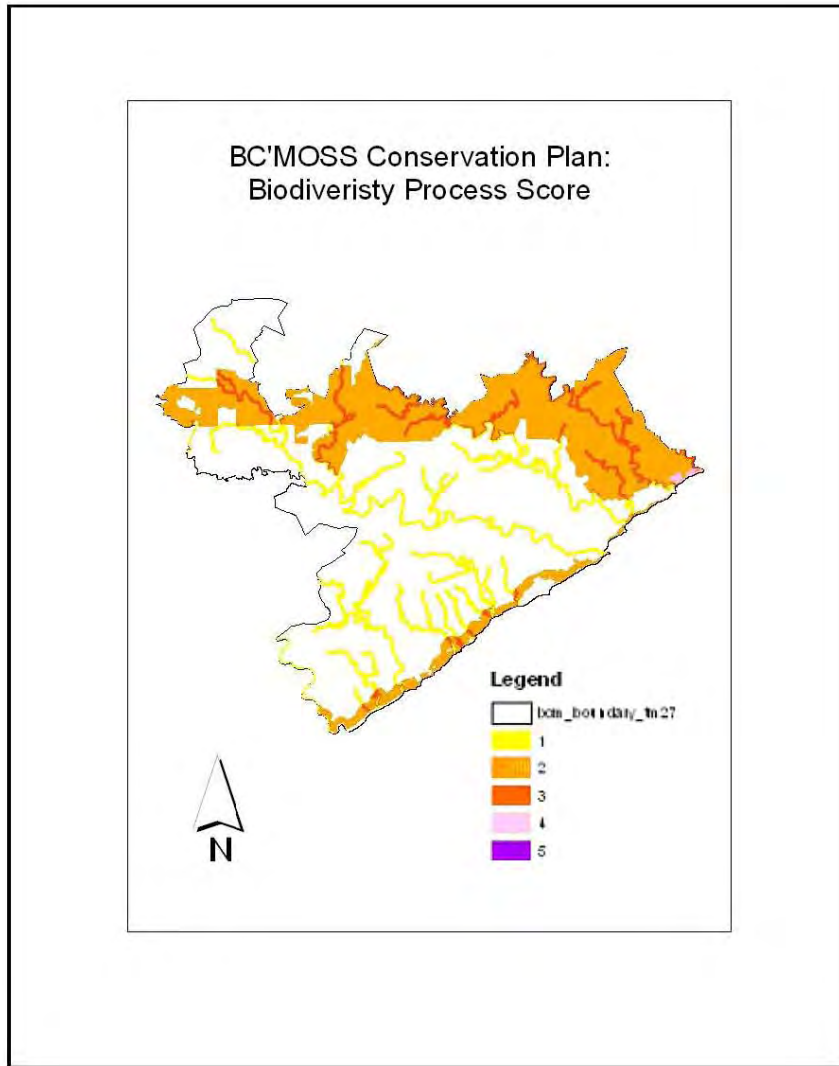
Ecosystem processes followed the stretch of the BCM coast and inland along major river corridors. The STEP network corridor ran broadly from the mouths of the Gonubie and Kwlera Rivers in the far north-eastern corner towards the Dimbaza settlement in the far north-western corner (Figure 4.3). In total ecological processes covered 117 558 ha or 47% of the BCM area with 4 299 ha, or 3.66% under protection.



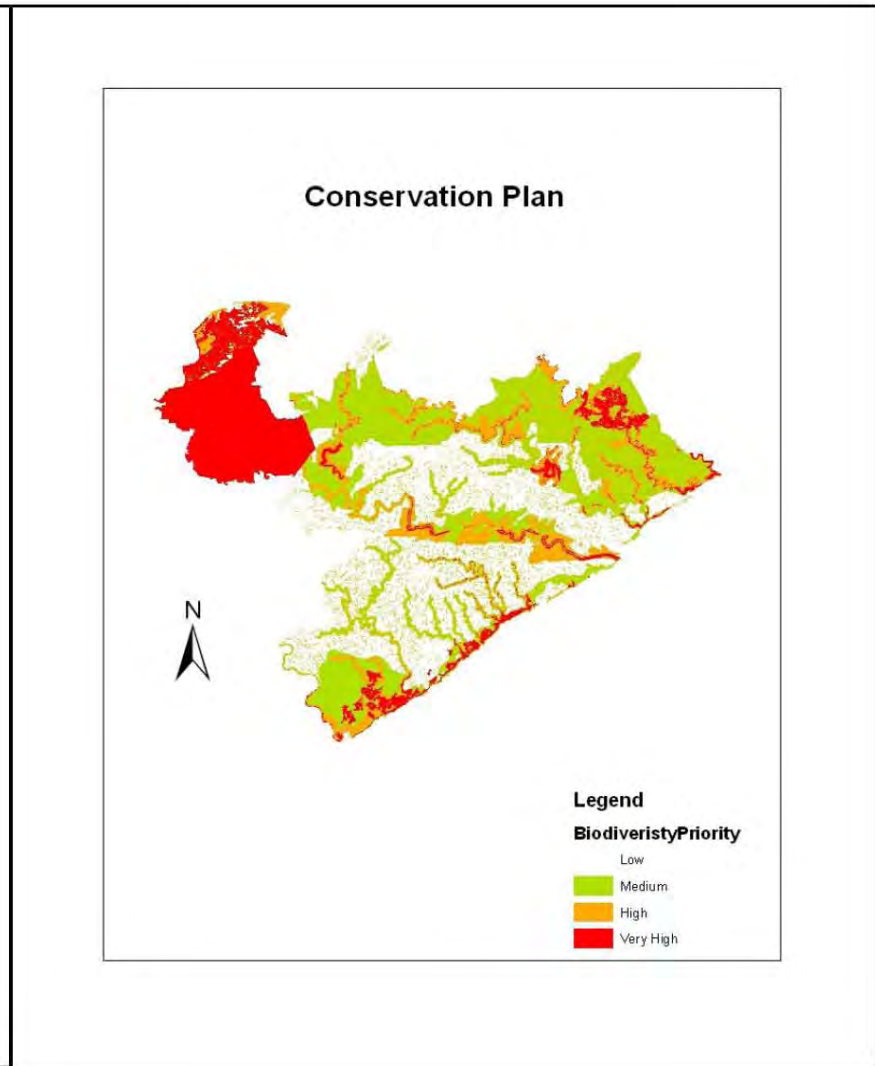
**Figure 4.1.** Biodiversity priority index scores for ecosystem type for the BCM highest biodiversity priority areas = highest BPI score)



**Figure 4.2.** Biodiversity priority index scores for species of species concern hotspots for the BCM (highest biodiversity priority areas = highest BPI score)



**Figure 4.3:** Biodiversity priority index scores for biodiversity processes for the BCM (highest biodiversity priority areas = highest BPI score)



**Figure 4.4:** Overall biodiversity priority index scores for the BCM

**Table 4.1.** Protection status of BCM ecosystem types

Ecosystem type	Area protected (ha)	Total area (ha)	Proportion under PA (%)
South East Coastal Vegetation	376	377	99.7
Transfish Dune Forest	1032	1436	71.9
Transfish Dune Thicket	633	1503	42.1
Inland Forest	1780	8860	20.0
Albany Coastal Thornveld	511	3044	16.8
Riparian	1246	7479	16.7
Umtiza Forest Thicket	189	1557	12.1
Estuarine	239	2113	11.3
Buffels Thicket	956	15615	6.1
Unknown ecosystem type	25	634	3.9
Hamburg Dune Thicket	318	9643	3.3
Coastal Grassland	62	2648	2.3
Cintsa Dune Thicket	71	3231	2.2
Watercourse	532	24321	2.2
Buffels Valley Thicket	65	8397	0.8
Inland Thornveld	45	9185	0.5
Berlin Savanna Thicket	558	117651	0.5
Kiwane Dune Thicket	12	10089	0.1
Amatole Afromontane Forest	0	6796	0.0
Bedford Savanna Thicket	0	0	0.0
Double Drift Karroid Thicket	0	2574	0.0
Inland Grassland	0	2267	0.0
Moist Mountain Grassland	0	2881	0.0
Mountcoke Grassland Thicket	0	23892	0.0
Mountvale Grassland Thicket	0	288	0.0

#### 4.1.2 Analysis of biodiversity priority protection

Broadly, areas of biodiversity priority (i.e. medium, high and very high BPI areas) included: a corridor between the Gonubie and Nahoon Rivers and along the Buffalo River extending north towards the Amathole Mountains (Figure 4.4); coastal grasslands, particularly in the Kiwane area, located in the far south-western corner of the BCM; the narrow coastal corridor along the entire length of the BCM; and major riparian areas along several smaller rivers. Total coverage for the biodiversity priority categories were roughly split equally between low, medium, and high combined with very high (Table 4.2).

**Table 4.2.** Coverage of biodiversity priority categories within the BCM

Biodiversity priority category	Total area (ha)	Proportion of total BCM area (%)
Low	88 306	33.0
Medium	86 811	32.5
High	41 023	15.4
Very high	51 148	19.1
BCM Total	267 289	100.0

Protected areas were mainly (66% of total) comprised of high or very high biodiversity priority areas and together with medium conservation priority areas they made up 80% of the total protected area coverage (Table 4.3). However, as a percentage of the entire BCM area (252 334 ha), only a tiny portion of medium (<1%), high (1.4%) and very high biodiversity priority (<1%) areas were under some form of protection, a reflection of the fact that only 3.45% of the BCM area was under protection.

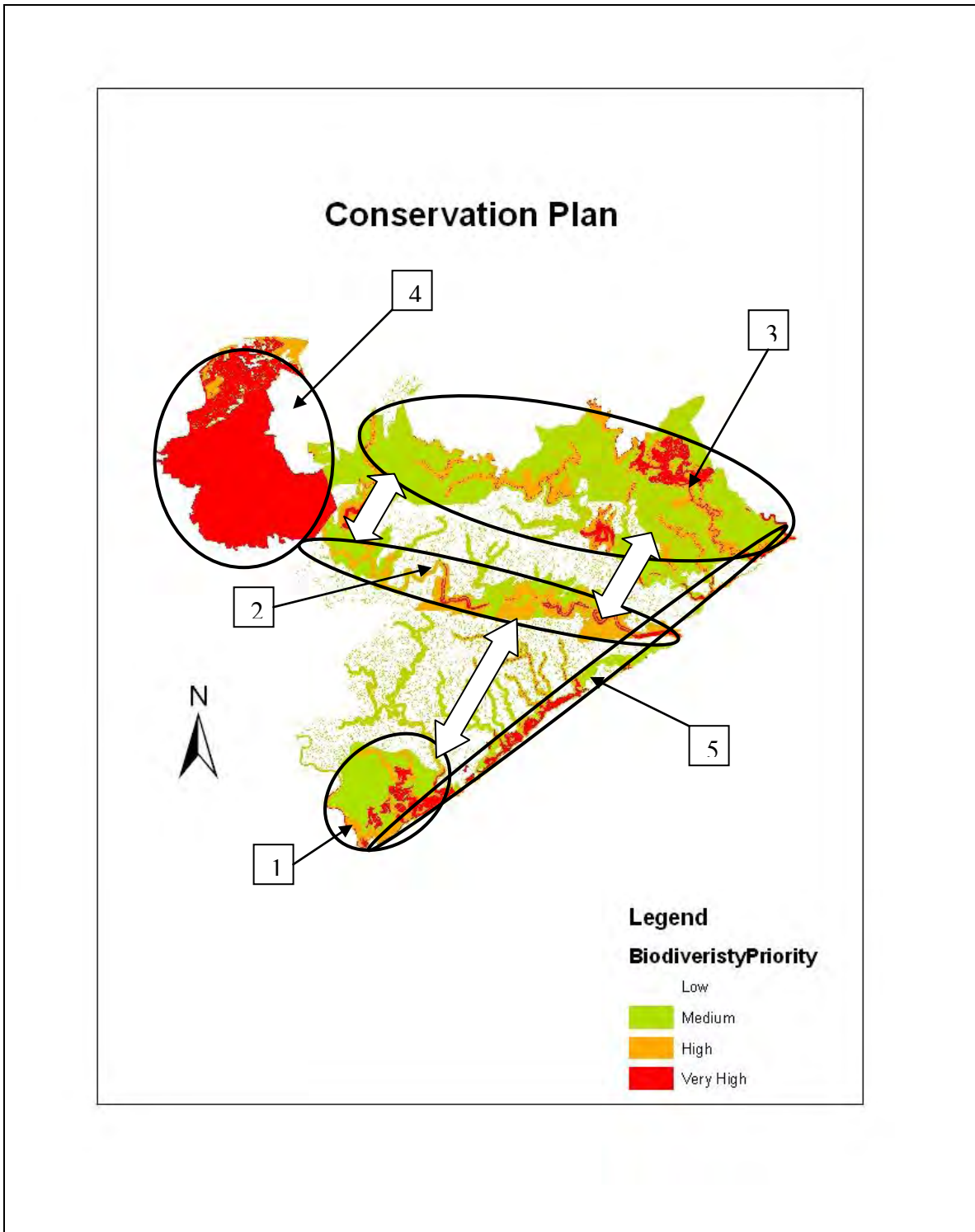
**Table 4.3.** Protection status for biodiversity priority categories within the BCM

Biodiversity Priority category	Total area (ha)	Proportion of total BCM area (%)	Proportion of PA total (%)
Low	1 662	0.7	19.1
Medium	1 294	0.5	14.9
High	3 395	1.4	39.0
Very high	2 346	0.9	27.0
Total protected area	8 697	3.5	100.0

#### 4.1.3 Biodiversity priority focused conservation action

Based solely on the biodiversity priority index five implementation “hotspot” areas were identified (Figure 4.5). These five biodiversity priority “hotspots” include: 1. Kiwani-Tsholmnaqua hotspot which includes coastal grasslands, Kiwani Dune Thicket and a number of species of special concern; 2. Buffalo Corridor hotspot which includes Umtiza Forest Thicket, Inland Forest, Buffels and Buffels Valley Thicket, a species of special concern and the riparian corridor along the Buffalo River; 3. Gonubie Corridor hotspot which includes a number of species of special concern, Inland Forest, Buffels and Buffels Valley Thicket, most of the STEP network area and riverine corridors of a number of major rivers; 4. Amathole Mountain hotspot which includes Amathole Afromontain Forest and the largest number of species of special concern; 5. Coastal Corridor hotspot

which includes Coast Forest and Dune Thicket, Coastal Grasslands, Estuarine ecosystems, the entire STEP coastal network and a number of species of special concern. As well as the “hotspots” Figure 4.5 also indicates, by way of arrows, potential linkage areas between hotspots. Such linkage corridors are proposed as a guide to possible extension of the “hotspot” areas, once the core is secured, and would incorporate more biodiversity priority areas not incorporated within the current “hotspots”.



