FYNBOS FORUM

ECOSYSTEM GUIDELINES
FOR ENVIRONMENTAL ASSESSMENT
IN THE WESTERN CAPE

Charl de Villiers, Amanda Driver, Barry Clark, Doug Euston-Brown, Liz Day, Nancy Job, Nick Helme, Pat Holmes, Susie Brownlie and Tony Rebelo

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JOHN MANNING

The striking vigour of Gladiolus watsonius *in flower sadly belies the precarious condition of many Western Cape lowland ecosystems.*

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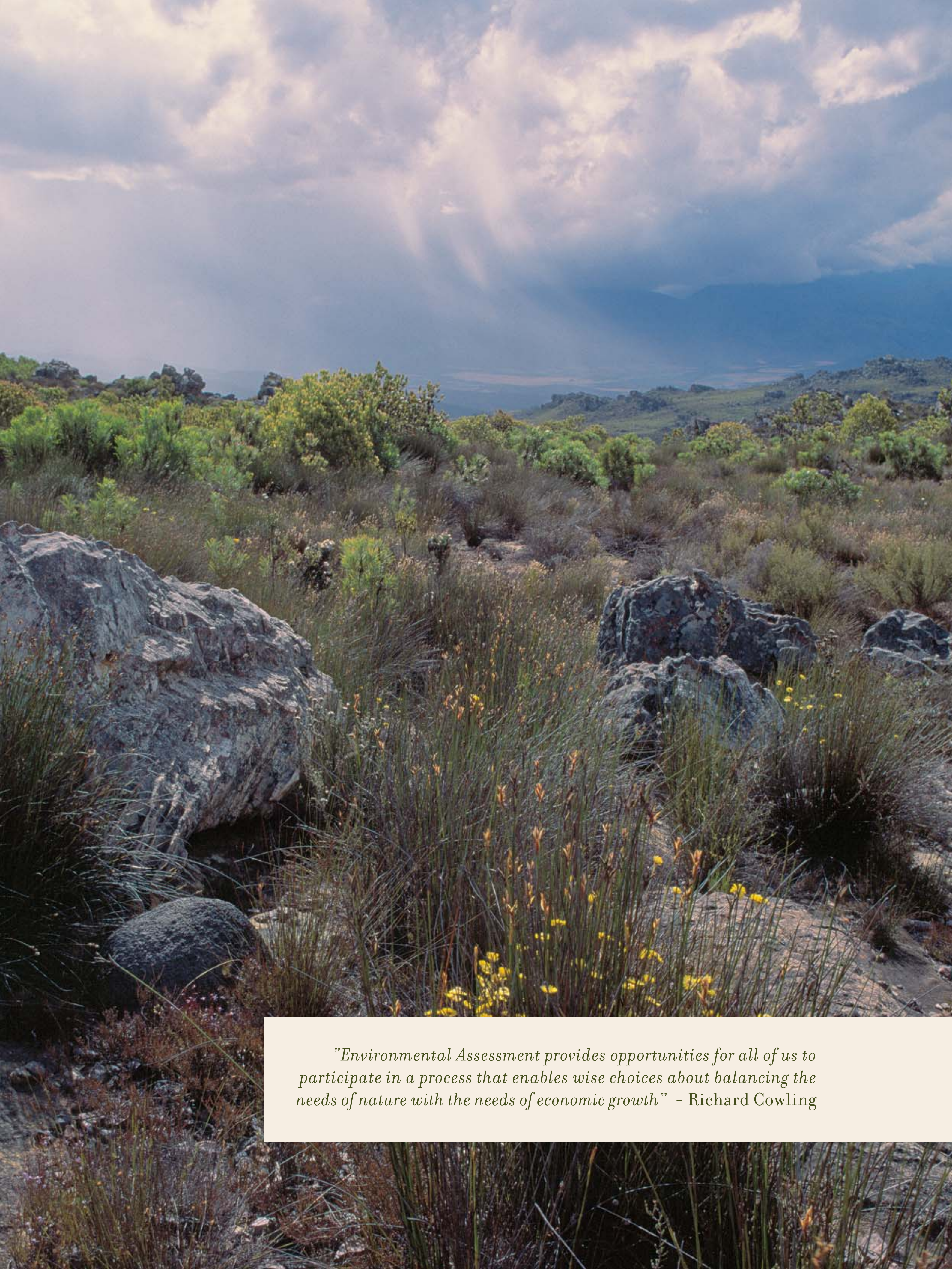


"Environmental Assessment provides opportunities for all of us to participate in a process that enables wise choices about balancing the needs of nature with the needs of economic growth" - Richard Cowling

FOREWORD

Richard Cowling - Nelson Mandela Metropolitan University

The Western Cape Province of South Africa is undoubtedly one of the most biologically rich parts of the world. No other entire nation - let alone a province therein - is home to three globally recognised "hotspots" of nature. These hotspots are areas of great natural wealth that are also under extreme pressure from human endeavour. The Western Cape includes substantial parts of the Cape Floristic Region, Succulent Karoo and Maputaland-Pondoland-Albany hotspots. What a marvellous legacy! And what a great responsibility we all have for its safeguarding.

The Western Cape is also a region of great scenic beauty and cultural diversity. Indeed, it is the birthplace of modern humans *Homo sapiens*. From this south-western corner of Africa, our species colonised the world. Early humans and their descendants - the San and the Khoe-Khoen - trod lightly on this captivating landscape. However, over the past 300 years the human footprint has become increasingly heavier, as a consequence of exponential increases in population size and consumption of goods and services. Sensible people agree that we cannot continue to compromise the prospects for healthy livelihoods of future generations by devouring our natural capital. Instead we must strive to identify and implement ways of living sustainably. This will require some difficult adjustments. At present our lifestyles are governed by the rhythm and run of market forces, which invariable place great stead on short-term interests. Yet our future is dependent on our ability to adjust to a different rhythm - that dictated by patterns and flows of ecosystems.

Making the transition to sustainable lifestyles is going to be a hard slog. But we must start now - and this document is, indeed, a great start. Environmental assessment provides opportunities for all of us to participate in a process that enables wise choices about balancing the needs of nature with the needs of economic growth. In the past, very poor decisions have been made and natural capital that could have served us indefinitely, has been needlessly degraded. We have witnessed the piecemeal destruction of beautiful landscapes of wild nature - death by a thousand cuts - that have provided short-term material benefits, largely for a privileged few. Many unwise decisions have been made simply out of ignorance of the requirements for maintaining ecosystem integrity and viable populations of plant and animal species. The publication of this document means that those involved in ecological assessment can no longer claim ignorance. These guidelines include the insights of a remarkable team of experts on all the Western Cape's sensitive and vulnerable ecosystems. The contributions are mindful of pattern, process, scale and context. In nature, everything is connected, and each of the contributions urges that this connectivity must be maintained.

Here we have the beginning of a process of mainstreaming the concerns for safeguarding wild nature into environmental assessment. While this may sound like a tautology, this is not the case. Hitherto, environmental assessment has seldom been informed by the pattern and pace that underpin ecologically healthy landscapes. This process does not end with the publication of this document. It will need to be revised and refined many times in the future, as our collective experience and insight grows.

So please, feed your comments back to the Fynbos Forum[1] (an extraordinarily effective institution) and let's keep marching towards a sustainable future.

COLIN PATERSON-JONES

1. The Fynbos Forum is a gathering of conservation scientists, managers, planners and non-governmental organisations working in the Cape Floristic Region, that 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.

PREFACE

Charl de Villiers

These guidelines represent a first attempt at reducing the complexity and value of Western Cape ecosystems to a set of basic but reliable pointers that will guide responsible and appropriately informed planning and decision-making about biodiversity in the province. A resource such as this is - and cannot but be - the product of a collective and inspired effort.

The development of these guidelines is rooted in a clear consensus arising from the Fynbos Forum: environmental practitioners and decision-makers need reliable, basic guidance on the importance, composition and functioning of ecosystems in the Western Cape, urgently so.

Biodiversity in the province is faced with a myriad coalescing threats - outright loss of critically important habitat, invasion by alien species, over-exploitation and degradation of natural capital and the impacts of increasingly unstable weather patterns due to accelerated climate change. By the same token, public awareness, progressive legislation and unprecedented international support for sustainable development have spurred a powerful surge of hope for biodiversity conservation in the region.

A basic consideration remains, though: in order for biodiversity to persist where it occurs, informed, accountable and effective intervention - on the part of developers and landowners, their advisers, the public and government - is a compelling task that can little afford delay. Hence this collaborative effort at turning specialist knowledge and accumulated field experience into decisive, effective action for biodiversity conservation in the Western Cape.

- This project would not have seen the light of day without the strategic insight and financial generosity of the Table Mountain Fund, an associated trust of WWF-South Africa; the contribution of the Trust to biodiversity conservation in the Cape Floristic Region is a hugely appreciated mainstay.

- Special appreciation is extended to Ms Julia Wood, Chairperson of the Fynbos Forum, for her and her committee's wholehearted and energetic support for this project.

- By being prepared to freely share their knowledge and expertise with a wide audience, the contributing ecologists have set a noteworthy example of how science can be turned to public benefit in the sphere of environmental governance in a global biodiversity "hotspot".

- Professor Richard Cowling of the Terrestrial Ecology Research Unit, Nelson Mandela Metropolitan University, is gratefully acknowledged for agreeing to write the Foreword to these guidelines; his unstinting championship of empowered, collaborative conservation action premised in rigorous science is without peer.

- Mr Jan Vlok, of Regalis Environmental Services, served as specialist reviewer. His scientific background, broad experience as applied ecologist and warm support for this project were indispensable to its execution.

- Dr Annelise Schutte-Vlok of CapeNature contributed important insights and valuable criticism.

One of the most significant aspects of current efforts to achieve enduring gains for biodiversity conservation in the Western Cape relates to the strong emphasis on planning for persistence - conserving those ecological and evolutionary processes that are essential for the maintenance of biodiversity pattern where it occurs in and across landscapes. In this regard, the individuals who participated in a workshop on devising practical guidelines for spatial components of ecological process at Kirstenbosch in March 2005 require special mention, viz:

ANTON WOLFAARDT	CapeNature
DON KIRKWOOD	CapeNature
AMANDA DRIVER	Botanical Society of South Africa, Conservation Unit
NANCY JOB	Botanical Society of South Africa, Conservation Unit
NICK HELME	Nick Helme Botanical Surveys
PAT HOLMES	Cape Ecological Services
PHILLIP DESMET	Conservation planner
SUSIE BROWNLIE	De Villiers Brownlie Associates
VERNA BOWIE	CapeNature

All decisions pertaining to content, interpretation and style remain, however, the prerogative of the editor, who remains accountable as such.

We trust that these ecosystem guidelines will be widely used, criticised and forged into an indispensable reference for those who benefit from, regulate or simply appreciate the globally irreplaceable natural heritage of the Western Cape.

Specialist knowledge is indispensable for ensuring that wise decisions are taken about the use and transformation of the Western Cape's globally unique biodiversity.

BOTANICAL SOCIETY OF SOUTH AFRICA

INTRODUCTION

Susie Brownlie

Purpose of the guidelines

These ecosystem-specific guidelines have been prepared to assist all stakeholders in the Western Cape who are involved in land-use planning and environmental assessment to take biodiversity concerns into consideration.

The guidelines aim to answer key questions about biodiversity that should be asked by a planner, environmental assessment practitioner and/or landowner embarking on a plan, project or activity, whether urban, industrial, agricultural or recreational. The guidelines should also add value to the deliberations of decision-makers on the environmental implications of development or land-use change.

The guidelines deal separately with each of the following groups of Western Cape ecosystems:

1. Coastal ecosystems
2. Lowland fynbos ecosystems
3. Midland and mountain fynbos ecosystems
4. Renosterveld ecosystems
5. Succulent karoo ecosystems
6. Mainland thicket ecosystems
7. Freshwater ecosystems
8. Spatial components of ecological processes

The guidelines adopt a broad landscape approach to biodiversity assessment, i.e. they aim to ensure that the ecological function of a site is considered within its landscape and regional context.

These guidelines represent a first attempt at reducing the complexity and value of Western Cape ecosystems to a set of basic but reliable pointers that will guide responsible and appropriately informed planning and decision-making about biodiversity in the province.

The earlier in the planning process these guidelines are used, the better. Ideally, their use should inform a plan or project, as described in the next section. Planning and the development of project proposals should strive to work within the opportunities and constraints of ecosystems, and to avoid potentially significant negative impacts. By so doing, the need for complex, costly and time-consuming environmental assessment could be minimized, and ecologically sustainable development, one of the main pillars of sustainable development, is more likely to be achieved.

The drafting process

The guidelines are the product of an inclusive process initiated by the Fynbos Forum in 2002. They draw on the experience and expertise of biodiversity specialists, environmental assessment practitioners and the Western Cape environmental and conservation authorities.

COLIN PATERSON-JONES

Undeveloped ecosystems can provide important direct benefits for people and the economy, as exemplified by the Flower Valley Conservation Trust.

The drafting process, which was co-ordinated by the Botanical Society's Conservation Unit, entailed:

- Identifying a range of important ecosystems and habitats within the Western Cape;
- Inviting more than 30 biodiversity specialists to contribute what they viewed as the most critical questions that should be asked when undertaking environmental assessments in each of these ecosystems or habitats;
- Collating these contributions and presenting them as a discussion document for further development and refining at a workshop hosted by the Fynbos Forum in 2004; and
- Refining the guidelines with further input from specialists.

Limitations of the guidelines

These guidelines are not intended to provide detailed instructions to land-use planners, environmental assessment practitioners or other users, or to substitute for scoping and/or the involvement of biodiversity (or other) specialists in the environmental assessment process when appropriate. Please refer to the Department of Environmental Affairs and Development Planning's (DEA&DP) *Guideline for involving biodiversity specialists in EIA processes* (Brownlie 2005) for additional information on when, how, and from whom to obtain specialist input on biodiversity.

Structure of the guidelines

The ecosystem-specific guidelines comprise eight separate sections covering different ecosystems, as listed in Table 1. Each section gives the following information:

1. The main 'drivers' of the ecosystem, which determine its composition and structure.
2. The main issues in, threats to, and vulnerabilities of the ecosystem.
3. The 'bottom lines' or 'non-negotiables' for change in the ecosystem if its functioning and biodiversity are to be conserved.
4. Considerations with regard to the most appropriate location or siting of infrastructure, activities and/or disturbance within the ecosystem, to minimize negative impacts.
5. Best management within the ecosystem to promote its persistence.
6. The use of appropriate indicators for monitoring change within the ecosystem.
7. The probable reversibility of impacts on the ecosystem after disturbance, and the potential for restoration.
8. Potential compensation or offsets for loss of biodiversity within the ecosystem.

(left) *Mountain fynbos complexes are mostly well-protected.*
(right) *Cultivation has irreversibly transformed many lowland ecosystems.*

CHARL DE VILLIERS

MANDY BARNETT

TABLE 1: GROUPS OF ECOSYSTEMS DEALT WITH IN THESE GUIDELINES	
COASTAL ECOSYSTEMS	*Estuaries* *Sandy shores and dunes* *Strandveld, Dune Thicket and Dune Fynbos*
LOWLAND FYNBOS ECOSYSTEMS	*Limestone Fynbos* *Sand Fynbos*
MIDLAND AND MOUNTAIN FYNBOS ECOSYSTEMS	*Alluvial Fynbos* *Granite Fynbos* *Grassy Fynbos* *Sandstone Fynbos*
RENOSTERVELD ECOSYSTEMS	*Coast Renosterveld* *Inland Renosterveld*
SUCCULENT KAROO ECOSYSTEMS	*Vygieveld* *Broken Veld* *Quartz patches*
MAINLAND THICKET ECOSYSTEMS	*Thicket* *Valley Thicket* *Arid Thicket*
FRESHWATER ECOSYSTEMS	*Rivers* *Wetlands*
SPATIAL COMPONENTS OF ECOLOGICAL PROCESSES	*Fixed components* *(ecological corridors and vegetation boundaries)* *Flexible components* *(gradients)*

The order of the eight ecosystem-specific sections broadly corresponds 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.

See Appendix 1 for a suggested grouping of South African vegetation types (Mucina *et al.* 2004) in terms of the groups of ecosystems identified for the purpose of these 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. Forest and Nama Karoo ecosystems have not been included. Indigenous forests are fully protected and therefore not viewed as vulnerable to development pressure. Nama Karoo, while not adequately protected, is not a threatened ecosystem in the Western Cape. Succulent Karoo ecosystems have, however, been included as many are experiencing degradation (such as over-grazing and erosion) which was not reflected in the National Spatial Biodiversity Assessment (NSBA) (Driver *et al.* 2005). The Succulent Karoo is also a global biodiversity “hotspot”.

The next section provides the rationale and a step-by-step guide for taking biodiversity considerations into account in the pre-application, planning phase of projects. This is followed by a detailed section on each of the ecosystems in Table 1. The guidelines are rounded off with useful references and websites for obtaining biodiversity resources and support services.

TAKING A PRO-ACTIVE APPROACH

Charl de Villiers

Why take a pro-active approach?

Early reference to these ecosystem guidelines and to available systematic biodiversity plans (see Table 2) in the pre-application stage of project development can support informed planning and decision-making while helping to timeously 'iron out' obstacles that might otherwise result in delays and additional costs to the project proponent. The pro-active emphasis on pre-application screening is consistent with the Western Cape Department of Environmental Affairs and Development Planning's (DEA&DP) *Guideline for involving biodiversity specialists in EIA processes: Edition 1* (Brownlie 2005).

Such a pro-active approach can:

- Show the decision-making authority that potential conflict between biodiversity priorities and other land-uses has been identified and resolved by well-informed project planning;
- Allow the proponent to take an informed decision about the biodiversity (and administrative and, by implication, financial) risks of proceeding with a particular project; and
- Identify the scope, type and intensity of environmental assessment that is likely to be required if an application were to proceed.

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

- 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);
- Emphasising the fundamental role of alternatives in selecting the best practicable environmental option;
- Giving effect to the mitigation hierarchy, or the sequential avoidance, minimising and remedying of impacts that may result in loss of biodiversity or disturbance to ecosystems; and
- Supporting the principle that environmental management must pay specific attention to planning procedures pertaining to sensitive, vulnerable, highly dynamic or stressed ecosystems.

