

EDITION 2 | 2016



ECOSYSTEM GUIDELINES

FOR ENVIRONMENTAL ASSESSMENT
IN THE WESTERN CAPE

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We trust that these Ecosystem Guidelines, like their predecessors, will be widely used and become a valuable reference for those who manage, regulate, benefit from or simply appreciate the extraordinary and irreplaceable natural heritage of the Western Cape.



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Acronyms

BA	Basic assessment	EN	Endangered (species or ecosystem)
BGIS	SANBI's Biodiversity Geographical Information System or Biodiversity-GIS website, a website for serving biodiversity information	ESA	Ecological Support Area
C.A.P.E.	Cape Action for People and the Environment	FEPA	Freshwater Ecosystem Priority Area
CARA	The Conservation of Agricultural resources Act (Act 43 of 1983)	HGM	Hydrogeomorphic
CBA	Critical Biodiversity Area	IBA	Important Bird Area
CD:NGI	Chief Directorate: National Geospatial Information	IUCN	International Union for the Conservation of Nature
CFR	Cape Floristic Region	LT	Least Threatened
CITES	Convention on the International Trade in Threatened and Endangered Species	NBA	National Biodiversity Assessment 2011
CR	Critically Endangered (species or ecosystem)	NEMA	The National Environmental Management Act (Act 107 of 1998)
CREW	Custodians of Rare and Endangered Wildflowers	NFEPA/FEPA	(National) Freshwater Ecosystem Priority Area
CWAC	Co-ordinated Waterbird Counts	PES	Present Ecological State
DEA	Department of Environmental Affairs (formerly DEAT – the Department of Environmental Affairs and Tourism)	SASS	South African Scoring System
DEA&DP	The Department of Environmental Affairs and Development Planning (of the Western Cape)	SDF	Spatial Development Framework
DWS	Department of Water and Sanitation	S&EIR	Scoping and Environmental Impact Reporting
EAP	Environmental Assessment Practitioner	ToR	Terms of Reference
EIA	Environmental impact assessment	VU	Vulnerable (species or ecosystem)
EMF	Environmental Management Framework	WRC	Water Research Commission
		WULA	Water use licence application

Note: This list includes the most often-used acronyms in the text.



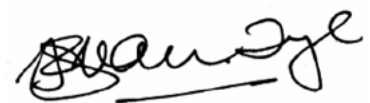
Foreword

The remarkable biological diversity, natural scenic beauty and rich cultural diversity of the Western Cape is a source of tremendous pride to the people of the Province. And with good reason: within the boundaries of the Western Cape lies a greater concentration and variety of species and ecosystems than is found anywhere else in South Africa, considering areas of comparable size. The international, national and regional significance of this incredible natural heritage is widely acknowledged – for example, the Cape Floristic Region (CFR) has been designated a World Heritage Site, Table Mountain is one of the seven Natural Wonders of the World; and three CFR wetlands are Ramsar sites of international importance.

The Western Cape is understandably greatly sought after as a place to live – the current population stands at some 5,8 million (more than 80% of which occurs within the boundaries of the City of Cape Town), and is growing annually at a rate of about 2.75%. This places heavy demand on land for urban expansion, especially around major urban centres and along the coast, and increases the demand for ecosystem services – such as the provision of clean water – from our already-stressed ecological infrastructure. The Province is the heart of the multi-million rand wine and fruit industries, amongst other important agricultural production sectors, and this places demand on land for large-scale agriculture. There has been recent expansion in the mining sector (for sand, granite, base metals and semi-precious and precious stones), and there is the prospect of large infrastructural developments linked to the exploration for shale gas or generation of alternative energy, such as from wind. It is critical in accommodating this growth and aspiring towards improved quality of life that a more sustainable balance is struck between economic growth, human activities and maintaining the ecological integrity of the unique ecosystems and biodiversity which underpins the ecosystem services we depend on, and of which we are the proud custodians.

The reality is that trying to meet the socio-economic development needs of a growing population while conserving natural ecosystems is a thorny problem. It is neither desirable nor practical to secure all of the important biodiversity and ecosystems of the Province through the creation of protected areas alone – although protected areas play a critically important role as the cornerstone of conservation efforts. Where we can make the biggest difference is in how we locate land uses and manage land beyond the boundaries of our protected areas. The question is not whether development will take place, but where and how. And it is these critical questions that the *Fynbos Forum Ecosystem Guidelines* help us answer.

At the Department of Environmental Affairs and Development Planning, we carry the legislative mandate, along with our Provincial conservation agency, CapeNature, to ensure the preservation of our biodiversity and ecosystems for current and future generations. It is our responsibility to make wise judgements and informed decisions about land use and management, whilst supporting the achievement of socio-economic development goals. In this we cannot act alone. It is our hope, therefore, that the revised *Ecosystem Guidelines for Environmental Assessment*, like its predecessor, will become a widely and routinely used tool by all environmental assessment practitioners, and by others whose activities either depend or impact on biodiversity and natural ecosystems in the Western Cape.



Piet van Zyl

Head of Department

Western Cape Department of Environmental Affairs and Development Planning



CHAPTER 1

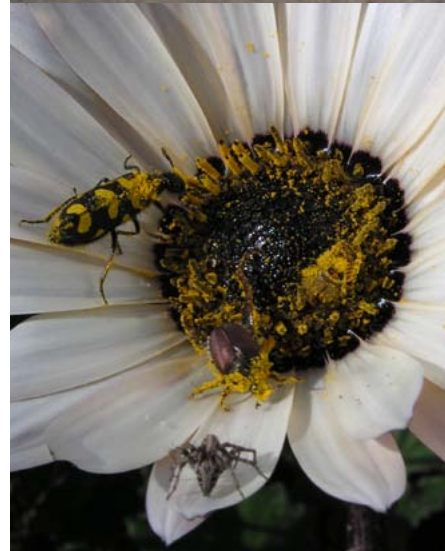
Introduction

The Western Cape is recognised globally for its extraordinary number and diversity of species and ecosystems, most of which occur nowhere else on Earth. Not only is this province home to the remarkably diverse plant communities that characterise the Fynbos Biome, but portions of the Succulent Karoo and Nama Karoo Biomes, as well as patches of the Albany Thicket, Forest and Grassland Biomes, also occur within its boundaries. This adds even greater biological and biophysical diversity and complexity. The diverse ecosystems of the Western Cape provide the natural resources and ecological infrastructure that underpin some of South Africa's most important agricultural landscapes (which collectively produce just under half of South Africa's agricultural exports), and provide numerous other ecosystem services that are essential for sustainable economic growth and social development.

The importance of the biodiversity and ecosystems of the region is recognised both internationally and nationally. This has given rise to enormous efforts from both government and civil society to ensure the conservation of the natural ecosystems of the Western Cape. Despite this, these ecosystems have undergone more extensive modification and degradation than in any other province of the country, and the province has the greatest number of critically endangered ecosystems and threatened species. Increasing population growth, increased demand for natural resources to feed the manufacturing sectors, and increased demand for land for urban settlement and intensification of agricultural output, means that the remaining areas of natural habitat in the Western Cape are under pressure and are at great risk of becoming fragmented, modified, degraded or lost altogether. This pressure is worsened by the impacts of altered fire regimes, illegal harvesting, infestation by invasive alien species and over-abstraction of water, as well as the long-term impacts of environmental shifts attributable to climate change.

This creates a scenario in which maintaining biodiversity patterns and ecosystem functioning is an increasingly complex and challenging task. It is imperative that sound decisions are made in environmental assessment – and, particularly, through proactive, biodiversity-inclusive land-use planning – in order to retain key natural assets and the ecosystem services that flow from these, for current and future generations. Individuals and institutions who work in the Western Cape need to be equipped with reliable, up-to-date information that can help them take land-use decisions which ensure that biodiversity is sufficiently considered – and safeguarded – in land-use planning and management.

These *Ecosystem Guidelines for Environmental Assessment in the Western Cape* have been produced as one of a suite of planning and decision-support tools that should be used to meet this need.





Background to development of the *Guidelines*

The first edition of the *Fynbos Forum Ecosystem Guidelines for Environmental Assessment in the Western Cape* (hereafter referred to as the '*Guidelines*') was published in 2005 (de Villiers *et al.*, 2005). They were the product of an inclusive consultative process initiated by the Fynbos Forum¹ in 2002 and co-ordinated by the then Conservation Unit of the Botanical Society of Southern Africa. Drafting the first edition of the *Guidelines* relied on inputs from many biodiversity specialists, environmental assessment practitioners and the Western Cape environmental, development planning and conservation authorities. These experts came together to identify important ecosystems and habitats in the Western Cape, frame the most critical questions that should be asked when undertaking environmental assessments in each of these ecosystems or habitats, and formulate answers that could be applied practically by a range of practitioners. The result was a set of ecosystem guidelines, with some accompanying contextual information, that represented a consensus of scientifically reliable information presented in a non-technical format that was accessible and relevant to a range of users, many of whom were not scientists or technical specialists. These guidelines represented a first attempt to reduce the complexity and value of Western Cape ecosystems to a set of basic, but reliable, pointers that could guide responsible and appropriately-informed decision-making about biodiversity. The *Fynbos Forum Ecosystem Guidelines for Environmental Assessment in the Western Cape*, as the publication came to be known, soon proved to be a valuable and much-used resource, and, over time, became one of the most frequently downloaded documents from the South African National Biodiversity Institute's BGIS (Biodiversity-GIS) website.

Since the publication of the first edition of the *Guidelines*, there have been many new developments, both at national and provincial level, in the regulatory, legislative and policy context relating to biodiversity management, and in the fields of biodiversity planning, biodiversity mainstreaming and ecosystem classification. A multitude of new planning instruments and decision-support tools has become available, such as biodiversity sector plans, guidelines on biodiversity offsets, environmental management frameworks and numerous detailed guidelines dealing with specific aspects of biodiversity planning, land-use management or environmental assessment (see Table 1 for a list of some of these). The state of the physical landscape has also changed over the last ten years, with respect to land-use patterns and pressures, habitat modification and protection, with both losses and gains taking place in certain ecosystems. These changes and developments meant that the original *Guidelines* needed to be revised and updated. The current volume is the result of this revision process.

¹ The Fynbos Forum is a gathering of conservation scientists, managers, planners and non-governmental organisations working in the Cape Floristic Region. It has met annually since 1977. Besides providing a forum for presentations on research findings, projects, lessons and challenges, the Fynbos Forum has also initiated several working groups and projects, including the development of these *Guidelines*.



What the *Guidelines* are

The purpose of these *Guidelines* is to provide a consistent benchmark and framework for addressing the biodiversity-related aspects of land-use planning, landscape management, environmental assessment and regulation in the Western Cape. They do this by answering key questions that should be asked by planners, environmental assessment practitioners, landowners or property developers when planning or embarking on a land-use activity, be it urban, industrial, agricultural or recreational. They provide a consensus of scientifically reliable information that can be used in conjunction with other decision-support tools to add value to the deliberations of decision-makers on the environmental implications of land-use changes.

The *Guidelines* adopt a broad landscape approach to biodiversity management and assessment, in which the overall aim is to ensure that the ecological function of a site is considered within its landscape and regional context. They provide information that will enable users to contextualise and interpret spatial biodiversity priority areas, such as those shown in systematic biodiversity plans. They make it possible for the user to ‘walk off the map’, and, with the aid of suitably-informed maps and other information, to understand broadly: (i) what drives each ecosystem in terms of ecological functioning; (ii) what the limits of acceptable change are within particular ecosystems (from a land-use planning and environmental perspective); and (iii) how to minimise negative impacts, interpret how impacts need to be managed and how to monitor whether impact-avoidance and land-management measures are being effective in securing biodiversity and ecosystem processes in these landscapes.

What the *Guidelines* are not

The *Guidelines* are not an exhaustive scientific reference work on the biodiversity and ecosystems of the Western Cape, or on biodiversity planning, environmental impact assessment, ecosystem management, land-use planning or environmental legislation – throughout the text, and at the end of the document (in Chapter 6: ‘Other Useful Resources’), reference is made to other literature and documents where more comprehensive information of this type can be found.

Using the *Guidelines* is NOT a substitute for making site visits or for involving biodiversity (or other) specialists in the environmental assessment process. Nor do the *Guidelines* give detailed instructions to land-use planners and environmental assessment practitioners (or other users). Rather, they provide a set of pointers that should be used in conjunction with other best practice guidelines, maps, plans and policies to incorporate biodiversity considerations proactively and meaningfully in land-use planning and decision-making, as described in Chapter 3. For more detailed guidance, users should consult: the *Guidelines for Involving Biodiversity Specialists in EIA processes* (Brownlie *et al.*, 2005) or any of the documents listed in Table 1, as appropriate.





When and how the *Guidelines* should be used

These *Guidelines* should be used as early on in the planning process as possible. Ideally, their use should inform a project up-front (as described in Chapter 3, section 3.3: 'Planning Ahead'), so that it is possible to work, from the start, within the ecological opportunities and constraints presented by these ecosystems, thus avoiding any potentially significant impacts or delays later on in the development planning process. If this is done, the need for complex, costly and time-consuming environmental assessment could be minimized, and ecologically sustainable development is more likely to be achieved.

Wherever possible, the *Guidelines* should be used in conjunction with other tools that exist – particularly the most up-to-date systematic biodiversity plans that are available for the area of concern, as well as sector-specific guidelines that provide more detailed information relating to particular kinds of land-use activities or particular ecosystems – Table 1 provides a summary of some of the key documents and tools of this type that are available for practitioners working in the Western Cape. (It should be noted that this is not an exhaustive list as new legislation, policies, plans and best practice guides are emerging all the time. Some of the plans and decision-support tools are also updated at regular intervals – such as the provincial map of Critical Biodiversity Areas or the provincial *State of Biodiversity Report*. Practitioners should check with the relevant authorities to ensure that they are always working with the most recent editions).



Who should use the *Guidelines*

These ecosystem-specific guidelines have been prepared primarily to assist stakeholders in the Western Cape who are involved in land-use planning and environmental assessment. However, there is a broad set of users who is likely to benefit from their use, including:

- decision-makers in national, provincial and local government, and other regulators of land use
- spatial planners
- environmental impact assessment practitioners (and the specialists who make contributions to environmental assessments)
- property developers
- agricultural extension officers and other specialist land-use advisors.

The *Guidelines* will also be of use to all industry and sector role-players whose activities impact on natural ecosystems in the Western Cape.

Structure of the *Guidelines*

The *Guidelines* are presented in six chapters. In addition to this general Introduction (**Chapter 1**), they include:

- An introduction to ecosystems of the Western Cape and the key ecological concepts underpinning the ecosystem guidelines (**Chapter 2**).
- Practical guidelines on planning a mosaic of land-uses in living landscapes; maintaining ecosystem processes; and pro-active consideration of biodiversity in land-use planning and decision-making (**Chapter 3**).
- General guidelines relating to planning for and managing risk (due to fire, floods, invasive alien species and climate change); restoration and *ex situ* conservation; and the persistence of animals in ecologically functional landscapes (**Chapter 4**).
- The ecosystem guidelines (**Chapter 5**), which constitute the ‘meat’ of the document. A ‘snapshot’ of each ecosystem is provided at the start of each section in this chapter.
- Other useful resources (**Chapter 6**), including a list of Western Cape vegetation types and their ecosystem threat status; a classification of inland aquatic ecosystems; templates for terms of reference to be used when commissioning the services of biodiversity specialists (for terrestrial and aquatic assessments); a glossary of terms; and a list of references.



The ecosystem guidelines (Chapter 5), provide relevant information and guidance based on 8 questions that should be addressed when contemplating the implications of changes in land use for biodiversity and ecosystem functioning. The questions are:

1. What are the key ecological 'drivers' maintaining ecosystem function, pattern and structure?
2. What are the main threats and pressures in these ecosystems?
3. What are the non-negotiables? (These are either the ecological 'bottom lines', or the minimum set of management actions that are needed to avoid or minimise negative impacts).
4. What are the critical things to maintain for biodiversity to persist?
5. What are the best spatial approaches (at a landscape scale) to avoid or minimise impacts and risk in these ecosystems?
6. What indicators should be used to assess and monitor ecosystem health?
7. How reversible are impacts within a period of 5 to 10 years?
8. What are acceptable compensation measures or offsets for biodiversity loss?

These questions are addressed separately for each of 9 main groups of Western Cape ecosystems, which are listed in Table 2 and described further at the start of each set of ecosystem guidelines in Chapter 5.

Geographic scope of the *Guidelines*

The scope of the *Guidelines* is defined by the boundaries of the Western Cape Province, as administrative responsibilities relating to environmental decision-making are primarily vested in the provincial sphere of government. Although the province is dominated by fynbos ecosystems, these form a mosaic along the western, northern and eastern boundaries of the Fynbos Biome with ecosystems belonging to the Succulent Karoo, Nama Karoo and Albany Thicket Biomes, and patches of the Forest Biome are found scattered along the coast and on mountain slopes throughout the Western Cape. Ecologically, these ecosystems are not isolated from each other and they need to be managed in an integrated way. It is for this reason that the *Guidelines* include sections on non-fynbos ecosystems.



Table 1: A list of some of the key biodiversity-related policies, planning and decision-support tools available to practitioners working in the Western Cape.

Note: This is not an exhaustive list. Users should check with CapeNature, the Western Cape Department of Environment Affairs and Development Planning or SANBI to ensure that they are working with the most up-to-date editions of these documents, or to check for any new legislation, policies or best-practice guidelines that may have come into effect.

DOCUMENT	WHERE IT CAN BE ACCESSED
The National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis Report Driver, A.; Sink, K.J.; Nel, J.N.; Holness, S.; van Niekerk, L.; Daniels, F.; Jonas, Z.; Majiedt, P.A.; Harris, L. and Maze, K. (2012). South African National Biodiversity Institute, Pretoria. See also the associated technical reports: Terrestrial ecosystems (Vol 1), Freshwater ecosystems (Vol 2) and Estuaries (Vol 3).	http://bgis.sanbi.org/nba/NBA2011_SynthesisReport_lowres.pdf
The National Freshwater Ecosystem Priority Areas (NFEPA) project: Technical Report Nel, J.L.; Murray, K.M.; Maherry, A.M.; Petersen, C.P.; Roux, D.J.; Driver, A.L.; Hill, L.; Funk, N.; Swartz, E.R.; Sith-Adao, L.B.; Downsborough, L.; Nienaber, S.; and van Deventer, H. (2011). South African National Biodiversity Institute, Pretoria	http://bgis.sanbi.org/nfepa/NFEPA_Technical_Report.pdf
Implementation Manual for Freshwater Ecosystem Priority Areas Driver, A.L.; Nel, J.L.; Snaddon, K.; Murray, D.J.; Roux, L.; Hill, L.; Swartz, J. Manuel, J. and Funke, N. (2011). WRC report no. 1801/1/11, Water Research Commission, Pretoria	http://www.wrc.org.za/Pages/DisplayItem.aspx?ItemID=9448&FrmURL+%2fPges%2fDefault.aspx%3f
Atlas of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources Nel, J.L.; Driver, A.L.; Strydom, W.F.; Maherry, A.M.; Petersen, C.; Hill, L.; Roux, D.J.; Nienaber, S.; van Deventer, H.; Swartz, E.R.; and Smith-Adao, L.B. (2011). WRC Report No. TT500/11. Water Research Commission, Pretoria.	http://www.wrc.org.za/Pages/DisplayItem.aspx?ItemID=9576&FrmURL=%2fPages%2fDefault.aspx%3f
The Vegetation of South Africa, Lesotho and Swaziland. Mucina, L. & Rutherford, M.C. (eds) Reprint (2006). Strelitzia 19. South African National Biodiversity Institute, Pretoria	Can be accessed via the SANBI BGIS website: http://bgis.sanbi.org
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continued ...

DOCUMENT		WHERE IT CAN BE ACCESSED
SANBI Red List of South African Plants: Guidelines for Environmental Impact Assessment Driver, M.L.; Raimondo, D.; Maze, K.; Pfab, M.F.; and Helme, N.A. (2009). South African National Biodiversity Institute, Pretoria.		http://redlist.sanbi.org/eiaguidelines.php
Maps of Critical Biodiversity Areas and Municipal Biodiversity Sector Plans for the Western Cape		Visit http://bgis.sanbi.org for a comprehensive list of biodiversity plans that are available
Western Cape Biodiversity Framework 2014 Status Update: Critical Biodiversity Areas of the Western Cape. Pence, G.Q.K. (2014). Unpublished CapeNature Project Report. Cape Town, South Africa.		http://bgis.sanbi.org/WCBF2014%20Update_Final%20Report_31March2014.pdf
Western Cape Provincial State of Biodiversity Report 2012 Turner, A.A. (2012). Cape Nature Scientific Service, Stellenbosch. ISBN 978-0-621-41407-3		Available from: www.capenature.co.za/wp-content/uploads/2013/09/State-of-Biodiversity-2012.pdf
Guideline for Involving Biodiversity Specialists in EIA Processes Brownlie, S. (2005). Provincial Government of the Western Cape Department of Environmental Affairs and Development Planning		http://biodiversityadvisor.sanbi.org/wp-content/uploads/2012/04/Involving_Biodiversity_Specialists.pdf For other guidelines on involving specialists in EIA processes, see: http://eadp.westerncape.gov.za/your-resource-library/policies-guidelines
Information Document on Biodiversity Offsets, EIA Guideline and Information Document Series Department of Environmental Affairs & Development Planning (2011). Western Cape (DEA&DP), October 2011.		Available at: http://www.capecgateway.gov.za/eadp OR www.iaia.za/File_Uploads/File/DEADP_EI_Info_Soc_on_Biodiversity_Offsets_Oct2011.pdf
Guidance Document on Biodiversity, Impact Assessment and Decision Making in Southern Africa. Brownlie, S.; Walmsley, B.; and Tarr, P. (2009). <i>CBBIA-IAIA Guidance Series</i> . Capacity Building in Biodiversity and Impact Assessment (CBBIA) Project, International Association for Impact Assessment (IAIA), North Dakota, USA.		Available from the website of the International Association for Impact Assessment.
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SANBI Biodiversity GIS Enquiries	http://bgis.sanbi.org BGISHelp@sanbi.org.za	Ph 021 799 8738 Fax 021 7971940 Biodiversity GIS Kirstenbosch Research Centre Private Bag X7 CLAREMONT 7735
SANBI Biodiversity Advisor Enquiries	http://biodiversityadvisor.sanbi.org/ BAHelp@sanbi.org.za	



CHAPTER 2

Introduction to Ecosystems of the Western Cape

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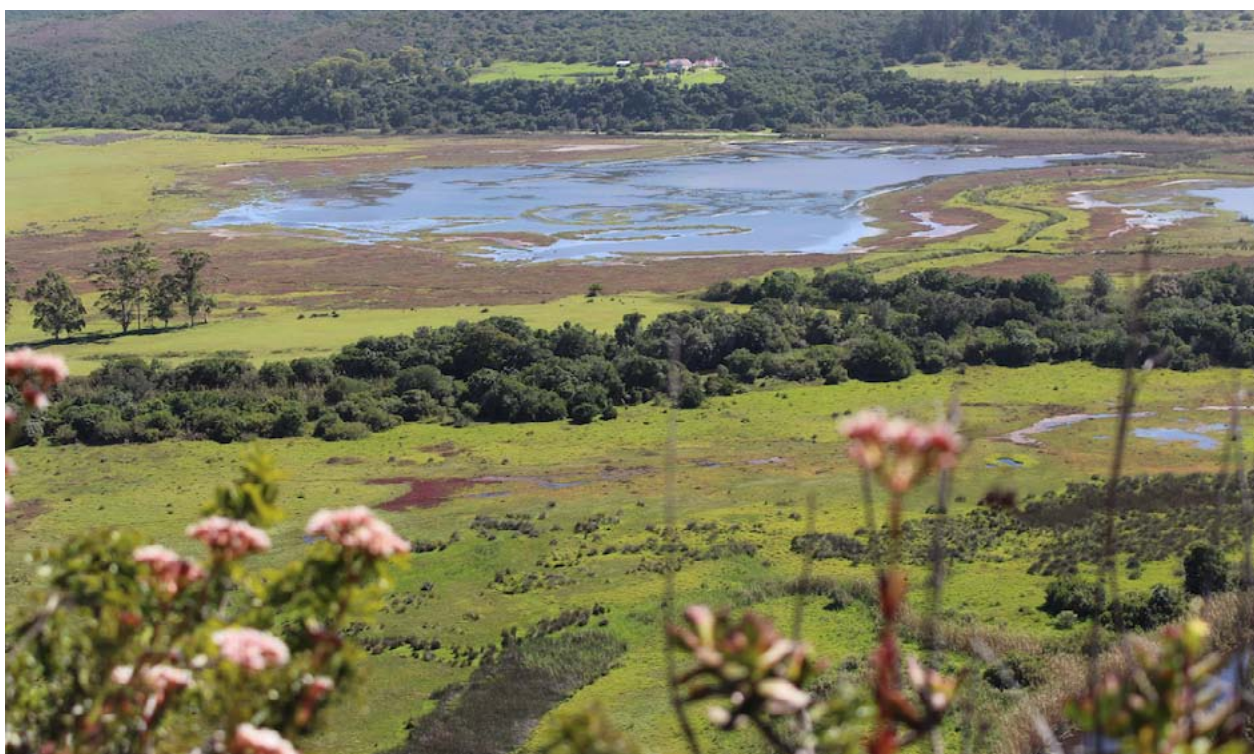
2.1. An ecosystem approach to planning and decision-making

In these *Guidelines* we promote a '**landscape approach**' to conserving the ecosystems and biodiversity of the Western Cape. This recognises the need to balance biodiversity conservation with resource utilisation and sustainable development across the entire landscape. It is achieved by a combination of formal protection with a range of other management approaches and tools that can be used beyond the boundaries of protected areas to maintain functional ecosystems across large areas of land, securing both the biodiversity patterns (species assemblages) and ecological processes that are supported by these ecosystems. In this approach, protected areas (declared in terms of the *National Environmental Management: Protected Areas Act* (Act 57 of 2003, as amended) are viewed as part of a mosaic of land-uses in which biodiversity management objectives are built into the strategies, production practices and land-use decisions of all land and resource users. This means that areas important for biodiversity conservation can be maintained and managed in a natural or near-natural state throughout the landscape, and that connectivity can be kept, supporting the ecological processes that operate at a large scale.

The landscape approach recognises that:

- almost all ecosystems are already influenced or modified to some extent by human activity
- people are an integral part of landscapes
- not all land uses are compatible with biodiversity conservation, although some are, and the impacts of others can be minimised through well-informed planning and improved practices
- all ecosystems undergo change, but, there are thresholds or levels of change, beyond which the ability of the landscape to sustain life and productivity is seriously diminished
- management actions must be carried out at the spatial and temporal scale suited to the issue being addressed.

Importantly, the landscape approach actively enables an '**ecosystem approach**' to conservation of biodiversity, as laid out in the Convention on Biological Diversity (see Box 1). The ecosystem approach allows for integrated and holistic management of land, water and living resources that promotes conservation and wise use of natural resources in an equitable way. Like the landscape approach, it stresses that people are an integral part of landscapes.



BOX 1 The ecosystem approach of the Convention on Biological Diversity

12 principles of the ecosystem approach as laid out in the Convention on Biological Diversity are that:

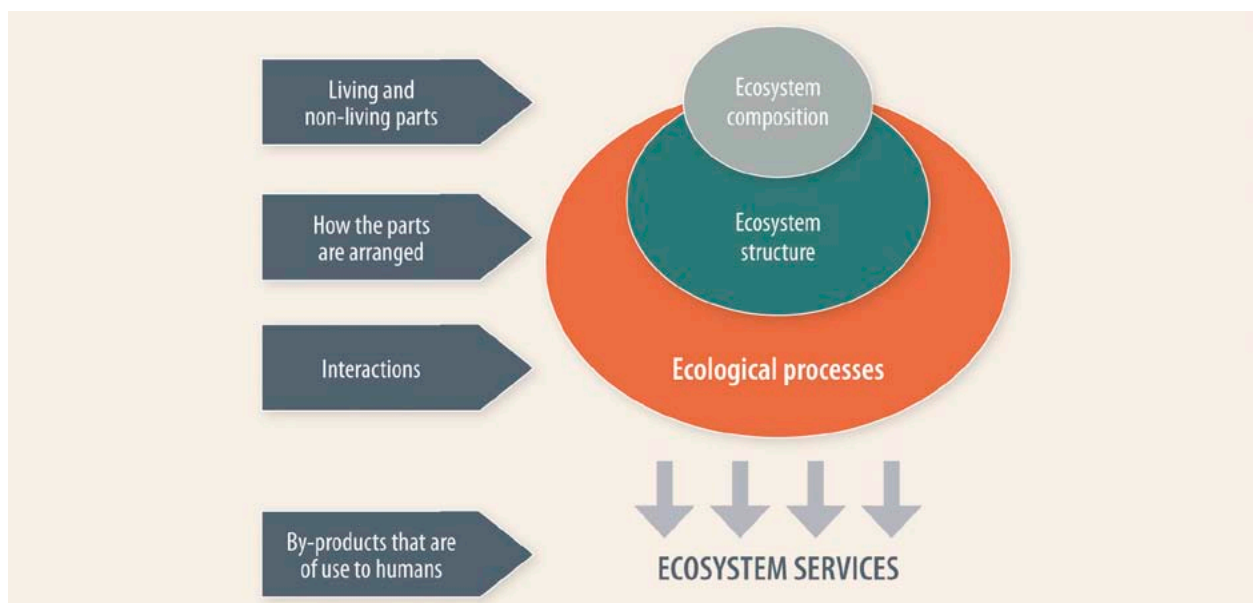
1. Objectives for the management of land, water and living resources are a matter of societal choices.
2. Management should be decentralized to the lowest appropriate level.
3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
4. Recognising the potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:
 - a) Reduce those market factors that adversely affect biodiversity.
 - b) Align incentives to promote biodiversity conservation and sustainable use.
 - c) Internalize costs and benefits in the given ecosystem to the extent feasible.
5. Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.
6. Ecosystems must be managed within the limits of their functioning.
7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
8. Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set for the long term.
9. Management must recognise that change is inevitable.
10. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biodiversity.
11. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
12. The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

Although this thinking is well-entrenched in environmental planning and decision-making in the Western Cape, in practice, it is sometimes difficult to implement. One of the best opportunities for getting it right lies in incorporating biodiversity priorities proactively and meaningfully into environmental assessment, so that the interconnected issues faced by biodiversity and society can be addressed in an integrated and sustainable way. By taking an ecosystem approach to doing this, it is possible to reduce the complexity of working in diverse biomes involving so many different species and ecosystems and many different land-use sectors, to a set of basic but reliable pointers that can guide responsible and appropriately informed land-use planning and decision-making about ecosystems and the biodiversity they support.

Defining ecosystems

Ecosystems, in a general sense, are assemblages of living organisms, the interactions among them and between them and their physical environment. Each ecosystem is characterised by its *composition* (the living and non-living parts of which it is made), its *structure* (how the parts are arranged in time and space) and the *ecological processes* (functions such as nutrient cycling, water flows and dispersal) that maintain the composition and structure and keep it functioning as a unit (see Figure 1). Healthy, functioning ecosystems with intact biodiversity, supply numerous ecosystem services (see Box 2), which are by-products of natural ecosystem functioning that are of benefit to people and that support livelihoods and economic production activities.

Figure 1: Diagrammatic representation of the components of an ecosystem



A useful way of classifying biodiversity within biomes is to use vegetation types as surrogates for ecosystems, and this is the approach adopted in much of the biodiversity planning that is practiced in South Africa today. This has been made possible largely by the existence of a regularly updated vegetation map, and maps of river ecosystems and wetland types that provide consistent coverage of the whole country at an appropriate scale (1:250 000).

Ecosystems can, however, be defined at many different scales and in these *Ecosystem Guidelines* for the Western Cape, we have taken a broad ecosystem approach, treating clusters of vegetation types (as recognised in the SA Map of Vegetation Types – Mucina, Rutherford and Powrie, 2012) as groups of ecosystems that have similar ecological characteristics, and share similar management requirements. The nine groups of ecosystems that are used in these *Guidelines* are described in greater detail in the ‘*Snapshots*’ in Chapter 5.



Taking this broad ecosystem approach means that action can be focused on ecosystem processes that operate at larger scale, and areas that are important for ecosystem-based adaptation to climate change, and not only on individual species or vegetation types. This approach also encourages best practice in environmental assessment by addressing potential opportunities and constraints to development at the appropriate ecological scale, as opposed to purely site-based decision-making, which often fails to consider the ecological value of a site within its broader landscape and regional context, and which sometimes does not adequately address the potential for cumulative impacts.

Thresholds of change in ecosystems

It is important to recognise that ecosystems are dynamic and undergo both natural and induced change all the time. All ecosystems can absorb a certain amount of change yet still remain functional — this is the concept of **resilience**, and some ecosystems are more resilient than others. But there is a point at which, if an ecosystem becomes increasingly degraded (i.e. losing aspects of composition, structure or functioning), it is pushed beyond a ‘tipping point’ or threshold, at which it undergoes fundamental and irreversible change – it becomes something different in terms of its composition, structure and functioning, and this could affect the ecosystem services it can provide (Figure 2). If people are relying on the ecosystem services (see Box 2 for a more detailed explanation) for their livelihoods, then the resilience of the ecosystem is an important factor for them, whether they know it or not.

BOX 2 Ecosystem services and ecological infrastructure

Ecosystem services are the benefits people derive from functioning ecosystems. They include provisioning services (such as food, water, timber, fibres, and genetic resources); regulating services (such as the regulation of climate, floods, disease and water quality); cultural services (such as the provision of recreation opportunities, aesthetic enjoyment and spiritual fulfilment); and supporting services (such as soil formation, pollination, clean air and nutrient cycling). Ecosystem services are interlinked and often inter-dependent.



There is fairly widespread recognition of the importance of ecosystem services to human well-being and the ability of societies to meet their resource needs and build sustainable livelihoods – in the Western Cape, the total annual value of ecosystem services in the Cape Floristic Region is estimated to be about R10 billion, equivalent to over 10% of South Africa’s Gross Geographic Product.

Ecosystem functioning, and the delivery of ecosystem services, can be impaired or lost if the composition, structure or processes that maintain the system are disrupted. Biodiversity loss disrupts ecosystem functioning, making the ecosystem more vulnerable to shocks and disturbances (like the impacts of climate change), and less able to supply society with critical ecosystem services. Although ecosystems that are not in top ecological condition may still be able to provide some ecosystem services, many ecosystem services cannot be replaced by artificially produced substitutes, which means that there is no readily available means for compensating for their loss. This is especially true for the rural poor, who are entirely dependent on functional natural ecosystems for their survival, and cannot afford substitutes, even where these do exist.

Maintaining the flow of ecosystem services requires that essential ecological infrastructure is kept intact. **Ecological infrastructure**, which forms part of our natural capital, refers to the components of naturally functioning ecosystems that deliver ecosystem services. It is the nature-based equivalent of built or hard infrastructure, and can be just as important for providing services and underpinning socio-economic development. Ecological infrastructure does this by providing cost effective, and long-term natural solutions to service delivery that can supplement, and sometimes even substitute for, built infrastructure solutions. If ecological infrastructure is degraded or lost, the flow of ecosystem services will diminish and ecosystems will become less resilient.

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Ecological infrastructure includes features such as healthy mountain catchments, rivers, wetlands, coastal dunes, and nodes and corridors of natural habitat, which together form a network of interconnected structural elements in the landscape. It is critically important that the ecological infrastructure that underpins the sustainable provision of socially-important ecosystem services is depicted in spatial plans (such as SDFs, EMFs and biodiversity plans). These features must also be adequately considered in environmental assessment, to ensure that they can be protected and managed as a vital public good. This requires effective institutions and appropriately informed, good governance.

Wetlands and coastal dune fields are examples of ecological infrastructure that provides a diverse range of regulatory services that are of direct benefit to people and the economy of the Western Cape.

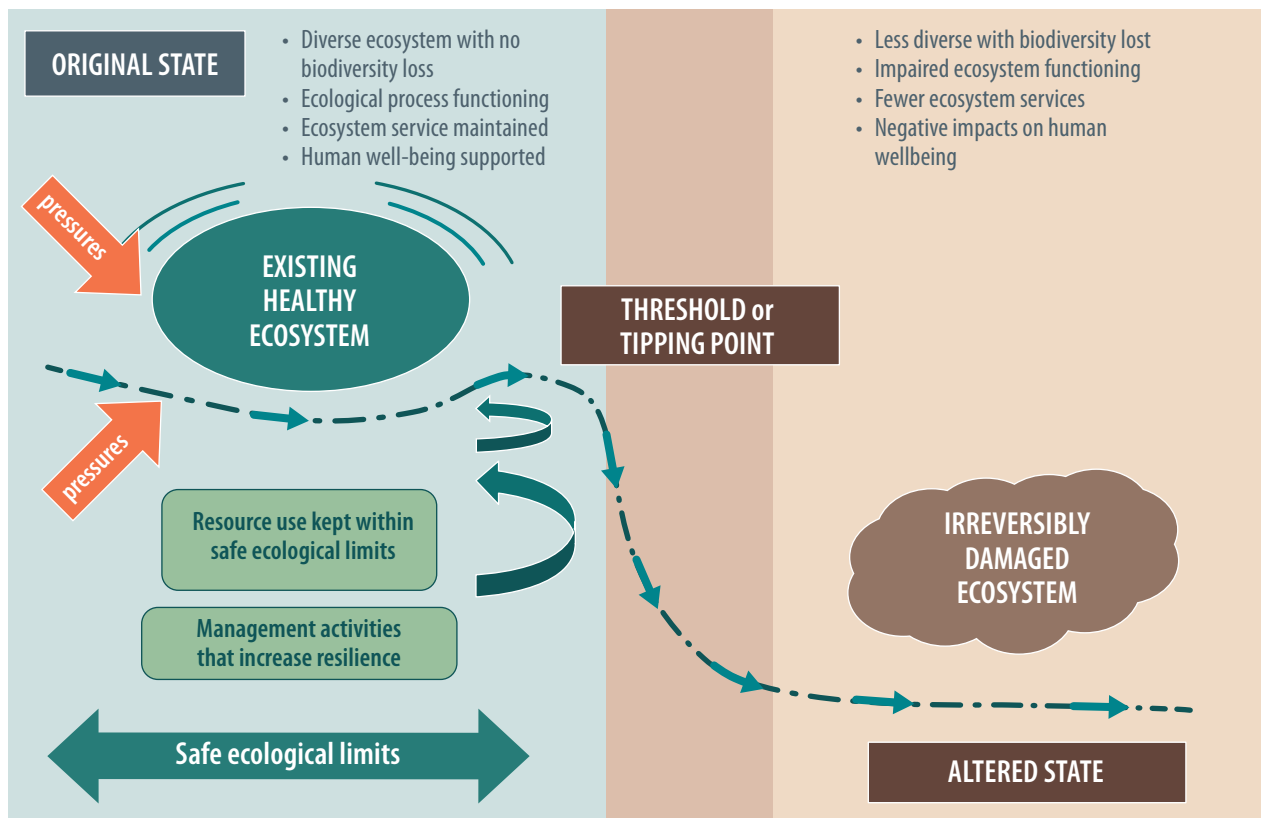
Wetlands: the numerous wetlands in the Western Cape provide a wide range and large number of ecosystem services including: regulation of stream flow (which is essential for water security); flood attenuation; flood protection, and sediment control. The degradation of the catchments in which wetlands occur is as much of a problem as the outright loss of the freshwater habitats themselves, as systemic degradation reduces the ability of freshwater ecosystem to effectively perform their natural functions and recover from environmental shocks and stresses.



Dune fields: Coastal dunes are another example of ecological infrastructure that, if carefully maintained in a natural state, provides exceedingly important services to coastal cities and settlements. Dune cordons, with their hardy and specially-adapted vegetation, are naturally adapted to absorbing environmental pressures including the erosion and migration of sandy shorelines, inundation brought about by storm surges, and the desiccating effect of summertime south-easterlies and wind-borne spray. Coastal buffering is arguably the single most important regulatory service associated with intact dune systems with sufficient space in which to migrate naturally, to absorb wave-driven erosion, and to accrete ('re-form') under calmer conditions. This applies particularly to coastal areas that are exposed to storm surges that can be associated with high spring tides and on-shore winds (such as in the Langebaan area).



Figure 2: Ecosystem resilience and thresholds of change

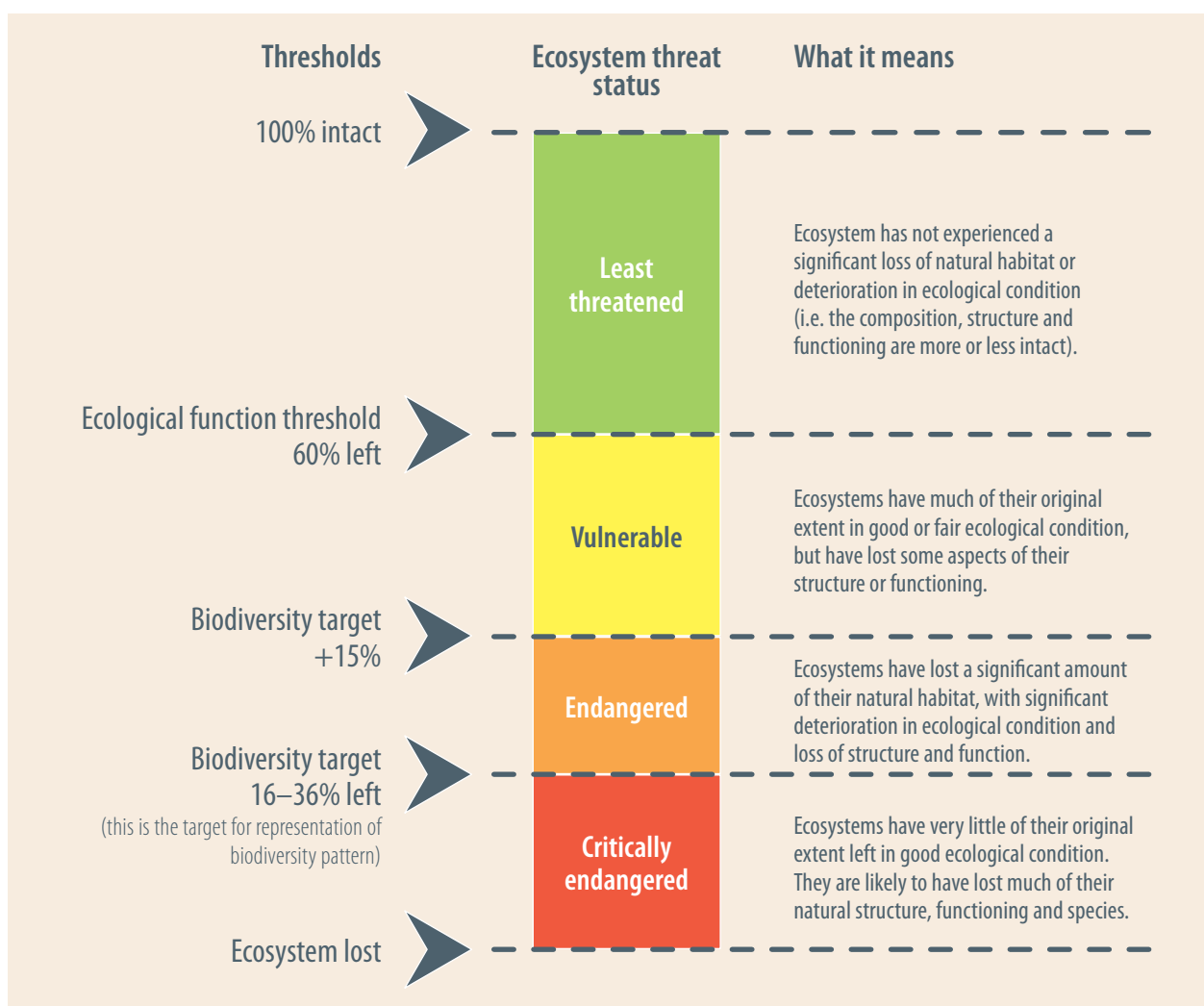


Ecosystems under pressure

Many of the ecosystems of the Western Cape are at high risk of being lost due to conversion of natural habitat for a variety of land uses, or degraded through poor land-use practices, invasion by alien species, pollution (of water, soil and air) and altered weather patterns attributable to climate change. *The National Environmental Management: Biodiversity Act (Act 10 of 2004, hereafter referred to as 'the Biodiversity Act')*, makes provision for the classification of ecosystems according to a threat status scale that categorises the extent of risk faced by an ecosystem. Ecosystem threat status is a measure of how threatened an ecosystem is based on how much of its original area remains intact relative to three thresholds or 'tipping points'. These thresholds indicate the points at which it is estimated, based on the best available scientific information, that the ecosystem will undergo fundamental change, either in terms of biodiversity pattern or ecological processes (see Figure 3 for an explanation of these thresholds). Ecosystems are categorised as Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Least Threatened (LT), with those in the first three categories (CR, EN and VU) collectively referred to as 'threatened ecosystems'. The purpose of designating and listing threatened ecosystems is to allow conservation action to be focussed strategically on those ecosystems facing the highest degree of risk.

Threatened ecosystems, or ecosystems in need of protection, that are gazetted in terms of Section 52 of the Biodiversity Act, can be a trigger for environmental authorisation in terms of the National Environmental Impact Assessment Regulations as laid out in the National Environmental Management Act (NEMA, Act 107 of 1998, as amended).

Figure 3: Thresholds for assessing ecosystem threat status



Note: the definitions of ecosystem threat status categories provided here are simplified, plain-language descriptions. Full legal and technical definitions are provided in the Biodiversity Act.

Ecosystem threat status is worked out in broadly equivalent ways in terrestrial and aquatic ecosystems. The main steps involved include: mapping and classifying ecosystem types; mapping ecological condition; and, evaluating the proportion of each ecosystem type that remains in a relatively good condition relative to the three thresholds.

South Africa's first *List of Threatened Ecosystems* was published in 2011 (G34809, Government Notice 1002, 9 December 2011). This list can be easily accessed on the BGIS website of the South African National Biodiversity Institute (<http://bgis.sanbi.org/ecosystems/project.asp>). The Western Cape includes the greatest number of threatened ecosystems of any of the provinces in South Africa, and the highest number of Critically Endangered terrestrial ecosystems (see Box 3). It should be noted, though, that patterns of land use and the face of the province are changing all the time. For this reason, the Western Cape provincial conservation authorities regularly re-assess ecosystem threat status as part of the process of keeping the provincial biodiversity framework up-to-date as a key informant in environmental decision-making. To obtain a full picture regarding ecosystem threat status, practitioners should be sure to consult both the gazetted *List of Threatened Ecosystems* as well as the most up-to-date version of the *Western Cape Biodiversity Framework* (Pence, 2014), which is available from CapeNature, or can be accessed via SANBI's BGIS website at <http://sanbi.bgis.org>

BOX 3 Threatened Ecosystems in the Western Cape

According to the most recent assessments, there are 58 threatened terrestrial ecosystems in the Western Cape, of which only two are not endemic (unique to) or near-endemic to the province. Of these 58 threatened ecosystems, 21 are listed as Critically Endangered, 14 as Endangered, and the remaining 23 are classified as Vulnerable. These comprise, almost exclusively, fynbos vegetation types. It is a matter of some concern that ten Critically Endangered, six Endangered and nine Vulnerable ecosystems have no formal protection at the time of writing these *Guidelines*. In addition, the *Western Cape Biodiversity Framework* (2014) indicates that as many as nine of the listed threatened ecosystems in the Western Cape are currently more threatened than is indicated in the published *List*.

At the district level, the Cape Winelands District Municipality (CWDM) has the highest number of threatened terrestrial ecosystem types (just over half of which are Critically Endangered), followed closely by the City of Cape Town Metropolitan Municipality (CoCT), and the Overberg District Municipality (in both of which, threatened ecosystems account for one third of the total land surface area). The high numbers of threatened ecosystems in these areas can be ascribed to loss of natural habitat caused primarily by rapid urban expansion and the expansion of agricultural activities (particularly cultivation). Although the West Coast and Eden District Municipalities have a smaller proportion of threatened ecosystems, recent assessments show that Vulnerable ecosystems are increasing in these areas.

Extracted from: *Western Cape Province State of the Environment Outlook Report, 2013*





Species at risk

Although the focus of these *Guidelines* is on ecosystems, it is important to recognise that loss of species is one of the critical factors that can impair the functioning of ecosystems and contribute to declining ecosystem threat status. Threatened species are those that face a high risk of extinction in the near (or foreseeable) future. Threatened species are those that have been classified as Critically Endangered, Endangered or Vulnerable, based on a scientific conservation assessment (or Red List process), using a standardised set of criteria developed by the IUCN for determining the likelihood of a species becoming extinct. Information about threatened species (plants and animals) can be obtained by consulting the various Red Lists that are available (see Box 4), or SANBI's Threatened Species Programme.

BOX 4 Finding and using information on threatened species

- To obtain information on species listed on the Global IUCN Red List visit: www.iucnredlist.org
- To access information about the IUCN Red List status, CITES Appendix listing or TOPS (Threatened or Protected Species) status of a South African species, visit <http://sibis.sanbi.org>
- To find out more about the IUCN Red List Categories and Criteria visit: www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria
- For information on using IUCN Red List Categories and Criteria at regional levels visit: www.iucnredlist.org/documents/reg_guidelines_en.pdf



Other useful resources for working with threatened species in the Western Cape:

Raimondo, D.; Van Staden, L.; Foden, W.; Victor, J.E.; Helme, N.A.; Turner, R.C.; Kamundi, D.A. and Manyama, P.A (Eds). (2009). Red List of South African Plants. *Strelitzia* 25. South African National Biodiversity Institute, Pretoria.

Please note: this publication is updated every 6 months on the SANBI BGIS website, so the original book may be out of date for a particular species. Practitioners should be sure always to check the latest version that is available online.

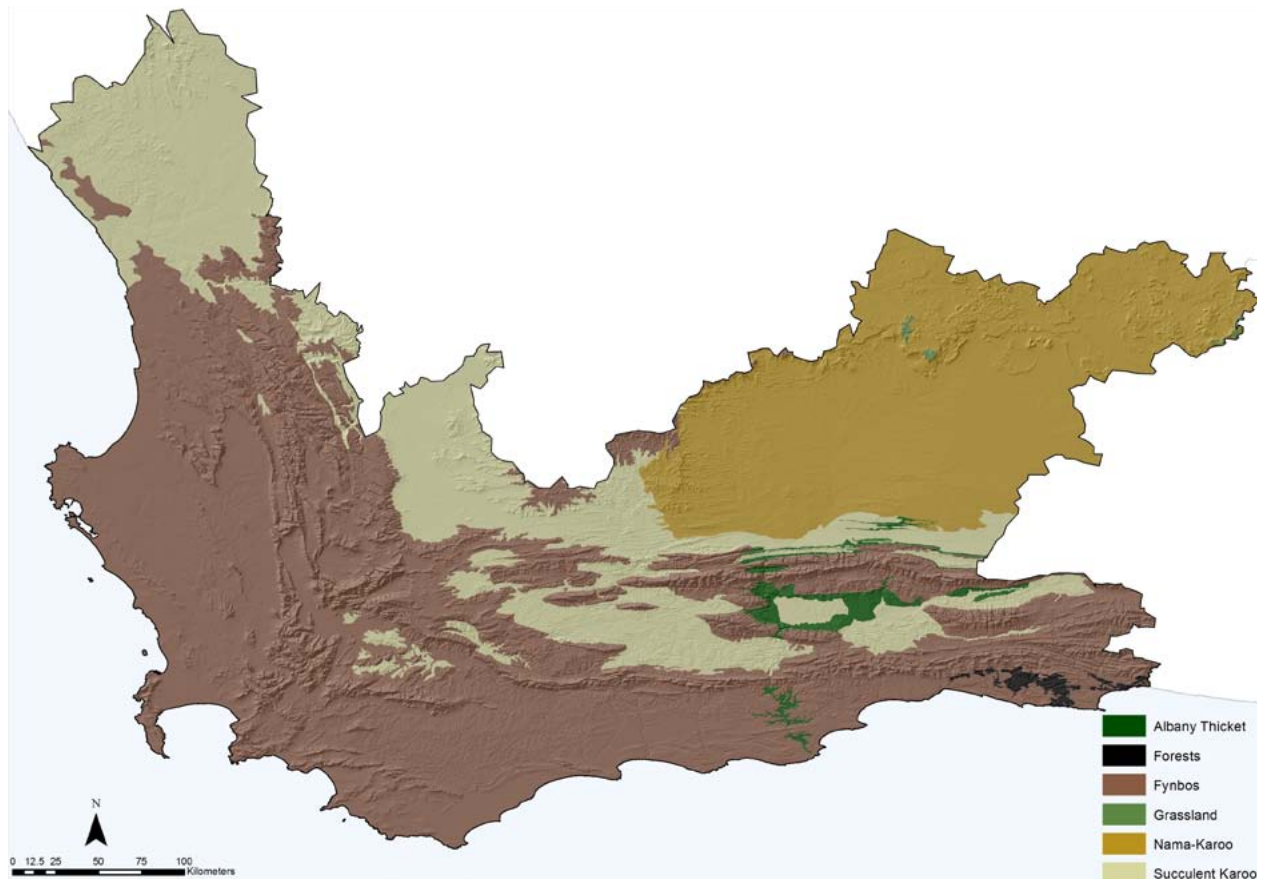
SANBI (2010). *Threatened species: A Guide to Red Lists and their use in Conservation*. Threatened Species Programme, SANBI, Pretoria. Available at: <http://bgis.sanbi.org/sites/default/files/documents/guide-threatened-species-and-red-listing.pdf/>

Driver, M.L.; Raimondo, D.; Maze, K.; Pfab, M.F.; and Helme, N.A. (2009). *Red List of South African Plants: Guidelines for Environmental Impact Assessment*. South African National Biodiversity Institute, Pretoria. Available at: <http://redlist.sanbi.org/eiaguidelines.php>

2.2. Ecosystems of the Western Cape

Ecosystems of the Western Cape fall mainly into the Fynbos Biome, but the province also includes significant parts of the Succulent Karoo and Nama Karoo as well as pockets of vegetation of the Albany Thicket and Forest Biomes (see Figure 4). The province is home to some 163 terrestrial vegetation types, over 50 estuarine ecosystems, and a rich diversity of marine and coastal habitats.

Figure 4: Biomes of the Western Cape (Source: South African National Biodiversity Institute)



Based on different combinations of species composition, community structure, abiotic (i.e. ‘non-living’) environmental factors and ecological characteristics, vegetation types of the Western Cape have been arranged for the purposes of these *Guidelines* into nine broad ecosystem groups. Each group of ecosystems is dealt with separately in the *Guidelines*, as shown in Table 2.

Table 2: Groups of ecosystems used in these *Guidelines*

Note: A full list of the vegetation types associated with each group, and their ecosystem threat status, is provided in Chapter 6, Appendix 1.

ECOSYSTEM GROUP	TYPES OF ECOSYSTEMS INCLUDED
1. Coastal ecosystems	Estuaries, Sandy Beaches and Dunes, Strandveld.
2. Lowland fynbos ecosystems	Limestone Fynbos, Sand Fynbos, Alluvium Fynbos
3. Midland and mountain fynbos ecosystems	Granite Fynbos, Grassy Fynbos, Sandstone Fynbos
4. Renosterveld ecosystems	Coastal Renosterveld, Inland Renosterveld
5. Succulent Karoo ecosystems	Vygieveld, Broken Veld, Quartz patches
6. Mainland Thicket ecosystems	Thicket, Valley Thicket, Arid Thicket
7. Nama Karoo ecosystems	Lower and Upper Karoo, Gamka Karoo, Hardeveld
8. Forest ecosystems	Afrotemperate Forest, Southern Coastal Forest
9. Inland Aquatic ecosystems	Rivers, Wetlands and Open Waterbodies

The order of the nine ecosystem-specific sections in the *Guidelines* corresponds broadly with two major terrestrial environmental gradients in the Western Cape:

- An increase in altitude and variation in topography as one moves from the coast inland.
- A shift towards wetter and more temperate conditions east of Cape Town, and drier ones in the western and northern parts of the province.

Appendix 1 (in Chapter 6) includes a full list of the vegetation types making up each group of ecosystems, and indicates their ecosystem threat status at the time of writing these *Guidelines*.



A ‘Snapshot’ of each group of ecosystems is provided in Chapter 5. These snapshots provide a ‘thumb-nail sketch’ of each group of ecosystems, including a brief summary of general characteristics (location, composition, notes on species or other features of special interest), and a few notes regarding current levels of protection, ecosystem threat status and land-use pressures and risks faced by the ecosystems. More comprehensive information can be found in other literature such as the relevant chapters of *The Vegetation of South Africa, Lesotho and Swaziland* (Mucina and Rutherford, 2006), the latest version of the Western Cape *State of Biodiversity Report* or other similar documents.



CHAPTER 3

Planning for a mosaic of land uses in living landscapes

Contributors: Charl de Villiers, Susie Brownlie, Tony Rebelo, Pat Holmes, Julia Wood, Kerry Maree, Sam Ralston, Jeffrey Manuel, Stephen Holness, Mandy Cadman and Amanda Driver.

3.1. Planning for living landscapes

The landscape approach to biodiversity conservation recognises that almost all ecosystems are already modified to some extent by human activity and that not all land-uses are compatible with biodiversity conservation. It seeks to keep those areas that are priorities for conserving biodiversity or ecosystem functioning as natural as possible and to manage them to meet biodiversity objectives. Across any given landscape, there are many possibilities for the kind of land-use mosaic that can emerge. What is possible in one particular situation depends not only on the 'conservation vision' for that land, but also on existing patterns of land use, land ownership and land-use rights, cultural values, economic development needs, laws and regulations and their enforcement. The land-use mosaic that exists at any one point in time is unlikely to be static, and adaptive management will be needed to maintain the landscape in a state that will be resilient to change over time.

Identifying areas of greatest biodiversity importance in the Western Cape

Valuable biodiversity is found throughout the Western Cape, but it is not evenly distributed across the landscape. Due to limited financial and human resources and other practical constraints, it makes sense to prioritise areas in terms of biodiversity importance, so that conservation action can be concentrated in areas where there are the best opportunities for meeting biodiversity targets, and other forms of land-use (such as mining, human settlements and agriculture) can be located where their impact on biodiversity can be minimised.

In South Africa, spatial biodiversity priorities are identified using systematic biodiversity planning, a method that aims to find the most efficient way to conserve enough biodiversity to ensure that it persists. See Box 5 for the basic principles of systematic biodiversity planning.



BOX 5 Principles of systematic biodiversity planning

Systematic biodiversity planning is a strategic and scientific approach to identifying those areas that are essential for biodiversity management and conservation. Three key principles underpin systematic biodiversity planning:

- The need to conserve a **representative** sample of biodiversity pattern, such as species and habitats (this is the principle of **representation**).
- The need to conserve the ecological and evolutionary processes that allow biodiversity to **persist** over time (this is the principle of **persistence**).
- The need to set quantitative **biodiversity targets** that tell us how much of each biodiversity feature should be conserved in order to maintain functioning landscapes and seascapes. Biodiversity targets should be based on best available science and may be refined as new information becomes available over time. Biodiversity targets define what resource planners and managers should aim for, and provide a basis for the monitoring that is so important for good management.

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There are two further principles that guide the process of systematic biodiversity planning:

- **Efficiency**, or striving to meet biodiversity targets in the smallest land area (or shortest river length) possible. Efficiency goes together with **complementarity**, which is the extent to which an area contributes biodiversity features not represented elsewhere in a region (i.e. that sensibly complements the choice of other areas).
- **Transparency**, or documenting a clear rationale for decisions, enabling them to be repeated and/or critically reviewed.

How are systematic biodiversity plans developed?

Systematic biodiversity planning involves the following steps:

- **Map** a wide range of information about biodiversity features and patterns of land and resource use, to understand what is located where.
- **Set biodiversity targets** that show how much of each ecosystem is needed to conserve it (see discussion below).
- **Analyse the data** using systematic biodiversity planning software – this identifies what needs to be prioritised and where, highlighting the most efficient options for meeting all biodiversity targets, as well as other possible (but less efficient) alternatives.
- **Interpret** the results of the biodiversity assessment and to generate a biodiversity priority areas map and land-use guidelines.



Setting biodiversity targets

An important step is that in which the **biodiversity targets** are set for each ecosystem. To do this, scientists work out the **ecosystem threat status**, which is a measure of how much of the ecosystem remains intact and how much at risk it is of undergoing further degradation or loss. An ecosystem is identified as being Critically Endangered, Endangered, Vulnerable or currently Least Threatened, based on how much of it remains intact relative to three biodiversity thresholds. These thresholds (which are explained and illustrated in Chapter 2) indicate the points at which it is estimated, based on the best available science, the limits of acceptable change will be reached – that is, the point at which, unless corrective management is put in place, an ecosystem could undergo irreversible change and become something quite different.

The point at which an ecosystem becomes Critically Endangered is the **biodiversity target**, and represents the minimum proportion of the ecosystem that must be kept in a natural or near-natural state to conserve it. This does not mean necessarily that it needs to be located within a protected area – it must, however, be kept in a natural (or near-natural) state and managed for biodiversity persistence. Biodiversity targets can also be set for other biodiversity features (such as species or ecological processes), and these are based on scientific research relating to those features.

The products of systematic biodiversity planning

The results of the planning process include maps, showing where the highest priority areas are within a broader landscape (enabling decision-makers to focus their attention on these,) and land-use guidelines that indicate what land-use types are compatible with maintaining biodiversity in these priority areas and how they should be managed. The areas of highest biodiversity priority are called **Critical Biodiversity Areas** (CBAs) and **Ecological Support Areas** (ESAs). Critical Biodiversity Areas are the areas required to meet biodiversity targets – if these areas were to be modified in some way, then the biodiversity targets could not be met. They need to be maintained in a natural or near-natural state and are ideally included in ecological corridors that maintain the connections between them. Ecological Support

Areas are areas where there are more options to conserve biodiversity whilst implementing other kinds of land use. These areas are not necessary for meeting biodiversity targets, but are needed to maintain the ecological functionality of the landscape by supporting the functioning of the Critical Biodiversity Areas, and delivering ecosystem services. Ecological Support Areas should be kept in at least a fair ecological condition.

In the Western Cape there are a number of systematic biodiversity plans available for practitioners to use, as well as other sources of biodiversity information that should be used as informants in land-use planning and environmental assessment. Some of these include: The *Western Cape Biodiversity Framework* (WCBF, 2014); fine-scale biodiversity plans and Biodiversity Sector Plans for district and local municipalities; the City of Cape Town's *Biodiversity Network* (BioNet); and Municipal Biodiversity Summaries. A brief description of each of these is provided in Box 6.