**Figure 4.5.** Priority implementation areas for focused conservation action based on biodiversity priority (1.Kiwani-Tsholmnaqua hotspot; 2.Buffalo Corridor Hotspot; 3.Gonubie Corridor hotspot; 4.Amathole Mountain hotspot; 5.Coastal Corridor hotspot; and arrows = potential lineage areas between hotspots)

## 4.2 Current transformation status of the Buffalo City Municipality

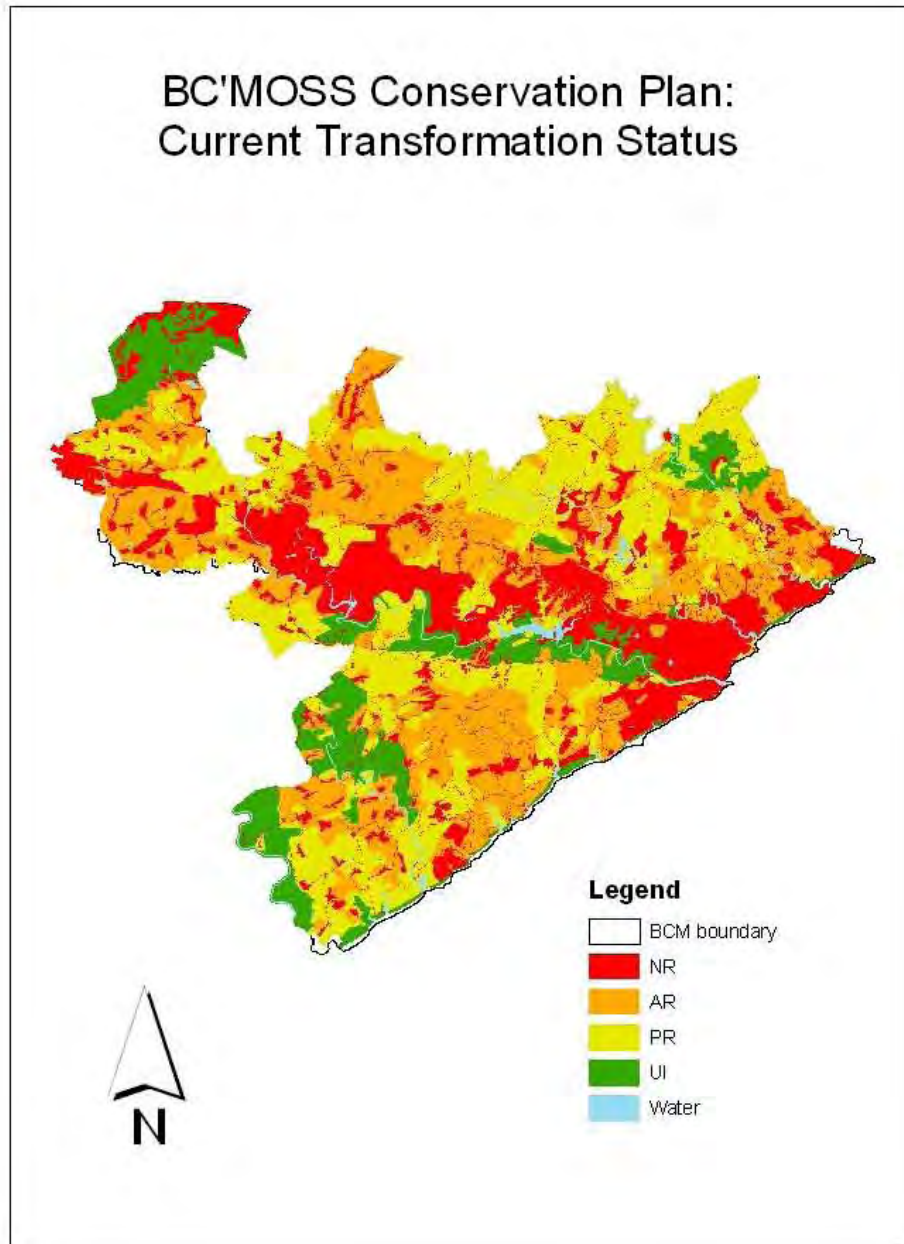
Much of the urban corridor between the East London, Mdantsane and King Williams Town fell within the not restorable (NR) category while the rural areas flanking this urban corridor to the east and west were categorised as restorable, either actively (AR) or passively (PR; Figure 4.6). Patches of areas categorised as un-impacted existed in various locations around the BCM.

Areas categorised as actively restorable comprised the largest percentage of the BCM closely followed by passively restorable areas (Table 4.4). These two restorable categories comprised just more than 60% of the total BCM area. Not restorable areas, thus completely lost to biodiversity conservation, comprised just less than a quarter of the total BCM area while un-impacted areas comprised just 12.3%. Open water only made up a small percentage (3.4%) of the total BCM landscape despite the presence of several large dams within the BCM. Biodiversity Intactness (BI) was calculated at slightly more than 55% of pre-transformation levels.

**Table 4.4.** Total coverage and biodiversity intactness (BI) for BCM transformation categories

Transformation category	Coverage (ha)	Proportion of total BCM (%)	Approx. mean BI	BI area (ha)
Not restorable	64 487	23.9	15	9 673
Actively restorable	82 194	30.4	45	37 887
Passively restorable	81 045	30.0	75	60 784
Un-impacted	33 204	12.3	95	31 544
Water	9 269	3.4	95	8 806
Total	270 199	100		148 694

## BC'MOSS Conservation Plan: Current Transformation Status



**Figure 4.6.** Current transformation status for the BCM (NR = non-restorable; AR = actively restorable; PR = passively restorable; UI = un-impacted)

#### 4.2.1 Analysis of current transformation status of ecosystem types

Of the total BCM area, 116 784 ha (44%) was covered by transformed (NR, AR or PR) Berlin Savanna Thicket (Table 4.5). The most highly transformed ecosystem types included Moist Mountain Grasslands, Cintsa Dune Thicket, Buffels Valley Thicket and Umtiza Forest Thicket. Every hectare of Amathole Afromontane Forest, Inland Forest, Transfish Dune Forest and South East Coastal Vegetation were characterised as un-impacted while eight ecosystem types did not contain a single hectare of remaining un-impacted area. Less than 1 ha of Bedford Savanna Thicket was found within the BCM and hence the values of zero for this ecosystem type. Only ten out of the 24 ecosystem types (excluding unknown) had more than 10% of their remaining area categorised as un-impacted. Moist Mountain Grassland was particularly highly transformed with 90% non-restorable and 9% actively restorable while Cintsa Dune Thicket was 80% non-transformed, 15% actively restorable and the remaining 5% passively restorable.

Of the endemic and near-endemic ecosystem types, Umtiza Forest Thicket, of which 100% is found within the BCM, was 67% non-restorable, 10% actively restorable, with the remaining 23% as passively restorable; Kiwane Dune Thicket, of which 98% is found within the BCM, 16% was categorised as untransformed and 50% was passively restorable. Buffels and Buffels Valley Thicket, of which 66% and 44% of their extents are found within the BCM respectively, were both significantly transformed.

**Table 4.5.** Area and proportion of BCM ecosystem types under different transformation categories

Ecosystem type	NR		AR		PR		UI		Water		Unknown		Total	
	Area (ha)	% of tot.	Area (ha)	% of tot.	Area (ha)	% of tot.	Area (ha)	% of tot.	Area (ha)	% of tot.	Area (ha)	% of tot.	Area (ha)	% of tot.
Albany Coastal Thornveld	404	13	392	13	1831	60	417	14	0	0	0	0	3044	100
Amatole Afromontane Forest	0	0	0	0	0	0	6796	100	0	0	0	0	6796	100
Bedford Savanna Thicket	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Berlin Savanna Thicket	31752	27	48671	41	36361	31	699	1	0	0	168	0	117651	100
Buffels Thicket	4521	29	3595	23	7120	46	249	2	0	0	130	1	15615	100
Buffels Valley Thicket	5704	68	1092	13	1363	16	238	3	0	0	0	0	8397	100
Cintsa Dune Thicket	2594	80	499	15	48	1	0	0	0	0	90	3	3231	100
Coastal Grassland	168	6	617	23	1850	70	13	0	0	0	0	0	2648	100
Double Drift Karroid Thicket	70	3	183	7	233	9	2088	81	0	0	0	0	2574	100
Estuarine	47	2	11	1	52	2	84	4	1494	71	425	20	2113	100
Hamburg Dune Thicket	3800	39	3953	41	1866	19	0	0	0	0	24	0	9643	100
Inland Forest	0	0	0	0	0	0	8860	100	0	0	0	0	8860	100
Inland Grassland	70	3	600	26	1597	70	0	0	0	0	0	0	2267	100
Inland Thornveld	2931	32	3184	35	2571	28	91	1	0	0	408	4	9185	100
Kiwane Dune Thicket	1001	10	2350	23	5046	50	1564	16	0	0	128	1	10089	100
Moist Mountain Grassland	2606	90	265	9	0	0	0	0	0	0	10	0	2881	100
Mountcoke Grassland Thicket	2270	10	7040	29	8585	36	5997	25	0	0	0	0	23892	100
Mountvale Grassland Thicket	47	16	77	27	66	23	98	34	0	0	0	0	288	100
Riparian	0	0	0	0	0	0	0	0	7427	99	52	1	7479	100
South East Coastal Vegetation	0	0	0	0	0	0	0	0	0	0	377	100	377	100
Transfish Dune Forest	0	0	0	0	0	0	1436	100	0	0	0	0	1436	100
Transfish Dune Thicket	648	43	123	8	120	8	79	5	0	0	533	35	1503	100
Umtiza Forest Thicket	1048	67	151	10	358	23	0	0	0	0	0	0	1557	100
Unknown ecosystem type	94	15	119	19	242	38	1	0	0	0	178	28	634	100
Watercourse	3988	16	8189	34	8553	35	3498	14	0	0	85	0	24313	100
<b>Total</b>	<b>63763</b>	<b>24</b>	<b>81111</b>	<b>30</b>	<b>77862</b>	<b>29</b>	<b>32208</b>	<b>12</b>	<b>8921</b>	<b>3</b>	<b>2608</b>	<b>1</b>	<b>266473</b>	<b>100</b>

#### 4.2.2 Current transformation status and biodiversity priority

Passively restorable, medium biodiversity priority; not restorable, low biodiversity priority; and actively restorable, low biodiversity priority comprised the greatest portions of area within the BCM (Table 4.6). Together they comprised approximately 35% of the total BCM area. Un-impacted, medium biodiversity priority comprised the smallest area.

**Table 4.6.** Transformation status for each biodiversity priority category including total area and proportion of transformation for each biodiversity priority category

Biodiv. priority cat.	NR		AR		PR		UI	
	Area (ha)	% of tot	ha	% of tot	ha	% of tot	ha	% of tot
Low	30323	32	30321	32	23791	25	8969	10
Medium	18147	21	29952	35	32678	38	5092	6
High	7017	20	7801	22	13558	38	7067	20
Very high	8999	19	14120	31	11017	24	12076	26

In terms of transformation status for each vegetation type, of significance is that fairly large proportions of high and very high biodiversity priority are still categorised as un-impacted and over 50% of each are categorised as either un-impacted or passively restorable. Only 6% of the medium biodiversity priority area was categorised as un-impacted, although a further 38% were categorised as passively restorable.

The guidance for landuse planning and decision making within the Buffalo City Municipality is presented in Table 4.7.

**Table 4.7.** Proposed levels of protection and guidance for landuse planners for various BCM landuse categories whereby 1 = “go”; 2 = “go-but”; 3 = “no-but”; 4 = “no go”)

Biodiversity priority category	NR	AR	PR	UI
Low	1	1	2	3
Medium	1	2	3	4
High	2	3	4	4
Very high	3	4	4	4

### 4.3 Ecosystem services provision within the Buffalo City Municipality

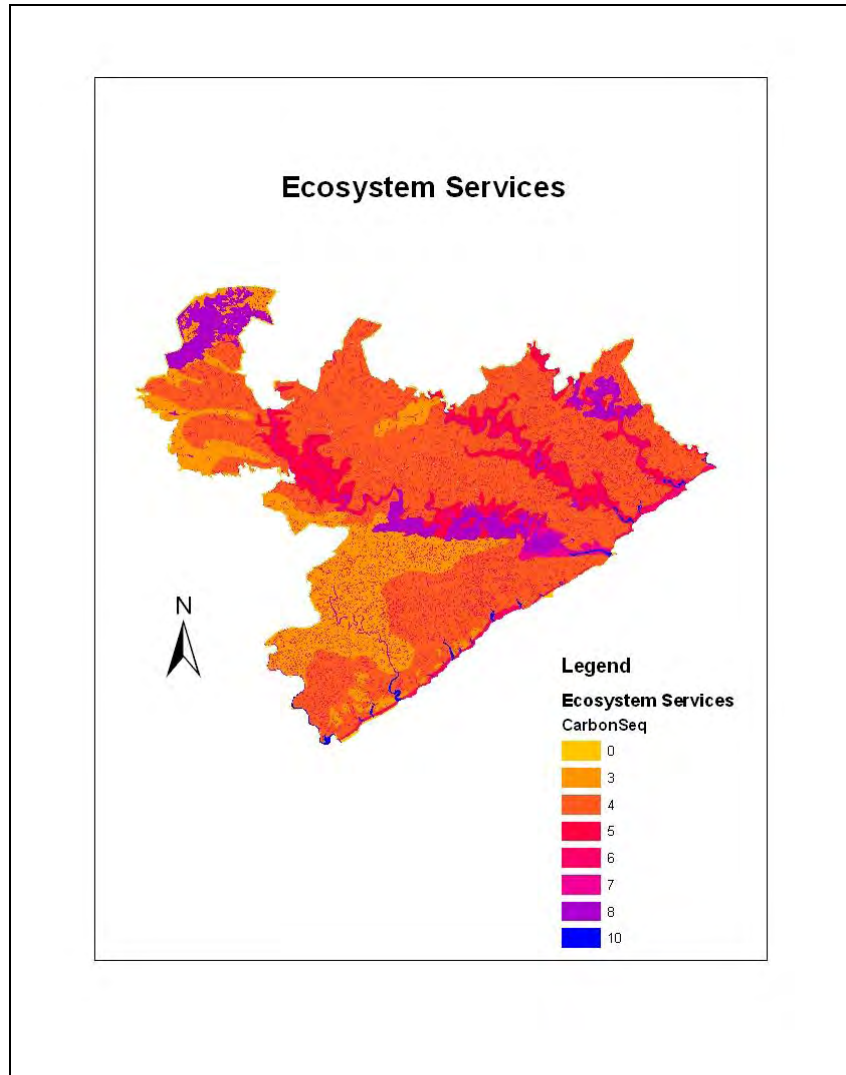
#### 4.3.1 Identification of ecosystem services provision

In total 25 ecosystem services were identified as being provided by natural capital within the BCM (Table 4.8). Of these eight fell within the regulation functions; eight within the production functions; and nine within the information functions categories.

**Table 4.8.** Ecosystem services provided within the BCM and their categorisation according to de Groot *et al.* (2002)

Ecosystem functions category	Ecosystem functions (de Groot <i>et al.</i> , 2002)	Benefit/ Ecosystem service (specific to BCM)	
Regulation functions	Climate regulation	Carbon sequestration and storage	
	Disturbance prevention	Flood protection and storm water discharge	
	Water regulation and supply	Fresh water provision	
	Soil retention	Erosion prevention Sand dune stabilisation	
	Pollination	Crop pollination	
	Biological control		Livestock parasite control Brown House Rat control
Production functions	Food	Wild fruit Wild vegetables Fish/ fish bait	
		Raw material	Building and manufacturing material: Fencing Building and manufacturing material: Construction timber Fuel and energy: Fuelwood Fodder and fertilize: Livestock production (commercial and subsistence)
	Medicinal resources	Medicinal resources	
	Information functions	Aesthetic	Scenic and aesthetically pleasing natural elements
Recreation		Recreation: Fishing Recreation: Walking/ relaxation	
Cultural and artistic		Cultural: Ritual slaughtering Cultural: Igoqo (cultural artefact) Cultural: Kraal Cultural: Grass broom	
		Spiritual and historic	Historically important natural elements relying on NC for interpretation
		Scientific and educational	Environments important for education and scientific research: Public nature reserves

Figure 4.7 shows the map for carbon sequestration and storage, with the spatial distribution of the index scores from zero to ten. Appendix 4 contains the maps for all of the 24 remaining ecosystems services, some of which are grouped together, and which are presented in Table 4.10.