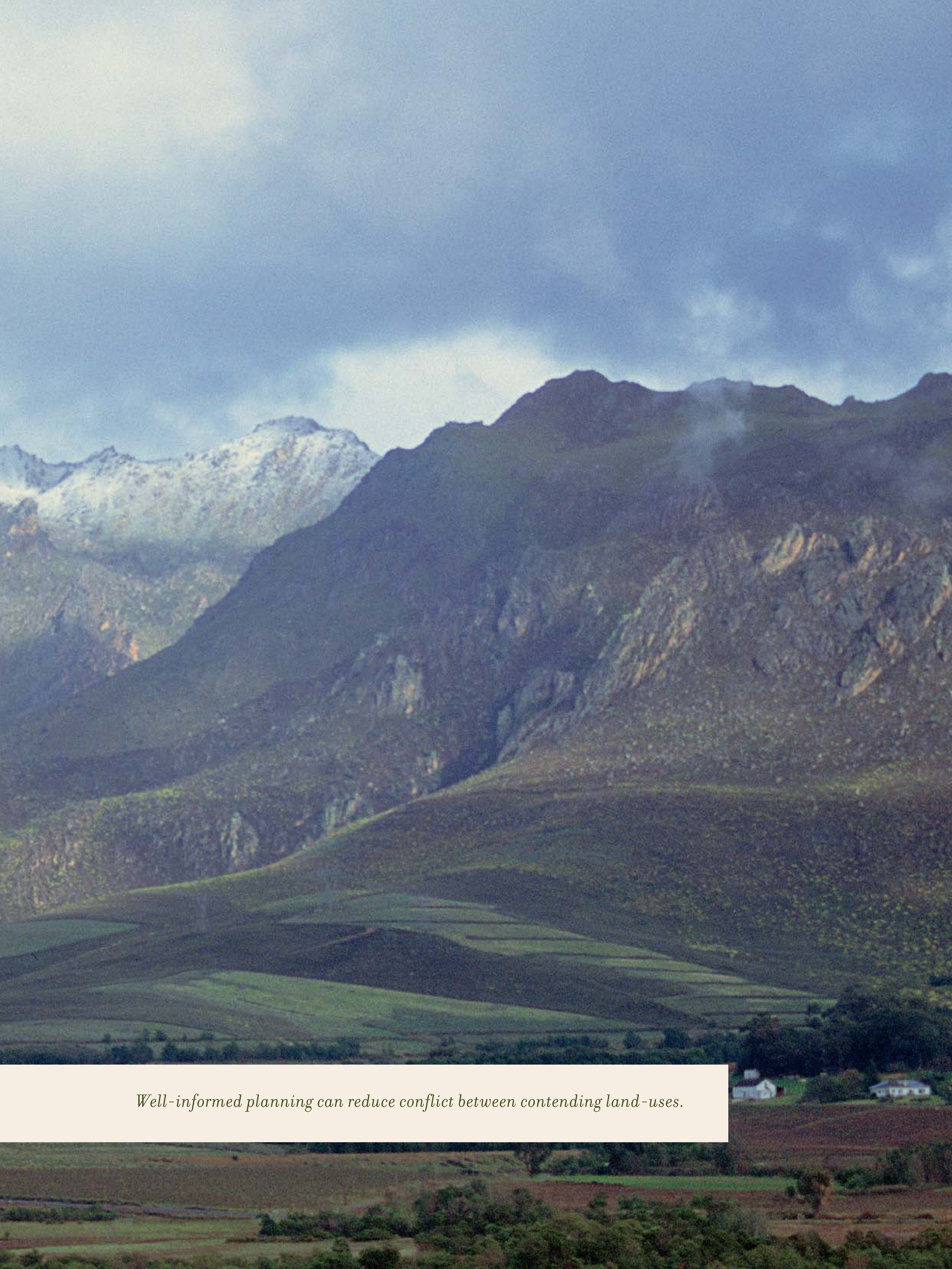
The credibility of this approach is strictly premised on site visits as an essential component of pre-application biodiversity screening. Without ground-truthing and accurate reporting, biodiversity screening that relies solely on reference to biodiversity maps and plans must be viewed as incomplete and therefore inadequate for the purposes of informed decision-making.

Environmental assessment practitioners without the appropriate biodiversity expertise should not resort to the approach advocated here as a substitute for specialist knowledge and review. Early appointment of a knowledgeable biodiversity specialist is strongly advised, especially where projects may be undertaken in Critically Endangered, Endangered or Vulnerable ecosystems.

There are several examples of *pro forma* terms of reference or guidelines for dealing with biodiversity in environmental assessment and planning:

- The most recent is the DEA&DP's biodiversity guideline (Brownlie 2005), which should be seen as complementary to these guidelines.

COLIN PATERSON-JONES



Well-informed planning can reduce conflict between contending land-uses.

- UNEP's voluntary guidelines on biodiversity-inclusive impact assessment (UNEP 2006) reflect an international best practice perspective on how to integrate biodiversity within EIA procedures.
- CapeNature has developed streamlined terms of reference (ToR) for the consideration of biodiversity in environmental assessment procedures (see Appendix 2). These ToR are viewed as sufficient for a 'first stab' at identifying and assessing potential biodiversity issues to inform pre-application project planning. It is also assumed that a sufficiently experienced field ecologist can in many instances make qualitative judgements about the potential likelihood and significance of impacts without the need for more in-depth investigation (Slootweg and Kolhoff 2003).

If the biodiversity specialist has any doubt as to the type and scope of terms of reference to undertake a credible biodiversity evaluation, or more than one biodiversity-related discipline is deemed necessary to properly understand and evaluate potential impacts, it is the responsibility of the environmental assessment practitioner to ensure that a defensible environmental process is put in place.

A step-by-step guide to pre-application biodiversity assessment

Systematic biodiversity plans (see Table 2) and these ecosystem guidelines can be applied to pre-application project planning by pursuing the following steps:

STEP 1 covers preparation for the site visit.
STEP 2 deals with the site visit and how biodiversity considerations should inform project planning.
STEP 3 explains what to do if a project will not have a significant impact on biodiversity.
STEP 4 suggests what to do if significant impacts on biodiversity cannot be avoided.
STEP 5 emphasises the importance of identifying opportunities to conserve biodiversity.
STEP 6 illustrates how biodiversity considerations can be written into recommendations .

STEP 1: PREPARE FOR SITE VISIT

(a) Consult the National Spatial Biodiversity Assessment (NSBA) (Driver *et al.* 2005) *to establish the ecosystem status of the vegetation type that may be affected by the proposed development.*

The NSBA (Driver *et al.* 2005) is the first national assessment of spatial biodiversity priorities. The terrestrial component of the NBSA used the new South African vegetation map (Mucina *et al.* 2004) as a basis for defining terrestrial ecosystems, and determined the 'ecosystem status' of each vegetation type.

Ecosystem status is a function of how much natural habitat has been lost in an ecosystem, in relation to a series of thresholds:

THREATENED ECOSYSTEMS	CRITICALLY ENDANGERED (CR) *ecosystems have lost so much of their original natural habitat that ecosystem functioning has largely broken down and a significant proportion of species associated with that ecosystem has been lost or is likely to be lost.*
	ENDANGERED (EN) *ecosystems have lost significant amounts of their original natural habitat with the result that their functioning is compromised.*
	VULNERABLE (VU) *ecosystems have lost some of their original natural habitat and their functioning will be compromised if they continue to lose natural habitat.*
LEAST THREATENED (LT) *ecosystems have lost only a small proportion of their original natural habitat and are largely intact (although they may be degraded to varying degrees).*	

Being forewarned about the ecosystem status of habitat that may be affected by a development holds a number of advantages:

- It indicates the potential significance of biodiversity as a factor in decision-making;
- It suggests the degree of effort that may be needed to find a suitable alternative to avoid significant loss of biodiversity or ecosystem function in a particular area; and
- It highlights from the outset the potential need to appoint a biodiversity specialist during project planning and design.

(b) Identify which systematic biodiversity plan or plans apply to the project area

Table 2 provides a list of available biodiversity plans (also referred to as conservation plans), and the elements of each plan that are relevant for environmental assessment. Broad-scale biodiversity plans (e.g. 1:250 000) provide information that is less spatially accurate than fine-scale biodiversity plans (e.g. 1:50 000). A spatial scale of 1:250 000 means that a point or line on the map may be out by up to approximately 250 m on the ground; information on a 1:50 000 map may be out by up to approximately 50 m on the ground.

In general,

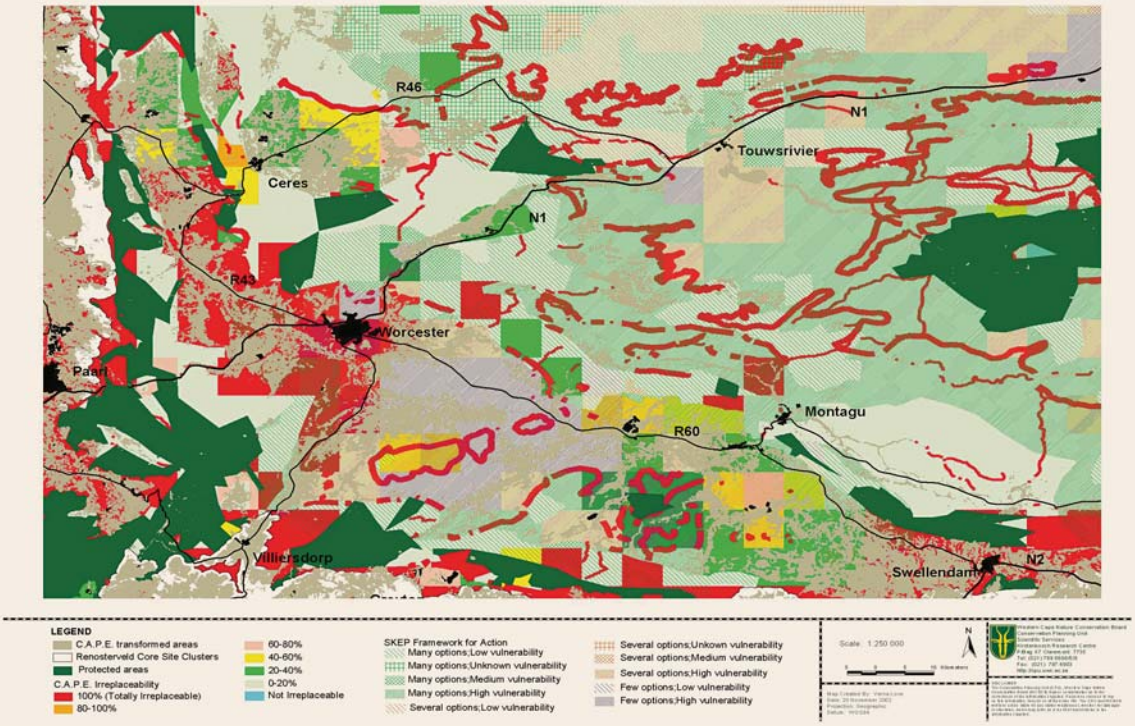
- Select the most recent plan mapped at the finest scale for the ecosystem or vegetation type that may be affected by the proposed development;
- If more than one plan applies, be guided by the highest ecosystem/conservation status in evaluating the potential significance of impacts on biodiversity;
- Be clear about what you are looking for when using a biodiversity plan; and
- Interrogate the supporting reports (Step 1c).

Contact the South African National Biodiversity Institute's Biodiversity GIS Unit for information on biodiversity plans at Ph (021) 799 8794 or e-mail BGISHelp@sanbi.org *or* http://bgis.sanbi.org.

TABLE 2: AVAILABLE SYSTEMATIC BIODIVERSITY PLANS

BIODIVERSITY PLAN	SPATIAL PRODUCTS THAT CAN INFORM ENVIRONMENTAL ASSESSMENT
Cape Action Plan for the Environment (CAPE) 1999 1:250 000	*- Irreplaceability (i.e. the likelihood that a land unit is required to meet a biodiversity target, or the likelihood that a target cannot be achieved if a land unit is lost)* *- Spatial components of ecological processes (e.g. edaphic interfaces, sand movement corridors, upland-lowland interfaces, riverine corridors)*
Succulent Karoo Ecosystem Plan (SKEP) 2002 1:250 000	*- Framework for action* *- Ecological processes* *- Areas of species richness & endemism*
Sub-Tropical Thicket Ecosystem Plan (STEP) 2003 1:100 000	*- Conservation priorities* *- Vegetation types* *- Ecological processes* *- Megaconservancy Network* *- Coastal corridors*
Cape Lowlands Renosterveld Project 2003 1:50 000	*- Conservation status* *- Vegetation remnants* *- Priority clusters* *- Special habitats* *- Ecological processes*
Little Karoo Vegetation Map* 2005 1:50 000	*- Habitat types* *- Vegetation units* *- Transformation (urban development, alien infestation, cultivation, grazing)*

*(Note: this is not a biodiversity plan, as it does not prioritise areas in terms of their biodiversity significance. However, it provides much valuable information for environmental assessment.)



Breede River valley: CAPE and SKEP

(c) Determine which reports are available to help you interpret biodiversity plans and maps.

Besides providing a variety of maps, biodiversity plans also include reports with useful contextual information dealing with aspects such as conservation assessment, ecological processes, pressures on biodiversity and biodiversity summaries. These reports can be obtained from the SANBI B-GIS unit at http://bgis.sanbi.org.

(d) Refer to the relevant Fynbos Forum guideline (pp 24-87) for the ecosystem/s that may be affected by the proposed activity. Identify ecosystems by referring to the vegetation types listed in Appendix 1.

(e) Decide whether to appoint a biodiversity specialist.

If your preparation indicates that the site and/or the surrounding area may be a biodiversity priority area, invite an ecologist or biodiversity specialist to visit the site to verify the information provided by the biodiversity plans.

Consult the *Guideline for involving biodiversity specialists in EIA processes* (Brownlie 2005) if you are uncertain about the type of qualifications, skills and expertise that are required from a biodiversity specialist for a particular area or type of biodiversity attribute or issue. There is no one 'biodiversity specialist' and the term covers a range of expertise in the field of biodiversity.

The biodiversity specialist may identify important biodiversity features on the site that were not highlighted by the biodiversity plan(s). If the specialist confirms that the site is of biodiversity significance, involve him or her in project planning (see Step 2).

STEP 2: THE SITE VISIT - PLANNING TO AVOID, MINIMISE AND REMEDY IMPACTS ON BIODIVERSITY

The search for the best practicable alternative should be guided by the primary objective of avoiding loss of biodiversity and disturbance to ecosystems, especially in threatened (CR, EN and VU) ecosystems.

- When undertaking pre-application project design, **always seek to maximise the retention of intact natural habitat and ecosystem connectivity** by selecting the most suitable project location, layout or scale.
- **Avoid** fragmentation of natural habitat and aim to maintain spatial components of ecological processes, i.e. ecological corridors and vegetation boundaries (see guideline 8, Spatial components of ecological processes).
- **Minimise** unavoidable impacts by reducing the project footprint on biodiversity pattern and ecological processes.
- **Remedy** habitat degradation and fragmentation through rehabilitation, especially in threatened ecosystems. Where possible, the goal of rehabilitation should be to reinstate pre-disturbance ecosystem functioning.


AMREI VON HASE

Fine-scale biodiversity maps are an important planning tool.

STEP 3: FINDING OF "NO SIGNIFICANT IMPACT"

Where appropriate, and with reference to the preceding steps, there may be situations in which a biodiversity specialist can confirm that project planning and design would result in avoiding, minimising or effectively remedying significant impacts on biodiversity in relation to:

- Threatened ecosystems
- Special habitats, or threatened or rare species
- Natural habitat in an ecological corridor or along a vegetation boundary.

If a finding of 'no significant impact' is appropriate, the biodiversity specialist should confirm this in a brief report that:

- Records that reference was made to the relevant biodiversity plans and ecosystem guidelines;
- Describes the site visit;
- Covers aspects such as: the ecosystem status of the vegetation in the vicinity of the project and its various alternatives; the relevant biodiversity pattern and ecological process characteristics of the alternatives - including degradation and alien infestation; how the proposed project would impact on broader, landscape-scale biodiversity attributes in the vicinity; and in which season the site visit was undertaken (see Appendix 2 for an example of *pro forma* terms of reference which can be adapted for use in pre-application biodiversity screening).
- Includes a map or maps at a meaningful scale (preferably ≥ 1:10 000) and interpreted photographs to illustrate the biodiversity implications of the proposed project.

The biodiversity specialist's report should be appended to the standard application form and scoping checklist and submitted to the relevant authority, such as DEA&DP.

STEP 4: WHEN SIGNIFICANT IMPACTS ARE UNAVOIDABLE

When pre-application project planning has exhausted the preceding steps, and significant impacts on biodiversity cannot be avoided, minimised or remedied, advise the proponent that the following courses of action ought to be pursued:

- CR ecosystems: Potential 'show-stopper', therefore proceed at risk;
- EN and VU ecosystems: Proceed to scoping and include appropriate biodiversity terms of reference in the Plan of Study: Scoping; emphasise restoration and biodiversity offsets; or
- LT ecosystems: Go for authorisation on the basis of the application form and scoping checklist, emphasising, where relevant, the maintenance of ecosystem functioning (i.e. retention of ecological corridors and vegetation boundaries) and the protection of critical habitats in project design, implementation and management.

STEP 5: CONTRIBUTING TO CONSERVATION GAINS

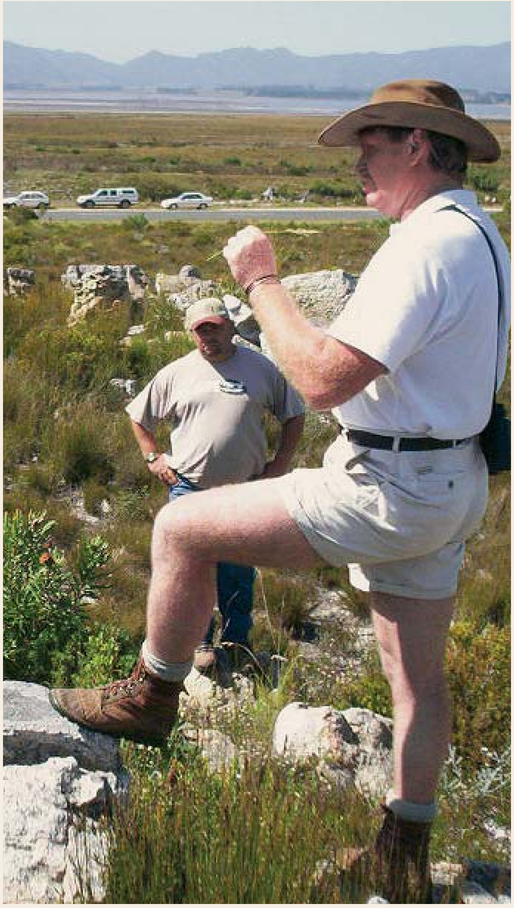
Always seek to take advantage of opportunities to conserve biodiversity when undertaking pre-application project planning.

Conservation gains can include:
- Setting aside part of the land on the site to be managed for conservation, through a stewardship agreement or biodiversity off-set;
- Setting aside another site of equivalent or greater biodiversity significance to be managed for conservation, through a stewardship agreement or biodiversity off-set;
- Clearing alien vegetation; and
- Rehabilitating or restoring land or aquatic eco-systems that have already been degraded (note that rehabilitating or restoring land or ecosystems that will be disturbed as a result of the development does not constitute a conservation gain).

CAPENATURE SHOULD BE CONSULTED ABOUT ANY OF THESE OPTIONS.

Site-specific conservation measures may also be translated into broader conservation benefits by:
- Aligning environmental assessment procedures and project planning with regional conservation programmes (e.g. the Greater Cederberg Biodiversity Corridor); and
- Piggy-backing on the Western Cape agriculture department's LandCare Area-wide Planning programme, informing Spatial Development Frame-works or influencing industry 'greening' strategies (e.g. agricultural produce accreditation schemes).

Consult CapeNature about identifying conservation opportunities on private land.



SUE WINTER

STEP 6: BIODIVERSITY INFORMANTS IN ENVIRONMENTAL ASSESSMENT REPORTING

Recommendations for project design and implementation should set out explicitly how biodiversity pattern and ecological processes have been taken into account, e.g. through:

- Determining the least damaging configurations/layouts of the proposed development and its accompanying infrastructure;
- Reducing the overall number of units to relieve pressure on natural habitat and ecological processes;
- Concentrating disturbance in degraded areas with little viability for natural regeneration or restoration of indigenous vegetation; and
- Recognising and taking advantage of opportunities for integrating *in situ* biodiversity conservation and management with the overall design and operation of the proposed development.

Public participation and authority review

This approach is not intended to supplant or side-track established good practice and legislated procedure in environmental assessment. Any application that has pursued the route outlined above will still enter the public domain for comment, and is equally subject to authority scrutiny.

Informed public participation is a cornerstone of these guidelines.

OWEN HENDERSON / CONSERVATION INTERNATIONAL

A NOTE ON FIRE

All fynbos types require periodic fires to stimulate recruitment and to retain maximum species richness. The different fynbos types do, however, differ vastly in terms of appropriate fire frequency.

Non-sprouting Proteas are the best indicators of an appropriate fire frequency, which should allow at least 50% of these Protea plants to have flowered three times before they are burned again. The maximum interval between fires should not exceed the active reproductive period of these plants.

Fire season is also vital to retain species richness, with late summer and autumn fires (December-April) giving the best recruitment results. Fire intensity is also important, with only 'clean' burns acceptable, where no fine material or unburned leaves remain after a fire.

The last important aspect is the size of the fire, where block burns should preferably not be smaller than 100 ha (ideally 200-500 ha) in size. To ensure successful recruitment after a fire, grazing by domestic stock (or large numbers of game) should not be allowed within the first two years after a fire.