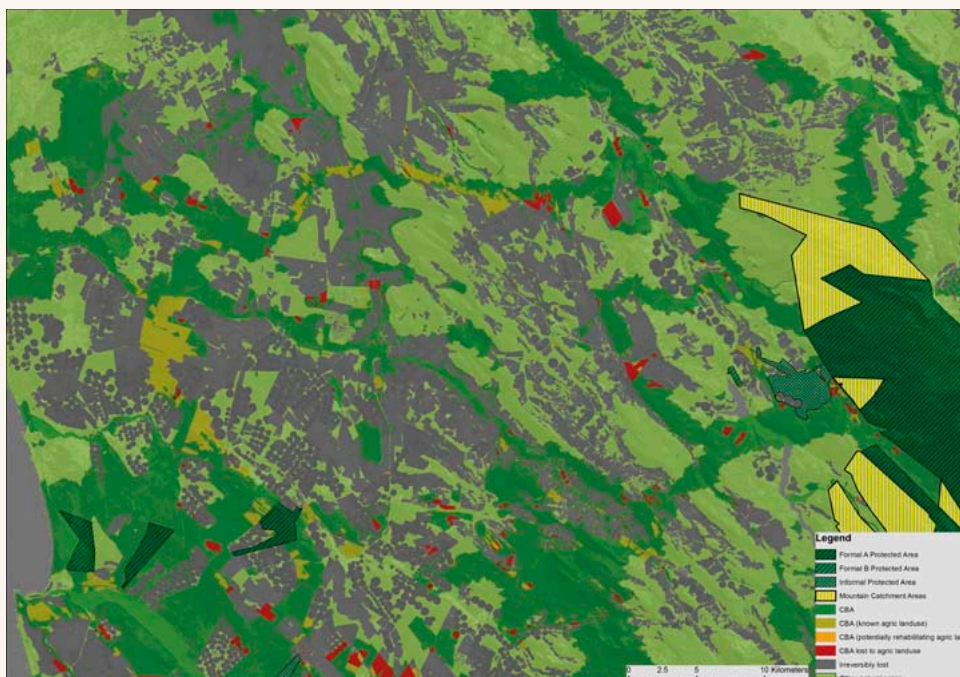
BOX 6 Biodiversity planning products, and other tools, available for use in the Western Cape

The Western Cape Biodiversity Framework (WCBF, 2014)

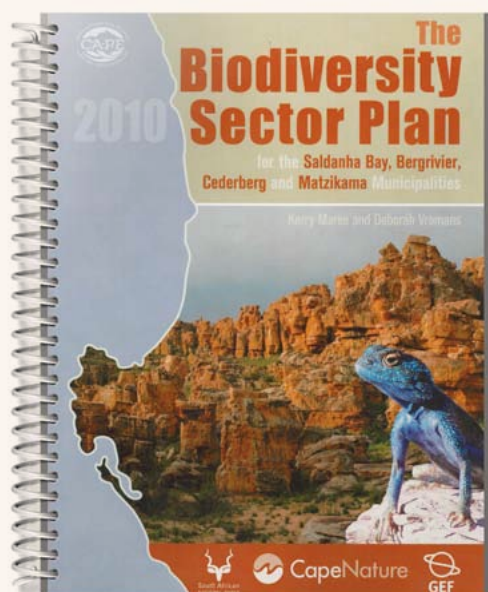
The *Western Cape Biodiversity Framework* (referred to here as the 'Framework', for simplicity) is a biodiversity plan aimed at a broader range of sectors than just conservation authorities and institutions. It is a tool for supporting and streamlining land-use planning and environmental decision-making across all sectors and tiers of government, with an emphasis on the spatial implications for both development and biodiversity conservation. The first version of the *Framework*, which was produced in 2010, was the first integration of biodiversity planning products into a common, user-friendly framework to guide land-use decision making in the Western Cape. It provided a clear indication of all Critical Biodiversity Areas (CBAs) identified across the province.

The 2014 update to the *Framework* highlights where the desired land management objectives, that were identified in 2010, have (or have not) been met, by analysing the provincial CBA footprint in terms of where CBAs have been brought into the conservation estate, or lost through modification for other kinds of land use. It also reports on the extent to which current CBAs and protected areas contribute to meeting national biodiversity targets, and makes updated ecosystem threat status information available for improved environmental decision-making. The 2014 *Framework* will be replaced by a province-wide systematic biodiversity plan (CBA Map), which will be released in 2016 and updated at regular intervals in the future.

A portion of the Critical Biodiversity Areas map provided in the WBCF (2014)



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Fine-scale biodiversity sector plans and other biodiversity planning products

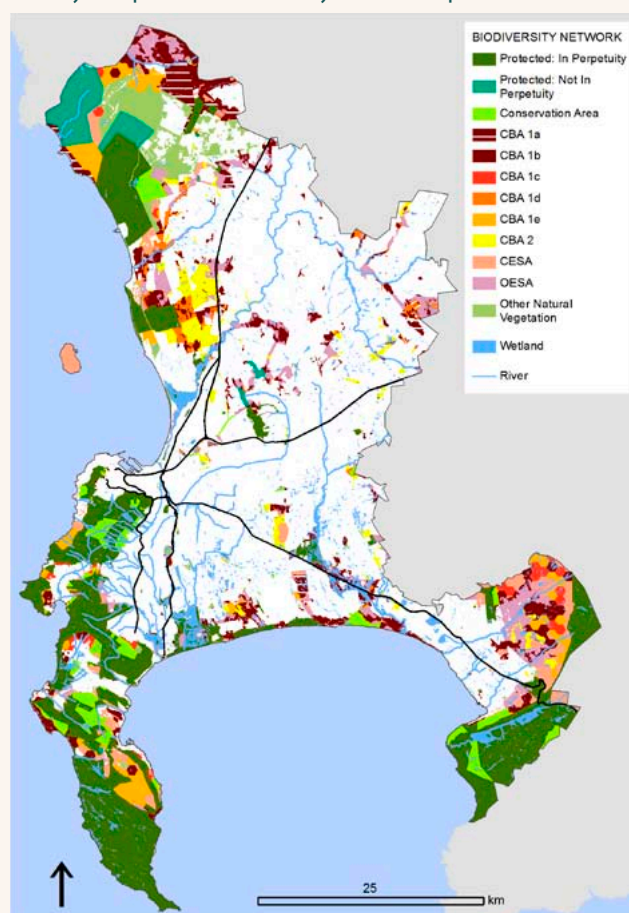
Fine-scale biodiversity plans, which have been produced at a scale suitable for incorporation into other planning instruments such as Spatial Development Frameworks (SDFs) and Environmental Management Frameworks (EMFs), exist for many of the District and Local Municipalities in the Western Cape. These take the form of Biodiversity Sector Plans, or other kinds of conservation frameworks or biodiversity plans, that include CBA maps, land-use guidelines and contextual information that should be used to inform project planning and environmental assessment. Visit SANBI's BGIS website for a comprehensive listing of all the fine-scale biodiversity planning products that are available for use in the Western Cape. These plans can also be downloaded from the website.

The City of Cape Town BioNet

The *Biodiversity Network (BioNet)* for the Cape Town Municipal area is a systematic biodiversity plan that identifies a network of areas that represent the minimum needed to conserve a representative sample of Cape Town's unique biodiversity and ecosystems, in support of sustainable development. Once implemented, this network will contribute to the City's goals of creating integrated human settlements, by improving quality of life and creating easy access to safe natural areas; promoting economic growth, by creating tourism and job opportunities; and supporting development, by ensuring sustainable use of natural and cultural resources.

Practitioners working within the boundaries of the City should use the *BioNet* as a critical informant in preparing their environmental impact assessments. The *BioNet* scan be obtained from the website of the City of Cape Town, at <https://web1.capetown.gov.za/web1/OpenDataPortal/>; <http://bgis.sanbi.org>

The City of Cape Town's Biodiversity Network map.



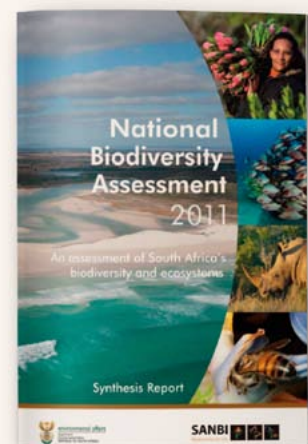


There are also some national-scale systematic biodiversity planning products that are of relevance to environmental assessment and land-use planning in the Western Cape, including the *National Biodiversity Assessment 2011* (Driver *et al.*, 2012), and the *Atlas of Freshwater Ecosystem Priority Areas* (Nel *et al.*, 2011) and its associated *Implementation Manual* (Driver *et al.*, 2011). These are summarised in Box 7.

BOX 7 National systematic biodiversity planning products relevant to the Western Cape

The National Biodiversity Assessment (NBA)

The *National Biodiversity Assessment 2011* (referred to as the NBA) provides a summary of spatial biodiversity priority areas that have been identified through systematic biodiversity planning at national, provincial and local level. It includes headline indicators and national maps for terrestrial, freshwater, estuarine and marine environments. It provides standard national spatial data layers that can be used in other national, regional or local planning projects and an agreed set of national biodiversity targets for ecosystems. The NBA products can be used to: streamline environmental decision making, strengthen land-use planning, identify priority areas for management and restoration, provide an initial identification of threatened ecosystems, and highlight those areas where more detailed planning is required. The NBA is updated at five-year intervals.



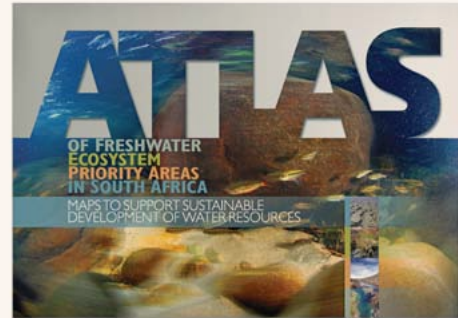
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The NBA products can be accessed via the BGIS website which is maintained by the South African National Biodiversity Institute (SANBI).

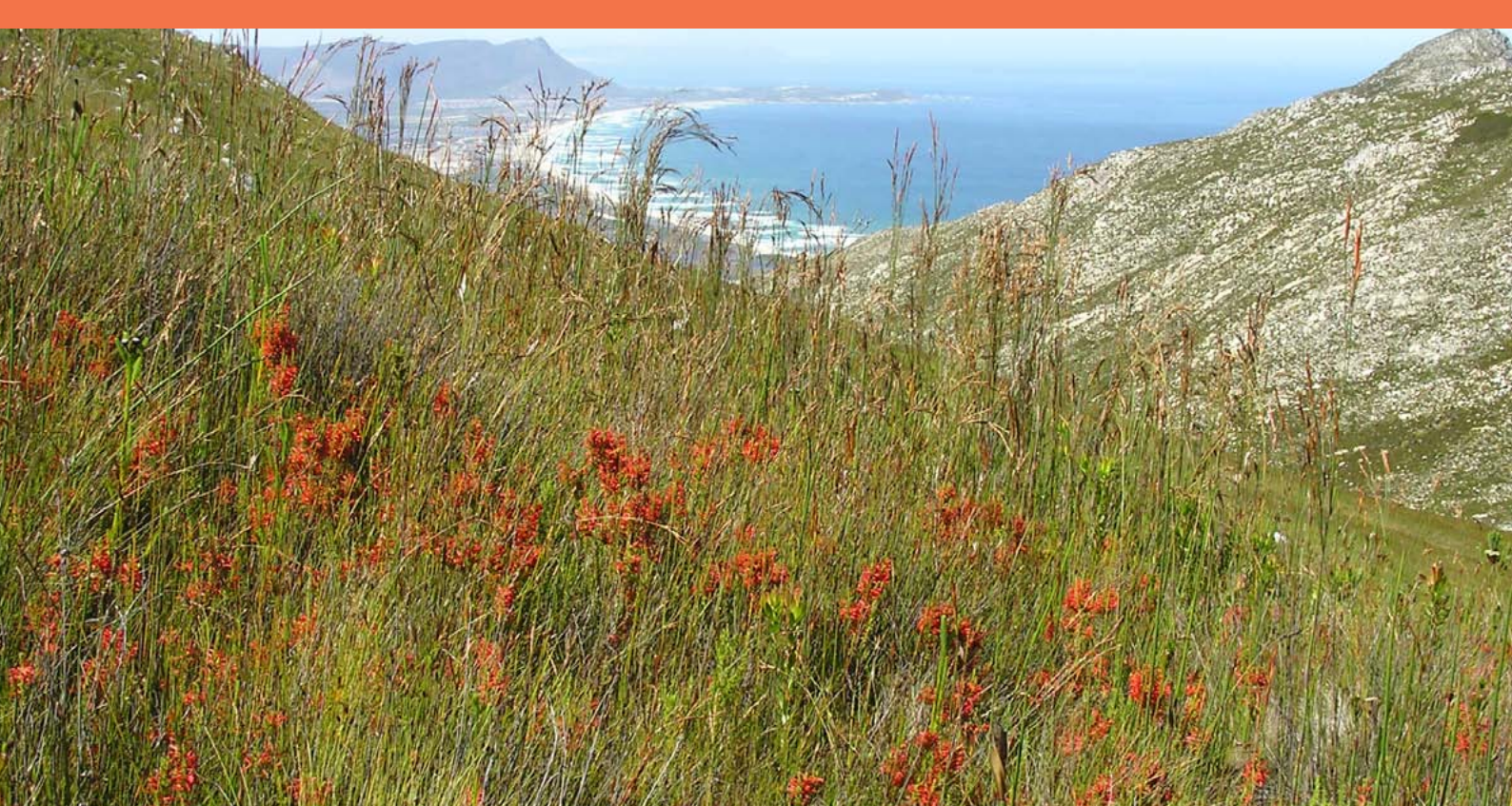
Visit <http://bgis.sanbi.org/nba/project.asp>

The Atlas of Freshwater Ecosystem Priority Areas (FEPAs) and the FEPA Implementation Manual

The National Freshwater Ecosystem Priority Areas (NFEPA) project identified a national network of freshwater priority areas that would be necessary to conserve a representative sample of the diversity of species and inland water ecosystems in which they occur, as well as the processes that generate and maintain diversity. NFEPA map products provide strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. These strategic spatial priorities are known as **Freshwater Ecosystem Priority Areas, or FEPAs**. FEPAs were determined through a process of systematic biodiversity planning based on a range of criteria that are described in detail in the NFEPA Technical Report. The FEPA maps are published in the Atlas of Freshwater Ecosystem Priority Areas, which is accompanied by an Implementation Manual that provides detailed, practical guidelines for managing land-uses and their impacts in the freshwater priority areas. The NFEPA products can all be downloaded from the BGIS website of the Water research Commission, which is at <http://www.wrc.org.za>



Section 3.3, below, provides guidance on how best to use these kinds of planning products in environmental assessment processes.



3.2. Planning for functional landscapes: spatial components of ecosystem processes

It is the aim of systematic biodiversity planning to ensure the persistence of biodiversity by conserving the ecological and evolutionary processes that maintain biodiversity patterns over the long term. ***‘Spatial components of ecological processes’*** (sometimes shortened to ‘spatial components’ for convenience) are those environmental features that can be mapped to serve as spatial surrogates for ecological and evolutionary processes.

Why spatial components of ecological processes are important

For biodiversity to be adequately addressed in land-use planning and environmental assessment, both biodiversity pattern (representation) and ecological processes (persistence) must be adequately considered. Limiting an assessment or specialist study to only one or the other, would mean that the full range of potential impacts on biodiversity will not be considered. The findings of such an assessment would be incomplete, with negative ramifications for project planning and authorisation (and for biodiversity).

Conserving ecological processes (i.e. achieving persistence) often requires a larger proportion of the landscape than is needed for conserving biodiversity pattern (i.e. achieving representation). However, the two are inextricably linked because without conserving sufficient habitat to maintain ecological processes, biodiversity pattern will be irreparably lost in the medium to long term. This has important implications for the location of land uses in the broader landscape.

It is clearly not realistic (nor would it be desirable) to aim to secure a large proportion of the total landscape in formal protected areas. Fortunately, maintaining the integrity of ecosystems across broad landscapes can be achieved by adopting a landscape approach to biodiversity conservation in which protected areas are one of a matrix of land uses in which biodiversity-compatibility and biodiversity management objectives are built into the plans, production practices and decisions of a range of land and resource users. Maintenance of ecological functioning (by securing both biodiversity pattern and ecological processes) can be consistent with a wide range of low impact land and resource uses, and Section 3.3 of this chapter provides guidance on how this can be achieved.

Mapping spatial components of ecological processes



Ecological processes may be difficult to observe or measure directly (for example, processes such as seasonal migration or seed dispersal). This is complicated by temporal (both seasonal and inter-annual) and spatial variations which may be hard to quantify or map. Fortunately, some ecological processes can be effectively represented by spatial surrogates, meaning that the environmental features that underpin these processes can be mapped. These spatial components include physical linkages, boundaries and gradients in the landscape, such as: river corridors; interfaces between different soil types, geology or vegetation types, or between flat areas and slopes; water production areas; animal migration pathways or home ranges, and nesting sites; and altitudinal changes in temperature and precipitation. These tend to function only when kept relatively intact in well-managed areas of natural or near-natural habitat.

Systematic biodiversity plans effectively conserve ecological processes by accommodating their spatial components in ecological corridors. These corridors (which could be aligned along rivers, upland-lowland gradients, soil interfaces or other ecological gradients in the landscape), are built into the network of Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) shown on CBA maps.

How much space do spatial components of ecological processes require?

There is a wide range of spatial components that occur at different scales, which means that they require different areas of natural habitat for their persistence. Some ecological processes (such as seasonal migration by animals, or the hydrological processes that operate across a landscape to maintain base flows) operate on a large scale. Maintaining these ecosystem processes requires that fairly large areas of habitat must be kept in a natural or near-natural state, and that these areas are connected across the landscape. Other ecological processes require less space – for example, some specialist plant-pollinator relationships involving insects may be effectively maintained in patches of intact habitat as small as 5 hectares. The bottom line in each case involving species (as pollinators or seed dispersers, or in other plant-animal interactions), is that enough habitat must be conserved for viable populations of these species to persist in the landscape.



It is important to note that securing ecosystem processes depends not only on the size of the area that is kept in a natural or near-natural state, but on other factors such as: the shape (spatial configuration) of the area; the kinds of landscape features required for maintenance of the ecological process (for example, certain pollinators require at least seasonally wet areas in order to breed successfully; maintaining faunal migration processes requires upland-lowland gradients); the kind of management being applied (for example, appropriate management of fire and invasive alien species); and the nature and ecological state of the surrounding area and the land-use practices prevailing there.

It is important that each situation is assessed on a case-by-case basis, and to understand that the amount of space needed for maintaining ecological processes will also be influenced by whether the spatial components are fixed or flexible.

Fixed and flexible spatial components of ecological processes

Systematic biodiversity planning recognizes two categories of spatial components of ecological processes: those that are spatially fixed, and those that are spatially flexible. These are described below.

Spatially fixed components capture processes associated with clearly defined, physical features in the landscape, such as quartz patches or rocky outcrops (Table 3). These are unique features requiring special attention. An example of this is plant diversification along soil interfaces, which can occur at varying scales. The spatial component (the interface) can consist of a strip only a few metres wide, where contrasting soils or rock types meet and where plant speciation is known to occur. In other situations, the interface can extend over wide areas, which provides a degree of flexibility in systematic biodiversity planning when selecting priority areas. Examples include the granite-sandstone interfaces and those vegetation units characterised by mosaics.



Spatially flexible components are those ecological processes that can persist in various spatial configurations, such as the migration of plants and animals along upland-lowland gradients where the precise migration route is not well defined. In such cases, several spatial options for securing these ecosystem processes could exist, especially where there are still large tracts of substantially intact habitat. Spatially flexible components of ecological processes also include macro-climatic gradients between lowland and upland areas.

In general, the less natural habitat there is across a landscape, the fewer options exist for meeting the spatial requirements of flexible ecological processes. In extreme cases these can become fixed and only a single viable option may remain.

Table 3: Examples of the functions of selected fixed and flexible spatial components of ecological processes

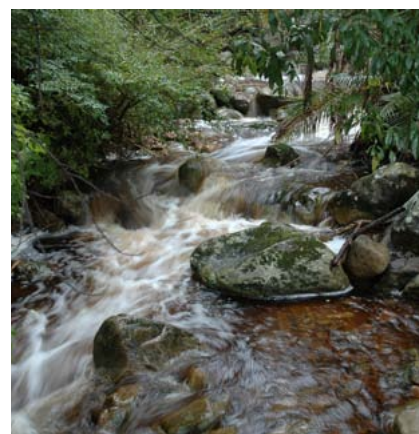
	SPATIAL COMPONENT	ECOLOGICAL FUNCTION
Fixed	Edaphic interfaces – restricted	Drive ecological plant diversification
	Entire sand movement corridors	Promote diversification of plant species
	Whole riverine corridors	Facilitate animal movement and plant dispersal along inland-coastal gradients
	Upland-lowland interfaces (ridges & riparian zones)	Ecological diversification of plant and animal lineages; support seasonal migration
Flexible	Upland-lowland gradients (slopes)	Support seasonal movement of animals and local-scale adjustment in the distribution of species in response to climate change
	Macroclimatic gradients	Important for diversification of animal and plant lineages, dispersal events and adjustment in the distribution of species in response to climate change
	Edaphic interfaces – extensive	Drive ecological plant diversification

Which spatial components of ecological processes have been mapped?

Not all spatial components of ecological processes are mapped in biodiversity plans – this may be for reasons of scale or regional conservation priorities.

In general, only those large-scale ecological processes considered important for achieving biodiversity targets at the broad, biome level have been explicitly mapped; numerous ecological corridors or vegetation boundaries that represent more localized, but equally important, processes within local catchments may not have been mapped in biodiversity plans, although this varies greatly from one plan to another. This places the responsibility for identifying local-scale ecological processes on the EAP. However, data are generally available to enable mapping of local-scale ecological processes and infrastructure and this information should be used in environmental assessments and land-use decision-making.

Some aspects of ecological infrastructure (i.e. naturally functioning ecosystems that deliver valuable services to people) have also been mapped in systematic biodiversity plans, but this is a work in progress. For example, the BGIS website (<http://bgis.sanbi.org>) includes various maps related to wetland infrastructure and ecosystem services under the NFEPA project. Examples of ecosystems or landscape features representing ecological infrastructure include: rangelands; resource harvesting areas (e.g. flowers, thatch, medicinal); urban open space used as cultural and recreational areas; coastal protection areas; climate corridors; wetland and river buffers; strategic water source areas; important wetland clusters; and estuaries.



Proactive planning considerations for maintaining functional landscapes

At the landscape level, environmental assessment practitioners, biodiversity specialists and spatial planners need to:

- Refer to existing systematic biodiversity plans (i.e. CBA maps) in order to determine which important spatial components of ecological processes in the affected area have been identified and mapped (either as Critical Biodiversity Areas or Ecological Support Areas). It is essential to ensure that sufficient area is set aside and managed to support these ecological processes. For example, the City of Cape Town's BioNet, has incorporated baboon home ranges into Ecological Support Areas. It is important that any proposed land use, even if it is deemed to be compatible with the desired management objectives of an ESA, does not disrupt these home ranges.
- Identify and map obvious local-scale landscape features that may serve as ecological corridors or vegetation boundaries (e.g. watercourses and riparian vegetation, ridges or dune systems). These may not already have been mapped as CBAs or ESAs.
- Aim to accommodate such corridors or vegetation boundaries in land-use plans and environmental assessments. Ensure that the features are manageable (both operationally and economically) in the long-term to ensure their persistence: this involves minimizing fragmentation of natural habitat, as small isolated patches and narrow corridors are much less able to support ecological functioning than are larger, connected areas. Also, edges must be minimized as edges degrade more readily, are subject to edge effects and are avenues for invasion by alien species.
- Refer to the relevant ecosystem guidelines and determine the drivers of the systems (e.g. floods, pollination, edaphic variation, sand movement, fire, or animal disturbance). Ensure that these drivers are identified and addressed in the planning phase of developments.



In the long term, effective conservation of ecological processes is enhanced by:

- Accurate mapping and delineation of ecological corridors and/or vegetation boundaries at a scale that is practical for land-use planning and decision-making, and ensuring that the land-use planning and decision-making processes take cognizance of these areas (i.e. biodiversity mainstreaming).
- Assigning appropriate management status to ecological corridors and/or vegetation boundaries (e.g. through biodiversity stewardship agreements or declaration of protected areas).



Procedures for including ecological processes in environmental assessments

As a general measure for ensuring an appropriate approach and level of rigour for including ecological processes in environmental assessment, the following recommendations apply:

- Further loss of habitat within mapped spatial components of ecological processes should be avoided.
- Where irreversible loss of habitat cannot be avoided or mitigated, offsets (See BOX 9, under Section 3.3. of this chapter) should be implemented, according to the relevant biodiversity offsets guidelines or policy.
- Generally, think in terms of creating functional networks. Where there are clear opportunities in the natural landscape for linking fragments of the same ecosystem type, and/or linking different ecosystems (e.g. coastal renosterveld to mountain fynbos, or a river system to associated wetlands or lowland vegetation), these opportunities should be accommodated within a spatial plan or project proposal. Setting aside natural habitat on one site with no connection to other natural or semi-natural areas could be of limited conservation value in the long-term.
- Consult the relevant ecosystem guidelines for the biodiversity pattern and ecological process requirements of specific ecosystems (e.g. Granite Fynbos, or wetlands) when undertaking environmental assessments for projects that may impact on spatial components of ecological processes.
- Prioritise restoration and clearing of invasive alien species in degraded habitat linkages that would otherwise be lost if neglected.
- Attempt to align irreversibly modified areas 'with the grain' of the ecological corridor or vegetation boundary that is being conserved. Avoid severing habitat linkages in ecological corridors or destroying indigenous vegetation along an entire soil or ecosystem interface.
- Obvious vegetation boundaries which reflect soil interfaces, upland-lowland interfaces, biome boundaries, riverine corridors and sand movement corridors should be maintained and accommodated within a spatial plan or project proposal.
- Narrow corridors such as riverine and sand movement corridors should be buffered to maintain their integrity within a spatial plan or project proposal.
- Consult CapeNature for input into environmental assessments or biodiversity studies involving spatial components of ecological processes.

It is important to note that, in addition to following these general recommendations, practitioners must give adequate consideration to the specific ecological circumstances prevailing at each site. The appropriateness of proposed land-uses should be informed by the desired management objectives for the area into which the site falls. This is described in detail in Section 3.3., which provides detailed, step-by-step guidance on proactive incorporation of biodiversity considerations into environmental assessment processes. In addition, each of the ecosystem guidelines provided in Chapter 5 includes recommendations about the best spatial approaches, at a landscape scale, for maintaining functional ecosystems.

3.3. Planning ahead: incorporating biodiversity considerations in the pre-application stage of project development

Note: Although this section focusses on the pre-application screening phase of environmental assessment, many of the general guidelines provided for proactive consideration of biodiversity can be applied to other planning and decision-making processes that impact on biodiversity and ecosystems (such as the development of Spatial Development Frameworks and Environmental Management Frameworks).



3.3.1. Why take a proactive approach?

The NEMA 2014 EIA Regulations¹ impose extremely tight timeframes on Basic Assessments and on Scoping and Environmental Impact Assessment processes (both referred to simply as ‘the EIA Process’) once applications have been submitted to the competent authority and ‘the clock starts ticking’. Engagement with the environmental authority, conservation agencies and key biodiversity stakeholders, as well as the involvement of specialists, is thus of the utmost importance **prior to submission of the application** for environmental authorization. Early identification of potential biodiversity issues, impacts and risks allows the proponent to adjust and shape the land-use proposal in such a way as to avoid these impacts and minimize the risks of refusal and/or having to re-start the application process.

With the range of spatial biodiversity information readily available in the Western Cape (see Table 1, Chapter 1, and Boxes 6 and 7, above), this pre-application stage is best suited to early identification of constraints and risks associated with biodiversity and ecosystem services. In this way, project proposals can be tailored to minimize their impacts and the risks of authorization being refused. In some cases, this intervention can enable proponents to avoid triggering the need for environmental authorization (e.g. by avoiding or minimizing modification of indigenous vegetation).

Early reference to these *Ecosystem Guidelines*, systematic biodiversity plans and other available biodiversity information, at the earliest possible stage of project planning, can help to ‘iron out’ obstacles that might otherwise result in delays and additional costs to the project proponent, and avoid negative impacts. Such actions are thus in the best interests of both the project proponent and the environment.

¹ Department of Environmental Affairs, 4 December 2014: R982–985.

Where natural habitat would be affected by a proposed land use, specialist biodiversity input is strongly advised. The proponent and/or appointed Environmental Assessment Practitioner (EAP) should engage an appropriate ecologist (i.e. a terrestrial, freshwater, wetland, estuarine or coastal ecologist) to identify potential biodiversity- and ecosystem services-related issues. By doing so, the ecologist can influence the proposal in such a way as to avoid or prevent significant negative impacts and risks, and optimize opportunities. Generic terms of reference (ToR) for an ecologist are provided in Appendix 3 and 4 (for terrestrial and aquatic ecologists, respectively). These ToR should be used in conjunction with the *Ecosystem Guidelines* to ensure proactive consideration of biodiversity in the pre-application stage of project development.

The emphasis on early consideration of biodiversity to halt ongoing loss is a defining principle of international best practice in environmental assessment. This is reinforced through rigorous application of the Mitigation Hierarchy.



The Mitigation Hierarchy

The National Environmental Management Principles contained in NEMA, require application of the Mitigation Hierarchy:

"Sustainable development requires the consideration of all relevant factors including... that the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimized and remedied."

This hierarchy is a fundamental tool used in the EIA process to manage biodiversity impacts (see Box 8) and risks. It emphasizes avoidance of potentially significant impacts over their minimization, and supports robust investigation of alternatives to support this end.

BOX 8 Broad categories of impacts on biodiversity

Direct impacts: these are directly linked to the land-use activity at the site (e.g. ploughing of land; erection of buildings).

Indirect impacts: these result from the land-use activity, but occur beyond the boundaries of the land-use site (e.g. abstraction of water from a river leading to reduced downstream water flows; migration of pollutants from a point source to sites downstream).

Induced impacts: these are not related to the land-use activity, but are anticipated to occur because of it (e.g. the secondary development of industries and settlements associated with construction of a road).

Cumulative impacts: these are the current impacts of the land-use activity combined with impacts from past, existing and future activities that will affect the same landscape, ecosystem or other natural resources (e.g. the development of several mines in the same catchment area).

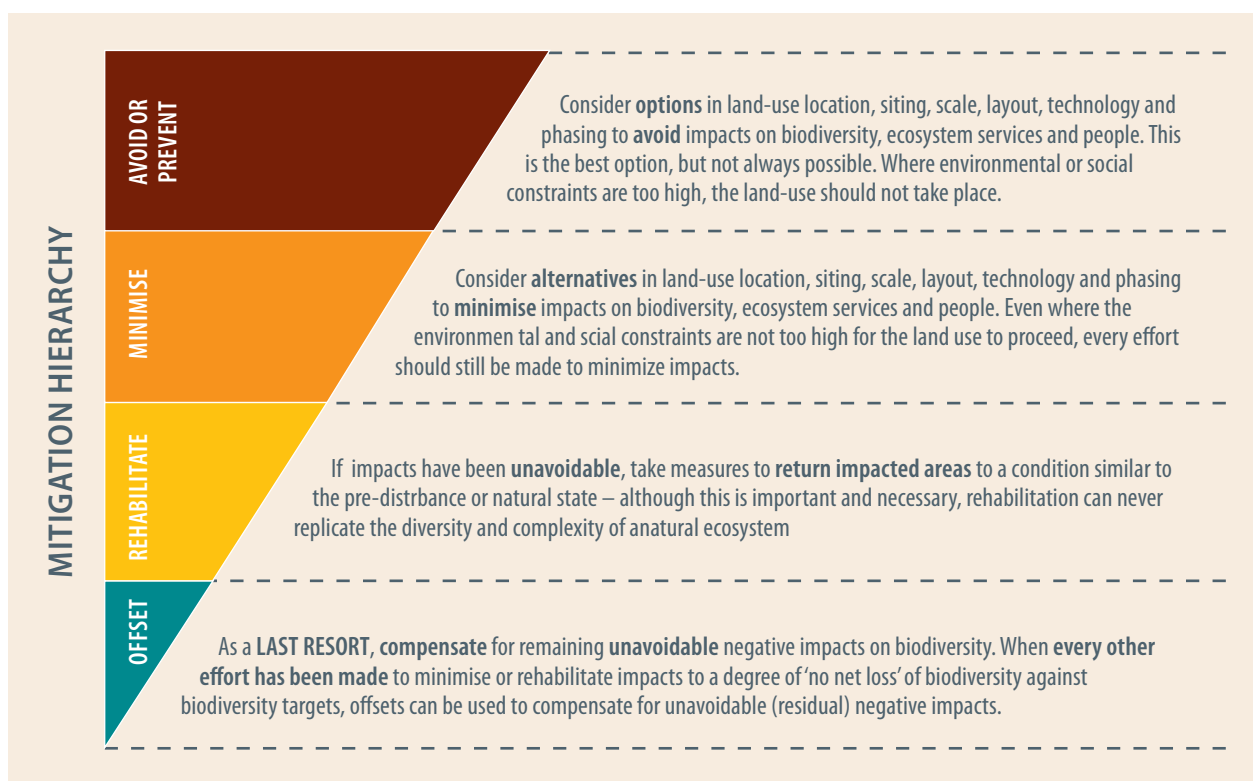
Impacts may be short term (e.g. taking place only during the construction of a road), or may last for longer periods or may even be permanent and irreversible.

Simply stated, the Mitigation Hierarchy (illustrated in Figure 5) requires a developer – in sequence – to:

1. Seek ways to **avoid or prevent negative impacts** (e.g. provide buffers or setbacks from sensitive areas, safeguard connectivity). Avoidance measures are the simplest (and cheapest) way of mitigating impacts on biodiversity.
2. **Minimize impacts** (e.g. employ measures to reduce the duration or intensity of impacts).
3. **Restore or rehabilitate** disturbed or damaged areas.
4. **Provide biodiversity offsets** equivalent to residual negative impacts, or compensation. Biodiversity offsets (See Box 9) should always be a ‘last resort’ once all other possibilities for mitigation have been exhausted.

Rigorous consideration of reasonable and feasible alternatives is crucial *at each step*.

Figure 5: The Mitigation Hierarchy



Over and above efforts to mitigate negative impacts through improving the location, siting, design, implementation and management of land uses, opportunities should be identified to leave the affected area **better off** from a biodiversity and ecosystem perspective than at the start of the project. Measures such as rehabilitation or restoration of important habitats could make a positive contribution.

It should be noted that a mechanism for implementing operational management of natural and restored areas is essential to prevent future degradation and ensure persistence of biodiversity and the ecosystem services it delivers. This should also be included in the mitigation measures.

Much of the information required for applying the Mitigation Hierarchy can be obtained from a desk-top study, but a visit to the proposed project site is crucial. By finding out whether or not there is any important biodiversity at or close to the intended land-use site, before firming up on a specific proposal, it is possible to shape and adjust initial design concepts to avoid likely impacts and risks, and exploit opportunities. This approach often translates into cost savings, may avoid stakeholder resistance to the proposal, and could facilitate obtaining environmental authorization.

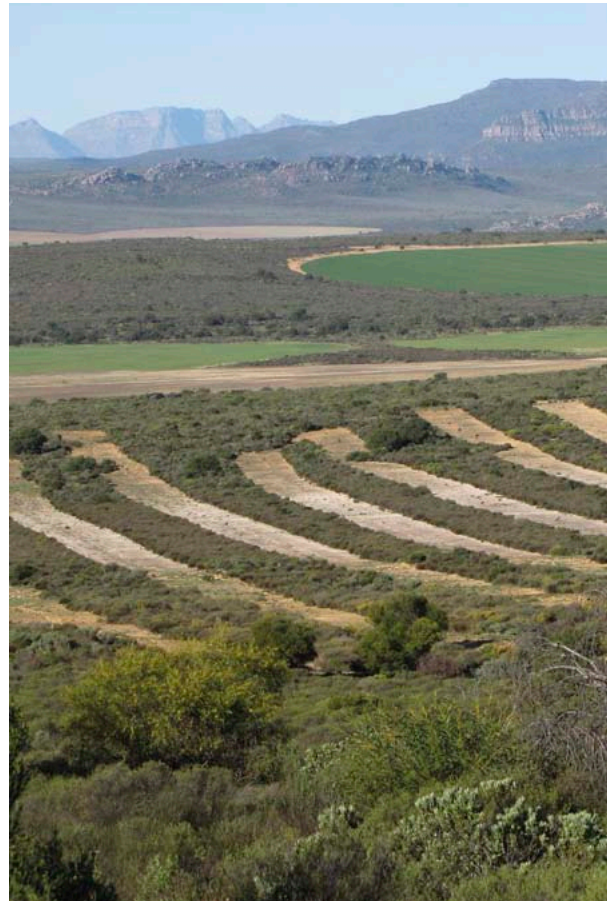
This approach also supports best practice in environmental assessment and planning by:

- a) Giving effect to a number of environmental management principles in NEMA, including the need to pay specific attention to planning procedures pertaining to sensitive, vulnerable, highly dynamic or stressed ecosystems.
- b) Ensuring that a project is consistent with the 'Duty of Care' principle (i.e. that the project proponent has taken reasonable measures to prevent significant degradation of the environment). Emphasizing the fundamental role of alternatives in selecting the 'best practicable environmental option'.

South Africa is developing a national policy framework for biodiversity offsets, and the Western Cape is currently revising its '*Information Document on Biodiversity Offsets*' (DEA&DP, 2011). The objective of offsets is to ensure that **residual** (i.e. remaining) **impacts** on biodiversity and ecosystem services that are of medium to high significance are duly compensated by developers.

Beyond addressing biodiversity offsets, these documents effectively define the desired outcome for biodiversity in the province and country and the levels of impact that would be acceptable. Property developers, EAPs and environmental specialists need to be aware of these draft documents in order to manage impacts and risks both to biodiversity and the proposed land-use.

The ideal outcome of early consideration of biodiversity is to ensure that all of the potentially significant impacts are avoided or minimized, so that remaining impacts would be of low significance, thus avoiding any need to provide biodiversity offsets – with associated time and resource costs in the long term.



BOX 9 Biodiversity offsets

Biodiversity offsets are measurable conservation outcomes resulting from actions to compensate for residual negative impacts. Biodiversity offsets, or compensation, are always a 'last resort' option in the mitigation hierarchy. However, for some projects (e.g. mining) where the project location is largely predetermined and coincides with priority areas for biodiversity or ecosystem services, or other projects of overriding national importance (e.g. large public infrastructure developments) where there are no feasible or reasonable alternatives that could be pursued to avoid impacts on priority biodiversity areas, the need for biodiversity offsets must be seen as 'a given' and known from project inception.

In these cases, a biodiversity offset specialist should be appointed in the pre-application stage, prior to formal submission of the application for environmental authorization. In this way, the biodiversity offset can be addressed as an integral part of the EIA process and the biodiversity offset specialist can engage with other biodiversity (and other) specialists to design an appropriate offset.

3.3.2. A step-by-step guide to considering biodiversity in the pre-application stage of environmental assessment

These Ecosystem Guidelines can be applied to pre-application planning by following five basic steps, as follows:

Step 1: Prepare for the site visit by synthesizing available information on biodiversity relevant to the site and project.

Step 2: Visit the site, ground-truth available information and gather additional baseline information where needed.

Step 3: Assess probable impacts on biodiversity, and identify mitigation measures to inform the land-use proposal.

Step 4: Achieve biodiversity gains by identifying opportunities to conserve or restore biodiversity.

Step 5: Report on findings.

Each of these steps is described in further detail below. The entire process is summarised in Figure 6.

Step 1: Synthesize available biodiversity information prior to a site visit

This entails understanding the biodiversity context of a proposed land use before visiting the site and surrounding areas.

This step and the next are aimed at answering three basic but important questions:

- How important is the site for meeting biodiversity objectives and targets for both pattern and ecological process?
- How important is the site for supplying highly valued ecosystem services on which there is high dependency for livelihoods, health and well-being?
- Is the proposed land use consistent with, or would it jeopardize meeting these biodiversity objectives and targets, and/or result in loss or degradation of important ecosystem services?

The proposed land use should first be evaluated in relation to the **broader ecological landscape**, and then focus on the **specific site** of the proposed activity.





Landscape-scale considerations

A landscape-scale approach is essential to identify and manage cumulative impacts on biodiversity and ecosystem services. The Western Cape is fortunate in having readily accessible systematic biodiversity plans or 'Critical Biodiversity Area (CBA) maps that specify *which parts* of the landscape need to be managed primarily for biodiversity conservation, and *how much habitat* must be retained in order for conservation to be effective in the long term. They provide an explicit and quantifiable indication of 'where we are' in relation to meeting biodiversity targets in the landscape and how close we are to reaching ecological thresholds. Quantitative thresholds and the management objectives for CBAs can be used to motivate for managing and/or rehabilitating priority habitat to a desired level of ecological quality and functioning.

It is important to identify key biodiversity issues and risks at this broad scale, including areas that have been identified as:

- being of international biodiversity importance (e.g. Ramsar sites, World Heritage Sites, and/or their buffer zones, UNESCO Biosphere Reserves)
- Critical Biodiversity Areas (CBAs) or Ecological Support Areas (ESAs)
- protected areas and/or their buffer zones, and areas earmarked for protected area expansion (in the Western Cape's Protected Area Expansion Strategy, currently in preparation)
- Freshwater Ecosystem Priority Areas (FEPAs)
- Estuarine Functional Zones
- important climate adaptation corridors
- 'sensitive' in applicable Environmental Management Frameworks (EMFs)
- coastal public property or within the Coastal Protection Zone
- important with regard to the provision of key ecosystem services or ecological infrastructure (e.g. water catchment areas)
- prone to flooding or other natural disasters (e.g. floodplains).

Sources of information for determining the biodiversity context

There are three main sources of mapped information to determine the biodiversity importance of a site in the broader landscape context, and to establish if any biodiversity features are present that must be safeguarded because they are critical for conserving biodiversity and maintaining ecosystem functioning:

- The National Biodiversity Assessment (NBA)
- Biodiversity plans/Critical Biodiversity Area (CBA) Maps
- Maps of Freshwater Ecosystem Priority Areas (FEPAs).

All of these maps and plans can be downloaded from the SANBI Biodiversity GIS website at <http://bgis.sanbi.org>. Also see the SANBI 'Biodiversity Advisor' at <http://biodiversityadvisor.sanbi.org> and SANBI's 'Land Use Decision Support (LUDS) Tool' at <http://bgis.sanbi.org/services.asp>.

Biodiversity plans and maps of Critical Biodiversity Areas

CBA maps identify the most efficient network of sites that are required to ensure the continued persistence of:

- biodiversity pattern (e.g. species, habitats, vegetation types and ecosystems)
- the ecological processes and disturbance regimes which maintain biodiversity pattern.

See **Box 10** for an overview of how CBA maps have contributed to refining an understanding of which areas or features are important for biodiversity conservation.

BOX 10 Economising biodiversity's slice of the landscape

One of the main achievements of fine-scale biodiversity planning is the extent to which it has reduced the amount of land needed for conservation purposes. With relatively less land needed for conservation, there is also less risk of friction between development objectives and biodiversity priorities. However, due to the threatened nature of many of our landscapes outside protected areas, sites and corridors identified as Critical Biodiversity Areas leave little room for negotiated trade-offs between biodiversity conservation and development. Planning and impact assessment therefore should aim to avoid any further loss of CBAs, and a strictly risk-averse approach is called for in these circumstances.



CBA maps depict categories that are linked to desired management objectives. The **categories** indicate the importance that is attached to a site owing to its contribution to meeting biodiversity targets, and serve as an explicit indication of a site's contextual significance. The **desired management objectives**, in turn, provide the test for determining the appropriateness of a proposed land use. Where the land-use is not compatible with the desired management objectives, alternatives should be explored.

Box 11 explains the relationship of Biodiversity Plans/CBA maps to Bioregional Plans and Biodiversity Sector Plans.

BOX 11 Critical Biodiversity Area Maps, Bioregional Plans and Biodiversity Sector Plans

Maps of Critical Biodiversity Areas are one of the building blocks that underpin Bioregional Plans which are formally gazetted in terms of Chapter 3 of the National Environmental Management: Biodiversity Act (Act 10 of 2004).

A Bioregional Plan can be a powerful device for ‘mainstreaming’ biodiversity considerations into spatial planning at a municipal level using instruments such as Environmental Management Frameworks or Spatial Development Frameworks. The National Guideline on the Preparation of Bioregional Plans (March 2009) specifies the requirements for bioregional plans. These include that the bioregional plan must:

- include a CBA map and land-use guidelines and other supporting information (including the supporting GIS files). The map must show terrestrial and aquatic CBAs that need to be maintained in a natural or near-natural state in order to meet biodiversity targets.
- be based on a systematic biodiversity plan that is characterized by the principles of representation, persistence and efficiency, setting of quantitative biodiversity targets and conflict avoidance.
- be undertaken at a meaningful spatial scale for informing land-use planning and decision making.

As well as providing the most important biodiversity layer for Spatial Development Frameworks and Environmental Management Frameworks, CBA Maps are the key component of municipal ‘Biodiversity Sector Plans’ which comprise:

- a map of Critical Biodiversity Areas
- a handbook of land-use guidelines
- a biodiversity profile and other contextual information
- various supporting products (such as wall maps) and technical reports.

Unlike Bioregional Plans, ‘Biodiversity Sector Plans’ are not published in the Government Gazette. Like Bioregional Plans, they represent an exceedingly important resource to inform municipal spatial planning.

In the Western Cape, fine-scale biodiversity plans are available for all municipalities (these can be downloaded from SANBI’s BGIS website), and the latest version of the *Western Cape Biodiversity Conservation Framework* (obtainable from CapeNature) provides CBA maps with provincial coverage.

Biodiversity features that are depicted on CBA maps include:

- Protected Areas
- Critical Biodiversity Areas (CBAs), with different sub-divisions, depending on the relevant CBA Map
- Ecological Support Areas (ESAs), which may also be divided into several sub-categories
- Other Natural Areas (ONAs).



Each mapped category is linked to a distinct set of **desired management objectives** as shown in Table 4, below.

Table 4: Desired management objectives of the main map categories shown on CBA maps

	CRITICAL BIODIVERSITY AREA (CBA)	ECOLOGICAL SUPPORT AREA (ESA)	OTHER NATURAL AREA (ONA)
MANAGEMENT OBJECTIVES	Maintain as natural land. Retain in good ecological condition and manage for no loss of biodiversity or natural habitat. (Any areas that are degraded should be rehabilitated and managed for no further degradation)	Maintain ecological processes. Keep in at least a fair ecological condition, and manage to maintain ecological functionality. Some loss of ecosystem composition or structure can be accepted.	Sustainable development and management according to general rural land-use planning principles. These are the areas in which impacts will be the least negative and have the greatest flexibility in terms of management objectives and permissible land uses.

A CBA Map is the first 'port of call' to find information on the biodiversity importance of a particular area by:

- Identifying areas that are essential for meeting biodiversity targets (CBAs) and that should be retained in a natural or near-natural condition or, where further environmental degradation and deterioration should be prevented with the view of restoring disturbed habitat to a natural or near-natural condition.
- Identifying areas (CBAs and ESAs) that need to be maintained and managed as ecological corridors or environmental gradients in support of functional aspects of biodiversity and ecosystem resilience.
- Identifying areas that may provide habitat for particular species of special concern.

The GIS shape-files for CBA maps or other biodiversity plans can be downloaded from the SANBI Biodiversity GIS Unit website <http://bgis.sanbi.org> (under 'Projects' > province of interest > relevant biodiversity plan). If shapefiles are available, they will be stored under 'Downloads' in the column at the left of the screen. The BGIS website also hosts interactive maps that can be accessed by following the same steps. For further information on how to use BGIS and other products hosted by SANBI, see the SANBI 'Biodiversity Advisor' at <http://biodiversityadvisor.sanbi.org>. Contact the South African National Biodiversity Institute's Biodiversity GIS Unit for information on biodiversity plans at (021) 799 8738 or e-mail BGISHelp@sanbi.org



Maps of Freshwater Ecosystem Priority Areas (FEPA Maps)

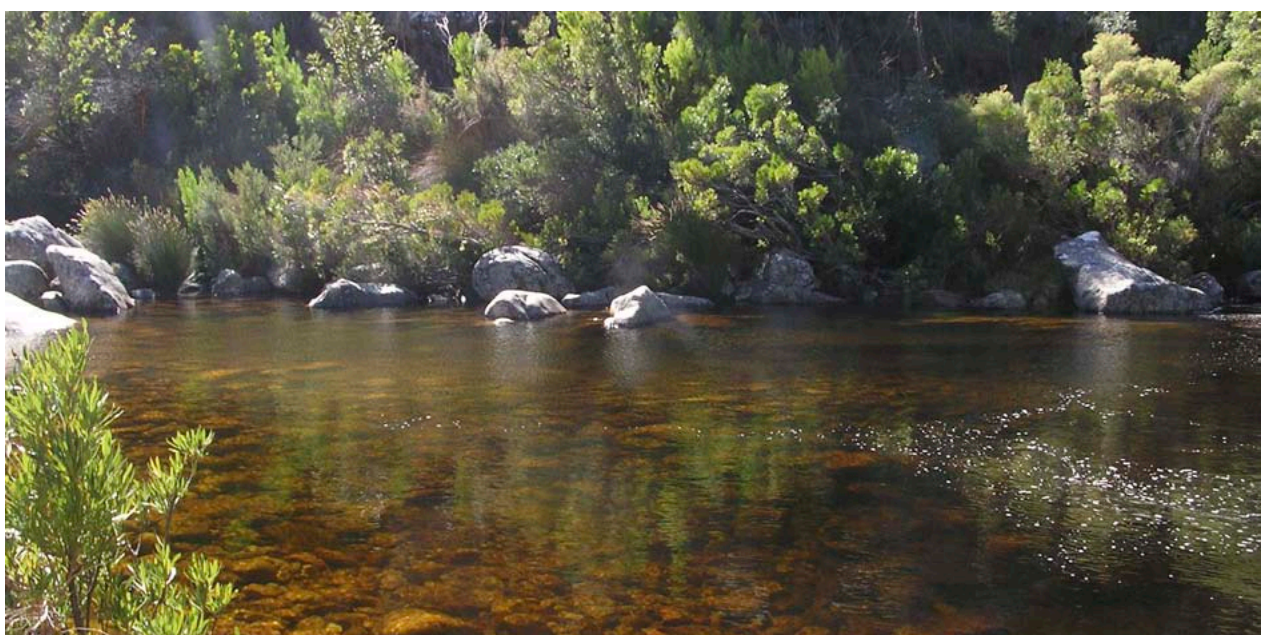
Maps produced for South Africa's National Freshwater Ecosystem Priority Areas (NFEPA) project depict areas that have been prioritized for conserving freshwater ecosystems and their biodiversity.

As with CBA maps, FEPA maps promote an *ecosystem perspective* in environmental assessment that covers the functional attributes of biodiversity at landscape level by providing spatial surrogates for ecological processes that may otherwise not be readily evident if an assessment were limited to a particular site.

The NFEPA project has produced maps for eight types of priority freshwater ecosystems:

- *River FEPAs and associated sub-quaternary catchments*: Areas that are essential for achieving biodiversity targets for river ecosystems and threatened or near-threatened fishes and that are in a 'natural' (A) or 'largely natural' (B) ecological condition; the sub-catchment must be managed to maintain the A or B condition.
- *Wetland or estuary FEPAs*.
- *Wetland clusters*: These are groups of wetlands in relatively natural landscapes that must be managed in support of maintaining ecological processes.
- *Fish sanctuaries and associated sub-catchments*: Rivers in a natural (A) or largely-natural (B) condition that are essential for protecting threatened and near-threatened indigenous freshwater species (a red fish on a FEPA map indicates that Critically Endangered and/or Endangered fish species may be present).
- *Fish support areas and associated sub-catchments*: Rivers with an ecological condition lower than A and B that are important for conserving and supporting the migration of threatened or near-threatened indigenous fish species.
- *Upstream management areas*: These are sub-quaternary catchments that need to be managed to prevent degradation of downstream FEPAs and fish support areas.
- *Free-flowing rivers*: These are represented by 19 rivers nationally that, due to their rarity as undammed systems, should never be impounded.

Detailed guidelines have also been published on the purpose, interpretation and application of FEPA maps to environmental impact assessment and development planning in general (see Driver *et al.*, 2011). The *Classification System for Wetlands and Other Aquatic Ecosystems in South Africa – User Manual: Inland Systems* (Ollis *et al.*, 2013) should be consulted for an authoritative guide on the structure and functioning of South African wetlands and rivers. **Box 12** introduces the FEPA implementation guidelines and the main management objectives for the various types of FEPA.



BOX 12 Implementation Guidelines for Freshwater Ecosystem Priority Areas

This resource gives a comprehensive overview of the different types of FEPA, the reasons for their selection, and how to use the various NFEPA products in environmental assessment. The FEPA implementation manual recommends five steps for using FEPA products to inform environmental assessments; the first two, consulting the relevant FEPA map and undertaking certain FEPA-related tasks during site assessments, correspond closely with steps 1 and 2 described in this section of these *Ecosystem Guidelines*.

The FEPA Implementation Manual includes management guidelines for the different types of FEPA that are linked to ecological objectives for rivers and wetlands. The management units and objectives that are addressed by the FEPA guidelines are:

FEPA TYPE	OVERALL MANAGEMENT OBJECTIVES	LAND-USE IMPLICATIONS
Wetland FEPAs and wetland clusters	Flow and inundation regime must keep wetland FEPAs in a good (A or B category) condition. If wetlands are not in an A or B condition, they must be managed to the best attainable ecological category (i.e. C or better).	• Practices that lead to the deterioration of wetland FEPAs are not acceptable. • Practices that would impede rehabilitation of a wetland FEPA are also not acceptable.
River FEPAs	River FEPAs that are currently in a good condition (A or B ecological category) should remain so.	• Practices that lead to deterioration in the current condition of a river FEPA are not acceptable
Sub-quaternary catchments associated with river FEPAs and upstream management areas	Management of land-use practices in the associated sub-quaternary catchment upstream management areas must aim to retain river FEPAs in their current condition. Cumulative impacts must be managed in the catchment and upstream areas.	• Land-use practices in the associated catchment must be managed. • Practices that result in the deterioration in the current ecological condition of a river FEPA are not acceptable. • Cumulative impacts need to be managed. Some streams and wetlands may be impacted, but only if this does not lead to a deterioration in condition of the downstream river FEPA.

The FEPA guidelines link a wide range of land-use practices and activities to three categories of stresses affecting wetlands and rivers, namely:

- changes in water quality
- changes in water quantity
- changes in habitat and biota.

Activities or processes that are covered include drainage, damming, canalisation, stormwater input, groundwater abstraction, mining and prospecting, afforestation and removal of indigenous vegetation, invasion by alien plants, waste discharge, irrigation return flows, increases in sedimentation and turbidity, habitat fragmentation, burning of wetlands etc.

A mandatory minimum buffer width of 100 m is recommended for all river and wetland FEPAs, prior to more detailed delineation.

Using CBA and FEPA maps to determine the biodiversity context of a site in the landscape

When using CBA and FEPA maps to determine the biodiversity context of a site, it is important to answer three questions:

Question 1: *What should be done if more than one systematic biodiversity plan applies to the project area?*

Previously, before CBA maps and fine-scale biodiversity plans became available, two steps had to be followed in order to determine the biodiversity context of a site:

- The National Biodiversity Assessment (NBA) of 2011 would be consulted to establish the importance of a site from a biodiversity pattern perspective.
- Broad-scale (<1: 50 000) systematic biodiversity plans would provide more insight into a site's ecological functional role in the wider landscape.

The recent CBA maps integrate biodiversity pattern and ecological process considerations into single categories, so this two-step approach is no longer necessary. These maps can, however, be interrogated on GIS to determine why a particular site has been selected for a particular map category, such as a terrestrial CBA or ESA. In some instances, biodiversity pattern considerations may be the main reasons for a site's inclusion in a CBA; in others (such as established cultivated areas) it could be included because a piece of land provides a crucial corridor connecting patches of indigenous vegetation in an otherwise fragmented landscape. That is, **the ecological condition of the vegetation on site is not the sole indicator of ecological value.**

Question 2: *What ecosystem guidelines apply to the ecosystem(s) that may be affected by the proposed activity?*

Identify the ecosystem that occurs in your area of interest by referring to the updated vegetation types (see Mucina & Rutherford, 2011). **Note:** *the SA Vegetation Map is updated periodically, and practitioners should ensure that the latest version is always used.*

Refer to the ecosystem guidelines in Chapter 5 for more detailed insight into factors such as:

- The main ecological processes that need to be taken into account in land-use planning.
- 'Minimum ecological requirements' (or 'bottom-lines') that must be maintained to ensure the persistence of the ecosystem.
- How resilient an ecosystem is to change and how to assess and monitor its health.

Site-specific considerations

Positive or proactive planning involves early identification of the opportunities, constraints and sensitivities presented by a particular site, and areas beyond the site, that could be impacted by a proposed land use, and developing a proposal that best accommodates them. This strategy contrasts with the relatively inefficient and ill-advised approach of imposing a fixed proposal on a project site: this inevitably leads to impacts on biodiversity and the need to modify the proposal to mitigate impacts (with time and cost implications).

Impacts of land uses on biodiversity depend in part on the sensitivity of the receiving environment, but also on the nature and scale of the proposed land use. For this reason the ecologist must, in addition to investigating biodiversity aspects, familiarize him/herself with the particular characteristics of the proposed land use at the outset. Key information would include the scale of the 'footprint', required inputs (e.g. water, chemicals, energy and transport routes), and the main outputs (e.g. emissions, radiation, effluent, solid wastes).

This stage must include the collection of enough reliable baseline information to identify key biodiversity issues and risks, including:

- The ecosystem threat status of affected vegetation types (Consult the latest National List of Threatened Terrestrial Ecosystems).
- The Western Cape Biodiversity Framework 2014, which provides wall-to-wall coverage of CBA categories and Habitat Condition information for the Western Cape (Pence, 2014).
- The particular reasons for selection of any areas as CBAs or ESAs, where these are likely to be affected by the proposal.
- Red Lists and/or Red Data Book information on threatened species.
- Google Earth or other images that provide information on particularly sensitive features such as wetland or mobile sand dunes that would present constraints to development.

Box 13 describes three important considerations when visiting the site and other potentially affected areas.

BOX 13 Important site-specific considerations

Determining ecosystem threat status

An impacted ecosystem may be listed within a particular category of ‘threatened’ ecosystem in the National List of Threatened Terrestrial Ecosystems, but that ecosystem threat status may have been revised and updated in the Western Cape Biodiversity Framework (2014, or its updates). **It is important to use the most up to date information.**

There are currently four main criteria used to categorize ecosystem threat status: A1 that deals with irreversible loss of natural habitat, A2 with ecosystem degradation; D1 with threatened plant species associations; and, F with priority areas in systematic biodiversity plans. In the 2011 listing of threatened ecosystems in the Western Cape, use was made mainly of criteria A1 and D1. However, in some cases, where an area is known to have a high concentration (>40) of threatened species, and Criterion D1 was not used to determine ecosystem threat status, then the ecosystem threat status may warrant revision, in discussion with CapeNature.

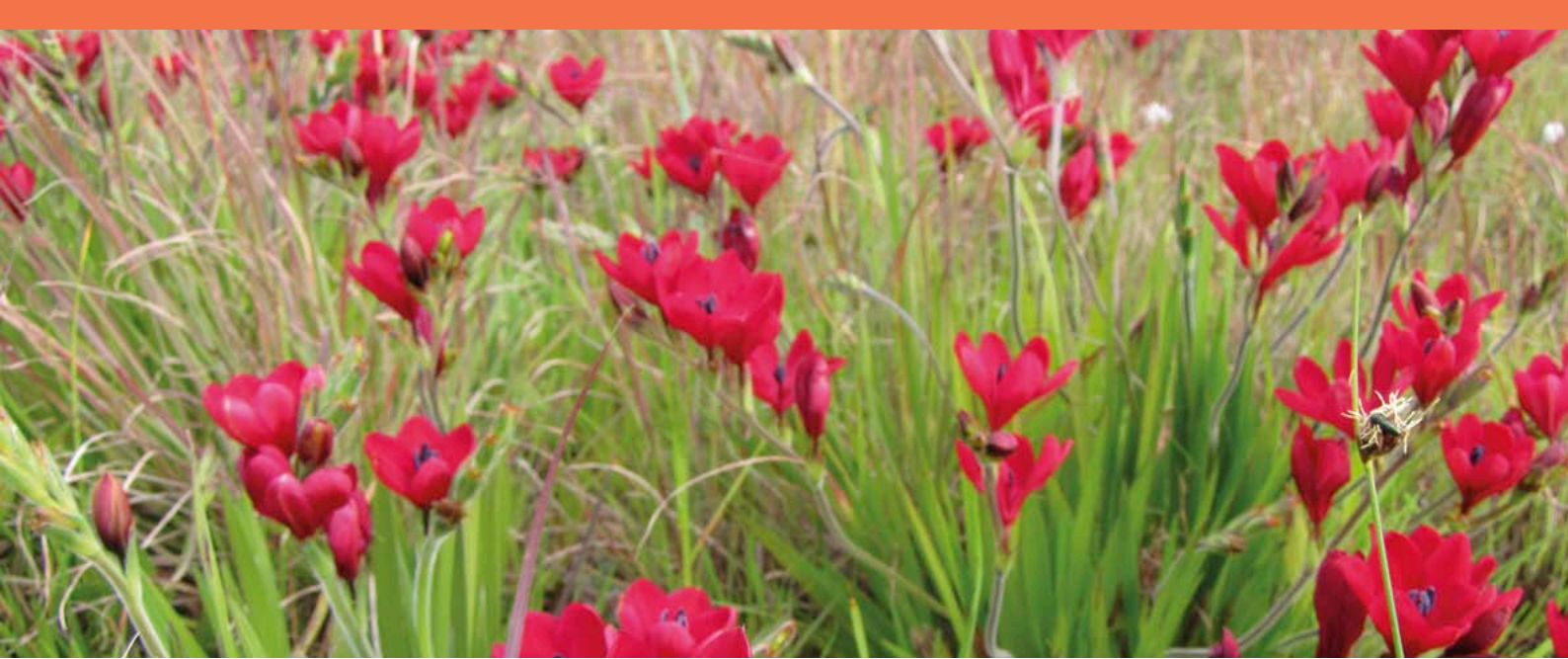
Checking attributes on the ground against reasons for identifying areas as CBAs or ESAs

The selection of CBAs and ESAs in biodiversity plans/CBA maps is based on a set of explicit criteria such as the ecosystem threat status of vegetation or habitat types, edaphic interfaces, ecological connectivity, the presence of Threatened Species, key hydrological areas, amongst others. The particular criteria that triggered selection of the CBAs or ESAs that could be negatively affected by development should be determined, as they provide an invaluable frame of reference for:

- Checking and verifying that these attributes are still present and applicable on the ground.
- Prioritizing mitigation measures to avoid or prevent impacts on these attributes; and, in situations where there are unavoidable, residual impacts and biodiversity offsets must be secured and managed.
- Ensuring that biodiversity offset sites have the same attributes as those negatively affected.

Threatened species

The listing of species threatened by restricted activities in terms of Section 56 of the Biodiversity Act (‘Threatened or Protected Species regulations, 2007 – ‘TOPS’) does not include species threatened by modification of habitat through development or by alien invasive organisms. That is, the species listed are not comparable with Red Data Book or Red List status. For this reason, both the TOPS listing and **Red Data Books and/or Red Lists should be used to identify threatened species.** It is also advisable to engage with the Custodians of Rare and Endangered Wildflowers, CREW, regarding records of threatened flora.



Question 3: *When should a biodiversity specialist be involved?*

Development planning should strive to be consistent with the desired management objectives of the various biodiversity categories depicted on CBA and FEPA maps.

If the work undertaken during STEP 1 of this process (i.e. preparing for the site visit) indicates that the site or the surrounding area may be a biodiversity priority (e.g. CBA, ESA or FEPA) that could be adversely affected by the proposed land use, then an ecologist or biodiversity specialist should be invited to visit the site to verify the information provided in the biodiversity plans.

It may also be necessary to consult a biodiversity specialist if any of the following features are known (or anticipated) to be present at the site (even if they have not been captured on the available biodiversity maps):

- special habitats (such as quartz patches)
- habitats of rare, threatened and range-restricted species
- ecological corridors
- edaphic interfaces
- Strategic Water Source Areas.

In some cases, the ecologist may identify particular biodiversity issues of concern (e.g. the presence of critically endangered species) which would require input and advice regarding optimum mitigation from a relatively 'narrow' specialist (e.g. herpetologist, entomologist, etc.). Consult the *Guideline for involving biodiversity specialists in EIA processes* (Brownlie, 2005) for guidance on the types of skills, qualifications and experience that are recommended for biodiversity specialists working in different thematic areas (e.g. entomologists, botanists etc.).

The Terms of Reference (ToR) for the ecologist and/or any additional 'narrow' biodiversity specialist must specify the need to gather enough relevant baseline information to inform the land-use proposal, and explicitly apply the Mitigation Hierarchy (see Appendix 3 in Chapter 6 for a generic Terms of Reference). The ecologist and/or biodiversity specialist(s) should be able to identify priority areas for biodiversity where negative impacts must first be **avoided or prevented** through area-based or practice-based changes to the proposal, and make firm recommendations for alternatives that would achieve that end.

A visit to the site of the proposed land use and broader surroundings by the EAP, ecologist and any other biodiversity specialists is essential. Ground-truthing to verify information in biodiversity plans and maps and obtain accurate baseline information is a critical step in this pre-application stage.