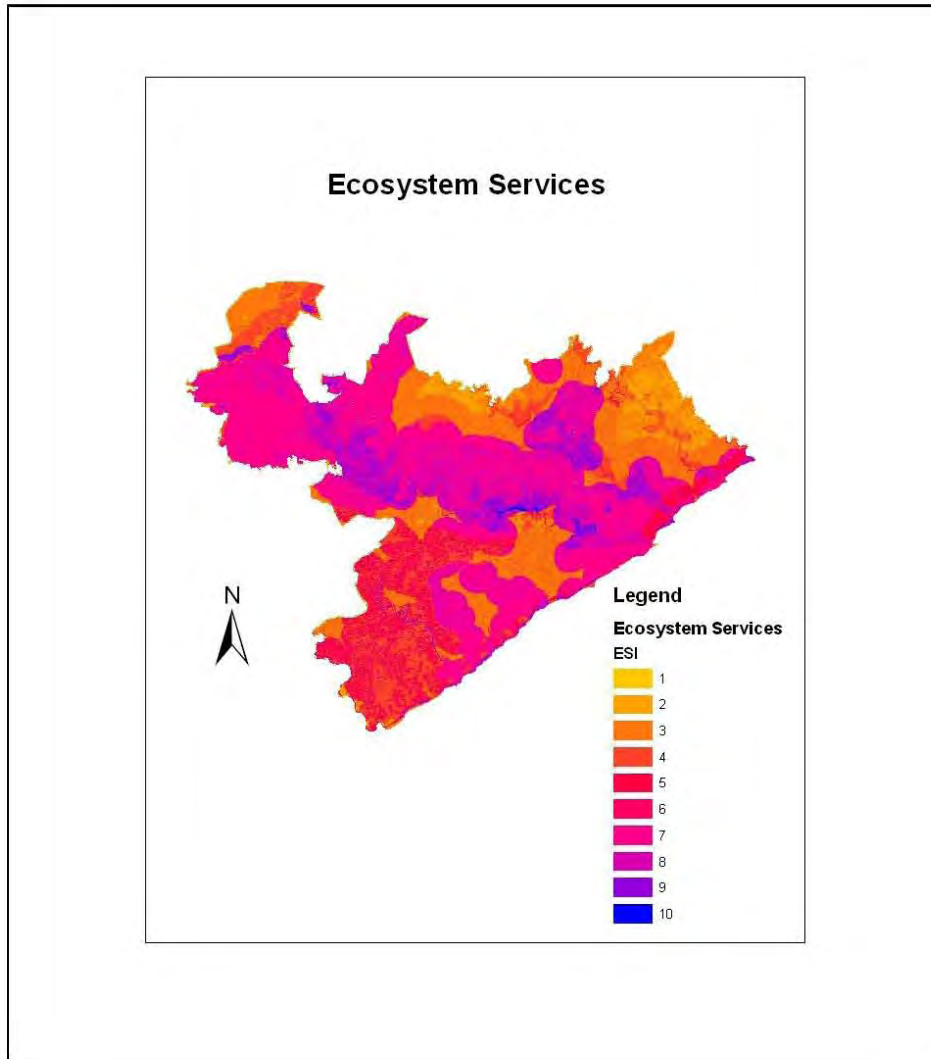


**Figure 4.7.** Ecosystem service index (ESI) scores for the carbon sequestration and storage service (highest provision of ecosystem service = highest ESI score)

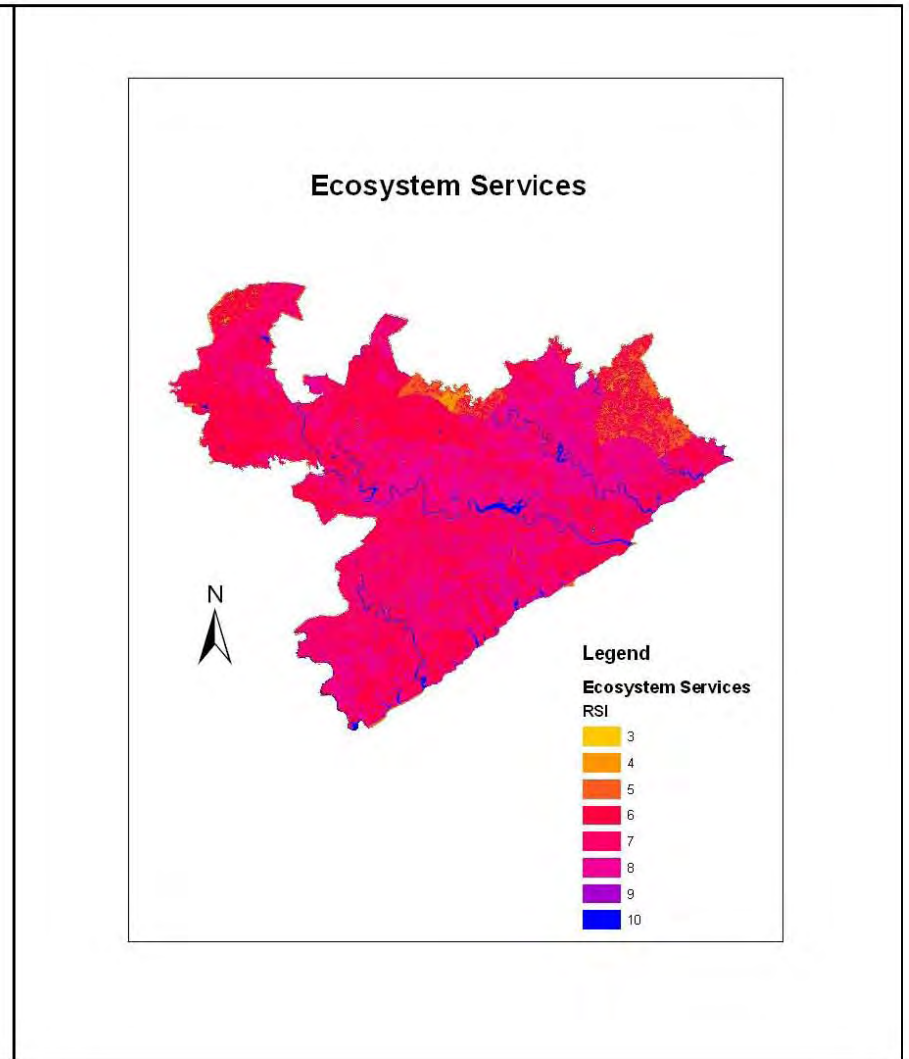
The overall ecosystem services index score for the BCM is spatially represented in Figure 4.8. A broad corridor, running along the Buffalo River catchment from the coast to the Amathole Mountains in the north west of the BCM, as well as a coastal corridor running

along the length of the BCM coastline was of higher relative ESI value compared to the rest of the BCM area. Individually, on the whole, coastal dune forests; inland forests; riparian and estuarine ecosystem types provided the greatest ESI value relative to other ecosystem types.

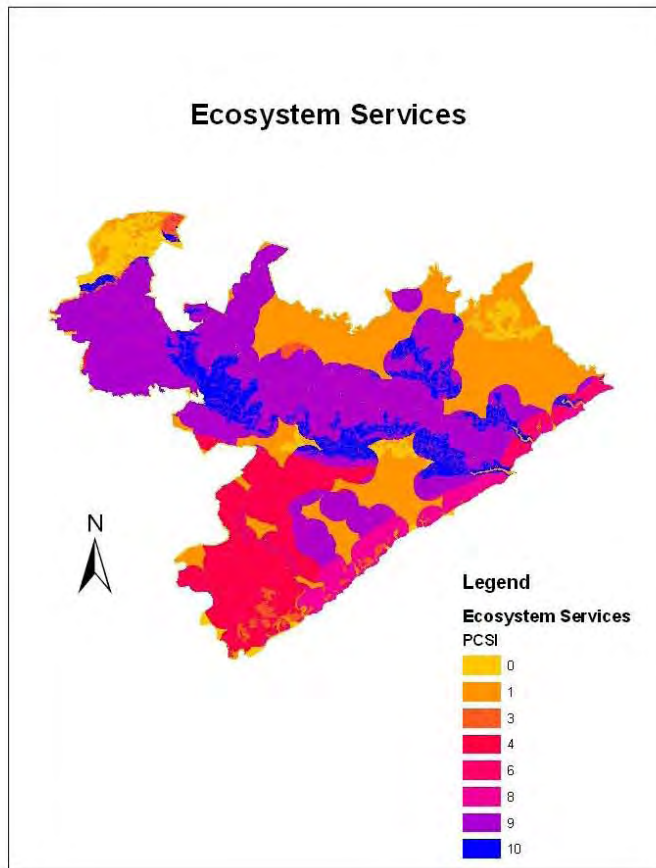
The ESI scores for ecosystem services grouped in their respective ecosystem functions categories (see: Table 4.7), regulation services, production and cultural services, and information services, are presented in Figures 4.9, 4.10 and 4.11.



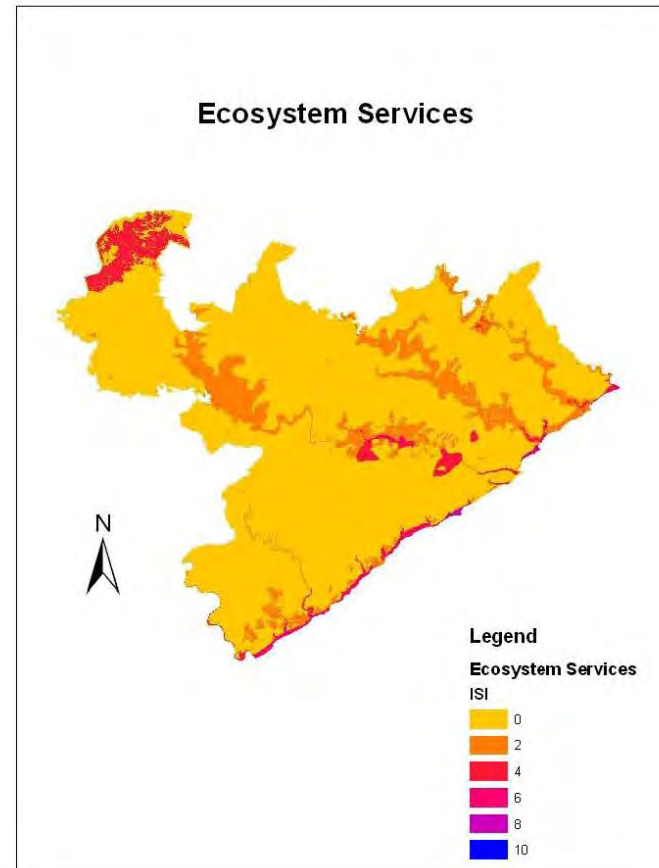
**Figure 4.8.** Overall ecosystem service index (ESI) scores for the BCM (highest provision of ecosystem service = highest ESI score)



**Figure 4.9.** Ecosystem service index (ESI) scores for all regulation services for the BCM (highest provision ecosystem service = highest ESI score)



**Figure 4.10.** Ecosystem service index (ESI) scores for all productive and cultural services for the BCM (highest provision of ecosystem service = highest ESI score)



**Figure 4.11.** Ecosystem service index (ESI) scores for all information services for the BCM (highest provision of ecosystem service = highest ESI score)

#### 4.3.2 Analysis of ecosystem services provision and biodiversity priority overlap within the Buffalo City Municipality

There was an insignificant degree of correlation between BPI and ESI overall (Table 4.9). Considering individual services, only the carbon sequestration and aesthetic information services had a weak, positive correlation with the BPI. There was also a weak, positive correlation between the BPI and the information services index (ISI).

Considering specific components of the BPI, ecosystem type had a strong positive correlation with the regulation and information services indices. Ecosystem type also had a strong positive correlation with five individual ecosystem services, including flood control, water provision and supply, pollination, aesthetic, and grass broom and a negative correlation with two, livestock parasite control and livestock production. Carbon sequestration and ecosystem type had the highest degree of correlation. Meanwhile species of special concern had a weak negative correlation with the overall ESI.

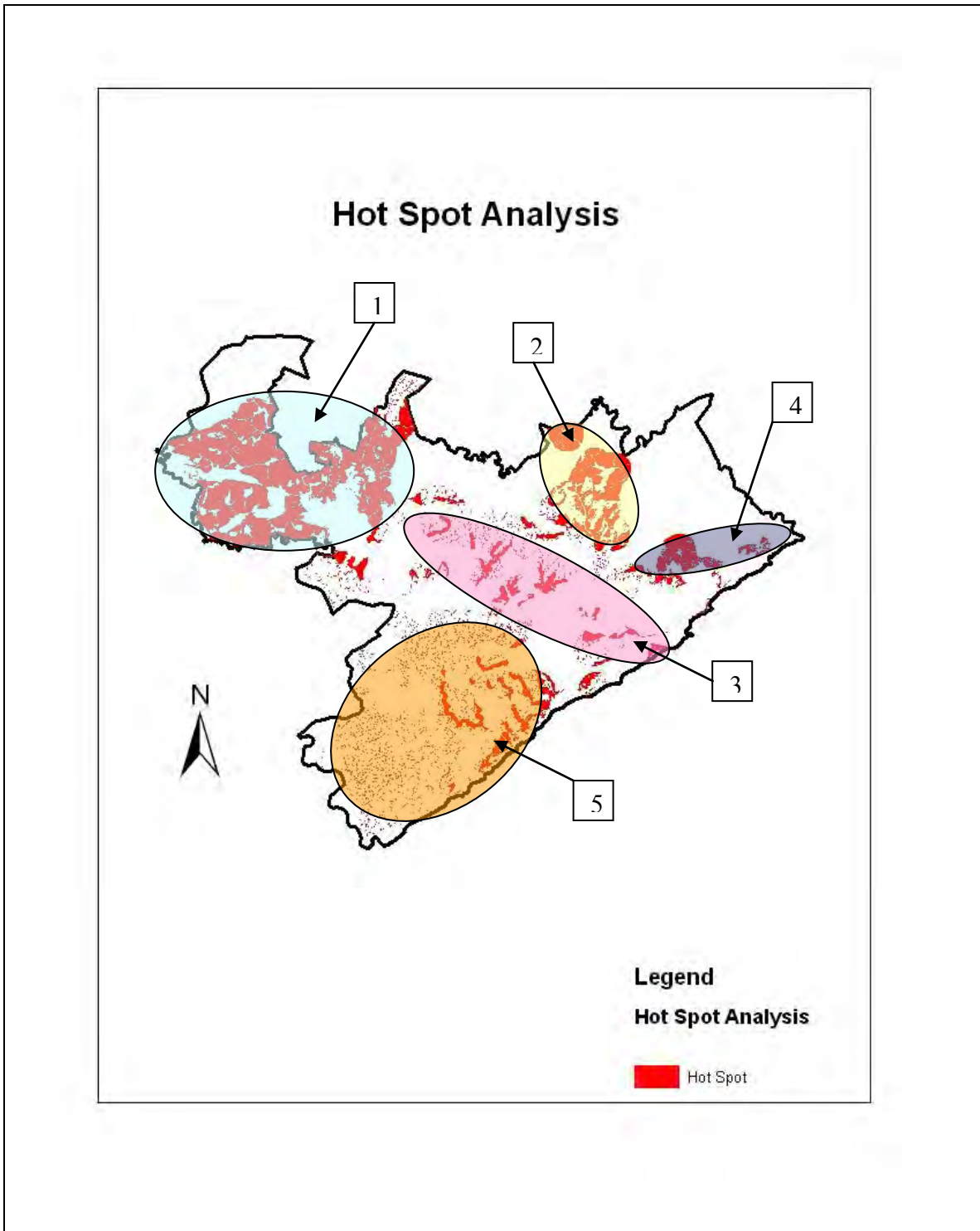
Figure 4.12 shows the results of spatially overlaying the ESI, BPI and current transformation status data layers to identify “hotspots” for implementation of biodiversity conservation using an ecosystem services approach. The areas in red indicated areas of high biodiversity priority ( $BPI > 5$ ), high ecosystem service provision ( $ESI > 5$ ) and which require restoration (passively or actively restorable). Table 4.10 provides a matrix of the most appropriate conservation actions to follow as determined by the variables of biodiversity priority, transformation status, ecosystem service provision (ESI) and land tenure.