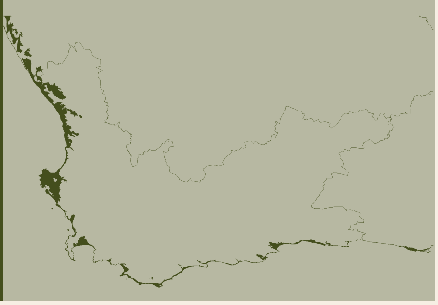
Block burns in areas where two or more different vegetation types co-occur, e.g. Limestone Fynbos, Sand Fynbos or Dune Thicket, will need special planning. The fire frequency of the fastest growing vegetation unit (e.g. Sand Fynbos) is usually the most appropriate, but then only part of the slower growing vegetation types (e.g. Limestone Fynbos) should burn. Such 'patchy' burns will retain the natural fire frequency of the other units present. Fire season and size would, however, not differ from those noted above.

Block burns in areas that are heavily infested by woody alien plants (e.g. *Acacia cyclops*) will also need special planning. Where high fuel loads are present the sites may have to be burned under cool, moist conditions.

It is best to obtain specialist advice from CapeNature or a fynbos ecologist before implementing managed burns.

COLIN PATERSON-JONES

Maintaining the correct frequency and seasonality of fires is a key factor in fynbos management.



ESTUARIES

COASTAL ECOSYSTEMS

Barry Clark

What are the key ecological "drivers" in terms of maintaining ecosystem function, pattern or structure?

- Freshwater input - quantity and variability.
- Freshwater water quality - nutrients, contaminants.
- Sediment input - terrestrial and marine sources.
- Oceanographic conditions - wave action, currents, water temperature, nutrients.

What are the key issues, vulnerabilities and threats?

The primary threat to estuaries relates to changes in freshwater input and/or quality through an increase/decrease in mean annual runoff, change in seasonality of flows, change in flood frequency and/or magnitude and change in water quality.

Change in the freshwater input and/or quality has typically been linked to changes in catchments:

- Change in land use (agriculture, forestry, urbanisation etc).
- Poor land use practices (increased sediment input, nutrient enrichment, contaminant input).
- Water abstraction (altered flow regime).
- Inter-basin transfers (altered flow regime).
- Input of contaminants (sewage, stormwater, agricultural runoff, industrial waste water).
- Infestation by alien vegetation (reduced freshwater input), climate change (altered freshwater inputs).

Secondary threats to estuaries include:

- Bank stabilisation.
- Canalisation and other flood control measures.
- Modification of mouth dynamics for maintenance of water level for recreation and other purposes.
- Encroachment by urban development and disturbance from human activities (e.g. power boating, water skiing or swimming).
- Exploitation of living resources (fish, invertebrates and estuarine vegetation).

What are the "bottom lines" and non-negotiables?

Few generic rules can be applied in respect of maintenance of estuarine biodiversity as estuaries are typically unique systems, the health of which depends on a complex interaction of many factors. For example, it is not possible to define a generic minimum proportion of the mean annual runoff required for maintenance of health for all estuaries or even for specific classes of estuaries. A comprehensive reserve determination process has been established by the Department of Water Affairs and Forestry for determination of required inputs (primarily in respect of quality and quantity of freshwater) for maintenance of estuarine health or for achieving a desired health status. Estuaries respond in a linear manner to anthropogenic disturbance over narrow tolerance ranges only, and generally respond in a

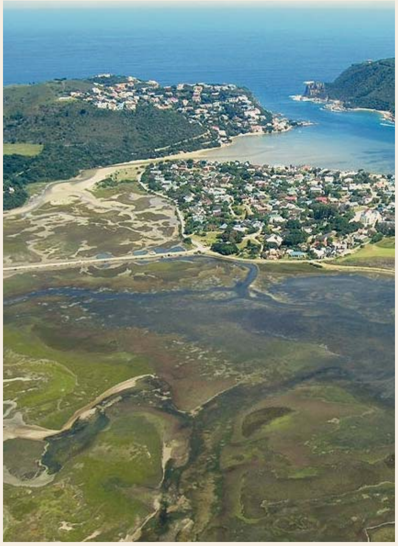
ANDREW BROWN

Estuaries are complex, dynamic systems affected by changes across all marine and terrestrial spectra.

non-linear manner over wider tolerance ranges. For example, a gradual reduction in freshwater input to an estuary that has a mouth that is permanently open to the sea will elicit only a small reduction in biodiversity until it reaches a point where the mouth begins to close for periods of time, at which point biodiversity will decrease sharply. Other examples of non-linear responses include changes entailing sediment input, flood frequency or magnitude, or contaminant input.

It is recommended that as a minimum the IUCN conservation guideline of conserving 20% be adopted for estuaries, but that this be directed at whole systems rather than portions of systems. Such an approach should take account of:

- Variations in estuarine importance (with respect to species richness, prioritising estuaries with higher importance scores).
- Representivity (biogeographic considerations and provision of sufficient habitat for all species utilising estuaries).
- The overall health of the systems (giving priority to those that are in good condition).
- Ensuring links between systems (maximum viable distances between systems).


ANDREW BROWN

Tidal flats are highly productive and irreplaceable habitats that should be left undisturbed.

What broad spatial guidelines can be given with respect to the best approach to development and disturbance?

Estuaries lie at the interface between terrestrial and marine environments and are therefore affected by changes across all terrestrial and marine spectra. Estuaries therefore require whole systems management approaches that incorporate the "source to sea" philosophy. The only real spatial guideline would be to minimise development (including agriculture) in the catchments of priority estuaries and to establish appropriate setback lines for development around estuaries.

In areas proximate to estuaries, tidal lagoons and tidal rivers, the Department of Environmental Affairs and Tourism[1] recommends that:

- Developments or activities should be set back behind a vegetated buffer strip. The width of the buffer strip should depend on the scale and type of the proposed development, the 1:50-year floodline, the likelihood of bank erosion, and the vegetation type used in the buffer strip.
- No permanent structures should be allowed below the 1:50-year floodline.
- Salt marshes should be protected and no activities allowed there.

What are the critical things to maintain in terms of managing these systems for biodiversity, and ensuring its persistence?

- Flow regimes as close to natural as possible (seasonality and flood frequency).
- Water quality (particularly quality of freshwater inputs).
- Mouth dynamics as close to natural as possible (opening and closure).
- Estuarine water quality (nutrients and contaminants).
- Good catchment management (e.g. appropriate land use practices and alien clearing).
- Sediment input (terrestrial and marine).

1. Department of Environmental Affairs and Tourism (1998) Guidelines for the Control and Management of Activities in Sensitive Coastal Areas, Document Two: Guidelines and Definitions. Department of Environmental Affairs and Tourism Coastal Management, Cape Town.

What, if any, reliable indicators could be used in monitoring ecosystem health, as related to key vulnerabilities?

- Freshwater input (quantity, quality and variability).
- Estuarine water quality (nutrients, heavy metals, hydrocarbons, pesticides, Chlorophyll A).
- Species richness and abundance (vegetation cover and composition, species composition and abundance of invertebrate, fish and bird fauna).

How reversible are impacts over a 5 – 10-year period?

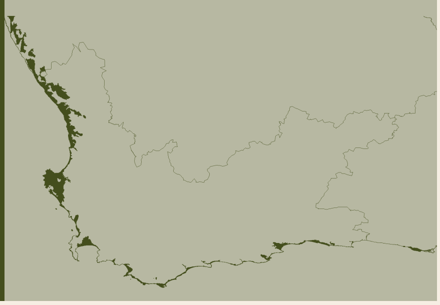
- Once functional factors such as natural flow regimes, mouth dynamics and nutrient status have been re-established, and resource use brought within sustainable limits, estuarine biodiversity will normally recover rapidly.
- Recovery from the effects of habitat modification (e.g. canalisation or bank stabilisation) would take longer and be less certain.

What are acceptable trade-offs, compensation or off-sets for biodiversity loss?

Estuaries represent unique habitats on which many plants, invertebrates, birds and fish rely for their continued existence. This is partly due to the paucity of marine habitat that is sufficiently sheltered from the effects of wave action. Few, if any, trade-offs can realistically be entertained.

The health of an estuary is as good as that of the catchment that feeds it.

ANTON WOLFAARDT



SANDY BEACHES & DUNE SYSTEMS

COASTAL ECOSYSTEMS

Barry Clark and Charl de Villiers

What are the key ecological "drivers" in terms of maintaining ecosystem function, pattern or structure?

- The natural oceanic wave climate.
- Mobility of sand is critical, particularly between frontal dunes and the beach, as are the seasonal cycles of deposition (summer) and erosion (winter).
- The deposition and decomposition of organic material such as kelp and carrion at the high water mark and on the back beach allows terrestrial animals to export energy from the beach system inland to the dunes.
- Sand mobility corridors (e.g. inland-trending dune fields, headland bypass and climbing-falling dunes) promote diversification of terrestrial plant species. Sand mobility also helps drive vegetation structure and successional dynamics in dune systems.
- Coastal thicket vegetation, as occurs on frontal dunes, is critical for maintaining ecological processes and the major biogeographical gradients - both longitudinally and in relation to the major drainage systems.

What are the key issues, vulnerabilities and threats?

- Stabilisation of naturally dynamic dune systems and sediment corridors due to infestation by rooikrans *Acacia cyclops* or for the purposes of property and other development has a significant impact on the integrity of coastal processes.
- Resort and housing developments on primary dune systems (including hummock, primary dunes, dune slack and secondary dunes) are destroying highly sensitive dune systems in certain areas. Examples of this type of development pressure can be found at Wilderness, Keurboomstrand, Hartenbos, St Francis Bay, Dana Bay and Victoria Bay.
- Linked to development is the disturbance of natural dune vegetation cover due to trampling, driving or earth-moving operations. This results in erosion and degradation of primary and foredunes, and mobilisation of driftsand.
- Infrastructure that impedes longshore drift and inshore sediment dynamics.
- Mortality and disturbance of sensitive beach fauna by Off-road Vehicles (ORVs).
- Mining - particularly diamond mining on the West Coast but also sand mining which, in turn, can give rise to the type of "downstream" disturbances that are often associated with coastal property development.
- Altered erosion patterns can result from the hardening of adjacent shorelines (land reclamation) and the construction of breakwaters and groynes.
- There is an increasing risk of coastal erosion associated with rising sea levels (and particularly when there is a combination of spring high tides, storm surges and inadequate development setback lines and degraded primary and foredunes).
- Harvesting of drift kelp.

COLIN PATERSON-JONES

Sandy beaches represent a highly dynamic and naturally unstable interface between the marine and terrestrial environments.

What are the "bottom lines" and non-negotiables?

- No development should be allowed in sand movement corridors, frontal dunes or dynamic dune systems. Developments should be placed inland of secondary dunes.
- Mobile dunes must not be stabilised.
- Strict control should be maintained over the use of Off-road Vehicles (ORVs) on beaches. There must be a strictly enforced ban (that includes management vehicles) against driving in dune systems and above the high water mark on beaches. Access to the beach must be controlled via designated access points.
- Provision should be made for rehabilitation of mined-out areas when mining ceases, and of historically mined areas.

What broad spatial guidelines can be given with respect to the best approach to development and disturbance?

- Infrastructure must be positioned to avoid damage from coastal processes and, where possible, to avoid the need for physical defences against potential damage resulting from coastal processes.
- No permanent infrastructure should be installed on sandy beaches and in dynamic or mobile dune systems.
- Development setback lines must be rigorously applied, taking into account the need to protect development from coastal processes by: absorption of the impacts of severe storm sequences; allowing for shoreline movement; allowing for global sea level rise; allowing for the fluctuation of natural coastal processes; and any combination of the above.[1]
- Development setbacks must also take into account biodiversity and ecosystem requirements (especially in Dune Thicket systems), landscape, seascape, visual amenity, indigenous and cultural heritage, public access, recreation, and safety to lives and property (consult the guideline on Dune Thicket and Dune Fynbos p.32).
- Avoid the removal and fragmentation of indigenous vegetation in the frontal dune area. Maintain a buffer of contiguous indigenous vegetation between the inland boundary of the youngest fixed dune trough and the seaward boundary of the development (the exact setback will depend on the biophysical characteristics and requirements of the area, and the type and scale of development)[2].
- There must be rigorous adherence to the precautionary principle when constructing fixed infrastructure below the high water mark.
- Driving on sandy beaches above the high water mark or in dune systems must be prohibited.
- The ban on driving should also be maintained at popular bathing beaches, on beaches that support important shorebird breeding, feeding or roosting sites, and in the coastal zone of coastal protected areas except on proclaimed roads.

Certain bathing beaches may eventually disappear if sand movement via headland by-pass dunes is impeded by property development and infestation by alien plants.

BOTANICAL SOCIETY OF SOUTH AFRICA

1. Western Australian Planning Commission (2003) *Statement of Planning Policy No 2.6 - State Coastal Planning Policy*. Prepared under Section 5AA of the Town Planning and Development Act 1928.
2. Council for the Environment (1991) *A policy for coastal zone management in the Republic of South Africa, Part 2: Guidelines for coastal land-use*. Council for the Environment, Pretoria.

ANDREW BROWN

The biophysical dynamics associated with coastal landforms need to be understood in development planning.

What are the critical things to maintain in terms of managing these systems for biodiversity, and ensuring its persistence?

- Avoid developments that may impede seasonal cycles of sediment deposition (summer) and erosion (winter).
- Maintain and restore, if invaded by rooikrans, unimpeded sand mobility corridors (including headland bypass and climbing-falling dunes).
- Indigenous vegetation structure and successional dynamics (including that of primary and foredunes, and in dune slacks) must be maintained.
- A functional corridor of indigenous vegetation must be retained along the coast to link inland-trending river systems. This is crucial for the migration and dispersal of plants and fauna.
- Decomposition processes at the high water mark and on the back beach should be maintained by confining the removal of drift kelp and other organic material to popular bathing beaches.
- Minimise disturbance of shore birds by people and dogs at important breeding, feeding and roosting sites.

What, if any, reliable indicators could be used in monitoring ecosystem health, as related to key vulnerabilities?

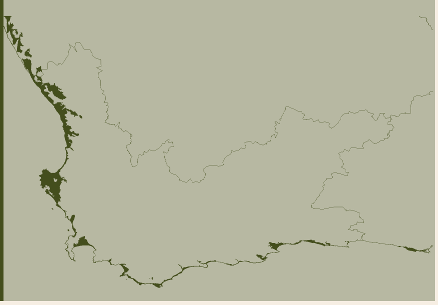
- Mobility of the sand.
- Shore bird species composition and abundance.
- Shorebird breeding success (number of hatchlings fledged per annum).
- Species composition and abundance of intertidal beach macrofauna.
- Density and extent of indigenous and alien dune vegetation cover.

How reversible are impacts over a 5 – 10-year period?

- In the case of disturbance that does not result in fixed infrastructure, 80-100% for most sandy-beach and dune habitats (excluding sand forest communities).
- Damage is irreversible if coastal environments are destroyed as a result of developments.
- Rehabilitation of eroded areas as a result of destruction of vegetation can be expensive. Recovery is very slow as vegetation must go through several succesional phases to reach maturity. In most cases, recovery to the climax phase will take 10 years and longer.

What are acceptable trade-offs, compensation or off-sets for biodiversity loss?

There are none.



INCORPORATING WEST AND SOUTH COAST THICKET TYPES

STRANDVELD, DUNE THICKET & DUNE FYNBOS

COASTAL ECOSYSTEMS *Nick Helme*

What are the key ecological "drivers" in terms of maintaining ecosystem function, pattern or structure?

- Strandveld types and Dune Fynbos occur in typically sandy soils, ranging from coastal calcareous sands to inland neutral and acid sands (the latter support Sand Fynbos rather than Strandveld). Distance from the sea is an important variable, usually correlated with change in soil type. Variations in soil type (depth, moisture capacity, rockiness, mineral composition) are very important for micro-variation, as they are in most vegetation types. Some of the more localised Namaqualand forms occur on sands rich in heavy minerals (titanium, ilmenite).
- In the West Coast region, annual rainfall is low (< 300 mm, decreasing to < 150 mm p.a. in Namaqualand) and occurs predominantly in winter. Rainfall is supplemented by heavy fogs, especially in autumn and spring. Altitudinal gradients are largely absent. Flowering and growth is thus highly seasonal (vegetation is mostly dormant November-April). The further north the more arid the system, and the fewer the species.
- Dune Thicket, in turn, is associated with spring-dominant bimodal rainfall patterns. Rainfall is also higher than on the West Coast, ranging from 400 mm - 900 mm p.a. between Cape Agulhas and Cape St Francis. Climax Dune Thicket can take on forest proportions in sheltered, fire-protected locations.
- High bird and animal densities are important for maintaining pollination and seed dispersal and Thicket has the highest proportion of fruit-producing plants for any vegetation type in the Fynbos Biome. Dispersal of berries and seed by frugivorous bird species is therefore a key "driver" of this system.
- In the more arid West Coast regions, fire is hardly ever a factor as fuel loads are too low. In more mesic coastal environments, however, fire fulfils an important functional role by helping maintain a mosaic-type vegetation pattern with fynbos. In Dune Thicket and Dune Fynbos mosaics, Dune Thicket occupies fire-protected sites (such as calcrete outcrops or the northern base of dunes) while the more combustible Dune Fynbos is often associated with fire-prone, usually wetter, locations. In the past this mosaic pattern was probably also maintained by impacts of large herbivores. In some areas, such as Goukamma Dune Fynbos, there are rare plant endemics associated with the Dune Fynbos that will disappear if the area is not periodically burnt. Left unburnt, Dune Fynbos is eventually replaced with Dune Thicket.
- In Dune Thicket, dune slack wetlands contribute to overall diversity of the system; water drainage is therefore an important driver of structure.
- Dune Thicket often acts as an important corridor for fauna (birds and mammals) along the coastal strip. In the South Cape, Dune Thicket in many instances provides the only remaining natural connectivity between inland-trending Valley Thicket remnants.

What are the key issues, vulnerabilities and threats?

- In the West Coast and Namaqualand regions, mining for heavy mineral sands and diamonds represents the greatest threat to Strandveld. Mining is mostly restricted to within 2 km of the coast.
- In the Sandveld region of the West Coast, agricultural transformation is a major problem, along with the over-utilisation of groundwater. Major crops are potatoes, rooibos tea and onions. West Coast

COLIN PATERSON-JONES

A narrow belt of Strandveld represents a tenuous ecological link between the Cape Peninsula and the mountains that rim the eastern shores of False Bay.

Strandveld is also increasingly under pressure from urbanisation, especially southwards from Lambert's Bay.

- There is a relatively low diversity of habitat endemics and rare species in West Coast Strandveld. Rare species tend to be concentrated in specific habitats (often in rocky areas) hence their vulnerability to mining and quarrying. Grazing is seldom of sufficient intensity to be a major threat. Wetland areas are very sensitive to lowered water tables, hence their vulnerability to over-utilisation of aquifers (see Guideline 7, Freshwater Ecosystems p.68).
- In Strandveld, alien plant invasion is largely unimportant, except for old man saltbush *Atriplex* spp. However, in the southern and eastern coastal areas, disturbed Dune Thicket is very vulnerable to invasion by woody alien plant species such as rooikrans *Acacia cyclops.*
- Dune Thicket in the southern and south-eastern coastal regions usually supports high densities of small animals and birds, but few rare or local plant species.
- This vegetation type is very vulnerable to altered natural fire regimes, especially fire frequency. In the absence of fire, fynbos elements in dune thicket can become senescent and prone to colonisation by thicket vegetation.
- Strandveld and Dune Thicket close to settlements can be vulnerable to hunting and very few game species such as porcupine or antelope are left in these areas.
- Resort and urban development poses the main threat to Strandveld, along with associated impacts such as hunting, fires, dumping and trampling. Uncontrolled driving by off-road vehicles is a major problem in certain areas.
- Dune Thicket is one of the vegetation types most heavily impacted by rapidly expanding coastal developments, and its conservation status will have to be revised regularly.
- Coastal dune systems are vulnerable to "blowouts" when the vegetation cover is disturbed.
- Migration corridors of certain bird species can be fragmented when Dune Thicket is lost or a connective matrix of non-Thicket vegetation is transformed.
- Once disturbed, Dune Thicket is prone to invasion by woody alien plants such as *Acacia cyclops.*


ANDREW BROWN

Ecological corridors should be at least 20 m wide in Dune Thicket, and development must be well set back from estuaries and wetlands.