Step 2: Visit the Site

Action 1: Compare ground-truthed land cover and biodiversity features with the information given on a CBA or FEPA map

It is essential to ground truth the information obtained from biodiversity plans/CBA maps and other sources to ensure that mapped biodiversity features are, in fact, present.



The fact that a Critical Biodiversity Area (CBA) or Ecological Support Area (ESA) is disturbed or degraded would not necessarily justify land-use change at that site. The underlying attributes of the site that qualified it as a CBA or ESA need to be ‘unpacked’; if they remain valid, despite the current ecological condition, then that categorization can be verified. There may be situations in which degraded areas have been identified as CBAs because they contribute to biodiversity pattern targets or fulfil an essential ecological function, such as forming part of an ecological corridor or a ‘stepping stone’ habitat (for example, cultivated areas may have been selected for their connectivity value).

However, situations may arise in which land-cover has changed since the area was mapped (e.g. as a result of changes in land-use or infestation by alien plants), or there may have been an error in land-cover classification, and the specific attributes of the site that justified its inclusion in a CBA or ESA have either been irreversibly destroyed or are invalid.

It is important to remember that, depending on such things as the time of the year, the history of fire at the site (etc.), the biodiversity that is visible at a particular site may change. In evaluating the ecological condition of a proposed land-use site, it is essential to take into account possible seed banks on the property; if land has never been ploughed and sown, and if less than two fire cycles have occurred since alien/crop/plantation canopy closure, then seed banks are probably still intact, even if no indigenous plants are visible on site.

If there is an apparent mismatch between mapped and observed biodiversity features, this needs to be recorded with explicit evidence to justify any deviation from biodiversity plans/CBA maps. The condition of affected ecosystems and levels of degradation, including infestation by invasive alien species, must be noted.

Note that the season of assessment is critical, as a significant portion of the flora is identifiable only in the winter or spring flowering season, nor is identification of perennials guaranteed in the early post-fire years. The most appropriate season may differ between the western and eastern parts of the province, and with the particular species concerned. Botanical assessments in the fynbos biome must include a late winter/spring census. Similarly, frogs are only easily identifiable by their calls in the rainy season.

More information on the interpretation of CBA and FEPA maps is provided in **Box 14**, titled ‘Frequently Asked Questions’.

What if natural habitat is found on a site but this is not indicated on the land-cover map (and therefore not classified as a CBA or ESA)?

If the map shows that no vegetation remains, but a site visit reveals the presence of natural habitat, refer to the vegetation data (GIS maps or CBA map) to identify the vegetation type and its ecosystem status. If the vegetation type is Critically Endangered or Endangered it should automatically be treated as a CBA. If the vegetation type is Vulnerable or Least Threatened, a biodiversity specialist should assess whether the site plays an important functional role. If it does, it should be treated as either a CBA or ESA. If wetlands or other special habitats or species are present, the site should also be treated as a CBA.

Do 'Other Natural Areas' (ONAs) need to be assessed?

In ONAs it is important to check for special biodiversity features, e.g. wetlands or species of special concern. Because knowledge of special features or species is incomplete, it is critical to verify that they do not occur on a site.

How does ecosystem threat status relate to a CBA or FEPA map?

Ecosystem threat status is a measure of how much of an ecosystem is left relative to a target or threshold. CBAs and FEPAs prioritize areas or features for conservation, based on biodiversity pattern and ecological process targets, including, but not limited to, biodiversity targets/thresholds for the vegetation types used in determining ecosystem threat status. All natural, intact patches of Critically Endangered ecosystems are included as CBAs. For Endangered, Vulnerable or Least Threatened vegetation types, the most efficient areas to meet biodiversity targets have been included in the CBAs, while the remaining ones are categorised as Other Natural Areas.

Can a CBA or FEPA map assist in the selection of land for biodiversity offsets?

CBAs are ideal biodiversity offset 'receiving areas', since securing and managing sites within CBAs would effectively safeguard priority areas for biodiversity. Offsets outside CBAs, FEPAs or ESAs would thus be sub-optimal, and could lead to small isolated 'pocket handkerchiefs' of habitat in the landscape that would not be viable in the long term.

How do CBAs, ESAs and FEPAs affect existing land-use rights?

Systematic biodiversity plans and maps do not grant or limit existing land-use rights. They are intended to inform proposed land-use changes. Municipal spatial planning must take CBA maps into account if they have been published as 'bioregional plans' in terms of Chapter 3 of the Biodiversity Act, or if the biodiversity sector plan is approved as municipal policy (as for the City of Cape Town).

Will all CBAs and FEPAs become Protected Areas?

It is not feasible for all CBAs to be formally conserved. Nonetheless, it is extremely important that they are at the very least managed against further degradation and afforded some protection through an appropriate mechanism. In addition to Protected Areas in terms of the National Environmental Management: Protected Areas Act (Act 57 of 2003), other mechanisms could include appropriate zoning, biodiversity management plans or biodiversity stewardship agreements.

What does it mean if a CBA or FEPA is lost?

A CBA map identifies the most land-efficient option to meeting national biodiversity targets. Any loss of habitat within a CBA could mean the irretrievable loss of an important ecological feature or that more land outside CBAs would be required in order to meet these biodiversity targets.

continued ...

Will a CBA or FEPA map ever change?

Land use is dynamic and all maps need updating over time. The CBA and FEPA maps will need updating owing to inconsistencies and changes in the land-cover information, unavoidable loss of CBAs and ESAs and improved biodiversity knowledge (e.g. the discovery of special species or improved understanding of ecosystem services). The current map will form the basis for future updates. If the map is used as the basis for a bioregional plan, it would have to be updated every five years in terms of the Biodiversity Act.

Extracted from: Maree KS and Vromans DC (2010) *The Biodiversity Sector Plan for the Hessequa and Mossel Bay Municipalities: Supporting land-use planning and decision making in Critical Biodiversity Areas and Ecological Support Areas for sustainable development*. Produced by CapeNature as part of the C.A.P.E. Fine-scale Biodiversity Planning Project.

**Action 2: Identify features and areas of biodiversity significance.**

Areas and features of significance for maintaining biodiversity patterns or ecological processes at the proposed land-use site, and in its area of influence (i.e. where impacts of that land use could be experienced), need to be identified as they will form the focus of mitigation measures and could have a major influence on the land-use proposal.

These areas generally comprise:

- a) Areas of biodiversity that need to be retained and protected, and on which impacts should be avoided or prevented. Such areas include:
 - CBAs
 - Critically Endangered ecosystems
 - FEPAs
 - special/unique habitats (that occur locally e.g. quartz patches)
 - areas that constitute crucial fixed (rather than flexible) ecological corridors across ecological gradients (including climate change adaptation corridors)
 - habitat of known Critically Endangered species and/or areas containing biodiversity that underpins ecosystem services on which there is high dependency and for which there are no substitutes.
- b) Areas that should preferably be avoided, with emphasis on Endangered ecosystems, but also Vulnerable ecosystems, ESAs, habitat of highly threatened species and/or concentrations of threatened species. Where avoidance is not entirely possible, impacts must be minimized.
- c) Areas where development setbacks would be required (e.g. around wetlands, next to rivers/streams, next to mobile sand dunes, watercourses or the coast, and/or to buffer specific habitats of threatened species or features of importance).
- d) Areas that are known to be important for biodiversity but are degraded or invaded by alien species and require rehabilitation/restoration, including areas that could improve connectivity and reduce fragmentation in the landscape.
- e) Areas that are worthy of protection through biodiversity stewardship.

Action 3: Collect additional baseline information and undertake surveys, if necessary, to establish a reliable biodiversity benchmark.

If, during the site visit, the ecologist/biodiversity specialist observes features or areas about which there is insufficient information on which to base a biodiversity assessment, s/he would need to undertake additional surveys or studies to address these gaps. Appropriate ToR for these studies would need to be drawn up collaboratively between the EAP and ecologist/specialist (See Appendix 3 and 4 for generic templates that could be used).

Step 3: Assess probable impacts on biodiversity and identify mitigation measures to inform/influence the proposal

Translate the important features and areas for biodiversity, identified before and during the site visit, into a 'so what' for the proposed land-use development.

The objective of this exercise is to arrive at a proposal that is least damaging to biodiversity and important ecosystem services by, for example:

- Ensuring that the location and layouts of the proposed land use and its accompanying infrastructure avoid priority areas.
- Changing the scale of land-use activities to avoid potentially significant impacts.
- Changing the technology used to relieve pressure on natural habitat and ecological processes.
- Specifying the timing of land-use activities to avoid impacting sensitive biota.
- Concentrating disturbance in degraded areas that have little viability for natural regeneration or restoration of indigenous vegetation.
- Accommodating those key 'drivers' (e.g. fire) that enable ecosystems to persist.



Assessing the potential for significant impacts and advising on the proposal

The ecologist/biodiversity specialist must:

- a) Describe and map important biodiversity at the site(s) *and in the wider landscape*, from both biodiversity pattern and ecological process perspectives. Areas or features off-site that could be indirectly impacted by the proposed land use (e.g. downstream watercourses or groundwater-dependent ecosystems, areas to be modified for transport/energy corridors) must be included in this analysis.
- b) Apply the Mitigation Hierarchy by identifying:
 - Areas where any loss of biodiversity would be irreplaceable (e.g. could lead to extinction of species and/or jeopardize meeting biodiversity targets for different ecosystems) and must be *avoided*.
 - Areas where any loss of important ecosystem services on which communities and/or society are highly dependent for livelihoods, health, safety or well-being would be irreversible and could not be substituted at all, or would be extremely expensive to substitute (e.g. loss of water supplies or flood buffers). These areas must be *avoided*.
 - Areas of high sensitivity on which impacts should preferably be *avoided or prevented*, or at least *minimized* (e.g. through buffers).
 - Biodiversity, habitat or ecosystems that could be harmed by emissions, discharges, effluent, disturbance (noise, lights, traffic, etc), changes in runoff or groundwater recharge, and/or introduction of invasive alien species, that would need specific *avoidance or minimization* measures. These measures could be area- or practice/management- based (for example, water use, changes in surface drainage or water quality, effluent, chemicals, solid waste, introduction of invasive alien species).
 - Areas that pose a natural hazard to the proposed activities and which require setbacks.
 - Areas that should be rehabilitated/restored.
 - Areas where impacts would be of low or negligible significance.
- c) Accommodate key drivers of the affected ecosystems:
 - Address the spatial/layout implications where fire/burning of veld is required.



Dealing with ‘unavoidable’ and/or residual negative impacts

When the land-use proposal cannot accommodate all the measures required to avoid or minimize potentially significant impacts on biodiversity (i.e. only when all reasonable and feasible alternatives have been given due consideration), the following courses of action ought to be pursued:

- In **Critical Biodiversity Areas, Freshwater Ecosystem Priority Areas** and habitat of **Critically Endangered species**:
 - Any irreversible loss of habitat would be highly undesirable and could constitute loss of irreplaceable biodiversity.
 - These features must be treated as potential ‘show-stoppers’ – their loss would be contrary to the Constitutional requirement for ‘ecologically sustainable development’ and a number of the NEMA principles.
 - Seek additional project alternatives to lower the significance of impacts and risks to biodiversity.
 - Proceed with extreme caution, knowing that there is relatively high risk that environmental authorization may be refused and there could be significant opposition/challenge from stakeholders.



- In exceptional cases, where there are no alternatives to the proposed land use and it is seen to be of overriding national or provincial significance, and it is authorized, then *compensation or biodiversity offsets* proportional to the loss of biodiversity would need to be provided through securing, and providing resources for managing, priority areas for conservation in the long term.
- Opportunities to restore/rehabilitate degraded habitat, reduce fragmentation and maintain ecological processes should be sought.
- In **Ecological Support Areas** or **Other Natural Areas** where ecosystems are **Endangered or Vulnerable, and/or habitat contains high numbers of threatened species**:
 - Seek additional project alternatives to lower the significance of impacts and risks to biodiversity.
 - *Biodiversity offsets* proportional to the loss of biodiversity would need to be provided through securing, and providing resources for managing, priority areas for conservation in the long term.
 - Opportunities to restore/rehabilitate degraded habitat, reduce fragmentation and maintain ecological processes should be sought.
- In **Ecological Support Areas** and **Other Natural Areas**:
 - Opportunities to restore/rehabilitate degraded habitat, reduce fragmentation and maintain ecological processes should be sought.

Step 4: Achieve biodiversity gains by identifying opportunities to conserve or restore biodiversity

Seek to take advantage of opportunities to conserve biodiversity.

Conservation gains could include:

- Setting aside part of the land at the land-use site to be managed for conservation through one of the biodiversity stewardship options.
- Clearing invasive alien vegetation and/or eradicating invasive alien fauna (e.g. fish). It must be noted, however, that the 'duty of care' principle requires such measures from landowners, although this is not always enforced.
- Rehabilitating or restoring degraded terrestrial and/or aquatic habitat (note that rehabilitating or restoring land or ecosystems that will be disturbed as a result of the land use does not constitute a conservation gain).

Site-specific conservation measures may also be translated into broader conservation benefits by contributing unmodified property to the consolidation of land in support of corridor or landscape initiatives, or securing priority CBAs.



Step 5: Report on findings

The ecologist must capture the findings of the biodiversity assessment in a specialist report.

Where required for an EIA process, the ecologist/biodiversity specialist must systematically assess and evaluate the likely significance of impacts of the proposed project, preferably incorporating (with the proponent's consent and commitment to) all changes to avoid or prevent and minimize potentially significant negative impacts on biodiversity.

The report must:

- a) Describe and map accurately the areas and features of importance to biodiversity and their sensitivity to the proposed land use.
- b) Demonstrate clearly how the Mitigation Hierarchy (including consideration of reasonable and feasible alternatives) has been used to formulate explicit recommendations to avoid or minimize potentially significant impacts that in turn have influenced or shaped the proposal.
- c) State clearly what impacts were unavoidable or could not be reduced sufficiently to ensure that they would be of low or negligible significance.
- d) State clearly if any impacts would be irreversible and lead to loss of irreplaceable biodiversity, or loss of important ecosystem services on which there is high dependency.
- e) Describe what measures would need to be taken during construction and operation to rehabilitate, compensate/offset and/or manage biodiversity impacts.
- f) State the explicitly required outcomes of these mitigation measures, to be incorporated in an Environmental Management Programme.

The ecologist/biodiversity specialist should:

- Make any assumptions and limitations (e.g. gaps in information, inability to visit site or do seasonal sampling) explicit.
- Refer to the sources of biodiversity information used (e.g. relevant and up to date biodiversity plans/CBA maps, FEPA maps, TOPS, listed ecosystems, amongst others, as well as any obtained through consultation with the competent authority, CapeNature, SANBI or the Custodians of Rare and Endangered Wildflowers 'CREW').

- State clearly that a site visit was carried out, in what season, the post-fire age of the vegetation and any limitations thereof (e.g. site burned recently).
- Document clearly (e.g. photographic evidence) if ground-truthing presented any conflicts or inconsistencies with biodiversity information in biodiversity plans/maps.
- Note the condition of affected ecosystems and levels of degradation, including infestation by invasive alien species.
- Include a map or maps at a meaningful scale (preferably >1:10 000) and photographs to illustrate the biodiversity implications of the proposed project, as well as the amended proposal, taking into account recommended area-base measures to avoid and minimize negative impacts.



The biodiversity specialist's report would form part of the application for environmental authorization, if appropriate, submitted to the competent authority.

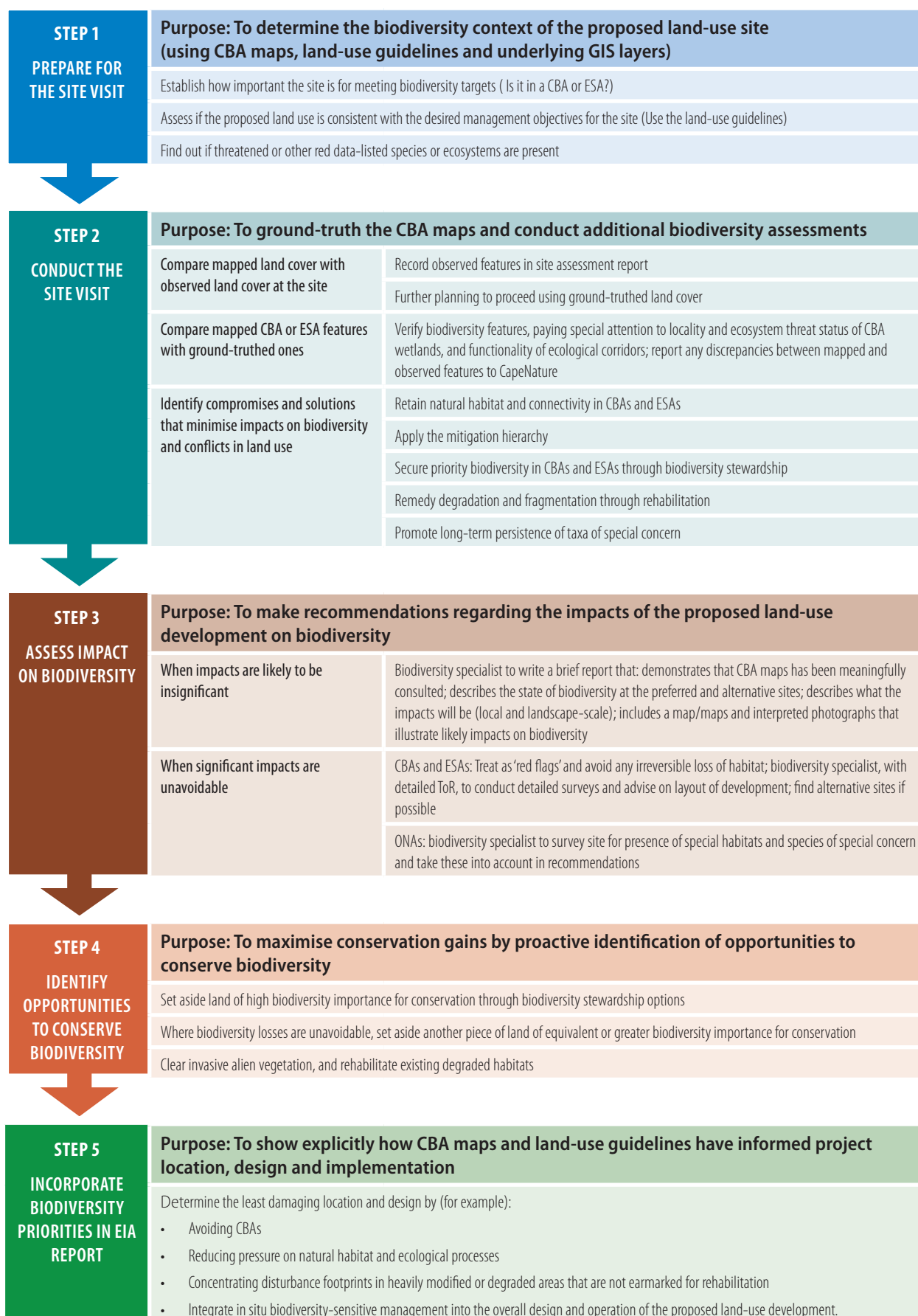
Engagement with key stakeholders and the competent authority

The NEMA EIA regulations (as amended in 2014) provide for engagement in the pre-application stage; engagement with the competent environmental authority and CapeNature is advisable at minimum, and with groups such as CREW where threatened flora are involved, for example. Careful records must be kept of any biodiversity issues raised; these issues should be addressed by the ecologist/biodiversity specialist and/or EAP.

Any application for environmental authorization will also be subject to legally required public participation processes after the application enters the formal process.



Figure 6: Summary of five steps to be followed in proactive consideration of biodiversity in environmental assessment





CHAPTER

Planning for and managing risk, restoration, *ex situ* conservation and animals

4

Contributors: Pat Holmes, Clifford Dorse, Tony Rebelo, Nick Helme, Julia Wood, Guy Palmer and James Harrison

4.1. Planning for and managing risk

4.1.1. Planning for fire

Fire is a normal, natural process that is essential for maintaining fynbos and renosterveld ecosystems in a healthy condition. Periodic fire in these ecosystems stimulates re-sprouting and seedling recruitment and promotes maximum species richness. Different fynbos vegetation types, however, differ in terms of appropriate fire frequency, season and intensity – fires occurring too close together or too far apart, or in the wrong season, could have disastrous impacts. Natural fire cycles have generally become severely disrupted due to increasing habitat fragmentation, poor planning, the misconceptions about the valuable role fire plays in fynbos ecosystems, and the risks associated with managing fire in built-up areas and production landscapes. Poorly-timed or unplanned fires can have negative impacts on natural ecosystems as well as presenting a danger to lives, property and physical infrastructure. It is essential that land-use planners, decision-makers and environmental assessment practitioners understand enough about fire in different ecosystems to predict what the effects of different land-use practices (or changes in land use) will be on the fire regime that is needed to maintain the ecological health of these ecosystems.



Detailed guidelines on fire ecology and management in fynbos (and associated vegetation types) are provided in *Fynbos Ecology and Management* (Esler *et al.*, 2014), as well as various other publications, so this information will not be repeated here. However, a few general principles are highlighted below.

General principles

The key ecological aspects of fire management in fynbos are: the frequency (timing and interval), seasonality (time of year), intensity (whether a fire is hot and fast, or slow and cool) and the extent (size) of fires.

Fire frequency: The intervals between fires should be neither too long nor too short. The appropriate fire return interval should be determined by the length of time that non-sprouting plants take to reproduce. Not all non-sprouting species mature at the same rate, but non-sprouting proteas (specifically sugarbushes and cone-bushes) can be used as the best indicators of appropriate fire frequency in fynbos. A rough index that can be used to determine the shortest interval between fires (i.e. the minimum fire return interval) is that at least 50% of the protea plants present should have flowered three times before they are burned again. Ideally, at least 90% of the slowest-maturing non-sprouting species should have flowered before the next fire. Typically this interval is between 10 and 20 years (if the fire interval is too short, slower-maturing species will become locally extinct).

The longest interval that should occur between fires can be determined by the length of time it takes before non-sprouting species become too old (i.e. senescent) to flower anymore, or produce enough seeds to ensure successful

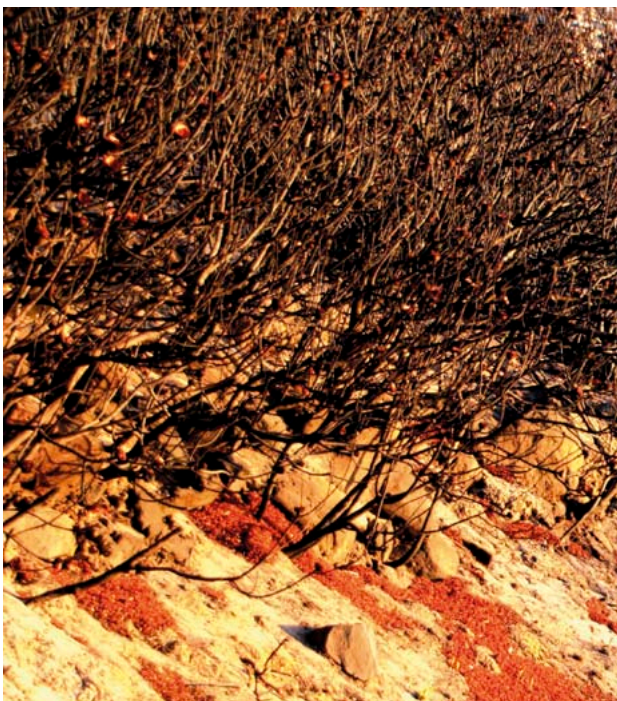
reproduction – this can vary from about 25 to 40 years. Several species of sugarbush can be used as indicators of the maximum age the fynbos should reach before being burnt again.

Generally, the biggest challenge is protecting fynbos from fires that are too frequent. As a general rule of thumb, prescribed burns should not occur more often than every seven years in fynbos – if they do, it may result in loss of species that have not matured and produced seeds. Research indicates that under natural conditions, fynbos should be burnt between 8 and 20 years after the last fire.

Renosterveld contains a higher proportion of fast-growing grass plants than is found in fynbos, which means that renosterveld can be burnt more frequently than fynbos, possibly about every three to 10 years. However, if renosterveld vegetation types are burnt too frequently, it will lead to the disappearance of species that require longer fire cycles in order to reproduce (such as species of legumes). As a general guideline, renosterveld should not be burnt if: (a) the vegetation is shorter than 50 cms; and (b) there is not a good mix of different species, all with mature plants present.

Fire season and intensity: The time of year (season) in which a fire occurs is closely linked to its intensity (whether it is a hot, quick-burning fire, or a cool, slow-burning one). Fire intensity is influenced by the fuel load, moisture content of the vegetation and soil, relative humidity and wind speed.

Optimal fire season is vital to retain species richness, with late summer and autumn fires (December-March) giving the best recruitment results in the south-western Cape (where most rain falls in winter). Fires that occur in summer and autumn generally have the least negative impacts on plants and animals such as birds and tortoises. In the eastern parts of the province, where more rain falls in summer and autumn than it does in the west, pinpointing the ideal fire season is more complicated, but ecologically 'ideal' fires are those that occur under hot berg wind conditions that are followed by rain. Hot, quick-burning fires result in 'clean burns' in which no fine material or unburned leaves remain after the fire – only 'clean burns' are considered acceptable. It should be noted, though that fires can become too hot and intense under some circumstances, especially when fuel loads are high (in old veld), when areas are infested by invasive alien species, or where cleared invasive plants have been left in the veld stacked in piles.





In general, most fynbos species require high intensity fires to maintain them, but lower intensity fires are often favoured by land managers for safety reasons. The ecologically ideal fire season (late summer and autumn, when fires are more intense) may be in conflict with the times at which fires can be considered 'safe' (i.e. when the veld is moist and green and the fires are less intense), and a compromise between these considerations is essential. Planned burns should usually be carried out in autumn (February to April) in the south-western Cape, and under milder conditions in the southern and south-eastern Cape. The season for prescribed burns in the Western Cape is mid-January to mid-May, although CapeNature and the relevant District Council may permit prescribed burns to be carried out at other times if necessary.

Fire size: Determining the ideal size of a fire in fynbos and renosterveld habitats is a complex issue that depends on many factors. Many land managers prefer burning over smaller areas because the fire is easier to manage, but this may not be ecologically desirable as it affects the reproduction and regeneration of plants. Extensive fires, which remove the vegetative cover over large tracts of land (in the order of thousands of hectares) may also be undesirable.

It is vitally important to maintain a mosaic of vegetation of different ages within any given tract of land, no matter how large or small it may be. As a general guideline, the area over which burns take place should, ideally, not be smaller than 100 hectares (ideally 200–500 hectares). Smaller areas tend to be invaded by predators and pathogens, affecting seedling recruitment or plant regrowth. To ensure successful recruitment after a fire, grazing by domestic livestock (or large numbers of game) should not be allowed within the first two years after burning. (*Note: Correctly-timed, small fires are still better than excluding fires completely!*).

Special circumstances

Burning in areas with multiple vegetation types present: Species occurring in different vegetation types might mature at different rates and be adapted to fire differently. This means that burning in areas where two or more different vegetation types co-occur requires special planning. In these cases, the fire frequency suited to the fastest growing vegetation type (e.g. the Sand Fynbos) is usually the most appropriate to use, but care should be taken to ensure that at least some of the slower growing vegetation type is not burned. Implementing this type of 'patchy burn' will help retain the natural fire frequency of the other vegetation types present. Requirements in terms of fire season, intensity and size would be the same as those noted above.

Fire and invasive alien species: Burns in areas that are heavily invaded by woody invasive alien plants (e.g. *Acacia* species) will also need special planning. Where high fuel loads are present, the site may have to be burned under cool, moist conditions (after the soil has become wet enough to prevent the destruction of seeds and soil by the fire), or, alternatively, they will have to be stack-burned in winter.

Developing a proactive fire management plan

The most important use of fire for conservation management is to maintain viable populations of natural plant and animal species. This needs to be reconciled with use of fire for other management purposes, such as reducing fuel loads to prevent unmanageable wildfires, controlling invasive alien plants, improving grazing or promoting desirable plants for the flower-picking industry.

Proactive fire management through well-planned and controlled burning is an essential part of wise landscape management in the Western Cape. Management of fire is governed by law and there are legal implications to negligence in the management of fire. All landholders are required by law to draw up and implement an appropriate fire management plan. In order to undertake a burn in the prescribed season, permission has to be obtained from the relevant Fire Protection Association (FPA), which will issue a permit.

It is best to obtain specialist advice from CapeNature or a fynbos ecologist in drawing up a fire management plan, before implementing managed burns. All landowners should also be members of the local Fire Protection Association (FPA), for legal and practical reasons. (Note, however, that an FPA is primarily concerned with fire safety, rather than burning according to sound ecological principles). A rule of thumb is to plan for safe, managed burns, and allow wildfires – where safe.

Additional advice can be obtained from:

CapeNature: www.capenature.org.za

Working on Fire: www.workingonfire.org

FireWise: www.firewisesa.org.za



4.1.2. Planning for heavy rains and floods

Flood risks and ecosystems

Floods are part of the natural disturbance regime of aquatic ecosystems and play important roles in 're-setting' river and wetland habitats through sediment deposition or scour, and by flushing out accumulated organic material and other sources of nutrients. However, where surrounding land uses encroach into natural floodplains, they constrain natural ecosystem processes (such as migration of river channels across floodplains), restrict natural flooding patterns, (such as through efforts to 'fix' river channels through canalisation), or worsen them (for example by removal of natural riparian vegetation and damage to wetlands in river catchments). Under such circumstances, the disturbance associated with floods is often in excess of what would occur naturally, with the result that high levels of bank and bed erosion may take place. This can lead to severe ecological degradation that is unlikely to be addressed without costly artificial intervention.

Flood risks and infrastructure

Flood damage to infrastructure such as roads and bridges can have devastating consequences in terms of disrupting access, costs of repair and lost time. The repair of such damage often simply entails a 'like-for-like' replacement of structure. In the long term, such an approach may increase both the ecological and economic costs of ongoing flood damage, if issues such as changes in catchment characteristics or climate change are not addressed. For example, many catchments

in the Western Cape are subject to high levels of infestation by woody invasive alien species. This means that their debris load under flood conditions is often much greater than under natural pre-invasion conditions – a problem compounded by related impacts such as high levels of erosion, which adds additional sediment to flood debris. This means that bridges and roads that may have held up adequately in large floods in the past, may now be ill-designed to withstand sediment-laden floods carrying large, woody debris such as tree trunks. The repeated replacement of infrastructure simply means that the frequency of disturbance (as a result of erosion of these structures) may exceed the rate of rehabilitation. This results in a cycle of increasing ecological degradation and unsustainable costs of repair. Repeated damage to infrastructure as a result of flooding may signal a need to revisit design, in the light of changing environmental conditions.

Flood risks and climate change

The impacts of climate change are predicted to include, amongst other things, increased climatic variability, with more frequent, intense floods and drought likely in fynbos areas (see Section 4.1.4). Maintaining ecosystem resilience is increasingly important in such scenarios, so that affected ecosystems are able to withstand these stressors without succumbing to erosion and general ecosystem degradation. Factors that address resilience in freshwater ecosystems include preventing water quality impacts, maintaining and managing adequate riparian corridors and setbacks from adjacent land-use, controlling the spread of invasive alien plants and ensuring that natural biodiversity patterns and processes are maintained.

Implications for environmental assessment

It is important that space is provided in land-use plans for processes such as flooding, and that this space is managed to allow for natural processes such as flushing, and for mitigation against flood damage caused by erosion. Provision of adequately-vegetated buffer strips along all riverine and wetland ecosystems, and observing ecological setback lines, are two means of addressing this issue. (Refer to the section on inland aquatic ecosystems in Chapter 5 for additional guidance).

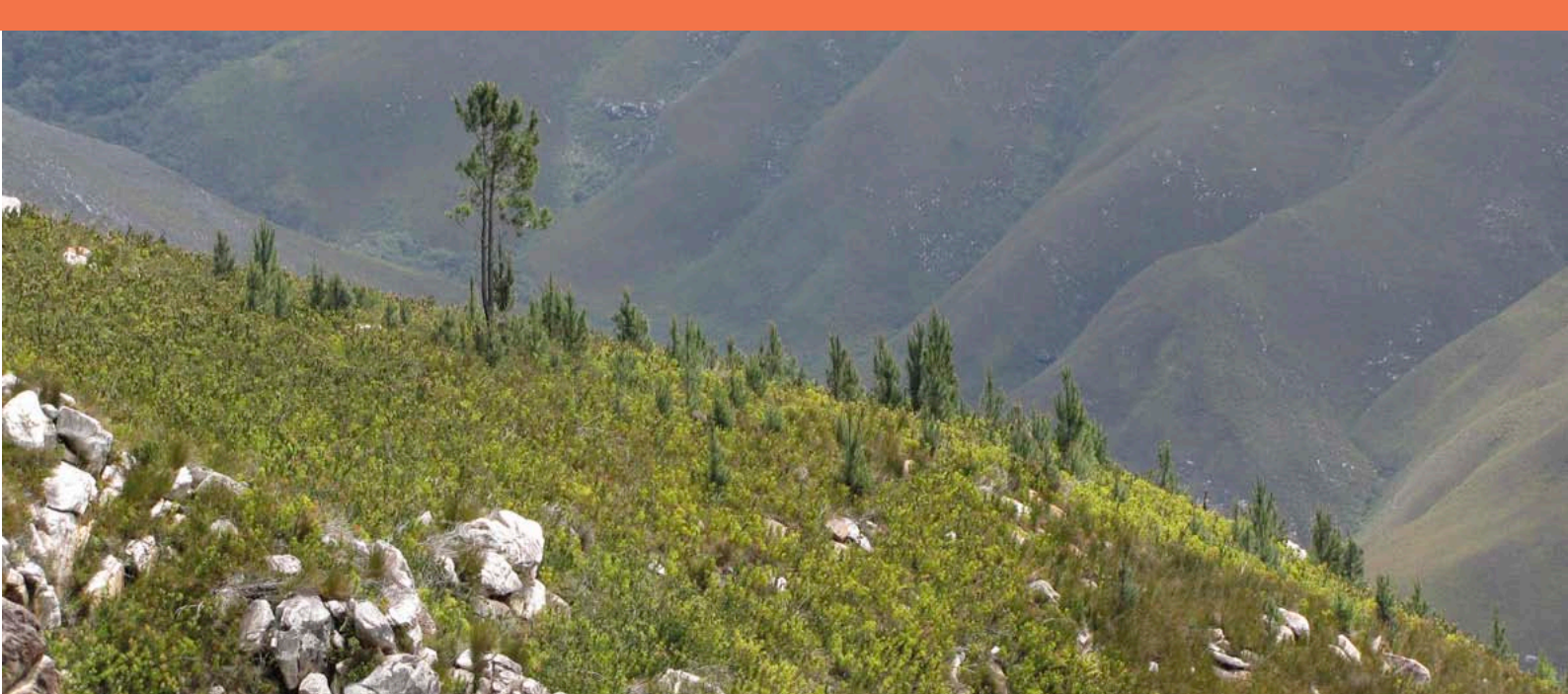
4.1.3. Planning for and managing invasive alien species

Invasive alien plants



The second greatest threat to biodiversity and ecosystem functioning in the Western Cape, following direct habitat loss, is infestation by invasive alien species. These are a subset of species that were introduced intentionally or by accident and that have spread beyond their original point of introduction to invade natural ecosystems. Many of these species displace indigenous biodiversity and alter ecosystem functioning to the detriment both of natural ecosystems and human well-being.

The presence and even dominance of invasive species on a site does not necessarily mean that the ecosystem is irretrievably modified and that no natural biodiversity survives. Provided that a site has not been previously ploughed, soil-stored propagules of indigenous species may survive and provide the basis for re-vegetation of the area after invasive aliens have been cleared. It is



important that environmental assessment practitioners assess the restoration potential of a site, particularly in the case of threatened ecosystems and CBAs. Factors such as previous land use and duration of invasion are important to consider in such an assessment, as are biodiversity pattern and ecological processes.

Landowners are legally responsible for controlling invasive alien species on their land and there are several different pieces of legislation governing the control and management of alien invasive species (See Esler, *et al.*, 2014, page 70, for a summary). As a minimum, environmental assessment practitioners and land developers should be aware that:

- Species that are listed invaders under the Biodiversity Act must be controlled according to the invasive species regulations and this is the responsibility of the landowner (see Government Notice: No. 37885 National Environmental Management: Biodiversity Act 2004, *Alien and Invasive Species Regulations*, 2014).
- Invasive alien species that are commercially important require a permit to be grown or retained on a property and any spread of the species beyond the boundaries of the property must be controlled by the permit-holder.
- Sellers of properties must notify the Department of Environmental Affairs and potential purchasers in writing of the presence of listed invasive species on that property.

A considerable body of information is available on control measures for particular species of invasive alien plants. The Working for Water Programme has made significant progress in removing species such as black wattle (*Acacia mearnsii*) in major river catchments, and can be approached for advice. Visit the Working for Water operational website at www.wfw.org.

Alien invasive animals

Attention on invasive alien species is often focussed on plants – and with good reason, because they pose such a high risk to almost all ecosystems, and water delivery, in the Western Cape. However, there are numerous alien species of animals that pose a serious risk to certain ecosystems, especially in the Fynbos Biome. These include invertebrates (ants, wasps, mites), molluscs (snails and slugs), millipedes,



spiders, and a number of vertebrates (including species of bird and fish). Some of the most problematic of these invasive alien animals include: the Argentine Ant (*Linepethema humile*, which, amongst other harmful impacts, displaces indigenous ant species that are important for dispersing the seeds of many fynbos plants and serving as hosts to the caterpillars of certain butterflies); the Varroa Mite (*Varroa destructor*, which invades and destroys the hives of Cape honeybees, which are important pollinators of fynbos species and commercial crops); and a number of species of alien fish (including carp, smallmouth bass and barbel, which have had a devastating impact on populations of indigenous freshwater fish through competition, predation and habitat modification). Any proposed land uses should give adequate consideration to the possible impacts related to the introduction, spread or control of invasive alien animal species.

4.1.4. Planning for climate change

Planning for climate change

The Western Cape Province is particularly vulnerable to the anticipated impacts of climate change. As a predominantly winter rainfall area, the ecosystems and agricultural conditions are largely unique to the province, resulting in a particular climate vulnerability which differs in some respects from that of the rest of the country (where rain falls mainly in summer).

First order impacts of climate change in the Western Cape are projected to be:

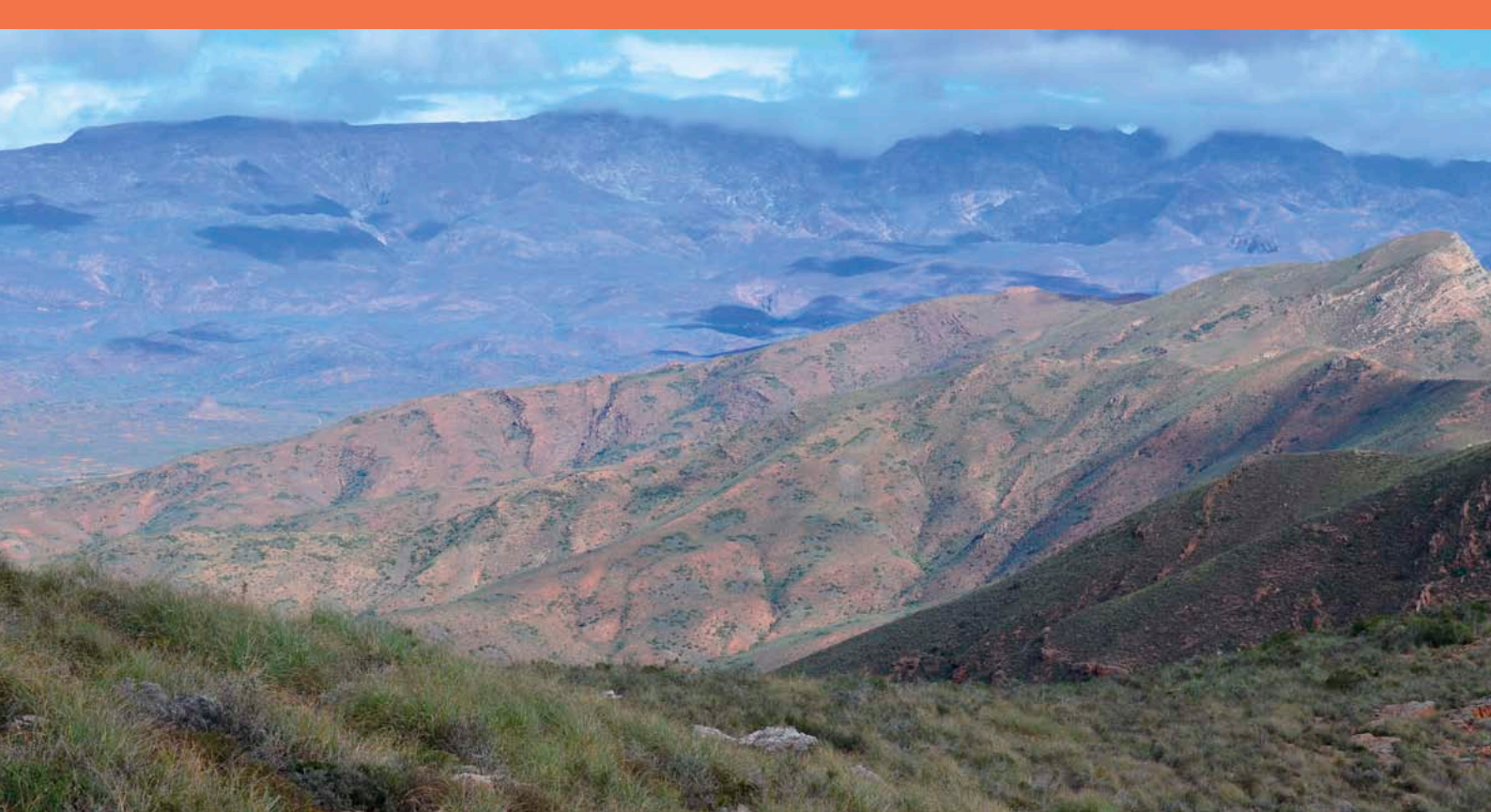
- Increased **temperature**, especially for the December-March and July-September periods (with predictions of +1.5 °C at the coast and +2–3 °C inland of the coastal mountains).
- Altered **rainfall patterns**, with overall drying, a shorter winter rainfall season, and longer time periods between more intensive, heavy rainfall events or storms (differing between mountain and lowland environments) – this is a matter of particular concern in an already water-stressed region.
- **Sea level rise** of 0.2 m by 2020 and 1.0 m by 2100.
- Stronger prevailing summer south-east **wind**, especially in coastal regions.

These projected changes will result in several second-order impacts including increased incidence of floods and drought, and a greater vulnerability to risk caused by erosion of coastal habitats, the increased incidence of damaging fires and invasions by alien species.

These changes are expected to impact negatively on biodiversity patterns and ecosystem functioning, as well as having negative socio-economic impacts arising from the loss of ecosystem services. This raises the risk profile of the province, which is characterised by a service-based economy in which agricultural production is a key driver. The province has a long coastline, and increased coastal vulnerability poses a significant risk to tourism, coastal properties and infrastructure, and fisheries-based livelihoods.

Planning for climate change

Systematic biodiversity planning takes into account both the spatial components of ecological processes, and spatial biodiversity patterns, in order to promote long-term persistence of biodiversity in strategically-located, well-connected and wisely-managed networks of natural habitat (see Box 5). The available systematic biodiversity plans for the Western Cape (including the *Western Cape Biodiversity Framework*, the City of Cape Town *BioNet*, and fine-scale biodiversity plans in district and local municipalities), identify networks of Critical Biodiversity Areas and Ecological Support Areas in configurations that facilitate the functioning of ecosystems, both currently and in the face of anticipated climate change. They do this by application of the following principles:



- Conserve those aspects of the biophysical environment that enhance climate change resilience, including:
 - movement corridors, stepping stones and habitat refugia.
 - Climatic refugia, including areas with steep ecological gradients, southern slopes, kloofs and areas with diverse micro-climates.
 - habitat refugia, including areas supporting threatened species, with sufficient habitat for minimum viable population sizes to persist in order to promote *in situ* adaptation. Local centres of endemism and areas with high species richness along environmental gradients are important in this regard.
- Enhance regional connectivity by:
 - ensuring conservation, at the landscape scale, of priority climate change adaptation corridors.
 - enhancing landscape connectivity and minimizing habitat fragmentation, by maintaining local-scale ecological corridors in good ecological condition.
- Sustain ecosystem process and function by:
 - increasing the resilience of ecosystems through improved operational management.
 - restoring biodiversity in degraded ecosystems, including ecological and faunal movement corridors.
 - protecting from disturbance areas that are essential for the delivery of ecosystem services (e.g. flood plains and coastal dune vegetation).

Ecosystem-based adaptation and mitigation

International best practice promotes the adoption of ecosystem-based adaptation as a critical element in climate change response strategies. In South Africa, this approach is reflected in climate change strategies or policies at national, provincial and municipal levels. The *Western Cape Climate Change Response Strategy* (2014) identifies well-managed natural systems as one of its three key outcomes. Well-managed, minimally-disturbed natural ecosystems are more resilient to climate change impacts than degraded ecosystems, and deliver a wealth of ecosystem services that contribute to both climate change mitigation (for example, through carbon sequestration) and climate change adaptation (for example, through protection from storm surges by coastal dune vegetation, flood attenuation by wetlands, and delivery of clean water from mountain catchment areas or aquifers).



4.2. Planning for Restoration and Rehabilitation

Restoration is the process of assisting the recovery of habitat that has been degraded, damaged or destroyed. Different terms are sometimes applied to different levels of restoration, depending on the goal of the restoration process.

Rehabilitation refers to actions that re-establish certain ecosystem functions, productivity and services such that the ecosystem regains some of the value it previously had to society. The purpose of rehabilitation is to achieve a resilient ecosystem that responds to change and is self-sustaining. It may not necessarily have any benefits for biodiversity.

Ecological restoration aims to re-establish the former functions and characteristic structure and composition of the pre-disturbance ecosystem. The goal is to restore an ecosystem to its natural or so-called pre-disturbance or 'reference' state. This involves active re-establishment of indigenous biodiversity as well as creating conditions suitable for formerly-occurring species to return naturally.

For detailed guidelines on restoration in various ecosystems of the Western Cape refer to Esler *et al.*, 2014, pages 130–156). For information on wetland rehabilitation, refer to WET-RehabMethods (WRC TT 341/09, available from the website of the Water Research Commission) and for river rehabilitation, refer to the guidelines and technical manual developed by the Water Research Commission.

Some general guidelines for planning and implementing restoration projects are provided below (see also 'Search and Rescue', in Section 4.3):

- Project planning should begin at least one year prior to implementation to allow for seasonality in seed collection, propagation, sowing and planting.
- Project objectives should be clearly defined based on an assessment of the extent and type of degradation at the site, the landscape context and feasibility. Objectives must be measurable and continually monitored and evaluated.
- A suitably qualified restoration practitioner, with a good understanding of the local ecology, should be contracted to design and oversee the restoration process.
- A local site with similar biophysical conditions and undisturbed natural vegetation must be identified to serve as a reference point for planning and monitoring purposes.
- The restoration site should be monitored for at least three years to measure the success of interventions relative to the restoration objectives.

- The key ecological drivers operating in the ecosystem must be integrated, either directly or indirectly, into the restoration plan. For example:
 - Fire is a key driver in fynbos and seed beds should be prepared with fire or introduced seed should first be smoke-treated.
 - In aquatic ecosystems, restoration of freshwater flows (i.e. natural hydroperiod) is usually the first and most important step towards restoring natural ecosystem functioning. The temporal variability of the restored flows should match natural variability as far as possible or, if this cannot be achieved, can be engineered (under the guidance of a freshwater or estuarine ecologist) to ensure maximum benefit.
- Rehabilitation of aquatic ecosystems should be integrated with rehabilitation of the surrounding landscape in order to address the upstream and downstream causes of degradation.
- Topsoil must be conserved, and if removed, stored appropriately (for as short a period as possible) to maximize propagule viability. Topsoil should not be moved during the rainy season when there is a higher risk of compaction.
- Propagules and plants used in restoration must be sourced from the local gene pool as far as possible. The high turnover in fynbos species between different habitats and landscapes can result in hybrids or disruption of local gene pools if inappropriate material is introduced.
- Re-introduction by sowing seed is preferred to planting propagated material. Seeding promotes greater diversity and minimizes the risk of introduced pests and pathogens. However, planting is useful for re-introducing certain threatened and rare species or species that do not readily establish from seed.
- Invasive alien species should not be used as part of the restoration process. This includes rye grass (*Lolium* spp) and the non-local African grass *Eragrostis curvula*. Vetiver grass (*Chrysopogon zizanioides*) should not be used in wetland rehabilitation. Where the impacting land-use activity borders a natural area, local indigenous species should be substituted for commercially available species.



For a restoration project to be effective and sustainable, there must be ownership of the project by local stakeholders (e.g. landowners, conservation bodies and land managers), who demonstrate commitment to sustaining the integrity of the ecosystem.

4.3. Planning for *ex situ* conservation: Search and Rescue

‘Search and Rescue’ refers to the *ex situ* conservation or translocation of species of conservation concern from a site at which infrastructural development or other impacting land use is taking place. It may also include the translocation of vegetation sods, topsoil rich in geophytes or soil-stored seed banks and propagules. Search and Rescue is *not* a mitigation measure to redress significant negative impacts of a land-use development, for the following reasons:

- It does not mitigate for habitat loss.
- Suitable receptor sites may not be available or may be limited.

- Most species (especially in fynbos) cannot be easily translocated.
- Translocations are expensive and are rarely successful.
- Translocated species (or translocation activities) may impact negatively on other species at the receptor site.
- Translocated material may contain pathogens, parasites or invasive alien species.
- *Ex situ* conservation results in the erosion of genetic diversity.

However, if *in situ* conservation of rare or threatened species is not possible or viable, owing to extreme habitat fragmentation and loss of key ecological processes, it is important to include the option of Search and Rescue as a way of minimising impacts.

Search and Rescue of plants

A specialist botanical report must be prepared to provide recommendations on the rescue techniques to be used for the particular species and vegetation type that is to be affected. This report must specify the season of rescue and replanting, as well as the methodology to be used. The information should be sufficiently detailed to guide the appointment of a suitable contractor with the necessary skills to carry out the rescue operation.



Some general guidelines that should be followed include:

- A suitable receptor site, endorsed by the relevant conservation agency (e.g. CapeNature), must be identified before Search and Rescue can be considered a viable intervention.
- In the case of sites that will be disturbed by the proposed land-use activities, but later rehabilitated, Search and Rescue should, as a minimum, concentrate on saving bulbs, succulents and aerial seed banks. Bulbs should be marked in spring when they flower or are in leaf, but they should only be transplanted once their leaves have dried off.
- Rescued bulbs should be transplanted in autumn (April–May), whilst succulents and other propagated or rescued material should be transplanted after heavy winter rains. Seeds should be sown before the first heavy winter rains (typically April).
- In all cases, topsoil (at least the upper 150 mm, and, ideally, with additional subsoil to a depth of 500 mm) should be removed before an area is disturbed, and replaced after the operational phase of the project. Removal of topsoil should occur in the dry season and the material should be spread out before the onset of the winter rains.
- In the case of recently burned sites, the seedlings of most shrubs can be rescued by means of retaining soil sods ($\pm$ 30 cm x 30 cm x 15 cm deep) in trays, or by transplanting individually into nursery bags.
- A three year maintenance phase is advised following translocation of topsoil or sods, to allow for the control of alien or invasive species that may proliferate in response to the disturbance.

Search and rescue of animals

When an extensive area of natural vegetation is to be destroyed, Search and Rescue of fauna is often deemed essential by NGOs and private individuals. Unfortunately the loss of the habitat will be catastrophic for the fauna that did exist there and, as with plants, translocation of fauna does nothing to mitigate the loss of habitat. It may, however, reduce the negative impacts of the impacting land-use activity.



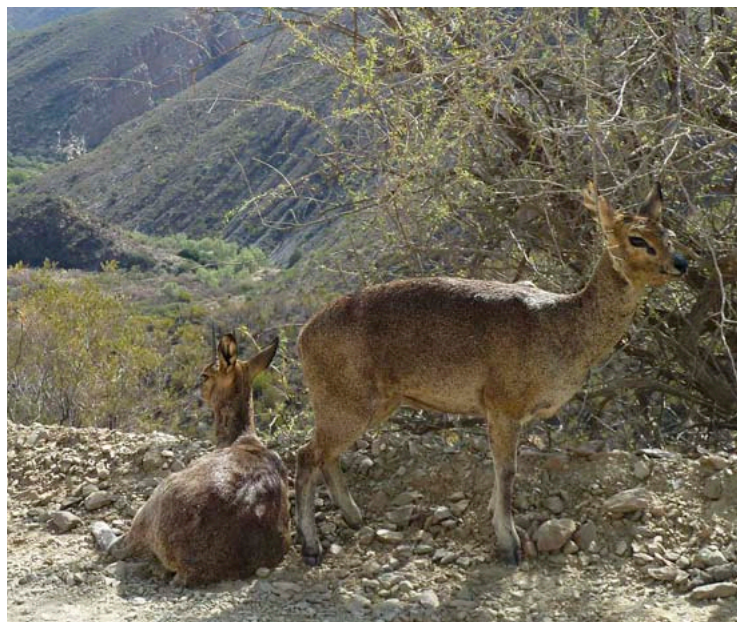
Search and Rescue efforts are often focused on more conspicuous or charismatic species such as tortoises and chameleons or on species of particular conservation concern. However, caution has to be applied to the relocation of these animals, as moving large numbers of them to neighbouring areas can also have negative impacts. These include overpopulation of the species at the receptor site, the introduction of disease and pathogens, and the disruption of the predator-prey balance.

Despite these potential impacts, Search and Rescue can be supported if it is properly planned and implemented, with animals moved to the closest suitable piece of natural habitat. For species of conservation concern, and where there is a programme to re-establish a species in a nearby protected area, then the focused capture and relocation of the target species should be a priority.

In all cases, the advice of suitable experts should be obtained to inform the Search and Rescue operation.

4.4. Planning for Animals: working in faunal habitats

Animals occur in all of the ecosystems that are treated in these *Guidelines*. In general, application of the *Guidelines* to minimise impacts in these ecosystems should also promote the persistence of any animals occurring in the affected habitats. However, special consideration should also be given to the ecological requirements of different kinds of animals, and this chapter provides some specific guidelines for working in faunal habitats – these guidelines given below should be read in conjunction with the guidelines for the specific ecosystem in which the animals occur.





Faunal diversity and endemism

The Western Cape is famed for its exceptionally high levels of plant diversity and, by comparison, its animal diversity may seem to be relatively low. Although it has never supported herds of large mammals of the size or density of those found in savannas, the Western Cape did once support significant populations of several well-known large mammal species such as lion, eland, buffalo, elephant, black rhinoceros and hippopotamus – most of these species, however, were exterminated through hunting after the arrival of European settlers in the 1800s. Despite this, there is a significant diversity of smaller nocturnal and cryptic mammal species that persist, even in small remnants of habitat, with 4 of the 90 known species of mammals being endemic to the region. Some animal groups, most notably freshwater fish, amphibians and invertebrates, display high levels of endemism and have many range-restricted species. Although the diversity of birds is relatively low, the region is an internationally-recognised Endemic Bird Area. Animals play a critically important role as pollinators and dispersers of seeds, and perform many other roles that are critical for maintaining ecosystem functioning. It is important, therefore, that the habitat requirements of animals are given careful consideration in environmental assessments.

While the vertebrate groups represented in the ecosystems of the Western Cape are well known, much less is known about the invertebrates. This means that environmental assessment practitioners and faunal specialists do not always have reliable information available on the animal groups present at a site. In the absence of detailed information on the animals themselves, it is hoped that by taking an approach in which a representative sample of habitats and ecosystems is conserved, the associated fauna will also be adequately conserved (i.e. habitat is used as a surrogate for the associated fauna). However, where specific information exists for particular faunal groups, this must always be taken into account in an environmental assessment.

Indicator species and species of conservation concern

It is often impractical to obtain full species lists of the animals at a site within a short timeframe and with limited resources. It is recommended that when detailed information is not available, the biodiversity assessment should focus on particular species whose presence, absence or relative abundance can be used as a measure of faunal diversity or importance, or to indicate the ecological health of the ecosystem, as follows:

Keystone species: These are species that play a unique and critical role in the way a particular ecosystem functions. If these species were to be lost from the ecosystem, it could result in the loss of other species (i.e. extinction cascades would take place), and the ecosystem would become significantly different, or would cease to function altogether. For example, the presence of a keystone pollinator (such as the Long-nose Tangle-veined Fly, *Moegistorhyncus longirostris*) can indicate that the ecosystem is relatively intact, whilst its absence would indicate that the ecosystem is not functioning as it should.

Indicator species: These are species whose presence and abundance serves as a measure of particular environmental conditions or the overall ecological condition or state of an ecosystem. For example, in some fynbos ecosystems the presence of large numbers of digging (fossorial) rodents such as Cape Gerbil (*Tatera afra*) or Dune Molerats (*Bathyergus suillus*), is an indicator of disturbance in the ecosystem, perhaps due to past disturbances such as heavy trampling, ploughing or a loss of predators.

There are also species whose presence or location can be used to help make strategic conservation-related decisions. These include:

Umbrella species: These species may be selected because if they (or their habitats) are conserved, it results, indirectly, in the conservation of other species that regularly co-occur in the same habitat. The umbrella species will usually be one that occupies a larger habitat, which incorporates populations of other species with smaller distributional ranges. Many top predators can be effectively used as umbrella species owing to their large home ranges, such as Honey Badger (*Mellivora capensis*) and Aardvark (*Orycteropus afer*). If these umbrella species are present, it indicates that the ecosystem is still relatively intact and connected. A faunal specialist would be able to identify if any umbrella species are present at a site, so that a suitable management plan can be put in place for them. Environmental assessments should adopt a precautionary approach when umbrella species have been identified at a site.

Species of conservation concern: Species of conservation concern are those whose populations are known to be declining or at risk and that require concerted conservation effort, as determined through a scientific conservation assessment. When a species that is of conservation concern is known (or predicted) to occur at a site, the impact of the proposed land-use activity on the species must be evaluated specifically. Ideally, a specialist study conducted by a faunal expert should quantify the impact on the species, including the cumulative impact of further habitat loss. The report should also, where practicable, emphasise impact avoidance as the most appropriate form of mitigation.



Threatened or Protected Species (TOPS): Threatened species are those that have been classified as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU), based on a conservation assessment (i.e. a Red List process), using standard criteria developed by the IUCN for determining the likelihood of a species becoming extinct. Threatened species face a high risk of extinction in the near future.

Protected species are those that are protected by international, national or provincial legislation – hunting, owning, translocating, breeding or trading of such species is illegal without valid permits or licenses.

The names of threatened or protected species are listed in international conventions (such as The Convention on International Trade in Endangered Species – CITES), national acts (such as the Biodiversity Act) and provincial ordinances, policies or other reports (such as the Western Cape State of Biodiversity Report – Turner, 2012).

Practitioners should consult the following for information on protected or threatened animal species in the Western Cape:

- For information on species listed on the Global IUCN Red List, visit: www.iucn.org
- To access information about the IUCN Red List status or CITES Appendix listing or Biodiversity Act TOPS status of Western Cape species, consult: <http://sibis.sanbi.org>
- For specific information on threatened or protected animal species in the Western Cape, consult the latest version of the Western Cape State of Biodiversity Report (which can be accessed from the CapeNature website).

If threatened or protected species are present at a site for which an environmental assessment is being prepared, this may trigger certain provisions of the EIA Regulations and will mean that a faunal biodiversity specialist must prepare a specialist report.

Making allowances for faunal movement

It is important that connections between patches of natural habitat are retained to facilitate movement of animals. This includes both local-scale movement (such as daily movements an animal may undertake in search of food), as well as landscape-scale movement (such as seasonal migration routes). Migration routes are of critical importance and the assessment of all species (including birds) requiring seasonal or annual migrations (which may also involve altitudinal shifts) is an important consideration that must be included in site assessments.

Well-managed corridors are effective tools for facilitating faunal movement.

Determining the dimensions of corridors: It is recommended that, where feasible, the minimum corridor widths specified for particular ecosystems should be adopted (consult the ecosystem guidelines in Chapter 5 of this book for more information). If this is not possible, then the dimensions of the corridor should be determined after consideration of three key principles by a faunal specialist:

- The width of the corridor must be influenced by its length (i.e. the longer the corridor, the wider it needs to be).
- The habitat requirements and behavioural traits of the target species must be adequately met.
- The neighbouring land use and the associated edge effects on the habitat must be considered.

Land use within corridors: The type of land use that will be appropriate in these corridors depends on the target species. Natural vegetation is ideal for facilitating the movement of all animal species and for maintaining ecosystem processes. Some species, such as Bat-eared Fox (*Otocyon megalotis*) and Honey Badger (*Mellivora capensis*), can also use agricultural lands for meeting their foraging and general movement requirements. However, corridors comprising long stretches of open agricultural land would not suit the movement requirements of small bush birds, reptiles and most insects.

Ideally, roads should not be constructed through faunal movement corridors as the functionality of the corridors will be compromised if they are bisected by roads. Where this is unavoidable, or where there are existing roads, the construction of overpasses and underpasses should be investigated.

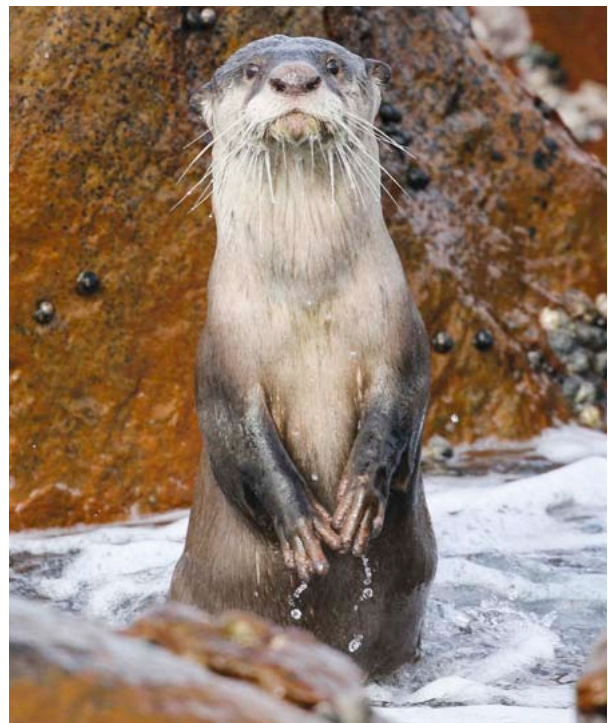
Land use in adjacent areas: The corridor width required for facilitating the movement of particular animal species will also be influenced by land uses in neighbouring areas, and the edge effects that are associated with these. For instance, if a corridor traverses a high density residential suburb, the edge effects would be severe for non-urban species. This means that to meet the needs of such species, corridors would need to be wider in urban areas (to reduce the impact of edge effects) than they would be in a less built-up area.



Mitigating or minimising the impacts of proposed land uses on animals

When applications for land-use change are approved in natural habitats, there are often long-lasting impacts on the local fauna. This is especially important in land-use developments in which sensitive natural areas have been set aside for conservation management within or adjacent to the impacting land-use activity. Planning for minimising impacts on faunal habitats during the design phase can reduce the long-term impacts of a land-use development on faunal persistence. Things to consider include:

- Lighting should be carefully designed so as not to shine into the remnant vegetation or impact-sensitive habitats. Light pollution not only attracts some animals to their doom, it scares off others who will avoid the areas, and it disrupts circadian rhythms and seasonal cues.
- Houses should not back up against natural vegetation as this promotes disturbance such as dumping of garden waste into the veld. Ideally housing should face onto the veld with a road between the houses and the remaining natural habitat to double as a fire break.
- Large barrier walls and electric fencing around estates and other kinds of land-use development can pose a significant barrier to faunal movement. These boundaries should be designed so that they allow for the movement of small fauna. Palisade is an example of a type of fencing which is permeable to most small fauna. Solid walls should be avoided or should at least include regular gaps to allow faunal movement and no electric strands should be below 15 cm above ground level. This is particularly important for species such as Western Leopard Toads (*Amietophrynus pantherinus*) that forage in gardens.
- Drains, canals and swimming pools should be designed so that they do not act as pitfall traps from which small fauna cannot escape. The sides of such structures should be angled at less than 45 degrees. Swimming pools should be of the beach type or should be raised or surrounded by walls.