The “hotspots” have been clustered into five “hotspots” that would assist with implementation of an ecosystem services approach to conservation within the BCM. The five “hotspots” can be described as: the north western region of BCM between King Williams Town and the Amathole Mountain Range; the northern region surrounding the Nahoon Dam/ Newlands area; central region/ Buffalo River Corridor from around Mdantsane and the Umtiza Forest to the East London coastline; north eastern coastal region between the Gonubie and Nahoon Rivers; southern coastal region between the

Gulu and Tsholmnaqua Rivers. As with Figure 4.5 above, the identified implementation “hotspots” are meant only as a guide to focus implementation.

**Table 4.9.** Correlation (r) between overall BPI, and its components (ecosystem type; biodiversity processes; and species of special concern), and the ecosystem services index (ESI) as well as individual ecosystem services and functions groups (regulation services (RSI); productive and cultural services (PCSI); information services (ISI))

	Carbon Seq	Flood	Water Prov	Erosion	Dune Stabil	Pollinatio	BioConLive	BioContRod	Wild Fruit
BPI	0.20	0.06	0.04	-0.07	0.01	0.11	-0.13	0.07	-0.03
EcoSysType	0.81	0.47	0.40	0.07	0.07	0.46	-0.47	0.05	-0.07
BioProcess	0.00	-0.14	-0.13	-0.03	-0.04	0.07	-0.13	0.13	0.04
SSC	0.16	0.09	0.07	-0.17	0.11	0.12	0.03	-0.23	-0.11
	Wild Veg	Fish	Fence	Construction	Fuelwood	Livestock P	Medicinal	Aesthetic	Rec Fishing
BPI	0.15	0.07	0.01	-0.01	-0.01	-0.03	0.08	0.27	0.08
EcoSysType	0.38	0.24	-0.17	-0.01	-0.01	-0.64	-0.28	0.40	0.26
BioProcess	0.03	-0.01	0.12	0.07	0.07	0.11	0.16	0.15	-0.02
SSC	-0.19	0.08	-0.18	-0.26	-0.26	0.01	-0.16	0.17	0.09
	Rec Walking	Slaughtering	Igoqo	Kraal	Grass Broom	Historic	Educational		
BPI	0.08	-0.01	-0.01	-0.01	0.04	0.01	0.00		
EcoSysType	0.33	-0.01	-0.01	-0.01	0.40	0.06	0.19		
BioProcess	0.16	0.07	0.07	0.07	-0.13	-0.04	-0.07		
SSC	-0.08	-0.26	-0.26	-0.26	0.07	0.09	0.01		
	ESI	RSI	PCSI	ISI					
BPI	0.07	0.05	0.02	0.19					
EcoSysType	0.12	0.36	-0.02	0.45					
BioProcess	0.09	-0.07	0.08	0.11					
SSC	-0.21	-0.01	-0.25	0.09					



**Figure 4.12.** Implementation “hotspots” for ecosystem services (1. north western hotspot; 2. northern hotspot; 3. central region/ Buffalo River corridor hotspot; 4. north eastern coastal hotspot; 5. southern coastal hotspot)

**Table 4.10.** Landuse and conservation planning matrix indicating the most appropriate conservation actions to follow as determined by the variables of biodiversity priority (BPI) transformation status (CTS), ecosystem service provision (ESI), and land tenure (public, private and communal); whereby: 0. No action currently; 1. Protected area expansion a) formal protected areas, b) conservancies; 2. Conservation development; 3. Policy measures for land owners; 4. Restoration; 5. Payment for ecosystem services

CTS		NR			AR			PR			UI		
Land tenure		Pub.	Pri.	Comm.	Pub.	Pri.	Comm.	Pub.	Pri.	Comm.	Pub.	Pri.	Comm.
BPI	ESI												
Low	<5	0	0	0	0	0	0	0	0	0	0	2/3	0
	>5	0	0	0	0	0	0	0	0	0	0	2/3/5	5
Med	<5	0	0	0	0	0	0	0	2/3	0	1a	1b/2/3	1b
	>5	0	0	0	0	0	0	0	2/3/5	5	1a/5	1b/2/3/5	5
High	<5	0	0	0	4	2/3/4	4	1a	1b/2/3	1b	1a	1a/b	1a/b
	>5	0	0	0	4/5	2/3/4/5	4/5	1a/5	1b/2/3/5	1/b/5	1a/5	1a/b/5	1a/b/5
Very High	<5	4	4	4	1a/4	1a/b/2/3	1a/b/4	1a	1a/b	1a/b	1a	1a/b	1a/b
	>5	4/5	4/5	4/5	1a/4/5	1a/b/2/3	1a/b/4/5	1a/5	1a/b/5	1a/b/5	1a/5	1a/b/5	1a/b/5

## CHAPTER 5: DISCUSSION

### 5.1 The status of biodiversity within the Buffalo City Municipality

#### 5.1.1 Analysis of protection status for ecosystem type, species of special concern and ecological processes

If it is the goal of the BCM to protect a representative sample of each ecosystem type based on the IUCN's target of 10% (SCBD, 2004) then of primary attention are the 11 ecosystem types of which less than 1% were under protection. Of secondary importance were the other five ecosystem types of which less than 5% were under protection. However, the need to protect specific ecosystem types needs to be ranked against other criteria, including how much of the ecosystem type has been lost to transformation, which is discussed further in section 5.2, and the level of endemism of the ecosystem type to the BCM. The BCM clearly has sole responsibility for endemic, and a major responsibility for near endemic, ecosystem types as these ecosystem types cannot be adequately protected anywhere else. Other ecosystem types, of which a large portion is found outside of the BCM, could potentially be better and more effectively protected in other municipalities, and this would have to be investigated on a case by case basis. This under representation of ecosystems within protected areas is not unique to the BCM and the situation was similar elsewhere in South Africa (Rouget *et al.*, 2003; Stewart *et al.*, 2005).

Both coastal dune ecosystem types (Transfish Coastal Forest and South East Coastal Vegetation) and a number of forest ecosystem types were either almost totally protected or highly protected by the current protected area network. These ecosystem types also received a high level of protection through other legislative means (e.g. the National Forest Act, 1998 and the National Environmental Management Act: EIA Regulations, 2006). Therefore, despite the fact that they are often cited as being of high conservation value within the BCM (Buffalo City Municipality, 2005) these vegetation types actually require little more in the way of further protection. However, it must be noted that legislative protection does not ensure the continued intactness of ecosystems and enforcement of legislation is required as in many cases the intactness, and therefore the

continued functioning, of these ecosystem types is under threat from ecosystem degradation (Buffalo City Municipality, 2005).

It is of concern that less than 3% of the area containing species of special concern is under formal protection of any kind. The RDB status of these species requires that they should undergo no further habitat loss. Ideally these species should be prioritised for formal protection, particularly where they are under high levels of threat from further landuse changes. Kerley *et al.* (2003) and Stewart *et al.* (2005) similarly found that the existing protected area networks within the Cape Floristic Region and the Nelson Mandela Bay Metropolitan area were insufficient for protecting species of special concern within these study areas.

Biodiversity processes as well were not well protected with less than 4% under protection. The long-term existence of biodiversity within the BCM, and more broadly, is reliant on the maintenance of these processes (Rouget, 2006a). It is therefore crucial that areas required for biodiversity processes are conserved as part of the overall conservation plan.

#### 5.1.2 Analysis of biodiversity priority protection

Overall, biodiversity within the BCM is not being adequately protected within the current protected area network. Future expansion of the protected area network to protect biodiversity should be focused on the spatially identified areas in Figure 4.5 which fall outside of the current protected area network. However, as is the case elsewhere, protected areas alone are unlikely to be an effective strategy for biodiversity conservation within the BCM (Margules & Pressey, 2000; Rouget *et al.*, 2003). Even focusing on very high priority biodiversity areas only would require the protection of 51 148 ha, or 19% of the BCM land area. Using a conservative estimate for BCM land value of R3 000/ha this would amount to more than R153 000 000 which, given the council's lack of financial resources for conservation, would not be financially feasible. Ideally much of the high and medium priority areas would also receive biodiversity action in some form. Clearly a broader set of conservation actions is required to support the protected area approach.

Despite the general lack of protection, however, the current BCM protected area network has been fairly efficient in capturing areas of higher biodiversity priority which can be attributed to the fact that the majority of protected areas within the BCM have been established for the conservation of biodiversity and have tended to focus on biodiversity rich habitats such as coastal dune and inland forests (Buffalo City Municipality, 2006a).

## **5.2 Current transformation status of the Buffalo City Municipality**

Conserving a representative sample of local biodiversity within the BCM will require conservation of biodiversity outside of formally protected areas. As well as this, the majority of ecosystem types, species of special concern and biodiversity processes were highly transformed. Ensuring adequate and representative conservation of biodiversity would therefore have to be achieved through preventing further degradation of the restorable, both active and passive, land parcels which together comprise 60% of the total BCM area. Ideally these actively and passively restorable land parcels would be restored to enhance their biodiversity intactness and value. To achieve this, biodiversity outside of protected areas will have to be conserved within productive, living landscapes (Knight & Cowling, 2003).

Biodiversity intactness (BI) for the BCM was just over half of pre-transformation levels and provides a useful overall measure against which to monitor progress of conservation action in the future. Scholes and Biggs (2005) determined a BI value for the entire South Africa of 84% although Rouget *et al.* (2006b) found this figure to be inflated due to the coarseness of the transformation data used by Scholes and Biggs. Using finer scale transformation data, Rouget *et al.* (2006b) determined a BI value of 66.8 and 65.4 for an area within the Sub-tropical Thicket and Succulent Karoo biomes, respectively. The transformation categorisation for the BCM was undertaken at a finer scale than that used by Rouget *et al.* (2006b).

Currently the BCM Integrated Development Plan contains an objective to decrease the loss of biodiversity within the BCM. However, there is no useful measure or target against which this can be objectively evaluated (Buffalo City Municipality, 2006b). It is

proposed therefore that the BI would provide a useful and objective measure for the council to determine progress towards its objective to decrease the loss of biodiversity.

#### 5.2.1 Analysis of current transformation status of ecosystem types

A number of ecosystem types were highly transformed and required urgent conservation attention. In particular, Cintsa Dune Thicket required conservation action despite coastal fore-dune vegetation along the BCM being well conserved. This is because land directly behind coastal fore-dunes is considered as being of prime development potential in urban areas and in many cases as prime agricultural potential in rural areas (Buffalo City Municipality, 2005).

Similar conservation action should be considered and undertaken for Moist Mountain Grassland although this should be weighed up against the fact that just more than 1% of the total extent of the ecosystem type occurs within the BCM (Table 2.1) providing ample opportunity to conserve it elsewhere. In the case of Cintsa Dune Thicket, 20% of the total ecosystem type is found within BCM.

For the endemic and near-endemic ecosystem types the results suggested that Umtiza Forest Thicket, Buffels and Buffels Valley Thicket, and Kiwane Dune Thicket were all of potentially conservation concern. The status of these ecosystem types was also confirmed by the STEP assessment (Pierce, 2003). Ecosystems types that are endemic or near-endemic should receive priority conservation attention as the opportunities for ensuring their future existence resides either entirely or largely within the BCM. Other, non-endemic ecosystem types could potentially be better conserved outside of the BCM where such options still exist.

#### 5.2.2 Current transformation status and biodiversity priority

Of some relief when comparing transformation status and biodiversity priority is that the percentage of non-restorable areas was highest for low biodiversity priority areas and lowest for high and very high priority. This relationship was reversed when looking at un-impacted areas, where very high biodiversity priority areas had the greatest percentage

while low and medium priority had the lowest. This suggested that current patterns of development and conservation had been biased towards protecting higher biodiversity priority areas. Making use of the guidance for landuse planning and decision making (Table 4.7) would help to enhance this bias in the future.

### **5.3 Ecosystem services provision within the Buffalo City Municipality**

#### **5.3.1 Identification and valuation of ecosystem services provision**

The study deliberately favoured ecosystem services which required high levels of biodiversity intactness in order to increase the likelihood of spatial congruence between biodiversity priority and ecosystem service provision (Balvanera *et al.*, 2001). The classification of ecosystem functions provided by de Groot *et al.* (2002) provided a highly useful tool for engaging with stakeholders and identifying ecosystem services provision within the BCM. While Boyd & Banzhaf's (2007) definition of *final* ecosystem service provided a useful means to focus a somewhat complex exercise of identifying ecosystem service provision.

The natural capital providing the 26 ecosystem services identified by the study can be regarded as critical according to the definition provided by Ekins *et al.* (2003). All of the services identified could not be substituted for, at least not within the limits of the local financial resources available to the BCM; the loss of these services would be irreversible, again given the limits of available local resources; and their loss would entail immoderate losses to the people of the BCM.

Although it was not the object of this study, numerous other studies at global and local level have shown that there is significant monetary value derived from ecosystem services (Costanza *et al.*, 1997; Shackleton *et al.*, 2001; Postel & Thompson, 2005). A number of studies at both global and local level have shown that it is economically beneficial to invest financial capital into maintaining and rehabilitating natural capital that provides ecosystem services (Balmford, 2002; Anon, 2004; Kremen & Ostfeld, 2005). For instance, at a global scale conservative estimates valued the benefit: cost ratio of an intact global ecological or protected area system at 100:1, thus a \$45 billion dollar a

year outlay would deliver between \$4.4 and \$5.3 trillion dollars in ecosystem services (Balmford, 2002).

### 5.3.2 Analysis of ecosystem services provision and biodiversity priority overlap within the Buffalo City Municipality

The degree of overlap between the overall ESI and BPI was weak. However, if one investigates the components of the two indices there are some that held promise and warrant future investigation. In particular, carbon sequestration and storage held promise as the results show that there was a significant overlap between this particular ecosystem service and biodiversity priority in general and ecosystem type specifically. Another five ecosystem services had a positive correlation with ecosystem type including flood control and water provision and supply, pollination, aesthetic information, and grass broom provision. If combined together with carbon sequestration and storage as a group of services, they would provide a basket of ecosystem services which could be mapped, along with the users of these ecosystem services, to harness local action for biodiversity conservation. The merits of utilising these components within a more refined index are discussed further below.

### 5.3.3 Recommendations for a refined ecosystem service index for the Buffalo City Municipality

The scores for carbon sequestration, derived from a similar study done for the eThekweni Municipality (Glenday, 2007), should be more accurately measured for BCM ecosystem types. The methodology of the eThekweni study could be adapted for the BCM. Internationally there is a great deal of funding available for measures which prevent greenhouse gas emissions and generate carbon credits through the Kyoto Protocol and its Cleaner Development Mechanism (CDM).

Water supply and provision and flood control are particularly well researched elsewhere within South Africa and around the world and measures for implementing Payment for Ecosystem Services (PES) programmes for this service are underway (Anon, 2004). Again the methodologies employed by these studies could be replicated within the BCM,

although they may be more applicable on a water catchment scale. Currently most of the BCM area, including all of the major dams and urban areas, are contained within the Buffalo River primary catchment which is therefore an ideal study area to apply research on fresh water provision as well as flood protection and storm water discharge services. Both of these services would be of relevance to the general population but also to the BCM council and other water service authorities within the area. These authorities are responsible for providing potable water to the citizens within the BCM and, in the case of the municipal council, for providing and maintaining storm water protection and discharge (Buffalo City Municipality, 2002).