What are the "bottom lines" and non-negotiables?

- In the West Coast and Namaqualand regions, it is important to keep coastal/ inland (west-east) gradients intact.
- In the south-western area (Cape Town-Lambert's Bay), at least 80% of the remaining Strandveld should be retained. All special habitats should be conserved, e.g. unique mineral-rich dunes, *Odyssea*-dominated grasslands and rocky outcrops.
- Due to its aridity Strandveld is slow to recover after physical disturbance and fires. Physical disturbance and fires therefore should be limited to the minimum in Strandveld.
- As a general rule, connectivity must be maintained and fragmentation of habitat actively avoided. This is particularly relevant in Dune Thicket and Dune Fynbos. Remnants can be very small and remain

fairly viable, but unless they have good connectivity (within a few hundred metres) they will have far fewer mammals and birds.

- Birds are more affected by patch size than by patch isolation. Since many of the plants are resprouters they can persist for centuries without pollinators.

What broad spatial guidelines can be given with respect to the best approach to development and disturbance?

- In the West Coast and Namaqualand regions, avoid all rocky outcrops and coastal dunes (this has important implications for quarrying and mining).
- Ideally, natural corridors should be kept intact along north-south as well as coast-inland gradients. This can mean retaining habitat corridors between or even within large mining developments.
- In general, avoid impacting on any wetland areas or riverine fringes. Estuarine systems are particularly important.
- In Dune Fynbos, nodal development is better as it makes it easier to maintain appropriate burning patterns. Fire is not necessary or desirable in Dune Thicket.
- In Dune Thicket and Dune Fynbos, retain corridors of intact natural vegetation (at least 20 m wide) to allow for movement of birds and animals between areas of undisturbed or contiguous habitat. Unbroken linear development is therefore not appropriate in these systems.
- Avoid developments that sever linkages between inland-trending Mainland (Valley) Thicket types and Dune Thicket along the coast, especially in the Southern Cape.

Coastal development policy in the Western Cape discourages ribbon development.

NICK HELME

What are the critical things to maintain in terms of managing these systems for biodiversity, and ensuring its persistence?

- Maintain habitat connectivity and minimise disturbance. Predators are important for controlling fauna such as dassies, rodents and termites.
- Manage fire. As a general rule, fire must be kept out of West Coast and Namaqualand Strandveld and Dune Thicket. Dune Fynbos needs fire at appropriate intervals and seasons.
- Dune Fynbos is very prone to alien invasion by rooikrans *A. cyclops* and managers need to ensure that areas are kept free of alien vegetation. Woody plant invasives also increase the fuel load, resulting in more intense burns and therefore increased risk to the survival of indigenous seed banks.
- Birds and small animals should be present as they are important for dispersal.

What, if any, reliable indicators could be used in monitoring ecosystem health, as related to key vulnerabilities?

- The presence of rare and endemic plant species that appear to be reproducing.
- The diversity of habitat types, intact soil crusts and lichens, and no loss of species diversity.
- Functioning wetland systems and the maintenance of dune slack wetlands, especially where these have a high species diversity and are not dominated by bulrush *Typha capensis*.
- The presence of indigenous fauna e.g. rooikat, aardvark, mongoose, genets, porcupines, small antelope, and the presence and number of birds (frugivores and nectarivores in particular).
- The presence of intact vegetation, with associated understorey (often herbs), creepers, grasses, and Thicket (shrubby, spinescent and small tree) elements.
- The absence of alien invasive plants.

L-R: NICK HELME; CITY OF CAPE TOWN; CAPE FLATS NATURE


(left) Maximise connectivity by avoiding wholesale clearing of vegetation when installing services.
(centre) Urban sprawl is placing immense pressure on Strandveld ecosystems in the Cape Town Metropolitan Area.
(right) Windswept sand is characteristic of areas stripped of Strandveld by alien-fuelled fire, trampling and clearance for habitation.

How reversible are impacts over a 5 – 10-year period?

- Ploughed lands are very unlikely to be restored after 5-10 years. In the more arid West Coast and Namaqualand regions, 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 mined areas is more successful if areas are irrigated with freshwater for at least two years. Saltwater irrigation is not conducive to recovery of diversity. Rehabilitation should not use alien species such as rye grass as cover crops.

CAPE FLATS NATURE

Strandveld is adapted to withstand salt-laden, desiccating winds, but sheltered and wetter patches can support populations of the arum lily Zantedeschia aethiopica.

- Dune Fynbos and Dune Thicket may be quick to reappear after disturbance such as fire or even bush-cutting, especially in the bimodal or higher rainfall areas east of Cape Town.
- However, if Dune Thicket and Dune Fynbos are burnt too regularly (e.g. parts of the Cape Flats) recovery will be severely compromised, and may take centuries.
- Dune Thicket, if burnt at appropriate intervals or bush-cut, will recover well. But if bulldozed and underground rootstocks are destroyed, it will take centuries to recover. Although some of the larger trees, such as 'seegwarrie' *Euclea racemosa* and milkwood *Sideroxylon inerme* are capable of resprouting, they may be killed by very hot fires associated with dense stands of alien rooikrans.

? *What are acceptable trade-offs, compensation or off-sets for biodiversity loss?*

- Certain key areas must be avoided along the West Coast and in Namaqualand. These include the titanium-rich dunes near Brand-se-Baai, the northernmost outliers of Sand Fynbos in the far North and parts of the north-western Sandveld. These rare and threatened habitats must be complemented with an appropriate increase in the extent of statutory conservation areas. Woody invasive alien plants must be cleared in Dune Thicket and Dune Fynbos - both in and around densely invaded areas - with clearance being prioritised in threatened ecosystems and ecological corridors.
- Corridors should be restored between remnants of Dune Thicket and Dune Fynbos and along the major biogeographical axes: usually coastal-inland, and parallel to coast, especially where Dune Thicket connects inland-trending Valley and Mainland Thicket.
- As a general rule, off-sets should be pursued when irreversible loss of habitat or ecosystem function cannot be avoided in threatened ecosystems.

INCORPORATING SAND FYNBOS AND LIMESTONE FYNBOS

LOWLAND FYNBOS ECOSYSTEMS

Nick Helme, Pat Holmes and Tony Rebelo

What are the key ecological "drivers" in terms of maintaining ecosystem function, pattern or structure?

- Limestone Fynbos and Sand Fynbos often occur in a matrix, and ecological processes that affect the one may be closely inter-related with the other.
- Fire frequency must ensure sufficient seed-set in slow-maturing species such as the Proteaceae. This can be up to 30 years in arid areas.
- The appropriate seasonal fire regime must be retained. Fire should occur 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. End boundaries of fires are usually other vegetation types and young veld.
- Allow for sufficient seed-set in slow-maturing species.
- In Limestone Fynbos and Sand Fynbos, there can be a high incidence of species turnover along habitat or environmental gradients, i.e. beta diversity is high. Many edaphic gradients are found on edges of Limestone Fynbos and Sand Fynbos communities. Subtle edaphic variations, such as the depth of overlying sand, have a dramatic effect on community structure. There are also substantial unexplained variations in species richness, and concentration of rare and endemic plants, from area to area.
- Patch size and connectivity with other limestone outcrops may be important to retain certain species.
- Seasonal wetlands and seeps are important to retain certain distinct communities. Regional and local natural water drainage patterns are thus also important drivers of biodiversity pattern.
- Natural grazing and physical soil disturbance by fauna may be important to retain a high incidence of spring annuals, which is unusual in fynbos.

What are the key issues, vulnerabilities and threats?

- There can be a very high occurrence of rare and regionally endemic plant species in Limestone Fynbos and Sand Fynbos, many of which are very localised within what might appear to be fairly homogenous habitat. In Sand Fynbos, the incidence of rare and endemic plant species is particularly high in the South.
- Vulnerable habitats include wetlands, sink-depressions and moister soil facies. These ecotypes are at risk due to their higher agricultural potential.
- Both Limestone Fynbos and Sand Fynbos are vulnerable to changes in the natural fire regime (to promote grazing, for example) and invasion by 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 due to abstraction of groundwater.
- Limestone Fynbos is highly susceptible to invasion by rooikrans *Acacia cyclops*, especially on deeper sands in valleys between rocky outcrops. However, in areas of severe invasion even the rocky pavements are affected. Besides being vulnerable to rooikrans, Sand Fynbos is also susceptible to invasion by Port Jackson *Acacia saligna*, *Eucalyptus gomphocephala* and *Leptospermum laevigatum*, and annual grasses *(Avena, Briza)*.

COLIN PATERSON-JONES

Limestone Fynbos, Groot Hagelkraal

- Veld clearance for rooibos tea and potato cultivation is particularly prevalent in Leipoldtville Sand Fynbos. Parts of the Sandveld region are also experiencing added pressure from excessive groundwater abstraction.
- The establishment of monocultures of indigenous species - such as rooibos tea, honeybush tea, buchu and protea orchards - also represents a significant threat to these vegetation types.
- 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 result in the contamination of aquifers.
- The expansion and development of urban areas, resorts and small holdings is a major cause of habitat loss between Atlantis-Hopefield, Cape Town and the Overberg coast. Sand Fynbos and Limestone Fynbos are also under pressure from resort development and urban expansion in the Gourits-Mossel Bay region.

What are the "bottom lines" and non-negotiables?

- Fragmentation of Limestone Fynbos and Sand Fynbos should be avoided. Little information is available on minimum patch size and the degree of connectivity required to retain species richness, but small remnants (< 100 ha) are likely to be vulnerable to a loss of species due to altered ecological processes, e.g. losses of pollinators, changes in fire frequency and edge effects which encourage alien invasion.
- Sand Fynbos is particularly vulnerable to disturbance resulting from nutrient enrichment (e.g. fertilizer run-off) or invasion by alien legumes (*Acacia* spp). Nutrient enrichment promotes competitive alien annual and indigenous grass species, resulting in an ecological equilibrium that excludes most fynbos species. It is not known if Sand Fynbos systems thus disturbed can easily be restored.
- Lowland fynbos seed banks are less persistent than those of mountain fynbos. This results in a rapid change in community structure following an alien or agricultural disturbance. Post-disturbance recovery is slow and dependent on the proximity of suitable seed sources (hence the importance of maintaining connectivity in these vegetation types).
- Habitats of threatened species must not be developed, and should be incorporated into conservation areas. These rare species "hotspots" can be identified by a detailed botanical survey.
- Biocontrol "reserves" (*Acacia cyclops* and *A. saligna*) must be maintained and monitored.
- Aquifers must be allowed to recover fully to natural levels during winter, otherwise woody components will go extinct and only restioid and annual elements will survive.
- The habitats of Critically Endangered and Endangered species must not be developed, and should be incorporated into conservation areas.

What broad spatial guidelines can be given with respect to the best approach to development and disturbance?

- Because Sand Fynbos and Limestone Fynbos are very prone to alien invasion, habitat fragmentation and disturbance of edges of patches must be avoided.
- In general, housing infrastructure is not compatible with conserving fynbos or any other fire-prone vegetation type. In order to allow burning, nodal or clustered development is preferable to a spreading, linear layout. To minimise the impacts of developments in fynbos, houses should be clustered within a fire-free zone and protected with an appropriate fire belt. Firebreaks must be cleared within the development footprint, not in adjacent veld. Building materials should be fire-resistant. Thatched roofs may therefore be inappropriate in developments adjacent to, or in, natural fynbos areas such as parts

of the Cape Peninsula or Overberg coast. By contrast, a thatched house in forest or thicket may be more compatible with conservation.

- All further development of wetlands (pans, vleis, marshes, riverine areas, drainage lines), seeps or peaty soils should be avoided and preferably stopped. Wetlands must be buffered and links maintained with conservation areas.
- Most community patterns within Sand Fynbos and Limestone Fynbos are orientated parallel to the coast, with the exception of riparian communities. Spatial planning should ensure representation of sub-units perpendicular to riparian communities and, in non-riparian communities, perpendicular to the coast.
- The loss of Sand Fynbos within Limestone Fynbos must be mitigated with corridors perpendicular to the long axis of sand-filled depressions.
- No more agricultural expansion should be allowed in Leipoldtville, Atlantis, Cape Flats and Hangklip Sand Fynbos.
- Corridors in strip-ploughed Sand Fynbos should be at least 300 m wide.
- Most Limestone Fynbos types are slow growing and vulnerable to trampling. Remnant Limestone Fynbos within residential areas therefore should be safeguarded against physical disturbance.

Intensive cultivation poses a major challenge to the persistence of lowland fynbos ecosystems such as Leipoldtville Sand Fynbos.

COLIN PATERSON-JONES

NICK HELME

Leipoldtville Sand Fynbos, and Graafwater Sandstone Fynbos dominating the higher ground.

What are the critical things to maintain in terms of managing these systems for biodiversity, and ensuring its persistence?

- Manage these systems to maintain the appropriate fire regime and to prevent overgrazing, invasion by alien plant species and over abstraction of groundwater.
- Development should be avoided and strongly discouraged in habitat associated with Critically Endangered and Endangered ecosystems or species, particularly in corridors and vegetation boundaries.
- Maintain ecotones that bracket edaphic boundaries, e.g. the interfaces between limestone-sandstone or limestone-shale.

What, if any, reliable indicators could be used in monitoring ecosystem health, as related to key vulnerabilities?

- The density of alien invasives, i.e. there are no dense stands, isolated plants are being controlled, and biocontrols are present.
- The type, age and condition of indigenous plant cover, species richness and the presence of key guilds (serotiny, woody shrubs, winter annuals). Adherence to appropriate fire regimes can be reflected in senescence of indigenous vegetation in strip-ploughed lands (burns are too infrequent) or invasion by grasses and weedy species such as slangbos *Stoebe* spp. and *Aspalathus* spp. (burns that are too frequent, or unseasonal).
- The abundance and distribution of populations of Red and Orange List species.
- The maintenance of natural water tables, especially adequate winter recovery, should be monitored (ideally by the Department of Water Affairs and Forestry in vulnerable areas such as the Sandveld).

How reversible are impacts over a 5 – 10-year period?

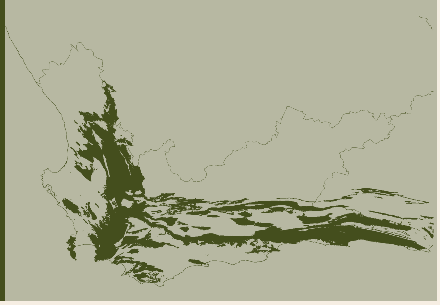
- Environmental assessments should preferably be undertaken in spring when most annuals and bulbs are flowering.
- Search-and-rescue is important for all development, especially when development may result in the irreversible loss of rare or threatened plant populations. A specialist botanical report must provide recommendations on rescue techniques and CapeNature should endorse the sites to which these plants are translocated. Rehabilitation of rare or threatened plants should not be considered as adequate mitigation for loss of pristine habitat. In the case of sites that will be disturbed by development but later rehabilitated, search-and-rescue should, as a minimum, concentrate on saving bulbs and succulents. 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. In all cases topsoil (upper 150 mm) should be removed before an area is disturbed and replaced after the construction phase. In the case of recently burned sites, the seedlings of most shrubs can be rescued by means of retaining soil sods (± 30 cm x 30 cm x 15 cm deep) in trays. Transplantation of rescued plants must take place in autumn (March-April).

What are acceptable trade-offs, compensation or off-sets for biodiversity loss?

- Certain areas should be treated as out-of-bounds to development if they are important corridors, represent important vegetation boundaries or support rare species.
- Alien clearance can be a very worthwhile mitigation measure.
- Biodiversity offsets may be appropriate in certain instances, assuming that standard mitigation has identified key areas as "no go" development areas. Where highly irreplaceable Sand Fynbos or Limestone Fynbos will be disturbed, a similar or larger area of the same vegetation type must be conserved.

Leipoldtville Sand Fynbos, an Endangered ecosystem.

ANTON WOLFAARDT



INCORPORATING ALLUVIAL FYNBOS, GRANITE, FERRICRETE, CONGLOMERATE & SILCRETE FYNBOS, GRASSY FYNBOS, AND SANDSTONE FYNBOS

MIDLAND & MOUNTAIN FYNBOS ECOSYSTEMS

MIDLAND & MOUNTAIN FYNBOS ECOSYSTEMS

Nick Helme, Pat Holmes and Tony Rebelo

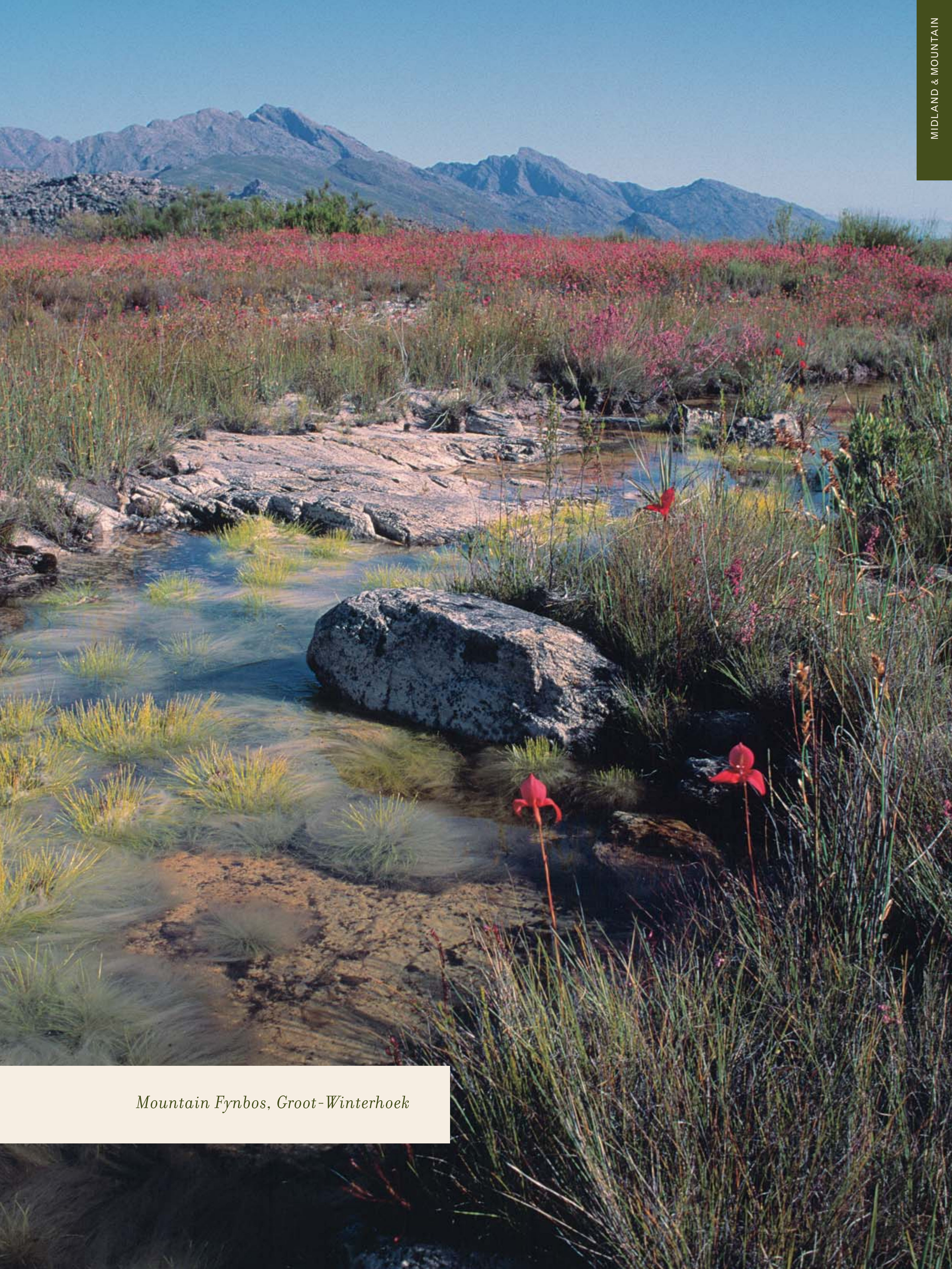
What are the key ecological "drivers" in terms of maintaining ecosystem function, pattern or structure?