- Tall, steep roadside curbs trap small animals, making them vulnerable to being hurt or killed by vehicles. Curb stones should have a gentle gradient, or be less 60mm tall, so that small animals can easily move off roads and onto verges.
- Any storm water that enters wetlands of conservation significance would require a specialist report to assess the significance of any potential impacts on animals, and to identify mitigation measures.
- The impact of pets should be minimized and managed effectively. The high concentration of domestic cats in residential developments neighbouring natural vegetation disrupts the predator-prey relationship. While it is acknowledged that this is very difficult to prevent, it is an important consideration where small fauna of conservation concern occur within the footprint of or land neighbouring a housing development. In some cases, it may be worth considering approaching the home owners' associations to include a condition which bans or limits the numbers of cats that an individual home owner can possess.

Search and Rescue may be considered as an option for reducing the negative impacts of a land-use activity on specific animal species, but it cannot be considered as adequate mitigation of habitat loss. Some general guidelines for undertaking Search and Rescue operations involving animals are provided in Section 3.2.4, above.

Notes on specific groups of animals

Threatened species: Practitioners can check the latest conservation assessments (i.e. Red Lists) and the latest *Western Cape State of Biodiversity Report* (available from CapeNature) for information on threatened species (details of these references are provided in the reference list at the end of these *Guidelines*). If any threatened or near-threatened species are known to occur in or near a proposed land-use site, a specialist report must assess the potential impacts of the land-use activity on the species concerned.

Mammals: Although most of the larger mammal species have been lost in the Western Cape, some species such as leopard (*Panthera pardus*), Aardvark (*Orycteropus afer*), Cape Clawless Otter (*Aonyx capensis*) and Chacma Baboon (*Papio ursinus*) still persist in many areas. These species require extensive home ranges and their persistence is dependent on the existence of large and well-connected areas of natural habitat, including both protected areas and natural rangelands in production landscapes. Land-use activities within or buffering these habitats can lead to human-animal conflicts. For instance, small stock farming brings leopards into conflict with farmers, which results, potentially, in persecution of the leopards. Similarly, when housing developments are built within the home ranges of baboons, it results in shrinkage of their natural foraging areas, and increased conflict between people and the baboons.

Many areas of natural veld are subjected to the introduction of large game. Both historically-occurring and extra-limital game species can have marked negative impacts on the ecological condition of the natural habitat. All game introductions should follow CapeNature's Game Translocation and Utilisation Policy (<http://www.capenature.co.za/wp-content/uploads/2013/11/Game-Translocation-Policy.pdf>) and should be accompanied by a Faunal Management Plan which clearly outlines an ecological monitoring programme and sets the carrying capacity limits.



Where vegetation remnants are set aside as a result of an environmental authorisation, they need to be appropriately managed if the animal species on site are to persist. In some areas, fencing is needed to control human access and, depending on the neighbouring land use, can either facilitate or prevent faunal movement. This is particularly important for small antelope such as Cape Gysbok (*Raphicerus melanotis*) populations of which can be rapidly decimated by illegal hunting with dogs or snares.

Relatively little known is known about bats, and several Near Threatened species occur in the Western Cape. Bat roosting sites identified within or near any proposed development would require a specialist report to be prepared. Wind energy facilities can have significant negative impacts on bats (especially through barotrauma). The *South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments* should be consulted: <http://www.ewt.org.za/programmes/WEP/bats.html>.

Birds: The Important Bird Area (IBA) Programme identifies and works to conserve a network of sites critical for the long-term survival of bird species. For any proposed land uses in or neighbouring an IBA, special attention should be given to potentially negative impacts on the avifauna. For more information consult: <http://www.birdlife.org.za/conservation/important-bird-areas>.

Many coastal habitats and wetlands of local, regional or international significance occur in the Western Cape and protection of these critical habitats is essential. Estuarine habitats are particularly important for migratory water birds. All heronries and breeding sites of coastal water birds are sensitive to impacts and are of conservation significance; negative impacts on these must be avoided.



Wind farms can potentially have significant negative impacts on birds and special attention must be given to avoid or mitigate these potential impacts. BirdLife South Africa and the Endangered Wildlife Trust have developed best practice guidelines for avian monitoring and impact mitigation at the sites of proposed wind farms in southern Africa. Information can be obtained from <http://www.birdlife.org.za/conservation/birds-and-wind-energy> and www.ewt.org.za.

Amphibians: The Western Cape has a high diversity of amphibians, with many species classed as threatened and/or having restricted distributions. There have been several recent changes in frog taxonomy which have resulted in the description of new species and the re-drawing of the distribution ranges of existing described species. These recent changes are not reflected in the current *Atlas and Red Data Book for Frogs*, and specialist input will be required where amphibians are present.

Some amphibians are sensitive to environmental factors such as water pollution and/or altered water regimes. The input of stormwater into wetlands can have significant negative impacts on the amphibian fauna. In cases where a proposed land use is expected to affect inflows to habitats that are important for amphibians, a specialist report should assess the significance of potential impacts and suggest mitigation measures. Altered fire regimes, especially unseasonal fires, can also have significant negative effects on amphibians.

It is worth noting that several species of frog are only associated with wetland habitat during their short breeding season. For the remainder of the year, they forage in neighbouring terrestrial habitats where they are vulnerable to disturbances. The Endangered Western Leopard Toad (*Amietophrynus pantherinus*) is a prime example of this. In addition, Rain Frogs (*Breviceps* spp.) which occur in the Western Cape are not associated with wetlands at all, and these frogs can be negatively impacted by land-use practices well away from wetlands.

Reptiles: The Western Cape is a hotspot for both reptile diversity and endemism. In addition, it is also a hotspot for reptiles of conservation concern. Habitat loss and degradation are the major threats to the reptile fauna, and road kill is also significant, especially in wide-ranging and long-lived species. As such, new roads through natural habitats and 'greenfield' developments place the reptile fauna at high risk.

Freshwater Fishes: The Western Cape has the highest number of threatened and endemic freshwater fish species in South Africa, and freshwater fishes are also the most threatened of all vertebrate animal groups in the province. Major threats to these fish include invasive alien fish species and destruction and disturbance of their river and wetland habitats. The presence of any indigenous freshwater fish in or neighbouring the site of a proposed land-use is significant, and expert input must be obtained to assess and mitigate any potential negative impacts on the fish and their habitat.

Invertebrates: In general, conserving a representative sample of the Western Cape's habitats and ecosystems is thought to be an adequate surrogate for conserving the associated invertebrate fauna. However, some groups are relatively well studied and information is available in the relevant *Red Lists* (Butterflies, Dragonflies and Damselflies).





CHAPTER 5

Ecosystem Guidelines



COASTAL ECOSYSTEMS: Estuaries

Contributor: Barry Clark

Snapshot of Estuarine Ecosystems

Estuarine Ecosystems form where rivers feed into the sea. Estuaries are bodies of surface water that are not themselves part of the ocean, but are permanently or periodically open to the sea and, therefore, are subject to marine exchange and the influence of tidal fluctuations. Estuaries are categorised into numerous different types, based on their physical and biogeographic features. There are 53 estuaries in the Western Cape, distributed along the coastline from the Olifant's River Estuary on the West Coast, to the Bloukrans Estuary on the south-eastern boundary of the province. These estuaries, with a collective area of 18 560 ha, account for 21% of the national estuarine area.

General characteristics

- Estuaries along the West Coast fall into the cool-temperate category, whilst those on the southern and south-eastern coastline are of the warm-temperate biogeographic type.
- There are 6 estuaries along the coastline of the West Coast District Municipality, 16 within the area of jurisdiction of the City of Cape Town, 11 falling under Overberg District Municipality, and 20 on the south coast within Eden District Municipality.
- Only five estuaries in the Western Cape are in a natural or unmodified state; these include: the Shuster, Krom, Klipdrifsfontein, Keurbooms and Soutrivier-Oos estuaries.
- Three Western Cape estuaries are designated Ramsar Sites of international conservation significance: the Heuningnes (or De Mond) estuary, and the Verlorenvlei and Wilderness estuarine lakes. Although all estuaries provide important habitats for water birds, seven of them fall within designated Important Bird Areas (IBAs) and thus play an especially important role in conserving avian biodiversity. These are the Bot/Kleinmond; Groot Berg; Heuningness; Olifants and Reitsvlei/Diep River estuaries and the Verlorenvlei and Wilderness estuarine lakes.



Conservation, land-use pressures and risks

Although in general, the estuaries of the Western Cape are in a fair to good ecological condition, few (5) are in a natural or unmodified state, more than half (55%) of them are threatened, and most (70%) are unprotected.

- *Ecological condition:* The predominantly closed estuaries, especially along the West coast, are mostly in good ecological condition, whilst the large, permanently open estuaries are generally in a fair ecological condition. The numerous small, temporarily open/closed estuaries around the City of Cape Town mostly exhibit high levels of pollution and are in a poor ecological condition. These include the Diep/Rietvlei, Sout-Wes, Elsies, Houtbaai, Bokramspruit, Shuster, Silvermine, Sand (Zandvlei), Eerste, Sir Lowry's Pass, Zeekoei, Onrus and Buffels (Wes) estuaries. 11% of the Western Cape estuaries are in an excellent ecological state, and these are mostly along the south/south-eastern coast.
- *Ecosystem threat status:* Estuaries are amongst the most highly threatened habitats in the Western Cape, with 27 (54%) of them listed as threatened, and most of these critically endangered. The situation is the worst along the coastline of the City of Cape Town, with 13 of the 16 estuaries listed as threatened (11 critically endangered and 2 vulnerable), followed by the Overberg District Municipality (9 of the 11 estuaries are critically endangered), and the West Coast District Municipality, where four of the estuaries are threatened (3 critically endangered and 1 vulnerable). The situation in Eden District Municipality is much better, with only one (the Gouritz) of the 20 estuaries there being threatened.
- *Ecosystem Protection levels:* Most estuarine ecosystems in the Western Cape do not fall within protected areas. At the time of writing, one of the estuaries in the City of Cape Town was protected and 3 in process for proclamation, only 2 are protected in the West Coast DM (the Sout and Groot Berg), 3 are protected in Overberg DM (2 of these, Heuningnes and Klipdriffontein, are well-protected, and one – the Breë, is moderately protected), whilst in the Eden District Municipality only 2 estuaries (the Gwaing and Kaaimans) have no formal protection – the rest of the estuaries in this District are either well-protected (11 out of 20) or moderately protected (6 out of 20).
- *Land-use pressures:* Most of the population of the Western Cape lives within 25 kms of the coast, which places coastal ecosystems, and estuarine ecosystems in particular, under increasing pressure from a variety of land uses. The health of estuarine ecosystems is placed at high risk by land uses both at the coast and in the upstream catchments, resulting in: reduction of freshwater flows, increased sedimentation and pollution, interference with natural mouth dynamics and other hydrological processes, loss of estuarine vegetation, and over exploitation of living resources

(Note: statistics extracted from: *Western Cape State of the Environment Report, 2013*).



What are the key ecological ‘drivers’ maintaining ecosystem function, pattern or structure?

- **Freshwater flows:** Estuaries require freshwater inputs in order to function properly. Freshwater flows can range from flood events that scour out the channel and open the estuary mouth, to dry season base flows that maintain crucial estuarine processes. Important factors include the quantity of water, its quality (nutrient status, turbidity, and contaminants) and the natural variability in flow regime (seasonal and inter-annual variations, including floods of different magnitudes).
- **Sediment input:** Sediment inputs, from both terrestrial and marine sources, and the correct balance between sediment entering and leaving the estuarine system, are critically important for maintaining structure and function in estuarine ecosystems.
- **Oceanographic conditions:** Factors such as wave action, daily tidal fluctuations, currents, water temperature, water quality (nutrients), and periodic flushing or salt water inputs from tidal and storm surge events, are all important for maintaining the natural variation in physical and chemical conditions that characterises estuaries.

What are the main pressures and threats in these ecosystems?

Estuaries are naturally dynamic systems that show great variation in biophysical conditions, both over the length of the system and over time, and they are naturally subject to rapid and sometimes extreme changes. Although most of the estuaries in the Western Cape are rated as being in a fair to good ecological state, many of them are threatened due to land-use pressures and human-induced changes that differ from the natural patterns of variability. The main pressures on estuaries include:

- **Changes in freshwater inputs:** Alterations to the quantity, timing and quality of freshwater inputs represent the primary threat to the health of estuaries. These changes are brought about through increases or (more commonly) decreases in mean annual runoff, alterations to the seasonality of flows, changes in flood frequency or magnitude and changes in water quality (nutrients, contaminants, turbidity and sediment load). These changes are typically caused by:
 - direct water abstraction, or impoundment (damming, which alters the flow regime and affects scouring, mouth closure patterns, salinity levels and gradients, and nutrient inputs).
 - unnatural flow augmentation, caused by runoff of storm water, hardening of surfaces around the estuary and in the upstream catchment, discharge of treated sewage, managed release of water from impoundments and inter-basin transfers.
 - changes in land cover and land use in the catchment, leading to changes in the quantity or quality of freshwater flows.

- poor or inappropriate land-use practices and development in the catchment feeding the estuary, leading to increased sediment inputs (from erosion), nutrient enrichment (from fertiliser return flows or effluent discharges) and input of contaminants, and accelerated sedimentation as a result of upstream activities that cause erosion.
- pollution, from sources such as sewage, storm water, agricultural runoff and industrial wastewater.
- infestation by invasive alien plant species that cause reduced freshwater flows.
- impacts of climate change.
- **Urban development and disturbance from other human activities:** Encroachment by urban development and disturbance caused by recreational activities (such as power-boating, water-skiing and swimming), gives rise to a variety of secondary threats to estuaries, including
 - artificial bank stabilisation.
 - canalisation and other engineered flood control measures.
 - altered mouth dynamics (artificial breaching) for maintenance of water levels for recreational activities and other purposes.
 - dredging, and other disturbances resulting in habitat destruction, burial of organisms, erosion, re-mobilisation of pollutants from sediments and increased turbidity.
 - activities that reduce or restrict tidal action in a normally tidal ecosystem, with negative impacts on a variety of estuarine processes including inflows of seawater, oxygenation of water and larval dispersal.
 - inappropriate land-use and development around the estuary (i.e. in the estuary functional zone) resulting in habitat degradation or loss, altered tidal flows, increased sediment loading, impacts on estuarine biota and loss of aesthetic value of the estuary.
 - excavation, reclaiming or draining of coastal wetlands, salt marshes, reed beds and intertidal mudflats that form an integral part of estuarine ecosystem.
 - introduction of alien predatory fish species of other habitat-altering species.
 - over-exploitation of living resources such as fish, invertebrates and estuarine vegetation.

What are the non-negotiables?

- **The National Estuary Biodiversity Plan (Turpie *et al.* 2011) must be implemented without delay and appropriate levels of protection must be applied to all estuaries identified in this plan:** The *National Estuary Biodiversity Plan* was developed as part of the Estuaries component of the *National Biodiversity Assessment 2011*. This identified a list of priority estuaries in South Africa which require full or partial protection in order to adequately protect estuarine biodiversity at the national scale. Towards these ends, protected areas need to be established on all priority estuaries with effective no-take zonation, and the freshwater requirements of these estuaries must be guaranteed. Consult the *National Estuary Biodiversity Plan* or *NBA 2011* to establish which estuaries in the Western Cape are designated as priority estuaries).
- **Estuary Management plans should be developed and implemented for all estuaries in the province¹:** The *National Estuary Management Protocol* gazetted under the *National Environmental Management: Integrated Coastal Management Act* (Act no. 24 of 2008), recognises that estuaries are sensitive and complex environments affected by activities in terrestrial, freshwater and marine environments. This means that estuarine ecosystems require integrated, cross-sectoral planning and management. The *Estuary Management Protocol* stipulates that individual Estuary Management Plans must be drawn up for all estuaries in the country; it sets minimum standards for these management plans, and identifies the authorities responsible for drawing up and implementing such plans. Important aspects that must be addressed in each plan include: (i) measures to ensure that freshwater flow

¹ At the time of writing these *Guidelines*, estuary management plans are under development for at least 16 of the estuaries in the Western Cape and Estuary Management Forums have been established, through a process co-ordinated by CapeNature.

requirements (quantity and quality) of each estuary are met (as dictated by the target health class of the estuary); (ii) that development within the estuarine functional zone (5 m contour)² is kept to a minimum; and (iii) that adequate protection is provided for living aquatic resources in each system. Of particular importance is the need to maintain a natural flood regime, as well as adequate low flows and good water quality. Large floods are critically important for resetting estuaries, particularly in temporally open-closed systems. These large floods serve to remove accumulated sediment and other debris and lower the height of the berm (barrier) at the estuary mouth, thus increasing the period of time for which the mouth remains open during the dry season or between floods. Maintaining dry-season flows is also important as these can play a critical role in keeping the mouth open³ for permanently open systems, and in preventing hyper-salinity and maintaining water levels in temporally open-closed systems. Maintaining good water quality is also important, particularly in temporally open-closed systems, which rapidly become eutrophic if freshwater inflows contain elevated levels of nutrients or organic matter.

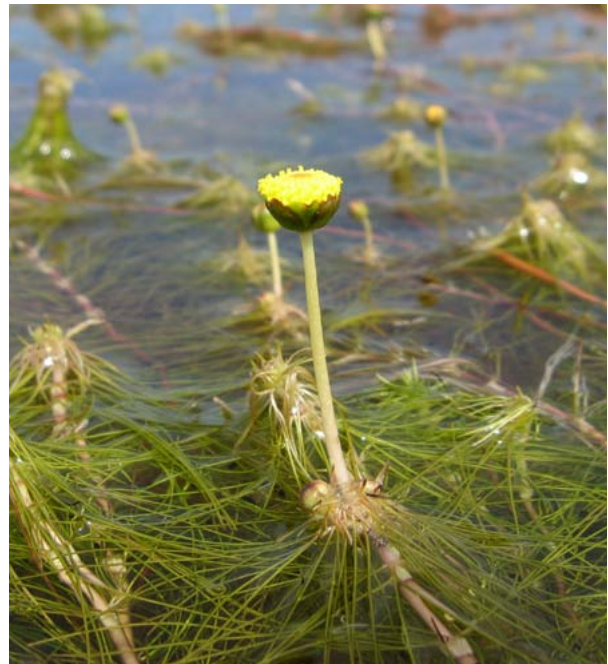
- **Any form of artificial mouth breaching or manipulation must be carried out in a formal and well-documented manner:** The need for breaching and the associated implications for the natural and social environment must be captured in the estuary management plan. A specific mouth management protocol must be developed with inputs from estuary specialists, government departments and other relevant stakeholders.
- **The Ecological Reserve must be determined and implemented for all priority estuaries:** The Ecological Reserve (the minimum freshwater flows required to maintain biodiversity and ecological functionality) is determined using standardised, scientific methods that are entrenched in the *National Water Act* (Act 36 of 1998). The models used to determine the estuarine Reserve must be calibrated with those used to determine the freshwater/catchment Reserve.
- **Exploitation of living estuarine resources must be kept within sustainable limits:** Exploitation of living resources in estuaries (both flora and fauna) needs to be strictly controlled as over-exploitation of these resources (e.g. bait, fish and/or flora) can disrupt natural food chains and ecological functioning, as can disturbance (e.g. trampling) associated with harvesting activities. Harvesting of living resources is subject to regulations set by the provincial authorities.



- 2 The extent of the estuarine functional zone has been mapped for nearly 300 estuaries along the South African coastline as part of the National Biodiversity Assessment and is available as a GIS shape file on the SANBI BGIS website (<http://bgis.sanbi.org/>). For estuaries where this has not already been defined, the 5 m contour should be used as a general guideline, and it must be recognised that this level may not be applicable in all cases. Criteria that consider the local context of a specific estuary for which the functional zone has not already been delineated must also be applied in determining the limits of the estuarine functional zone. For example, along the Cape Flats section of the False Bay coastline, the flat topography would result in an extensive area being included in the estuarine functional zone, simply because it falls within the 5 m contour and not necessarily because of any functional characteristics. In other cases, all of the area within the 5 m contour has already been modified by various land-uses, which means that this can hardly be regarded as an estuarine functional zone. This means that determining the extent of the estuarine functional zone must be carried out on a case-by-case basis and factors other than a contour-line cut-off must be considered.
- 3 Management of estuary mouths must be suitably contextualised, and trade-offs may need to be struck between what is ecologically desirable (i.e. simulating natural mouth dynamics) and what is practically possible in terms of managing risk to already-established infrastructure.

What are the critical things to maintain for biodiversity to persist?

- Maintain freshwater flow regimes that are as close to natural as possible; low (dry season) flows, seasonality and flood frequency are of utmost importance.
- Maintain the minimum freshwater flows (i.e. the Ecological Reserve) required for maintenance of estuary health and protection of estuarine biodiversity. Water resources planning initiatives such as Classification and Reserve Determination studies are designed to establish minimum freshwater flows that are needed to maintain functional estuarine ecosystems. These classifications and reserve determinations represent the most effective tools for ensuring adequate freshwater flows for estuaries, with priority given to the 'priority estuaries' identified in the *National Biodiversity Assessment*. Such an approach should take account of:
 - Variations in estuarine importance (with respect to species richness, with priority given to estuaries that have higher importance scores).
 - Representivity (biogeographic considerations and provision of sufficient habitat for all species utilising estuaries).
 - The overall health of the ecosystem (giving priority to those that are in good ecological condition).
 - Ensuring links between ecosystems (by maintaining maximum viable distances between them).
- Maintain and monitor water quality, particularly the quality of freshwater inputs.
- Maintain mouth dynamics (opening and closure) that are as close to natural as possible (given the proviso described in the 'Notes' above). Any form of artificial mouth management should form part of the holistic estuary management plan.
- Ensure that harvesting or utilisation of living estuarine resources (flora and fauna) is kept within sustainable limits.
- Encourage land-use practices that minimise loss of natural habitat and erosion, and avoid the introduction of habitat-altering invasive alien species of plants and animals (such as large predatory fish). Where stands of invasive alien vegetation are present around the estuary or in its catchment, implement appropriate clearance programmes.



What are the best spatial approaches (at a landscape scale) to avoid or minimise impacts and risk in these ecosystems?

- Implement 'whole systems' management approaches that incorporate the 'source-to-sea' (or catchment-to-coast) philosophy. Estuaries lie at the interface between terrestrial and marine environments and are affected by changes and management practices across all terrestrial and marine spectra. Because of the way in which estuaries integrate with their catchments through hydrological processes, they are both indicators of and subject to the impacts of land-based catchment management practices. Estuaries are also integrally linked to the marine and coastal environment. Cooperation among local, provincial and national government agencies with different mandates (freshwater, marine and terrestrial) is, therefore, necessary for effective protection of estuarine ecosystems. Estuary-specific management plans and associated Estuary Management Forums that can link with established Local, Provincial and National Coastal Committees, and Catchment Management Forums, are effective tools for facilitating such cooperative management at a landscape scale.

- Establish buffers around estuaries to prevent loss of important habitat. Estuaries are popular sites for recreational activities and are often nodes for urban, commercial and recreational development. Adequate buffers need to be established surrounding estuaries to prevent loss of important habitat as a result of land uses encroaching on these ecosystems. The estuary component of the National Biodiversity Assessment recommends that no modifying land-use activity be permitted below the 5 m contour surrounding estuaries, which corresponds with the extent of the estuarine functional zone for most systems.
- Where it is still possible, ensure that impacting activities are avoided or minimised in the estuarine functional zone and adhere to coastal management lines, where these have been set by the Municipality or Province for estuaries (information on coastal management lines can be obtained from the Department of Environmental Affairs and Development Planning). The coastal management lines define the amount of space that should be left between any buildings or other infrastructure and the estuary as a means of mitigating impacts related to infrastructural development, and to reduce risk to infrastructure due to natural processes.
- Maintain linkages between the estuary and surrounding salt marshes, reed beds, coastal wetlands and mudflats.
- Implement zonation plans for all recreational activities (these should be embedded in Estuary Management Plans).

What indicators should be used to assess and monitor ecosystem health?

The health of an estuary can be described in terms of its present ecological state (excellent, good, fair or poor), the extent to which it has been modified from a natural or reference state, and its biological functionality, which is determined by calculating an estuary health score using the Estuary Health Index (see the *Western Cape State of Biodiversity Report*, 2012, for more information).



The types of indicators used to assess and monitor estuary health include:

- Freshwater inflows, including the quantity of water (measured as the % change in mean annual runoff), its quality (chemistry, nutrients, salinity), and the variability of flow (which should be as similar to the natural flow regime as possible).
- Mouth dynamics (opening and closure).
- Physical habitat and sediment loads.
- Species composition, richness and abundance of plants (terrestrial vegetation cover as well as aquatic macrophytes and microalgae), invertebrates, fish and birds.

Assessing and monitoring estuary health requires the inputs of an estuarine specialist, and an assessment of thresholds of potential concern for each indicator will need to be carried out on a case-by-case basis. As a minimum, these indicators should be maintained above degradation threshold levels, or should be improved as stipulated by the specialist. Refer to the current version of the *Western Cape State of Biodiversity Report* for data on the state of health of estuaries in the Western Cape.

The relationship between present ecological state, biological functionality and ecological management class of estuaries

PRESENT ECOLOGICAL STATE (PES)	EXCELLENT	GOOD	FAIR		POOR	
% biological functionality retained	91% or more	75–90%	61–75 %	41–60%	21–40%	20% or less
Functionality	Retains biodiversity pattern and ecological processes		Some loss of either biodiversity pattern or ecological processes		Biodiversity pattern and ecological processes almost entirely lost	
Health condition	A Natural	B Largely natural with a few modifications	C Moderately modified	D Largely modified	E Heavily degraded	F Critically degraded

(adapted from Chapter 3: Estuarine Ecosystems, in the *Western Cape State of Biodiversity Report*, – Turner, 2012)

How reversible are impacts within a period of 5 to 10 years?

- Estuarine biodiversity will normally recover rapidly (often within 5 years), once functional factors such as natural flow regimes, mouth dynamics and nutrient status have been re-established, and resource use has been brought within sustainable limits.
- Recovery from the effects of habitat modification (e.g. canalisation or bank stabilisation) can take longer (generally longer than 5 years), and is not guaranteed. In cases where the loss of biodiversity pattern and ecological functionality has fallen below the 20% level, the damage to the ecosystem is probably irreversible.

What are acceptable compensation measures of offsets for biodiversity loss?

Estuaries are unique habitats on which many plants, invertebrates, birds and fish (both resident and migratory) rely for their continued existence. They are also highly productive systems. Few, if any compensation measures or offsets can realistically be entertained.



COASTAL ECOSYSTEMS: Sandy beaches and dune systems

Contributors: Barry Clark and Charl de Villiers

Snapshot of Sandy Beach and Dune Ecosystems

The Western Cape coastline is a mix of rocky shores interspersed with pocket beaches, long sandy shores and rocky promontories.

General characteristics

- On sandy beaches there is a progression from the intertidal zone through a gradation of dunes to the coastal forelands. Small embryo dunes, with very little vegetation cover, give way to local mobile dunes (large areas of moving sand, with some patches of pioneer vegetation, such as wheat grass, and semi-fixed dunes) through to fixed dunes with an almost complete vegetation cover of strandveld (incorporating thicket communities), with the taller thicket type, Southern Coastal Forest, most extensive in the south-east.
- Mobile dune systems operate over a range of spatial scales. They play numerous vitally important ecological roles including: serving as buffers against storm surges; regulation and control of wind-blown sand; regulation of localised weather conditions; and provision of environments that harbour important biodiversity (both plant and animal). They are also important for aesthetic reasons and for providing a sense of place.

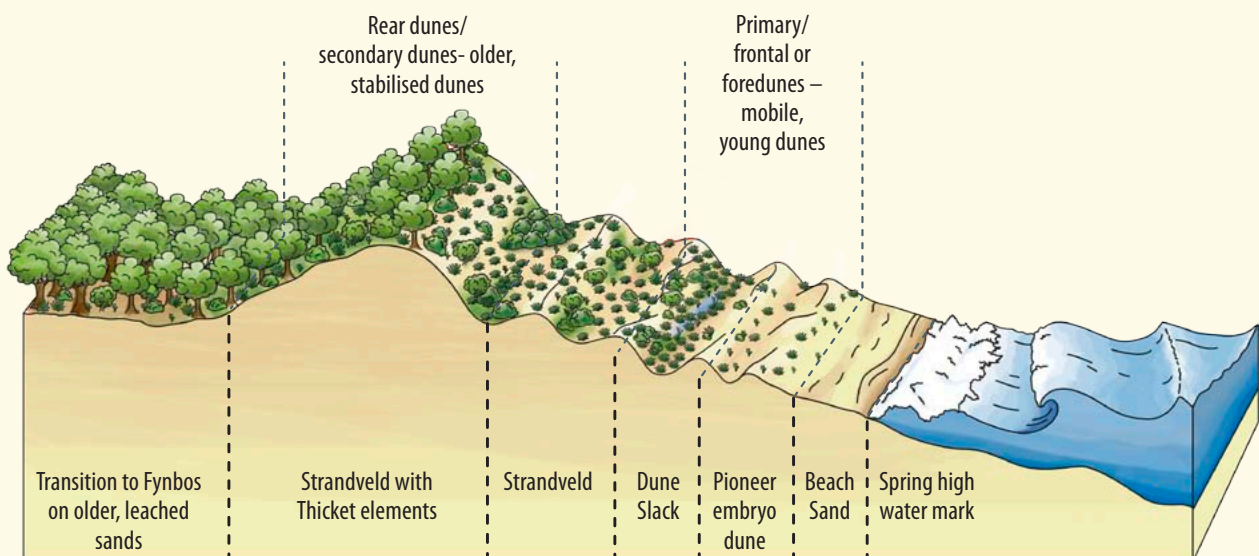
Conservation, land-use pressures and risks

- Beaches are home to one vegetation type which is classed as Least Threatened and well-protected: a total of 97% of the historical extent of this vegetation type remains.
- Most dune systems in the Western Cape have been heavily impacted by human activities of various types. In the past, highly mobile dunes were seen as undesirable and alien plants were established on them to try and stabilize them in order to limit their impact on coastal infrastructure.
- All remaining dune systems in the Western Cape are a high priority for conservation and management.



- The key land-use pressures and risks faced by these ecosystems include: establishment of built infrastructure, lack of maintenance of stormwater and drainage systems abutting dune cordons, stabilisation of mobile dune fields and disruption of sand mobility corridors, disturbance of natural dune vegetation, illegal use of off-road vehicles in the coastal zone, dune mining, and invasion by alien plants.
- Inappropriate location of impacting land uses on coastal dune systems increases the environmental risks posed to this ecological infrastructure, placing an increased management burden on municipalities and conservation authorities. The problem is that the marine and climatic component (the drivers) of the dynamic coastal system remains functional, regardless of the disturbance or attempted stabilization caused by coastal developments. This leads to various management problems including: excessive build-up of sand; altered dune profiles, change in patterns of sand deposition and erosion; the loss of sediment bypass systems and consequential impact on sediment budgets; the loss of sandy beaches due to reduced sediment budgets; establishment of artificial and sedentary dune systems where they did not previously exist, and beach regression eating into coastal vegetation.

Figure 7: Dune and beach vegetation profile



What are the key ecological ‘drivers’ maintaining ecosystem function, pattern and structure?

- **The natural oceanic wave climate:** Factors such as wave height, wave processes, surface wind and other ocean surface characteristics are the key drivers influencing the structure and functioning of coastal ecosystems.
- **Wind:** Sandy beach and dune environments are wind-driven ecosystems, affected by alternating seasonally dominant winds from the south-east and north-west.
- **Mobility of sand:** Seasonal cycles of sand deposition (in summer) and erosion (in winter) are critically important for maintaining ecosystem function and structure both along the shore and between the foredunes, the beach and the surf zone. Sand mobility also influences vegetation structure and successional dynamics in dune systems, and sand mobility corridors (such as inland-trending dune fields, headland-bypass and climbing-falling dunes) promote diversification of terrestrial plant species.
- **Nearshore currents and circulation, and offshore sediment transport:** In addition to the important role played by direct wave action, patterns of nearshore and offshore water movement, including longshore drift, play a critically important role in the natural cycle of sand movement and deposition in the littoral active zone.
- **The deposition and decomposition of organic material:** Material such as kelp (and other seaweed), carrion (dead animals that wash up on the beach) and other organic detritus that is deposited at the high water mark and on the backshore, provides an important source of food for animals (such as shore birds) that then export energy from the beach system inland to the dunes. This is important for maintaining nutrient cycles and food webs in dune ecosystems. Kelp also contributes to the ecology of sandy beaches and dune systems in a range of other ways. It traps wind-blown sand, elevating the beach profile (see Figure 7) and thus reducing rates of beach regression. During a storm surge, kelp collects at the toe of dune cordons thus providing some protection to these dunes during such events. The role of kelp in protecting dunes is pronounced during the second high tide of the storm surge when beach-cast kelp is ‘established’ at the toe of the dune systems.
- **Colonisation of dunes by beach and strandveld vegetation:** The pioneer beach vegetation and strandveld that occurs on primary and frontal dunes, respectively, is critical for maintaining ecological processes and major biogeographical gradients, both longitudinally and in relation to the major drainage systems.

What are the key pressures and threats in these ecosystems?

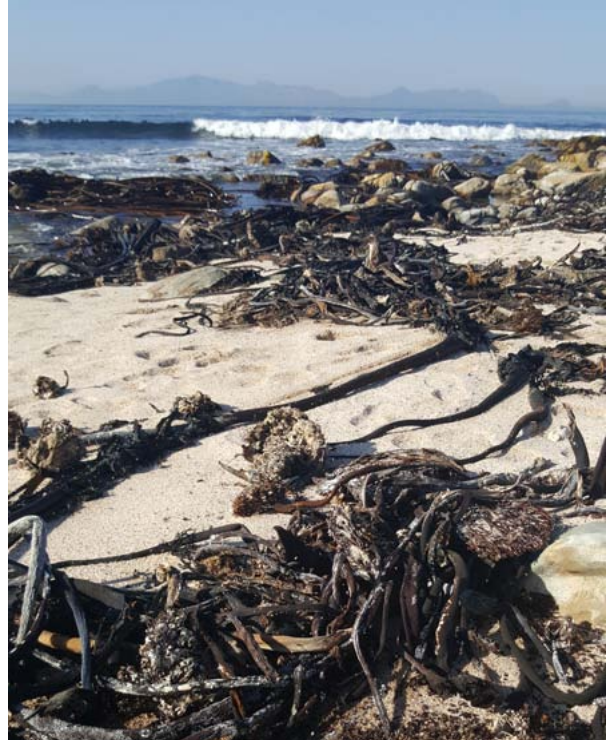
- **Stabilisation of mobile dunes and sand movement corridors:** Artificial stabilisation of naturally mobile beach-dune systems, and disruption of sediment corridors, leads to sediment starvation elsewhere in the littoral active zone, or further along the coast, with negative impacts on the functioning of the ecosystem. Along the Western Cape coast, and particularly in proximity to the main development nodes (such as Saldanha, the City of Cape Town, George, Knysna and Plettenberg Bay), the mobility of beach-dune systems has been impeded by the installation of various kinds of infrastructure (such as roads, housing, carparks, retaining walls and other structures intended to protect property and infrastructure from coastal processes) as well as infestation by invasive alien species such as rooikrans (*Acacia cyclops*).
- **The establishment of resorts and housing estates on dune systems:** The establishment of housing infrastructure or resorts on primary dunes, dune slacks and secondary dunes is destroying these highly sensitive ecosystems in certain areas, such as Wilderness, Keurboomstrand, Hartenbos, Dana Bay and Victoria Bay. Loss of the foredunes not only disrupts the processes required for maintaining sandy beaches, but also removes the natural coastal buffer that otherwise would protect the coastal forelands from flooding during exceptionally high tides and severe storms, or raised sea levels as a result of climate change.
- **Disturbance of natural dune vegetation cover:** Vegetation is disturbed by trampling, illegal off-road driving and earth-moving operations (linked to the establishment of resorts and housing estates), resulting in erosion and degradation of the primary and foredunes. This also leads to mobilisation of drifts and blow-outs.



- **Disruption of offshore sediment transport patterns:** The establishment of infrastructure such as ports, marinas and groynes impedes longshore drift and inshore sediment dynamics. This impacts negatively on the natural processes required to maintain the natural shore profile and may lead to beach regression placing both public and private infrastructure at risk.
- **Disturbance by vehicles, people and pets:** Illegal off-road driving and pets on the beach have negative impacts on sensitive beach fauna (particularly birds and mammals), either by causing death or through disturbance at breeding, feeding and roosting sites.
- **Mining:** Diamond mining on the West Coast, sand mining, and mining for rare earths from dunes and the intertidal zone, causes severe disturbance and the removal of vast quantities of sand. This, in turn, can give rise to the type of 'downstream' disturbances that are often associated with coastal property development. Sand mining in rivers also impacts on coastal ecosystems, as the sediments that are removed from the rivers should naturally be transferred to the coastal environment to contribute to beach accretion.
- **Altered erosion patterns:** The natural cycle of erosion that maintains shore profiles is being increasingly disrupted by the hardening of adjacent shorelines (land reclamation, road construction), dune stabilisation (particularly headland bypass dune fields) and the construction of breakwaters and groynes.
- **Harvesting of drift kelp:** Kelp drifts that wash up on the beach play a role in mitigating coastal erosion, as the kelp traps wind-blown sand, thus elevating the beach profile and initiating the formation of embryo dunes. Harvesting of the drift kelp disrupts dune formation and deprives beach fauna of an essential food source, thus disrupting food webs and nutrient cycles.
- **Climate change:** The natural process of coastal erosion is expected to be accelerated by rising sea levels and the increased frequency and intensity of storms resulting from global climate change. These impacts will be compounded by inadequate planning (such as a lack of adherence to coastal management lines) and loss of primary and foredunes. Shifting wind regimes (i.e. increasing duration and intensity of south easterly winds) are expected to have a significant impact, especially in terms of wind-driven wave chop on the False Bay coastline.

What are the non-negotiables?

- No construction (or other unnatural disturbance) should be allowed in sand movement corridors, on foredunes or in mobile dunefields. All infrastructure should be placed inland of the secondary dunes, within the coastal management lines determined by DEA&DP or the Municipality, or contained in any current Coastal Management Plans, strictly applied.
- Ideally, mobile dune systems should not be stabilised. However, there are some mobile systems that have had to be stabilised (e.g. at Table View), and these systems need to be managed on an ongoing basis.
- The use of off-road vehicles (ORVs) on beaches should be strictly regulated, including a strictly-enforced ban (that includes management vehicles) on driving in dune systems and above the high water mark on beaches.
- Access to the beach should be regulated by establishing designated access points.
- All mined-out and historically-mined areas should be rehabilitated. All mining companies should have adequately resourced, detailed rehabilitation plans.
- Kelp on the beach should not be removed and must be left in its natural configuration.
- Stormwater and drainage systems for any hard surface abutting the littoral active zone must be maintained at all times.



What are the best spatial approaches (at a landscape scale) to avoid or minimise impacts and risk in these ecosystems?

- Locate infrastructure and buildings so as to avoid damage from coastal processes and, where possible, to avoid the need for physical defences against potential damage resulting from natural coastal processes.
- Municipal planning decisions should include phased retreat of infrastructure along the coast, where possible.
- Permanent infrastructure should not be installed on sandy beaches, close to river mouths or in dynamic or mobile dune systems.
- Coastal management lines⁴, (previously called 'development setback lines'), must be rigorously enforced along the entire coastline. Coastal management lines influence how and where development may proceed and how existing infrastructure should be maintained. The delineation of coastal management lines must be carried out in full alignment with the provisions of the National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008, as amended by Act 36 of 2014), the NEMA: Environmental Impact Assessment Regulations (Act 107 of 1998 amended in 2014), the *Western Cape Provincial Coastal Management Plan* (in draft form at the time of writing these *Guidelines*) and the current edition of the *Western Cape Provincial Spatial Development Framework* as well as Municipal Coastal Management Programmes.

⁴ The Western Cape Department of Environmental Affairs and Development Planning is currently engaged in a project to develop coastal management lines (with an associated implementation strategy) for the entire Western Cape coastline, by reviewing and updating the draft coastal management lines that were developed for the Overberg and West Coast District Municipalities in 2010 and 2011/12. These coastal management lines will influence how existing infrastructure along the coast is maintained and how and where new development can proceed.



- From an ecological perspective, the delineation of coastal management lines needs to take into account, as a minimum:
 - the need to protect infrastructure from coastal processes by allowing for: absorption of the impacts of severe storm sequences, shoreline movement, global sea level rise and increased storm surges, the fluctuation of natural coastal processes, and any combination of these factors.
 - the ecological requirements for maintaining biodiversity pattern (especially in strandveld ecosystems) and ecosystem processes, in combination with factors such as biodiversity and ecosystem requirements, landscape, seascape, visual amenity, indigenous and cultural heritage, public access, recreation, and safety to lives and property.
 - the need to treat the coast as an indivisible system.
 - the need to establish and maintain a buffer of contiguous indigenous vegetation between the inland boundary of the youngest fixed dune trough and the seaward boundary of any impacting land-use activity (the exact set-back will depend on the biophysical characteristics and requirements of the area, and the type and scale of the infrastructural development).

The determination of coastal management lines also needs to take into account socio-economic elements, as it is this dimension that ultimately has an impact on these natural systems and, therefore, is an aspect that needs to be carefully managed. For more information in this regard, practitioners are referred to: Colenbrander, D.R and Sowman, M.R. 2015. Merging Socioeconomic Imperatives with geospatial Data: A Non-negotiable for Coastal Management in South Africa. *Coastal Management* 43 (3): 270–300. (Available online at <http://dx.doi.org/10.1080/08920753.2015.1030321>).

- Ideally, avoid placing any infrastructure below the high water mark, but, where this is unavoidable, adhere rigorously to the precautionary principle and ensure elements of flexibility are drawn into the design of the structure.

- Prohibit all driving on sandy beaches above the high water mark or in dune systems. The ban on driving should be maintained at popular bathing beaches, on beaches that support important breeding, feeding or roosting sites for shorebirds, and in the coastal zone of coastal protected areas (except on already-proclaimed roads).

What are the critical things to maintain for biodiversity to persist?

- Maintain pathways for natural dune migrations, including seasonal cycles of sediment deposition (summer) and erosion (winter), by:
 - avoiding the construction of any infrastructure that may impede or obstruct the natural mobility of dune systems.
 - maintaining unimpeded sand mobility corridors (including headland-bypass dunes).
 - restoring sand migration pathways that are infested with invasive species such as rooikrans.
- Maintain indigenous vegetation structure and successional dynamics (including that of the primary and foredunes, and in dune slacks).
- Retain a functional corridor of intact indigenous vegetation along the coast to link inland-trending river systems. This is crucial for facilitating the migration and dispersal of plants and fauna.
- Maintain decomposition processes at the high water mark and on the backshore by prohibiting the removal of drift kelp and other organic material, except at popular bathing beaches.
- Minimise disturbance at the breeding, feeding and roosting sites of shore birds by people and dogs.



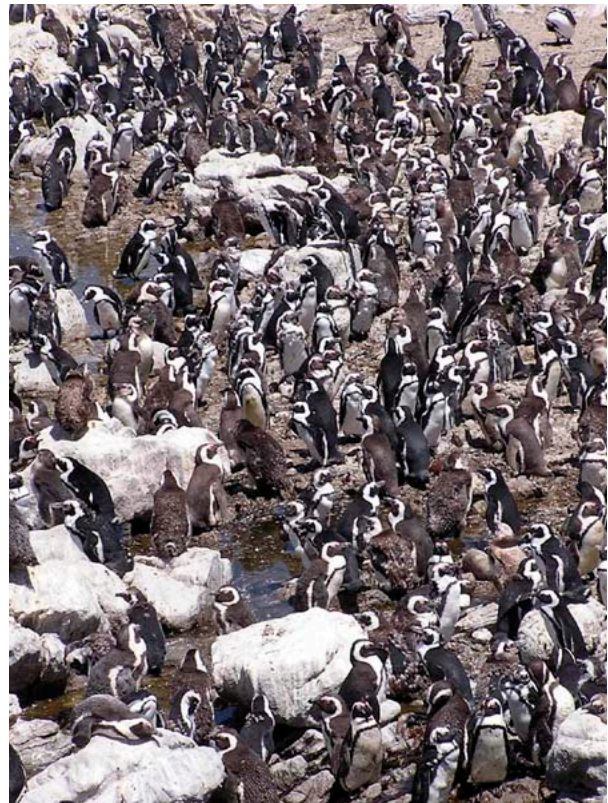
What indicators should be used to assess and monitor ecosystem health?

The type of monitoring and number of indicators required will depend upon the nature of the proposed land use and the characteristics of the particular beach. Either baseline conditions will need to be determined as part of the assessment, or a reference beach should be used to indicate desirable benchmarks for each appropriate indicator, as determined by a coastal expert. The types of indicators should include, though may not be limited to:

- Shoreline profiles (long-shore and cross-shore profiles) and beach width.
- Sediment grain size (the extent to which this resembles the natural grain size at any particular location along the coast, when compared to relevant benchmarks).
- Species composition and abundance of intertidal beach macrofauna (to be assessed by a specialist, with any loss of species or reduction in abundance taken as an indicator of declining ecosystem health).
- Species composition and abundance of shore birds, as assessed by a specialist.
- Breeding success (measured as number of hatchlings fledged per annum) of shore birds.
- Density and extent of indigenous and alien dune vegetation cover, with a low density of invasive alien vegetation indicative of healthy ecosystems.

How reversible are impacts within a period of 5 to 10 years?

- In the case of disturbance that does not result in fixed infrastructure or that does not result in permanent changes to sand transport processes, a 60–80% recovery can be expected for most sandy beach and dune habitats within 5 years, and a 90–100% recovery within 10 years (with the exception of sand forest communities).
- Rehabilitation of eroded areas as a result of destruction of vegetation can be expensive. Recovery is slow as vegetation must go through several successional phases to reach maturity. In most cases, recovery to the climax phase will take at least 10 years or longer.
- Damage is irreversible if coastal environments are destroyed as a result of land-use activities or if sand transport corridors are permanently impeded or obstructed.



What are acceptable compensation measures or offsets for biodiversity loss?

There are no acceptable compensation measures or offsets for biodiversity loss in these ecosystems.



COASTAL ECOSYSTEMS: Strandveld

Contributors: Nick Helme and Tony Rebelo

Snapshot of Strandveld Ecosystems

(Note: In the first edition of the 'Guidelines', strandveld was grouped with dune fynbos and dune thicket. In the latest classification of vegetation types in South Africa, dune fynbos is treated as a type of strandveld, and dune thicket as a type of forest, and it is for this reason that dune fynbos and dune thicket are not grouped with strandveld ecosystems in these revised 'Guidelines').

Strandveld, which is made up of a mixture of fynbos, succulent karoo and thicket elements, occurs in a narrow strip extending along the Western Cape coast from the Olifants River estuary to as far east as Knysna. True strandveld is located mostly along the west coast, whilst along the southern and eastern parts of the coastline, strandveld tends to be dominated by thicket communities.

General characteristics

- A generally succulent shrubland occurring on deep, well-drained, calcareous, alkaline sands in scattered patches along the coastline from the Olifants River estuary, as far east as about Knysna on the south-eastern coast. The greatest concentration of strandveld occurs in the area north of Melkbosstrand, followed by the Cape Flats north of False Bay, with smaller enclaves in the vicinity of Cape Agulhas and eastwards.





- Strandveld is characterised by sparse to moderate plant cover, in which there is a post-fire fynbos element, and succulent karoo elements on the west coast, and thicket elements on the south coast. Growth forms include restios, succulent shrubs, dwarf shrubs and trees (such as *kershout* or *sea gwarrie*), interspersed with scattered annuals and bulbs.
- Strandveld does not burn regularly because of the succulent character of the plants and the dune topography of the landscape.
- Denser, taller strandveld was formerly known as dune thicket, but in the latest classification of vegetation types it is regarded as a type of forest (Southern Coastal Forest) and should be managed accordingly.
- Strandveld endemics occur particularly on specialised substrates (such as mineral-rich deposits) and many of the endemics are range-restricted.

Conservation, land-use pressures and risks

- Strandveld includes 10 vegetation types of which 3 are Endangered, 1 is Vulnerable, and 6 are Least Threatened. Two are well protected, 2 are moderately protected, 4 are poorly protected and 2 are not protected. In total, 74% of the historical strandveld vegetation extent remains intact.
- Very little strandveld is formally protected and all of it faces high risk of modification as a result of sand-mining, mining for minerals (diamonds and heavy-metals such as titanium), conversion of habitat for farming or coastal resort development, over utilisation of groundwater, invasion by alien vegetation and altered fire cycles.



What are the key ecological ‘drivers’ that maintain ecosystem function, pattern or structure?

- **Variation in soil type:** Strandveld vegetation types typically occur in sandy soils, ranging from coastal calcareous sands to inland neutral and acidic sands. Changes in soil type are usually correlated with distance from the sea. Variations in soil depth, moisture-holding capacity, rockiness, and mineral composition are important features correlated with micro-variation in these vegetation types (for example, some of the more localised Namaqualand forms of strandveld occur on sands rich in heavy minerals such as titanium and ilmenite).
- **Rainfall:** Variations in the amount and seasonality of rainfall between the western and southern/south-eastern Cape affect the distribution of different vegetation types, species richness, plant growth rates and flowering patterns, with the following key trends:
 - In the West Coast region, total rainfall is low (< 300 mm, decreasing to < 150 mm per annum in Namaqualand) and occurs predominantly in winter. Altitudinal gradients in rainfall are largely absent. Rainfall is supplemented by heavy fogs, especially in autumn and spring. As a result, plant flowering and growth is highly seasonal, with the vegetation mostly dormant from November to April. The further north the location, the more arid it is, with fewer species. Northern strandveld communities tend to be more similar to Succulent Karoo, and can be managed as such.
 - In the southern and south-eastern Cape, rainfall is higher than on the West Coast, ranging from 400 mm–900 mm per annum between Cape Agulhas and Cape St Francis. The occurrence of thicket is associated with the Spring-dominant bimodal rainfall pattern. Due to vigorous growth associated with the rainfall patterns, climax thicket can take on the proportions of forest in sheltered, fire-protected locations. These strandveld communities tend to be more similar to Albany Thicket, which is largely absent in the Western Cape, and many aspects of forest management apply in these areas.
- **Dispersal of berries and seed by frugivorous bird species:** Strandveld and thicket has the highest proportion of fruit-producing plants of any vegetation type in the Fynbos Biome, and high bird and animal densities are important for maintaining pollination and seed dispersal.
- **Fire:** In the more arid West Coast regions, fire is hardly ever a key driver of ecosystem function or structure, as fuel loads are too low to carry significant fires. In more mesic coastal environments, fire plays an important role in maintaining dune fynbos-thicket mosaics. In these mosaics, thicket occupies the fire-protected sites (such as calcrete outcrops or the northern base of dunes), whereas the more fire-prone (and often wetter) locations have



an early stage of fynbos maturing to thicket. In older veld there may be no sign of these fynbos elements. In the past, the impact of large herbivores, in combination with fire, probably also played a role in maintaining these thicket-fynbos mosaics.

- **Drainage patterns:** Drainage of water is an important driver of vegetation structure and composition in strandveld and thicket ecosystems, with dune slack wetlands contributing significantly to overall diversity of the ecosystem.
- **Corridors for faunal movement:** Strandveld and thicket often serves as an important corridor facilitating the movement of fauna (birds and mammals) along the coastal strip. In the southern Cape, thicket in many instances provides the only remaining natural connectivity between inland-trending Valley Thicket remnants.

What are the key pressures and threats in these ecosystems?

- **Mining:** Along the West Coast and Namaqualand regions, mining for heavy mineral sands and diamonds, which is restricted mostly to within 2 kms of the coast, represents the greatest threat to strandveld ecosystems. Although there is a relatively low diversity of endemics and rare species on the West Coast, the rare species that are present tend to be concentrated in specific habitats (often in rocky areas), hence their vulnerability to mining and quarrying.
- **Large-scale habitat conversion for farming activities:** In the Sandveld region of the West Coast, large-scale loss of natural habitat for conversion to agricultural use (for cultivation of crops such as potatoes, rooibos and onions) poses a serious risk to strandveld habitats.
- **Over-utilisation of groundwater:** Large-scale expansion and intensification of agricultural land uses has also led to over-utilisation of groundwater in the Sandveld region. Wetland areas are especially sensitive to lowered water tables, hence their vulnerability to over-utilisation of aquifers (see the chapter on Inland Aquatic Ecosystems for more information).
- **Infestation by invasive alien species:** In strandveld ecosystems, infestation by old man saltbush (*Atriplex* spp.) presents a problem, but otherwise, infestation by invasive alien species does not pose much risk. However, in the southern and eastern coastal areas, thicket is vulnerable to invasion by woody alien plant species (such as rooikrans, *Acacia cyclops*), especially in areas where the natural habitat has been disturbed.
- **Altered fire cycles:** Strandveld and thicket vegetation types are vulnerable to altered natural fire regimes, especially fire frequency. On the other hand, the absence of fire disrupts fynbos-thicket mosaics, with fynbos elements becoming senescent and prone to colonisation by thicket vegetation. Where invasive alien vegetation is present, the impact of disrupted natural fire cycles is worsened.
- **Resort and urban development:** Coastal habitats are under increasing pressure from the multiple impacts associated with urbanisation and the establishment of resorts. In addition to causing habitat loss or fragmentation, urban land uses have many associated impacts including increased fires, dumping of litter and waste and trampling. Off-road driving is also a problem in certain areas. Strandveld and thicket habitats close to settlements are vulnerable to hunting, with the result that very few game species, such as porcupine or antelope, are left in such areas. Strandveld is under particular pressure from urbanisation in the area extending southwards from Lamberts Bay towards Cape Town. Strandveld and thicket are amongst the vegetation types most heavily impacted by rapidly expanding coastal developments, and the ecosystem threat status of these vegetation types will have to be revised regularly as urban development proceeds apace.
- **Habitat fragmentation:** Thicket in the southern and south-eastern coastal regions usually supports high densities of small animals and birds, although few rare or localised plant species. Intact thicket provides important corridors for movement of animal species. Migration corridors of certain bird species become disrupted when thicket elements in strandveld are lost, or when the connective matrix of non-thicket vegetation is heavily or irreversibly modified from the natural condition. Coastal dune systems are also vulnerable to blowouts when the vegetation cover is disturbed.



What are the non-negotiables?

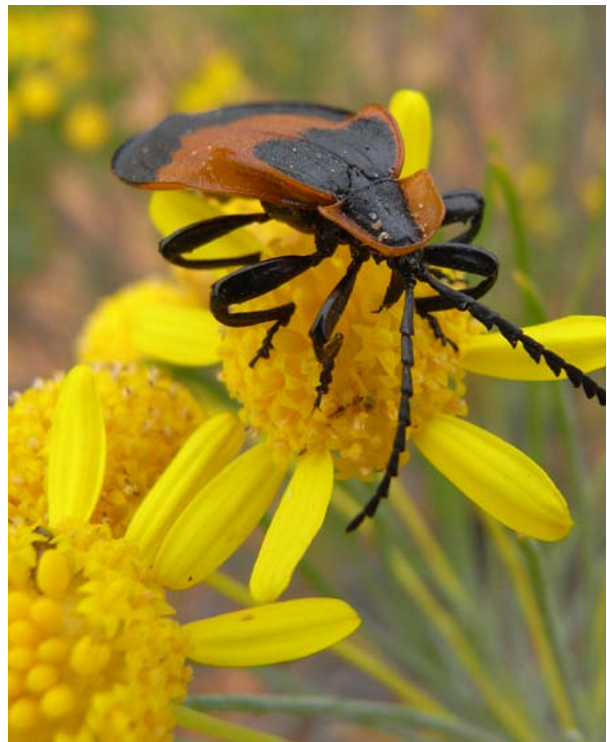
- Keep coastal/inland (west-east) gradients intact in the West Coast and Namaqualand regions.
- Retain at least 80% of the remaining strandveld in a natural or near-natural condition in the south-western areas (Cape Town-Lamberts Bay), and conserve all special habitats (such as unique mineral-rich dunes, *Odyssea*-dominated grasslands and rocky outcrops).
- Do not allow further loss of good quality examples of the endemic-rich Saldanha Limestone and Saldanha Granite Strandveld vegetation types.
- Physical disturbance and fires should be kept to the minimum in strandveld, as, due to its aridity, strandveld has a slow recovery rate.
- As a general rule, connectivity must be maintained and fragmentation of habitat actively avoided. This is particularly relevant in thicket. Remnants can be very small and remain fairly viable, because many of the plants are re-sprouters and they can persist for centuries without pollinators. However, if vegetation patches do not have good connectivity (within a few hundred metres) they will be able to support far fewer mammals and birds (although birds, being able to fly, are more affected by patch size than by patch isolation).
- Rehabilitation should not use invasive alien species such as rye grass as cover crops.





What are the best spatial approaches (at a landscape scale) to avoid or minimise impacts and risk in these ecosystems?

- In the West Coast and Namaqualand regions, exclude all rocky outcrops and coastal dunes from the development footprint of any impacting land use (this has important implications for quarrying and mining). Ideally, corridors of natural habitat at least 200m wide should be kept intact along north-south as well as coast-inland gradients. This can mean retaining corridors of natural habitat between or even within large mining developments.
- In general, avoid impacting on any wetland area, riverine fringes or estuarine systems (these are particularly important).
- In thicket, retain corridors of intact natural vegetation (at least 50 m wide) to allow for movement of birds and animals between areas of undisturbed or contiguous habitat. Standard ecological (i.e. for flora as well as fauna) corridors should ideally be at least 200m wide in these systems. Unbroken, linear development is not appropriate in these systems.
- Avoid land uses that sever linkages between inland-trending Mainland (Valley) Thicket types and thicket along the coast, especially in the southern Cape.



What are the critical things to maintain for biodiversity to persist?

- Maintain habitat connectivity and minimise disturbance, by establishing ecological corridors that are at least 200m wide. In areas of exposed granite and limestone, no disturbance or loss of connectivity between patches is appropriate.
- Manage fire. As a general rule, fire must be kept out of strandveld and thicket. However, fires at intervals of about 100 years are natural except in the denser thicket patches. (Consult Esler *et al.*, 2014, for more detailed guidelines).
- Avoid and manage infestation by invasive alien species. Strandveld and thicket is prone to invasion by rooikrans (*Acacia cyclops*), and land managers need to ensure that areas are kept free of invasive alien vegetation. Woody invasive plants also increase the fuel load, resulting in more intense burns and, therefore, increased risk to the survival of indigenous seed banks.
- Maintain populations of small animals, birds and predators (such as raptors, caracal and genets). Birds and small animals should be present as they are important for seed dispersal. Predators are important for controlling fauna such as dassies, rodents and termites.



What indicators should be used to assess and monitor ecosystem health?

Healthy strandveld and thicket ecosystems are characterised by:

- The presence of healthy populations of rare and endemic plant species that appear to be reproducing. These populations would need to be identified by a plant specialist.
- The presence of a diversity of habitat types and intact soil crusts and lichens as identified by a specialist.
- No loss of species diverse or habitat types (also to be assessed by a specialist).
- Functioning wetland ecosystems and dune slack wetlands, especially where these have high species diversity (note that wetlands dominated by bulrush '*Typha capensis*' usually are degraded as a result of eutrophication).
- The presence of indigenous fauna such as caracal, aardvark, mongoose, genets, porcupines and small antelope, and the presence and number of birds (frugivores and nectarivores in particular).
- The presence of intact natural vegetation, with associated understorey (often herbs), creepers, grasses, and thicket (shrubby, spinescent and small tree) elements, as assessed by a specialist.

- The absence of invasive alien plants, or a low density of invasive alien species. (Note: if invasive alien species are present, it does not mean that the habitat is of lesser conservation value, as strandveld restores well following clearance of invasive alien species. However, factors such as the extent of disturbance, the size of the habitat remnant and surrounding land use should all be taken into consideration).

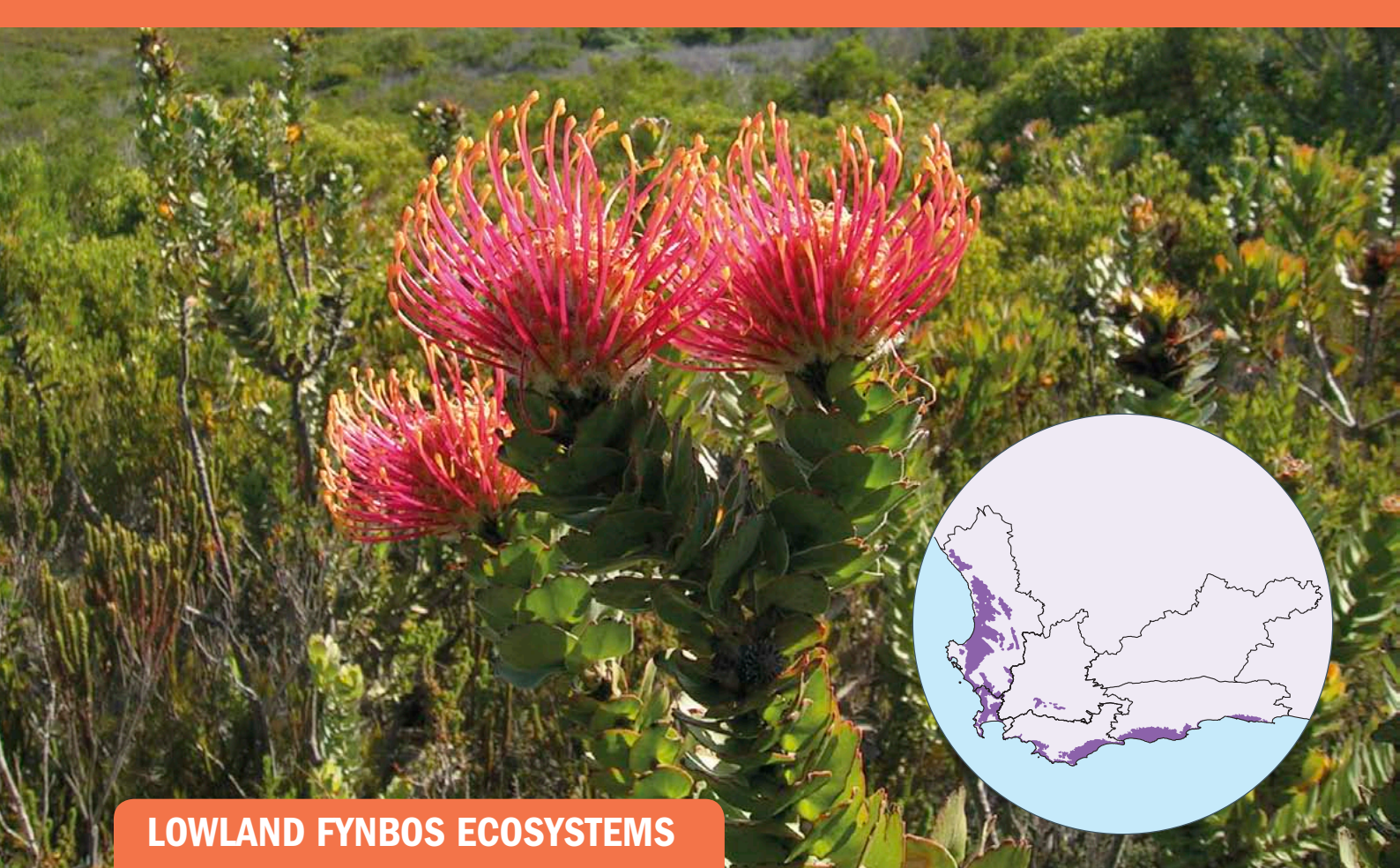
How reversible are impacts over a period of 5–10 years?