Agri-industry is important within the BCM (Buffalo City Municipality, 2006b; Buffalo City Municipality, 2006c) and including pollination within an ecosystem service index would give biodiversity relevance to this sector. The importance of pollinators in agriculture is being increasingly recognised and there is currently a growing interest from governments internationally for research into the role of pollinators and their contribution to their economies (BBKA, 2009). Within the BCM this would involve further refining the list of economically important plant species, their specific pollinators and the ecosystem requirements of these pollinators as well as more detailed spatial mapping of the pollinator habitat requirements.

The service provided by scenic and aesthetically pleasing natural elements would have broad appeal, particularly to political decision makers, if it can be linked to the continued provision of tourism benefits. Tourism is known to translate into economic benefits and job creation and this is recognised by the BCM's Tourism Master Plan (Buffalo City Municipality, 2004).

Finally, the inclusion of at least one productive and cultural service, in the form of the provision of materials for producing grass brooms, would be of direct appeal to the *amaXhosa* population within the BCM as it would provide a strong cultural incentive to maintain natural capital (Cocks, 2006). Grass brooms fill both a productive and cultural function within a typical *amaXhosa* household within the BCM (Cocks, 2006). It is

proposed that this cultural connection would provide a far stronger rationale for protection of natural capital, for the general citizenry of the BCM, than more abstract services such as carbon sequestration and aesthetically pleasing landscapes.

## **5.4 Focusing conservation action within the Buffalo City Municipality**

### 5.4.1 Identifying spatial priority areas for conservation implementation

Clustering priority areas into “hotspots” for implementation provided a useful context to spatially guide conservation implementation and also provided a useful guide for where further, finer scale analysis for ecosystem services and biodiversity should be undertaken (but see: Naidoo *et al.*, 2008). Given that conservation resources are low, such an approach is essential to utilising available resources in the most efficient means possible. Using the results, several approaches to spatially focussing conservation action are discussed below.

For programmes specifically aimed at ecosystem service provision (Figure 4.11), or any of the figures spatially representing an individual service or functions categories, should be used to guide the implementation of such programmes. For programmes aimed at restoration of ecosystems, Figure 4.6 spatially depicting current transformation status could guide such programmes but should be coincided with either biodiversity priority or ecosystems service provision, or both, in order to ensure such programmes deliver the multiple benefits to society. The section below further discusses what conservation action could be undertaken within such “hotspots” and other priority spatial areas.

It is important to note that the identified implementation “hotspots” were meant as a guide to focus implementation. It may not be necessary for the entire “hotspot” to be under conservation action but rather that the priority areas within these “hotspots” should be targeted.

### 5.4.2 Implementation options for conservation action

The BCM has a number of potential conservation actions that it could follow in implementing its conservation plan and in preserving ecosystem services. The four main

variables to consider in determining an appropriate conservation action for a given land parcel, or group of land parcels, are:

1. The level of biodiversity priority, from low to very high;
2. The level of relative ecosystem service provision from 1 (low) to 10 (high);
3. The transformation status of the land, from non-restorable to un-impacted; and
4. The land tenure and ownership of the particular land parcel(s) in question, including public, private or communal.

There are also a number of conservation actions, or combination thereof, which could be implemented for any given land parcel, or group of land parcels, and which would be influenced by the above mentioned variables including:

- Protected area expansion
  - Formal protected areas
  - Conservancies
- Conservation development
- Policy measures for land owners
- Restoration
- Payment for ecosystem services

The above are by no means an exhaustive list of conservation actions that could be used for conservation within the BCM but are felt by the author to represent a good cross section of those available and with a realistic chance of success within the context of the BCM. Other conservation actions that may also be considered include conservation farming within commercial farmlands (Koelle *et al.*, 2003); reconciliation ecology, described as the science of accommodating wild nature within human-modified landscapes, particularly within urban areas (Miller, 2006); and community-based natural resource management (CBNRM) within communal areas (Fabricius *et al.*, 2004).

For any given land parcel or group of land parcels, the appropriate conservation action will be determined by the four variables mentioned above. Other factors or variables may well also be influential in determining the most suitable action, such as available

finances, but for the purposes of this study these were not considered further. These individual conservation actions mentioned above are also discussed in the context of two potential conservation models, biosphere reserves and ecologically sustainable landuse. Finally the section ends with a discussion of a new conservation model that could be adapted for the BCM and used to ensure effective conservation action.

#### 5.4.2.1 Protected areas

Protected area expansion is the traditional model for conservation (Edwards & Abivardi, 1998) and there is already an existing protected area network within the BCM. According to the IUCNs definition for protected areas there are a number of protected area categories to consider (IUCN, 1994). Boitani *et al.* (2008) however, argue for a re-evaluation of the IUCN protected area categories based on biodiversity outcomes rather than the current management outcomes. For the purposes of this study protected areas as discussed here include: 1. formally protected areas under South African legislation, whether national, provincial or local and 2. conservancies, where privately owned land is put aside for the purposes of conservation and which at a minimum receives a level of protection through the BCM zoning regulations (this would normally be a zoning of Open Space 1, 2, or 3).

Protected area expansion should be considered the highest level of conservation action and should be considered for any area of very high conservation value whether requiring restoration or providing ecosystem services, as well as for high biodiversity priority land parcels. Land parcels providing high levels of ecosystem services, or a particularly important specific service, and which requires high levels of protection to ensure the continued provision of the service, or services, should also be considered, although other conservation models may be more appropriate. Expansion of future protected areas within the BCM guided by biodiversity priority or ecosystem service value would help ensure that they are determined based on their biodiversity, rather than management, outcomes (Boitani *et al.*, 2008).

Whether the land parcel should be formally protected or fall into a conservancy would depend largely on whether the land was publicly or privately owned. A number of policy measures are available for privately owned land (Doremus, 2003; Pence *et al.*, 2003). The conservancy model could also potentially be used for communally owned land parcels, although again there may be better models to utilise.

#### 5.4.2.2 Conservation development

Conservation development (Pejchar *et al.*, 2006) could be a particularly useful model to follow for land parcels under private land ownership, which are not necessarily suitable for protected area status but which contain elements of priority biodiversity or high levels of ecosystem service provision. This route is likely to be utilised more on an ad-hoc basis as and when private landowners apply to exercise development rights they may have over land that contains elements of biodiversity or ecosystem importance. The basic premise of conservation development is that a landowner is able to develop a portion of their land in exchange for providing protection of areas requiring protection. This is also a useful model to follow where active restoration of the land parcel requiring protection is needed, as the development of the remaining land can fund the restoration and future protection of the biodiversity priority land parcels. Ideally the land parcels requiring protection should receive at least a minimum of open space zoning protection under the BCM zoning regulations, as previously discussed above for conservancies.

The conservation development model could be followed for any level of biodiversity priority and ecosystem service provision, although the protected area model would be more suited for very high, and potentially even some high priority areas. Equally it could be followed for any level of transformation status. With regards to land tenure it is obviously more appropriate for private land ownership, with it being unlikely to be applied to public and communally owned land.

#### 5.4.2.3 Policy measures for land owners

Priority biodiversity and high ecosystem services provision land parcels can be utilised to guide the implementation of policy measures for private land owners. These measures

can be packaged into two main forms that could be applied by the BCM council based on Pence *et al.* (2003). As a local authority, the BCM council is responsible for the setting and implementation of its rates. Therefore, as a financial incentive, it has the power to set lower rates for land parcels managed for biodiversity and ecosystem service provision as described by Pence *et al.* (2003). Alternatively, as a disincentive, it could apply higher rates for land being inappropriately managed such as alien infested land.

With regards property rights instruments, the BCM has adopted zoning as a landuse restriction rather than conservation easements or title deed restrictions, which effectively achieve the same outcome (Buffalo City Municipality, 2007). Also, once a parcel of land is zoned from open space, or for conservation, any change in landuse would constitute a listed activity in terms of South Africa's Environmental Impact Assessment Regulations. This adds another level of protection which would not be achieved with title deed restrictions alone. The second property rights measures would therefore be entering into management agreements, also known as stewardship agreements, with landowners, but should also include conservation education measures as well as management assistance (Pence *et al.*, 2003). This package of measures could also potentially be applied to communal land users in certain cases.

#### 5.4.2.4 Restoration

The restoration conservation action would mainly be applied to very high and high biodiversity priority land parcels and potentially those providing high levels of ecosystems services. Obviously intensive restoration activity should be reserved for actively restorable, and in rare cases non-restorable land parcels of very high biodiversity priority. Passive land management techniques, such as controlling grazing pressure or re-implementing fire regimes, rather than active restoration would be more suitable for land parcels categorised as passively restorable. However, restoration would best be suited for biodiversity features requiring protection for which there are not enough un-impacted and passively restorable land parcels to achieve a required biodiversity target. Targets, however, were not a subject of this research and therefore these would need to be determined through further study. However, this research does provide useful guidance as

to which biodiversity features are highest priority and towards which limited research budgets should be directed.

It is proposed that restoration efforts adopt a pragmatic or ecosystem services approach (Clewell & Aronson, 2006) to increase support for such projects and to provide a goal oriented approach, i.e. the restoration of a clearly defined ecosystem service or group of ecosystem services. All of the ecosystem services identified as part of this research require high levels of biodiversity intactness and thus their restoration would, in any case, also require the restoration and conservation of biodiversity.

For land managed by the BCM itself and for other public land, grant funding received, particularly from national government for ecosystem management programmes (e.g. Working for Water (WfW) and Coast Care) should be channelled towards these restoration activities on public and also communal land. Restoration activities, under the South African approach, have the added benefit of creating local employment as well as restoring ecosystem services and helping to protect biodiversity (Gutman, 2003).

#### 5.4.2.5 Payment for ecosystem services

For those ecosystem services which have a high level of overlap with biodiversity priority, it would be useful to investigate payment for ecosystem service (PES) programmes (Gutman, 2003; Kremen & Ostfeld, 2005). It is recommended that more detailed spatial congruence analysis for these specific ecosystem services and biodiversity priority is undertaken to confirm the results of this study. PES programmes could be carried out over land parcels under any level of transformation status and land tenure. In cases where land requires restoration, the PES programme should invest in restoration of these areas. PES programmes for ecosystem services that do not necessarily have a high level of congruence with biodiversity priority may still be of interest to sectors other than the conservation sector (e.g. the water or agricultural sectors).

### 5.4.3 Determining a framework for implementing conservation action

To achieve the above implementation actions within the priority areas for implementation a broader conservation framework is proposed. There are two conservation concepts, one fairly old and one fairly recent, which are proposed to be utilised as the basis for the proposed framework, and which are expanded upon further below.

#### 5.4.3.1 Biosphere reserves and ecologically sustainable landuse

Any given area identified for implementing conservation action is likely to contain a diversity of land uses and therefore it is unlikely that only one of the above mentioned conservation actions is likely to achieve the desired result. It is likely that a broad range of actions will be required to achieve the desired result for such a diversity of land uses. A suitable conservation framework is therefore required to ensure that these diverse sets of land uses and conservation actions are managed towards a common objective.

Ecologically sustainable land management in the form of the mega-conservancy concept has been promoted by the STEP programme (Knight & Cowling, 2003) and provides a useful framework which can be used by the BCM for implementing conservation action. This concept is particularly useful for implementing the network areas identified under the STEP programme. Another useful framework for implementing conservation action is the biosphere reserve concept (Brunckhorst, 2001; Nations, 2001) and which again would provide a useful framework for implementing conservation action with the BCM.

The biosphere reserve concept is internationally well known and is governed by a set of guidelines under the United Nations Man and the Biosphere Programme. Both concepts are similar in that they provide a conservation framework within which a variety of landuses and conservation actions can be included. It is proposed that the BCM draws from both of these conservation frameworks for implementing conservation action within focus areas, although it may be more sensible for practical purposes to choose one or the other as the primary framework within a given focus area.

#### 5.4.3.2 Towards an implementation plan for conservation action

It is important that the spatial data generated be used to guide conservation action on the ground to bridge the planning-action gap (Knight *et al.*, 2006). An attempt to try to bridge that would be supported by a spatially applicable decision support matrix for determining the most appropriate conservation action (Table 4.10). The appropriate action is influenced by the four major variables discussed in section 5.4.2 above. If necessary, this matrix can be spatially “mapped” based on these variables to provide a further decision support tool.

The proposed conservation actions should not be seen as static and „cast in stone“ but rather the matrix should be seen as a dynamic entity that is adjusted and updated as conservation implementers gain experience in the implementation of the conservation plan (Knight *et al.*, 2006). The proposed actions should be seen as just that, proposed, and an initial attempt around which further discussions may eliminate, add or completely change any of the proposed actions. It is hoped that such a spatially explicit implementation plan would bridge the planning-action gap (Knight *et al.*, 2006) and help to crystallise conservation action in a manner that merely providing a map of conservation priority would not.

It should be noted that although the protected area model was put forward as a potential conservation action in a number of cases, it is only in a small number that it was put forward as the only option for conservation action. Land parcels for which this was the case account for less than 10% of the total area of the BCM (Table 4.6) and this is discounting the ecosystem service variable which would provide a further potential conservation option in the form of PES. Thus this percentage is likely to be far lower and given that the BCM currently only has around 3% of its land area under formal protection there is room for expansion of this protected area network. It is also worth noting that not all of this proposed protected area network will fall on publicly owned land and thus the financial burden, and potential benefits, of conservation would not just be borne by the public sector.

## **5.5 Discussion of methods and refinement of spatial data**

This study should be seen as an initial first step towards developing a far more comprehensive understanding of conservation planning and the use of ecosystem services for the protection of biodiversity within the BCM. The study created three main data layers and the sections below briefly discuss what needs to be done so that each of these layers can be improved and in so doing provide a better overall picture of biodiversity and ecosystem services with the BCM in the future.

### **5.5.1 Refining the biodiversity priority index**

This study required a means for determining biodiversity priority that was rapid but provided useful information regarding the status of biodiversity within the BCM. It thus made use of, and improved upon where possible, spatial data that were already in existence, particularly for ecosystem type and ecological processes. While it is felt that this method provided a level of data relevant to the context of this study, it is recommended that more accurate mapping and potential subdivision of biodiversity features is undertaken. The existing ecosystem type, ecological processes and SSC layers, however, provide a good basis from which to work on such a refinement.

The hotspot method of mapping SSC was a simple but useful method where detailed species distribution data were incomplete or totally lacking. In interpreting the biodiversity priority index, it is important to consider which component of biodiversity is driving the underlying score, and in the case where it is species of special concern, then the accuracy of these data should be considered, particularly if the data are being considered at a fine-scale.

This approach it must be said treats every species equally and other conservationists may well correctly argue that some species are “more equal than others”, such as keystone or flagship species. Future updates of the SSC data layer should potentially take this into account. It should also be noted that the list may not be complete, particularly with regards to invertebrates, as it was based on available information for the area, which is especially limited for this taxonomic group.

Future research into targets for the above mentioned biodiversity features is also recommended. This will allow the conservation plan to be aligned with the current national guidelines for publishing conservation plans, also referred to as bioregional plans, under the National Environmental Management: Biodiversity Act, 2004. Future versions of a BCM conservation plan could greatly benefit from the use of a more target oriented approach.

#### 5.5.2 Refining the ecosystem service index

It is important to recognise that the objective of this study was not to produce a highly accurate prediction of ecosystem service value but rather a useful approximation that could be used to guide further research into ecosystem service provision. Accurate data to support a highly accurate index do not exist at this stage. The objective of this study was to get an indication of the potential for the use of ecosystem services as a biodiversity conservation tool within the BCM. However, by determining which services are likely to be the best candidates for such further research, the current index provides a useful first step in the direction of a more refined and accurate index. The individual ecosystem services with high levels of congruence, discussed in section 5.3.3 above, are therefore recommended for future, more in-depth research.