- Fire is integral to the persistence of fynbos ecosystems, and naturally occurs during the hot, dry season, i.e. summer or early autumn.
- Generally, edaphic conditions - especially in terms of nutrient status, depth and water availability - largely determine the species composition of communities and the occurrence of rare species.
- 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 degree and type of grazing applied. Little information is available on the most appropriate fire season. Seasonality of fire can have a noted effect on community structure, with winter and spring fires generally favouring the grass component.
- In Granite Fynbos, and the other fynbos types associated with specific lithologies, young veld is characterised by dense stands of (early seral) pioneer plant species. These take 4-8 years to disappear and be replaced by typical fynbos.
- In most fynbos types, but specifically in Alluvial Fynbos, localised soil moisture gradients are important drivers of diversity. Seasonal wetlands and seeps exemplify environments where these gradients occur. Due to edaphic and other factors, Alluvial Fynbos is usually surrounded by other vegetation types, most commonly Mountain Fynbos on the upper side, and often with renosterveld below.
- Many Alluvial Fynbos areas are in alluvial fans where mountain rivers open out on to the flats or occur on old floodplains with meandering braided streams such as the upper Breede River and Slanghoek valleys. Deep, well-drained, sandy areas support a very different flora to that on poorly drained sands.
- Subsurface drainage is a key determinant of community structure and mosaic patterning in Alluvial Fynbos systems. The degree of rockiness (given similar moisture regimes) is also important - rocky sites often support a different community to that on deep sands.

What are the key issues, vulnerabilities and threats?

- Alien invasive species represent a key threat in fynbos ecosystems. Without natural enemies to control them, alien invasives out-compete indigenous plant species for space, nutrients and light. The enhanced biomass that results from dense stands of woody aliens increases the intensity 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 alien species after physical disturbance and unseasonal and too-frequent fires.
- Pines and hakea represent the predominant invasives affecting fynbos ecosystems inland. Long-leafed wattle *Acacia longifolia* (and locally poplar) tends to invade seeps and gulleys in Sandstone Fynbos habitats, while the latter habitats are vulnerable to infestation by bramble *Rubus* in Granite, Shale, Ferricrete, Conglomerate and Silcrete Fynbos. *Eucalyptus* can be invasive on slopes in these ecosystems. Black wattle *Acacia mearnsii* can spread virulently in mountain streams.

COLIN PATERSON-JONES



Mountain Fynbos, Groot-Winterhoek

- Altered fire regimes can also be a major problem in fynbos ecosystems. Veld is either burnt too frequently to promote grasses for grazing potential, or fire is actively suppressed in fynbos abutting urban or peri-urban areas or smallholdings.
- Cultivation is by far the greatest land-use pressure on inland fynbos, especially for those fynbos vegetation types that occur in wetter or cooler areas. Vineyards, olives and deciduous fruit will continue to drive transformation, especially in cooler, ecotonal areas. Afforestation is also a problem.
- Conversion to monocultures of indigenous species such as buchu, rooibos tea, honeybush tea and protea orchards also represents a significant land-use pressure in certain areas.
- Over-harvesting of selected indigenous plant species such as buchu for flowers or even whole plants is a chronic threat, especially in the Groot-Winterhoek and Olifants River mountains.
- Water-dependent communities such as those of seeps, wetlands and riparian zones are vulnerable to changes in hydrological systems, including the abstraction of groundwater (see Guideline 7, Freshwater Ecosystems p.74).
- Patches of seasonal wetlands within agricultural lands are often surrounded by drainage ditches designed to prevent flooding of adjacent fields, which can impact on groundwater processes.
- Quarrying for stone and gravel, especially in the upper Berg River area near Paarl and Franschhoek, represents a threat to Alluvial Fynbos, which is a Critically Endangered ecosystem.
- In Grassy Fynbos, the higher nutrient status of the soils and relatively high rainfall often mean that these areas have been heavily transformed for agriculture, or are targeted for golf course or housing estates.
- Reduced fire frequency associated with development means that many patches convert to thicket or forest. Heavy grazing after fire favours less palatable species which displace the more vulnerable species.
- In farming areas, changes in natural burning and grazing regimes have often altered edaphic condition and community structure to the point that much of the original beta diversity of Grassy Fynbos has been lost.
- Grassy communities may be an important habitat for certain bird species.
- In many fynbos types the introduction of alien fauna such as the Argentine ant *Linepithema humile* can displace vital dispersal and pollinating agents.
- Mountain tops and other sites at high altitudes are often used as locations for telecommunication masts. The natural vegetation of these sub-alpine areas is sensitive to disturbance and often rich in highly localised species.
- There has been a proliferation of 4x4 trails in mountainous areas. These tracks are often poorly designed and can result in the degradation of seeps, wetlands and watercourses, as well erosion of open slopes. They also increase the risk of localised invasion by alien plants.
- Mountain resorts with vehicular access may also increase the risk of fires, alien invasion, trampling and flower-picking in sensitive or rare habitats.

NICK HELME

Wildflower orchards must be carefully located to avoid hybridisation with related indigenous species.

What are the "bottom lines" and non-negotiables?

- Alien plants and animals must be removed and prevented from spreading.
- Appropriate fire regimes must be maintained.
- Surface and underground hydrological systems and wetland habitats must be maintained.
- Small remnants of Alluvial Fynbos (<100 ha) are likely to suffer losses of pollinators, changes in fire frequency and edge effects that encourage invasion by alien plants.
- Red Data List species must be monitored, and significant, viable populations of such species should not be lost to any form of development.
- Biocontrol "reserves" (for controlling hakea and *Acacia* spp) must be maintained and monitored.
- Development of habitat of Critically Endangered or Endangered plant species must be avoided and discouraged.

What broad spatial guidelines can be given with respect to the best approach to development and disturbance?

- Nodal development is preferable to linear or diffuse development in order to allow managed burning of fynbos and to accommodate wildfires. In general, housing infrastructure is not compatible with conserving fynbos or any other fire-prone vegetation type. To minimise the impacts of developments in fynbos, buildings should be clustered within a fire-free zone and protected with an appropriate firebelt. Avoid using flammable building materials such as thatch. Fire belts must be included in the development footprint, and not considered to be part of the surrounding natural veld.
- Lower-lying fynbos types, and particularly those associated with particular geologies (such as Granite, Shale and Ferricrete Fynbos), are often highly fragmented. It is therefore essential to maintain and restore connectivity within and between these vegetation types.
- Rocky outcrops and screes provide good stepping-stones and a high degree of connectivity between larger remnants of untransformed vegetation, and across edaphic and other vegetation boundaries.
- Habitats are usually parallel to the contours, with the exception of riparian and spur communities. Conservation should attempt to preserve the upslope habitats in representative spur, riparian and flat-slope environments.
- Avoid developments 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 transform seeps and marshes - avoid and strongly discourage the development 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 out of these areas.
- Orchards of cultivated indigenous species (such as proteas, buchu and honeybush tea) and their cultivars must be located more than 2 km away from sites where related species occur naturally.
- 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.

? *What are the critical things to maintain in terms of managing these systems for biodiversity, and ensuring its persistence?*

- Manage fires correctly and, in Grassy Fynbos, maintain appropriate grazing regimes to retain maximum species richness in communities.
- The natural fire season is during the hot dry season (i.e. summer or early autumn).
- In Granite Fynbos, 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 large-seeded, early seral species which are very prominent in these communities.
- Sandstone Fynbos is inadequately mapped and comprises many sub-units which need to be considered - and preferably maintained - when assessing development. 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.
- The maximum viable distance between patches of Alluvial Fynbos is unknown. Where possible, patches should be linked upslope to Mountain Fynbos along drainage lines; these corridors should be at least 100 m wide. Such linkages help prevent groundwater being polluted by fertilizers and pesticides.
- Subterranean and surface water movement is often altered by agricultural drainage, water abstraction, canalisation and dams. This can result in the drying up of seasonally wet areas, even if they have not been directly transformed.
- Maintain buffer zones between drainage ditches and habitat remnants.

Breede Shale Fynbos abutting higher-lying Winterhoek Sandstone Fynbos

ANTON WOLFAARDT

- Sedimentation and erosion into Alluvial Fynbos habitat from agricultural lands must be prevented.
- Alien species must be removed correctly.
- Seeps and marshes must be monitored to detect changes where surface water or groundwater is abstracted.
- No flowers, seeds or plants must be harvested in nature reserves and hybridisation from protea orchards must be monitored.
- Rubbish disposal should be carefully controlled and development footprints kept as small as possible to minimise the spread of invasive Argentine ants.
- Patch connectivity must be maintained and maximised to allow for movement of pollinators.


CHARL DE VILLIERS

Soils derived from quartz-rich sandstones are prone to erosion.

What, if any, reliable indicators could be used in monitoring ecosystem health, as related to key vulnerabilities?

- The absence of alien invasives.
- The abundance and distribution of populations of Red and Orange List species.
- The type, age and condition of indigenous plant cover, species richness and the presence of key guilds (serotiny, woody shrubs, winter annuals).
- Monitoring should at least look out for serotinous overstorey proteas and large-nut overstorey Proteaceae (e.g. *Mimetes* and *Leucospermum*).
- Monitor biocontrol reserves.
- Monitor harvesting levels of wild plants.
- In Sandstone Fynbos, monitor Black Eagles, grey rhebok, baboon and leopard, In Granite Fynbos, Shale, Ferricrete, Conglomerate and Silcrete Fynbos, monitor for porcupine, duiker, baboon and caracal.
- Although most healthy Grassy Fynbos will have thicket patches, thicket should not be encroaching. The complete conversion to grassland indicates too-frequent, unseasonal fires.
- 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 relative abundance of unpalatable species, e.g. *Aristida diffusa.*

How reversible are impacts over a 5 – 10-year period?

- Reversibility of impacts and the time required for restoration depends on the extent and type of the proposed development, and the receiving environment, which means that general rules cannot readily be applied.
- Fynbos is fire-determined and complete regeneration will only commence after the next fire. A 5 - 10-year period is therefore not applicable. Partial recovery may commence if agricultural land is left fallow, or plantations or aliens are removed. If the topsoil and seed-banks remains intact, a large proportion of the species should recover following the next fire. This applies to alien infestation for up to three fire cycles after 90% alien canopy cover.
- If disturbance has altered soil characteristics and alien species have moved in, recovery is not guaranteed. Remove aliens. In most cases there is more than enough cover to promote fire, so vegetation

will move in from neighbouring areas; recovery is possible within three fire cycles (20-120 years). For large areas, rates of recovery are 50 m from the edge per fire cycle (5-40 years) for serotinous species and 10 m per fire cycle for myrmecochorous species. If regeneration is insufficient to carry a fire, recovery will take much longer. 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 aliens or too-frequent burning), recovery takes about three fire cycles if remnant patches survive. Otherwise seeds should be broadcast-sown after the first post-fire rains.
- Recovery of myrmecochorous species is slower and more labour-intensive (and costlier) than for serotinous species.

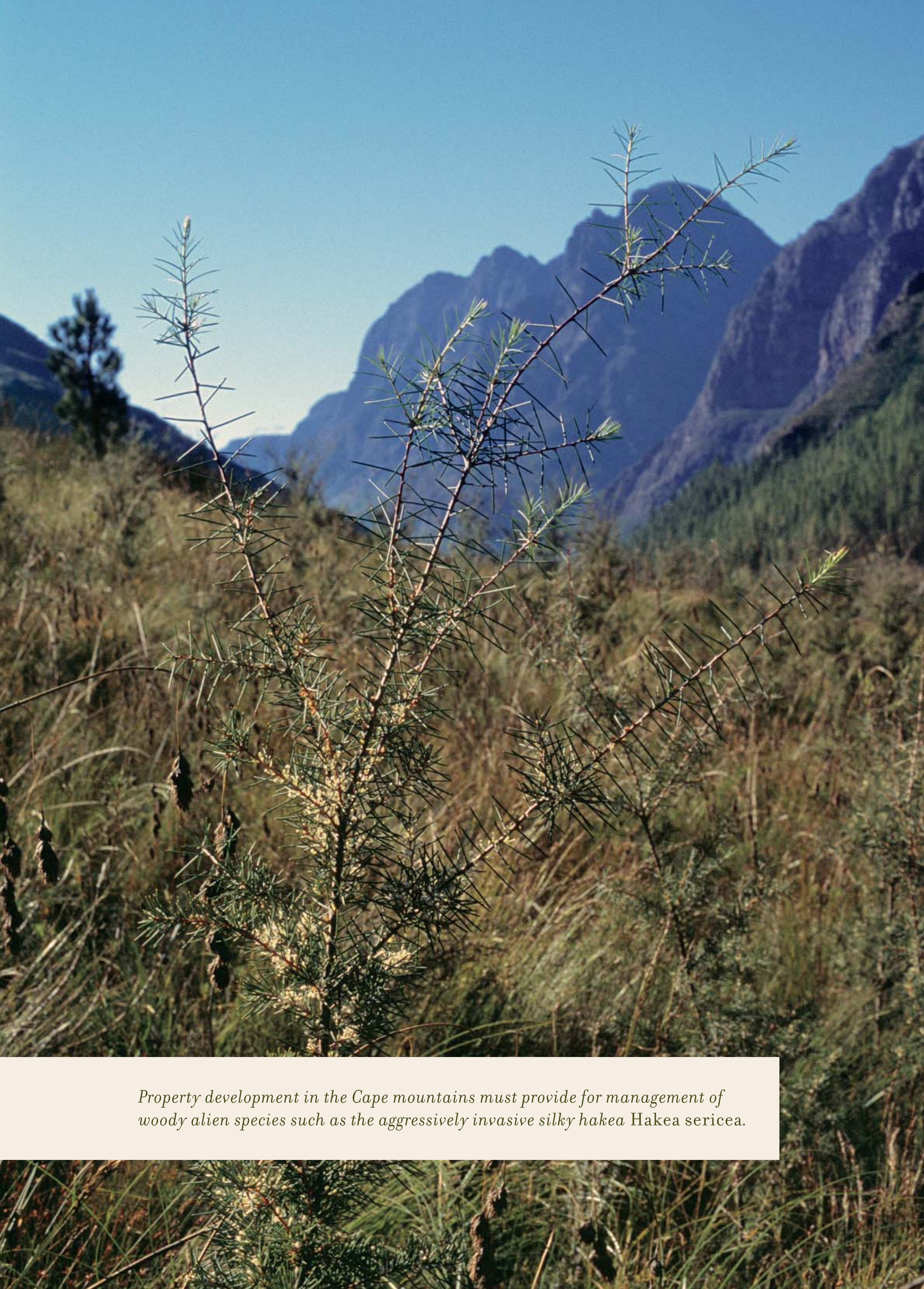
? *What are acceptable trade-offs, compensation or off-sets for biodiversity loss?*

- Habitat in threatened (Critically Endangered and Endangered) ecosystems, corridors and vegetation boundaries must be avoided, as must sensitive habitats such as wetlands and riparian fringes.
- For all types of development, footprints should be minimised. The focus should be on selecting alternatives that maximise the retention of indigenous habitat, species and ecological processes. This means, for example, seeking less destructive methods of cultivating buchu, using local indigenous plants species in landscaping and retaining wetland features as natural habitats and corridors.
- Many of the rare species are localised, and these populations can often be avoided by good environmental assessments and planning.
- There are no acceptable trade-offs for losing the habitat of Critically Endangered and Endangered species, or the species themselves.
- Large developments are not recommended.
- Search-and-rescue is important for all development, especially when development may result in the irreversible loss of rare or threatened plant populations. A specialist botanical report must provide recommendations on rescue techniques and CapeNature should endorse the sites to which these plants are translocated. Rehabilitation of rare or threatened plants should not be considered as adequate mitigation for loss of pristine habitat. In the case of sites that will be disturbed by development but later rehabilitated, search-and-rescue should, as a minimum, concentrate on saving bulbs and succulents. 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. In all cases topsoil (upper 150 mm) should be removed before an area is disturbed and replaced after the operational phase. In the case of recently burned sites the seedlings of most shrubs can be rescued by means of retaining soil sods (± 30 cm x 30 cm x 15 cm deep) in trays. Transplantation of rescued plants must take place in autumn (March-April).
- In threatened ecosystems, or where sensitive habitats or ecological corridors or vegetation boundaries may be transformed, biodiversity off-sets must be considered after all standard mitigation has been carried out. The selected areas should support vegetation of the same or better quality than that found on the developed site.

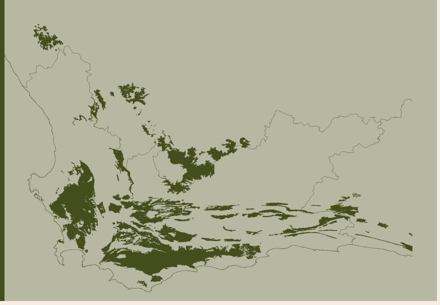
Frequent, high-intensity summer fires and over-harvesting have reduced the Clanwilliam cedar Widdringtonia cedarbergensis *to remote sites in the higher-lying parts of the Cederberg.*

PIETER MALAN

COLIN PATERSON-JONES



Property development in the Cape mountains must provide for management of woody alien species such as the aggressively invasive silky hakea Hakea sericea.



INCORPORATING COAST & INLAND RENOSTERVELD

RENOSTERVELD ECOSYSTEMS

RENOSTERVELD ECOSYSTEMS *Nick Helme and Tony Rebelo*

What are the key ecological "drivers" in terms of maintaining ecosystem function, pattern or structure?

- Periodic defoliation by fire and grazing is important to retain biodiversity richness in renosterveld types. The appropriate fire frequency ranges from 10-15 years in wetter areas, but in drier inland areas it can be much longer.
- Renosterveld occurs on relatively nutrient-enriched clay soils derived from shales or granite.
- Edaphic boundaries are the prime drivers of the fynbos/renosterveld ecotone, but fynbos can replace renosterveld on clay soils where rainfall exceeds 600 mm p.a.
- Little information is currently available on how the fire-grazing balance should be retained, but it would differ in the different renosterveld types.
- Ideally both browsers and grazers should be maintained to prevent dominance of either grasses or overstorey shrubs respectively.
- Variations in edaphic conditions (soil type, depth, moisture capacity, rockiness and mineral composition) and water availability determine variation in plant communities and the occurrence of rare and threatened plant species. Community variation 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.
- Patches of silcrete, ferricrete or quartz support concentrations of rare and endemic plant species, many of which are succulents. In the case of silcretes, shallow soils and clays on steep concave slopes support high concentrations of endemic succulents. Quartz patches are characterised by delicate soil crusts, and may also support numerous endemic succulents.
- Many renosterveld plant species are pollinated by specialised pollinators such as long-tongued flies. The requirements of these pollinators are poorly known.
- 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).
- Renosterveld harbours rare and threatened fauna such as the geometric tortoise *Psammobates geometricus.*
- Biogenic crust is important for the soil and damage to it could lead to large quantities of top soil loss and erosion.

What are the key issues, vulnerabilities and threats?

- Nearly half of renosterveld ecosystems are either Critically Endangered or Endangered. They harbour very high numbers of rare and localised species which are often associated with very specific edaphic or alluvial environments. Most renosterveld habitats should be treated as threatened.
- Agriculture is by far the most important and ongoing threat to renosterveld, especially in the West Coast forelands, Overberg, Rûens and Riversdale Coastal Plain. Past cultivation for crops such as wheat and oats accounted for the most widespread loss of habitat in renosterveld. Heavy grazing has also taken its toll. The production of wine and olives has replaced cereals as the main "driver" of transformation, especially in cooler ecotonal areas that are suitable for viticulture.

COLIN PATERSON-JONES

Lowland Renosterveld is severely threatened: the remaining nine per cent has been reduced to 18 000 patches, of which more than 50% are less than one hectare in extent.