- Ploughed lands are unlikely to be restored within 5–10 years. In the more arid West Coast and in Namaqualand Strandveld, disturbances to the soil will normally take decades to recover, if ever. Recovery from fire and other disturbance is generally much slower in the drier, more seasonal West Coast areas.
- Rehabilitation of mine tailings and excavations in arid areas is more successful if rehabilitated areas are irrigated with freshwater during the rainy season for at least two years, especially in years when rainfall is lower than average. It should be noted, though, that saltwater irrigation is not conducive to recovery of diversity.
- Strandveld and thicket may be quick to reappear after disturbance such as fire or even bush-cutting, especially in areas with bimodal or higher rainfall east of Cape Town. However, if burnt too regularly (e.g. as occurs in parts of the Cape Flats), recovery could be severely compromised, and may take centuries.
- Thicket communities, if burnt at appropriate intervals, or bush-cut, will recover well, by resprouting within five years. But if it has been bulldozed and underground rootstocks have been destroyed, thicket will take centuries to recover to its pre-disturbance state. Although some of the larger trees, such as 'seeghwarrie' (*Euclea racemosa*) and milkwood (*Sideroxylon inerme*) are capable of resprouting, they may be killed by hot fires associated with dense stands of invasive alien species such as rooikrans.
- Areas of exposed granite or limestone are not likely to rehabilitate after disturbance within 10 or even 20 years.

What are acceptable compensation measures or offsets for biodiversity loss?

- Impacts should be completely avoided in certain rare and threatened habitats along the West Coast (as identified in the most recent fine-scale biodiversity plan, or by a specialist as part of the environmental impact assessment process). These areas include, amongst others, the titanium-rich dunes, the northern-most outliers of Sand Fynbos in the far north and parts of the north-western Sandveld, and the best patches of Saldanha Limestone Strandveld and Saldanha Granite Strandveld. Where impacts in these habitats cannot be avoided by application of standard mitigation measures, their loss must be off-set by the establishment of protected areas that include these habitat types elsewhere.
- Woody invasive alien plants must be cleared – both in and around densely invaded areas – with clearance being prioritised in threatened ecosystems and ecological corridors. (Detailed guidelines for managing invasive alien species in these ecosystems are provided in Esler *et al.*, 2014).
- A proposed mitigation measure for loss of habitat is to restore corridors of natural habitat between remnants of thicket and fynbos and along the major biogeographical axes, which are usually coastal–inland and parallel to coast, especially where thicket connects inland-trending Southern Cape Valley Thicket.
- As a general rule, offsets should only be pursued when irreversible loss of habitat or ecosystem function cannot be avoided in threatened ecosystems.





LOWLAND FYNBOS ECOSYSTEMS

Incorporating Sand Fynbos and Limestone Fynbos

Contributors: Nick Helme, Pat Holmes and Tony Rebelo

Snapshot of Lowland Fynbos Ecosystems in the Western Cape

Lowland fynbos is restricted to the plains lying between the coast and the foothills of the mountains, throughout the Western Cape. (It also extends into the Eastern Cape, as far as Port Elizabeth, and into the Northern Cape as far as Kommagas).

General characteristics

- Comprises some 13 vegetation types divided into two main types that occur in a mosaic on different soils, as follows: **sand fynbos** grows on acidic, sandy soils between the Olifants River in the north-west and Knysna on the south-eastern coast; and **limestone fynbos** occurs on outcrops of limestone rock between Pearly Beach and Mossel Bay in the south-east.
- **Sand fynbos** is characterised by the presence of dense populations of tall restios, ericoid shrubs and many proteas, interspersed with patches of annual plant species. Ericas are uncommon, especially in drier areas.
- **Limestone fynbos** is restricted to rocky limestone outcrops of the Bredasdorp geological formation. It is characterised by many proteoid elements and shrubs of the plant families Rutaceae, Fabaceae, Polygalaceae and Ericaceae.
- Both sand and limestone fynbos are characterised by high levels of species richness, rarity and endemism. The concentration of rare and endemic species is highest in the southern parts of the distribution.
- Lowland fynbos occurs in areas where rainfall varies from about 250 mm per annum (western coastal lowlands), to 800 mm per annum (in the Garden Route in the south-east). Average rainfall is in the order of 400–500 mm per annum. West of Cape Agulhas, rainfall is concentrated in the winter months, but to the east a significant amount of rain also falls in spring and autumn.
- Variations in soil type are a key driver of biodiversity patterns in lowland fynbos. Both the acidic soils of sand fynbos, and the limestone substrates on which limestone fynbos occurs, are nutrient poor.



Conservation, land-use pressures and risks

- Outside of protected areas, such as the De Hoop Nature Reserve, lowland fynbos persists mainly in fragmented patches and many of the rare, endemic and threatened species in these habitats are under-protected. Four lowland fynbos vegetation types are Critically Endangered, 2 are Endangered and 4 are Vulnerable, with 3 having Least Threatened status. None of these are well-protected, 3 are moderately protected, 19 are poorly protected and 6 unprotected. Overall, a little over 58% remains of the historical extent of lowland fynbos, but for some vegetation types (e.g. Cape Flats Sand Fynbos) less than half the area required to meet the national target remains.
- Agricultural expansion, development of coastal resorts, invasion by alien species, inappropriate burning and uncontrolled wild-flower picking place these ecosystems at high risk of degradation or being lost altogether.
- From a socio-economic perspective, these ecosystems also are important, for example sand fynbos in the southern Cape supports dense stands of reeds that are used for thatching ('dekriet', *Thamnochortus insignis*).



What are the key ecological ‘drivers’ maintaining ecosystem function, pattern and structure?

Limestone fynbos and sand fynbos usually occur in a matrix, and the effects of ecological processes on the one may be closely inter-related with effects on the other. Some of the key ecological drivers in these systems include:

- **Fire:** Fire frequency must allow for sufficient seed-set in slow-maturing species such as the Proteaceae – this can be between eight years (in wetter areas) and up to 30 years (in arid areas). The appropriate seasonal fire regime must be retained with fires occurring in summer to early autumn (December to March). Under natural regimes, fires are slow moving, ignition is extremely rare (most fires start ‘elsewhere’) and fires burn unimpeded over large areas with the end boundaries of the fires usually being other vegetation types and young veld.
- **Habitat and environmental gradients:** In lowland fynbos ecosystems, there is a high incidence of species turnover along habitat or environmental gradients (i.e. beta diversity is high). Many edaphic gradients are found at the edges of these fynbos communities, and subtle edaphic variations, such as the depth of overlying sand, have a dramatic effect on plant community structure. There are also substantial, unexplained variations in species richness and concentration of rare and endemic plants from area to area in these vegetation types. It is known that patch size and connectivity between limestone outcrops may be important to retain certain species.
- **Regional and local natural water drainage patterns:** These are important drivers of biodiversity pattern, and seasonal wetlands and seeps are important for retaining certain distinctive plant communities.
- **Natural grazing and physical soil disturbance:** Limited natural grazing, and soil disturbance caused by animals, may be important for retaining a high incidence of spring annuals in lowland fynbos (this is not usually the case in fynbos vegetation types).

What are the main pressures and threats in these ecosystems?

- **Local-scale habitat loss especially for rare, localised and endemic species:** There is a high incidence of rare and regionally endemic plant species in lowland fynbos — many of these species are highly localised within what might appear to be fairly homogenous habitat. In sand fynbos vegetation types, the incidence of rare and endemic plant species is particularly high in the south. Habitats with a high incidence of rare and endemic species are particularly vulnerable to impacts at the local scale and habitat loss at any one particular site can lead to the loss of these species.
- **A high-incidence of vulnerable species and habitats:** Both limestone and sand fynbos vegetation types are particularly vulnerable to changes in the natural fire regime (to promote grazing, for example) and infestation by invasive alien plants. They are also at risk from veld clearance and ploughing, over-harvesting of species (flowers and whole plants), and changes in water availability caused by abstraction of groundwater. Particularly



vulnerable habitats include wetlands, depressions and areas of elevated soil moisture – these habitats are at greater risk due to their high agricultural potential.

- **Invasive alien species:** Limestone fynbos is highly susceptible to invasion by rooikrans (*Acacia cyclops*), especially on the deeper sands in valleys between rocky outcrops. However, in areas of severe infestation, even the rocky pavements in these ecosystems are affected. Sand fynbos is also susceptible to invasion by Port Jackson willow (*Acacia saligna*), species of gum (*Eucalyptus*), the Australian myrtle (*Leptospermum laevigatum*), and some annual grasses (such as *Avena* and *Briza* species).
- **Habitat conversion for cultivation:** Veld clearance for cultivation of rooibos tea and potatoes is particularly prevalent in Leipoldtville Sand Fynbos and in parts of the Sandveld. The establishment of monocultures of indigenous species (such as rooibos, honeybush tea, buchu and protea orchards) causes large-scale loss of natural habitat, placing lowland fynbos vegetation types at high risk.
- **Other impacts associated with agriculture:** Expansion of agricultural activities in sand fynbos and the Sandveld, places lowland ecosystems under additional pressure due to excessive groundwater abstraction. Other potential impacts associated with agriculture include aeolian soil erosion in ploughed areas and changes in soil nutrient status due to enrichment by fertilizer run-off. Nutrient-enriched run-off can also cause contamination of aquifers.
- **The establishment and expansion of urban areas, resorts and small-holdings:** This type of land use is a major cause of habitat loss between Atlantis, Hopefield, Cape Town and the Overberg coast. Sand fynbos and limestone fynbos are also under increasing pressure from resort development and urban expansion in the Gourits-Mossel Bay region.

What are the non-negotiables?

- Areas should be treated as 'no-go' for any kind of land use or development if they are important corridors, represent important vegetation boundaries or support rare and threatened species.
- Avoid loss or fragmentation of lowland fynbos. Little information is available on minimum viable patch sizes and the degree of connectivity required to retain species richness, but small remnants (< 100 ha) are likely to be more vulnerable to loss of species due to altered ecological processes, such as loss of pollinators, changes in fire frequency and edge effects (which encourage infestation by invasive alien species).
- In sand fynbos, avoid nutrient enrichment (caused, for example, by fertilizer run-off) or infestation by invasive alien legume species, as these vegetation types are especially vulnerable to these impacts. Nutrient enrichment promotes infestation by competitive annual grass species (indigenous and alien), resulting in an altered ecological equilibrium that excludes most fynbos species. It is not known if sand fynbos systems that have been disturbed in this way can easily be restored.
- Maintain seed banks. Lowland fynbos seed banks are less persistent than those of mountain fynbos. This results in a rapid change in community structure following disturbance caused by agricultural activities or infestation by invasive alien species. Post-disturbance recovery is slow and dependent on there being suitable seed sources nearby (hence the importance of maintaining connectivity between these vegetation types).
- Conserve habitats of threatened species. 'Hotspots' for rare species (as per the Red List) and threatened ecosystems should be identified through a detailed botanical survey and incorporated into conservation areas. In particular, the habitats of Critically Endangered and Endangered species must not be modified by any kind of land use, and these habitats must be incorporated into conservation areas.
- Maintain and monitor biocontrol 'reserves' (of *Acacia cyclops* and *A. saligna*).
- Allow aquifers to recover fully to natural levels during winter, otherwise indigenous woody components of the vegetation will go extinct and only restioid and annual species will survive.
- Carry out environmental assessments in spring when most annuals and bulbs are flowering.

What are the best spatial approaches (at a landscape scale) to avoid or minimize impacts and risk in these ecosystems?

- Avoid fragmentation of lowland fynbos habitat and disturbance at the edges of vegetation patches. This is because lowland fynbos vegetation types are prone to infestation by invasive alien species, the risk of which increases with increased fragmentation and disturbance.
- Avoid locating housing in lowland fynbos habitat (or take measures to minimise impacts when locating housing in lowland fynbos cannot be avoided). In general, the establishment of housing infrastructure is not compatible with conserving lowland fynbos or any other fire-prone vegetation type. However, when housing estates are established in lowland fynbos areas, nodal or clustered development is preferable to a spreading, linear layout, as nodal development is better-suited to allowing periodic burning of the vegetation. To minimise the impacts of housing developments in lowland fynbos, houses should be clustered within a fire-free zone and protected with an appropriate fire belt – this holds the added benefit of minimising potential risk to infrastructure. Firebreaks must be cleared within the development footprint of the housing estate, not in the adjacent veld. Building materials should be fire-resistant, which means that thatched roofs may be inappropriate in houses that are located adjacent to, or in, natural fynbos areas, such as occurs parts of the Cape Peninsula or the Overberg coast.
- Avoid locating any further land uses in wetlands (pans, vleis, marshes, riverine areas, drainage lines) and seeps, or on peaty soils. Wetlands must be appropriately buffered and links between wetlands and conservation areas must be maintained through the establishment of suitably managed corridors of natural habitat.
- Incorporate appropriately-orientated corridors of natural habitat in land-use plans to maintain linkages and vegetation community patterns, as follows:
 - take the spatial orientation of lowland fynbos communities into account when identifying representative portions of lowland fynbos to be kept in a natural state. Most vegetation communities within sand and limestone fynbos are orientated parallel to the coast – the exceptions are the riparian communities which are orientated perpendicular to the coast.
 - establish corridors of natural vegetation that are perpendicular to the long axis of sand-filled depressions, in order to mitigate against the loss of sand fynbos within limestone fynbos areas.
 - corridors in strip-ploughed sand fynbos should be at least 300 m wide.
- Do not allow any further disturbance in areas that include Leipoldville, Atlantis, Cape Flats and Hangklip Sand Fynbos.
- Protect from physical disturbance (such as trampling) any remnants of limestone fynbos that occur within residential areas, as these vegetation types are slow-growing and vulnerable to the effects such disturbance.

What are the critical things to maintain for biodiversity to persist?

- Maintain the appropriate fire regime and prevent overgrazing, infestation by invasive alien plant species and over-abstraction of groundwater in these ecosystems.
- Avoid any kind of impacting land use in habitat associated with Critically Endangered and Endangered ecosystems or species, particularly in corridors and at boundaries between vegetation types.
- Maintain ecotones that incorporate edaphic boundaries, such as the interfaces between limestone and sandstone or limestone and shale-derived soils.

What indicators should be used to monitor ecosystem health?

- The density of invasive alien species, assessed using percentage canopy cover or stem density (per m²) – although the density of invasive alien vegetation is best assessed alongside indigenous vegetation canopy cover. In healthy

ecosystems there should be no dense stands of invasive alien species, isolated plants of invasive species should be controlled, and biocontrols should be present.

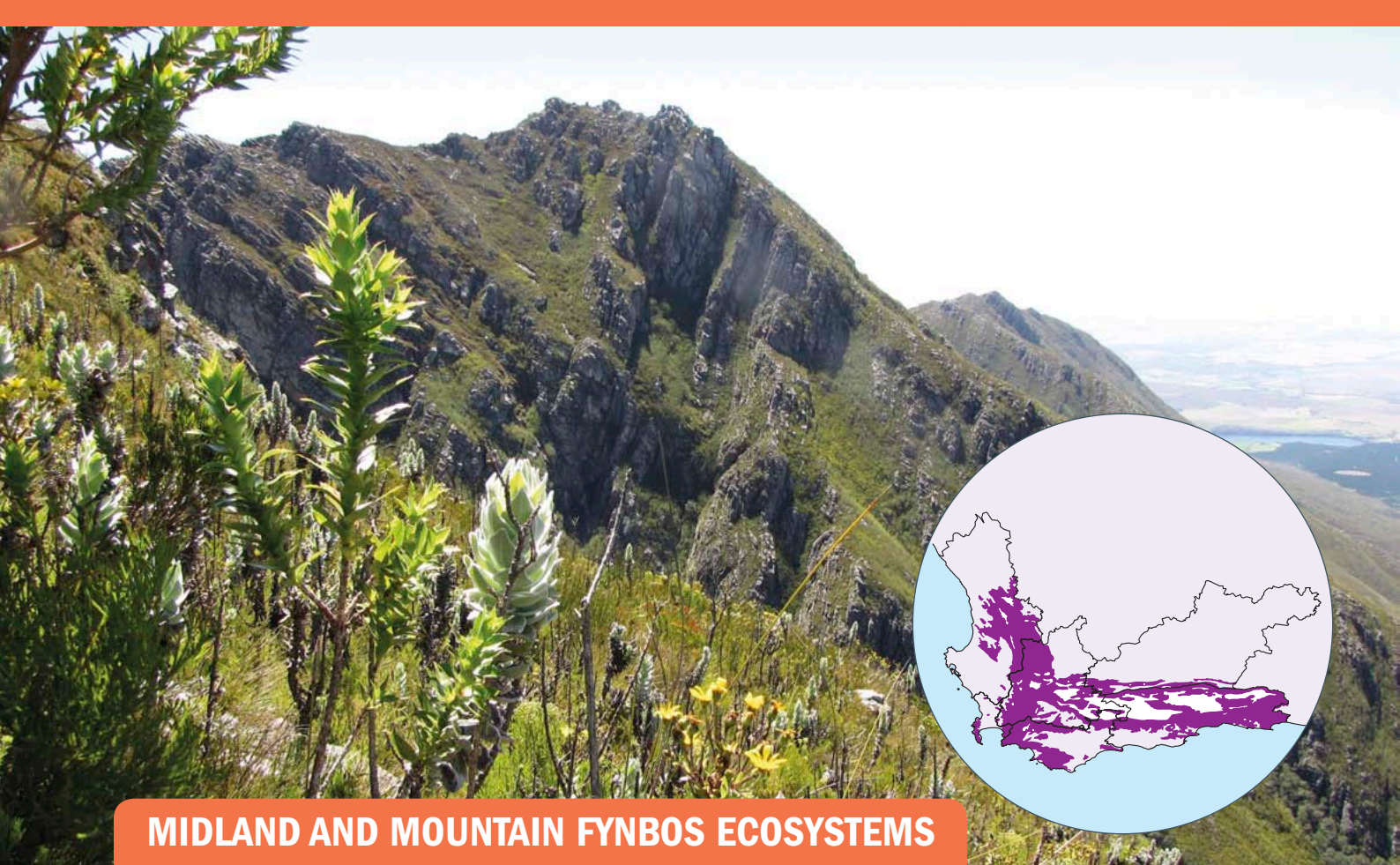
- The indigenous plant cover (its type, age and ecological condition), species richness, and the presence of key guilds of species (such as serotinous shrubs that only release their seeds in response to an environmental trigger such as fire; or woody, perennial shrubs, and winter annuals). This should be assessed by a specialist.
- The abundance and distribution of populations of threatened species and others of conservation concern (consult the Red List of South African Plants – Raimondo *et al.*, 2009, and its annual online updates) should be at least maintained, or improving.
- Signs that appropriate fire regimes are being applied (as assessed by a specialist). For example, senescence of indigenous vegetation in strip-ploughed lands can indicate that burns are too infrequent, and invasion by grasses and weedy species such as slangbos (*Stoebe* spp.) and *Aspalathus* spp. indicates burns that are too frequent, or unseasonal. The maintenance of natural water tables, especially adequate winter recovery, should be monitored. Ideally monitoring should be carried out by the Department of Water Affairs, with specialist inputs, especially in vulnerable areas such as the Sandveld, and where central pivot irrigation (which can influence water tables in a wider area) is taking place.

How reversible are impacts within a period of 5 to 10 years?

- The impacts of soil disturbance are not easily reversible, and wind erosion and increased nutrient levels may further impede recovery. Soil disturbance must be avoided.
- Recovery after infestation by invasive alien species is determined by the length of time over which the area has been infested, and the fire history within that period. In limestone fynbos that has been densely infested by invasive alien species (i.e. 90% cover), indigenous species may be irreversibly lost after three fire cycles (10–90 years).
- Seed banks in sand fynbos are less persistent than those in sandstone fynbos and it is likely that recovery in these ecosystems will be poor following dense, long-duration (>20 years) infestation by invasive alien vegetation, altered fire regimes, altered groundwater availability and physical disturbance.

What are acceptable compensation measures or offsets for biodiversity loss?

- No compensation measures can remedy the loss of lowland fynbos habitat that supports rare or threatened species or areas that serve as ecological corridors.
- Biodiversity offsets may be appropriate in certain instances, assuming that standard mitigation has identified key areas (see above) as “no go” areas for land-use change or development. Where the disturbance of highly irreplaceable sand fynbos or limestone fynbos cannot be avoided, a similar or larger area of the same vegetation type must be conserved elsewhere as a compensation measure.
- Effective control of invasive alien vegetation (i.e. that leads to a reduction in the extent of invasion) can be a worthwhile mitigation measure.
- Search-and-Rescue is an important measure for minimising negative impacts when land-use activities may result in the irreversible loss of rare or threatened plant populations. However, rehabilitation or translocation of species of conservation concern, cannot be considered as adequate mitigation for loss of pristine habitat or as an acceptable measure to compensate for or offset residual impacts. Where Search and Rescue is to be undertaken, a specialist botanical report must provide recommendations on appropriate rescue techniques and CapeNature should endorse the sites to which these plants are to be translocated. In the case of sites that will be disturbed by the land-use activity but later rehabilitated, search-and-rescue should, as a minimum, concentrate on saving bulbs and succulents. General recommendations for Search and Rescue are provided in Chapter 4, and further advice can be obtained from Cape Nature.



MIDLAND AND MOUNTAIN FYNBOS ECOSYSTEMS

Incorporating Alluvium, Granite, Ferricrete, Conglomerate, Shale, Silcrete and Sandstone Fynbos, and Grassy Fynbos.

Contributors: Nick Helme, Pat Holmes and Tony Rebelo

Snapshot of Midland and Mountain Fynbos Ecosystems

These ecosystems are made up of ericoid, restioid and proteoid elements occurring in the forelands, foothills and uplands of coastal mountain ranges in the Western Cape. They include over 60 different vegetation types that, by area, collectively account for more than half the extent of the Fynbos Biome.

General characteristics

- Midland (or foothill) fynbos occurs at lower altitudes on soils derived from a variety of geological formations including granite, shale, silcrete, ferricrete, conglomerate and alluvium; these substrates tend to produce soils that are richer and more fertile than those in the uplands, resulting in tall, shrubby vegetation. Although all three 'typical' fynbos elements (ericoids, restioids and proteoids) are present, ericas and restios tend to be less abundant than in the uplands. There is a predominance of species from the daisy family (Asteraceae), gorse (Fabaceae) and *Cliffortia* species (Rosaceae), and grasses and geophytes (bulbs) are common after fires. Grassy fynbos is more common on the lower, north-facing mountain slopes that are relatively warm and dry, in the eastern parts of the province. Midland fynbos tends to occur in slightly drier areas than mountain fynbos, and rainfall is in the range of 400–650 mm per annum.
- Mountain fynbos occurs in the uplands of the coastal mountain ranges on acidic, nutrient-poor, sandy soils that are derived from sandstone and quartzite. Distinction can be made between two broad categories of mountain fynbos based on variation in the underlying rock type: **mesic mountain fynbos** – occurs on sandstone, in areas of higher rainfall (400–1 000 mm per annum, or even up to 3 000 mm on some south-western mountain peaks) and **arid mountain fynbos** – on quartzite, in areas of lower rainfall (250–400 mm per annum).



- Midland and mountain fynbos ecosystems exhibit exceptionally high levels of species richness and endemism, with many of the endemics being range-restricted, non-sprouting shrubs with short-distance seed dispersal.

Conservation, land-use pressures and risks

- Of the 63 vegetation types occurring in midland and mountain fynbos, six are Critically Endangered, 6 are Endangered and 12 are Vulnerable, with 39 categorised as Least Threatened. Some 35 vegetation types are well-protected, 3 are moderately protected, 19 are poorly protected and 6 are not protected. A total of just over 83% of these fynbos ecosystems remains relative to their historical extent.
- Inappropriate burning and invasion by alien vegetation represent two of the greatest risks faced by these fynbos ecosystems, followed by ploughing for indigenous crops (such as rooibos tea,) and vineyards, unsustainable wildflower harvesting, inappropriate development on mountain tops and disturbance to the underlying hydrology (e.g. by quarrying). At lower altitudes, on more nutrient-rich soils, many fynbos ecosystems have already been irreversibly modified for the establishment of orchards and vineyards, and expansion of these activities needs to be carefully planned to minimise further loss.



What are the key ecological ‘drivers’ maintaining ecosystem function, pattern or structure?

- **The natural fire regime and the interplay of fire and grazing:** Fire is integral to the persistence of fynbos ecosystems, and occurs naturally during the hot, dry season, i.e. summer or early autumn. In most grassy fynbos-thicket mosaic vegetation types, biodiversity pattern is largely retained by a fine balance between fire and grazing regimes. To retain species richness, appropriate grazer-browser ratios and certain fire regimes must be retained. Fire frequency depends in part on the degree and type of grazing applied. Seasonality of fire can have a noted effect on community structure, with winter and spring fires generally favouring the grass component.
- **Edaphic conditions and underlying lithology:** Species composition and the occurrence of rare species in these ecosystems is determined largely by edaphic conditions, especially factors such as nutrient status, soil depth and water availability. In particular, it should be noted that:
 - in granite fynbos, and the other fynbos types associated with specific lithologies, young veld is characterised by dense stands of pioneer (early seral) plant species. These take 4–8 years to disappear and then are replaced by typical fynbos.
 - due to edaphic and other factors, alluvium fynbos is usually surrounded by other vegetation types, most commonly mountain fynbos vegetation types on the upslope side, and renosterveld downslope.
 - sub-surface drainage is a key determinant of community structure and mosaic patterning in alluvium fynbos. The degree of rockiness (given similar moisture regimes) is also important – rocky sites often support different vegetation communities to those occurring on deep sands.
- **Drainage patterns and soil moisture gradients:** In most midland and mountain fynbos vegetation types, but specifically in alluvium fynbos, localised soil moisture gradients are important determinants of diversity. Seasonal wetlands and seeps exemplify environments where these gradients occur. Deep, well-drained sandy areas support a different flora to that found on poorly-drained sands. Many alluvium fynbos ecosystems occur on alluvial fans where mountain rivers open out onto the flats, or occur on old floodplains with meandering braided streams, such as in the upper Breede River and Slanghoek valleys.

What are the main pressures and threats in these ecosystems?

- **Invasive alien species:** These represent a significant threat to midland and mountain fynbos ecosystems. Without natural enemies to control them, invasive alien species out-compete the indigenous plant species for space, nutrients and light. They also take up more water than naturally-occurring fynbos, leading to reduced water yields and catchment values. The enhanced biomass that results from dense stands of woody invasive alien species increases the severity and temperature of fires which, in turn, can destroy indigenous seed banks and change the physical structure and composition of soil. Fynbos is particularly prone to the spread of invasive alien species after physical disturbance and fire. In particular, it should be noted that:
 - pines and hakeas are the main invasive alien species affecting midland fynbos ecosystems.
 - long-leaved wattle (*Acacia longifolia*) and, locally, poplar (species of *Populus*) invade seeps and gullies in sandstone fynbos habitats.
 - gullies are also vulnerable to infestation by bramble (*Rubus*) in granite, hale, ferricrete, conglomerate and silcrete fynbos ecosystems.
 - species of gum (*Eucalyptus*) can be invasive on slopes in these ecosystems.
 - black wattle (*Acacia mearnsii*) can spread virulently along mountain streams.

In many fynbos vegetation types the introduction of alien animal species such as the Argentine Ant (*Iridomyrmex humilis*) displaces the indigenous dispersal and pollinating agents that are vital for maintaining these ecosystems.



- **Changes in natural burning and grazing regimes:** Altered fire and grazing regimes can be a major problem in midland and mountain fynbos ecosystems, because:
 - veld is either burnt too frequently to promote grass growth for grazing potential, or fire is actively suppressed in fynbos abutting urban or peri-urban areas or small-holdings.
 - reduced fire frequency associated with most land uses means that many patches of fynbos convert to thicket or forest.
 - in farming areas, changes in natural burning and grazing regimes have often altered edaphic conditions and plant community structure to the point that much of the original beta diversity of grassy fynbos has been lost.
 - heavy grazing after fire favours the growth of less palatable species, resulting in displacement of the more vulnerable, palatable species.
- **Large-scale, commercial cultivation:** This places by far the greatest land-use pressure on inland fynbos ecosystems, especially in those vegetation types that occur in wetter or cooler areas, because it involves large-scale loss of natural habitat, as well as having other impacts. In particular:
 - cultivation of grapes, olives and deciduous fruit will continue to drive habitat modification and loss, especially in cooler, ecotonal areas. Associated with this is often the need to build large dams for irrigation of these crops.
 - commercial afforestation causes large-scale habitat loss, and has impacts on hydrological ecosystem processes.
 - conversion of natural habitat for the establishment of monocultures of indigenous species such as buchu, rooibos tea, honeybush tea and protea orchards, represents a significant land-use pressure in certain areas.
- **Over-harvesting of selected indigenous plant species:** Unsustainable harvesting of parts of plants (or whole plants) for aromatic oils (such as buchu) and flowers (such as proteas and pincushions), represents an ongoing problem, especially in the Groot-Winterhoek and Olifants River mountains, and, increasingly, in areas closer to urban settlements.
- **Changes in hydrological patterns:** Water-dependent vegetation communities (in seeps, wetlands and riparian zones) are vulnerable to changes in hydrological patterns caused by the abstraction of groundwater or by the construction of drainage ditches around fields. Patches of seasonal wetland within agricultural lands are often surrounded by drainage ditches designed to prevent flooding of the adjacent fields, and this can impact on groundwater processes (for more information refer to the ecosystem guidelines for Inland Aquatic Ecosystems).
- **Quarrying for stone and gravel:** This activity represents a threat to alluvium fynbos (a Critically Endangered ecosystem), especially in the upper Berg River area near Paarl and Franschhoek.
- **Loss of grassy fynbos communities:** Because of the higher nutrient status of the soils, and relatively high rainfall that prevails where grassy fynbos communities occur, these ecosystems have been heavily modified for agricultural land use. They are often also targeted for the establishment of golf courses or housing estates. This results in the loss of indigenous plant species and impacts heavily on animal populations, especially certain species of birds that are dependent on grassy fynbos habitats.

- **Disturbance on mountain tops and other high altitude sites:** Mountain tops and other sites at high altitudes are often used as locations for telecommunication masts, the establishment of 4×4 trails and mountain resorts. This is concerning as the natural vegetation of sub-alpine areas is often rich in highly localised species that are especially sensitive to disturbance. In particular:
 - the construction of telecommunication masts can lead to loss of species and usually requires the construction of roads for inspection and maintenance purposes.
 - there has been a proliferation of 4×4 trails in mountain areas. These tracks are often poorly designed and maintained and can result in the degradation of seeps, wetlands and watercourses, as well as erosion of disturbed areas. They also increase the risk of localised infestation by invasive alien plants.
 - the construction of resorts, especially those with vehicular access, may also increase the incidence of fires, invasion by alien plant species, trampling and picking of wild flowers in sensitive or rare habitats. This includes invasion by alien animal species, such as Argentine Ants, feral cats and other commensals. Firebreaks are often cleared around such resorts, and, if done inappropriately (by bulldozer), this can cause permanent loss of species.

What are the non-negotiables?

- Habitat must not be modified or impacted by any land-use activities in Critically Endangered and Endangered ecosystems, corridors and vegetation boundaries, and sensitive habitats such as wetlands and riparian fringes.
- Avoid habitat loss or degradation in habitats that harbour Critically Endangered, Endangered or Critically Rare plant species.
- Remove invasive alien plants and animals and prevent their re-growth (or re-introduction) and spread.
- Maintain appropriate fire regimes. (Consult CapeNature or a specialist for advice, or refer to publications such as Esler *et al.*, 2014 for more detailed guidance).
- Maintain surface and underground hydrological systems and wetland habitats in a healthy, undisturbed state.
- Avoid fragmentation of alluvium fynbos habitats. Small remnants (<100 ha) are likely to suffer losses of pollinators, changes in fire frequency and edge effects that encourage invasion by alien plants.
- Monitor populations of Red List species (both threatened species and others of conservation concern) and ensure that viable populations of such species are not lost to any kind of land-use activity.
- Maintain and monitor biocontrol 'reserves' (for controlling *Hakea* and invasive *Acacia* species).



What are the best spatial approaches (at a landscape scale) to avoid or minimise impacts and risk in these ecosystems?

- Nodal development footprints are preferable to linear or diffuse ones, as nodal patterns allow for managed burning of fynbos and better accommodate wildfires. In general, housing infrastructure is not compatible with conserving fynbos or any other fire-prone vegetation type. However, to minimise the impacts of housing developments in fynbos, buildings should be clustered within a fire-free zone and protected with an appropriate firebelt. Flammable building materials such as thatch should be avoided. Fire belts must be included **within** the development footprint, and should not be part of the surrounding natural veld. (Consult Esler *et al.*, 2014, pages 64–65, for additional advice on optimal layouts, or consult with planners at CapeNature, or the Department of Environmental Affairs and Development Planning who can provide specialist advice).

- Maintain and restore connectivity within and between highly fragmented lower-lying fynbos types, especially those associated with particular geologies (such as granite, shale and ferricrete fynbos).
- Maintain rocky outcrops and screes in a natural state to provide good stepping-stones and a high degree of connectivity between larger remnants of unmodified vegetation, and across edaphic and other vegetation boundaries.
- Preserve the upslope habitats in representative spur, riparian and flat-slope environments. These habitats are usually orientated parallel to the contours (with the exception of riparian and spur communities).
- Avoid land-use activities that fragment existing ecological corridors (e.g. riparian vegetation) and interfaces between different soil and vegetation types. These corridors and boundaries may be important for the long-term viability of small conservation areas, or for the maintenance of large-scale ecological and evolutionary processes in response to environmental change.
- Do not modify seeps and marshes – avoid and strongly discourage the establishment of 4x4 tracks, trails, roads, dams and any other infrastructure in these habitats.
- Do not convert sandy flats and perched sand valleys to protea orchards, and keep roads and paths out of these areas.
- Locate orchards of cultivated indigenous species (such as proteas, buchu and honeybush tea) and their cultivars more than 2 km away from sites where related species occur naturally (this is to prevent hybridisation).
- Mountain peaks should not be used to erect telecommunication masts or other fixed infrastructure, including 4x4 tracks and any other roads. Hiking trail paths need to be carefully laid out and regularly maintained, especially for erosion. Calcium-based concrete must not be used in the construction of such paths.



What are the critical things to maintain for biodiversity to persist?

- Maintain appropriate fire cycles and manage fires correctly. The natural fire season is during the hot dry season (i.e. summer or early autumn). In granite, ferricrete, conglomerate and silcrete fynbos, hot burns are required to prevent over-dominance of weedy elements such as renosterbos (*Elytropappus rhinocerotis*) and *Cliffortia* spp. Hot-burning fires also allow recovery of the large-seeded, early seral species (i.e. those that appear earlier in the ecological succession sequence), which are prominent in these plant communities. (Additional guidelines on fire management in these ecosystems can be obtained in Esler *et al*, 2014, pages 45–68).
- Maintain appropriate grazing regimes in grassy fynbos to retain maximum species richness in these plant communities.
- Retain local-scale variations in habitat in sandstone fynbos. These ecosystems include many local variants (which may not be captured on maps) which need to be considered – and preferably maintained – when assessing the impacts of a proposed land-use activity. Habitats that require specific attention include high altitude and perched seeps and marshes, and sandy flats and perched sandy valleys (especially the lower reaches) which often contain significant wetland habitats.
- Maintain buffer zones between drainage ditches and remnant patches of natural habitat. Subterranean and surface water movement is often altered by agricultural drainage, water abstraction, channelisation and dams. This can result in the drying up of seasonally wet areas, even if they have not been directly modified.
- Monitor seeps and marshes to detect changes where surface water or groundwater is abstracted.
- Prevent sedimentation and erosion into alluvium fynbos habitat from agricultural lands.
- Remove invasive alien species correctly (obtain advice from CapeNature or Working for Water).

- Do not allow flowers, seeds or plants to be harvested in nature reserves.
- Monitor and mitigate hybridisation from protea orchards.
- Keep development footprints as small as possible to minimise the spread of invasive Argentine Ants and manage rubbish disposal carefully.
- Maintain and maximise patch connectivity to allow for movement of pollinators. To be functionally viable, larger patches should be located within 500 m of each other, and must be connected by pollinator-friendly terrain. Where possible, patches should be linked upslope to mountain fynbos along drainage lines; such corridors should be at least 300 m wide to maintain a natural fire regime. These linkages also help prevent groundwater from being polluted by fertilizers and pesticides.

What indicators should be used to assess and monitor ecosystem health?

- The density of invasive alien species is a good indicator of ecosystem health, with a low density or absence of invasive alien species indicative of healthy ecosystems (**Note:** the mere presence of invasive alien species does not always imply that the ecosystem is unhealthy).
- The abundance, health and distribution of populations of threatened species and other species of conservation concern (as per the Red List – consult Raimondo, *et al.*, 2009 and annual online updates), with benchmarks determined by a specialist.
- The type, age and condition of indigenous plant cover, species richness and the presence of key ecological guilds (groups of plant species that use resources in similar ways), should be assessed by a specialist. Particular attention should be paid to monitoring the presence of serotinous over-storey proteas and large-nut, over-storey *Proteaceae* (e.g. *Mimetes* and *Leucospermum*), as these should be well-represented in healthy ecosystems. With the inputs of appropriate experts, monitor the populations of animal species whose presence and abundance can be taken as a measure of ecosystem health, as follows:
 - monitor populations of Verreaux eagle, grey rhebok, baboon and leopard in sandstone fynbos habitats.
 - monitor porcupine, duiker, baboon and caracal in granite, shale, ferricrete, conglomerate and silcrete fynbos.

In general, the changes in these animal populations would need to be monitored at a large scale and over time, and would be unlikely to be detected within the time-frame of an environmental impact assessment. However, these indicators should be used to monitor the impacts on ecosystem health of any approved land-use changes.
- With advice from a specialist, monitor encroachment by thicket elements into grassy fynbos. Although most healthy grassy fynbos will normally have thicket patches present, thicket should not be encroaching or dominating. Conversely, the absence of thicket elements in grassy fynbos vegetation types means that fires are too frequent or unseasonal.
- Richness of bird species is an important indicator of ecosystem health in grassy fynbos, as is the occurrence of palatable grass species, e.g. *Themeda triandra*, and the relative abundance of unpalatable species, e.g. *Aristida diffusa* – there should be fewer unpalatable species present in healthy ecosystems.

How reversible are impacts within a period of 5 to 10 years?

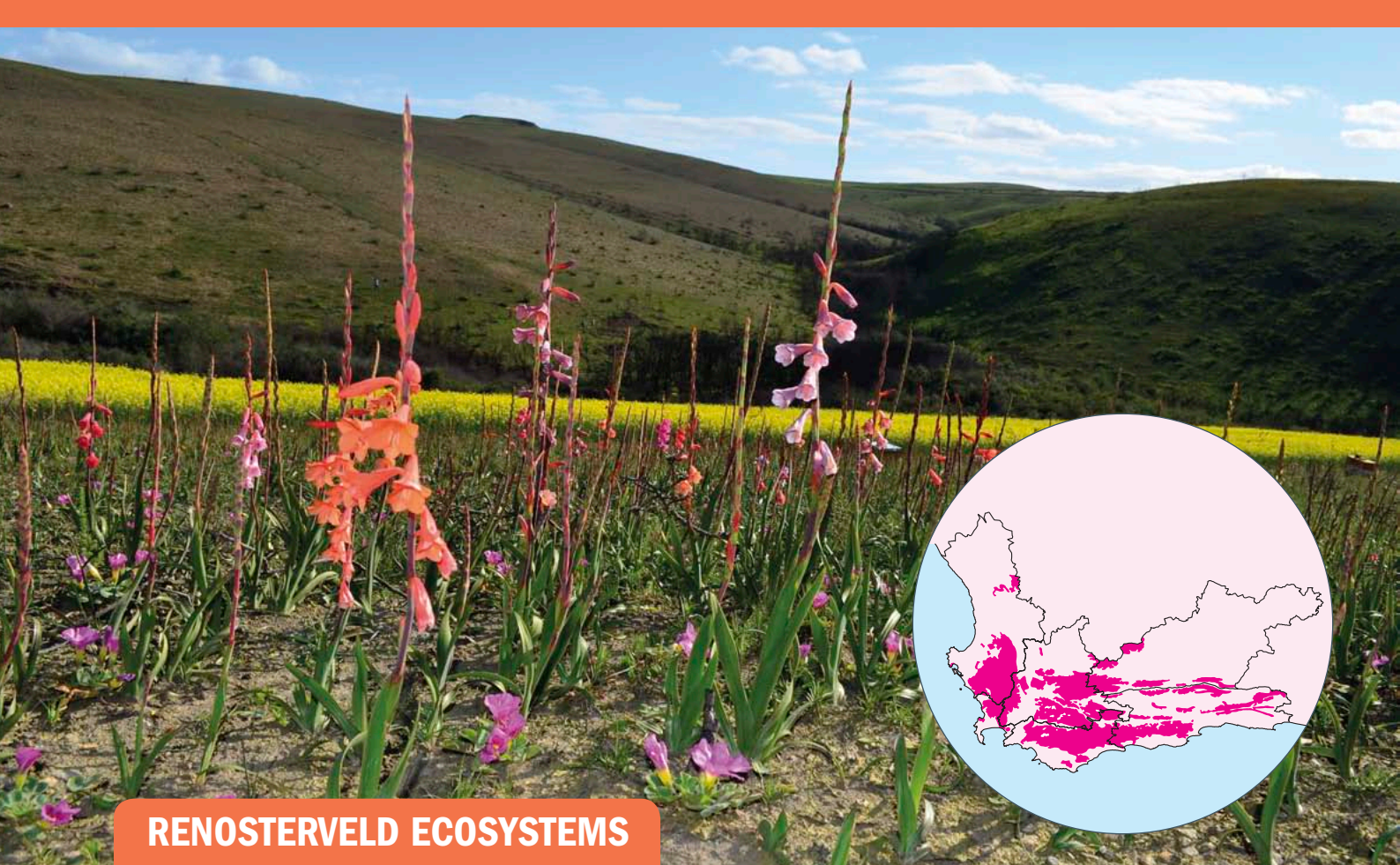
- Reversibility of impacts and the time required for restoration depends on the extent and type of the proposed land use, and the particular receiving environment, which means that general rules cannot readily be applied.
- Fynbos is fire-determined, which means that complete regeneration of impacted areas will only commence after the next fire. A 5 to 10-year period is therefore not applicable for monitoring regeneration of fynbos, as the interval between fires is usually longer than this. Partial recovery may commence within 5 to 10 years if agricultural land is left fallow, or if plantations or invasive alien species are removed. If the topsoil and seed-banks remain intact, a large proportion of the fynbos species should recover following the next fire. However, full recovery may take up to three fire cycles, especially in areas that have been heavily infested by invasive alien species (i.e. with a 90% alien canopy cover).



- If disturbance has altered the soil characteristics and invasive alien species have moved into the area, recovery is not guaranteed. In these cases, invasive aliens should be controlled and a prescribed burn carried out – in most cases there is more than enough cover to promote fire, and fynbos species will move in from neighbouring areas, if these are burned at the same time. However, recovery is only possible within three fire cycles (20–120 years). For large areas, rates of recovery are 50 m from the edge of the disturbed area per fire cycle (5–40 years) for serotinous species and 10 m per fire cycle for ant-dispersed (myrmecochorous) species. Active restoration in the form of sowing local fynbos seed post-fire could speed up recovery (Southern Cape areas with more regular rainfall will restore much faster than drier ones).
- If serotinous species are lost from the system (as happens under conditions of infestation by invasive alien species or too-frequent burning), recovery takes about three fire cycles, as long as remnant patches of intact fynbos survive. Otherwise seeds should be broadcast-sown after the first post-fire rains.
- Recovery of ant-dispersed species is slower, more labour-intensive and more costly than for serotinous species; typically, the ant-dispersed species are lost when soil characteristics have been changed.

What are acceptable compensation measures or offsets for biodiversity loss?

- There are no acceptable biodiversity offsets or compensation measures for losing the habitat of Critically Endangered and Endangered species in midland and mountain fynbos.
- In the rare event that it is impossible to avoid impacts on vulnerable ecosystems, sensitive habitats (such as wetlands), ecological corridors or vegetation boundaries, biodiversity offsets may be considered, but only after all standard mitigation has been carried out, as there may be residual impacts. Both the size and ecological condition of the land should be considered in selecting sites for offsets, and the provincial biodiversity offsets guidelines must be strictly applied.
- For all types of land use, development footprints should be minimised. Large-scale developments of any type are not recommended. The focus should be on selecting land-use alternatives that maximise the retention of indigenous habitat and maintain species diversity and ecological processes. This means, for example, seeking less destructive methods of cultivating buchu (see, for example, Esler *et al.*, 2014, pages 182–203), using local indigenous plant species in landscaping, and retaining wetland features as natural habitats and corridors within the development footprint.
- Many of the rare species in these ecosystems are highly localised, and impacts on these populations can often be avoided through good environmental assessments and planning. Search and Rescue is an important of good practice when impacts cannot be avoided, but it does not constitute adequate mitigation for loss of rare and threatened species or habitats. Where Search and Rescue is used, follow the recommendations in Chapter 4 of these *Guidelines*.



RENOSTERVELD ECOSYSTEMS

Incorporating Coast and Inland Renosterveld

Contributors: Nick Helme and Tony Rebelo

Snapshot of Renosterveld Ecosystems

Renosterveld is found only in the relatively moist south, south-west and south-eastern parts of the Western Cape. Although this fire-prone shrubland may superficially resemble fynbos, it differs in important ways.

General characteristics

- Made up of small-leaved, low-growing, evergreen and fire-prone shrubland, usually dominated by 'renosterbos' (*Elytropappus rhinocerotis*) or grasses. Renosterveld shows high species richness and endemism with a particularly high number and diversity of bulbs (geophytes) that produce spectacular flower displays in Spring, especially post-fire, and members of the daisy, and grass plant families. Renosterveld, unlike most fynbos vegetation types, may have high grass cover. It usually lacks Cape reeds (restioids), proteas and ericas.
- Comprises some 23 vegetation types, mostly associated with shale (but also other substrate types (such as granite, silcrete, dolerite, alluvium).
- Occurs on soils that are fine-grained, clay-rich and fertile, mostly derived from shales and granites, with much of the extraordinary species richness and endemism exhibited by this ecosystem linked to variations in soil type.
- *Heuweltjies* (nutrient-rich areas due to subterranean termite mounds) are a characteristic feature of renosterveld landscapes. These are regular, circular patches in the landscape that in some regions support dense bush-clumps, in others are bare in the dry season but covered with annuals in spring.
- Historically, renosterveld supported large herds of grazing and browsing game species.
- Rainfall is usually between 250–600 mm per annum, with at least 30% falling in winter. In areas where rainfall is less than 250–300 mm, renosterveld gives way to succulent karoo elements, and where it is more than 600 mm, it is replaced by fynbos.



Conservation, land-use pressures and risks

- Includes 23 vegetation types, 9 of which are Critically Endangered, 1 is Endangered and 5 are Vulnerable, with 8 Least Threatened. Only one renoesterveld vegetation type is well-protected, 7 are poorly protected and 14 are not protected at all. Overall, just over 50% of renoesterveld remains, but for some renoesterveld vegetation types as little as 4% of the original extent remains, with much of it replaced by heavily modified agricultural lands.
- Renoesterveld harbours a high number of threatened plant and animal species including insects (e.g. Dickson's Monkey Blue, Cottrell's Blue and Lions Head Copper butterflies); birds (Grass Owl, Martial Eagle, Lappet-faced Vulture; Ludwig's Bustard and Stanley's Bustard) and mammals (Cape Mountain Zebra, African Wildcat, Antbear, Honey Badger and White-tailed Mouse).
- Renoesterveld occurs on fertile soils and has a relatively high grass content, so these areas are sought after for agricultural land uses (cultivation of crops and grazing lands). This, compounded by inappropriate land-use practices (overgrazing, bad ploughing practices, use of non-biodegradable poisons and incorrect burning practices), invasion by alien vegetation and illegal flower picking, places the remaining areas of renoesterveld at high risk of degradation or loss.
- Remaining lowland renoesterveld vegetation types are highly fragmented, and may take a long time to recover from disturbance, but, if managed properly, they are relatively stable.





What are the key ecological ‘drivers’ maintaining ecosystem function, pattern or structure?

- **Fire and grazing patterns:** Periodic defoliation by fire and grazing is important to retain diversity in renosterveld vegetation types. The appropriate fire frequency ranges from 5–10 years in wetter areas, but in drier, inland areas it can be much longer.
- The factors responsible for maintaining the appropriate fire-grazing balance vary in different renosterveld vegetation types. Ideally, populations of both browsers and grazers should be maintained to prevent dominance by either grasses or overstorey shrubs.
- **Variations in edaphic conditions and water availability:** Variations in soil type (depth, moisture-holding capacity, rockiness and mineral composition) and water availability determine fine-scale variation in plant communities and the occurrence of rare and threatened plant species. These variations can be highly localised, especially when linked to special habitats such as seasonal wetlands or silcrete, ferricrete and quartz patches. Subsurface drainage is a key determinant of community structure and mosaic patterning in alluvial renosterveld systems.
- **Edaphic boundaries:** These are the primary determinants of the fynbos-renosterveld ecotone. Renosterveld occurs on relatively nutrient-enriched clay soils derived from shale or granite, but fynbos can replace renosterveld on clay soils where rainfall exceeds 600 mm per year.
- **Underlying geology:** Patches of silcrete, ferricrete or quartz support concentrations of rare and endemic plant species, many of which are succulents. High concentrations of endemic succulent species are found on silcretes, shallow soils and clays on steep, concave slopes. Quartz patches are characterised by delicate soil crusts, and may also support numerous endemic succulents.
- **Specialised plant-pollinator interactions:** Many renosterveld plant species have specialised pollinators, such as long-tongued flies. The habitat requirements of these pollinators are poorly known, but the presence of these animals is essential for maintaining species diversity and population dynamics in renosterveld.
- **Plant-plant interactions:** Periodic dominance by renosterbos (*Elytropappus rhinocerotis*), as an overstorey species, is required to reset understorey plant-plant interactions (especially competitive ability of the grass component).

- **Living (biogenic) soil crust:** Biogenic soil crusts (made up of a combination of fungi, lichens, moss and blue-green algae growing on the soil surface) are important for maintaining healthy renosterveld ecosystems. Living soil crusts play an important role in nitrogen fixation and nutrient-holding, rates of water infiltration, and formation and binding of soil. If the biogenic soil crust is damaged, it can lead to loss of top soil, erosion and nutrient-depletion, with a consequent loss of biota.

What are the main pressures and threats in these ecosystems?

More than half of all renosterveld ecosystems are either Critically Endangered or Endangered, and the balance are Vulnerable or Least Threatened. They harbour high numbers of rare and localised species which are often associated with specific edaphic or alluvial environments. This means that inappropriate land use at even one site can result in these species being irretrievably lost, and most renosterveld habitats should be treated as threatened.

The main risks posed to renosterveld ecosystems arise from various agricultural activities, changes in natural fire and grazing regimes, soil erosion, infestation by invasive alien species and poorly-planned urban expansion. Key issues for noting include:

- **Large-scale conversion of natural habitat:** Loss of natural habitat to make way for cultivation is by far the most important and ongoing land-use pressure in renosterveld, especially in the West Coast forelands, Overberg, Rûens and Riversdale Coastal Plain. Past cultivation of crops such as wheat and oats has accounted for the most widespread loss of habitat in renosterveld and heavy grazing has also taken its toll. The production of wine and olives has replaced cultivation of cereals as the main driver of habitat modification, especially in cooler ecotonal areas that are suitable for viticulture.
- **Drainage of seasonal wetlands:** Alluvial renosterveld habitat is destroyed when wetlands are drained to facilitate the establishment of fields.
- **Trampling:** Trampling by livestock (or people) can result in the irreversible modification of silcrete, ferricrete and quartz patches.
- **Use of herbicides and pesticides:** Spraying of crops with herbicides and pesticides (especially when spraying is done by aeroplane) may kill the pollinators of specialised plant species, thus disrupting ecosystem functioning.



- **The introduction of ostriches and other extra-limital game species:** This can alter natural grazing regimes and result in trampling and damage to the biogenic soil surface. Ostriches are often introduced after wheat fields have been harvested and they tend to use the remnant renosterveld patches (in the fields) heavily.
- **Changes in natural fire and grazing regimes:**
 - Agricultural activities often disrupt natural fire and grazing regimes (and the fine balance between them). This alters the species richness of all renosterveld vegetation types. Many landowners do not burn remnant renosterveld patches due to fear that fires may spread into their lands. On the other hand, fields (such as wheat fields) are sometimes burned to remove stubble and these fires may impact on adjacent renosterveld, especially if burning takes place too frequently.
 - Many of the non-toxic geophytes and annuals in renosterveld are vulnerable to grazing pressure from domestic stock in the first two years after a fire.
 - The spread of urban settlements is intensifying in some areas, which has a negative impact on the maintenance of an appropriate fire regime in adjacent areas of natural habitat. When fires start in proximity to settlements, they are often put out (as people fear damage to their property). This results in dominance by slower growing, woody species at the expense of bulbs, herbs, and grasses. In other cases, fires are often deliberately set (to burn rubbish, clear veld or promote grass growth for grazing), resulting in too-frequent burns. Under these conditions, the slower-growing, re-seeding species will be lost from the ecosystem.
- **Invasive alien species:** Renosterveld vegetation types are susceptible to invasion by annual alien grass species that replace the indigenous bulb flora. This is probably as a result of eutrophication (resulting from use of fertilizers) and the use of herbicides, coupled with inappropriate grazing.
- **Soil erosion:** Most renosterveld vegetation types are prone to soil erosion; physical disturbance of remaining intact patches of renosterveld, especially any disturbance of the soil crust, should be kept to a minimum.
- **The establishment of infrastructure for large wind-energy facilities:** This land-use type, which is accompanied by extensive road construction that causes habitat fragmentation and loss, is placing increasing pressure on renosterveld in the Klein Roggeveld.

What are the non-negotiables?

- Avoid any further habitat modification in areas with intact renosterveld vegetation that is in good ecological condition. Habitat modification or fragmentation must be avoided in all threatened renosterveld vegetation types.
- Any plans to modify renosterveld should always be preceded by a detailed botanical assessment carried out by a specialist. Small remnants (~1 ha) can be important for the conservation of individual species and achieving some biodiversity pattern targets. However, in order to be functionally viable, larger patches of remaining renosterveld should be located within 500 m of each other and connected by pollinator-friendly terrain.
- It is critical to maintain pollinator-plant associations, which means that pollution by herbicides, fertilisers and insecticide spray must be minimized.
- Avoid disturbances (including grazing and all forms of physical modification) to silcrete, ferricrete and quartz patches.
- Maintain and manage appropriate fire regimes and control managed burns carefully (consult CapeNature or Esler *et al.*, 2014, for more guidelines).
- Eradicate invasive alien species using appropriate methods and carry out suitable follow-up procedures.
- Prevent or avoid introduction of extra-limital game species to renosterveld habitats.
- Undertake environmental assessments in spring (when the bulk of the annuals and bulbs are flowering), and in veld that is between 4 and 12 years old.



What are the best spatial approaches (at a landscape scale) to avoid or minimise impacts and risk in these ecosystems?

- All core renosterveld conservation areas should be buffered by an area of natural habitat of at least 30 m breadth. It is especially important to establish buffers when renosterveld patches are adjacent to agricultural lands.
- Avoid any further fragmentation of renosterveld. These ecosystems are usually already highly fragmented, so connections between patches should be maintained. Wherever possible, habitat links should be rehabilitated.
- Fence off silcrete, ferricrete and quartz patches to protect them from physical disturbance. The fencing should, however, accommodate the movement of tortoises and small antelope species.
- Avoid impacts on populations of rare and highly localised renosterveld species (for example, those occurring in wetter areas or on ferricrete patches), by proactive incorporation of spatial biodiversity priorities into land-use planning and environmental assessment. Use the latest available fine scale biodiversity plan or consult CapeNature or a specialist for advice.

What are the critical things to maintain for biodiversity to persist?

- Maintain patch connectivity to allow for movement of pollinators.
- Maintain appropriate fire regimes. Burns should occur in the right season and at the appropriate frequency and scale to prevent localized overgrazing. Grazing by domestic stock should not be allowed within the first two years after a fire.
- Manage grazing appropriately. Renosterveld can be lightly grazed in early summer to autumn (January to early March). Grazing by livestock should not be allowed in the winter and spring flowering and growing seasons.
- Control invasive alien plants and encroachment by commercial cereal species and associated weeds.
- Maintain the natural bulb flora by preventing dominance by annual alien grass species.
- Planting of old man salt bush (*Atriplex* spp.) should be discouraged.
- Maintain healthy populations of plant pollinators by preventing exposure of renosterveld vegetation to fungicide, herbicide and insecticide spray.



What indicators should be used to assess and monitor ecosystem health?

- A low density of invasive alien species, especially alien annual grasses, indicates a relatively healthy renosterveld ecosystem.
- In healthy ecosystems there should be stable populations (that are reproducing at least periodically) of species of conservation concern (as per the Red List – Raimondo *et al.*, 2009 and online updates, and as assessed by a specialist).
- Indigenous plant cover and species richness, especially of bulbs, grasses (both exotic and indigenous) and palatable species, can be used as a measure of ecosystem health (with benchmarks determined by a specialist), as can the presence of healthy populations of longer-lived re-seeders and understorey bulbs and herbs. Monitoring these indicators will require inputs of a specialist.
- The presence (and re-introduction) of mammals such as aardvark, bat-eared fox, duiker and porcupine, will indicate intact ecosystems.

How reversible are impacts over a period of 5 to 10 years?

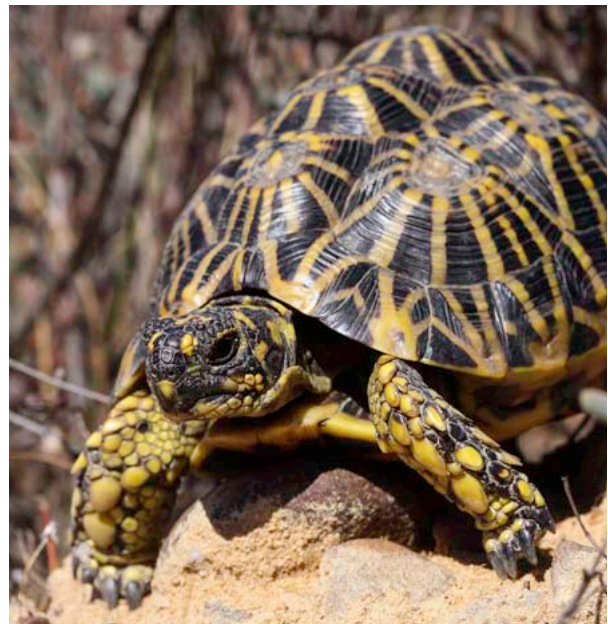
- Renosterveld is a fire-determined ecosystem, so complete regeneration after disturbance will only happen after the next fire has passed through. This means that one cannot expect to achieve full recovery within a 5 to 10 year period as the natural fire interval in renosterveld is usually longer than this. Partial recovery, however, may take place within 5 to 10 years after the removal of invasive alien species (or plantations of exotic species). If the topsoil and seedbank remains intact, a large proportion of the renosterveld species, and particularly the bulbs and indigenous grasses, should recover following a fire – this applies even after heavy infestation with an alien canopy cover of 90% or more. However, if disturbance has altered the soil characteristics or has caused loss of seedbanks, then recovery is not guaranteed. Southern Cape areas that experience more regular rainfall will be restored much faster than drier areas (such as those on the West Coast or inland).

- It may be possible to restore renosterveld that has a history of incorrect burning and grazing, as long as the soil structure has not been disturbed. Overgrazed areas, which have lost their geophytes and grasses, can simply be rested to recover the grasses, but bulbs require lengthy periods (> 20 years) and active reintroduction to recover. No fertilizer should be used in restoration projects.
- Disturbance to vegetation communities on quartz and silcrete patches is practically irreversible due to disruption of the biogenic soil crust and changes in soil structure and the consequent loss of biota.



What are acceptable compensation measures or offsets for biodiversity loss?

- There are no acceptable compensation measures or offsets for losing habitat that harbours Critically Endangered and Endangered species in renosterveld.
- Most renosterveld ecosystems represent a national (and international) conservation priority as they are at high risk of being lost, and the achievement of biodiversity targets for over half of all renosterveld vegetation types has already been irrevocably compromised through negative impacts associated with inappropriate land uses. No further modification of threatened renosterveld habitat is recommended. Instead of allowing further modification of remaining renosterveld, areas of degraded renosterveld should be obtained for rehabilitation and restoration, especially where there is potential for reconnecting isolated patches of remaining intact natural habitat.
- In all renosterveld ecosystems (regardless of ecological condition) avoidance is preferable to offsetting impacts. However, in those cases where there are no alternatives for locating a proposed land use elsewhere, the mitigation hierarchy should be strictly applied, with offsets being pursued as a last resort, and then only in full compliance with the provincial biodiversity offsets policy.
- For all types of land use, footprints should be minimised. In applying the mitigation hierarchy, the focus should be on selecting alternatives that maximise the retention of indigenous habitat, and maintain species diversity and ecological processes.
- Large-scale wind energy facilities in the Roggeveld and Klein Roggeveld should ensure that all remaining natural vegetation is effectively conserved and well managed for the persistence of biodiversity.
- Search and Rescue is not an adequate mitigation measure for loss or fragmentation of habitat. It is, however, part of good practice when loss or disturbance of habitat is unavoidable (after application of the mitigation hierarchy). A specialist botanical report must provide recommendations on the rescue techniques to be used and CapeNature should endorse the sites to which the affected plants are to be translocated. Consult Chapter 3 of these *Guidelines* for further information on Search and Rescue techniques.





SUCCULENT KAROO ECOSYSTEMS

Incorporating vygieveld, broken veld and quartz patches

Contributor: Nick Helme

Snapshot of Succulent Karoo Ecosystems in the Western Cape

The Succulent Karoo Biome, which covers a total land area of some 117 000 ha, stretches along the Atlantic Coast, from southern Namibia to as far south as about Lamberts Bay in the Western Cape, and extends into the western and south-western interior of South Africa, occupying parts of the Western and Northern Cape. It is the only semi-arid region in the world recognised as a biodiversity hotspot, with nearly 40% of its flora being endemic, and with a remarkably high diversity of invertebrates, reptiles, mammals and amphibians.

General characteristics

- In the Western Cape, Succulent Karoo dominates the arid interior plains of the province, occurring mainly in the West Coast, Cape Winelands and Central Karoo districts.
- Succulent Karoo is a diverse, semi-arid environment characterised by a sparse vegetation cover comprising mainly dwarf, succulent-leaved shrubs (especially vygies, which are members of the family Aizoaceae – previously known as Mesembryanthemaceae, and *Crassulas*), minute succulents (the so-called stone plants such as *Lithops*), an extremely rich bulb flora (more species of bulbs occur here than in any other comparable arid area in the world), and a large variety and biomass of spring-flowering annuals, mostly from the daisy family (which tend to dominate in areas that have been previously disturbed).
- There are 31 Succulent Karoo vegetation types that occur in the Western Cape; many of them are highly localised and so are vulnerable to impacts even at the local scale.
- A combination of high topographic variability (incorporating rugged mountains of variable geological composition, semi-arid plains and sandy coastal flats and dunes), combined with diverse underlying soil types, accounts for the extremely high levels of species diversity and endemism observed in Succulent Karoo. The underlying geology includes granite, gneiss, quartzitic sandstones, lava, dolomite, conglomerate and shale. Many of the rare, endemic and range-restricted species in Succulent Karoo are extreme habitat specialists associated with particular types of substrate, such as quartz or dolomite patches.



- *Heuweltjies* (nutrient-rich areas due to subterranean termite mounds) are a characteristic feature of Succulent Karoo landscapes. These are regular, circular patches in the landscape that in some regions support dense bush-clumps, in others are bare in the dry season but covered with annuals in spring.
- Rainfall is low (20–290 mm per annum), falling in winter, with sea fog serving as a significant form of precipitation along the coast.
- Winter temperatures are mild in the day-time (but can become cold at night), and day-time temperatures in summer can be extremely hot (up to 40 °C).