Ultimately, as better and more accurate data become available for ecosystem services, the ESI should be incorporated as a “biodiversity feature” within a more comprehensive conservation plan. Conservation planning should not be confined purely to the protection of biodiversity for the sake of maintaining biodiversity, but rather should include social and economic concerns (Driver *et al.*, 2005). The list of 26 ecosystem services determined through this study provide a good indication of what these social and economic concerns are. The conservation sector itself may wish to focus on those that are most congruent with high biodiversity priority areas within the BCM but it is also worth ensuring that other sectors consider the broader array of ecosystem services within their planning as all 26 ecosystem services identified require high level biodiversity intactness and therefore the protection of these services would contribute greatly to overall biodiversity conservation.

Finally, individual ecosystem services used for the ESI were spatially mapped using available information and in certain cases assumptions and predictions were used e.g. the use of ecosystem types as a prediction of species distribution for the production and cultural services. This would clearly have an effect on the accuracy of data for individual species and therefore the index as whole, although in the case of the index it is hoped that the accumulative total of the individual services would serve to balance out any inaccuracy at an individual level. The author's view is that the existence of a positive or negative correlation of ecosystem service provision with biodiversity priority should be viewed as a basis for further research and confirmation of this correlation. The result of this study is therefore to give direction to further research into ecosystem service provision within the BCM.

### 5.5.3 Refining the current transformation status layer

The current transformation status data layer was considered sufficient for the purposes of this study. However, future conservation plans for the BCM could potentially benefit from improved mapping of transformation status. This is, however, with the proviso that the biodiversity layer itself is better refined as it makes little sense to have a refined transformation layer without a corresponding refinement of the biodiversity data. It is therefore recommended that the biodiversity layers, in particular the ecosystem type layer, be better refined before focusing on transformation status.

Mapping transformation against past, and future, aerial photography sets and determining the BI will allow for a useful time-series comparison on the rate of biodiversity loss over time. It would also be useful to compare the BI against the national average and other geographical areas, including other municipalities, which have also undertaken this exercise.

## 5.6 Conclusions

The BCM is endowed with numerous ecosystem services, 26 of which were identified as part of this study. The BCM also contains nationally and globally important biodiversity which is under increasing threat. This study has concluded that the full scope of this biodiversity is not adequately protected and new and effective means for conserving biodiversity outside of protected areas is required. There are a number of appropriate conservation actions available to the BCM which have been discussed as part of this study and which could be relevant under a diversity of landuse scenarios.

To mainstream the protection of biodiversity it will be necessary to make biodiversity relevant to broader society and ecosystem services provide a useful means for doing so. The use of ecosystem services, in the form of payment for ecosystem services, to ensure that priority biodiversity is protected has merit within the BCM as there is correlation between at a number of specific ecosystem services and priority biodiversity areas. The study identified priority focus areas within which conservation action should be concentrated.

Outside of the BCM it seems likely that the results of this study would be applicable within the subtropical thicket biome. It is expected that the spatial coincidence of priority ecosystem service areas and priority biodiversity areas may be a matter of local significance. However, it also seems likely that similar studies of other local areas within the subtropical thicket, and other biomes, are likely to find similar coincidence with at least some of their own sets of ecosystem services. This should be taken advantage of and used as a tool within the conservation arsenal. Ultimately it seems fair to conclude therefore that ecosystem services are globally relevant but locally applicable.

## CHAPTER 6: REFERENCE LIST

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## APPENDICES

**Appendix 1.** de Groot *et al.* (2002) classification of ecosystem functions

Functions Category	Functions	Ecosystem Processes and Components	Examples of Goods and Services
Regulation functions	Gas regulation	Role of ecosystem in bio-geochemical cycles (e.g. CO <sub>2</sub> / O <sub>2</sub> balance, ozone layer, etc)	Uvb-protection by O <sub>3</sub> (preventing disease)  Maintenance of (good) air quality Influence on climate (see also func. 2)
	Climate regulation	Influence of land cover and biol. Mediated processes (e.g. DMS-production) on climate	Maintenance of a favorable climate (temp., precipitation, etc) for, for example, human habitation, health, cultivation
	Disturbance prevention	Influence of ecosystem structure on dampening environmental disturbances	Storm protection (e.g. by coral reefs)  Flood prevention (e.g. by wetlands and forests)
	Water regulation	Role of land cover in regulating runoff and river discharge	Drainage and natural irrigation
	Water supply	Filtering, retention and storage of fresh water (e.g. in aquifers)	Medium for transport Provision of water for consumptive use (e.g. drinking, irrigation and industrial use)
	Soil retention	Role of vegetation root matrix and soil biota in soil retention	Maintenance of arable land
	Soil formation	Weathering of rock, accumulation of organic matter	Prevention of damage from erosion/ siltation Maintenance of productivity on arable land Maintenance of natural productive soils
	Nutrient regulation	Role of biota in storage and recycling of nutrients (e.g. N,P and S)	Maintenance of healthy soils and productive ecosystems
	Waste treatment	Role of vegetation and biota in removal or breakdown of xenic nutrients and compounds	Pollution control/ detoxification  Filtering of dust particles Abatement of noise pollution
	Pollination	Role of biota in movement of floral gametes	Pollination of wild plant species Pollination of crops
	Biological control	Population control through trophic-dynamic relations	Control of pests and diseases  Reduction of herbivory (crop damage)

Habitat functions	Refugium function	Suitable living space for wild plants and animals	Maintenance of biological and genetic diversity (and thus the basis for most other functions)
	Nursery function	Suitable reproduction habitat	Maintenance of commercially harvested species
Production functions	Food	Conversion of solar energy into edible plants and animals	Hunting, gathering of fish, game, fruits, etc.
	Raw materials	Conversion of solar energy into biomass for human construction and other uses	Small-scale subsistence farming and aquaculture Building and Manufacturing (e.g. lumber, skins)
	Genetic resources	Genetic material and evolution in wild plants and animals	Fuel and energy (e.g. fuel wood, organic matter) Fodder and fertilizer (e.g. krill, leaves, litter) Improve crop resistance to pathogens and pests
	Medicinal resources	Variety in (bio)chemical substances in, and other medicinal uses of, natural biota	Other applications (e.g. health care) Drugs and pharmaceuticals
	Ornamental resources	Variety of biota in natural ecosystems with (potential) ornamental use	Chemical models and tools Test and essay organisms Resources for fashion, handcraft, jewelry, pets, worship, decoration and souvenirs (e.g. furs, feathers, ivory, orchids, butterflies, aquarium fish, shells, etc)
	Information functions	Aesthetic information	Attractive landscape features
	Recreation	Variety in landscapes with (potential) recreational uses	Travel to natural ecosystems for eco-tourism, outdoor sports, etc
	Cultural and artistic information	Variety in natural features with cultural and artistic value	Use of nature as motive in books, film, painting, folklore, national symbols, architect, advertising, etc.
	Spiritual and historic information	Variety in natural features with spiritual and historic value	Use of nature for religious or historic purposes (i.e. heritage value of natural ecosystems and features)
	Science and education	Variety in nature with scientific and educational value	Use of natural systems for school excursions, etc.  Use of nature for scientific research

**Appendix 2.** Species providing productive and cultural services within the BCM

Scientific name	Common name	Type	Habitat	BCM biome/ ecosystem type	Ecosystem Services (Pote <i>et al.</i> , 2006; Cocks, 2006; Shackleton <i>et al.</i> , 2001; Shackleton & Shackleton. 2006)
<i>Ptaeroxylon obliquum</i>	Sneezewood	Tree	Woodland, scrub forest, montane forest	Thicket, forest, savanna	Kraal building (rural and urban); Fuelwood (rural); Ritual slaughtering (rural and urban); Fencing (rural); Igoqo (rural); Construction Timber (rural)
<i>Olea europea subsp. Africana</i>	African Olive	Tree	Stream banks, riverine fringes, open woodland, mountain ravines	Riparian, thicket, savanna, forest	Kraal building (rural), Fuelwood (rural); Ritual slaughtering (rural and urban); Fencing (rural); Igoqo (rural); Stick (urban)
<i>Pappea capensis</i>	Jacket-plum	Tree	Open woodland, riverine fringes	Thicket, savanna, riparian	Kraal building (rural)
<i>Coddia rudis</i>	Small Bone-apple	Tree	Open woodland and scrub, forest margins	Thicket, savanna, forest	Kraal building (rural and urban)
<i>Ehretia rigida</i>	Puzzle-bush	Tree	Evergreen forest margins, open woodland, coastal and karroid scrub	Thicket, savanna, forest, coastal forest	Kraal building (rural and urban); Construction Timber (rural)
<i>Acacia karroo</i>	Sweet Thorn	Tree	Grassland Savanna	Savanna	Kraal building (urban); Fuelwood (rural and urban); Igoqo (rural and urban)
<i>Noltea africana</i>	Soap Shiny-leaf	Tree	High altitudes, along stream banks	Riparian	Fuelwood (urban)
<i>Scotia afra</i>	Karoo Boer-bean	Tree	Karroid bush and scrub, dry watercourses	Thicket, savanna	Fencing (rural)
<i>Cyperus spp</i>		Sedge	Watercourses, wetlands	Watercourses	Grass broom (urban)
<i>Phoenix reclinata</i>	Wild Date Palm	Tree	Riverbanks in low-lying open grassland	Riparian (in Grasslands)	Grass broom (urban)
<i>Hareephyllum caffrum</i>	Wild Plum	Tree	Forest	Forest	Wild fruit (rural)
<i>Dovyalis lucida</i>	Glossy Sourberry	Tree	Forest	Forest	Wild fruit (rural)
<i>Scutia myritina</i>	Cat-thorn	Tree	Coastal and scrub forest, forest margins	Forest, coastal forest, thicket	Wild fruit (rural)

<i>Tarchonanthus camphoratus</i>	Camphor-bush	Tree/ Shrub	Coastal dunes, forest margins, karroid scrub	Coastal forest, forest, thicket	Igoqo (Urban)
<i>Rhus dentata</i>	Nana-berry	Shrub/ Tree	Thornveld, open woodland and bushveld, margins of forest, riverine forest	Riparian, thicket, savanna, forest	Igoqo (Urban)
<i>Bulbine latifolia</i>		Herb	Grassland Savanna	Grassland, savanna	Medicinal
<i>Dioscorea sylvatica</i>	Forest Elephant's Foot	Flower/ Climber	Scrub, forest coast to mountains	Thicket, forest, coastal forest	Medicinal
<i>Hypoxis hemerocallidea</i>	Star-flower	Flower	Grassland	Grassland	Medicinal
<i>Ilex mitis</i>	African Holly	Tree	Forest	Forests	Medicinal
<i>Rhoicissus digitata</i>	Wild Grape	Flower	Coastal Dunes	Coastal forest	Medicinal
<i>Acalypha glabrata</i>	Forest False- nettle	Shrub/ Tree	Coastal forest, Forest, woodland, stream banks	Coastal forest, forest, thicket, watercourse	Construction Timber
<i>Brachylaena ilicifolia</i>	Small-leaved Silver-oak	Shrub/ Tree	Bush, Scrub Forest	Thicket	Stick (urban)
<i>Trichocladus ellipticus</i>	White Witch- hazel	Shrub/ Tree	Forest, streams and rivers	Forest, watercourse, riparian	Kraal, Fuelwood, Construction Timber, Ritual Slaughtering, Wild vegetable
<i>Olea capensis subsp. capensis</i>	Small Ironwood	Shrub/ Tree	Bush, littoral scrub, forest	Thicket, forest, coastal forest	Fuelwood, Ritual Slaughtering
<i>Vepris lanceolata</i>	White-ironwood	Shrub/ Tree	Forest, littoral thicket & dunes	Forest, Coastal forest/ thicket	Fuelwood
<i>Gymnosporia capitata</i>	Ashen Spikethorn	Shrub	Valley Thicket along Rivers	Valley thicket	Fuelwood
<i>Acacia caffra</i>	Common Hook Thorn	Tree	Woodland, wooded grassland, along rivers & streams	Thicket, savanna, riparian forest, watercourse	Construction Timber
<i>Mystroxydon aethiopicum</i>	Kooboo-berry	Shrub/ Tree	Forest, riverine fringes, open woodland	Forest, riparian, thicket, savanna	Fuelwood
<i>Lactuca inermis</i>	Wild Lettuce	Herb	Disturbed areas	Grassland	Wild vegetable
12 Spp Invertebrates		Inverteb rates	Estuaries	Estuarine	Fish/ fish bait
18 Fish spp		Fish	Estuaries	Estuarine	Fish/ fish bait
Grass spp		Grass	Grasslands, woodlands	Grassland, savanna, thicket	Grazing land for livestock (subsistence & commercial)

**Appendix 3.** Summary of the ecosystem service index mapping

Ecosystem Functions Category	Ecosystem Functions (de Groot <i>et al.</i> , 2002)	Benefit/ Ecosystem Service (Specific to BCM)	First natural capital filter	Second natural capital filter	Ecosystem service beneficiary “mapping”
<i>Regulation Functions</i>	Climate regulation	Carbon sequestration & storage	Vegetation types sequestering carbon	Entire BCM	All BCM residents & global community
	Disturbance prevention	Flood protection & stormwater discharge	Riparian vegetation, wetlands, catchment	In catchments with urban areas & settlements	Urban areas & settlements within specific catchment
	Water regulation & supply	Fresh water provision	Riparian vegetation, freshwater wetlands & catchments	Within catchments utilized for domestic, industrial and agricultural water provision	All users supplied by domestic, industrial and agricultural water
	Soil retention	Erosion prevention	Riparian vegetation, wetlands and vegetation on steep slopes	Catchments that contain human settlements (rural & urban) and agriculture	Settlements and farmers within catchments
		Sand dune stabilization	Coastal dune forest and fore dune vegetation	Buffer zone settlements within 1km (ref – CZM Bill/ CZMP?)	Residents of urban area/ settlements within buffer zone
		Pollination	Crop pollination	All vegetation types containing pollination agents	All habitat of pollinators within total potential range (as per Agric MP) of crops requiring pollination and foraging range buffer distance (6km) (ref)
<i>Production Functions</i>	Biological control	Livestock parasite control;	All vegetation types containing biological control agents	All habitat of cattle egret within total potential livestock farming range and foraging range buffer distance	Livestock owning households/ farms
		Rodent control	All vegetation types containing biological control agents	Buffer around settlements/ urban areas equalling the foraging range of owl spp	All urban/ settlement areas
	Food	Wild fruit	Ecosystem types within which species utilized are found	Within 2km (ref) buffer zone of urban area/ settlement	Residents of urban areas/ settlements within buffer zone
		Wild vegetables	Ecosystem types within which species utilized are found	Within 2km buffer zone of urban area/ settlement	Residents of urban areas/ settlements within buffer zone
		Fish	Ecosystem types within which species utilized are found	Within 2km buffer zone of urban area/ settlement	Residents of urban areas/ settlements within buffer zone
	Raw material	Building & manufacturing	Ecosystem types within which	Within 2km buffer zone of urban	Residents of urban areas/