- Urban expansion is a problem in some areas. Urban development in adjacent areas can have a negative impact on the maintenance of an appropriate fire regime. When fires start they are often put out and not allowed to burn (resulting in dominance by slower growing, woody species, to the detriment of bulbs, herbs, and grasses). In other cases, fires are often deliberately set, resulting in too-frequent burns; slower-growing reseeding species will be lost from the system.
- Drainage of seasonal wetlands destroys alluvial renosterveld habitat.
- Trampling, such as by livestock, can result in the irreversible transformation of silcrete, ferricrete and quartz patches.
- Spraying of crops with insecticides may lead to the killing of pollinators of specialised plant species.
- The introduction of ostriches and other extra-limital game species into renosterveld can alter grazing regimes and result in trampling and damage to the biogenic surface. Ostriches are often introduced after wheat fields have been harvested and they can utilize remnant renosterveld patches heavily.
- Changes in the natural fire and grazing regimes (and the fine balance between them) will alter the species richness of all renosterveld types.
- Fields are often burned to remove stubble. These fires may impact on adjacent renosterveld if burnt too frequently.
- Renosterveld types are susceptible to invasion by annual alien grasses that replace bulbs. This is probably due to a mixture of eutrophication and herbicides, coupled with inappropriate grazing, but the details of this are not understood.
- Most renosterveld types are prone to soil erosion; physical disturbance of remaining intact examples of renosterveld should be limited to the minimum.
- When crops are sprayed (especially by aeroplane), renosterveld patches and their insect populations can be exposed to drift of herbicides and insecticides.
- Many landowners do not burn remnant renosterveld patches due to fear that fires may spread. Managed burns must be carefully controlled.
- Many of the non-toxic geophytes and annuals are vulnerable to grazing pressure by domestic stock in the first two years after a fire.

? *What are the "bottom lines" and non-negotiables?*

- No more transformation is desirable in areas with intact, high quality vegetation. Habitat conversion must be avoided and strongly discouraged in threatened renosterveld.
- Plans to transform renosterveld should always be preceded by a botanical evaluation. Small remnants (~1 ha) can be very important for the conservation of individual species and achieving some pattern targets. However, in order to be functionally viable, larger patches should be within 500 m of each other and connected by pollinator-friendly terrain.
- It is critical to maintain pollinator-plant associations and pollution by herbicides, fertilisers and insecticide spray must be minimised.
- Avoid perturbations (including grazing and all forms of physical transformation) to silcrete, ferricrete and quartz patches.
- Appropriate fire regimes must be maintained.
- Alien species should be eradicated.
- Extra-limital game species should not be introduced to renosterveld.

The Endangered geometric tortoise Psammobates geometricus*: a renosterveld endemic.*

BOTANICAL SOCIETY OF SOUTH AFRICA


BOTANICAL SOCIETY OF SOUTH AFRICA

Geissorhiza radians

What broad spatial guidelines can be given with respect to the best approach to development and disturbance?

- Ideally a buffer of at least 30 m should be left between any development - especially agricultural lands - and core renosterveld conservation areas.
- Avoid further fragmentation of renosterveld. Systems are usually already highly fragmented, so connections between patches should be maintained. Where possible, habitat links could be rehabilitated.
- Fence off silcrete, ferricrete and quartz patches. Fencing should accommodate the movement of tortoises and small antelope species.

What are the critical things to maintain in terms of managing these systems for biodiversity, and ensuring its persistence?

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

What, if any, reliable indicators could be used in monitoring ecosystem health, as related to key vulnerabilities?

- The lack of alien invasives, especially invasive alien annual grasses.
- Stable populations and periodic reproduction of Red Data List and Orange List species.
- Indigenous plant cover and richness, especially bulbs, grasses (alien and indigenous) and palatable species; presence of healthy populations of longer lived reseeders and understorey bulbs and herbs.
- The presence (and reintroduction) of mammals such as aardvark, bat-eared fox, baboon, duiker and porcupine.

How reversible are impacts over a 5 – 10-year period?

- Renosterveld is fire-determined and complete regeneration will only commence after the next fire. A five to 10-year period is therefore not applicable. Partial recovery may commence if plantations or aliens are removed. If the topsoil and seedbank remains intact, a large proportion of the species should recover following the next fire. This applies to alien infestation for up to three fire cycles after 90% alien canopy cover. However, if disturbance has altered soil characteristics and alien species have moved in, recovery is not guaranteed. Southern Cape areas with more regular rainfall will be restored much faster than drier (e.g. West Coast or inland) areas.
- Overgrazed areas which have lost their geophytes and grasses can be rested to recover the grasses, but bulbs appear to require lengthy periods (> 20 years) and active reintroduction to recover. No fertilizer should be used in restoration projects.
- Transformation of quartz and silcrete patch communities is practically irreversible due to the changes in soil and crust structure.
- If serotinous species are lost from the system (as happens under aliens or too-frequent burning), recovery takes about three fire cycles if remnant patches survive. Otherwise seeds should be broadcast-sown after the first post-fire rains.
- Recovery of myrmecochorous species is slower and more labour intensive (and costlier) than for serotinous species.
- It may be possible to restore renosterveld with a history of incorrect burning and grazing, but restoration is not possible for sites where the soil has been disturbed. Once invaded by high densities (> 80%) of alien annuals - mostly grasses - most species are lost and few can be restored; perhaps the only exception is renosterbos *Elytropappus rhinocerotis.*


BOTANICAL SOCIETY OF SOUTH AFRICA

Sparaxis tricolor

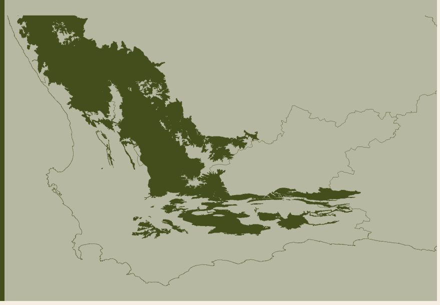
What are acceptable trade-offs, compensation or off-sets for biodiversity loss?

- No further conversion of threatened renosterveld habitat is recommended as most renosterveld ecosystems represent a national (and international) conservation priority due to threats. The achievement of conservation targets for half of the renosterveld vegetation types has already been irrevocably compromised by development. Instead, land should be obtained for rehabilitation and restoration, especially where there is potential for reconnecting isolated patches of natural habitat.
- For all types of development, footprints should be minimised. The focus should be on selecting alternatives that maximise the retention of indigenous habitat, species and ecological processes.
- Many of the rare species are localised (for example in wetter areas or ferricrete patches), and these populations can often be avoided by good environmental assessments and planning.
- There are no acceptable trade-offs for losing the habitat of Critically Endangered and Endangered species, or the species themselves.
- Search-and-rescue is important for all development, especially when development may result in the irreversible loss of rare or threatened plant populations. A specialist botanical report must provide recommendations on rescue techniques and CapeNature should endorse the sites to which these plants are translocated. Rehabilitation of rare or threatened plants should not be considered as adequate mitigation for loss of pristine habitat. In the case of sites that will be disturbed by development but later rehabilitated, search-and-rescue should, as a minimum, concentrate on saving bulbs and succulents. 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. In all cases topsoil (upper 150 mm) should be removed before an area is disturbed and replaced after the operational phase. In the case of recently burned sites the seedlings of most shrubs can be rescued by means of retaining soil sods (± 30 cm x 30 cm x 15 cm deep) in trays. Transplantation of rescued plants must take place in autumn (March-April).
- Environmental assessments must preferably be undertaken in spring when the bulk of the annuals and bulbs are flowering, and when the veld is between 4 and 12 years old.
- If development is proposed in degraded examples of this vegetation type, biodiversity offsets should be investigated where equal-sized or larger areas of the same vegetation type are secured for conservation by funding from the developers. These areas should support vegetation of the same or better quality compared to that found on the site.




(top - bottom) BOTANICAL SOCIETY OF SOUTH AFRICA; NICK HELME; BOTANICAL SOCIETY OF SOUTH AFRICA; ANTON WOLFAARDT

(top - bottom) *Newly cleared land encroaches on the interface between renosterveld and mountain fynbos; These koppies support Rûens Silcrete Renosterveld, a Critically Endangered ecosystem; Renosterveld is often associated with specific edaphic or alluvial environments and should be treated with utmost caution in project planning; To be functionally viable, larger renosterveld patches should be within 500m of each other and connected by pollinator-friendly terrain.*



INCORPORATING VYGIEVELD, BROKEN VELD & QUARTZ PATCHES

SUCCULENT KAROO ECOSYSTEMS

SUCCULENT KAROO

Nick Helme

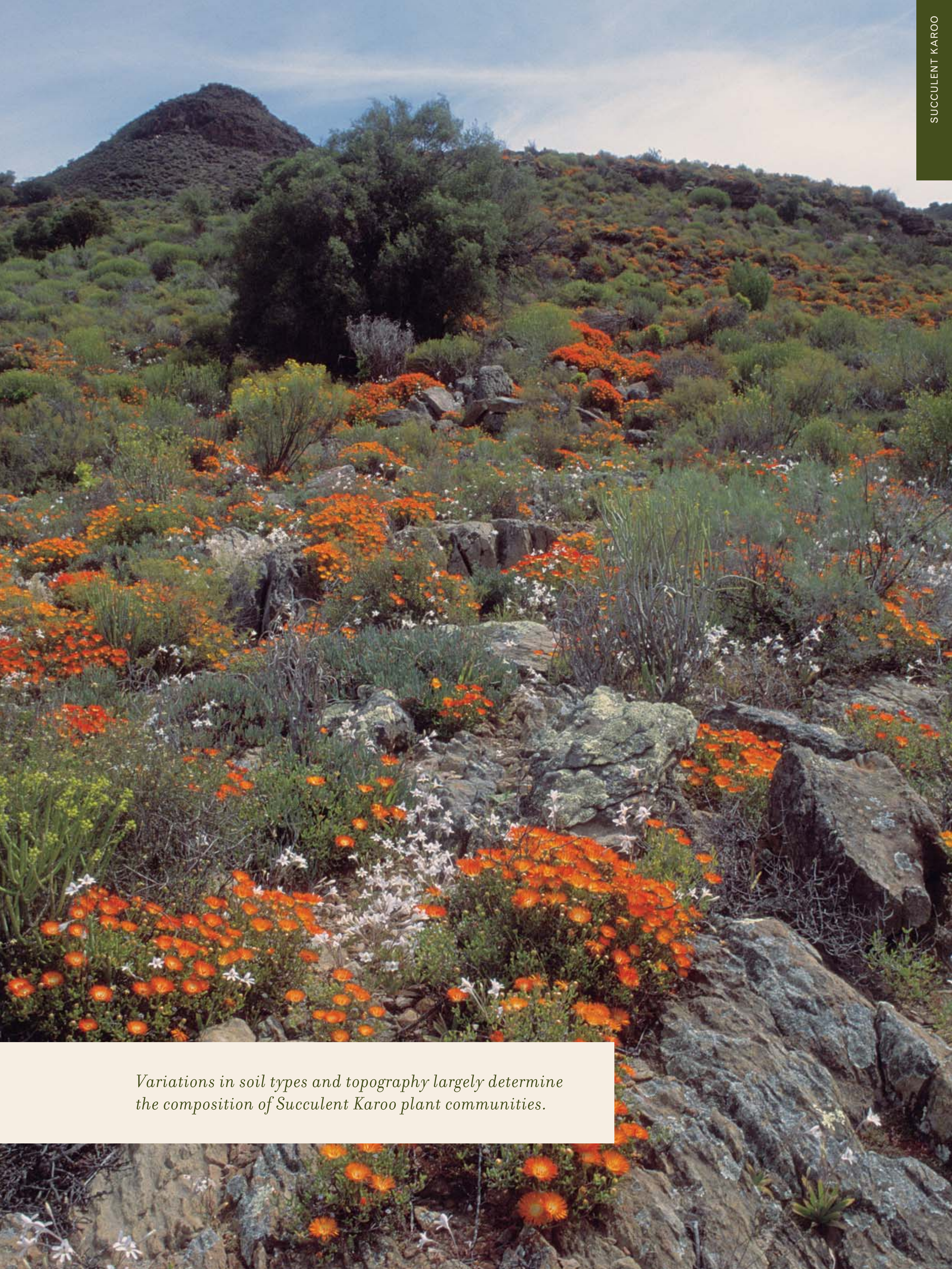
What are the key ecological "drivers" in terms of maintaining ecosystem function, pattern or structure?

- Variations in soil type (such as depth, moisture capacity, rockiness, mineral composition and acidity) largely determine plant community composition and occurrence of rare species. Many of the rare localised species are restricted to distinctive habitats such as quartz patches and rocky outcrops.
- Total rainfall, and rainfall seasonality, have important effects on community structure and diversity. Low but fairly reliable winter rainfall and hot, dry summers characterise the Succulent Karoo. Rainfall ranges from 20 to 290 mm p.a., with more than 40% of precipitation occurring in winter. Seaward-facing slopes and sites that catch the sea fogs are often very rich in localised endemics. Altitudinal gradients and topographic variation are very important in the Richtersveld and Kamiesberg, and along the Namaqualand escarpment.
- Small patches (~1 ha) could be viable for a long time, given that most succulents have very small dispersal distances (often no more than a few metres) and that many habitats (e.g. quartz patches) are naturally < 1 ha in extent.
- Maximum rain water infiltration is vital for plant growth and groundwater availability and its rate is largely determined by plant cover, plant litter and condition of biogenic soil crust (lichens and mosses).
- Termitaria ('heuweltjies') often are an important feature in lower-lying areas with loamy soils. Besides supporting distinctive plant communities, they are important browsing "hotspots" for smaller fauna.
- Grazing, especially by small resident antelope, may be an important factor in regulating competitive interactions between plants.
- Certain species (especially *Pteronia* spp.) act as important "nursery" plants for smaller species. They are also important for successional development after disturbance.
- Tortoises and mammals such as the bat-eared fox are important seed dispersal agents.
- Fires occur in only a few of the wetter Succulent Karoo types and at very low frequencies (> 50 years), but are usually of a very high intensity. Annuals and *Hermannia* species dominate post-fire vegetation and some of them seem to be fire-dependent.

What are the key issues, vulnerabilities and threats?

- Rare species tend to be concentrated in small specific habitats, often in rocky areas, hence their pronounced vulnerability to mining and quarrying.
- Heavy grazing pressure (by both domestic stock and extra-limital game species) and trampling of the biogenic crust are a significant cause of habitat degradation. There are a number of invasive plant species that have infested Succulent Karoo habitats and ecosystems, such as *Nerium oleander* (mostly in watercourses abutting the Fynbos Biome), Mesquite (*Prosopis* spp.) prickly pear (*Opuntia* spp.) and saltbush (*Atriplex* spp.). Watercourses and drainage lines are particularly vulnerable to invasion. Agricultural transformation is a major threat along most of the major river and floodplain systems.

COLIN PATERSON-JONES



Variations in soil types and topography largely determine the composition of Succulent Karoo plant communities.

- Quarrying for granite ("dimension stone") is an increasing problem in the granite areas of Garies, Bitterfontein, Springbok and Pofadder, as is quarrying for gravel in the Saldanha Bay area. Climate change may have a substantial negative effect on many of the localised endemics.
- Certain succulent species are threatened by illegal collection.
- A proliferation of game fences in some areas may threaten faunal migration.

What are the "bottom lines" and non-negotiables?

- Physical disturbance of the vegetation should be limited to the minimum as most Succulent Karoo plant communities recover very slowly, if at all, after heavy grazing or other pressures.
- Grazing by domestic stock and game species should follow recommendations of the Department of Agriculture and CapeNature.
- Abstraction of ground and surface water should be controlled and carefully monitored.
- All concentrations of rare and endemic plant species should be considered as "no go" areas for development. No viable populations of such species should be lost to development.

What broad spatial guidelines can be given with respect to the best approach to development and disturbance?

- Avoid all rocky outcrops, especially by mining or quarrying.
- Avoid quartz patches and ridges, particularly those regarded as being acidic.
- Avoid impacting on any wetland areas or riverine fringes.
- Limit development to disturbed environments such as old lands and heavily overgrazed sites.

What are the critical things to maintain in terms of managing these systems for biodiversity, and ensuring its persistence?

- Avoid disturbance to the biogenic crust and special habitats such as quartz patches. Generally minimise disturbance to 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.
- The presence of rare and endemic species that are reproducing.

(left) Avoid disturbing special habitats such as quartz patches and ridges as they cannot be rehabilitated once disturbed.
(right) Rare species are often associated with specific habitats, such as the quartz patches of the Knersvlakte – a Succulent Karoo "hotspot".

ANTON WOLFAARDT

ANTON WOLFAARDT

ANTON WOLFAARDT

Argyroderma delaetii *is a habitat specialist associated with the quartz patches of the Knersvlakte.*

What, if any, reliable indicators could be used in monitoring ecosystem health, as related to key vulnerabilities?

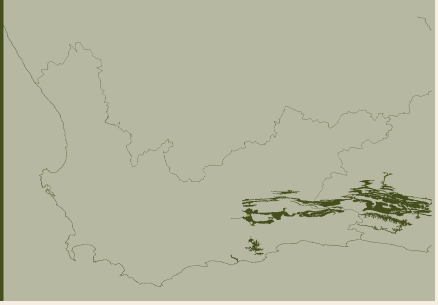
- The presence of palatable species and, especially on 'heuweltjies', absence of invasive plant species.
- The presence of predators and other native mammal species, such as aardvark.
- The presence of unbroken soil crust and lichens.

How reversible are impacts over a 5 – 10-year period?

- Disturbances to the soil will normally take decades to recover in these arid areas, if ever.
- Quartz patches cannot be rehabilitated once disturbed.
- In general, rehabilitation of sensitive habitats cannot be considered effective mitigation for habitat loss.

What are acceptable trade-offs, compensation or off-sets for biodiversity loss?

- Loss of undisturbed natural vegetation must be compensated for by an increase in the extent of statutory conservation areas in selected priority areas. If there is to be development, there should be a net gain for conservation.
- Search-and-rescue is important for all development, especially when development may result in the irreversible loss of rare or threatened plant populations. A specialist botanical report must provide recommendations on rescue techniques and CapeNature should endorse the sites to which these plants are translocated. Rehabilitation of rare or threatened plants should not be considered as adequate mitigation for loss of pristine habitat. In the case of sites that will be disturbed by development but later rehabilitated, search-and-rescue should, as a minimum, concentrate on saving bulbs and succulents. 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. In all cases topsoil (upper 150 mm) should be removed before an area is disturbed and replaced after the operational phase. In the case of recently burned sites the seedlings of most shrubs can be rescued by means of retaining soil sods (± 30 cm x 30 cm x 15 cm deep) in trays. Transplantation of rescued plants must take place in autumn (March-April).



INCORPORATING THICKET, VALLEY THICKET & ARID THICKET

MAINLAND THICKET ECOSYSTEMS

MAINLAND THICKET *Doug Euston-Brown*

What are the key ecological "drivers" in terms of maintaining ecosystem function, pattern or structure?

- Herbivory is an integral part of thicket evolution and therefore function, pattern and structure. Thicket represents the backbone resource for browsing animals in Southern Africa: it is drought tolerant, reliable and enduring. Being further from the savannas and associated animals, thicket in the Western Cape may have been less influenced by herbivory than in the Eastern Cape. However, many animals such as kudu continue to make seasonal east-west migrations to escape winter droughts in the Eastern Cape and summer droughts in the Western Cape.
- Seed dispersal 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.
- Fires are important in maintaining thicket boundaries when they occur in the adjacent grassland and fynbos biomes. Thicket mosaics tend to develop in these boundary areas. Solid or uniform thicket tends to be associated with topographically-determined fire refugia - such as deep kloofs, cliffs and scree - or climatically-determined fire refugia, i.e. areas too arid to support flammable vegetation. Heavy grazing can reduce fuel loads, which can retard the spread of fire and allow the establishment and spread of thicket clumps.
- Climate variability - droughts, floods and heat waves - has little impact on thicket vegetation. Relative to the other biomes in the Western Cape, thicket is probably the most resilient to climate change. Thicket is therefore critically important for the health and persistence of broader ecosystems. Arid Thicket is probably the most resilient to climate change, but is most vulnerable to disturbance resulting from heavy browsing or grazing.
- Winter versus summer rainfall ratios (≥ 20% annual rain in winter, April-August) strongly influence the distribution of thicket. The western limit of Mainland Thicket correlates closely with the transition to a higher proportion of winter rainfall, and dominance by the Fynbos or Succulent Karoo biomes. Coastal Thicket only penetrates inland in the Western Cape where the maritime influence on the climate ameliorates summer drought.
- Topography, geology and soil type also drive the distribution of thicket vegetation. Mainland Thicket in the Western Cape is usually associated with the base of, or valleys within, the Cape Fold Mountains. 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 the Fynbos Biome on the mountains and the Succulent Karoo Biome on the drier hills and flats.