Conservation, land-use pressures and risks

- None of the Succulent Karoo vegetation types is Critically Endangered or Endangered, 2 are Vulnerable, and 29 are Least Threatened, but fracking may alter this. None are well protected, 6 are moderately protected, 11 are poorly protected and 14 are not protected. Some 97% of the historical extent of this vegetation remains.
- The predominant land-use in Succulent Karoo landscapes is grazing of small stock (goats and sheep), with increasing demand for land for commercial-scale ostrich farming. Although grazing is a potentially biodiversity-compatible land-use, over-grazing is a problem over much of the area and stocking rates need to be carefully managed. Commercial cultivation of crops generally poses a low risk in these arid landscapes, except in some fertile river valleys.
- In addition to the ongoing demand for rangelands, land-use pressures from mining and quarrying and the illegal and unsustainable collection of flora (by succulent-growers) and fauna such as reptiles (for the specialist pet trade) is placing these ecosystems under increasing pressure. Fracking and climate change are likely future threats to some vegetation types.



What are the key ecological ‘drivers’ maintaining ecosystem function, pattern or structure?

- Variations in soil type and underlying geology:** Factors such as soil depth, moisture-holding capacity, rockiness, mineral composition and acidity are the primary determinants of the composition of plant communities and the occurrence of rare species in Succulent Karoo. Many of the rare, localised species are extreme habitat specialists that are restricted to specific soil types or to distinctive habitats such as quartz patches and rocky outcrops.
- Topographic and climatic variability:** The combination of the variation in soil types with extreme topographic diversity and climatic variability (extreme heat in summer, extreme cold in winter, summer drought and winter rain), produces the diverse and unique flora of the Succulent Karoo, with its high number and variety of bulbs and succulents.
- Rainfall and fog:** Both the amount and seasonality of rainfall have important effects on plant diversity and the structure of plant communities. Low, but fairly reliable winter rainfall and hot, dry summers characterise the Succulent Karoo. Rainfall ranges from 20 to 290 mm per annum, with more than 40% of the rain falling in winter. Sea fogs are also an important source of precipitation along the coast, with seaward-facing slopes (and other sites that catch the sea fogs) often being rich in localised endemic species. Altitudinal gradients and topographic variation are important factors influencing local variation in precipitation. Maximum rain water infiltration is vital for plant growth and groundwater availability and infiltration rate is largely determined by plant cover, plant litter and condition of the biogenic (living) soil crust (which is made up of lichens and mosses).
- Dispersal distances and patch size:** Small habitat patches (~1 ha) can remain viable for a long time, given that most succulents have short dispersal distances (often no more than a few metres) and that many habitats (e.g. quartz patches) are naturally < 1 ha in extent. Many species in Succulent Karoo are also long-lived.
- Termitaria (*heuweltjies*):** These are an important feature in lower-lying areas with loamy calcium-rich soils. They contain higher levels of nutrients than the surrounding areas due to the accumulation of organic matter collected and digested by the termites over long periods. Besides supporting distinctive plant communities, *heuweltjies* are important browsing ‘hotspots’ for smaller fauna. Birds also perch on *heuweltjies*, and deposit seeds of thicket species there.
- Plant-plant interactions:** Some plant species (especially species of the daisy shrub *Pteronia*) act as important ‘nursery plants’ for smaller species – they provide the shelter that the smaller, more vulnerable species require to establish themselves. These ‘nursery plants’ are also important for successional development after disturbance.
- Plant-animal interactions:** Grazing, especially by small resident antelope, may play an important role in regulating competitive interactions among plants. Birds, tortoises and mammals such as the bat-eared fox are important seed dispersal agents.
- Fire:** Generally, the plant cover in Succulent Karoo is too sparse and succulent to sustain significant fires. However, in some of the Succulent Karoo vegetation types that are found in wetter areas (that show more vigorous growth), fires do occur at low frequencies (with a fire interval of more than 50 years), and when they occur, are usually of a high intensity. In these vegetation types, various annuals and species of the genus *Hermannia* dominate the post-fire vegetation and some of these species seem to be fire-dependent.





What are the main pressures and threats in these ecosystems?

- **Mining and quarrying:** Mining for diamonds, base metals, granite, sandstone, gypsum and quartz (amongst other things) impacts significantly on Succulent Karoo landscapes, causing extreme and often irreparable modification of natural habitats. Apart from the many physical impacts of mining and quarrying, these activities pose a particular risk to the survival of many of the rare, habitat-restricted species that characterise Succulent Karoo. These rare species tend to be extreme habitat specialists that are concentrated in small, highly specific habitats, often in rocky areas (such as quartz patches). Base-metal seams also coincide with areas that have high concentrations of succulent species, which makes these species vulnerable to the impacts of mining and quarrying. Quarrying for granite ("dimension stone") is placing increasing pressure on ecosystems in the Bitterfontein area.
- **Heavy grazing pressure (by both small domestic stock and extra-limital game species):** Grazing by small stock (goats and sheep), ostrich farming and small-game ranching are the dominant land uses over much of the Succulent Karoo and evidence of over-grazing is widespread. Heavy grazing pressure reduces plant cover and causes trampling of the biogenic soil crust. These impacts lead to soil compaction, erosion and land degradation. The expansion of the ostrich industry poses particular management issues as ostriches are high-impact animals when they occur in large numbers – they are selective feeders, with preference for eating protein-rich plants and seeds, and cause significant trampling and soil compaction.
- **Invasive alien species:** There are a number of invasive alien plant species that have infested Succulent Karoo habitats and ecosystems, such as *Nerium oleander* (mostly along watercourses in areas abutting the Fynbos Biome), mesquite (*Prosopis* spp.), prickly pear (*Opuntia* spp.), annual grasses (e.g. *Bromus* spp.) and saltbush (*Atriplex* spp.). Watercourses and drainage lines are particularly vulnerable to invasion. Infestation by invasive alien species reduces water yields and catchment values and poses a threat to sustainable management of scarce water resources in this semi-arid environment.
- **Habitat loss linked to agricultural activities:** Although habitat loss due to cultivation is not widespread across the Succulent Karoo, it does place ecosystems along most of the major river and floodplain systems at high risk of being modified or fragmented. This is because cultivation generally takes place along rivers and around wetlands, and these areas are also important for conservation. Robertson Karoo in the Breede River valley is the only vegetation type within the Succulent Karoo to be heavily impacted by agriculture. It faces severe, ongoing pressure, with many plant communities inadequately represented in the few conservation areas that exist.
- **Unsustainable or illegal harvesting:** Many unique plant species (such as rare succulents on quartz patches) and rare animals (such as certain tortoises and other reptiles like the Armadillo Girdled Lizard) are highly sought after by local and international collectors for the horticultural and wildlife (pet) trade. Some species are so heavily

impacted by unsustainable and illegal collection that they face the risk of extinction in the wild. The use of certain plants for medicinal purposes has long been practiced in the area, and it is important to ensure that these resources are harvested in a sustainable manner. Of greater concern, however, is the proliferation of bio-prospecting and commercial interest in medicinal plant species in the region.

- **Disruption of faunal migration routes:** A proliferation of impermeable game fences in some areas may pose problems for faunal migration.
- **Climate change:** Although it is not known what the impacts of climate change on ecosystems in the Succulent Karoo will be, it is predicted that disruptions of the winter-rainfall pattern that sustains these ecosystems may have substantial negative effects on the occurrence of localised endemics.

What are the non-negotiables?

- Limit physical disturbance to the absolute minimum, as most Succulent Karoo plant communities recover very slowly, if at all, after heavy grazing or other disturbances. Some ecosystems, such as shallow or rocky soil habitats and wetlands, should not be disturbed at all. (These habitats should be recognised as 'no-go areas' in land-use plans and environmental assessments).
- Avoid overgrazing by implementing well-planned grazing management, with careful attention paid to stocking rates. (Although grazing, in principle, is a viable and biodiversity-compatible land use, careful attention needs to be paid to stocking rates if over-grazing is to be avoided). Grazing management plans for domestic stock and game species (especially in catchment areas and wetlands) should follow the recommendations of the Department of Agriculture and CapeNature.
- Regulate and monitor the abstraction of both ground and surface water.
- Viable populations of rare and/or endemic species should never be lost through habitat modification for any kind of land-use activity. All areas with high concentrations of rare and/or endemic plant species should be considered as 'no go' areas in land-use plans and environmental assessments.



What are the best spatial approaches (at a landscape scale) to avoid or minimize impacts and risk in these ecosystems?

- Avoid impacting on any rocky outcrops, especially through mining or quarrying.
- Quartz patches and ridges, particularly those regarded as acidic, should be kept in a natural, undisturbed state.
- Avoid impacting (directly or indirectly) on any wetland areas or riverine fringes.
- Limit impacting land-use activities to already-disturbed environments such as old lands and heavily overgrazed sites (unless these have been ear-marked for restoration).

What are the critical things to maintain for biodiversity to persist?

- Avoid disturbance of the biogenic (living) soil crust and special habitats such as quartz patches or any other rocky outcrops. Generally minimise disturbance to any natural vegetation.
- Prevent soil erosion as windblown sediments can smother sensitive areas such as quartz patches and small rocky outcrops.
- Retain indigenous fauna and their migration corridors.
- Retain natural vegetation in floodplains.

What indicators should be used to assess and monitor ecosystem health?

- Healthy ecosystems should have populations of rare and endemic species (to be identified by a plant specialist) that are reproducing.
- The presence and abundance of palatable species and, especially on *heuweltjies*, the absence (or a low density) of invasive alien plant species, would indicate a healthy ecosystem.
- The presence and abundance of natural predators and other native mammal species, such as Aardvark, would indicate ecosystem health, with suitable benchmarks established by a faunal specialist.
- The presence of unbroken soil crust and lichens denotes a healthy Succulent Karoo ecosystem.

Assessing these indicators, and determining thresholds of potential concern, will need to be carried out by a Succulent Karoo specialist.

How reversible are impacts over a period of 5 to 10 years?

- The soil in these arid areas will normally take decades to recover from disturbance, if it recovers at all.
- Quartz patches are particularly sensitive to any form of physical disturbance and cannot be rehabilitated once disturbed.

What are acceptable compensation measures or offsets for biodiversity loss?

- In general, rehabilitation of sensitive habitats cannot be considered as effective mitigation for habitat loss.
- Loss of undisturbed natural vegetation must be compensated for by an increase in the extent of statutory conservation areas in selected priority areas where undisturbed natural habitat remains. If habitat is to be lost through the impact of land uses, then there should be a net gain for conservation.
- Search and Rescue is an important measure for minimising negative impacts when land-use activities may result in the irreversible loss of rare or threatened plant populations. However, habitat rehabilitation or translocation of species of conservation concern, cannot be considered as adequate mitigation for loss of pristine habitat, or as an acceptable measure to compensate for or offset residual impacts. Where Search and Rescue is to be undertaken, a specialist botanical report must provide recommendations on appropriate rescue techniques and CapeNature should endorse the sites to which these plants are to be translocated. In the case of sites that will be disturbed by the land-use activity but later rehabilitated, Search and Rescue should, as a minimum, concentrate on saving bulbs and succulents. General recommendations for Search and Rescue are provided in Chapter 4, and further advice can be obtained from CapeNature.



MAINLAND THICKET ECOSYSTEMS

Incorporating Thicket, Valley Thicket and Arid Thicket

Contributor: Douglas Euston-Brown

Snapshot of Mainland Thicket Ecosystems

Mainland Thicket Ecosystems form part of the Albany Thicket Biome which is more widespread in the Eastern Cape, but extends slightly into the Western Cape between Willowmore and Ladysmith, as well as inland of the Gouritz River valley, as far as Riversdale. The Albany Thicket Biome forms part of the Albany Centre of Plant Diversity and Endemism and is part of the internationally recognised Maputaland-Pondoland biodiversity 'hotspot.'

General characteristics

- Thicket comes in many different forms, but is most often made up of a dense tangle of shrubs, vines and small trees, many of them succulent (with succulent leaves or stems) or spiny. In some areas thicket is extremely dense (and impenetrable), forming an unbroken canopy over large areas (referred to as 'solid' thicket), whereas in other areas, it occurs in discrete clumps of thicket (bushclumps) scattered amongst a matrix of other kinds of vegetation, which could include fynbos, succulent karoo or grassy elements (this is referred to as 'mosaic' thicket).
- The main thicket vegetation type present in the Western Cape is Gamka Thicket, which is dominated by low-growing, sometimes open, succulent vegetation. In its pristine state, dense stands of spekboom (*Portulacaria afra*) occur, often in combination with *Euclea undulata*, *Pappea capensis*, *Searsia glauca* and other shrubs. The grass component is poorly developed, except after good rain.
- Mainland thicket occurs in areas with low, non-seasonal rainfall (100–540 mm per annum), and fairly frequent frost in winter.
- It occurs mostly on hillsides and in valley lowlands and is largely restricted to deeper, heavy (loamy-clayey) soils on Enon Formation conglomerates or shales.



- Important tree taxa include *Aloe ferox*, *Aloe speciosa*, *Vachellia karroo*, *Pappea capensis*, *Schotia afra* var. *afra*. Endemic taxa include the succulent shrub *Euphorbia gamkensis* and geophytic herbs *Eriospermum rhizomatum* and *Lachenalia haarlemensis*.

Conservation, land-use pressures and risks

Much of the area in which mainland thicket occurs is used as rangeland for grazing sheep and goats, and for game farms, with large tracts of vegetation cleared along river valleys for commercial cultivation of various crops. Although this is currently a Least Threatened vegetation type, with 9% of the historical extent conserved within nature reserves (Swartberg, Groenefontein and Gamkapoort), it is easily degraded by over-grazing (or excessive browsing), and is slow to recover.





What are the key ecological ‘drivers’ in terms of maintaining ecosystem function, pattern and structure?

The diverse floristic composition, unique structural characteristics and geographic distribution of thicket ecosystem types is determined by the complex interplay of several kinds of natural disturbance, principle amongst these being herbivory and fire. It is the interplay of these factors, overlaid by variations in rainfall, topography, soils and various plant-plant and plant-animal interactions that maintain the diverse and complex mosaic of vegetation types that makes up Albany Thicket. Key ecological drivers in these ecosystems include:

- **Herbivory:** Regular defoliation (browsing) by a wide range of herbivores has been an integral part of thicket evolution and is thought to have led, amongst other things, to the predominance of spiny plants that characterise most thicket vegetation types. Thicket represents the ‘back-bone’ resource for browsing animals in Southern Africa as it is a drought tolerant, reliable and enduring food source. Large herbivores (such as elephants, black rhinoceros and some of the larger ungulates) are important for maintaining the matrix habitat between thicket bush clumps, whilst small herbivores such as tortoises play an important role in influencing the abundance of low-growing succulents and geophytes through selective herbivory. It is possible that thicket in the Western Cape – which has lower concentrations of larger, naturally-occurring herbivores – has been less heavily influenced by herbivory, but many browsing animals such as kudu are known to make seasonal east-west migrations in response to regional, seasonal fluctuations in rainfall.
- **Fire:** Fire, and its interplay with herbivory, is an important driver in thicket ecosystems. Thicket is generally fire-resistant, but any alteration to natural fire regimes can have harmful effects on thicket ecosystems. Fires in adjacent habitats such as grassland, savanna and fynbos, are important for maintaining the thicket boundaries where thicket mosaics tend to develop. Solid or uniform thicket tends to be associated with topographically-determined fire refugia (fire-safe places such as deep kloofs, cliffs and scree slopes) or climatically-determined fire refugia, (which are those areas that are too arid to support flammable vegetation). Heavy grazing can reduce fuel loads, resulting in less intense, more slow-moving fires that allow the establishment and spread of thicket clumps. (Conversely, infestation by woody invasive alien species can increase both the frequency and intensity of fires, with harmful effects on thicket vegetation).
- **Rainfall:** Thicket occurs in landscapes with widely differing amounts of annual rainfall (anything from 290–950 mm per annum), but only occurs in areas where the proportion of winter:summer rainfall is approximately even, or where the proportion of annual rain falling in winter (April to August) is at least equal to or greater than 20%. The western limit of mainland thicket correlates closely with the transition to a higher proportion of winter rainfall, and dominance by vegetation characteristic of the Fynbos or Succulent Karoo Biomes.

Coastal thicket penetrates inland in the Western Cape only where the maritime influence on the climate ameliorates summer droughts.

- **Climatic variability:** Climatic extremes, including droughts, floods and heat waves, have little impact on thicket vegetation. This means that where thicket occurs in mosaics with other vegetation types (such as fynbos and succulent karoo), it provides an important buffer against these climatic disturbances. Thicket vegetation has, relative to other vegetation types, faster growth rates under current and increasing CO₂ levels, with arid thicket probably showing the highest resilience to climate change (though it is also the most vulnerable to over-grazing or heavy browsing). Relative to the other biomes in the Western Cape, thicket is probably the most resilient to climate change, which means that its persistence is critically important for the health and persistence of non-thicket ecosystems. It also means that, under predicted climate change scenarios, thicket has the potential, with time, to displace and encroach into neighbouring vegetation such as Succulent Karoo Shrubland.
- **Ecosystem engineers:** Spekboom (*Portulacaria afra*) has recently been referred to as an 'ecosystem engineer' because of the critically important role it plays in thicket restoration and promoting the recruitment of other thicket species. This characteristic thicket plant also resists droughts and floods and encroachment by fire from neighbouring landscapes dominated by grassland and savanna.
- **Seed dispersal by animals (especially birds):** Thicket has an abundance of plant species that bear fleshy fruits. Dispersal of these fruits and seeds by animals, especially birds, results in the development of bush clumps around solitary perch sites such as pioneer trees and termite mounds. Bush clumps enlarge and, depending on local site conditions, eventually coalesce into dense thickets.
- **Topography, geology and soil type:** Variations in these factors also drive diversity patterns and the distribution of thicket vegetation. Mainland thicket in the Western Cape is usually located at the base of Cape Fold Mountains, or in the intervening valleys. This correlates with a transition to a more arid climate and a change from sandstone to non-sandstone soils. Thus, thicket acts as a buffer or barrier between elements of the Fynbos Biome on the mountains and Succulent Karoo vegetation types on the drier hills and flats. Thicket is often also associated with and forms mosaics with renosterveld vegetation which tends to occupy similar habitats.

What are the main pressures and threats in these ecosystems?

- **Over-grazing:** Most thicket landscapes are used by commercial and subsistence farmers as rangelands for small domestic stock (especially goats). Over-stocking, combined with a lack of appropriate grazing management techniques over extended periods, has resulted in a large proportion of thicket landscapes becoming over-grazed, with many negative consequences, including severe soil erosion and loss of certain species. Aspects of over-grazing that are of particular concern include that:
 - In the more mesic areas, conditions of persistent overgrazing result in the invasion of thicket by indigenous woody shrubs (such as sweet-thorn, *Acacia karoo*, and honey thorn – or kriedoring. *Lycium oxycarpum*), especially where thicket interfaces with Nama Karoo and Succulent Karoo vegetation types. In drier areas, persistent over-grazing leads to the loss of desirable succulents, especially species such as spekboom, with many knock-on effects.



- Spekboom is an essential component of thicket. It plays a critical role in ecological succession processes, buffers habitats against the impacts of fire and is highly favoured by browsers. In thicket habitats in the Western Cape it is often the dominant species at the base of north-facing sandstone slopes. Over-grazing, especially by goats, in combination with drought, leads to loss of spekboom, with multiple impacts including the death of other plant species, loss of aerial cover and subsequent soil erosion. The loss of spekboom from the boundaries of thicket bushclumps lowers the resilience of the ecosystem to fire.
 - Over-grazing and wild fires in hot, dry conditions represent a significant threat to thicket. Although intact, healthy thicket is essentially unflammable, overgrazing of the succulent component (particularly the spekboom) results in the ecosystem becoming vulnerable to encroachment by woody shrubs (such as *Lycium* and *Rhus*) and C4 grasses. Encroached areas become more flammable, meaning that fires can then penetrate vegetation that otherwise never would have been exposed to fire (at least not in recent times). This can result in the elimination of fire-intolerant thicket species.
 - Many stock farmers actively burn thicket (or clear it) to improve the grazing potential of the land. This has reduced the extent and abundance of thicket patches in the landscape, especially those that occur in mosaics with renosterveld and fynbos vegetation on deeper and less nutrient-poor soils.
 - The introduction of non-indigenous (and extra-limital) game species may also have negative impacts on thicket vegetation, as the introduction of these species may upset the natural grazer/browser ratios, thus subjecting the habitat to excessive grazing or browsing pressure.
- **Clearing of thicket vegetation to make way for cultivation:** Large tracts of thicket vegetation have been cleared for cultivation of various crops, particularly in linear strips along fertile river valleys. This results in direct loss of thicket habitat, and fragmentation, with a subsequent loss of connectivity between remaining patches of intact thicket habitat. Issues of particular concern are that:
 - The loss of connectivity of thicket patches affects ecosystem function. Historically, thicket was more connected across the landscape than it is now. Habitat loss has resulted in a fragmented pattern that reduces resilience to environmental change and causes isolation of gene pools and the loss of gene flow within and between patches. Isolation due to human-induced fragmentation may result in some species losing their adaptive potential, increasing the risk of species or varieties becoming extinct.
 - Due to historical patterns of clearing of thicket patches to make way for agriculture, dune thicket may now provide the only connectivity between mainland thicket habitats that occur in inland-trending valleys. Various coastal land uses (such as the development of golfing estates) threatens to sever these surviving linkages.
 - Game fences prevent some animal and plant species from migrating, and may ultimately place their survival at risk.



- **Invasive alien vegetation:** Invasive species disturb ecological processes and biodiversity patterns in thicket vegetation types. Infestation by woody invasive alien species such as back wattle (*Acacia mearnsii*), rooikrans (*Acacia cyclops*) and guava (*Psidium guava*) occurs in disturbed areas. These species out-compete the indigenous flora and increase fuel loads. The presence of invasive woody species in adjacent fynbos vegetation increases the severity of fires and the likelihood of fire penetrating thicket at the fynbos/thicket boundary.

What are the non-negotiables?

- Avoid over-grazing in valley or arid thicket, as these ecosystems are at risk of being irretrievably lost if unsustainable grazing pressure persists.
- Avoid the introduction of extra-limital, non-thicket game species (and remove extra-limital species where they have previously been introduced).
- Avoid fragmenting patches of intact thicket. Where fragmentation has occurred, set aside corridor areas of intact habitat to reconnect the patches.
- Avoid allowing land uses to impact on transitional or boundary areas where thicket adjoins or forms mosaics with other vegetation types associated with other biomes (Fynbos or Succulent Karoo). These boundary areas accommodate the highest levels of biodiversity and require special conservation measures.
- Retain appropriate grazer-browser ratios in game species, as well as the required fire regime, for maintaining the vegetation in an optimum ecological state. Many of the mosaic thicket vegetation types are maintained by a fine balance between specific fire and grazing regimes.
- Avoid disturbance to riparian areas, on steep slopes and in valleys where thicket vegetation is present.
- Avoid disturbance to rocky outcrops, geological/soil type boundaries and islands where thicket vegetation is present.
- No surface or ground water abstraction should be allowed if it might impact on thicket vegetation. Groundwater abstraction must also be monitored for impacts on biodiversity and ecosystem function.

What are the critical things to maintain for biodiversity to persist?

- Maintain all remaining intact thicket fragments across the range of mainland thicket vegetation types to help buffer against the impacts of climate change.
- Rehabilitate corridors that connect isolated patches of intact mainland thicket. Corridors are especially effective measures for conserving thicket because they enable the persistence of natural patterns of seed dispersal (in bird-dispersed species) and herbivore migration.
- Maintain natural mosaic patterns and minimum viable patch sizes. Establishing the minimum viable patch size and isolation distances between thicket patches, or the structure and maintenance of the mosaic pattern, all require detailed, on-site assessments at $\leq 1:5\ 000$ scale. Only fine-scale, detailed analysis of present and past thicket distribution patterns can determine minimum viable patch sizes.



- Maintain natural disturbance regimes through integrated management of fire and grazing and drought. Current climate trends might allow thicket to encroach into and displace less-resilient neighbouring vegetation types, so maintaining the mosaic patterns will become increasingly important to preserve biodiversity patterns at the landscape scale.
- Certain patches of thicket, especially solid, non-mosaic vegetation types, require total protection from fire. Fire and infestations of invasive alien plants must, therefore, be managed in the adjacent, non-thicket, ecosystems. Never allow adjacent 'fire-adapted' vegetation types (such as fynbos) to remain unburnt for longer than 30 years, or to become infested with woody alien invasive species. Degraded solid thicket should be prioritised for restoration.
- Maintain the appropriate fire regime in terms of fire frequency and seasonality in fire-prone thicket types.
- Ensure that planting of spekboom (as a restoration measure) only happens in areas where this species occurs (or occurred) naturally - consult with an experienced plant ecologist to obtain this information. Most areas will not be suitable for planting spekboom and it could have a negative impact on naturally-occurring species if spekboom is introduced.
- Keep thicket patches and their surrounds free of invasive alien vegetation.

What are the best spatial approaches (at a landscape level) to avoid or minimise impacts and risk in these ecosystems?

- Prevent further fragmentation of thicket and, where possible, reconnect intact expanses of thicket. Modification of thicket habitat should never be allowed to sever intact thicket patches or connecting corridors, and rehabilitate degraded corridors connecting mainland thicket patches.
- Boundaries between thicket and non-thicket biomes must be maintained by avoiding artificial disturbances in these areas, but natural disturbance regimes – such as those related to herbivory and fire – should be maintained.
- Manage grazing carefully (with attention paid to stocking rates and rotation) and ensure that grazing management is well co-ordinated with fire management, clearing of invasive alien species and other aspects of land management (such as measures for avoiding soil erosion) across the landscape. This is critically important for effective conservation of thicket habitats.
- The boundaries of conservancies and other land management initiatives should be organised to incorporate the natural fire zone, or broader ecosystem or habitat unit for that particular region.

What indicators should be used to assess and monitor ecosystem health?

- The presence and percentage cover of spekboom is an important indicator of ecosystem health. Most arid and valley thicket types should have a relatively high cover of spekboom when they are in a healthy state. In particular, healthy thicket patches should have spekboom present at their boundaries, as this protects the vegetation within the bushclumps from fire. The absence of spekboom, usually as a result of over-grazing, indicates, poor ecological condition.
- Monitor mortality rate of adult trees during drought periods. Death of adult trees during drought periods indicates thicket that is in poor ecological condition.
- Monitor encroachment of thicket into the surrounding matrix vegetation in thicket-mosaic vegetation types. The presence of a distinct boundary between thicket patches and the adjacent vegetation types (such as fynbos or succulent karoo) will indicate healthy ecosystems. Thicket clumps should only coalesce and displace adjacent vegetation types in prescribed areas where solid thicket previously occurred and not in areas where mosaic vegetation types are found.
- The presence and density of invasive alien species, or the extent of invasion by weedy but indigenous woody species, should be monitored, with a low density (or absence) of these species indicative of healthy thicket ecosystems.



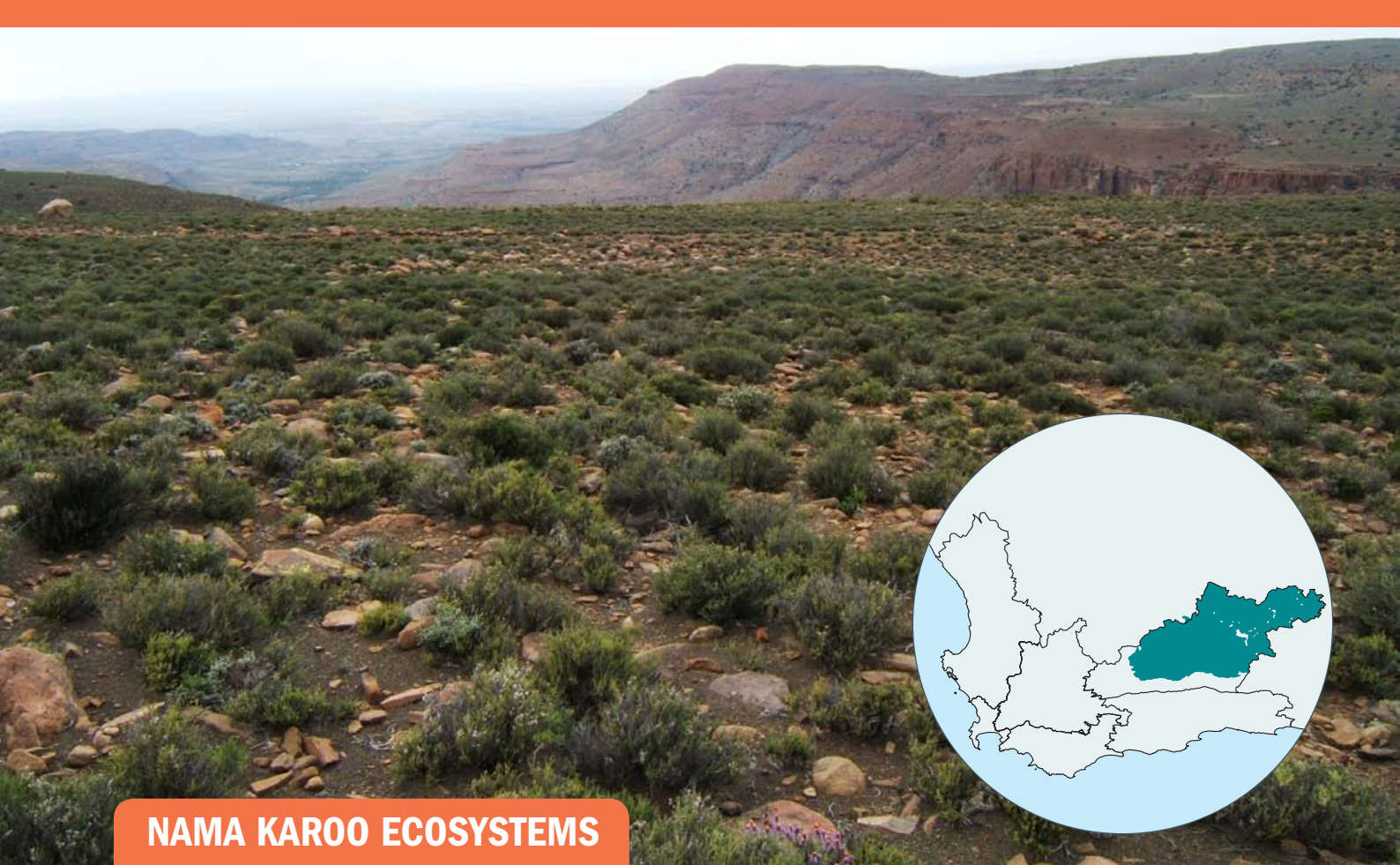
- Changes in the presence and density of succulent species, especially in arid thicket vegetation types, indicate a change in ecosystem health. A decline in the proportion of succulents may indicate declining ecosystem health, usually as a result of persistent over-grazing.
- In thicket-mosaic vegetation types, monitor signs that appropriate fire intervals and management are being applied. If fire is absent from mosaic vegetation types for longer than the prescribed period, then targeted burning will be required to prevent a deterioration in ecosystem health.

How reversible are impacts within a period of 5 to 10 years?

- Impacts may be reversible in areas where rainfall is higher (i.e. closer to the coast or in topographically-induced areas), but the restoration process will be extremely slow (longer than 10 years) and costly.
- In more arid thicket vegetation types, impacts such as over-grazing or cultivation are probably irreversible over short time scales, but could be reversible at a 100-year time scale.
- Restoration by planting of rows of spekboom truncheons across large areas (of about 3 500 ha) has been done in the Eastern Cape. It is possible that in the long-term this could promote thicket recovery and if so this method could be used in the Western Cape.

What are acceptable compensation measures or offsets for biodiversity loss?

- Restoration of degraded thicket should be a mandatory condition for authorisation of any application for land-use change in this at-risk biome. Never underestimate the restoration potential and importance of thicket in areas where it used to occur.
- The identification of acceptable offsets for biodiversity loss in spatial planning and authorisation of EIAs should require the compilation of detailed 1:5 000 maps depicting fine-scale biodiversity patterns and their extent of modification. These maps will facilitate proactive consideration of the impact of any proposed land-use change (and its associated disturbance of natural habitat) on fine-scale variation patterns and capacity to meet biodiversity targets for thicket vegetation types.



NAMA KAROO ECOSYSTEMS

Incorporating bedrock, sandy & stony plains, pans and dry river systems

Contributors: Sue J. Milton & W. Richard J. Dean

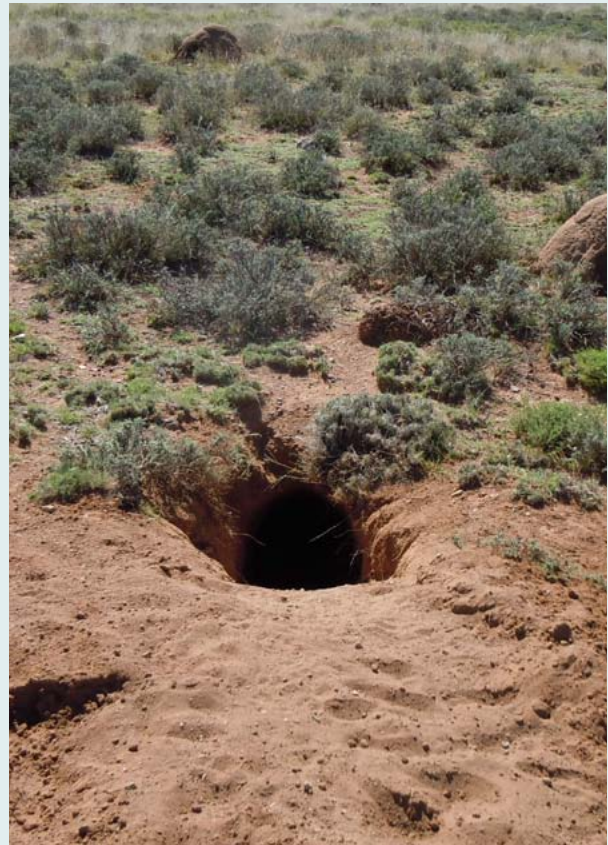
Snapshot of Nama Karoo Ecosystems

The Nama Karoo Biome occupies much of the central plateau of the western half of South Africa, extending approximately 500 km north-south (from Aggeneys to Leeugamka) and west-east (Middelpos-Middelburg). It borders on Succulent Karoo to the south-west, arid Savanna to the north-west, and the Grassland Biome to the east. Elements of these biomes increase towards the boundary zones. In the Western Cape, Nama Karoo occurs mainly in the Central Karoo District Municipality in which it is the dominant ecosystem.

General characteristics

- Nama Karoo is a semi-desert landscape, dominated by deciduous, low shrubland, mixed with succulents and grasses, and scattered trees along water courses and on rocky hillslopes. Plant community composition changes with altitude, which ranges from about 600 m to 1 800 m above sea level. Vegetation on south-facing slopes tends to be more shrubby and less palatable to game and livestock than the more grassy vegetation on warmer north- and west-facing slopes. At higher altitudes, where frost is frequent in the winter, succulent plant species are limited to northern and western slopes. Grasses tend to be more common in depressions and on sandy soils, with the north-eastern Nama Karoo being grassier than the south-western region in most years, owing to the greater amount of rain falling in the north-east.
- Of the 15 vegetation types recognised in the Nama Karoo Biome, 5 occur within the boundaries of the Western Cape. Highly variable azonal vegetation (known as Southern Karoo Riviere) is found along the drainage systems.
- Low rainfall (100–520 mm per annum) falls mainly in summer, with areas in the north-east receiving more rain per year than those in the south-west. Summers are extremely hot, and winters are cold with frequent frost and snow falling on mountain peaks in winter.

- Skeletal soils derived from mudstones or dolerite are the most common substrate in Nama Karoo ecosystems, but deep wind-blown sand, dunes, clay pans, and outcrops of calcrete and exposed bedrock sheets and domes also occur. Each of these substrate types supports characteristic animals and plant communities that vary in composition, structure and palatability to herbivores.
- The Aardvark (*Oryctoropus afer*) and its food species (termites and ants) are considered to be keystone species in the Nama Karoo. The burrows that aardvarks dig are later used by numerous other species that are unable to dig their own burrows in rocky ground. Beneficiaries include Porcupine, Bat-eared and Cape Fox, South African Shell Duck, honeybees, Ant-Eating Chat and many others.
- The relatively few known endemic plant species in the Nama Karoo are largely restricted to high altitude Karoo and are associated with exposed rock habitats. They include *Aloe chlorantha*, *Aloe longistyla*, dwarf succulents *Stomatium suaveolens*, *Adromiscus humilis* and a few geophytes (*Gethylis*, *Lachenalia*, *Ornithogalum*).



Conservation, land-use pressures and risks

- Most of the vegetation types in Nama Karoo are currently categorised as Least Threatened, but they are also mostly unprotected or poorly protected.
- Much of the area is used as rangeland for sheep and goats, with commercial cultivation of olives, citrus and deciduous fruit taking place in river valleys. Mining and quarrying, ploughing (resulting in erosion), loss of riverine habitat, overgrazing, over-harvesting, infestation by alien invasive plant species (such as *Prosopis* and *Tamarix*), and the installation of infrastructure (wind farms and solar energy plants, roads, 4×4 tracks) are all placing Nama Karoo ecosystems in the Central Karoo District Municipality under increasing pressure. It is also anticipated that the likely impacts of shale gas fracking will be significant and negative.

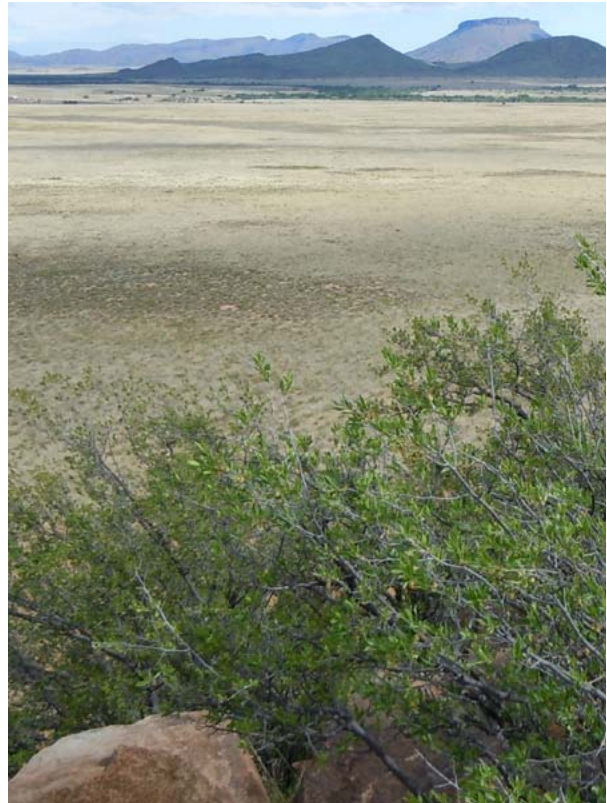




What are the key ecological ‘drivers’ maintaining ecosystem function, pattern and structure?

- **Latitude and longitude:** The Nama Karoo is a vast inland area extending approximately 500 km north-south (Aggeneys to Leeugamka 28°-33°S) and west-east (Middelpos-Middelburg 18°-26°E). It borders on Succulent Karoo to the south west, arid savanna to the north-west, and grasslands to the east. Elements of these vegetation types increase towards the boundary zones.
- **Altitude:** Altitude in the Nama Karoo ranges from around 600 m (Leeugamka, Beaufort West) to 1800 m (Middelburg). Lower altitude areas experience higher summer temperatures, whereas the frequency of winter frost and snow increase with altitude. Plant community composition changes with altitude.
- **Aspect:** Vegetation on south-facing slopes tends to be more shrubby and less palatable to game and livestock than the more grassy vegetation on warmer north- and west-facing slopes. At higher altitudes, where frost is frequent in the winter, succulent plant species are limited to northern and western slopes.
- **Substrate:** Skeletal soils derived from mudstones or dolerite are the most common substrates in Nama Karoo ecosystems. Less common substrates are deep wind-blown sand, dunes, clay pans, and outcrops of calcrete, evaporite and exposed bedrock sheets and domes. Each of these substrates supports characteristic plant communities that vary in composition, structure and palatability to herbivores. Sandy soils are dominated by grasses in even the most arid parts of the region, whereas the grass component on fine-textured soils depends on adequate summer rainfall. The distribution of burrowing invertebrates (spiders, scorpions, cicadas) and rodents (gerbils, whistling rats), reptiles that need thermal refuges, and ephemeral aquatic organisms (brine shrimp, frogs) are determined by substrate attributes such as soil texture, soil stability, horizontal cracks in rocks and hollows in rocks.
- **Drainage:** Few perennial rivers, but many large, dry water courses run through Nama Karoo ecosystems. At altitudes below 1 200 m these support woodland corridors dominated by trees of 4–6 m in height (*Vachellia karroo*, *Searsia lancea*) with an understorey of fleshy-fruited shrubs (*Diospyros*, *Lycium*, *Searsia* spp) and grasses. At higher altitudes woody shrubs are limited to rocky gullies, and the water courses, springs and marshes (*kuile*) are dominated by reeds and grasses.
- **Inclination:** The flat plains of the Nama Karoo are broken by the Great Escarpment to the south, by ‘spitzkoppe’ or conical hills formed by weathering of mudstones, and by ridges and ‘saai-koppe’ where weathering has exposed hard, rocky dolerite intrusions. Steep slopes that cross bands of horizontal mudstones differing in texture may support banded vegetation. Instability on steep slopes results in rocky scree colonised by bird-dispersed shrubs that establish in shaded, frost-free micro-sites among boulders.

- **Rainfall:** Rainfall is one of the key drivers in Nama Karoo ecosystems. Both mean annual rainfall and the component of the rainfall falling in summer increase from the south-west to the north-east of the Nama Karoo. As summer rainfall is a major driver of grass cover and species richness, the north-eastern Nama Karoo is grassier than the south-western region in most years.
- **Drought:** Drought, or a series of years receiving rainfall well below average for the area, is characteristic of the Nama Karoo. Drought events lead to reduction in density and cover of paucennial and herbaceous plants (including grasses, weedy Mesembs, *Chrysocoma*, *Pentzia incana*). Drought mortality reduces competition so that abundant plant recruitment generally follows drought-breaking rains. Droughts lead to episodic changes in vegetation composition. The composition of the new vegetation will depend on the soil seedbank and the seed produced after the drought by the remaining plants.
- **Fire:** Fire is rare in the south-western Nama Karoo but increases in frequency towards the north-east. Most grasses, but only a few Karoo shrub species, re-sprout after fire. Shrub recovery from seed is slower than grass recovery by re-sprouting so that grass will dominate the veld for a few years after a fire. Fire followed by drought or grazing during the recovery phase leaves the veld vulnerable to soil erosion, particularly on steep slopes.
- **Hail:** Hail storms are associated with convectional rain in summer. Although infrequent and spatially patchy, hail defoliates, debarks and sometimes kills shrubs, making way for vegetation change. The density of re-sprouting shrubs or grasses increases during the recovery period of hail-damaged vegetation patches.
- **Browsing and grazing:** Browsing and grazing by domestic livestock and other large herbivores is always selective. Toxic plant species are avoided and less-defended species (such as those with fewer thorns) are selected. Where herbivory is more frequent than the time required for a plant species to re-grow, flower and seed, that species will decrease in cover and abundance over time, being replaced by less palatable plant species following rainfall sequences that favour germination and recruitment. In this way, herbivory leads to vegetation changes such as the replacement of one long-lived plant species by another. Such changes are costly or impossible to reverse.
- **Ecosystem engineers:** Animal species that alter substrates, creating structures or micro-sites suitable for plants or other animal species, are known as ecosystem engineers. In Nama Karoo ecosystems the most significant of these is the aardvark. The large burrow systems they dig for shelter are later used for dens or nest sites by porcupines, foxes, jackals, aardwolves, mongooses, South African Shelduck, Ant-eating Chat, and honey bees. As none of these species can dig their own burrows, all are dependent upon the presence of aardvark. The burrow systems of Whistling Rats (*Parotomys* spp) provide shelter for elephant shrews, snakes and geckos. Foraging digs by aardvarks and porcupines are micro-sites for seedling establishment.
- **Seed dispersers:** Frugivorous birds (mousebirds, bulbuls, Pied Barbet), and many insectivorous and omnivorous birds include fruit in their diets (bustards, crows, scrub robins, thrushes, warblers), and disperse the seeds of *Lycium* spp., *Thesium* spp., mistletoes and other fleshy-fruited plants to perch sites on termitaria, fences, and trees. Mammals including Bat-eared Fox and Black-backed Jackal, Vervet Monkey and Chacma Baboon are important dispersers of the larger fruits such as *Diospyros* species to drainage lines and scree slopes. Leopard Tortoises move seeds of herbaceous plants to moist sites, and plants adapted for dispersal on fur (*Setaria verticillata*) are dispersed by animals that rest and shelter in shady riparian habitats.



What are the main pressures and threats in these ecosystems?

- Ploughing:** Ploughing of the few deep soil habitats on the floodplains of major water courses has resulted in soil erosion, alteration of drainage patterns and salinization. It has also largely destroyed the habitat of the Riverine Rabbit. Rapid runoff from denuded alluvium contributes to flash flooding that uproots large trees in river beds.
- Inappropriate grazing practices:** Poor grazing practices can cause local extermination of palatable plant species (leading to an increase in long-lived toxic plant species), or a loss in vegetation cover (leading to accelerated soil erosion). Such practices pose a major long-term threat to the Nama Karoo ecosystem because the changes they cause are so costly and difficult to reverse over large areas.
- Roads for prospecting, 4×4 trails and lifestyle/tourism farms:** Uncontrollable soil erosion and defacing of the landscape is being caused by the current practice of making roads around perimeter fencing regardless of the gradient or soil type, developing 4×4 trails to view sites at the top of steep ridges, developing grids of tracks for uranium prospecting and using a scraper blade to clear all vegetation and stones from road surfaces.
- Open cast and adit mining for uranium:** This type of mining activity is likely to increase in the Nama Karoo over the next two decades because Peninsula Energy (Australia) holds the mining rights for many farms in the Nama Karoo. The impacts associated with uranium mining include: the development of new roads; irreparable damage caused by box-cut, open cast mines in bedrock; tailings dumps; water abstraction and the storage and transport of radioactive ore. Impacts that must be minimised or mitigated are vegetation removal, damage to animal refuges in bedrock habitats, and possible surface and subsurface water pollution.
- Shale gas prospecting and production activities:** These activities are likely to place the health and survival of Karoo ecosystems at great risk over the next five decades. Activities include road construction, gravel mining, sand mining, water abstraction, increased road transport, vegetation removal, increased movement of dust and soil by wind and water, construction of slimes dams, high noise levels, transport and storage of fuel, chemicals, produced water, and radioactive materials. Ecological impacts are likely to include loss of plant and animal habitat specialists, contamination of soil and surface water, possible changes in surface water availability or quality, habitat fragmentation, increased road kills, soil erosion, disruption of breeding in disturbance-sensitive bird species, and increased infestation by invasive alien plant species.
- Installation of solar power facilities:** Solar power facilities are planned to cover many thousands of hectares in the Nama Karoo. Activities associated with the construction of such facilities include: vegetation clearance, installation of panels, site offices, roads, substations and overhead high voltage cables. Impacts are likely to include increased soil erosion, infestation by invasive alien plants, bird strikes, local reduction in populations of ground-dwelling vertebrates and invertebrates and less mobile vertebrates (tortoises and other reptiles).
- Installation of wind energy facilities:** Activities associated with the construction of wind energy facilities include vegetation clearing for foundations and 'lay-down' areas, construction of roads and wind generators with rotating blades, substations and overhead high voltage cables. Impacts include soil erosion, infestation by invasive alien plants, and increased mortality of large birds and bats striking the propellers or overhead cables.
- Quarrying and mining for road materials:** Quarrying for materials including hard rock, gravel, calcrete and silica sand are likely to increase to serve the needs of construction, road building and fracking. These activities all involve clearing of natural vegetation, excavation and alteration of micro-topography and local hydrology. They pose risks



for plants that are substrate specialists associated only with calcrete, sand or bedrock. Colonisation of such sites by invasive alien plants and dassies (*Procavia capensis*) following mining usually delays or prevents recovery of the vegetation.

- **Clearing of roadsides and servitudes:** Clearing of vegetation along roadsides and power-line routes makes Nama Karoo ecosystems vulnerable to infestation by invasive alien trees (*Prosopis* sp., *Tamarix ramosissima*), grasses (*Bromus* spp., *Pennisetum setaceum*), herbaceous weeds (*Cirsium*, *Argemone*, *Salsola kali*) and Cactaceae (*Tephrocactus*, *Opuntia*).
- **Game fencing and fencing that includes electric circuits:** This type of fencing is becoming more frequent in the Nama Karoo where it is used to contain game, exclude jackal and reduce stock theft. By inhibiting faunal movement or killing some animals (tortoises), fences fragment terrestrial mammal populations that have large home ranges and low population densities. This may lead to inbreeding and increased population vulnerability to factors such as disease and climate change.
- **Alteration of faunal composition:** These changes which are brought about through persecution of predators, introductions of extra-limital game, and reintroductions of nomadic game to fenced farms with permanent water, may all disrupt the ecological integrity of Nama-Karoo ecosystems. In particular:
 - Removal of medium-sized predators such as caracal and Black-Backed Jackal from Nama Karoo ecosystems has been shown to lead to an increase in small mustellid predators (such as Striped Polecat, Grey and Yellow Mongoose) that, in turn, reduce the breeding success of ground-nesting birds. Contained game, particularly Springbok, can lead to rapid changes in vegetation composition.
 - Plant and animal habitat specialists such as the Riverine Rabbit, various scorpion and trap-door spider species with special substrate needs and poor mobility, and succulents such as *Neohenricia* and *Stomatium suaveolens* that are confined to cracks in exposed bedrock, are vulnerable to disturbance.
- **Slow recovery rates:** Nama Karoo vegetation is slow to recover from clearing or grazing because conditions for recruitment are infrequent and because few long-lived and dominant plant species (whether they are tree shrubs such as *Rhigozum obovatum*, dwarf shrubs such as *Euryops* and *Pteronia* or bulbs such as *Boophane* and *Ammocharis*), maintain seed banks.
- **Over-exploitation of plant resources:** Over-harvesting of plant resources for medicinal purposes (*Boophane*), and firewood (*Searsia* spp, *Vacehllia karroo*) causes changes in the structure and composition of vegetation in the vicinity of settlements. In turn, these changes are likely to lead to changes in the avifauna. Should human populations in Karoo villages increase greatly in response to employment opportunities related to mining (and other infrastructural developments), these resources may come under greater harvesting pressure.





What are the non-negotiables?

- Limit physical disturbance of the vegetation, for ploughing, mining, roads or construction, to the minimum as most Nama Karoo plant communities recover very slowly, if at all, after disturbance.
- Limit ploughing of alluvial soils to sites where sustainable crop production is likely. Abandonment of ploughed alluvium leads to soil erosion, salinization, habitat loss and infestation by invasive alien plants as well as loss of the flood attenuation services provided by natural vegetation.
- Follow the recommendations of the Department of Agriculture and CapeNature for grazing by domestic stock and game species.
- Minimise vehicle access, particularly on steep slopes, as this causes accelerated erosion of skeletal soil that is difficult to control.
- Determine baseline data for ground- and surface water quality; abstraction of ground and surface water should be controlled and carefully monitored.
- No land-use activities should take place in a pan, or within 200 m of a natural fountain, major drainage line, river or water course or artesian water supply. This includes mining, fracking, establishment of renewable energy facilities, and storage facilities for fuel, contaminated water and tailings.
- Under no circumstances should invasive alien plant species be used to re-vegetate degraded areas. This includes species such as. Ouman Soutbos (*Atriplex nummularia*), Mesquite (*Prosopis* sp), Prickly Pear (*Opuntia ficus-indica*), Tree Lucerne (*Cytisus proliferus* syn. *Chamaecytisus palmensis*), and Fountain Grass (*Pennisetum setaceum*).
- Wind farms should never be situated within 100 m of cliff faces, rock shelters or caves as proximity to flight-paths and nest sites of raptors, other cliff-nesting birds and bats as this will greatly increase bird strikes.
- Roadside vegetation should not be 'skoffelled' or poisoned as this promotes infestation by invasive alien plant species.
- Treat uncommon substrate types (such as calcrete outcrops), bedrock exposures, clay pans and seeps or marshes as sensitive habitats. All habitats including concentrations of threatened and rare or locally endemic plant species should be considered as 'no-go' areas for land-use activities. Significant, viable populations of such species should not be lost to any kind of land-use development.

What are the best spatial approaches (at a landscape scale) to avoid or minimise impacts and risk in these ecosystems?

- Avoid siting land uses on rocky outcrops, and ensure that these are adequately buffered in land-use plans.
- Avoid prospecting, mining and storage of tailings or stockpiles on exposed bedrock and limestone as this is likely to cause irreversible damage.
- Avoid seasonal pans, marshes, alluvium or riparian areas, and give these areas large buffers (preferably a minimum of 200 m wide) when planning any infrastructure development, construction of storage facilities or roads, or crop production.
- Maintain ecological connectivity between habitat and substrate patches and along major riparian corridors.
- Avoid routing powerlines near pans and cliffs as these are used by large birds that are vulnerable to being killed if they collide with cables. Add flappers or other high visibility devices to cables on flight paths.
- Avoid placing wind generators near pans or on known flight paths of large birds or bat colonies.
- Wherever possible, use disturbed or degraded environments for any impacting land-use activity or infrastructural development.

What are the critical things to maintain for biodiversity to persist?

- Minimise disturbance to natural vegetation.
- Maintain exposed bedrock and calcrete outcrops that are habitats for rare plants and that provide shelter for specialized fauna.
- Maintain intact vegetation on steep slopes to limit soil erosion. Avoid running tracks, roads and powerline servitudes up steep slopes so as to prevent soil erosion.
- Retain indigenous fauna and their migration and movement corridors.
- Retain natural vegetation in pans and floodplains. Do not overgraze wetlands or locate renewable energy facilities or mines in or near wetlands or pans. Wetlands are particularly important in arid areas due to their rarity.
- Retain trees (*Searsia*, *Vachellia*), tree shrubs (*Carissa*, *Diospyros*, *Grewia*, *Euclea*), aloes (*Aloe broomii*, *A. claviflora*, *A. longistyla*, *A. variegata*) and bulbs as these are long-lived but slow-growing plants that supply critical food (nectar, fruit) and shelter to birds and other animals.

What indicators should be used to assess and monitor ecosystem health?

- The presence of viable populations of threatened, rare and locally endemic species (with young and old individuals in the population) – with benchmarks to be established by a specialist.
- The presence of old and young individuals of palatable perennial shrub and grass species, especially near water and on footslopes, indicates a healthy ecosystem. Dominance by unpalatable species (such as kraalbos (*Galenia africana*), bitterbos (*Chrysocoma ciliata*) and some harpuis/rapuis (*Euryops species*) as well as annual grasses (*Enneapogon desvauxii*, *Eragrostis lehmanniana*) is usually indicative of selective overgrazing.
- Absence of invasive plant species indicates ecosystem health. Invasion of mesquite (*Prosopis* sp.), cactus (*Opuntia*,



Echinopsis) thistles (*Cirsium* spp., *Argemone* spp.) and alien annual grasses (*Bromus* spp.) indicates past ploughing, overgrazing or physical disturbance.

- Minimal soil erosion especially on steep slopes is a healthy sign. Dongas, rills and sheet erosion, exposed plant roots and pedestalled stones indicate an unstable, eroding and disturbed landscape.
- The presence of predators (leopards, jackal, caracal) and other native “keystone” mammal species, such as aardvark, are signs of normal ecosystem functioning. Absence of these animals may indicate either removal or a shortage of prey caused by ecosystem degradation.
- Presence of trapdoor spiders, insectivorous birds and tortoises indicates intact food chains and adequate vegetation cover.
- Vegetated floodplains are indicative of a healthy ecosystem, whereas bare, saline (puffy) soils and bare ground on flood plains indicates past disturbance, instability and low productivity.

How reversible are impacts over a period of 5 to 10 years?

- Disturbances to the vegetation and soil generally take decades to recover in arid areas.
- The most resilient Nama Karoo habitats are deep sandy plains dominated by a few species of perennial grasses. These communities are likely to recover within a decade provided that the physical and chemical structure of the soil has not changed. Sand dunes, unlike plains, are likely to be destabilised by disturbance and clearing, and should be regarded as sensitive habitats.
- Vegetation cover will return to most stony plains within one decade of vegetation clearing provided that rehabilitation includes topsoil replacement, reseeding, erosion control and herbivore exclusion for at least one year. Nevertheless, as for Succulent Karoo (see Helme, 2014), many plant and animal species do not return to the ecosystem within this time frame. Return of long-lived plant species to disturbed sites is limited by seed availability because seeds survive for less than one year and have poor dispersal abilities. Such species include wildegarnaat (*Rhigozum obovatum*), bietou (*Tripteris* spp.) and other shrubs (*Euryops*, *Eriocephalus* and *Pteronia* species), aloes, and large-seeded geophytes (*Amaryllids*). Rainfall sequences and soil water retention will also affect the recovery time and trajectory.
- Stable bedrock habitats that have been shattered can never be reconstructed, as it is the very stability of the habitats, and the micro-sites provided by the rock cracks, to which specialised plants, reptiles (including two tortoise species endemic to Nama Karoo, *Homopus boulengeri*, *H. femoralis*) and invertebrates are adapted.
- Soil erosion and vegetation loss caused by linear disturbances, such as roads running downslope, is difficult to reverse and tends to accelerate over time because of episodic high rainfall interspersed with droughts that prevent vegetation recovery.





- Return of palatable species to extensive overgrazed areas may take centuries because the process is limited by a combination of seed availability, competition from long-lived unpalatable species, and rare occurrence of rainfall sequences that favour germination and recruitment.

What are acceptable compensation measures or offsets for biodiversity loss?

- Loss of undisturbed natural vegetation must be compensated for by an increase in the extent of statutory conservation areas in priority areas such as vegetation types that are below their biodiversity targets, and dispersal corridors that cross steep altitudinal, geological and rainfall gradients.
- Primary mitigation should involve complete avoidance of all particularly high-sensitivity habitats, such as wetlands, pans, rocky outcrops, alluvium and steep slopes.
- In all cases, the topsoil (ideally the upper 100 mm, as most soils are skeletal and seed banks are shallow) should be removed before an area is disturbed, and replaced as soon as possible, ideally within three months. Long term storage of topsoil is not desirable as it will result in mortality of material in the stockpile.
- In the case of rocky environments, broken rocks should be replaced in heaps rather than evenly spread. Rock piles provide micro-sites that shelter small mammals and reptiles and also attract birds that bring seeds of appropriate fleshy-fruited shrubs.
- Compacted surfaces should be ripped to facilitate seed trapping and water penetration and to provide micro-sites that are sheltered from sun, wind and frost.
- In the case of borrow pits and depressions made by excavation and mining, runoff water should be directed away from the depression and back to the nearest water course. Inundation of hollows prevents revegetation, deprives drainage lines of water, and facilitates invasion by alien plant species.
- Erosion control measures should be implemented on denuded slopes and water management is essential following closure of roads, paths and tracks on gradients. A combination of berms (barriers), replacement of rocks and reseedling is recommended.
- Livestock and game should be fenced out of areas requiring rehabilitation and excluded for up to ten years after the initiation of the rehabilitation phase, because repeated grazing reduces plant growth, seeding and recruitment.
- Search and Rescue is relevant for certain large geophytes (*Ammocharis*, *Boophane*), Aloes and some *Euphorbia* spp. in the Nama Karoo, but cannot be applied to woody species. As is the case in all other ecosystems, a specialist botanical report must provide recommendations on rescue techniques and the relevant provincial conservation body should endorse the sites to which these plants are translocated.



FORESTS

Contributed by: Tony Rebelo

Snapshot of Forest Ecosystems

The term 'forest' has many interpretations, but in these *Guidelines* it refers to indigenous natural forests and not commercial timber plantations or stands of woody invasive alien species. Natural forests are made up of multiple layers of indigenous evergreen or semi-deciduous trees that form a closed canopy (with a crown cover of 75% or more).

In the Western Cape, forests occur on sheltered seaward slopes, coastal scarps and plateaus, old stabilised dunes and limestone outcrops, in small patches along the coast from Nature's Valley in the east, as far west as Llandudno on the Atlantic seaboard of the Cape Peninsula. They also occur in niche habitats throughout the Cape Fold Mountains, as well as on Table Mountain, in fire-safe localities such as at the base of south-facing slopes, in narrow gullies and open kloofs, along the banks of perennial water courses and on rocky screes. Although forests account for a rather small proportion of the vegetation cover of the Western Cape, they represent an important habitat in the broader fynbos-forest-thicket mosaic, along the coastline in particular.

General characteristics

- There are two main types of forest in the Western Cape: Southern Afrotemperate Forest, and Southern Coastal Forest (which often used to be called Western Cape Milkwood Forest). Although they differ in terms of structure and species composition, these forest vegetation types are generally similar in their ecology.
- The most extensive areas of Southern Afrotemperate Forest occur in the Knysna-Tsitsikamma Region at the eastern boundary of the Western Cape. These forests are dominated by a mixture of tall (up to 30 m) canopy tree species including yellowwoods (*Podocarpus latifolius* and *Afrocarpus falcatus*), ironwood (*Olea capensis* subspecies *macrocarpa*), stinkwood (*Octoea bullata*) and white pear (*Apodytes dimidiata*). There is a well-developed understorey of sub-canopy species, with a well-defined shrub layer and an herbaceous layer made up of ferns, bulbous plants, wild irises and various soft-leaved herbs. Lianas and epiphytes are also present and in damp areas tree ferns may occur. On scree slopes the forest tends to be more stunted and gnarled, with a slightly different mix of species and a more poorly-developed understorey and herbaceous layer.



- Southern Coastal Forest is a more low-growing forest type that occurs in small patches along the coast in areas where soil and moisture conditions are suitable and where there is protection from fire. It is dominated by White Milkwoods (*Sideroxylon inerme*), with Wild Camphor (*Tarchonanthus camphoratus*), seegwarrie (*Euclea racemosa*) and candlewood (*Pterocelastrus tricuspidatus*) as sub-dominants. In the east, species such as White Stinkwood and the Confetti Tree (*Nuxia floribunda*) tend to be more abundant. The understorey in milkwood forest is generally poorly developed.
- At forest edges, numerous pioneer species, stunted thicket species and sclerophyllous shrubs (including fynbos elements) form an ecotone between the forest and the surrounding vegetation types.

Conservation, land-use pressures and risks

- All forests are protected by law in South Africa, but, because of their high edge-to-area ratio they are still vulnerable to impacts resulting from a variety of land uses in adjoining areas. Forest patches are vulnerable to edge effects that may disrupt the ecological integrity of the ecotone at the forest boundary. Conserving the ecological integrity of these forest patches cannot be achieved in isolation: a landscape approach that includes the fynbos and thicket areas around the forests is essential. This allows the mammals and birds that disperse forest seeds, maintain gap processes for succession and maintain gene flow within and between forested areas, to persist.
- Invasion by alien vegetation represents one of the greatest risks to the integrity of coastal forests, followed by land uses such as coastal resort development that hold the potential to disrupt connectivity between forest patches.





What are the key ecological ‘drivers’ maintaining ecosystem function, pattern and structure?

- The succession pathway of forest regeneration:** This is a complex, multi-faceted process that is critical for maintaining species composition and community structure in forest patches, and for enabling forest regeneration at disturbed sites. Important components of the succession pathway include seed dispersal, seedling recruitment and the creation of regeneration opportunities:
 - Seed dispersal:** The mode of dispersal influences how a forest community develops, and this varies with forest size. Dispersal by birds is crucial in smaller patches. Many species maintain a seedling or sapling bank that requires a canopy gap for recruits to grow into mature trees.
 - Regeneration opportunities:** Gaps in the canopy are created naturally by tree fall (due to death and disease, as well as rock falls, windfall and stream erosion) or occasional fires, or the activities of animals and people. These gaps are important as they provide the opportunity for saplings to grow and establish themselves as mature trees. Some forest types experience higher natural disturbance regimes than others, depending on their position in the landscape.
- Fire:** This is the most important factor influencing the location of forest in the landscape. Forests in fynbos landscapes usually occur as relatively small patches, in fire-safe habitats such as kloofs, gullies and ravines. Fires also regulate forest edge processes. Distinctive fire-tolerant communities – dominated by *Virgilia* species – occur on the forest edge. The forest-fynbos boundary is dynamic and determined by the weather and climatic conditions prevailing at the time of a fire: hot fires during drought conditions can reduce the area of forest, whereas cool or infrequent fires can allow forest expansion. Fire is a natural and important part of natural forest dynamics. However, invasive alien species occurring in dense stands can lead to heavy fuel accumulation, allowing fires to burn unnaturally far into forests, and under these circumstances, species that are not usually exposed to fire may be burnt. Exclusion of fire will allow temporary forest expansion, but subsequent fires will establish the natural equilibrium.
- Canopy cover and moisture levels:** Forests are characteristically cooler, and moister than the surrounding environments. The year-round shade provided by the canopy, and moisture-conserving leaf-litter on the forest floor, limits the growth of herbaceous plants to shade-loving plants such as ferns, although epiphytes and lianas may be common in moist forest types. A closed canopy and intact forest margin, in combination with location in the landscape, is important for maintaining a moist, shaded interior.