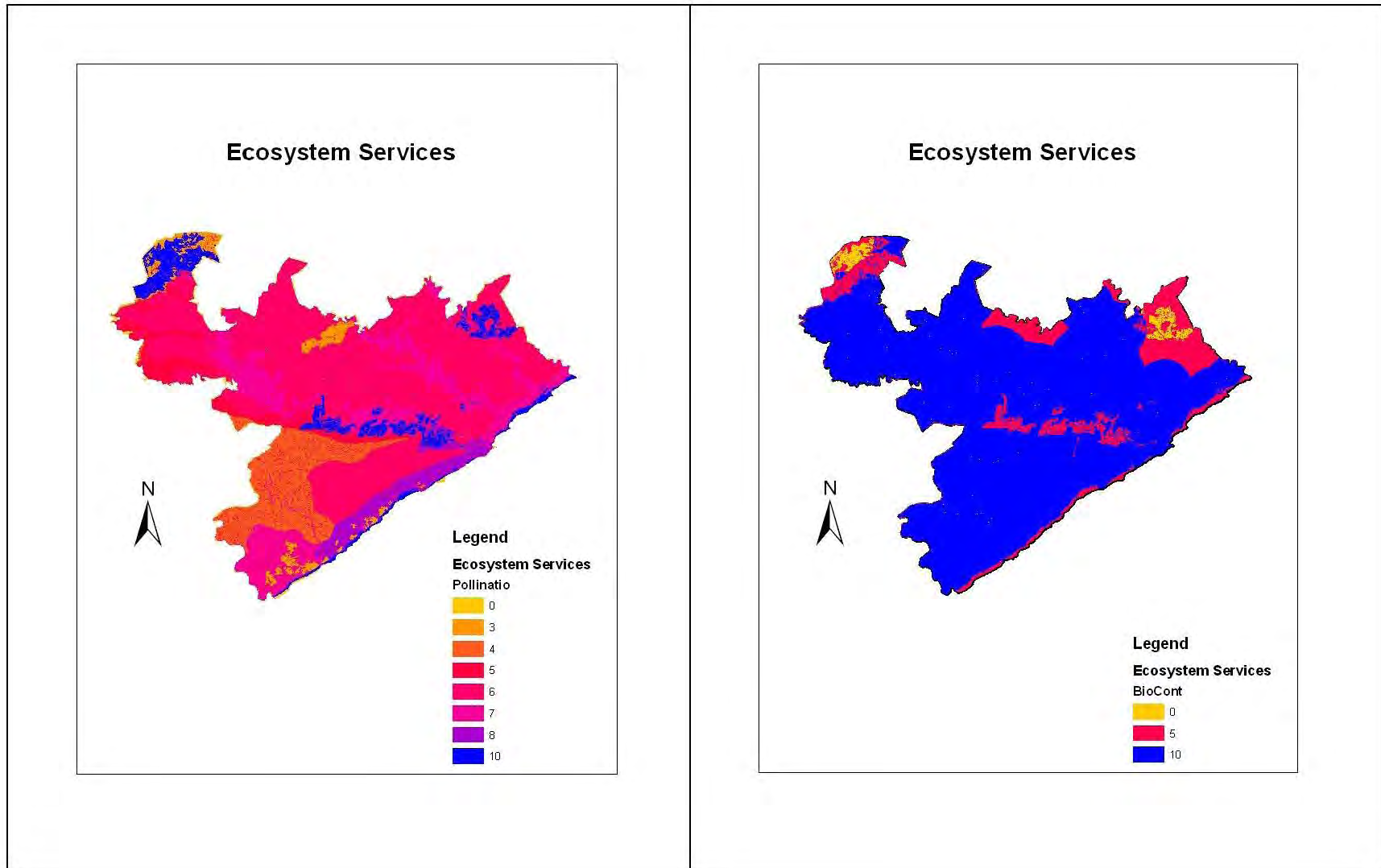
		material: Fencing	species utilized are found	area/ settlement	settlements within buffer zone
		Building & manufacturing material: Construction timber	Ecosystem types within which species utilized are found	Within 2km buffer zone of urban area/ settlement	Residents of urban areas/ settlements within buffer zone
		Fuel & energy: Fuelwood	Ecosystem types within which species utilized are found	Within 2km buffer zone of urban area/ settlement	Residents of urban areas/ settlements within buffer zone
		Fodder & fertilizer: Livestock production (commercial & subsistence)	Ecosystem types within which species utilized are found	Ecosystem types within the total potential livestock potential range	Livestock owning households/ farms
<i>Information Functions</i>	Medicinal resources	Medicinal resources	Ecosystem types within which species utilized are found	Within 2km buffer zone of urban area/ settlement	Residents of urban areas/ settlements within buffer zone
	Aesthetic	Scenic & aesthetically pleasing natural elements	Surrounding natural environments within which the aesthetic information resides	List as per chapter 3	Tourism enterprises; general residents
	Recreation	Recreation: Fishing	Surrounding natural environments within which recreational opportunity occurs	List as per chapter 3	Fishing clubs; tourism enterprises
		Recreation: Walking/relaxation	Surrounding natural environments within which recreational opportunity occurs	List as per chapter 3	Users of/ visitors to recreational facilities; tourism enterprises
	Cultural & artistic	Cultural: Ritual slaughtering	Ecosystem types within which species utilized are found	Within 2km buffer zone of urban area/ settlement	Residents of urban areas/ settlements within buffer zone
		Cultural: Igoqo	Ecosystem types within which species utilized are found	Within 2km buffer zone of urban area/ settlement	Residents of urban areas/ settlements within buffer zone
		Cultural: Kraal	Ecosystem types within which species utilized are found	Within 2km buffer zone of urban area/ settlement	Residents of urban areas/ settlements within buffer zone
		Cultural: Grass broom	Ecosystem types within which species utilized are found	Within 2km buffer zone of urban area/ settlement	Residents of urban areas/ settlements within buffer zone
	Spiritual & historic	Historically important natural elements relying on NC for interpretation	Surrounding natural environments within which the historical information resides	List as per chapter 3	Historical institutions
	Scientific & educational	Environments important for education and scientific research: Public nature reserves	Surrounding natural environments within which the scientific and educational information resides or	List as per chapter 3	Educational/ research institutes

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recreational opportunity  
occurs

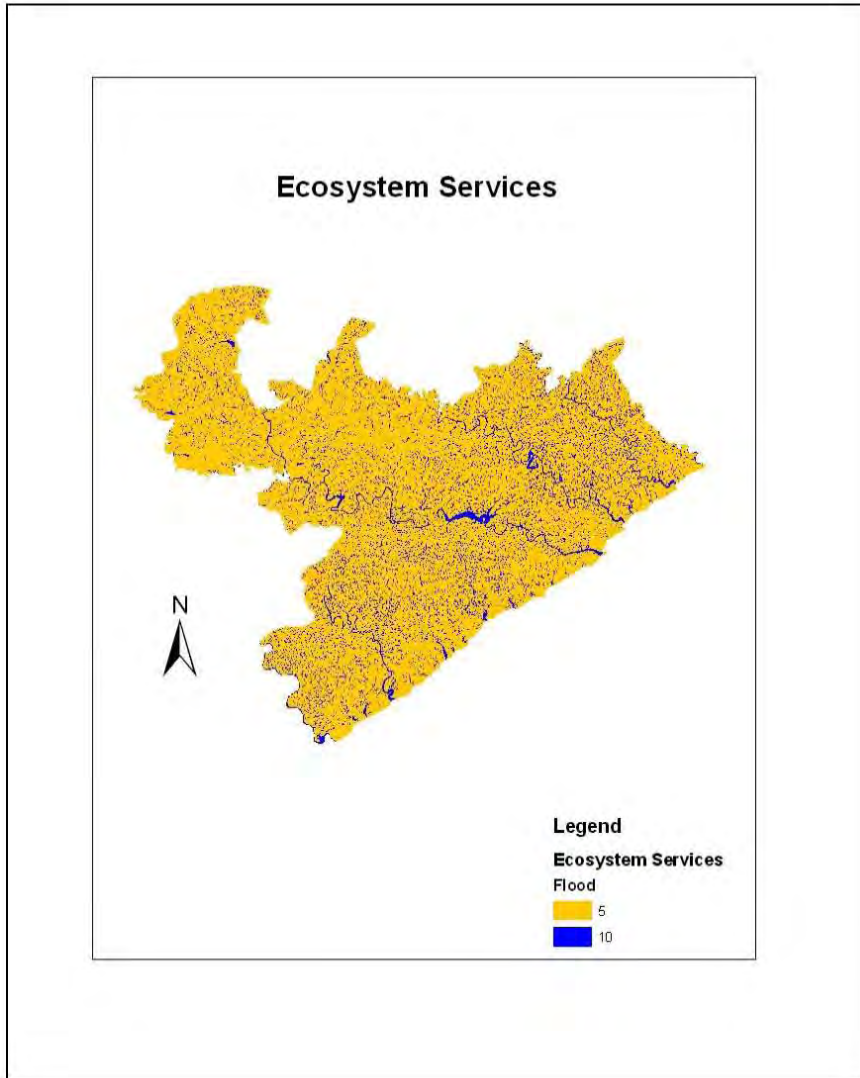
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**Appendix 4.** Ecosystem services maps for individual regulation, productive and cultural, and information services

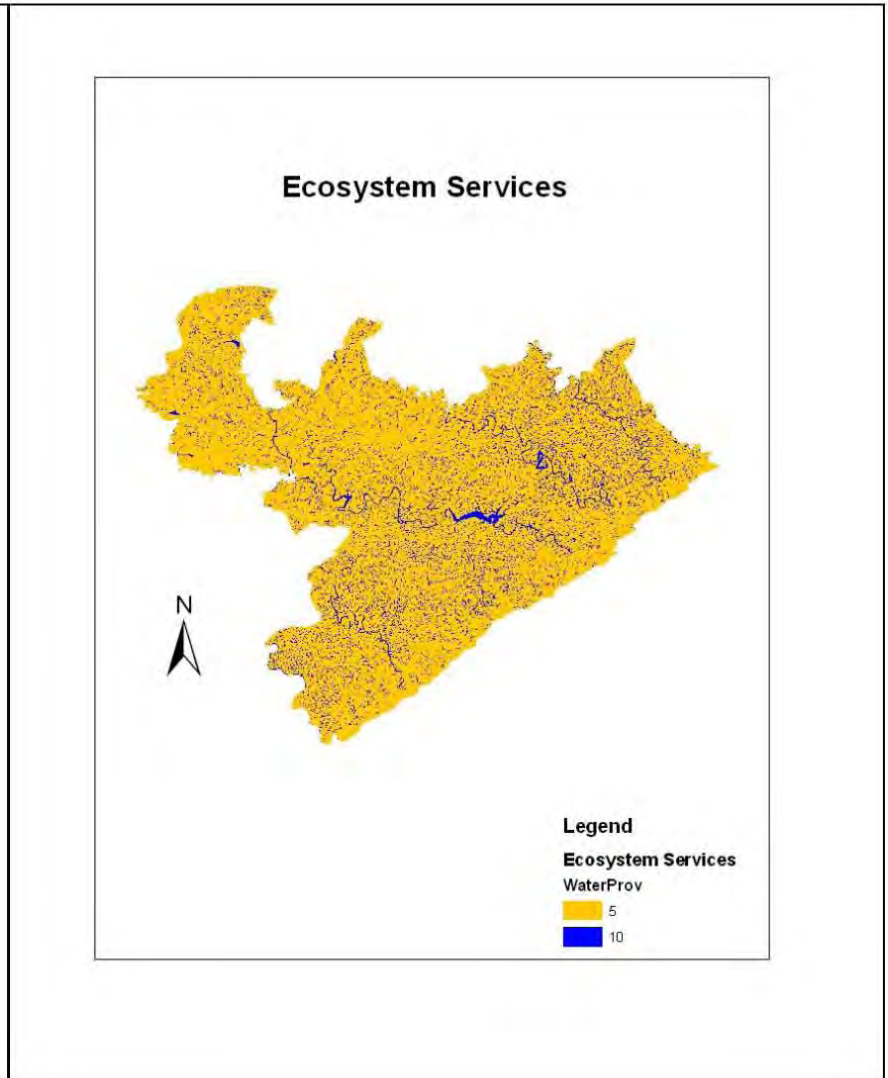


**Appendix 4.1.** Ecosystem service index (ESI) scores for pollination

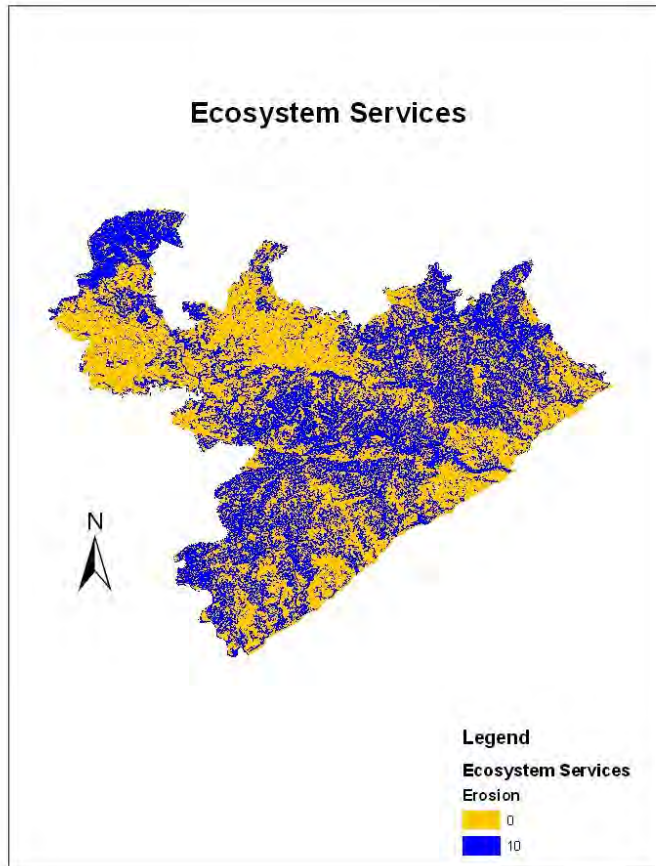
**Appendix 4.2.** Ecosystem service index (ESI) scores for biological control



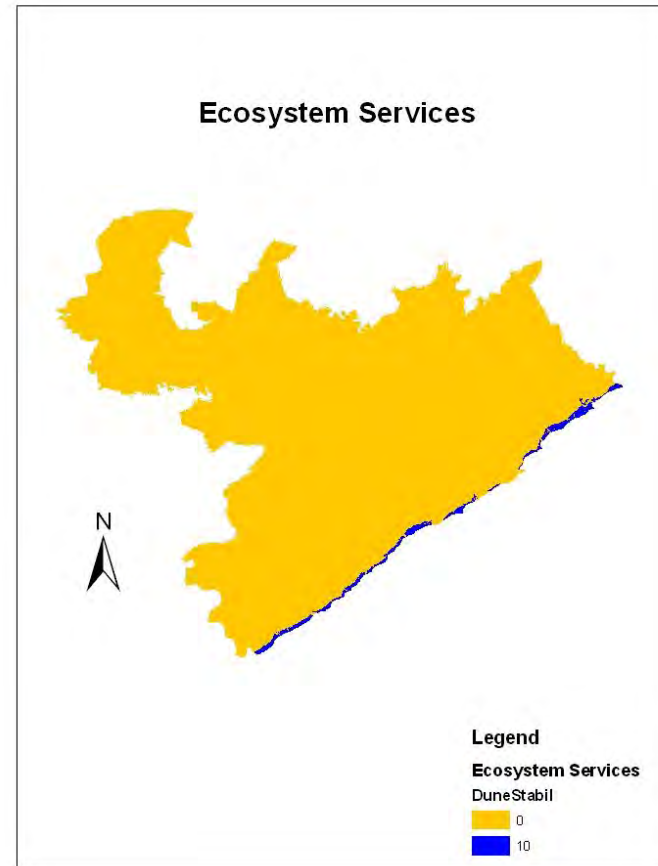
**Appendix 4.3.** Ecosystem service index (ESI) scores for flood protection and storm water discharge