What are the key issues, vulnerabilities and threats?

- Overgrazing, especially by goats, in combination with drought has led to the demise of spekboom *Portulacaria afra*. Spekboom is an essential component of thicket, especially in the Western Cape, where it is often the dominant species at the base of north-facing sandstone slopes. It appears to be a pioneer species that may facilitate the establishment of other thicket species. Once spekboom is lost, many other thicket species also die, and the slope becomes barren and prone to erosion. Such areas do not

JAN VLOK

Spekboom Portulacaria afra *(foreground) is an essential component of Mainland Thicket.*

appear to recover naturally, and are invaded by exotic species or other non-thicket species.

- Over-grazing and wild fires in hot, dry conditions hold a significant threat to thicket. Although thicket is essentially a fire-proof vegetation, overgrazing of the succulent component results in the system being open to the invasion of shrubs and C_4 grasses. Such areas may then become flammable, allowing fires to penetrate vegetation that otherwise never would have been exposed to fire in recent times. This can result in the elimination of many fire-intolerant thicket plants. Fires can also penetrate into Thicket and Valley Thicket in some situations, such as when areas are cleared for stock grazing. The occurrence of alien invasive acacias in fynbos increases the likelihood of fire penetrating thicket vegetation at the fynbos/thicket boundary.

JAN VLOK

Mosaic thicket depends on maintaining a fine balance between grazing and fire.

- The loss of connectivity of thicket patches affects ecosystem function. Historically, thicket was more connected than it is now. Transformation 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.
- Game fences prevent some animal and plant species from migrating, and may ultimately threaten their survival. The introduction of non-indigenous game also presents a threat to thicket vegetation.
- Due to historical transformation of adjacent, non-thicket habitat such as Coast Renosterveld or Dune Thicket may provide the only connectivity between Mainland Thicket types that occur in inland-trending valleys. Coastal development threatens to sever these surviving linkages.

? *What are the "bottom lines" and non-negotiables?*

- Avoid over-grazing in Valley or Arid Thicket - otherwise the system will disappear.
- Avoid the introduction of extra-limital, non-thicket game species.
- Avoid severing or fragmenting patches of intact thicket. Where this has occurred, set aside corridor areas to reconnect the patches.
- Avoid transitional or boundary areas where thicket abuts or forms mosaics with vegetation associated with the adjacent biome. Such areas accommodate the highest levels of biodiversity and require special conservation measures.
- Many of the mosaic thicket vegetation types are maintained by a fine balance between specific fire and grazing regimes. Retain appropriate grazer-browser ratios in game species as well as the required fire regime.
- Avoid disturbance to riparian areas or steep slopes and valleys where thicket vegetation is present.
- Avoid disturbance to rocky outcrops, geological/soil type boundaries and islands where thicket vegetation is present.
- Never underestimate the restoration potential and importance of thicket in areas where it used to occur.

Avoid disturbing transitional areas between thicket and non-thicket vegetation types.

What broad spatial guidelines can be given with respect to the best approach to development and disturbance?

- Prevent further fragmentation of thicket and where possible reconnect thicket. Transformation of thicket habitat should never sever patches or connecting corridors. Corridor areas must be restored to reconnect Mainland Thicket types. Ensure dedicated rehabilitation of corridor areas through disturbed habitat.
- Boundaries between thicket and non-thicket biomes must be maintained.
- Grazing must be carefully monitored and co-ordinated with fire management, alien clearing and other types of land-use planning and management. This is critically important for effective thicket conservation.
- Any area where thicket does or used to occur needs a fire management plan. Alien clearing should also be prioritised. Properties in thicket areas must have uniform fire management guidelines.
- Conservancies and other land management initiatives must be organised to incorporate the natural fire zone, or broader ecosystem or habitat unit for that particular region.
- No surface or ground water abstraction should be allowed if it may impact on thicket vegetation. Groundwater abstraction must also be monitored for impacts on biodiversity and ecosystem function.

What are the critical things to maintain in terms of managing these systems for biodiversity, and ensuring its persistence?

- Maintain all remaining intact fragments across the range of Mainland Thicket to help buffer against climate change.
- Corridors are especially effective for thicket because of bird-dispersed seed and herbivore migration. Rehabilitation of connecting corridors between isolated patches is critical.
- The minimum viable size and isolation of thicket patches, or the structure and maintenance of the mosaic pattern, all require detailed, on-site assessments. Only fine-scaled, detailed analysis of present and past thicket distribution patterns will determine mosaic patterns and minimum viable patch sizes. There must be integrated management of disturbances such as fire, grazing and drought.
- Certain patches of thicket, especially solid, non-mosaic units, require total protection from fire. Fire and alien plant invasions must therefore be managed in the adjacent, non-thicket, ecosystem. Never allow adjacent "fire biomes" to remain unburnt for longer than 30 years, or to become invaded. 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. Farms should be organised into Fire Protection Associations to avoid unnecessary clearance of fire breaks.
- Keep patches and surrounds free of alien vegetation.

What, if any, reliable indicators could be used in monitoring ecosystem health, as related to key vulnerabilities?

- Most of the Arid and Valley Thicket types should have a relatively high cover percentage of spekboom. The absence of spekboom often indicates a transformed state.
- If adult thicket trees die during drought periods, remove all stock and game and implement rehabilitation.
- If fire remains absent in mosaic types for longer than the prescribed period then targeted burning is required.
- If summer rainfall is below average, reduce stock density.
- If thicket clumps coalesce and displace plants of the adjacent biome, ensure that this only happens in prescribed areas where solid thicket once occurred and not in areas where mosaic types are found.

How reversible are impacts over a 5 – 10-year period?

- Where rainfall is higher - closer to the coast or topographically induced - impacts may be reversible, but restoration of thicket is a very slow and costly process. Almost no information is available on thicket restoration techniques or recovery rates.
- In more arid types, impacts such as over-grazing or cultivation are probably irreversible at this time scale.

What are acceptable trade-offs, compensation or off-sets for biodiversity loss?

- Restoration of degraded thicket areas should be a mandatory condition of authorisation for development activity in this threatened ecosystem.
- Trade-offs involving spatial planning and development authorisations should require detailed maps on biodiversity pattern and transformation so that proposals can be carefully assessed in accordance with current conservation targets for thicket.

JAN VLOK

Thicket acts as an ecological buffer between the Fynbos Biome and the Succulent Karoo.

FRESHWATER ECOSYSTEMS: WETLANDS

Liz Day and Nancy Job

INWARD-DRAINING (ENDORHEIC) WETLANDS - *many of these receive water directly from precipitation or groundwater seepage. The category is further divided into permanently and seasonally inundated basins, and includes salt pans and reed and sedge pans*
RIVERINE WETLANDS - *including riparian fringes, seepage lines, floodplains and river source sponge areas*
LACUSTRINE (LAKE-LIKE) WETLANDS - *including coastal lakes, permanent and temporary freshwater pans, blackwater lakelets*
PALUSTRINE WETLANDS - *including seasonal and permanent marshes and swamps, springs, sedge, restio and reedbed marshes and Cape fynbos seasonal wetlands*
ARTIFICIAL WETLANDS - *including dammed or drowned basins within river catchments*
ESTUARINE AND LAGOONAL WETLANDS - *see Guideline 1, Coastal Ecosystems p.24*

? *What are the key ecological "drivers" in terms of maintaining ecosystem function, pattern or structure?*

- Water quantity and flow regime, including surface and groundwater sources.
- Water quality.
- Geology and soil type and structure.
- Biological processes, affecting biotope quality and availability.

? *What are the key challenges affecting management?*

- General lack of knowledge as to how many systems function, their biodiversity and their links to other systems.
- Inadequate implementation of existing laws and policies aimed at protecting wetland resources and ecosystems.
- Integration of social / political and economic imperatives with ecological ones.
- Maintenance of:
  - natural or near-natural hydrological regime - including hydrological linkages throughout the catchment and seasonal or permanent links with groundwater.
  - natural or near-natural water quality.
  - natural erosion and sedimentation processes.
  - function - e.g. water quality amelioration; infiltration; floodwater retention, provision of low flows to downstream users.
  - maintenance of biological connectivity in the catchment and in the broader system - including potential ecological linkages with terrestrial ecosystems (e.g. pollinators, seed dispersers).
  - specific habitat quality and availability (genetic integrity, including biodiversity).
  - maintenance of genetic integrity.
- Co-ordination of management interventions at a catchment scale so as to maximise the potential for achieving and sustaining all of the above objectives.
- Integration of ecological and social objectives, so that improvement to one is not at the expense of the other.

COLIN PATERSON-JONES

Seasonal wetlands represent highly specialised - and vulnerable - habitats in Lowlands Renosterveld.

What are the key issues, vulnerabilities and threats?

- Lack of knowledge of how systems function; their biodiversity and the nature of their links to other systems.
- Infilling/direct loss of aquatic habitats.
- Drainage of wetlands.
- Separation from up- and downstream systems - e.g. source areas, seepage lines, drainage corridors.
- Changes in water table (increases and decreases in level and changes in quality).
- Removal or degradation of indigenous vegetation in the system.
- Catchment hardening (loss of catchment habitat and ability to absorb flows, and increased stormwater runoff), encroachment, fragmentation/loss of corridors.
- Insufficient buffering between existing systems and developments.
- Over-abstraction from:
  - surface water
  - groundwater
- Impoundment, including deliberate transformation of wetland types to fulfil aesthetic or social demands, e.g. changing seasonal wetlands into open water habitat. As a general rule, the drier the wetland type, and the more seasonal it is, the more vulnerable it is to development impacts - particularly so as the drier seasonal wetlands may often be important habitats.
- Introduction to the system of:
  - terrestrial alien and invasive vegetation, including bulrush *Typha capensis*
  - aquatic alien vegetation
  - alien fish and other animals
- Pollution sources affecting water quality and water quantity (e.g. stormwater runoff, discharge from wastewater treatment works).
- Aesthetic degradation (e.g. litter) leading to generalised degradation (e.g. dumping of soil or rubble).
- Emphasis on development that compromises long-term ecosystem functioning.
- Unrealistic expectations, coupled with insufficient knowledge of how wetland systems function, that artificial wetlands can be created to off-set wetlands lost to development.
- Subjective expectations that eclipse knowledge of ecological function: e.g. transformation of seasonal wetlands into open water ponds or "lakes" to fulfil aesthetic, commercial or social imperatives.

BOTANICAL SOCIETY OF SOUTH AFRICA

Wise use of farmland can support wetland conservation in the Western Cape.

What are the "bottom lines" and non-negotiables?

- All wetlands have conservation significance, in terms of habitat type, and/or cumulative or singular functional value.
- Flow regimes must be able to maintain the wetland at its present extent and habitat quality, as well as downstream ecosystems.

- Water quality must be controlled to allow management of wetlands in relation to specific objectives, e.g. some wetlands may be deemed suitable for improving water quality; others would need protection from pollutants to maintain particular habitat quality.
- Hydrological connections between systems should be preserved.
- Existing ecosystem linkages/connectivity must be maintained at an appropriate scale.
- Buffers (i.e. building setbacks, preferably natural vegetation) should:
  - protect wetland systems from specific identified threats, as relevant to each system
  - provide sufficient space to allow for future rehabilitation and buffering of that ecosystem
  - protect the ecosystem health and integrity of receiving ecosystems.

What broad spatial guidelines can be given with respect to the best approach to development and disturbance?

- Wetlands should be delineated prior to planning for development.
- Wetland delineation and assessment should take place during the wet season; the level of confidence attached to wetland identification and delineation in the dry season is very low for all wetlands other than permanent systems.
- Allow adequate buffering of rivers and drainage lines. Ideally, buffer areas should first make allowance for future rehabilitation of the channel - e.g. regrading and reshaping of hardened river banks - and then impose development setbacks from the theoretical edge of the rehabilitated river bank. The City of Cape Town's Floodplain Management Guidelines[1] should be used as broad guidelines for minimum setback areas. Additional evaluation of specific functional requirements of the buffer areas, on a site-specific basis, is needed (e.g. providing an appropriate buffer width for a system receiving treated effluent runoff, versus providing an adequate buffer against noise pollution or alien invasion).
- Spatial depiction of existing or past linkages between wetlands, drainage channels and rivers/streams (these should be maintained or restored wherever possible) is required.
- Small wetland fragments should be linked by areas of open space; existing drainage lines and corridors should be conserved; previously disturbed areas should be used, where ecologically appropriate, for performing "services" such as stormwater treatment, leaving less disturbed areas in a relatively unimpacted, more isolated condition.
- Wetland services usually require a minimum size before they are effective. Note however that multiple small systems may nevertheless have an important cumulative effect.
- Appropriate unhardened terrestrial open space areas should be used as buffers/interfaces between developments and wetlands, performing services such as initial filtration and sedimentation of runoff. The land-use permitted in these areas should be in accordance with this function. The width of these buffer areas should be determined with regard to their required functions. Land-uses that potentially would add nutrients instead of performing a filtering function would be less appropriate, e.g. grazing of livestock, development of feedlots or equestrian areas.

What are the critical things to maintain in terms of managing these systems for biodiversity, and ensuring its persistence?

- Flow regime, including seasonality, water quantity and links to the water table and groundwater system.
- Water quality.
- Plant communities and habitat structure and zonation - invasion by opportunistic plant species can occur rapidly and permanently alter habitat quality and availability. Active management against invasion by opportunistic weeds and other invasive plant species such as bulrush *Typha capensis* and various

1. City of Cape Town (November 2000) *Development Control Guidelines for Flood-prone Areas* - Draft edition. CCT Catchment, Stormwater and River Management, Catchment Management Department, Cape Town.

exotic garden escapees is very important.

- Control over invasion by introduced exotic fish and other alien fauna.
- Habitat availability and accessibility.
- Maintenance of biological and hydrological linkages/connectivity in the catchment and in the broader system.
- Maintenance of genetic integrity and diversity.
- A buffer that protects the wetland habitat and its functions from encroachment and degradation.
- Hydrological connections between systems (surface or groundwater) should not be disrupted (includes the need to manage post-development high flow and low flow runoff volumes).
- Maintenance of a natural level of functions (e.g. water quality amelioration; infiltration; floodwater retention; provision of low flows to downstream systems). Note that even highly impacted wetlands, or wetlands that have been created as a result of human development, may contribute to biodiversity in terms of their functional roles.

? *What, if any, reliable indicators could be used in monitoring ecosystem health, as related to key vulnerabilities?*

- Water quality, particularly nutrient status, pH and conductivity levels.
- Plant community zonation (this is done by mapping the extent of different plant communities in an area, over time; changes in zonation and extent suggest changes in moisture or water quality regime).
- Soil type.

? *How reversible are impacts over a 5 – 10-year period?*

- This depends on the type of wetland - impacted reedbeds are usually easy to replicate or to restore. More complex (and ecologically important) habitats are very difficult to restore; impacts on these wetlands as a result of changes in water quality, water table and groundwater quality are probably irreversible in the medium term.
- Water quality impacts are reversible in the 5 - 10-year period, although they may be associated with long-term, practically irreversible impacts - e.g. domination of the wetland by bulrush *Typha capensis*.
- Invasion by alien species is often reversible if appropriate clearing methods are used; the potential ecological importance of alien-invaded wetlands should not be discounted.

? *What are acceptable trade-offs, compensation or off-sets for biodiversity loss?*

- A wetland system should be conserved if:
  - it has functional value (i.e. performs services such as amelioration of water quality, flood retention, contribution to downstream perenniality)
  - it has conservation value in terms of the plant and/or animal communities that it supports (either on a community or on a species level)
  - it is threatened, rare or sensitive, or a wetland type that is difficult to replace.
- Loss of high quality or ecologically important habitat (even if not specifically valued for its rare or endangered species) should be avoided.
- Weighting of all potential off-sets should be viewed in light of the ecological significance of the affected habitat both locally and within the catchment/broader landscape.
- Requirements for off-sets or compensation are likely to be very case-specific and need to be handled

ANDREW BROWN

Wetland buffers should constitute an outer "ecological" delimitation of the wetland, plus a 30m unhardened area where only low impact land-uses may occur.

on a case-by-case basis. However, requirements generally involve the same key elements, such as area, wetland functions, replacement ratios, monitoring, maintenance, buffers, and permanent protection.

- Habitats that are of ecological significance in their own right should not be sacrificed to provide off-sets against losses of other habitat types.
- Where off-sets are considered, they should be realistically achievable in terms of habitat quality as well as area or volume. Off-sets should also be measurable. A baseline functional assessment should be undertaken, so that gains in area and ecological function can be assessed.
- Off-set areas must include buffers that protect the wetland habitat and its functions from encroachment and degradation. Future land use dictates the size and composition that is necessary for a buffer that protects the wetland and its functioning. When the site for conservation contains large, diverse buffers that provide exceptional habitat, portions of the buffer may be acceptable as part of the off-set area.
- Where large areas of seasonal wetland are highly degraded, and are unlikely to be rehabilitated in the medium term (5-10 years) without the impetus of development, the loss or alteration of small areas of wetland could, in some cases, be considered effectively mitigated by the large-scale rehabilitation of the broader area.
- Usually, the kinds of habitats that give rise to important plant/animal communities cannot be successfully replicated. However, wetland functions can sometimes be replicated in slightly different locations within a development area without severe negative ecological impact. The off-set area should demonstrate a comparable increase in function, and the new "functional" area should ideally still treat water from the same source area that supplied the transformed wetland habitat.
- Rehabilitation that restores the natural hydrologic regime or involves alien clearing that successfully moves a wetland and adjacent habitat into a lower density class might be an acceptable offset for impeding the flow elsewhere (as long as it is still adequate to meet the Ecological Reserve) where transformation cannot be avoided.
- Tradeoffs in buffer width could be considered in response to changes in land use or landscaping of a development that are likely to result in decreased impacts on the wetland system.

INCORPORATING MINOR DRAINAGE LINES TO STREAMS AND LARGE RIVERS, AND EPHEMERAL, SEASONAL AND PERMANENT SYSTEMS

FRESHWATER ECOSYSTEMS: RIVERS

Liz Day and Nancy Job

What are the key ecological "drivers" in terms of maintaining ecosystem function, pattern or structure?

- Water quantity and flow regime - including surface and groundwater sources.
- Water quality.
- Geomorphological processes (erosion and sedimentation).
- Biological processes, affecting biotope quality and availability (e.g. algal abundance).
- Upstream/catchment processes.

What are the key challenges affecting management?

- Maintenance of hydrological regimes and the implementation of effective Instream Flow Requirements (IFR) for river systems. The limitations in terms of accuracy and methodology of the Department of Water Affairs and Forestry's present Ecological Reserve Determination should be clearly understood and reflected in a conservative approach to implementation of any particular reserve.
- Maintenance of natural or near-natural water quality, and improvement of water quality in degraded systems.
- Maintenance of natural (or sustainable, in an altered environment) erosion and sedimentation processes.
- Maintenance of biological and hydrological linkages throughout the catchment and seasonal or permanent links with groundwater and wetlands.
- Maintenance of specific habitat quality and availability.
- Maintenance of genetic integrity (including biodiversity).
- Co-ordination of management interventions at a catchment scale so as to maximise the potential for achieving and sustaining all of the above objectives.
- Integration of ecological and social objectives, so that improvement in one sphere is not at the expense of the other.