- **Exceptional invertebrate diversity:** It is not generally appreciated how diverse the invertebrate fauna of forests is. These invertebrates play an important role in decomposition and predation, and in maintaining competitive equilibria.

What are the main pressures and ‘threats’ in these ecosystems?

Forest ecosystems are protected by law throughout South Africa, but they are still placed under pressure by many land-use activities and other forms of disturbance, including:

- **Invasive alien plants:** Within the forest, invasive alien species disrupt successional processes and equilibria. The most problematic species in forests of the Western Cape are:
 - Blackwood – *Acacia melanoxylon*.
 - Bugweed – *Solanum mauritianum*.
 - Black wattle – *Acacia mearnsii*.
 - Tick berry – *Lantana camara*.
 - Syringa – *Melia azedarach*.
 - Castor oil – *Ricinus communis*.
 - Brazilian pepper – *Schinus terebinthifolius*.
 - Australian Cheesewood – *Pittosporum undulatum*.

Invasive alien species occurring in forest-adjacent fynbos habitats increase fuel loads and allow fires to damage forests.

- **Fire:** Although forests generally tend not to burn, or are naturally protected from fire by their location in the landscape, fires can pose a risk if there have been changes in the fire regime at the forest boundary. When fire has been kept out of the boundary or the surrounding fynbos, a large fuel load may accumulate, resulting in hot fires that are able to penetrate into the forest interior, which is not adapted to fire at all. The creation of unnatural gaps in the forest canopy allows flammable grasses, shrubs and invasive alien tree species to establish, thus exposing forests to a much higher risk of penetrating fires.
- **Grazing and browsing:** These are not viable activities in forests as nutrient levels are low and tightly cycled. Most large mammal forest dwellers, such as bushbuck, are territorial concentrate feeders that generally self-regulate their numbers and impacts. Natural grazers and browsers can help to keep the density of shrubs and climbers in check. Livestock, however, can cause damage through trampling, breaking young trees and altering decomposition and erosion cycles. Cattle cause erosion and sub-storey damage (allowing infestation by invasive alien species), and goats may eliminate seedling banks, preventing recruitment of key species. Access by livestock can only be acceptable if it is carefully managed.
- **Human activities:** Activities that have a direct impact on forests include:
 - Illegal extraction of timber, either of the mature trees or saplings.
 - Unsustainable harvesting of medicinal plants (whole plants or parts thereof) and tree bark.
 - Wholesale clearance of forest for the establishment of infrastructure, and partial clearance for the establishment of biking and hiking trails, are the major threats to remaining forest patches in the western parts of the Western Cape, whilst subsistence agriculture and mining are issues further to the east. All of these impacts increase fragmentation, reduce viability, or completely eliminate forest patches.



What are the non-negotiables?



Forests generally are self-sustaining in their natural state and require little management intervention. Management best practices should focus on protecting the forest patches from the impacts that place them at risk. This includes: preventing loss of forest habitat, maintaining a suitable fire regime, controlling invasive alien plants, regulating harvesting of forest resources and conserving the forest fauna that are responsible for pollination and seed dispersal. In particular:

- **Fire management should focus on protecting forests from *unplanned* fires.** This can be achieved by controlling fuel loads in the surrounding habitat and maintaining the health of forest margin communities, by applying the following general rules of thumb:
 - Burn adjacent fynbos regularly (at the appropriate interval) to prevent the expansion of forest into fynbos habitat and to reduce fuel loads. The burning guidelines for adjacent fynbos ecosystem types should be followed (see the ecosystem guidelines or consult Esler *et al.*, 2014).
 - Fires must be allowed to burn forest ecotones at an appropriate interval to remove moribund material and stimulate new growth.
 - Forest margins must be kept free of invasive alien species, otherwise fires may become too hot and cause damage. Ensure that follow-up clearing of invasive alien species that recruit after fire is planned.
- **Invasive alien plants must be controlled as a matter of priority.** The approach to dealing with invasive alien plants should be that of 'prevention is better than cure.' Keep invasive species out of forests by minimizing disturbance to mature forests and maintaining a closed canopy and a healthy, intact forest margin. If invasive alien plants are present, they must be removed according to a plan that incorporates both an initial clearing treatment and several annual, follow-up treatments.
- **Harvesting of forest resources must be regulated and kept at low levels of pressure.** Due to their small size and the large selective demand for the resources they provide, forests cannot sustain heavy levels of harvesting pressure. Although all forests are protected by law, the following **non-destructive** methods for harvesting should be encouraged where harvesting is known to occur:
 - Bark should be collected from side branches in longitudinal sections that allow for re-growth. Stems should never be ring-barked.
 - Whole plants should not be harvested – enough living material should always be left behind to allow the plant to regenerate.
 - Fallen branches and dead wood should not be collected for firewood as this dead material is vital for the return of nutrients to the soil and to sustain invertebrate populations. Woodlots should be used for firewood as an alternative.

- Local communities should be assisted to develop a self-regulating harvesting monitoring plan, especially for commercial harvesters.
- Poaching of wildlife in forests should be vigorously combated.
- Fragmentation of forest patches and loss of forest habitat should be avoided at all costs.
- Under the *National Forests Act*, (No. 84 of 1998) no forests may be modified from the natural state.
- Existing natural Milkwood plants (*Sideroxylon inerme*) may not be pruned or killed or removed without a permit from Cape Nature.

What are the critical things to maintain for biodiversity to persist?

- Maintain an intact forest margin and a smooth, unbroken canopy (excluding natural canopy emergents). Any activity that may cause unnatural drying out of the moist forest interior must be avoided.
- Conserve populations of keystone animal species (such as important bird species, certain invertebrates and ground-dwelling mammals) as their presence is critical for maintaining the ecological integrity of the forest ecosystem.
- Focus conservation management actions on the forest fauna that are responsible for pollination and dispersal of forest plants, and decomposition of litter.



What are the best spatial approaches (at a landscape scale) to avoid or minimize impacts and risk in these ecosystems?

- **Maintain connectivity** between forest patches across the landscape and avoid any further fragmentation of forest patches.
- **Implement adequate buffer zones.** All forests should be surrounded by a buffer zone of natural vegetation that is managed to reduce or eliminate the impacts of surrounding land-use practices on the forest. By implementing a 'no-go' buffer zone around and between forest patches, dispersal corridors can be maintained through which birds and other animals can migrate without risk from human interference. These corridors should connect the forest with key natural areas such as water courses and adjacent forest patches. The following general guidelines apply to the establishment of buffers around forests:
 - Buffer zones should be managed using tools such as fire and herbivory to prevent the gradual expansion of the forest into the surrounding fynbos habitats.

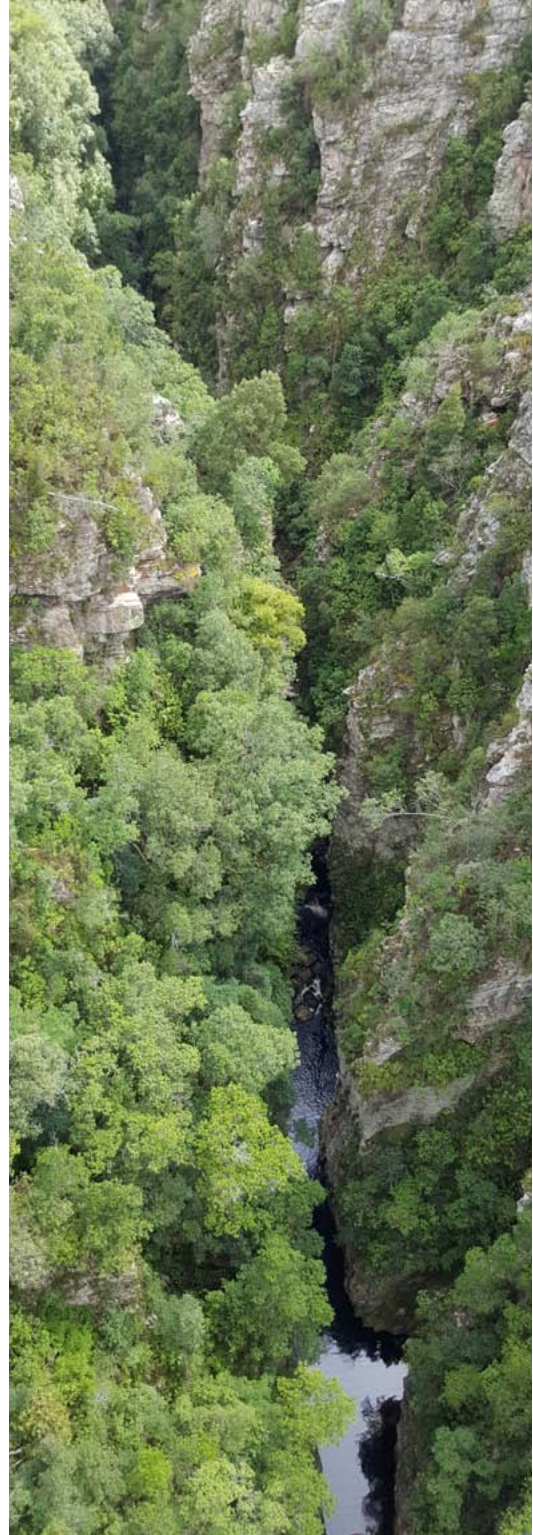
- Buffer widths will vary depending on the circumstances and expert advice should be obtained to determine what is appropriate in each case. A width of 40 m, measured from the edge of the forest ecotone, is the minimum acceptable width. But, this should be increased if the forest in question is home to threatened or rare species, or if land-use activities in the surrounding landscape are likely to have long-term or permanent impacts.

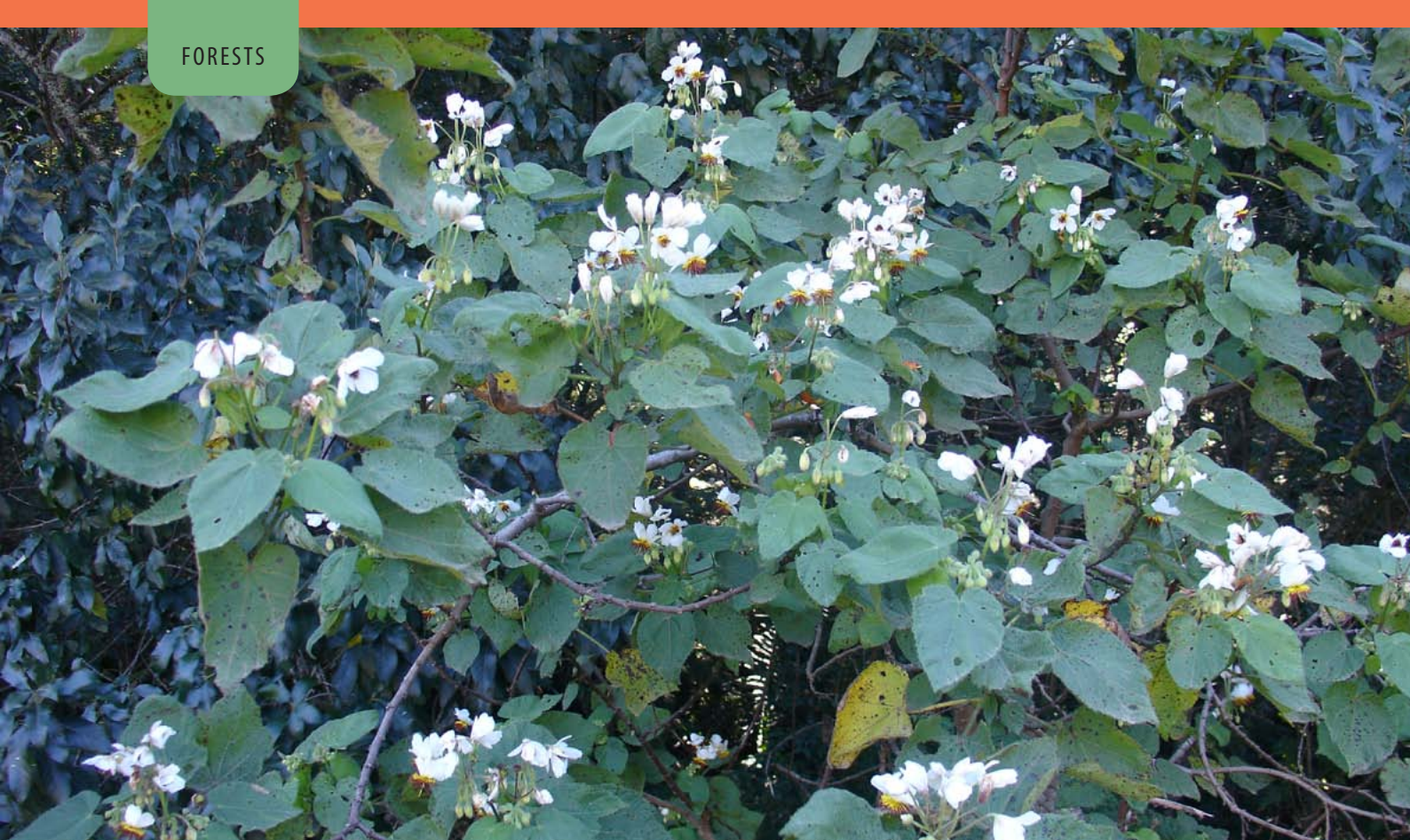
What indicators should be used to assess and monitor ecosystem health?

Monitoring the ecological integrity of forests is a complex activity that will require consultation with experts at times. There are some indicators that can be relatively easily monitored, but they can only be used meaningfully by comparing the current state with that of a forest of the same type that is in a healthy or reference condition.

Broad indicators of forest health include:

- An intact forest margin and a smooth, unbroken canopy (excluding natural canopy emergents).
- The presence of keystone animal species (such as important species of birds, certain invertebrates and ground-dwelling mammals).
- The absence of invasive alien species (or a low density of invasive alien species as, in reality, most forest patches have at least some exotic species present)
- The community structure of the forest, and forest margin and the presence, species richness and extent of mature canopy trees. A forest expert should assess the extent to which the forest is structurally intact, relative to a reference of the same forest community, and would need to define what the thresholds of potential concern would be.
- Changes in the height of the canopy, and density of the undergrowth.
- Presence, distribution and density of forest pioneer species such as *Trema orientalis*.
- The size of forest patches and linkage to adjacent patches at a landscape scale (i.e. this indicator cannot be applied to individual forest patches).
- Ecological condition of the habitat in a 500 m buffer around forest patches.
- No evidence of penetration by fire into the forest and forest margin.
- The absence of signs of human disturbance, such as tree-felling, human-induced gaps in the forest canopy or snares and traps set along forest paths.





How reversible are impacts over a period of 5 to 10 years?

Forests are essentially resilient ecosystems. Many forests in the Western Cape have been damaged by past logging and other usage, as evidenced by signs of old saw pits, old roads and breaks in the forest canopy. However, impacts generally are reversible provided that the key ecological processes are still able to operate.

The following factors should be considered when designing a forest rehabilitation plan:

- **Specific objectives** must be set, especially in those instances where a particular species composition or vegetation structure is required.
- The **removal of invasive alien plant species** is important, especially at the forest margins. It should be noted that, in some cases, it may be advisable to keep selected large invasive individuals as 'nursery' trees – these provide shade and close gaps in the canopy, so that indigenous forest species can re-establish. The 'nursery trees' can be ring-barked later when the natural forest species start occupying the sub-canopy.
- The **prevailing biophysical drivers** (such as temperature, rainfall and altitude) will influence the response of specific ecosystems to rehabilitation. For example:
 - high rainfall and warmer temperatures favour the re-establishment of woody species over relatively short time spans (10–15 years) without any physical intervention.
 - lower rainfall and colder temperatures will make the rehabilitation process take longer.
 - at the coast, the successional path will take less time (about 5 years), but more time (up to 15 years) further inland and above 1 000 metres above sea level.

What are acceptable, compensation measures or offsets for biodiversity loss?

Under the National Forests Act, (No. 84 of 1998) no forests may be modified from the natural state. Forests are so restricted in the Western Cape that no compensation or biodiversity offsets can be entertained.



INLAND AQUATIC ECOSYSTEMS

Incorporating rivers, wetlands and open waterbodies

Contributors: Kate Snaddon, Liz Day, Dean Ollis, Nancy Job

Snapshot of Inland Aquatic Ecosystems

There is a large number and variety of inland aquatic ecosystems in the Western Cape, including rivers, open waterbodies and wetlands (see Appendix 2 for a definition of each of these). Each of these can be further classified into numerous types, using criteria related to hydrological processes and geomorphological features. These hydrogeomorphic (HMG) types broadly describe how and where these aquatic ecosystems form, and how they are sustained ecologically. This has direct relevance for land use and management, impact assessment, rehabilitation, conservation, and many other activities and processes. More detailed information on the classification of aquatic ecosystem types can be found in Appendix 2 and in other literature, but the general characteristics of the inland aquatic ecosystems of the Western Cape are described below.

General characteristics of river ecosystems

- There are five main river systems in the Western Cape, three of which are contained fully within the province (the Berg, Breede and Gouritz river systems), and two which occur only partially within the Western Cape (the Olifants/Doring and the Buffelsrivier systems).
- In terms of water management, the province is divided into five water management areas, corresponding largely to the catchments of the five major river systems – these include the Berg, Breede, Gouritz and Olifants/Doring, with the Buffelsrivier in the east falling into the western part of the Tsitsikamma-Fish River Water Management Area (that is shared with the Eastern Cape).
- Rivers originating in the Cape Fold Mountains are generally acidic to neutral and, when undisturbed, carry relatively low nutrient loads (which has an important bearing on species diversity). In the Nama Karoo and Succulent Karoo parts of the province, rivers are generally more nutrient rich and their vegetation units reflect this.



- Many of the rivers in the Western Cape arise at high altitude, on south-facing aspects in spongy, peat marshes and have waters that are stained by tannins. Whilst the upper reaches are often narrow and fast-flowing, the middle and lower reaches tend to be wide and open, with broad alluvial banks and braiding, and often include wetlands in the riparian zone.
- Western Cape rivers are home to a rich variety of fish species, many of which are endemic. The Olifants/Doring river system is recognised as a hotspot of fish endemism.
- A plant characteristic of many inland aquatic ecosystems (both rivers and wetlands) in the Western Cape is Palmiet (*Prionium serratum*). It is able to withstand high water flows and is exceptionally valuable in preventing soils from being washed downstream during floods.

General characteristics of wetlands and other water-bodies

- The Western Cape is home to some 280 different wetland types, based on a combination of criteria. They vary greatly in geographic location, water source and permanence, and chemical properties. By far the most common wetland types are channelled valley-bottom and floodplain wetlands (See Appendix 2 for a description). These wetland types are found in the lowlands, and they tend to be larger wetlands, spreading out on valley floors and plains. The greatest total area of wetland is found in East Coast Shale Renosterveld, with floodplain wetlands dominating within this vegetation type.
- Wetland water chemistry can range from fresh to saline and from acidic to basic. This is related to the great variability of soils and geology, salinity range and flow regimes found in the province.
- The Agulhas Plain has an especially rich and large network of important wetlands, including the second largest coastal lake in South Africa: Soetendalsvlei, and two Ramsar sites, De Mond Estuary and De Hoop Vlei.
- Wetlands are more sparsely distributed along the semi-arid west coast and inland of the Cape Fold Mountains, with a high concentration of pans, now mostly embedded within a matrix of agricultural lands. Most are seasonal or temporarily wet, often “perched” on top of dense clays.

Conservation, land-use pressures and risks

- Inland aquatic ecosystems in the Western Cape are generally highly threatened ecosystems.
- Although some mountain streams, upper foothill rivers and wetlands in mountain catchments (as well as some smaller rivers elsewhere, such as in Table Mountain National Park) are in a good ecological condition, many of the larger, lower-lying inland ecosystems have been modified from the natural state and are degraded.
- The only major rivers that are in good ecological condition are those in the Kogelberg and the Southern Cape. Whilst those in the Kogelberg are well-protected, the ones in the Southern Cape are not, and they face growing pressure from the expansion of urban settlements.
- The main pressures on river ecosystems are caused by inappropriate land-use practices in the catchment that cause erosion and siltation, infilling of floodplains, over-abstraction of water, pollution and over-utilisation of living resources.
- 87% of Western Cape wetlands are in a moderate to heavily modified condition, and wetlands continue to be lost or impacted through inappropriate development, drainage, poor agricultural practices, human-induced erosion or infestation by invasive alien species.

What are the key ecological ‘drivers’ maintaining ecosystem function, pattern and structure?

A number of drivers act at a scale larger than the ecosystem, such as climate, catchment geomorphology and geology, as follows:

- **Climate:** Variables such as ambient temperature, precipitation, evaporation, solar radiation and the duration and direction of winds have a direct impact on the temporal and spatial availability of water to the ecosystem.
- **Catchment geomorphology:** The topographical shape of the catchment defines the landscape setting of an aquatic ecosystem. Factors to consider include:
 - **altitude** – for instance, the higher the altitude, the cooler the ambient temperatures.
 - **relief** (the shape of the catchment, particularly in relation to changes in altitude) – for instance, the greater the changes in relief within the catchment, the more diverse are the wetland types.
 - **slope form** (convex versus concave) **and gradient** – for instance, soil moisture tends to accumulate at the foot of a slope.
- **Geology:** The underlying geology in a catchment has a direct impact on the types of soils or sediment, and the chemistry of these substrates. The sandstones that dominate the high altitude areas of the Western Cape are old and well-weathered, and typically leach very few ions. As a result, the soils in these areas are usually low in nutrients, salts and minerals, and so are the waters that drain these soils. As a result, pristine wetlands and streams at higher altitudes in fynbos ecosystems tend to have low concentrations of total dissolved solids, including nutrients (that is, they are oligotrophic).



These large-scale drivers have a strong influence over the form and functioning of inland aquatic systems, as follows:

- **Substrate (soils/sediment):** Catchment geomorphology and geology have a strong influence over the type, depth, degree of wetness, and chemistry of the substrate within an inland aquatic system. Wetlands, and the lower reaches of most rivers, tend to have substrata with a coarse to fine texture (sand, silt, clay), while the upper and middle reaches of rivers tend to have unconsolidated, rocky substrata such as boulders, cobbles, pebbles and gravel. Substrate type, in turn, influences the vegetation and faunal composition within rivers, wetlands and open waterbodies, and the biological functions they can perform. Natural processes of erosion and deposition are amongst the most important processes forming and shaping wetlands and rivers. In this regard, special mention must be made of peat:
 - Organic soils, defined as those with an organic carbon content of more than 10%, typically develop under conditions of nearly continuous saturation, and this is an important component of the substrate. Peat (defined as “accumulated material comprising at least 30% dry mass of dead organic matter”) is rare in South Africa, largely due to the relatively warm and dry climate that speeds up the breakdown of organic material and so prevents the formation of peat. Palmiet peatlands do, however, occur in the Cape Fold Mountains, where they play a crucial role in flood attenuation, trapping sediment and slowing down water flow. When cultivation and infrastructure development lead to the draining and degradation of these wetlands, this often results in severe soil erosion and the washing away of precious agricultural land.

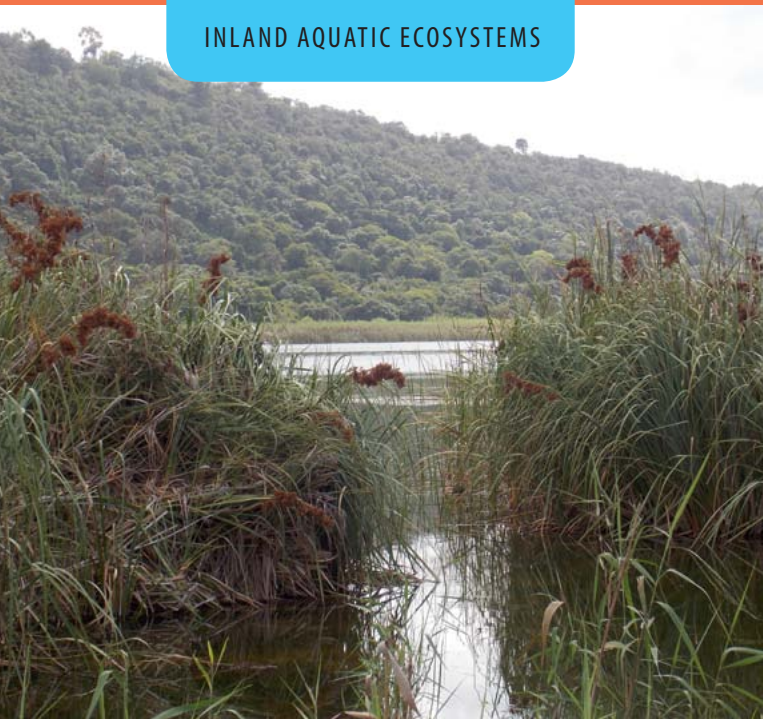


- **Water sources and hydrological regime:** The form and functioning of an inland aquatic ecosystem are influenced by the source and amount of water flowing into, through and out of it. Wetlands, rivers and open waterbodies essentially evolve as a result of a surplus of water at or near the ground surface. Water can enter an aquatic system from a river upstream, from diffuse surface or overland runoff from the catchment, or as lateral subsurface seepage (also referred to as interflow) through the surrounding soils. Some aquatic ecosystems may be wholly or partially groundwater-fed.
 - The *hydrological regime* (i.e. the timing, frequency, magnitude and duration of baseflow or floods) of flowing systems such as rivers, or the *hydroperiod* (i.e. the timing and duration of saturation or inundation) of standing systems such as wetlands and open waterbodies, directly affects their physical, chemical and biological characteristics and overall functioning. In rivers in the Fynbos Biome, for example, the timing and quantity of flows are essential determinants of biodiversity – wet season flushes and elevated flows act as cues for the emergence of many seasonal invertebrates and other fauna, depending on the timing of these flows, while the magnitude of floods determines important re-setting processes such as flushing and scour. For example, the flushing out of accumulated fine sediments is essential for maintaining the shape of the river channel.

Similarly, the frequency and duration of inundation and saturation of a wetland will determine its soil morphology and chemistry (for example, level of oxygenation, build-up of carbon and nutrient cycling), and, thus, will also determine the types of vegetation growing within the wetland.

- **Water quality:** Along with water sources and the hydrological regime, water quality is a major driver of ecosystem functioning in aquatic ecosystems. These ecosystems act as 'sinks' for the accumulation of materials mobilised within the catchment, either through natural processes or human activities. Inland aquatic ecosystems are particularly vulnerable to land-use practices throughout the catchment that may have an impact on the quality of either surface or subsurface water. It is important to protect the health of inland aquatic ecosystems from the risks of water quality impairment, and to ensure that these systems continue to provide critically important water quality-related ecosystem services (e.g. nutrient cycling, primary production) and habitat for biotic communities.

The suite of biotic communities inhabiting wetlands, rivers and open waterbodies is adapted to an optimal range of chemical conditions. For instance, the streams and seeps draining the sandstones of the Cape Fold Mountains have a characteristically low pH, sometimes dropping below 4, and the aquatic biota living in these systems have adapted to these conditions. Many fish, invertebrates and frog species occur only in these fynbos mountain streams while others prefer the alkaline coastal wetlands of the Cape Flats.



- **Biota and biological processes:** All of the drivers described above play a role in determining the form and functioning of inland aquatic systems, and in shaping the biotic communities and processes characterising each ecosystem. For instance, vegetation strongly influences geomorphological processes by slowing down water flow and capturing sediment, and in determining the chemistry of the water draining the catchment. The low pH of pristine wetlands and rivers in the Fynbos Biome (see comment above on water quality) is largely as a result of humic acids leached from the surrounding fynbos.
 - *Aquatic organisms* (biota) occur in the zone where conditions are optimal for productivity. For example, plant species that prefer saturated soil conditions year-round will be found in the permanently saturated or inundated zone of a wetland, whereas those that prefer seasonally saturated conditions will occur around the edges of the wettest zone, or only in seasonally saturated wetlands. The kinds of plants occurring in each zone provide visual evidence of wetland presence, even enabling wetland assessors to delineate the permanent, seasonal and temporary zones within a wetland. In rivers, plants and animals occur in the optimal biotope, which is a combination of habitat (mainly substrate and water depth) and flow type (fast or slow).
 - Some of the *biological processes* that may influence the form and functioning of inland aquatic systems include nutrient cycling, evapotranspiration, decomposition, succession, primary productivity, grazing, predation and competition. For example, some plant species such as bulrush, *Typha capensis*, and the common reed, *Phragmites australis*, grow particularly well in permanent waterbodies, especially where there is some nutrient enrichment. These species outcompete an often more diverse community of plants (such as sedges and restios) that would naturally occur in the wetland or stream, leading to mono-specific stands that inhibit the free flow of water.

What are the main pressures and threats in these ecosystems?

Inland aquatic systems receive runoff (of water, sediment and pollutants) from the surrounding landscape, and are thus particularly sensitive to activities in the catchment, even those operating some distance away. Poor and/or inappropriate land-use practices within the catchment of an inland aquatic system are largely responsible for the deterioration or loss of freshwater habitat and/or freshwater biodiversity. Inland aquatic ecosystems are also particularly vulnerable to climate change, as this leads to long-term changes in the hydrological regimes of surface and groundwater, temperature regimes and ultimately the biota associated with these systems. Wetlands are especially sensitive to climate change as they are delicately balanced between terrestrial and aquatic influences, where species may already find refuge from desiccation.

Generally, deterioration in the overall health of rivers, wetlands and open waterbodies occurs when the key 'drivers' are compromised, and this manifests as a loss or change of habitat and/or biodiversity. Specifically, the main pressures and threats in inland aquatic ecosystems in the Western Cape are:

- **Changes in natural disturbance regimes:** This includes alterations to the natural frequency or severity of fire, flooding, erosion, sedimentation and grazing within inland aquatic ecosystems and their catchments.
- **Land-use change and development:** Land uses such as agriculture, mining or the establishment of urban infrastructure result in catchment hardening, excavation, loss of organic-rich soils and the drainage and infilling of wetlands, rivers and floodplains.
- **Invasive alien plants and animals:** The presence of invasive alien species can have severe impacts on locally indigenous aquatic flora and fauna, and can upset the natural balance of an inland aquatic system. Invasive alien trees in particular can result in large-scale changes to river and wetland ecosystems, altering the flow regime and promoting down-cutting, channelisation and severe erosion.
- **Pollution and changes in water quality:** Pollution from both point and non-point sources, salinisation (i.e. an increase in the concentration of dissolved salts), nutrient enrichment and alkalinisation (i.e. an increase in the pH, leading to a decrease in the acidity) are of particular concern for inland aquatic systems in the Fynbos Biome, where the natural waters are typically acidic with low concentrations of total dissolved solids. Excessive and/or inappropriate use of fertilisers, herbicides and/or pesticides is particularly problematic, as is the discharge of mining effluents directly or indirectly into inland aquatic systems.
- **Changes in the flow regime:** This occurs in flowing-water systems such as rivers and riverine wetlands, as a result of practices such as water abstraction, diversion of flows, inter-basin water transfers, impoundment, canalisation, channelisation, irrigation, and poorly managed stormwater flows.
- **Changes in inundation or saturation patterns:** This happens in wetlands and open waterbodies such as lakes and dams, because of changes within the ecosystem itself or due to activities in the catchment that affect runoff patterns.
- **Changes in groundwater quality or quantity:** The quality or quantity of groundwater is affected by over-use or inappropriate use or land-based practices, such as the infiltration of sewage effluent or other contaminated waste from surface sources into the groundwater, or intensive irrigation, or the kinds of impacts that could result from mineral or shale gas prospecting or mining.
- **Changes in the sediment regime:** The amount of sediment entering or leaving inland aquatic ecosystems can be affected by changes in the natural cycles of erosion or deposition within the ecosystem (or its catchment), as a result of activities such as poor ploughing practices that lead to the constant mobilisation of sediments.
- **Fragmentation:** This is caused by a loss of connectivity between:
 - different parts of an inland aquatic system (e.g. the loss of upstream-downstream linkages through poor planning of roads, pipelines etc.).
 - geographically separate systems that were hydrologically or biologically connected in their natural state.
 - between inland aquatic systems and the adjacent/surrounding terrestrial ecosystems (such as from extensive clearing of natural vegetation within the catchment, or from the construction of levees).



- **Encroachment into inland aquatic systems and/or their buffers:** Activities such as infilling and excavation, inappropriate grazing (too close to, or overgrazing, of wetlands), and removal of naturally-occurring indigenous vegetation (directly, such as occurs for the cultivation of crops or plantations, or indirectly, as a result of desiccation, for example,) lead to degradation in many inland aquatic ecosystems.
- **Over-exploitation of biota in inland aquatic systems:** Over-exploitation of riparian trees, wetland plants, and indigenous fish, for subsistence or commercial use, represents a significant pressure in many inland aquatic ecosystems.

What are the non-negotiables?

- All rivers, wetlands and open waterbodies have some ecological importance or value. This may not necessarily be for the conservation or maintenance of biodiversity pattern and/or ecological processes, but in terms of functional value. For example, inland aquatic ecosystems generally provide water retention capacity, which is an important function in the catchment, especially in the context of the seasonally dry nature of the Fynbos Biome.
- The hydrological regime and water quality of a river, wetland or open waterbody must be adequate to maintain the ecosystem in a desired or attainable condition.
- No further degradation should be permitted in inland aquatic ecosystems that are designated as being of moderate to high conservation importance, as assessed by an appropriate specialist.
- All inland aquatic ecosystems must be appropriately buffered. Buffers must be provided for, such that they:
 - are adequate for the protection of the ecosystem from the pressures identified above.
 - maintain the ecosystem in a desired or attainable ecological condition.
 - allow for future rehabilitation or restoration.
- Human activities that will impact directly (e.g. encroachment) or indirectly (e.g. diffuse pollution) on a river, wetland or open waterbody, and/or its buffer, must be assessed by a suitably qualified and experienced specialist, and the ecosystems ground-truthed as part of any land-use change application, environmental assessment or licencing process.

What are the critical things to maintain for biodiversity to persist?

A number of factors must be taken into account in managing inland aquatic ecosystems so that biodiversity can persist or improve over the long term. It is not enough to consider only the area in which a wetland occurs or through which a river flows. Attention must also be paid, at the landscape scale, to maintaining the natural drivers of form and function in these ecosystems, as explained below:

- **Natural geomorphological processes** (erosion and deposition): Activities or land uses that affect these processes can modify habitat type and trigger knock-on effects such as flooding (for example, as a result of sediment 'islands' being formed in the channel, especially if invasive alien plants are present) and wetland drainage (as a result of downcutting/eroding of streams and wetlands). Even seemingly minor alterations can affect geomorphological processes by changing the slope of the river bed or wetland, or the availability and deposition of sediment. Sedimentation may also encourage invasion by alien plants, as the seeds of some alien trees grow well on sand banks formed in channels as a result of upstream erosion. Once established, the trees stabilise these areas resulting in channel shrinkage.
- **Natural hydrological regime** (flow or hydroperiod): Too-frequent floods result in disturbance levels that exceed recovery potential. Changing a river from a seasonal to a perennial river, or *vice versa*, results in dramatic changes to riverine biodiversity, with perennial flows in a seasonal ecosystem often promoting invasion by pest species such as bulrush (*Typha capensis*). In wetlands, seasonality of the hydroperiod is important, with inundation and desiccation serving as cues for the emergence and diapause of many crustaceans, some of which are endemic to the Fynbos Biome.



- **Natural water quality:** Freshening an aquatic ecosystem (i.e. making it less salty) can have as big an impact as making it too saline, and can result in dominance by nuisance, disturbance-tolerant species, rather than by natural communities adapted to natural water quality conditions. Maintenance of nutrient availability is also critical for biodiversity – changes (usually increases) affect plant competition, with nuisance, often invasive alien species out-competing indigenous ones, resulting in major biodiversity changes.
- **Natural physical habitat structure:** Most of the changes outlined above also bring about changes in physical habitat, for example by promoting plant growth that invades into previously open water habitat, increasing shading and adding to the rate of production of organic detritus on wetland floors or in riverine pools. Changes in structure of the physical habitat affect habitat quality and availability, and can create conditions that favour alien species at the expense of indigenous ones. This is particularly evident in destabilised river channels where habitat diversity is reduced as a result of erosion and the deposition of loose boulders and cobbles that are not optimal for the establishment of aquatic plants and invertebrates.
- **Naturally-occurring biotic communities:** Some human activities have a high potential for the accidental or deliberate import of alien or invasive species or even taxa from other catchments that may have a slightly different genetic makeup to those occurring naturally. Imported species may have a competitive advantage over those occurring naturally, leading to a loss of natural biodiversity. Although some naturally-occurring species may be a nuisance to humans (e.g. midges, mosquitoes, bulrushes, reeds), such organisms often play important roles in biodiversity maintenance (e.g. midge larvae feed on wetland sediments, support aquatic invertebrate and fish predators and, when they emerge as adults, birds, bats and insect predators). Maintenance of natural growth forms (e.g. a range of juvenile to mature plant species, providing a range of habitat types, rather than a neatly trimmed lawn) is also important, both from the perspective of habitat type, and to maintain biological processes.
- **Biological processes:** Natural patterns of succession, productivity, competition and predation are important in biodiversity maintenance. These may be affected by activities or land uses occurring outside of the wetland or river – e.g. loss of habitat for predators or prey of fauna that require aquatic habitats for only part of their life cycles, such as frogs and insects. Changes in habitat types (e.g. as a result of nutrient enrichment) may change competitive interactions between species, resulting in potentially nuisance species (e.g. bulrushes and midges) dominating at the expense of more diverse communities.
- **Natural ecological and hydrological linkages:** Corridors that allow for longitudinal movement up- and down river systems or laterally, between aquatic and terrestrial habitats, may be critical for the long-term survival of the taxa that rely on these migration routes to complete breeding cycles, find food sources or maintain genetic diversity. Maintenance of hydrological connectivity is equally important, allowing for natural surface flows into and out of rivers and wetlands and also allowing infiltration of surface water into areas of recharge that may be important for the maintenance of wetlands or rivers elsewhere.

What are the best spatial approaches (at a landscape scale) to avoid or minimise impacts and risk in these ecosystems?

- All inland aquatic ecosystems in the broader sub-catchment should be taken into account in any environmental assessment. For example, connectivity up- and downstream, between inland aquatic systems, and the associations with the terrestrial landscape must be considered.
- Wetlands and riparian areas should be accurately delineated at site level using a minimum mapping scale of 1:10 000 (1:50 000 is too coarse), prior to planning for a proposed land-use development, and the findings should be supported by well-documented reasoning. For wetlands, delineation should ideally take place in the wet season, but, if it must be done at other times of the year, a level of confidence in the delineation should be assigned to the results. Nationally approved wetland and riparian zone identification and delineation methodologies⁵ should be followed in wetland delineation and identification, to allow comparison between specialist studies.



Current national and provincial freshwater ecosystem priority maps showing the location and spatial extent of wetlands, give a false sense that detailed and consolidated knowledge exists about the wetlands of any given area. Wherever these maps/datasets are to be used in a desktop manner to inform decision-making beyond the site scale, such as in the case of Strategic Environmental Assessments and Environmental Management Frameworks, a wetland specialist should be consulted. Sufficient ground-truthing should be carried out, and the project area should be kept to a manageable size, so that knowledge about the characteristics of the wetlands can be built, and the spatial datasets reviewed and improved.

- Buffers should be established around all inland aquatic ecosystems. These must take into account the type, desired ecological condition and likely functions of the ecosystem, together with the spatial requirements of species that are dependent on the ecosystem for all or part of their life cycle, and the nature of the impacts of the proposed land-use activity. Buffers should accommodate the potential capacity of the site to cope with unexpected events such as fires, potential river migration areas, and other natural processes, as well as not foreclosing on opportunities for future restoration and/or rehabilitation.
- Land-use authorisations should be informed by assessments that adequately describe the key landscape drivers that may be affected by the land-use activity. Inland aquatic systems, particularly wetlands, are maintained by processes that often extend or originate well beyond the protection that can be afforded by a conventional buffer.
- Inland aquatic ecosystems in the broader sub-catchment and the linkages between ecosystems from source to sea should be taken into account in any environmental assessment. For example, the continuation of a particular wetland beyond the project area or site should be acknowledged. The current and historical connectivity up- and downstream and between inland aquatic ecosystems should be taken into consideration, as well as the associations with the surrounding terrestrial landscape.

⁵ See Department of Water Affairs and Forestry. 2005. A practical field procedure for identification and delineation of wetland riparian areas. Department of Water Affairs and Forestry, Pretoria, South Africa.

What indicators should be used to assess and monitor ecosystem health?

The kinds of indicators to use will depend on the type of assessment that is being carried out, and also the characteristics of the particular aquatic ecosystem(s) under assessment. There are a number of well-established, standardised methodologies for assessing and monitoring the health of aquatic ecosystems, including:

- Habitat Integrity (HI) or Present Ecological State (PES) Assessments. These assessments, which should be carried out with the involvement of a vegetation specialist, can be used to determine the state of the vegetation surrounding (or in) the aquatic ecosystem, and the physical condition of the riverbank or wetland boundary. A decline in the health of the ecosystem could be indicated by: changes in species composition or the absence of particular species (see below), infestation by invasive alien species, signs of accelerated bank erosion or the presence of actively-eroding headcuts, and a decline in vegetation cover in relation to an ecosystem of the same kind that is known to be in a good ecological condition.
- Assessments of Ecological Importance (EI) and Ecological Sensitivity (ES).
- The South African Scoring System, Version 5 (SASS 5), which is a system for the rapid bio-assessment of water quality of rivers (using riverine macroinvertebrates)⁶. SASS 5 can also be used to monitor water quality in wetlands as long as it is the water leaving the wetland that is assessed.
- WET-Health⁷, which is a tool that has been developed for rapid assessment of wetland health based on hydrology, geomorphology and vegetation. Besides providing a replicable and explicit measure of wetland health, the WET-Health system also helps to diagnose the causes of degradation, so that these can be appropriately addressed. The services of an expert who has experience in assessing wetland health must be secured to use WET-Health effectively.

In addition, the River Health Programme, which is managed by the South African Department of Water Affairs, has a well-established set of indicators for assessing the health of rivers.

These assessments make use of various indicators, such as:

- Water chemistry variables as indicators of water quality, particularly nutrients (such as phosphate, ammonia, nitrate, nitrite, potassium and sulphate), pH and conductivity levels, but also turbidity and conductivity. Assessments of water quality are complex and must involve a water quality specialist. They may include basic laboratory tests or other techniques that focus on the water itself, or the aquatic macro-invertebrate fauna of the water body (e.g. SASS 5 or WET-Health).
- Algal biomass (as chlorophyll-a) and diversity. The presence or absence of particular species (indicator organisms) can be used to detect species changes in environmental conditions, such as eutrophication, organic enrichment, salinisation or changes in pH.
- Plant diversity and community zonation (changes in zonation and extent indicate changes in moisture levels or water quality).
- The community structure of aquatic invertebrates, their sensitivity to water quality and habitat changes can provide a time-integrated measure of prevailing conditions in river ecosystems (which is something that analyses of water chemistry cannot do). The absence of particular groups of invertebrates (e.g. dragonflies) can indicate a decline in the health of the ecosystem.
- Soil type, soil moisture and signs of soil erosion.
- Depth to water table, especially in systems that are largely groundwater-fed.

⁶ See Dickens and Graham (2002) for methodology, and Dallas (2007) for interpretation guidelines specific to ecoregions and river types.

Chutter, F.M. (1998) Research on the rapid biological assessment of water quality impacts in streams and rivers – Final Report to the Water Research Commission. WRC Report 422/1/98, Pretoria.

Dallas, H.F. (2007) River Health Programme: South African Scoring System (SASS) Data Interpretation Guidelines. Prepared for Institute of Natural Resources and Department of Water Affairs and Forestry.

⁷ WET-Health can be accessed via the website of the Water Research Commission. Visit www.wrc.org.za, click on 'Knowledge Hub' and search for 'WET-Health'.

For aquatic ecosystems that have been designated as Freshwater Ecosystem Priority Areas (FEPAs), there are additional indicators that should be used, depending on the specific wetland type. Consult the Freshwater Ecosystem Priority Area Implementation Manual for more detailed guidelines.

A suitably experienced aquatic specialist should be consulted to conduct any assessment of ecosystem health and to assess relevant baselines (if these are not already established) and determine thresholds of potential concern in respect of each indicator.

How reversible are impacts within a period of 5 to 10 years?

This depends on the type of ecosystem, the integrity of the hydrological regime, and the type of impact. Some general guidelines include:

- Impacts on water quantity are probably reversible in the short-term, but may be associated with longer-term indirect and irreversible impacts. Such impacts may include decreases in water availability in the riparian zone leading to death of long-lived riparian trees, or decreased flows and loss of floods leading to sedimentation of the river channel and stabilisation of instream sand bars by vegetation.
- Impacts on water quality are generally reversible in a 5 to 10-year period, assuming that all contamination ceases. However, some impacts may be long-term and practically irreversible, such as nutrient enrichment that leads to the domination of a river channel by bulrush.
- Infestation by invasive alien plant species is often reversible if appropriate clearance methods are used, in conjunction with follow-up operations that ensure that the whole catchment has been cleared. If this is not the case, then sites are soon re-invaded by the same or other species. Note, however, that invasion by alien fish and their impacts on indigenous fish populations are difficult to reverse.

What are adequate compensation measures or offsets for biodiversity loss in these ecosystems?

All inland aquatic ecosystems have some conservation importance, and thus should be protected from human-induced impacts. In the Fynbos Biome, many of these ecosystems are considered unique, and so are irreplaceable. However, development is inevitable, and human activities have an impact on natural ecosystems. The mitigation hierarchy endorses impact avoidance over impact reduction, with rehabilitation of affected ecosystems required for unavoidable impacts. Offsets are relevant only when there still remains a residual negative impact of *medium* or *high significance* – refer to the national wetland offset best practice guideline of Macfarlane *et al.* (2014), and the National Framework for Biodiversity Offsets (SANBI/DEA, 2013) for more information. Impacts of *very high significance* (e.g. when the aquatic ecosystem is irreplaceable or particularly vulnerable) cannot be offset, and must be avoided. Impacts of *low significance* may not need to be offset, but the mitigation hierarchy must still be applied.

The challenge for determining acceptable offsets for inland aquatic ecosystems is that they must contribute to meeting biodiversity objectives (species, communities and ecosystem processes) as well as water resource objectives, as guided by the *National Water Act* (i.e. National Water Resource Strategy and Resource Directed Measures). Acceptable offsets or compensatory measures are those that adhere to the principle of no effective net loss but preferably a net gain of inland aquatic ecosystem biodiversity and ecosystem functioning. Macfarlane *et al.* (2014) provides an offset ‘calculator’ that makes use of a clearly defined ‘gains *versus* losses’ accounting system.

In order to be effective, any biodiversity offset must be explicitly defined and described in all Environmental Authorisations, Water Use Authorisations, and Environmental Management Plans.



CHAPTER 6

Other Useful Resources

This chapter includes six appendices that supplement the information provided in the other chapters in the *Guidelines*. These include:

Appendix 1: List of South African Vegetation Types, arranged according to the ecosystem groups in which they occur, and indicating their ecosystem threat status.

Appendix 2: A Note on the Classification of Inland Aquatic Ecosystems.

Appendix 3: Basic Terms of Reference for an Ecological or Biodiversity Specialist conducting an Environmental Assessment.

Appendix 4: Terms of Reference for Specialist Assessment of Inland Aquatic Ecosystems.

Appendix 5: Glossary of Terms.

Appendix 6: Reference.



Appendix 1: List of South African Vegetation Types

South African vegetation types occurring in the Western Cape, arranged according to the ecosystem groups used in these *Guidelines*, and indicating their ecosystem threat status.

LT = Least Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered

VEGETATION TYPE	ECOSYSTEM THREAT STATUS			
	LT	VU	EN	CR
Coastal Ecosystems (Estuaries, Sandy Beaches and Dunes, and Strandveld)				
Blombos Strandveld	*			
Cape Flats Dune Strandveld			*	
Groot Brak Dune Strandveld			*	
Lambert's Bay Strandveld	*			
Langebaan Dune Strandveld	*			
Overberg Dune Strandveld	*			
Saldanha Flats Dune Strandveld		*		
Saldanha Granite Strandveld			*	
Saldanha Limestone Strandveld	*			
Lowland Fynbos Ecosystems				
Agulhas Limestone Fynbos		*		
Agulhas Sand Fynbos			*	
Albertinia Sand Fynbos		*		
Atlantis Sand Fynbos				*
Canca Limestone Fynbos	*			
Cape Flats Sand Fynbos				*
De Hoop Limestone Fynbos	*			
Hangklip Sand Fynbos			*	
Hopefield Sand Fynbos		*		
Knysna Sand Fynbos				*
Leipoldtville Sand Fynbos		*		
Lourensford Alluvium Fynbos				*
Namaqualand Sand Fynbos	*			
Midland and Mountain Fynbos Ecosystems				
Bokkeveld Sandstone Fynbos		*		
Boland Granite Fynbos		*		
Breede Alluvium Fynbos			*	
Breede Quartzite Fynbos	*			
Breede Sand Fynbos		*		
Breede Shale Fynbos	*			
Cape Winelands Shale Fynbos		*		
Cederberg Sandstone Fynbos		*		
Central Coastal Shale Band Vegetation				
Central Inland Shale Band Vegetation	*			
Eastern Coastal Shale Band Vegetation		*		
Eastern Inland Shale Band Vegetation	*			
Elgin Shale Fynbos				*
Elim Ferricrete Fynbos				*
Garden Route Granite Fynbos			*	

(names correct according to Mucina, Rutherford and Powrie, 2012)

VEGETATION TYPE	ECOSYSTEM THREAT STATUS			
	LT	VU	EN	CR
Garden Route Shale Fynbos		*		
Graafwater Sandstone Fynbos	*			
Greyton Shale Fynbos			*	
Grootrivier Quartzite Fynbos	*			
Hawequas Sandstone Fynbos		*		
Kango Conglomerate Fynbos	*			
Kogelbeg Sandstone Fynbos				*
Kouebokkeveld Alluvium Fynbos			*	
Kouebokkeveld Shale Fynbos		*		
Kouga Grassy Sandstone Fynbos	*			
Kouga Sandstone Fynbos	*			
Matjiesfontein Quartzite Fynbos	*			
Matjiesfontein Shale Fynbos	*			
Montagu Shale Fynbos	*			
North Hex Sandstone Fynbos	*			
North Kamanassie Sandstone Fynbos	*			
North Langeberg Sandstone Fynbos	*			
North Outeniqua Sandstone Fynbos	*			
North Rooiberg Sandstone Fynbos	*			
North Sonderend Sandstone Fynbos	*			
North Swartberg Sandstone Fynbos	*			
Northern Inland Shale Band Vegetation	*			
Olifants Sandstone Fynbos	*			
Overberg Sandstone Fynbos				*
Peninsula Granite Fynbos				*
Peninsula Sandstone Fynbos			*	
Piketberg Sandstone Fynbos		*		
Potberg Ferricrete Sandstone Fynbos			*	
Potberg Sandstone Fynbos	*			
Robertson Granite Fynbos	*			
South Hex Sandstone Fynbos	*			
South Kamanassie Sandstone Fynbos	*			
South Langeberg Sandstone Fynbos	*			
South Outeniqua Sandstone Fynbos	*			
South Rooiberg Sandstone Fynbos	*			
South Sonderend Sandstone Fynbos	*			
South Swartberg Sandstone Fynbos	*			
Southern Cape Dune Fynbos	*			
Swartberg Altimontane Sandstone Fynbos	*			
Swartberg Shale Fynbos	*			
Swartland Alluvium Fynbos				*
Swartruggens Quartzite Fynbos	*			
Swellendam Silcrete Fynbos		*		
Tsitsikamma Sandstone Fynbos	*			
Western Altimontane Sandstone Fynbos	*			
Western Coastal Shale Band Vegetation	*			

(names correct according to Mucina, Rutherford and Powrie, 2012)

VEGETATION TYPE	ECOSYSTEM THREAT STATUS			
	LT	VU	EN	CR
Winterhoek Sandstone Fynbos	*			
Renosterveld Ecosystems				
Breede Alluvium Renosterveld		*		
Breede Shale Renosterveld	*			
Central Mountain Shale Renosterveld	*			
Central Rûens Shale Renosterveld				*
Ceres Shale Renosterveld		*		
Eastern Rûens Shale Renosterveld				*
Kango Limestone Renosterveld		*		
Langkloof Shale Renosterveld				*
Majtiesfontein Shale Renosterveld	*			
Montagu Shale Renosterveld		*		
Mossel Bay Shale Renosterveld			*	
Peninsula Shale Renosterveld				*
Rûens Silcrete Renosterveld				*
Robertson Granite Renosterveld	*			
Roggeveld Shale Renosterveld	*			
Swartberg Shale Renosterveld	*			
Swartland Alluvium Renosterveld		*		
Swartland Granite Renosterveld				*
Swartland Shale Renosterveld				*
Swartland Silcrete Renosterveld				*
Uniondale Shale Renosterveld	*			
Vanrhynsdorp Shale Renosterveld	*			
Western Rûens Shale Renosterveld				*
Succulent Karoo Ecosystems				
Agter-Sederberg Shrubland	*			
Central Knersvlakte Vygieveld	*			
Citrusdal Vygieveld	*			
Doringrivier Quartzite Karoo	*			
Eastern Little Karoo		*		
Hantam Karoo	*			
Kamiesberg Mountain Shrubland	*			
Klawer Sandy Shrubland	*			
Knersvlakte Dolomite Vygieveld	*			
Knersvlakte Quartz Vygieveld	*			
Knersvlakte Shale Vygieveld	*			
Koedoesberge-Moordenaars Karoo	*			
Little Karoo Quartz Vygieveld	*			
Namaqualand Arid Grassland	*			
Namaqualand Blomveld	*			
Namaqualand Heuweltjieveld	*			
Namaqualand Klipkoppe Shrubland	*			
Namaqualand Spinescent Grassland	*			
Namaqualand Strandveld	*			
Northern Knersvlakte Vygieveld	*			

(names correct according to Mucina, Rutherford and Powrie, 2012)

VEGETATION TYPE	ECOSYSTEM THREAT STATUS			
	LT	VU	EN	CR
Piketberg Quartz Succulent Shrubland		*		
Platbakkies Succulent Shrubland	*			
Prince Albert Succulent Karoo	*			
Robertson Karoo	*			
Roggeveld Karoo	*			
Swartruggens Quartzite Karoo	*			
Tanqua Escarpment Shrubland	*			
Tanqua Karoo	*			
Vanrhynsdorp Gannabosveld	*			
Western Gwarrieveld	*			
Western Little Karoo	*			
Willowmore Gwarrieveld	*			
Mainland Thicket Ecosystems				
Gamka Thicket	*			
Southern Cape Valley Thicket	*			
Nama Karoo Ecosystems				
Eastern Lower Karoo	*			
Eastern Upper Karoo	*			
Gamka Karoo	*			
Karoo Escarpment Grassland	*			
Upper Karoo Hardeveld	*			
Western Upper Karoo	*			
Forest				
Southern Afrotropical Forest	*			
Southern Coastal Forest	*			
Azonal Ecosystems				
<i>Note: These azonal vegetation types may be associated with more than one of the ecosystem groups used in these Guidelines. Refer to the relevant chapters of the 'The Vegetation of South Africa, Lesotho and Swaziland (Mucina & Rutherford, 2006) for more information on their specific distribution.</i>				
Arid Estuarine Salt Marshes	*			
Bushmanland Vloere	*			
Cape Coastal Lagoons		n/a		
Cape Estuarine Salt Marshes	*			
Cape Inland Salt Pans	*			
Cape Lowland Alluvial Vegetation				*
Cape Lowland Freshwater Wetlands	*			
Cape Seashore Vegetation	*			
Cape Vernal Pools			*	
Freshwater Lakes		n/a		
Fynbos Riparian Vegetation		n/a		
Muscadel Riviere				*
Namaqualand Riviere	*			
Namaqualand Salt Pans	*			
Namaqualand Seashore Vegetation	*			
Southern Karoo Riviere	*			
Tanqua Wash Riviere	*			

(names correct according to Mucina, Rutherford and Powrie, 2012)

Appendix 2: Notes on the Classification of Aquatic Ecosystems

Aquatic ecosystems (See Box 1, below) often have high biodiversity, ecological and resource values. They also typically provide numerous vital ecosystem services that are essential for sustaining human life and supporting essential production sectors. There are many different types of aquatic ecosystems, each with its own particular ecological characteristics. The Western Cape has a long coastline spanning two oceans, numerous important river systems and estuaries, coastal lakes, and thousands of wetlands. These aquatic ecosystems, many of which have already been extensively modified by human activities, are under increasing pressure from a variety of land-use practices. Locating these land uses wisely requires special consideration of the fact that these ecosystems are highly interconnected with each other, and with the surrounding terrestrial environment.

Classifying aquatic ecosystems into meaningful groups helps planners and practitioners to understand the broad ecological characteristics of the ecosystem type they are working with, the significance of its location in the broader landscape, and its vulnerability to different kinds of impacts.

BOX 1 Definition of an Aquatic Ecosystem

In these *Guidelines*, an 'aquatic ecosystem' is defined as one that is permanently or temporarily inundated by flowing or standing water, or which has soils or substrata that are permanently or periodically saturated within 0.5 m of the soil surface. (Ollis *et al.*, 2013).

Classification of aquatic ecosystems

In these *Guidelines*, the term 'classification' is used to refer to the grouping of aquatic ecosystems into different types, following the classification systems outlined in the *National Biodiversity Assessment 2011* (Driver *et al.*, 2012) and the *Classification System for Wetlands and other aquatic ecosystems in South Africa* (Ollis *et al.*, 2013).

Types of aquatic ecosystems

At the broadest level, aquatic ecosystems are classified as marine, estuarine or inland systems. They are defined as follows:

- **Marine Systems** are aquatic ecosystems that form part of the open ocean overlying the continental shelf and/or its associated coastline up to a depth of 10 m at low tide. At its landward edge, a marine ecosystem is characterised by exposure to wave action and tidal currents.
- **Estuarine Systems** form where rivers feed into the sea. Estuaries are bodies of surface water that are not themselves part of the ocean, but are permanently or periodically open to the sea (over a period of decades), and, therefore, are subject to marine exchange and the influence of tidal fluctuations. The rise and fall of the water level in the estuary (as a result of tidal action) is measurable at spring tides when the water course is open to the sea. Although salinity itself is not the defining characteristic of an estuarine system, salinity is often measurably higher in an estuary, as a result of the influence of the sea. The estuarine ecosystem is considered to extend as far upstream as the upper limit of tidal action or salinity penetration.
- **Inland Systems** are aquatic ecosystems with no *existing* connection to the ocean. They are characterised by the complete absence of marine exchange and/or tidal influence. Some inland aquatic ecosystems (such as Soutpan on the Agulhas Plain) may be relatively saline in character, but this is due to the accumulation of mineral salts, ancient salt deposits and/or high evaporation rates, as opposed to present-day intrusion of seawater. The occurrence of relatively saline inland aquatic ecosystems is the reason why the term 'inland aquatic ecosystems' is used in preference to 'freshwater ecosystems' in this classification system.

Each of these categories can be further sub-divided into types, as explained below.

Marine (and Coastal) Ecosystems

According to the classification system used in the *Marine and Coastal* component (Sink *et al.*, 2012) of the *National Biodiversity Assessment 2011*, marine ecosystems can be divided at the broadest level into **offshore**, **inshore** and **coastal environments**. Offshore environments (which extend from a depth of 30 m below the water to 200 nautical miles offshore) include **pelagic** (open water) and **benthic** (seabed) habitats. The coastal environment (which extends from 500 m inland to a depth of 5 m below water – or the point where wave action ceases to have impact), is divided into areas of **rocky coast**, **sandy coast** and **mixed coast**. Inshore environments (from a depth of 5–30 m below water) include habitats with either **rocky** or **unconsolidated (sandy, muddy or gravelly) substrata**.

Coastal and inshore habitats can be further sub-divided based on consideration of factors such as wave exposure, sand grain size, underlying geology, substrate, beach type and **biogeography** (division into ecozones or ecoregions such as Agulhas, Namaqua and Delegoa), whilst offshore habitats can be further subdivided using features such as depth and slope of the sea shelf, nature of the substrate (sand, mud, gravel, rock), sea temperature and turbidity (*for further details refer to the NBA, 2011, pages 95–97*).

Estuarine Ecosystems

The classification of estuarine ecosystems in the *National Biodiversity Assessment 2011* recognises 46 estuarine ecosystem types, based on a number of physical and biogeographic features. The physical features include:

- Estuary size – Large (>100 ha), Medium (100–10 ha) or Small (<10 ha)
- Mouth state – Permanently Open or Temporarily Open/Closed
- Salinity structure – Fresh or Mixed
- Catchment type – Turbid, Black or Clear.

The **biogeographical features relate to the region** in which an estuary is located (Cool Temperate, Warm Temperate or Subtropical), and reflect the oceanographic conditions that influence species composition and diversity in the estuary. In the Western Cape, estuarine ecosystems fall into the cool temperate or warm temperate types – on the west coast there are 34 cool-temperate estuaries (representing 12 different estuary ecosystem types), and on the southern and south-eastern coast there are 24 warm-temperate estuaries, representing 18 different ecosystem types. None of the estuaries in the Western Cape fall into the subtropical zone.

Estuaries are important because they provide nurseries for many marine fish species (including those that are commercially important), and because they deliver sediments that form beaches and provide nutrients for marine food webs. They also are often focal points for coastal development and recreation, which means that they are subject to multiple pressures resulting from land-use activities in and surrounding the estuary, and as a result of the cumulative impacts of land uses higher up in the river catchment that feeds the estuary.