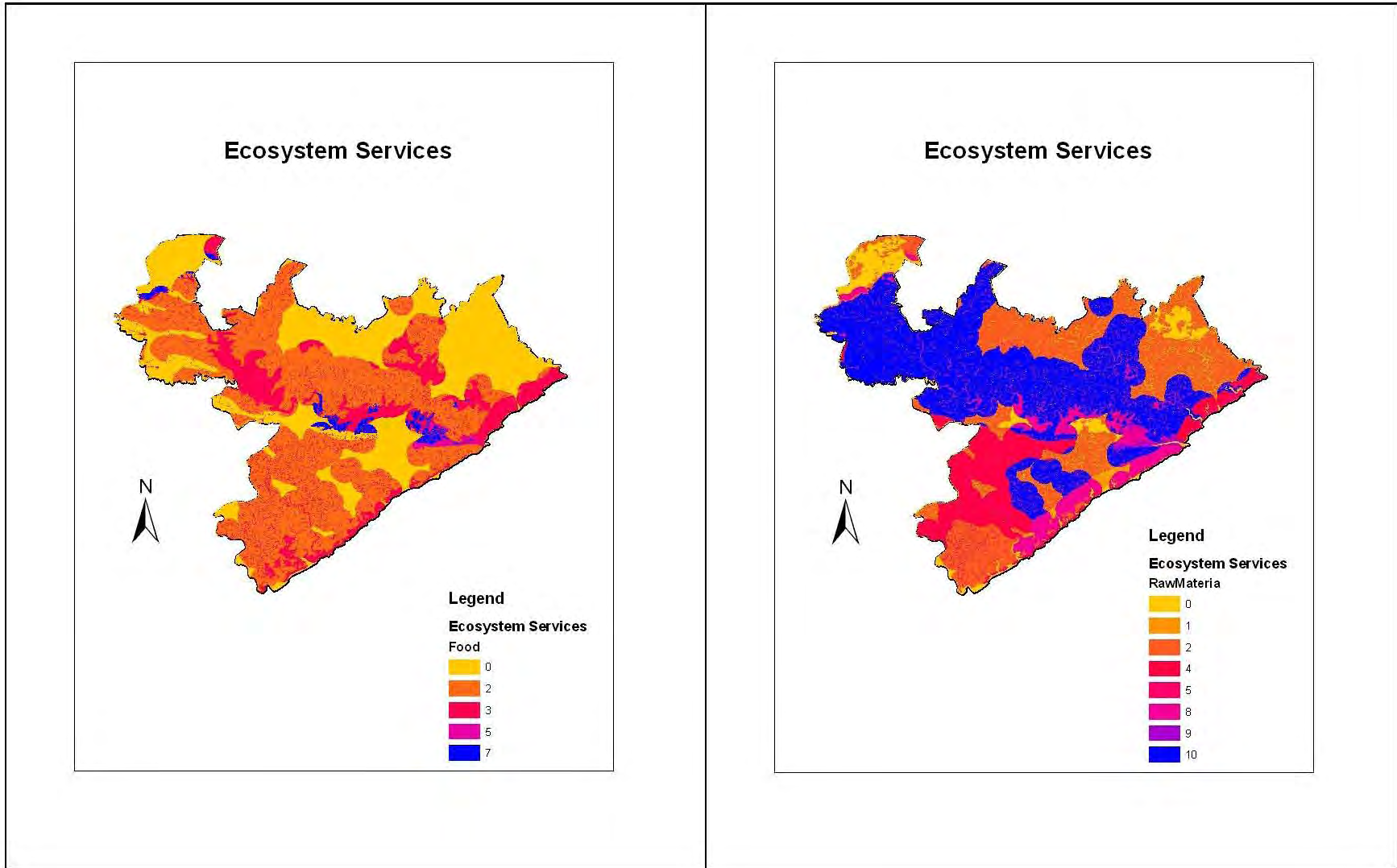
**Appendix 4.4.** Ecosystem service index (ESI) scores for fresh water provision



**Appendix 4.5.** Ecosystem service index (ESI) scores for erosion prevention

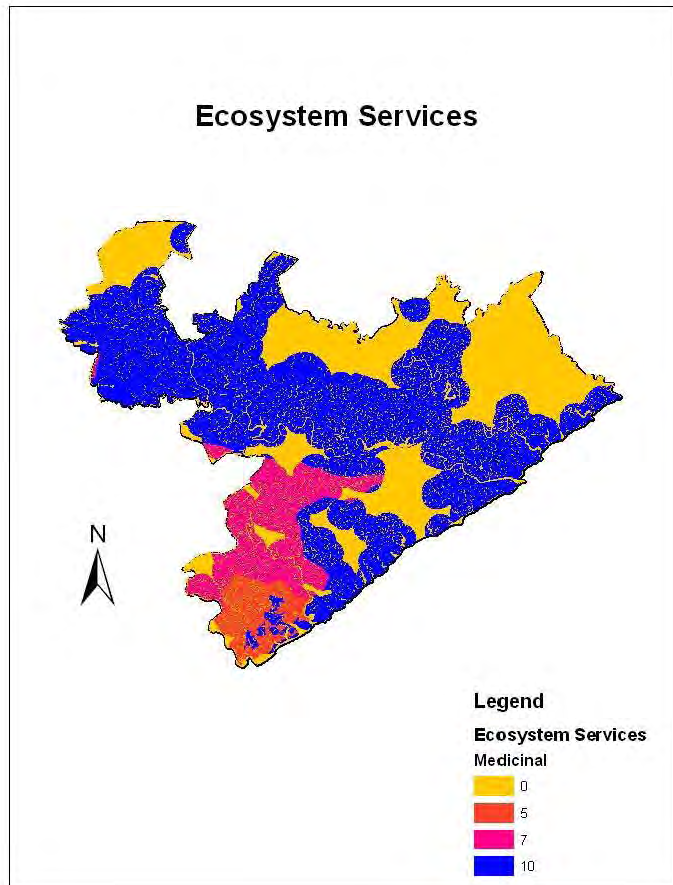


**Appendix 4.6.** Ecosystem service index (ESI) scores for sand dune stabilisation

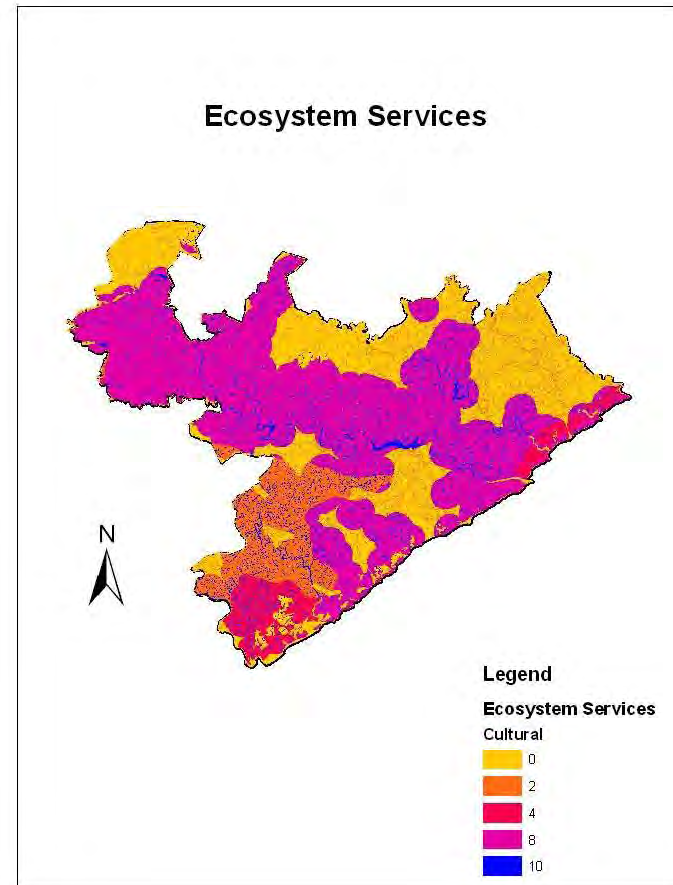


**Appendix 4.7.** Ecosystem service index (ESI) scores for food resources

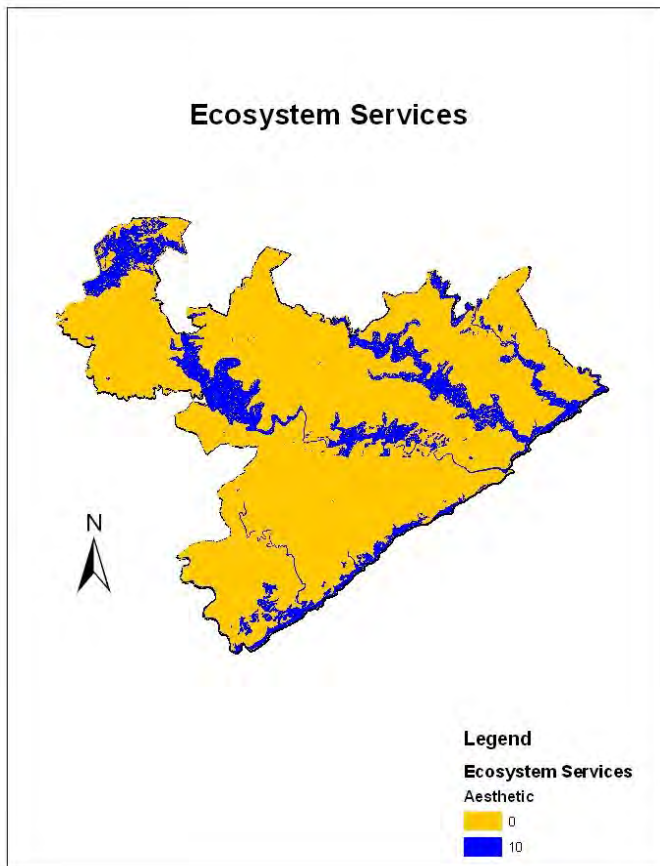
**Appendix 4.8.** Ecosystem service index (ESI) scores for raw material



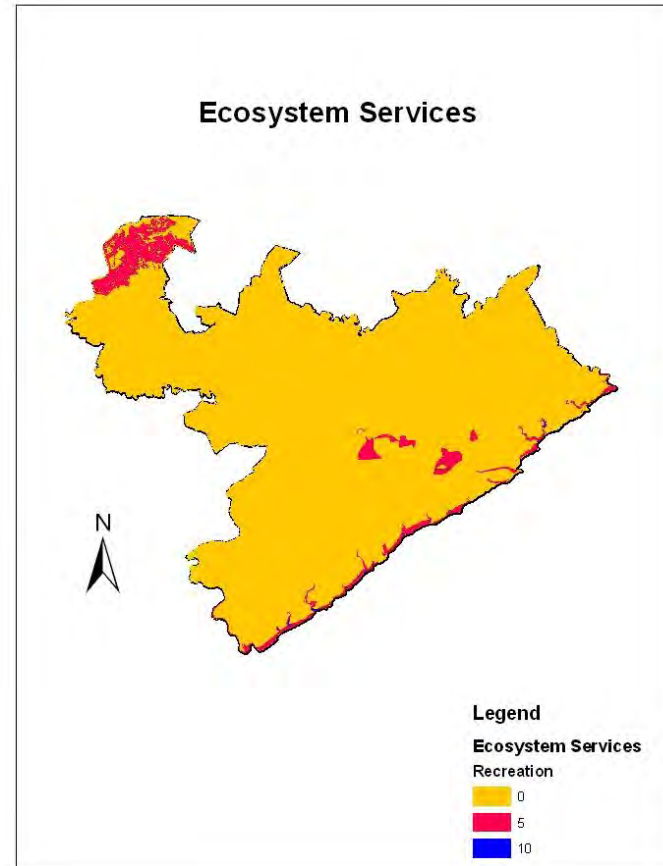
**Appendix 4.9.** Ecosystem service index (ESI) scores for medicinal resources



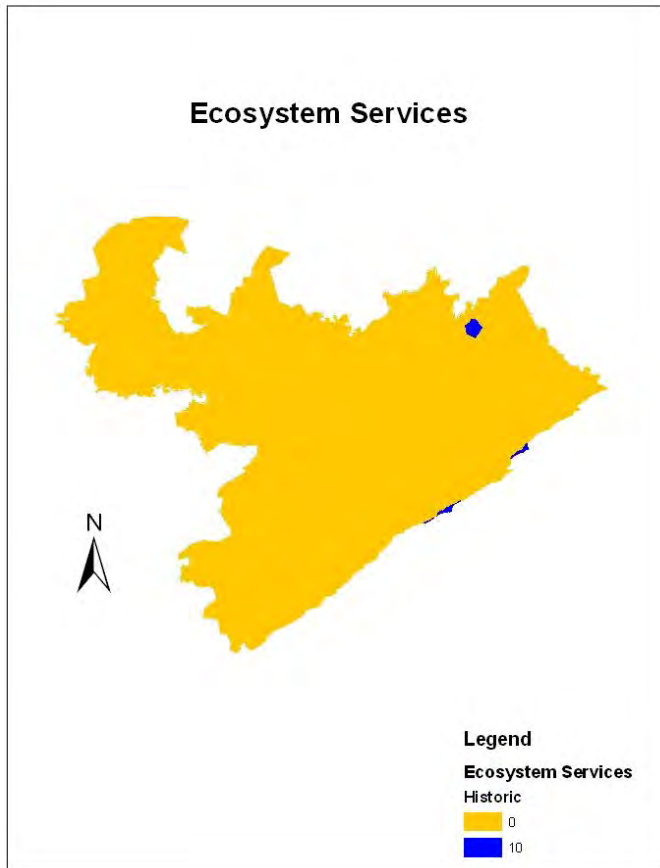
**Appendix 4.10.** Ecosystem service index (ESI) scores for cultural resources



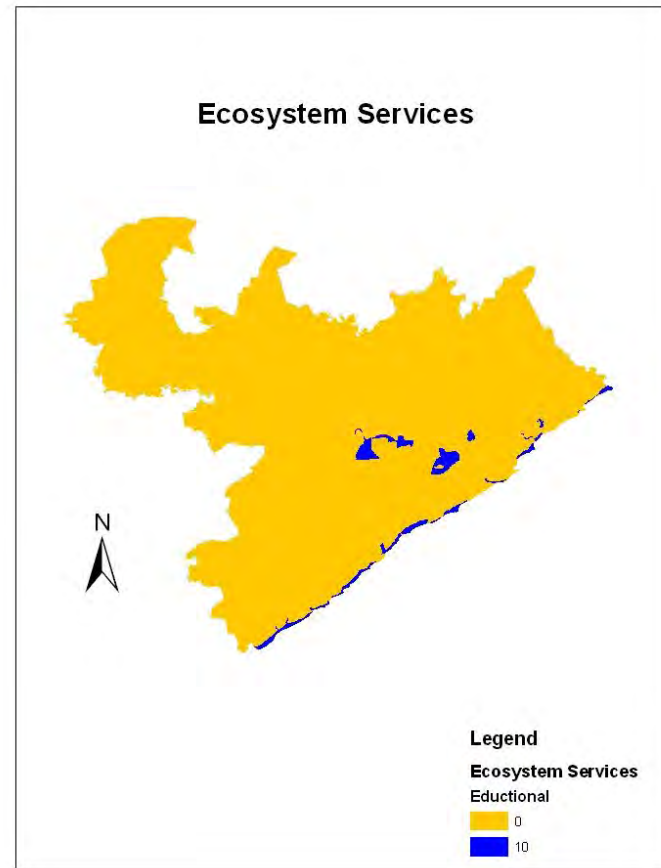
**Appendix 4.11.** Ecosystem service index (ESI) scores for aesthetic information



**Appendix 4.12.** Ecosystem service index (ESI) scores for recreational



**Appendix 4.13.** Ecosystem service index (ESI) scores for historical information



**Appendix 4.14.** Ecosystem service index (ESI) scores for educational information