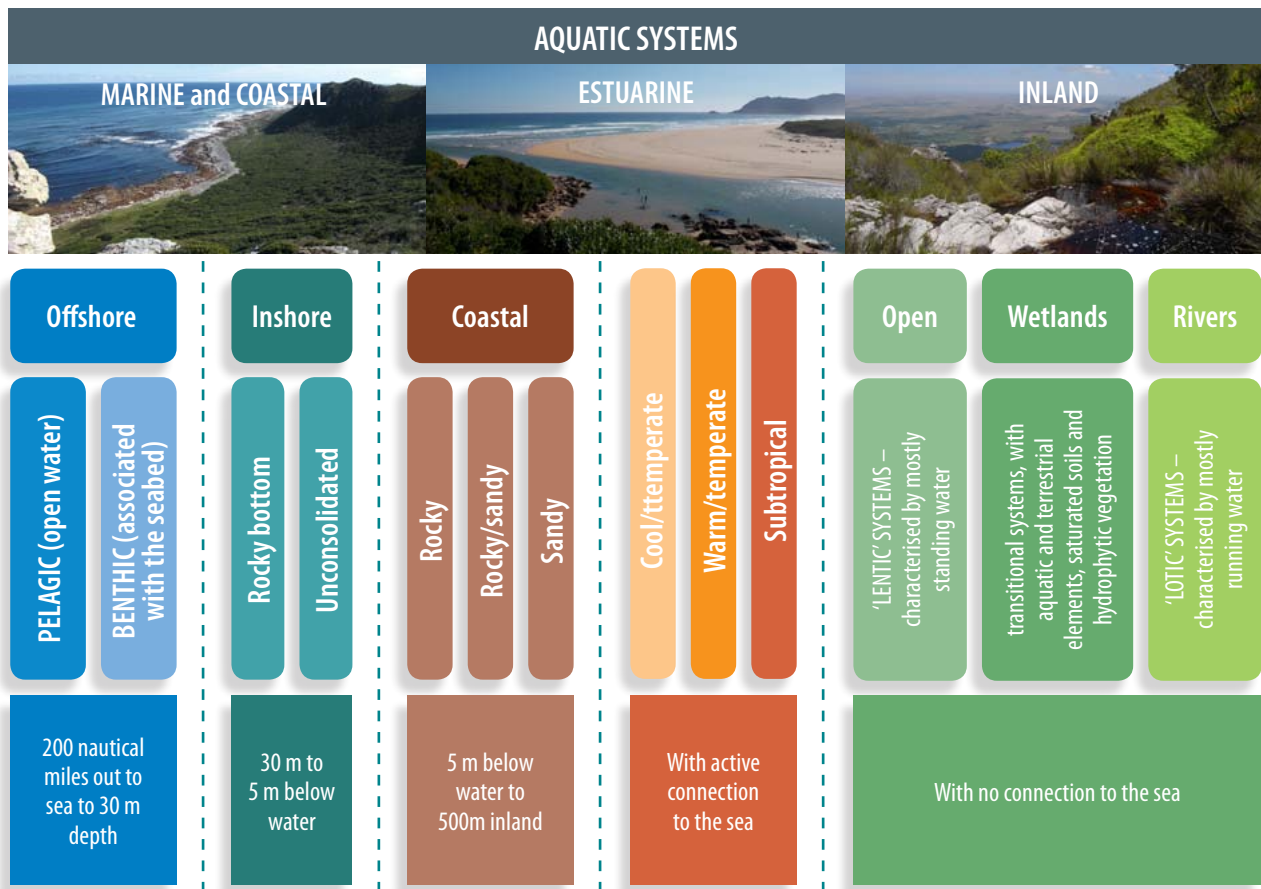
Inland Aquatic Ecosystems

There is a large number and variety of inland aquatic ecosystems in the Western Cape, but each can be assigned to one of three broad types:

- **Rivers**, which are 'lotic' aquatic ecosystems (that is, with permanently or periodically flowing water concentrated within a distinct channel).
- **Open waterbodies**, which are 'lentic' aquatic ecosystems, which are permanently inundated ecosystems in which standing water is the principal medium within which the dominant plants and animals live.
- **Wetlands**, which are transitional between aquatic and terrestrial systems, and are generally characterised by permanently to temporarily saturated soils and hydrophytic (water-adapted) vegetation. Wetlands are, in some cases, periodically covered by shallow water and may or may not lack vegetation.

These broad categories of aquatic ecosystem type are illustrated in Figure 1.

Figure 1: Diagrammatic representation of the broad categories of aquatic ecosystem types



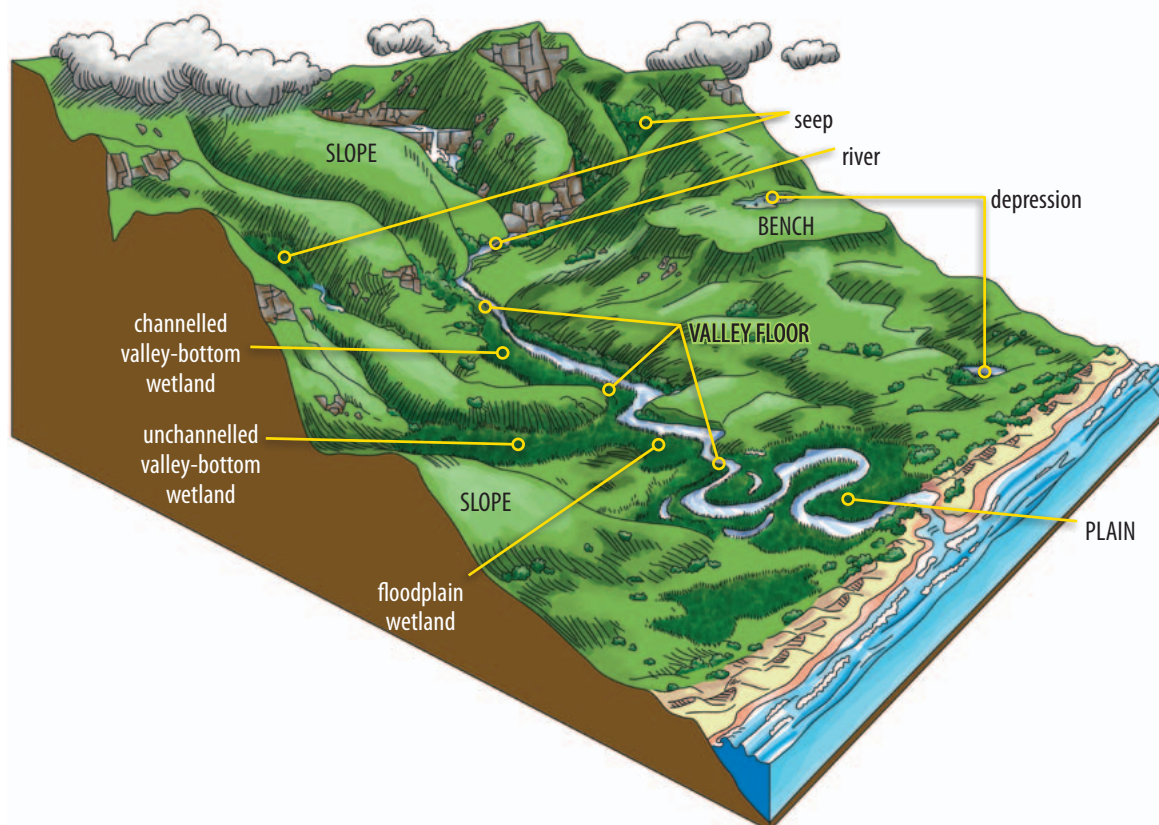
The enormous diversity of rivers, open waterbodies and wetlands has been simplified and described in the *User Manual for the National Classification System for wetlands and other inland aquatic ecosystems* (Ollis et al., 2013). This classification system groups inland aquatic ecosystems according to broadly similar *hydrological processes* (such as the way in which water moves into, through and out of the wetland systems) and *geomorphological factors* (such as the position of the wetland in the landscape, landscape shape and processes active in this location). This hydrogeomorphic (HGM) approach to classification recognises seven primary HGM types in South Africa that are presumed to represent aquatic ecosystem function, as follows:

- **River:** a linear landform with clearly discernible bed and banks, which permanently or periodically carries concentrated flows of water. A river unit is taken to include both the active channel and the riparian zone.
- **Floodplain wetland:** a wetland area on the mostly flat or gently-sloping land adjacent to and formed by an alluvial river channel, under its present climate and sediment load, and which is subject to periodic inundation by overtopping of the channel bank. Floodplain wetlands generally occur on a plain and are typically characterised by a suite of geomorphological features associated with river-derived depositional processes, including point bars, scroll bars, oxbow lakes and levees.
- **Valley-bottom wetland:** a mostly flat wetland area located along a valley floor. Valley-bottom wetlands are either channelled (i.e. connected to an upstream or adjoining river channel), or unchannelled.
- **Depression:** a wetland or aquatic ecosystem with closed (or near-closed) elevation contours and which increases in depth from the perimeter to a central area, and within which water typically accumulates. This type includes lakes, pans, and dams.

- **Seep:** a wetland located on gently to steeply sloping land and dominated by colluvial (i.e. gravity-driven), unidirectional movement of water and material down-slope. Seeps are often located on the side-slopes of a valley but they do not, typically, extend onto a valley floor.
- **Wetland flat:** a level or near-level wetland that is not fed by water from a river channel, and which is typically situated on a plain or a bench. Closed elevation contours are not evident around the edge of a wetland flat.

The HGM types can further be described in terms of their *position in the landscape* (i.e. on a valley floor, slope, plain or bench), as shown in Figure 2, and in terms of their *broad ecological context* (See Appendix 4 for an explanation of the different ways this can be done using various spatial frameworks).

Figure 2: Illustration of the seven primary HGM types and their typical landscape settings (based on drawing by Chip Snaddon, from Ollis et al. 2013)



The grouping or classification of inland aquatic ecosystems according to their similarities provides a useful framework for understanding the diversity of types in the landscape, and thus, by association, aquatic biodiversity. The HGM types broadly describe how and where these ecosystems form, and how they are sustained. This has direct relevance for land use and management, impact assessment, rehabilitation, conservation, and many other activities and processes.

Inland aquatic ecosystem types in the Western Cape

According to the NFEPA project, the Western Cape supports some 280 wetland types, based on a combination of grouped regional vegetation types and hydrogeomorphic units. By far the most common wetland types are channelled valley-bottom and floodplain wetlands. These wetland types are found on the lowlands, and they tend to be larger wetlands, spreading out on valley floors and plains. The greatest total area of wetland is found in East Coast Shale Renosterveld, with floodplain wetlands dominating within this vegetation type.

Seep wetlands – those occurring on slopes and also on benches at all altitudes – tend to be more numerous, but smaller in surface area. These wetlands are particularly important for groundwater recharge and water supply. Most of the strategic water source areas (or ‘water factories’) in the Western Cape are located in the many mountain ranges of the region, where seeps regulate water flow throughout the year.

The rivers of the Western Cape span ten primary or Level 1 ecoregions. The highest proportion of river length is located in Southern Folded Mountains and the Great Karoo ecoregions. Most of the total river length in the Western Cape has been classified as having ephemeral flow – that is, flowing for less than three months of the year. These rivers are located primarily in the Great Karoo and Nama Karoo ecoregions. The rivers of the Fynbos Biome tend to be seasonal or perennial, located as they are in the more mesic mountain ranges and coastal lowlands of the Western Cape.

According to the NFEPA project, there are some 64 river types in the Western Cape. These types are a combination of Level 1 ecoregion, flow type (perennial/seasonal or ephemeral/flashy) and the river zone (mountain streams, upper or lower foothill rivers, or lowland rivers). An assessment of river condition for the NFEPA project found that most of the river length in the Western Cape is in moderate (Present Ecological State category C) to good condition (combined category AB). Most rivers show deterioration in condition from source to sea. Roughly 40% of the total river length in the province comprises Endangered or Critically Endangered river types, while the remainder are Vulnerable or Least Threatened.

Representation of river and wetland biodiversity in the Western Cape

The classification system also uses the **regional setting** of aquatic ecosystems – that is, the location of the system within different ecoregions, themselves comprising broad regions that share similar physiography, climate, geology, soils and potential natural vegetation. By delineating the regional setting of an inland aquatic ecosystem, its broad ecological context is identified and one should be able to gain some understanding of the ecosystem characteristics that are to be expected. The regional setting is thus one of the key criteria typically used in biodiversity/conservation planning initiatives for inland aquatic ecosystems.

For rivers, the ‘Level I’ Ecoregions developed by the Department of Water Affairs (Kleynhans *et al.* 2005) are typically used as the spatial framework for identifying the regional setting. For example, these Ecoregions were used for rivers in the National Freshwater Ecosystem Priority Areas (NFEPA) and NBA 2011 projects, and they are used as the spatial framework for the national River Health Programme.

The *Vegetation of South Africa, Swaziland and Lesotho* (Mucina and Rutherford, 2006), describes several ‘azonal’ wetland types for the Fynbos Biome, including Cape Lowland Freshwater Wetlands, Cape Vernal Pools, Cape Inland Salt Pans and various alluvial and riparian (stream-side) vegetation types. These provide extremely useful and detailed descriptions of these vegetation types, and should be built upon, although the classification of inland aquatic ecosystem types is best dealt with using SANBI’s national classification system (Ollis *et al.*, 2013). For the time being, the vast majority of the wetlands of the Fynbos Biome fall within the ‘Cape Lowland Freshwater Wetlands’ vegetation type, a broad grouping considered to be inadequate to describe the variation found within the wetlands present. For example, perennially saturated grass and sedge wetlands on deep sands support quite different species and function differently to dry seasonal wetlands on clay soils, which in turn are very different from wetlands with peaty soils. For this reason, the C.A.P.E. Fine-Scale Planning Project, and the NFEPA and NBA 2011 Projects, assigned wetland regional types according to the vegetation types within which the wetlands were embedded. This was not a reference to plant species, but rather that the *Vegetation Types of South Africa, Swaziland and Lesotho* (Mucina and Rutherford, 2006) was considered to represent the current, most accurate, available spatial coverage of origins (paleoecological patterns), climate, geology and soils, all of which are potential regional spatial surrogates for endemic- or biodiversity-rich wetland types.

Appendix 3: Basic Terms of Reference for an Ecological or Biodiversity Specialist conducting an Environmental Assessment

Note: These Terms of Reference (ToR) should be read in conjunction with Section 3.3. in Chapter 3 of these Guidelines, where more detailed, step-by-step guidance is given on how to conduct the biodiversity assessment as part of an environmental assessment process. The ToR describe, in basic terms, the scope of work to be carried out by a terrestrial ecologist or biodiversity specialist. Specific and detailed ToR for aquatic specialists are provided in Appendix 4.

The ecologist or biodiversity specialist must have no financial or other vested interest in the proposed development, and must be professionally registered with the South African Council for Natural Scientific Professions, SACNASP.

1. Determine the biodiversity importance of the area in a landscape context from available information.

Using the *National Biodiversity Assessment (NBA)*, *Western Cape Biodiversity Framework (and associated CBA maps)*, fine-scale biodiversity plans, maps of Freshwater Ecosystem Priority Areas (FEPAs), as well as the provincial Protected Area Expansion Strategy (amongst others), determine the biodiversity importance of the particular site and its surroundings in a wider landscape context, and any likely biodiversity risks, including:

- areas of international importance (e.g. Ramsar sites, World Heritage Sites, and/or their buffer zones, UNESCO Biosphere Reserves).
- areas identified in bioregional or biodiversity sector plans as Critical Biodiversity Areas (CBAs) or Ecological Support Areas (ESAs).
- protected areas and/or their buffer zones, and areas earmarked for Protected Area Expansion (in the Western Cape's Protected Area Expansion Strategy).
- Freshwater Ecosystem Priority Areas (FEPAs).
- Estuarine Functional Zones.
- important climate-adaptation corridors.
- 'sensitive' areas in applicable Environmental Management Frameworks (EMFs).
- coastal public property or areas falling within the Coastal Protection Zone.
- areas that are important for the provision of key ecosystem services (e.g. water catchment areas/'water factories').
- areas that are prone to flooding or other natural hazards/disasters (e.g. floodplains).

2. Determine the biodiversity importance of the site, and areas beyond the site that lie within the area of influence of the proposed project, from available information.

- Determine the ecosystem threat status of affected vegetation/areas (refer to the latest version of the National List of Threatened Terrestrial Ecosystems, and the Western Cape's updated statistics on Ecosystem Threat Status (Pence, 2014).
- Using Red Lists and/or Red Data Book information, determine whether or not any threatened species or protected species could be negatively affected.
- Using Google Earth or other images, determine if there are any unique or sensitive features such as wetland or mobile sand dunes that would present constraints to development.

3. Considering the nature and scale of, proposed development, identify potentially significant impacts and risks that would typically be associated with the project.

These should include at least:

- Direct, 'footprint' impacts of the project and associated activities, facilities or infrastructure.
- Impacts arising from project inputs and outputs (e.g. water use, changes in surface drainage or water quality, emissions, effluent, chemicals, solid waste, introduction of invasive species, disturbance such as noise, lights and traffic).
- Indirect impacts (likely to occur in a different place or timeframe, as a result of the main project).

4. Undertake a site visit and ground-truth biodiversity information. Where required, undertaken baseline surveys and/or studies to supplement the information base and inform the assessment.

The site assessment should, as a minimum:

- a) Describe and map important biodiversity at the site(s) and in the wider landscape, in the appropriate season (which may vary between the western and eastern parts of the province, as well as by taxon), from both pattern and ecological process perspectives. Areas or features off site that could be indirectly impacted by the proposed land use (e.g. downstream watercourses or groundwater-dependent ecosystems, areas to be modified for transport/energy corridors) must be included in this analysis.
- b) Note the condition of affected ecosystems and levels of degradation, including infestation by invasive alien species.
- c) Record inconsistencies between the biodiversity plans/CBA maps/ FEPA maps and the 'on the ground' situation.

5. Identify features and areas of biodiversity significance that would be impacted or at risk as a result of the proposed land use, and make recommendations for mitigation to inform or influence the proposal.

Both area-based (i.e. spatial changes) and practice-based (i.e. management or choice of technology) measures should be addressed. All potential impacts (refer to Point 3 above) must be taken into account. Evaluate whether or not the likely impacts would compromise the desired management objectives for the specific biodiversity areas or features (CBA, ESA, FEPA, protected area, etc).

Engage with key biodiversity stakeholders (e.g. conservation NGOs, CapeNature, SANBI, CREW) as appropriate, to clarify or obtain additional biodiversity information.

Ensure that you:

a) Apply the Mitigation Hierarchy and:

- Identify areas where any loss of biodiversity would be irreplaceable (e.g. could lead to extinction of species and/or jeopardize meeting biodiversity targets for different ecosystems). These areas or features must be retained and protected; any impacts on them must be **avoided or prevented**.

These areas generally comprise:

- ✓ CBAs
- ✓ Critically Endangered ecosystems
- ✓ FEPAs
- ✓ special/unique habitats (that occur locally e.g. quartz patches);
- ✓ areas that constitute crucial fixed (rather than flexible) ecological corridors across ecological gradients (including climate change adaptation corridors);
- ✓ habitat of known Critically Endangered species and/or areas containing biodiversity that underpins ecosystem services on which there is high dependency and for which there are no substitutes.

- Identify areas of high importance or sensitivity on which impacts should **preferably** be **avoided or prevented** or, where they cannot altogether be avoided, should at least be **minimized** (e.g. through buffers or setbacks).

These areas include:

- ✓ Endangered ecosystems in particular, where the emphasis should be on avoidance/prevention.
- ✓ Vulnerable ecosystems.
- ✓ ESAs.
- ✓ Habitat of highly threatened species and/or concentrations of threatened species.
- ✓ Highly dynamic ecosystems (e.g. mobile sand dunes or watercourses).

- Identify areas where any loss of important ecosystem services on which communities and/or society are highly dependent for livelihoods, health, safety or wellbeing would be irreversible and could not be substituted at all or would be extremely expensive to substitute (e.g. loss of water supplies or flood buffers). Impacts in these areas must preferably be **avoided or at least minimized**.

- Identify areas that pose a natural hazard to land-use activities which require development or management setbacks.
 - Identify areas that are known to be important for biodiversity but are degraded or invaded by alien species and require rehabilitation/restoration, including areas that could improve connectivity and reduce fragmentation in the landscape.
 - Identify areas that would be worthy of protection (for example, through biodiversity stewardship).
 - Identify areas where impacts on biodiversity would be of low or negligible significance and where modifying land uses should be focused.
- b) Identify the need for, and investigate, **biodiversity offsets** as a last resort form of mitigation, only in cases where all reasonable and feasible alternatives have been duly considered and significant negative impacts cannot be avoided. *In these cases, recommend the involvement of a biodiversity offset specialist to design an appropriate and adequate offset in accordance with provincial offset guidelines.*
- Accommodate key drivers of the affected ecosystems, for example by addressing the spatial/layout implications where burning of veld is required.

6. Capture the findings of the biodiversity assessment in a specialist report, including:

- a) Any assumptions and limitations (e.g. gaps in information, inability to visit site or do seasonal sampling, post-fire age of veld).
- b) Reference to all the sources of biodiversity information used or obtained.
- c) A statement that a site visit was carried out, in what season, and any limitations thereof.
- d) An accurate description and map of the areas and features of importance to biodiversity and their sensitivity to the proposed development.
- e) Clear documentation (e.g. photographic evidence) if ground-truthing presented any conflicts or inconsistencies with biodiversity information in biodiversity plans/maps.
- f) A description of how the Mitigation Hierarchy (including consideration of reasonable and feasible alternatives) has been used to avoid or minimize potentially significant impacts that in turn have influenced or shaped the land-use proposal.
- g) An explanation of the protocol used to assess and evaluate the potential significance of negative impacts on biodiversity and ecosystem services, and levels of confidence in the assessment.
- h) A statement of impacts that could not be avoided or reduced sufficiently to ensure that they would be of low or negligible significance.
- i) An explicit statement of any impacts would be irreversible and lead to loss of irreplaceable biodiversity, or loss of important ecosystem services on which there is high dependency.
- j) A description of all recommended measures that need to be taken during construction and operational phases to rehabilitate, compensate/offset and/or manage biodiversity impacts.
- k) An explicit statement of the required outcomes of these mitigation measures, to be incorporated in an Environmental Management Programme.
- l) A map or maps at a meaningful scale (preferably >1:10 000) and photographs to illustrate the biodiversity implications of the proposed project, as well as the amended proposal, taking into account recommended area-based measures to avoid and minimize negative impacts.

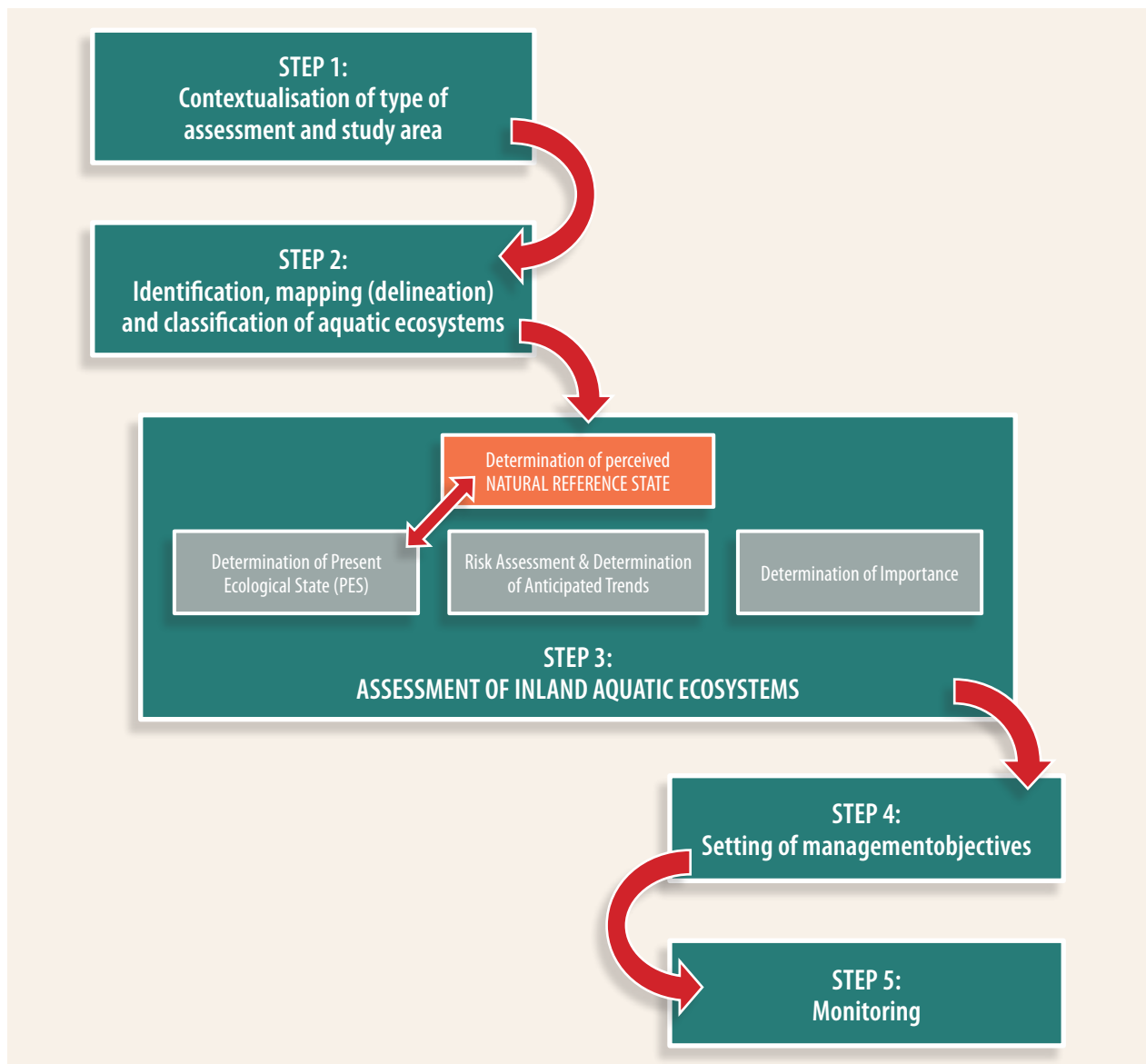
Appendix 4: Terms of Reference for Specialist Assessment of Inland Aquatic Ecosystems

Note: Acronyms used in these ToR are explained in the list of acronyms at the front of the book. The references cited in the text are included in the general reference list in Appendix 6.

Introduction

For any assessment of inland aquatic ecosystems, a suitably qualified aquatic specialist should be appointed to complete all or some of the tasks listed below, depending on the type and scope of study. The intention here is to provide guidance to EAPs or aquatic specialists for the drafting of project-specific terms of reference (ToR). The diagram below (Figure 1) provides a framework summarising the steps that are typically followed for the assessment of inland aquatic ecosystems. Not all steps are required for each type of study.

Figure 1: Framework for undertaking a specialist assessment of inland aquatic ecosystems



STEP 1: Contextualisation of assessment and study area

1.1. Type of study

The following types of studies typically require specialist input (refer to Table 1, below, for a summary):

- Site scan – a specialist may be required to ascertain whether there is an inland aquatic ecosystem that could be affected by a proposed activity.
- Constraints analysis – this generally requires the rough delineation or mapping of inland aquatic ecosystems and recommended buffers, in order to show the constraints on activities in and around the affected aquatic ecosystems. In addition, the specialist is usually required to give an opinion on the appropriateness of the proposed activities, and propose mitigation measures to reduce the potential negative impacts on aquatic ecosystems to acceptable levels. This type of study generally goes hand-in-hand with a site scan.
- Environmental authorisation – the National Environmental Management Act (Act 107 of 1998) and the EIA Regulations promulgated by NEMA, specify activities that require environmental authorisation before they may proceed. Authorisation requires that a systematic process of identifying, assessing and reporting on the expected environmental impacts associated with an activity takes place. This is done as either a Basic Assessment or as a Scoping and Environmental Impact Assessment, depending on the type of activity proposed, as listed in the relevant Government Notices.
- Water use authorisation – the National Water Act (Act 36 of 1998) regulates a number of consumptive and non-consumptive water uses. All of these uses must be registered and/or authorised as a water use, depending on the type and volume of use. Both consumptive and non-consumptive water uses require authorisation from the Department of Water and Sanitation, unless the proposed water use falls within the limits of the permissible water uses set out in Schedule 1 of the National Water Act. Authorisation is obtained either as a Water Use Licence (WUL), or as General Authorisation (GA), should the water use fall within the conditions and limits of a gazetted GA. A Water Use Licence requires the determination of the 'Reserve' for the relevant catchment.
- Strategic environmental assessment, environmental management framework, river management plan, biodiversity plan, etc – these types of studies generally apply to a wider geographical area than those described above, and will address broader objectives.
- Rehabilitation or restoration of degraded aquatic ecosystems – specialist input may be required at various levels of the rehabilitation/restoration process. Input could include the definition of objectives, determination of the best method for achieving the objectives, assessment of the condition and importance of the affected ecosystem (both before and after intervention), and in designing a monitoring programme looking at the effectiveness of the intervention.

Table 1: Types of studies requiring specialist terms of reference, and the steps required to meet the objectives of each study. The steps are expanded in Steps 2–5, below.

TYPE OF STUDY	STEP 1: Site Contextualization	STEP 2: Identification, mapping (delineation) and classification	STEP 3: Assessment of the ecosystem	STEP 4: Setting management objectives	STEP 5: Monitoring
Site scan	✓	✓			
Constraints analysis	✓	✓	✓		
Environmental authorisation	✓	✓	✓	✓	preferably
Water use registration or authorisation	✓	✓	✓	✓	required
Strategic environmental assessment, environmental management framework (EMF), river management plan, biodiversity planning, etc	✓	✓	✓	✓	generally
Rehabilitation or restoration of ecosystems	✓	✓	✓	✓	preferably

1.2. Site contextualisation

The assessment of inland aquatic ecosystems at any level of detail should include a description of the broader landscape and of the patterns and processes operating at this level. The inland aquatic ecosystems that are to be assessed can then be placed in this context, in particular in the context of the surrounding catchment. At the most basic level, this should aim towards a better understanding of:

- How and why the ecosystem(s) in question came to be there (e.g. through natural evolution of the ecosystem, or through anthropogenic interference).
- The surrounding landscape (topography, gradient, vegetation, soils, hydrology) and the landscape position (e.g. slope, bench, valley floor, plain) of the ecosystem.
- The processes occurring in and around the ecosystem that influence the form (shape, extent and type) and function of the ecosystem.
- The implications of degradation, rehabilitation or loss of the ecosystem.

In practical terms, site contextualisation should include:

- Provision of a good quality aerial photograph of the site and its surrounds, and photographs of the inland aquatic ecosystems on the site.
- Desktop delineation of the boundaries of the sub-catchment of the ecosystem and the surrounding quaternary catchment (the sub-catchment map is the River FEPAs map of NFEPA, quaternary catchment maps are available from the DWS website).
- Examination of 1:50 000 scale topographical maps of the study area (available from CD:NGI), and of (recent and historical) aerial photographs (also available from CD:NGI) and/or satellite imagery (e.g. Google Earth), to gain an understanding of the land uses on the site and in the surrounding sub-catchment.
- Examination of the relief of the site and surrounding areas by referring to the contour lines on a map (1:50 000 topographical maps show contour lines at 20 m intervals; contour lines at 10 m intervals are also available from CD:NGI) or at least to 'tilted' Google Earth 3D imagery of the study area.
- Desktop mapping of river reaches up- and downstream of the site, including tributaries (1:50 000 river line and river area maps are available from CD:NGI; 1:500 000 rivers maps are available from DEAT, but these are all represented on the NFEPA Rivers map, available from BGIS).
- Mapping the location of FEPA sub-catchments, fish sanctuaries, fish support areas and fish corridors in relation to the ecosystem on site (all of these NFEPA maps/databases are available on BGIS).
- Mapping the location of important wetlands within the sub-catchment of the affected aquatic ecosystem – this should at least include CBA and ESA wetlands, FEPA wetlands, Ramsar wetlands, FEPA wetland clusters, and any estuaries downstream of the site.
- Mapping the location of important bird areas (IBAs) in relation to the site (this map is available on BGIS).
- Collation of other potentially relevant biodiversity information available for the surrounding sub-catchment or, at the very least, quaternary catchment – for example, Protea Atlas data, Frog Atlas data, CWAC data.

STEP 2: Identification, mapping (delineation) and classification of inland aquatic ecosystems

2.1. Identification and mapping

For any assessment, the potentially affected inland aquatic ecosystems should be identified and mapped or delineated at an appropriate level of accuracy, based on a number of indicators. Inland aquatic ecosystem delineation includes:

- Confirmation of the **presence** of a wetland, open waterbody, river channel or riparian area.
- An approximate determination of the outermost **boundary** (and extent/length) of the aquatic ecosystem, generally depicted as a map on an aerial image.

There are three levels of detail when delineating inland aquatic systems, depending on the objectives of the study:

- Desktop mapping – the use of current and historical aerial imagery (obtainable from CD:NGI) is the best approach, with the next best option being good satellite imagery (such as SPOT) or, where no other options are available, Google Earth imagery.
- Desktop mapping with field verification.
- Delineation in the field.

Ecosystems should preferably be mapped at a scale of at least 1:10 000 (1:50 000 is too coarse in most cases). The scale of mapping and the confidence with which it was undertaken should be reported.

Field delineation must follow the accepted national protocol¹, and should result in:

- A map that includes the identified boundary and the field data collection points (which should include at least one point outside the wetland or riparian area).
- A report that explains how and when the boundary was determined² (details of the type and date of imagery used to support the delineation must be included (see SANBI, 2012)).

Timing of identification and mapping

The best time of year for determining the presence of inland aquatic ecosystems is the wet season. If the project timeframe does not allow for this, then the practitioner must state this in the constraints and limitations of the study. It is recommended that the practitioner inform the client of the risks of a dry season site visit, and that the project budget and timeframe should allow for a re-visit of the site in the wet season.

Field Indicators for inland aquatic ecosystems

The presence of an inland aquatic ecosystem requires the identification of *one or more* of a number of indicators. According to DWS's currently accepted and legislated protocol for delineation (DWA, 2005), the following are considered indicators of **wetland presence**:

- Terrain Unit – helps to identify those parts of the landscape where a wetland is most likely to occur.
- Soil Form – identifies soil form as defined by the Soil Classification Working Group (1991).
- Soil Wetness – identifies the morphological signatures developed in the soil profile as a result of prolonged and frequent saturation.
- Vegetation – identifies hydrophilic (water-loving; either obligate or facultative) vegetation associated with wetland soils.

Hydrology is currently not used as an indicator of wetland presence. However, where surface or subsurface water is visible or accessible (through auguring) this should be recorded.

The following are considered indicators of the **presence of riparian areas**:

- Topography associated with the watercourse – a rough indicator is the edge of the macro or outer channel bank.
- Vegetation – identifies where there is a marked change in species composition and growth form relative to terrestrial areas.
- Alluvial soils (defined as relatively recent deposits of sand, mud etc by flowing water) and deposited material (e.g. vegetation and soil deposits).

¹ In 2014, the accepted national protocol is that contained in the DWA (2005) delineation manual.

² Delineation may be complex, and in some cases, may call for a multi-disciplinary team including a soil scientist, botanist, hydrologist, etc. In difficult or potentially controversial cases, practitioners are advised to at least seek advice from these other disciplines.

2.2. Classification

The practitioner should use the Classification System for Wetlands and Other Aquatic Ecosystems in South Africa (Ollis *et al.*, 2013) to describe the types of aquatic ecosystems being assessed (see the Note on Classification of Aquatic Ecosystems in Appendix 2 of these *Guidelines*). The typing of inland aquatic ecosystems should preferably include all of the following, with the minimum requirement being Level 4, together with an indication of the degree of confidence for the classification in each case:

- Level 2: **regional setting**, using DWS Level 1 ecoregions (particularly relevant for rivers) and/or NFEPA WetVeg groups.
- Level 3: **landscape unit**, i.e. valley floor, slope, plain or bench.
- Level 4: **hydrogeomorphic (HGM) unit**, distinguished according to landform (shape and localised setting), hydrological characteristics (nature of water movement into and out of the ecosystem) and hydrodynamics (direction and strength of flow).
- Level 5: **hydrological regime**, describing the behaviour of water in the wetland or river and, for wetlands, the underlying soil, i.e. perennality of flow for rivers, and duration of saturation/inundation for wetlands.

Further detail provided by the descriptors at Level 6 is useful for understanding the complexity of a system, but may be unfeasible within the budget and timeframe of some projects. However, the practitioner should differentiate, where possible, between **artificial** and **natural** systems.

STEP 3: Assessment of inland aquatic ecosystems

3.1. Reference state

The presumed historical, undisturbed state of an aquatic ecosystem should be described (this is a requirement for a present ecological state (PES) assessment, see below), making use of historical imagery (obtainable from CD:NGI), anecdotal evidence, reports, etc. Knowledge of the historical ecosystem type is of particular importance, as the assessment of current condition is largely based on this. This requires an understanding of the drivers of change affecting the system, so that the trajectory of change can be described.

3.2. Assessment of present ecological state and importance

The Present Ecological State (PES) of all potentially affected naturally-occurring inland aquatic ecosystems should be determined, relative to the perceived natural reference state. An indication should be given of the confidence of these assessments. PES assessments are not applicable to artificial systems, as there is no natural reference state that can be used as the bench-mark.

For all potentially affected inland aquatic ecosystems (whether natural or artificial), the ecological/conservation importance should be determined, using appropriate methods. Again, an indication should be given of the confidence level of these assessments.

3.2.1. Present Ecological State

For **rivers** at a desktop level, the condition of 1:500 000 river reaches can be checked against the NFEPA Rivers layer, and for field verification, the practitioner could use DWS's Present Ecological State (PES) method (applying Ecological Categories A to F).

For **wetlands** at a desktop level, the condition assigned by NFEPA can be used, but in many cases NFEPA modelled condition, so field verification is strongly recommended. For field verification, the practitioner could use:

- Rapid Level 1 or Comprehensive Level 2 WET-Health (MacFarlane *et al.*, 2009), depending on the kind of study (Ecological Categories A to F). Level 2 is recommended when the focus is on one or two wetlands, or for monitoring of a system before and after development or rehabilitation.
- The Rapid Wetland-IHI (Index of Habitat Integrity) (DWA, 2007) for floodplain and Valley-Bottom Wetlands.
- DWS's Resource Directed Measures Rapid PES (DWA, 1999), developed for floodplain wetlands but generally applicable to all wetland types except for pans.

3.2.2. Ecological importance and sensitivity

For **rivers**, the DWS's EIS for rivers (DWA, 1999c) should be used. Recently, this has been split into ecological importance (EI) and Ecological Sensitivity (ES), but the protocols have not been published.

For **wetlands**, the accepted protocols are:

- Kotze *et al.*'s (2009) WET-Ecoservices, for the determination of the range of goods and services provided by a wetland.
- The Wetland EIS assessment tool of Rountree and Kotze (2013).

3.3. Impact assessment and mitigation

The practitioner must describe the nature and status (negative or positive) and evaluate the potential impacts on the hydrological regime, geomorphology, biodiversity and ecological functioning of the aquatic ecosystem. Impacts are described in terms of their extent, intensity, and duration (see the information box below). The other aspects that must be included in the evaluation are:

- Probability of the impact occurring.
- Reversibility of the impact.
- Irreplaceability of the lost resources/function.
- Extent to which the impact can be mitigated.
- Confidence in the evaluation.

The practitioner must provide the rationale behind the evaluation of impacts.

3.3.1. Significance ratings

The significance of an impact is rated according to extent, intensity, and duration. A guideline for determining impact significance is provided in the information BOX below. It is important to note that **FEPA wetlands or river reaches** should be assigned a **national** level for the extent of the impact, and CBA systems a regional extent.

All impacts must be rated with and without mitigation.

3.3.2. Cumulative impacts

A cumulative impact is described as one which, in itself, may not be significant, but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area. Cumulative impacts should be described as either additive – adding to other similar impacts – or interactive – where different impacts combine to result in a new kind of impact. As for other impacts, the relationship between the impact and the hydrological regime, geomorphology, biodiversity and ecological functioning of the aquatic ecosystem needs to be established.

3.3.3. Avoidance, mitigation and offsets

All predicted impacts should be linked to a recommendation for either avoidance or mitigation on site. Practical mitigation measures should be designed to minimise negative impacts, enhance beneficial impacts and assist in project design. If appropriate, practitioners must differentiate between **essential mitigation measures** which must be implemented (i.e. implicit in the 'assuming mitigation' impact significance rating) and **optional mitigation measures** which are recommended, but which do not affect the impact rating.

Practitioners should also provide a recommended **monitoring and review** programme in order to track the efficacy of the recommended mitigation measures.

Should there be significant residual impacts after avoidance and on-site mitigation measures have been considered and/or incorporated in project development, mitigation off-site as a **biodiversity offset** can be considered (this applies only to wetlands). Wetland offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse impacts on wetlands. The currently accepted protocol for the determination of appropriate wetland offsets must be consulted. Wetlands offsets are not appropriate for:

- Wetlands placed in an A or B Ecological Category
- FEPA or CBA wetlands
- Strategic water source areas
- Ramsar sites
- Critically Endangered or Endangered wetland types or wetlands supporting Critically Endangered or Endangered species
- Wetlands providing critical ecosystem services
- Key features in an RQO assessment
- Wetlands heavily relied upon by human communities.

STEP 4: Setting management objectives

3.1. Determination of the Recommended Ecological Category and setting of Resource Quality Objectives

For most water resource management studies, or for Water Use Licence Applications (WULAs), including applications for the registration of a General Authorisation, the Recommended Ecological Category (REC) needs to be determined for potentially affected inland aquatic ecosystems. This is a useful, though not compulsory, exercise for EIA studies too. For Reserve determination studies, the RQOs also need to be set for an inland aquatic ecosystem. Methods for the determination of the Recommended Ecological Category (REC – Categories A to D³) are provided in Kleynhans and Louw (2008) for rivers, and in Rountree and Kotze (2013) for wetlands.

The REC will influence the management objectives or the Resource Quality Objectives (RQOs) set for a particular inland aquatic ecosystem.

3.2. Setting buffers around inland aquatic systems

Activities within 32 m of a river or wetland trigger the NEMA regulations. This does not, however, equate to a buffer protecting water resources from human disturbance. Ideally, the setting of buffers should take into account the following:

- Ecosystem type

3 Categories E and F are not acceptable as REC's, as this implies that a very high to critical level of modification is acceptable as a future goal.

- Current and recommended ecological category
- Ecosystem functioning (provision of ecosystem services/ecological infrastructure)
- Spatial requirements of species dependent on the ecosystem for all or part of the life cycle
- Nature of the proposed activity;
- Links with other aquatic ecosystems and surrounding land
- Potential for rehabilitation and/or restoration.

Buffers must be measured from the top of the river bank, or the outermost edge of the wetland or riparian area, and must make use of the nationally or at least regionally applicable protocols for the determination of buffer widths. A buffer recommendation should be accompanied by the reasons for setting the width.

3.3. Water Use Authorisation

The DWS in the Western Cape and the provincial Department of Environmental Affairs and Development Planning (DEA&DP) have recently discussed a special operating procedure, whereby the environmental (basic assessment or EIA) and water use authorisation processes can occur in parallel, within an agreed timeframe. It is envisaged that this procedure will streamline the authorisation processes and approval for development required by these departments.

Considering that development is frequently delayed by a backlog for water use authorisation, it is advised that the specialist requirements for both the basic assessment or EIA and the water use authorisation be combined in one terms of reference.

STEP 5: Monitoring

It is recommended that, where possible, a monitoring component should be included in an assessment of inland aquatic ecosystems. Monitoring can measure either system **responses** or the **drivers** or **stressors** (refer to the ecosystem guidelines for inland aquatic ecosystems provided in Chapter 5 of these *Guidelines*). The monitoring programme needs to address (based on Kotze and Macfarlane, 2014):

- **Scope and objectives of monitoring:** This will depend on budget and time, but should define the appropriate level of monitoring, what is being monitored and why.
- **Site selection:** Monitoring sites must be carefully selected, in order to achieve the objectives.
- **Indicators to monitor:** Refer to the key indicators described in the ecosystem guidelines for inland aquatic ecosystems provided in Chapter 5 of these *Guidelines*.
- **Monitoring protocols:** These are the methods and equipment to be used for monitoring.
- **Monitoring frequency and responsibilities:** This will state how often monitoring is to be repeated and for how long, and by whom.
- **Data storage, analysis and reporting:** The monitoring data need to be stored and analysed, and finally, reported in an accessible manner, to the appropriate individuals, organisations and government departments. It is recommended that the landowner be provided with a report, in addition to the local or regional conservation authorities.

Appendix 5: Glossary of Terms

Note: this is not an exhaustive glossary, but provides an explanation of the most often-used technical terms in this document.

Abiotic: Non-living, in this case taken to mean the non-living components of ecosystems (e.g. wind, temperature, geological features, precipitation, and so on).

Basal Cover: A measure of the area of ground covered by the rooted or basal portions of plants in a given landscape.

Biodiversity: The diversity of genes, species and ecosystems on Earth, and the ecological and evolutionary processes that maintain this diversity.

Biodiversity assessment: An assessment of the state of biodiversity, at the ecosystem, species or genetic level. The output of a biodiversity assessment could be, for example, a map of ecosystem threat status, ecosystem protection level or irreplaceability.

Biodiversity hotspot: An area characterised by high levels of biodiversity and endemism, and that faces significant threats to biodiversity.

Biodiversity offsets(s): Measurable conservation outcome(s) resulting from actions to compensate for residual negative impacts (of a development project) on biodiversity. Biodiversity offsets are the last option in the mitigation hierarchy, and should be considered only after other options have been pursued.

Biodiversity pattern: The compositional and structural aspects of biodiversity, at the species and ecosystem level.

Biodiversity planning: The process of developing a spatial plan that identifies one or more categories of biodiversity priority area, using the principles and methods of systematic biodiversity planning. *See 'systematic biodiversity planning.'*

Biodiversity priority areas: Features in the landscape (or seascape) that are important for conserving a representative sample of ecosystems and species, for maintaining ecological processes, or for the provision of ecosystem services. Different categories are recognised, as detailed in the Box at the end of this glossary.

Biodiversity sector plan: A map of biodiversity priority areas (critical biodiversity areas and ecological support areas) accompanied by contextual information, land-use guidelines and supporting GIS information. The map must be produced using the principles and methods of systematic biodiversity planning, in accordance with nationally agreed guidelines. A biodiversity sector plan represents the biodiversity sector's input to planning and decision-making in a range of other sectors. It may, but does not have to be, formally published in the Government Gazette as a *bioregional plan*.

Biodiversity stewardship: A model for expanding protected areas in which the state conservation authority enters into legal agreements (contracts) with private and communal landowners to protect and manage land in biodiversity priority areas. Different categories of agreement confer varying degrees of protection on the land and hold different benefits for landowners and require different levels of restriction on permissible land uses. In this model, the landowner retains title to the land, and the primary responsibility for management remains with the landowner, with technical advice and assistance provided by the conservation authority.

Biodiversity target(s): Quantitative targets, based on best available science, that indicate the minimum proportion of each ecosystem type that should remain in a natural or near-natural state (or a good ecological condition) in order to maintain viable representative samples of all ecosystem types and the majority of species associated with them.

Biodiversity thresholds(s): A series of thresholds used to assess ecosystem threat status, expressed as a percentage of the original extent of an ecosystem type. The first threshold, for Critically Endangered ecosystems, is equal to the biodiversity target; the second threshold, for Endangered ecosystems, is equal to the biodiversity target plus 15%; and the third threshold, for Vulnerable ecosystems, is usually set at 60%.

Biomass: A measure used in ecology to refer to the total quantity or weight of living material present in a landscape or ecosystem.

Biome: An ecological unit of wide extent, characterised by complexes of plant communities and associated animal communities and ecosystems, and determined mainly by climatic factors and soil types. A biome may extend over large, more or less continuous expanses of land surface, or may exist in smaller, discontinuous patches. Biomes recognised in South Africa include: Grasslands, Savanna, Desert, Fynbos, Succulent Karoo, Nama Karoo, Albany Thicket, Forests and Indian Ocean Coastal Belt.

Bioregional plan: A biodiversity sector plan that has been published in the Government Gazette in accordance with the NEM: Biodiversity Act (Act 10 of 2004), and that has been produced in accordance with nationally agreed *Guideline for the preparation and publication of Bioregional Plans* as published in the National Biodiversity Framework (Notice No.291, Government Gazette No. 32006, March 2009).

Biotic: Living, in this case taken to mean the living components of ecosystems (e.g. plant and animal species, micro-organisms and so on); also referred to as the 'biota' in an ecosystem.

Carbon sequestration: A biochemical process through which atmospheric carbon is absorbed and stored by living organisms including plants and soil micro-organisms, and involving the storage of carbon in soils, with the potential to reduce atmospheric carbon dioxide levels.

CBA map: A map showing Critical Biodiversity Areas and Ecological Support Areas, based on a systematic biodiversity plan. A CBA map usually forms the basis for a Biodiversity Sector Plan or Bioregional Plan.

Climate change: Long term changes in the Earth's weather patterns, including temperature, wind and rainfall, especially as a result of the increase in temperature of the Earth's atmosphere resulting from the increased concentration of certain gases (the so-called 'greenhouse gases').

Climate change adaptation: Initiatives and measures to reduce the vulnerability of natural and human systems to the actual or expected impacts of climate change. Adaptation may be of several different types.

Critical Biodiversity Areas (CBAs): All the areas that are required to meet the targets for species, ecosystem types and ecological processes, as determined in a systematic biodiversity plan. CBAs may be terrestrial or aquatic, are often (but not always) in a good ecological state and should be retained in a natural or near-natural state in good ecological condition. Loss or degradation of CBAs should be avoided.

Development: A broad process of social and economic improvement in society.

Disturbance: A general term used in ecology to describe a range of factors that cause change in an ecosystem or that disrupt ecosystem functioning; disturbances may be natural (e.g. natural fires, floods) or artificial (e.g. ploughing, clearing of vegetation for building etc.).

Ecological condition: An assessment of the extent to which the composition, structure and function of a site, or biodiversity feature, has been modified from a benchmark or reference condition of 'natural.'

Ecological infrastructure: Naturally-functioning ecosystems that deliver valuable services to people. Ecological infrastructure need not be in good ecological condition, but should retain at least some of its natural ecological functioning. One piece of ecological infrastructure may deliver several ecosystem services. Networks of ecological infrastructure may take the form of large tracts of natural land, or small remaining patches or corridors embedded in production landscapes. If ecological infrastructure is degraded or lost, the flow of ecosystem services will be diminished.

Ecological processes: All the processes that result from the relationships and interactions within and between ecosystems are called ecological processes. These processes operate at various scales and include, for example, nutrient cycles, energy flow, soil formation, nitrogen fixation, carbon storage, predator-prey interactions, fire cycles, seasonal migrations of species and pollination. Ecological processes might sometimes be referred to, interchangeably, as *ecosystem processes* or *ecosystem functions*.

Ecological Support Areas (ESAs): Areas that are not essential for meeting biodiversity pattern targets, but that play an important role in supporting the ecological functioning of Critical Biodiversity Areas and/or for delivering ecosystem services, as determined in a systematic biodiversity plan. In most cases ESAs are currently in at least a fair ecological condition, and should remain so.

Ecosystem: an assemblage of living organisms, the interactions between them and with their physical environment. Each ecosystem is characterised by its composition (the living and non-living components of which it is made), its structure (how the components are organised in time and space) and the ecological processes (functions such as nutrient cycling) that maintain the structure and composition of the ecosystem and keep it as a functioning unit. Ecosystems can be delineated at various scales.

Ecosystem approach: A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. The ecosystem approach recognises that humans are an integral part of ecosystems and stresses the need for integrated and holistic environmental decision-making.

Ecosystem protection levels: An indicator of the extent to which an ecosystem type is represented in the protected area network. Ecosystem types are categorised as well protected, moderately protected, poorly protected or unprotected, based on the proportion of the biodiversity target for each ecosystem type that is included in one or more protected areas. Unprotected, poorly protected and moderately protected ecosystem types are collectively referred to as under-protected ecosystems

Ecosystem resilience: The ability of an ecosystem to maintain its functions (biological, chemical, and physical) in the face of disturbance or to recover from external pressures. A *climate-resilient* ecosystem would retain its functions in the face of climate change. Ecosystem-based adaptation will require measures to maintain the resilience of ecosystems under new climatic conditions, so that they can continue to supply essential services.

Ecosystem services: The benefits that people obtain from ecosystems, including provisioning services (such as food and water), regulating services (such as flood control), cultural services (such as recreational benefits), and supporting services (such as nutrient cycling, carbon storage) that maintain the conditions for life on Earth.

Ecosystem threat status: a measure of how threatened an ecosystem is, based on how much of the ecosystem's original area remains intact relative to three different thresholds or 'tipping points'. These thresholds indicate the points at which it is estimated that the ecosystem would undergo fundamental change, either in terms of biodiversity pattern or ecological processes. Ecosystems are categorised as Critically Endangered, Endangered, Vulnerable or Least Threatened.

Ecosystem type: An ecosystem unit that has been identified and delineated as part of a hierarchical classification system, based on biotic and/or abiotic factors. Ecosystems of the same type are likely to share broadly similar ecological characteristics and functioning.

Endemic: Restricted or exclusive to a particular geographic area and occurring nowhere else. *Endemism* refers to the occurrence of endemic species.

Estuarine Functional Zone: The open water area of an estuary together with the associated floodplain, incorporating estuarine habitat (such as sand and mudflats, salt marshes, rock and plant communities) and key physical and biological processes that are essential for estuarine ecological functioning.

Fair ecological condition: An ecological condition class in which ecological function is maintained even though composition and structure have been compromised. This term can apply to a site or an ecosystem.

Fish sanctuary: A river reach that is essential for protecting threatened or near-threatened freshwater fish that are indigenous to South Africa. Fish sanctuaries that are in good ecological condition are FEPAs, and the associated sub-quaternary catchment is marked with a red or black fish symbol on FEPA maps. Fish sanctuaries that are not in good ecological condition are Fish Support Areas.

Fish Support Area: A river reach that is essential for protecting threatened or near-threatened freshwater fish that are indigenous to South Africa, but that is not in good ecological condition (i.e. a fish sanctuary that is not in good ecological condition), OR a river reach that is important for migration of threatened or near-threatened fish species. Sub-quaternary catchments associated with Fish Support Areas that are fish sanctuaries are marked with a fish symbol on FEPA maps; those that are important for migration are not marked with a fish symbol.

Flood attenuation: The natural or man-made processes or structures that reduce the severity of potential flooding.

Freshwater Ecosystem Priority Area (FEPA): A river or wetland that is required to meet biodiversity targets for freshwater ecosystems.

Free-flowing river: A long stretch of river that has not been dammed, flowing undisturbed from its source to the confluence with another large river or the sea. A flagship free-flowing river is one of 19 that have been identified as representative of all remaining free-flowing rivers in South Africa.

Forb(s): herbaceous plants with soft leaves and non-woody stems.

Forest: A biome dominated by tall trees that form a closed canopy; in South Africa forest is usually found in areas of higher rainfall, on cooler southern slopes or in deep or steep river valleys, particularly in mountainous regions of the east and south-east, but it is also found in coastal areas. The only large expanses of forest that remain in South Africa today are found in the south-eastern Cape, but smaller patches are also found in other parts of the country. Forest occupies only 2% of the land-surface of South Africa and is the smallest of the nine biomes.

Fynbos: A biome dominated by shrubby vegetation, mostly with very small, narrow ('fyn' meaning 'fine' or 'narrow') leaves, like heather, along with wiry, reed-like plants called restios, and taller shrubs and bushes with broader, leathery leaves, like proteas. Fynbos occurs predominantly in the south-western Cape, a winter-rainfall area, but small patches of fynbos can be found in mountainous areas in the eastern parts of South Africa and tropical East Africa. The fynbos of the Cape Floristic Region has a unique floristic composition (combining particular taxonomic groupings of plants) and high levels of endemism.

Geology: The study of the Earth's crust and its rock formations

Geophyte(s): Perennial plant(s) having underground perennating organs such as bulbs, tubers or corms.

Good ecological condition: An ecological condition class in which composition, structure and function are still intact or largely intact. This term can apply to a site or an ecosystem.

Grassland: A biome dominated, at least visually, by different species of grasses, and characterised by a lack of tall shrubs and woody plants. Grasslands are also home to a rich variety of herbaceous forbs (small, non-woody plants) and bulbous plants. In South Africa, grassland covers much of the central and eastern parts of the country, in regions dominated by summer rainfall.

Growth forms (or life forms): The categorisation of plants according to structure and the position of the growth points (buds) during the adverse (cold, dry etc) season; categories may include trees, shrubs, forbs, graminoids, vines, geophytes etc.

Guild(s): The categorisation of organisms according to shared characteristics, e.g. pollinator guild, seed dispersal guild, nectarivore guild.

Habitat: The area or environment occupied by a species or groups of species, due to the particular set of environmental conditions that prevails there.

Herbaceous: A term used to describe soft-leaved, soft-stemmed plants that do not develop a conspicuous woody layer.

High water yield area: A sub-quaternary catchment where mean annual runoff is at least three times more than the average for the related primary catchment.

Humic (soils): A term used to describe soils that are rich in humus (decomposing organic matter).

Hydromorphic: A term used to describe soils that are associated with bogs, marshes, swamps and other poorly drained areas; these soils undergo protracted periods of being waterlogged, and usually comprise an upper layer containing decaying plants or organic matter, and a lower layer of clay.

Hydrology: The distribution, timing and movement of water through a wetland and its soils.

Hydrophytic: A term used to describe vegetation that grows wholly or partly in water or wet habitats.

Indicator species: A species that describes a characteristic or the ecological condition of the environment in which it occurs.

Integrated Development Plan (IDP): a strategic development plan required by law and developed through participatory processes, to guide and inform all planning, budgeting, management and decision-making in a municipal area in South Africa.

Karroid: 'Karoo-like', used here to describe plants that are similar to those found in the region known as the Karoo (i.e. small, much-branched shrubs with small, tough or succulent leaves).

Keystone species: A species that has a disproportionately large effect on its environment relative to its abundance.

Landscape approach: The landscape approach to biodiversity conservation involves working both within and beyond the boundaries of protected areas, to manage a mosaic of land uses including protection, restoration, production and subsistence use, in order to deliver ecological, economic and social benefits. Partnerships between diverse role-players, and effective mainstreaming of biodiversity considerations in land-use planning and operations of multiple sectors, are critical elements of the landscape approach.

Lentic: Pertaining to still-water ecosystems such as isolated wetlands and organisms that live in still water.

Lotic: Pertaining to flowing-water ecosystems such as rivers and organisms that live in flowing water.

Mitigation: Measures to reduce negative impacts on the environment from land-use activities; in terms of climate change, measures to reduce greenhouse gas emissions into the atmosphere, and enhance greenhouse gas sinks.

Myrmechochory/myrmechochorous: Dispersal of seeds by ants.

Natural capital: Natural resources, species.

Pauciennial: A plant that lives for only a few years.

Persistence: A principle of systematic biodiversity planning, referring to the need to maintain the ecological and evolutionary processes that enable ecosystems and species to persist over time.

Poor ecological condition: An ecological condition class in which ecological function has been compromised in addition to structure and composition. This term can apply to a site or an ecosystem.

Production landscape: A landscape in which land use is directed primarily towards economic activities that modify natural ecosystems to produce goods for human consumption or use. Production landscapes include those that support subsistence or commercial wild-harvesting of natural products to provide livelihoods for local communities.

Protected area: An area of land or sea that is protected by law and managed primarily for biodiversity conservation. There are numerous categories of protected area, defined by the *National Environmental Management: Protected Areas Act* (Act 57 of 2003, as amended) and distinguished according to management objectives, permissible land-use types and management authority.

Rare species: A species that is not exposed to any known threat but that has a restricted range, is a habitat specialist, occurs in low densities or has a small global population.

Red List: A publication that provides information on the conservation and threat status of species, based on scientific conservation assessments.

Representation (or representivity): A principle of systematic biodiversity planning that describes the need to maintain a representative sample of species and ecosystems.

Resilience: A term referring generally to a system's capacity to absorb expected and unforeseen change, whilst retaining its character and functionality. See also '*ecosystem resilience*'.

Restoration: All interventions designed to aid the repair or recovery of degraded ecosystems, in some cases with a focus on restoring basic ecological functioning, and in others with restoring structure and composition as well.

Savanna: A biome occurring in summer-rainfall regions of South Africa, and made up of grasses and scattered trees and bush-clumps of varying density. Sometimes called '*bushveld*' in South Africa.

Serotiny/serotinous: Seed storage in canopy structures such as cones and follicles. Serotinous species usually only release their seeds after events such as fire.

Severely or irreversibly modified: An ecological condition category in which the loss of natural habitat, biota and basic ecosystem functions are extensive. In some cases modifications have reached a critical level and the ecosystem has been modified completely with an almost total loss of natural habitat and biota. In these cases, basic ecosystem functions have been destroyed and the changes are irreversible.

Spatial Development Framework (SDF): A spatial plan developed as part of an Integrated Development Plan to indicate current and future patterns of land use by all sectors such as agriculture, housing, industry and conservation. The Spatial Development Framework guides and informs all decisions of the municipality relating to planning, development and use of land.

Species of special concern (also 'species of conservation concern'): Species that have particular ecological, economic or cultural significance, including but not limited to threatened species.

Strategic Water Source Area (SWSA): An area that supplies a disproportionate amount of mean annual runoff to a geographical region of interest. In South Africa, SWSAs are the 8% of the land area that delivers 50% of mean annual run-off.

Systematic biodiversity planning: A scientific methodology for determining areas of biodiversity importance involving: mapping biodiversity features (such as ecosystems, species, spatial components of ecological processes); mapping a range of information related to these biodiversity features and their condition (such as patterns of land and resource use, existing protected areas); setting quantitative targets for biodiversity features, analysing the information using software linked to GIS; and developing maps that show spatial biodiversity priorities. Systematic biodiversity planning is sometimes called 'systematic conservation planning'.

Threatened ecosystem(s): An ecosystem that has been classified as Critically Endangered, Endangered or Vulnerable, based on an analysis of ecosystem threat status. A threatened ecosystem has lost, or is losing, vital aspects of its structure, composition or function. The Biodiversity Act makes provision for the Minister of Environmental Affairs, or a provincial MEC of Environmental Affairs, to publish a list of threatened ecosystems.

Threatened species: A species that has been classified as Critically Endangered, Endangered or Vulnerable, based on a conservation assessment (Red List), using a standard set of criteria developed by the IUCN for determining the likelihood of a species becoming extinct. A threatened species faces a high risk of extinction in the near future.

Threshold(s): In the context of biodiversity and ecosystems, these are the points at which or an ecosystem will undergo fundamental and (often) irreversible modification from a previous state.

Tipping-point: A threshold, as described above.

Tributary: A smaller river that feeds into a main river within a quaternary catchment.

Umbrella species: A species selected for making conservation-related decisions as its protection indirectly ensures the protection of many other species.

Veld: A South African term referring to open land containing natural vegetation.

Vulnerability: The degree to which a system is susceptible to, and unable to cope with, the adverse effects of climate change.

Wetland health: A measure of the similarity of a wetland to a natural or reference condition.

BOX 2 Defining Spatial Biodiversity Priority areas

Biodiversity priority areas are features in the landscape that are important for conserving a representative sample of ecosystems and species, and for maintaining ecological processes, or for the provision of ecosystem services. The biodiversity priority areas that are of relevance to people include the following:

Protected Areas: Areas of land or sea that are formally protected by law and managed mainly for biodiversity conservation.

Critically Endangered ecosystems: Ecosystems that have very little of their original extent left in a natural or near-natural condition.

Endangered ecosystems: Ecosystems that are close to becoming critically endangered.

Critical Biodiversity Areas: all areas required to meet biodiversity targets for ecosystems, species or ecological processes, as identified in a systematic biodiversity plan.

Ecological Support Areas: Areas that are not essential for meeting biodiversity targets, but that play an important role in supporting ecological functioning of Critical Biodiversity Areas, or in delivering ecosystem services.

Freshwater Ecosystem Priority Areas: Rivers and wetlands required to meet biodiversity targets for freshwater ecosystems.

High Water Yield Areas: sub-quaternary catchments where annual runoff is at least three times more than the average for the rest of the related primary catchment.

Flagship free-flowing rivers: The 19 free-flowing rivers that have been identified as representative of the remaining 63 free-flowing rivers in South Africa (these are long stretches of river that have not been dammed, and that are able to flow freely from their source to a major confluence, or to the sea).

Priority estuaries: Estuaries that are required to meet targets for representing estuarine ecosystems, habitats and estuary-dependent species.

Focus areas for land-based protected area expansion: large, intact and unfragmented areas of high biodiversity importance, suitable for the creation and expansion of large protected areas.

These categories are not mutually exclusive, and may overlap in some cases, often because a particular site is a priority for more than one reason. The different sets of biodiversity priority areas should be seen as complementary to one another, rather than contradictory, with the overlaps re-inforcing the importance of an area from a biodiversity perspective. A map of currently identified biodiversity priority areas, with supporting spatial data and reports, is available on the BGIS website (<http://bgis.sanbi.org.za>).

Appendix 6: References

Main source materials used in compilation of the Guidelines

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Additional reading

There is an extensive body of literature available on the biodiversity and ecosystems of the Western Cape, systematic biodiversity planning and environmental assessment, as well as numerous pieces of legislation, policies and guidelines for incorporating biodiversity considerations into land-use planning and decision-making. Many of them are available on the internet and SANBI's BGIS website (<http://bgis.sanbi.org.za>) or the Biodiversity Advisor portal (<http://biodiversityadvisor.org.za>) make good starting points for sourcing relevant literature or information.

Note: There are fine-scale biodiversity plans available for all municipalities in the Western Cape and these can also be accessed from the BGIS website.



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