What are the key issues, vulnerabilities and threats?

- Catchment hardening (loss of wetlands and natural drainage patterns; loss of natural habitat at a catchment level leading to increased volume and rate of runoff).
- Fragmentation/loss of biological corridors and natural connectivity through *inter alia* diversion and in-filling of riverine wetlands.
- Direct loss of aquatic habitats (including diversion, canalisation and dredging, and loss of associated floodplains) due to encroachment of developments.
- Removal or degradation of indigenous vegetation in the system.
- Over-abstraction from:
  - surface water
  - groundwater
- Impoundment.

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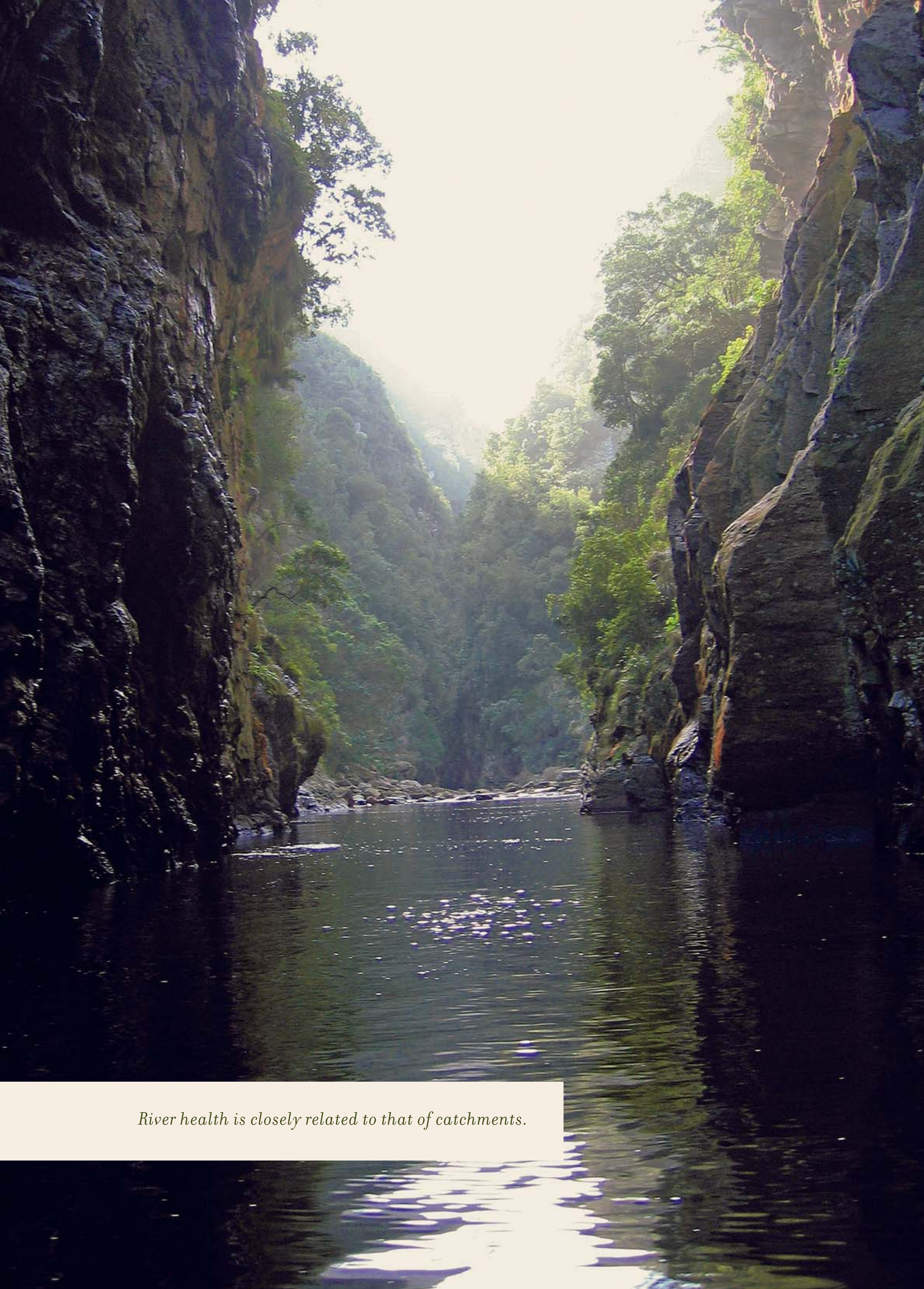

River health is closely related to that of catchments.

- Introduction to the system of:
  - terrestrial alien and invasive vegetation
  - aquatic alien vegetation
  - alien fish and other animals
- Pollution sources affecting water quality - point and non-point sources.
- Pollution sources affecting water quantity (e.g. stormwater runoff; discharge from waste water treatment works).
- Inter-basin transfers.
- Emphasis on development that compromise long-term ecosystem functioning.

What are the "bottom lines" and non-negotiables?

- A flow regime that is adequate to maintain the river at a desired and attainable Management Class.
- Water quality that is adequate to maintain the river at a desired and attainable Management Class.
- Buffers that:
  - are adequate to protect from the threats identified below, as relevant to each system,
  - allow for future rehabilitation, and
  - protect the habitat integrity of the receiving watercourse.
- Maintenance of existing ecosystem linkages/connectivity at an appropriate scale.
- No new concrete canalisation or piping of river channels.

What broad spatial guidelines can be given with respect to the best approach to development and disturbance?

- Allow adequate buffering of rivers and drainage lines. Ideally, buffer areas should first make allowance for future rehabilitation of the channel e.g. regrading and reshaping of hardened river banks - and then impose development setbacks from the theoretical edge of the rehabilitated river bank. The City of Cape Town's Floodplain Management Guidelines[1] should be used as broad guidelines for minimum setback areas. Additional evaluation of specific functional requirements of the buffer areas, on a site-specific basis (e.g. providing an appropriate buffer width for a system receiving treated effluent runoff, versus providing an adequate buffer against noise pollution or alien invasion).
- Spatial depiction of existing or past linkages between wetlands, drainage channels and rivers/streams should be provided, including groundwater information where applicable; these linkages should be maintained where possible, and restored where feasible and ecologically desirable.

What are the critical things to maintain in terms of managing these systems for biodiversity, and ensuring its persistence?

- Flow regime, including seasonality, water quantity and links to the water table and groundwater system.
- Water quality.
- Bank slope and stability.
- Maintenance of natural erosion and sedimentation processes.
- Plant community structure and zonation.
- Habitat availability and accessibility.
- Instream biotope quality and availability.
- Control over invasion by opportunistic weeds and other invasive plant species.
- Control over invasion by introduced exotic fish and other alien fauna.

1. City of Cape Town (November 2000) *Development Control Guidelines for Flood-prone Areas* – Draft edition. CCT Catchment, Stormwater and River Management, Catchment Management Department, Cape Town.

- Maintenance of genetic integrity.
- A buffer that protects river habitat and functions from encroachment and degradation.
- As a minimum, the Ecological Reserve should be maintained in terms of water quantity and quality. Abstraction should be viewed as an issue covering both water quantity and water quality. Reserve Determinations should be dealt with cautiously due to the risk of methodological inaccuracy.
- Maintenance of biological and hydrological linkages/connectivity in the catchment and in the broader system.

What, if any, reliable indicators could be used in monitoring ecosystem health, as related to key vulnerabilities?

- Water chemistry as an indicator of water quality - particularly nutrient status, pH and conductivity levels.
- Algal communities.
- SASS5[2] bioassessments of water quality, using macroinvertebrates. See Chutter (1998)[3] and Dallas (1995)[4] for methodology; scoring system revised for the Western Cape by the River Health Programme.
- Habitat integrity assessments.

How reversible are impacts over a 5 – 10-year period?

- Water quantity impacts 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 fringe 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.
- Water quality impacts are reversible in the 5 - 10-year period, although they may be associated with long-term, practically irreversible impacts e.g. domination of the channel by bulrush *Typha capensis.*
- Invasion by alien plant species is often reversible if appropriate clearing methods are used. Note, however, that the invasion by alien fish and their impacts on indigenous fish populations are very difficult to reverse.

What are acceptable trade-offs, compensation or off-sets for biodiversity loss?

- In terms of the loss of flows, these issues should be viewed in the context of an IFR assessment and the desired Ecological Management Class[5] for the river.
- Weighting of all potential off-sets should be viewed in light of the ecological significance of the affected habitat both locally and within the catchment/broader landscape.
- Where off-sets are considered, they should be realistically achievable in terms of habitat quality as well as area or volume. Off-sets should also be measurable. A baseline functional assessment should be undertaken, so that gains in area and ecological function can be assessed.
- Rehabilitation that restores the natural hydrologic regime or involves alien clearing that successfully moves a water-course and adjacent habitat into a lower density class might be an acceptable offset for impeding the flow elsewhere (as long as it is still adequate to meet the Ecological Reserve) where transformation cannot be avoided.

2. South African Scoring System – a system for the rapid bioassessment of water quality of rivers using invertebrates
3. Chutter FM (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.
4. Dallas HF (1995) An evaluation of SASS (South African Scoring System) as a tool for the rapid bioassessment of water quality. Unpublished MSc Thesis, University of Cape Town.
5. The Present Ecological Status Category for which the river will be managed. Criteria for selecting the River Management Class include (after DWAF 1999):
- The sensitivity of the river to impacts of water use (whether due to ecological sensitivity, or the sensitivity of downstream water users)
- The importance of the resource, in ecological, social/cultural or economic terms
- What can be achieved towards improvement of resource quality, given that some prior impacts or modifications may not be practically reversible due to technical, social or economic constraints.

SPATIAL COMPONENTS OF ECOLOGICAL PROCESSES

Charl de Villiers, Susie Brownlie and Amanda Driver

SYSTEMATIC CONSERVATION PLANS[1] HAVE IDENTIFIED A NUMBER OF SPATIAL SURROGATES FOR LANDSCAPE-SCALE ECOLOGICAL AND EVOLUTIONARY PROCESSES.

These are referred to as "spatial components of ecological processes", i.e. environmental features such as river corridors or vegetation boundaries that are critical for the long-term persistence of biodiversity and can be identified on maps.

This section covers:
1. An overview of spatial components of ecological processes
2. The scale at which spatial components of ecological processes can function
3. Fixed and flexible spatial components of ecological processes
4. Mapped spatial components of ecological processes
5. The conservation of important ecological process areas
6. Environmental assessment procedures for considering spatial components of ecological processes
7. Land-use guidelines for spatial components of ecological processes
8. Background resources

1 *Overview of spatial components of ecological processes*

Biodiversity conservation is guided by two interdependent objectives: representation and persistence.

- "Representation" means securing a representative example of biodiversity composition and structure, or biodiversity pattern.
- "Persistence" is about maintaining those ecological and evolutionary processes that underpin this distribution and variety, without which biodiversity cannot survive in the long term.[2]

It is important to note that the conservation of ecological processes requires a significantly larger proportion of the landscape than is needed to represent biodiversity pattern. However, without conserving sufficient habitat to maintain ecological processes, biodiversity pattern will be lost in the medium to long term.

For example, to ensure representation of 75% of our plant species would need some 16-36% of our landscape; to ensure persistence would require more or less double this area. It is clearly not realistic to aim to secure some 60% of our total landscape in protected areas. However, we must strive to manage natural or semi-natural areas outside formally protected areas in such a way as to allow ecological processes to persist. Fortunately, maintenance of ecological functioning is often consistent with a wide range of low impact land and resource uses.

If biodiversity is to be adequately addressed in project planning and assessment, both biodiversity pattern and ecological processes must be considered by environmental assessment practitioners and

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1. The terms "conservation plan" and "biodiversity plan" are interchangeable, but represent a shift in emphasis from planning that identifies priorities for expanding formal reserve networks to identifying biodiversity features that require special attention in land-use planning and management. 2. The term "ecological and evolutionary processes" is shortened to "ecological processes" in these guidelines.

Undeveloped land in servitudes and road reserves can provide critically important ecological refugia in highly fragmented ecosystems.

Quartz patches can support a wide array of succulents, such as *Gibbaeum pubescens*, *Astroloba* sp. and *Glottiphyllum depressum*.

biodiversity specialists. Limiting an environmental investigation to one or the other means that the full range of potential impacts on biodiversity has not been considered. The findings of such an assessment would be incomplete, which can have negative ramifications for project planning and authorisation.

What complicates matters, though, is that ecological processes are seldom easy to see - take, for example, pollination, seasonal migration or seed dispersal - and can occur with great temporal and spatial variation.

Nevertheless, some ecological processes can be effectively represented by spatial surrogates - mappable environmental features that serve as area-specific substitutes for the actual processes that need to be maintained.

Spatial components of ecological process include physical linkages, boundaries and gradients in the landscape, such as:

- River corridors,
- The interface between different soil types, or between flat areas and slopes, or
- Altitudinal changes in temperature and precipitation.

Spatial components of ecological processes can thus be defined as mappable environmental features that are required to maintain specific ecological processes.

2 How much space do spatial components of ecological processes require?

The Framework for a Conservation Plan for the Cape Floristic Region (Cowling *et al.* 1999) presented a wide range of spatial components of ecological processes that occur at different scales, and require significantly different areas of natural habitat for their persistence. Some examples are given below (see Table 3).

TABLE 3: SCALES AT WHICH ECOLOGICAL PROCESSES MAY FUNCTION

ECOLOGICAL PROCESS	SPATIAL COMPONENTS (NATURAL HABITAT)
Specialist pollinator relationships	*Small (5-1000 ha) fragments*
Regular, whole-patch fires	*Small (ca 500-1000 ha) fragments*
Predator-prey processes involving smaller to larger predators	*Large (50 000-100 000 ha) areas to mega-sized (250 000-1 000 000 ha) areas*
Diversification of plant lineages in relation to macro-climatic and fine-scale geographical gradients	*Large (50 000-100 000 ha) areas that encompass maximal heterogeneity*
Plant herbivore processes involving megaherbivores	*Mega-sized (250 000-1 000 000 ha) areas*
Faunal seasonal migration	*Areas spanning lowland-upland gradients*
Diversification of plant lineages in relation to lowland-upland gradients	*Areas spanning lowland-upland gradients*
Resilience to climate change	*Large and steep climatic gradients along north-south and east-west axes in lowland and upland regions*

3 Fixed and flexible spatial components of ecological processes

Systematic conservation planning recognises two categories of spatial components of ecological processes: those that are spatially fixed, and those that are spatially flexible. Both are described below.

- SPATIALLY FIXED COMPONENTS OF ECOLOGICAL PROCESSES

Spatially fixed components of ecological processes capture processes associated with clearly defined, physical features in the landscape. There are no alternative corridors or vegetation boundaries for accommodating them, so they are unique and require special attention. An example is plant diversification along soil interfaces, which can occur at varying scales. The spatial component (the interface) can consist of a strip just 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 such as those characterised by mosaic thicket types. Vegetation boundaries associated with mosaic vegetation units often contain locally adapted endemic species.

Spatially fixed components of ecological processes include:
- Soil (edaphic) interfaces,
- Upland-lowland interfaces,
- Sand movement corridors, or
- Riverine corridors.

- SPATIALLY FLEXIBLE COMPONENTS OF ECOLOGICAL PROCESSES

Spatially flexible components of ecological processes capture 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 could exist, especially where there are still large tracts of substantially intact habitat.

Spatially flexible components of ecological processes include:
- Upland-lowland gradients, and
- Macro-climatic gradients (east-west and north-south) between upland and lowland 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.

The functions of spatial components of ecological processes can be summarised as:

	SPATIAL COMPONENT	ECOLOGICAL FUNCTION
FIXED	SOIL INTERFACES	*Drive ecological plant diversification*
	ENTIRE SAND MOVEMENT CORRIDORS	*Promote plant species diversification*
	WHOLE RIVERINE CORRIDORS	*Facilitate animal movement and plant dispersal across inland-coastal gradient*
	UPLAND-LOWLAND INTERFACES	*Ecological diversification of plant and animal lineages; support seasonal migration*
FLEXIBLE	UPLAND-LOWLAND GRADIENTS	*Support seasonal movement of animals and local-scale adjustment of plant species distribution to climate change*
	MACRO-CLIMATIC GRADIENTS	*Important for diversification of animal and plant lineages, dispersal events, species distribution adjustment in response to climate change*

4 Which spatial components of ecological processes have been mapped?

For reasons of scale and prioritisation of regional conservation actions, not all spatial components of ecological processes are mapped in biodiversity plans.

In general, only those large-scale ecological processes deemed to be important for achieving biodiversity targets at the broad, biome level have been mapped; numerous ecological corridors or vegetation boundaries that represent more localised but equally important processes at the scale of landscapes and catchments have not been mapped in most biodiversity plans.

Spatial components of ecological processes have been mapped as follows:

- The C.A.P.E. plan mapped selected fixed processes, e.g. edaphic interfaces, sand movement corridors and riverine corridors. Flexible processes, such as upland-lowland gradients and macro-climatic gradients, were mapped by finding the most efficient routes or paths for these gradients through intact natural habitat.
- The STEP Conservation Priority Map captures fixed processes as "Process areas" and flexible processes as "Conservation paths" that provide the core areas for the proposed Mega-conservancy Network.
- The SKEP project mapped a separate layer of fixed processes, which includes quartz and gravel patches, sand movement corridors, and soil interfaces. Flexible processes are shown as arrows representing upland-lowland gradients and climatic gradients.
- The Cape Lowlands Renosterveld Plan mapped a number of ecological processes at 1:50 000 scale, namely soil type transitions, river corridors, upland-lowland gradients, upland-lowland transitions (interfaces) and coast-interior gradients.

Table 4 (see overleaf) summarises the fixed processes recognised by the CAPE and STEP projects and provides some examples of their location. The majority of spatial components of ecological processes can be mapped either as an ecological corridor, or as a boundary between two ecosystems or vegetation types. We suggest that for the purposes of environmental assessment, it may be more useful to think in terms of "ecological corridors and vegetation boundaries" rather than "spatial components of ecological processes", which can be difficult to conceptualise.


BOTANICAL SOCIETY OF SOUTH AFRICA

Spatial components of ecological processes are surrogates for depicting ecological processes such as pollination.

5 The conservation of important ecological corridors and vegetation boundaries

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

- Refer to existing systematic biodiversity plans in order to determine which important fixed or flexible ecological processes have been identified and mapped in the affected area. Where these areas have been mapped, it is essential to ensure that sufficient habitat is set aside and/or managed to support those ecological processes for which each spatial component was identified.

TABLE 4: EXAMPLES OF SPATIAL COMPONENTS OF ECOLOGICAL PROCESSES AND THEIR LOCATION

	TYPE	OBJECTIVES & CHARACTERISTICS	SCALE AT WHICH SPATIAL COMPONENTS OF ECOLOGICAL PROCESSES FUNCTION	EXAMPLES
ECOLOGICAL CORRIDORS	RIVER CORRIDORS	- To maintain migration and exchange between inland and coastal biotas (and also between lowland and upland biotas) by protecting riverine habitats that function as ecological corridors - Riverine corridors in many lowland areas retain some of the last remaining semi-continuous patches of natural vegetation and thus have special significance in terms of providing ecological connectivity between areas - Migration of plant species along riverine corridors has resulted in species diversification - Riverine corridors may also serve as fire refugia. The lower frequency of fire results in a different plant and animal community - Riverine corridors also serve as refugia from drought and have provided refugia for mesic species during major climatic events in the past	- Ecological processes can function at a very wide scale in the case of riverine systems that breach the Cape Fold Belt and link the Karoo basin with the coastal forelands - The scale is reduced with single drainage basins – and even more so with individual tributaries – on the coastal plain	*The Gouritz River corridor (widescale; links Nama Karoo-Succulent Karoo to the Indian Ocean coast)* *Coastal plain section of the Gouritz River (Riversdale Plain)* *Olifants-Doring (links Tankwa Karoo with Sand Fynbos of West Coast forelands)* *Goukou River (links Langeberg mountains to the Indian Ocean coastline)* *Breede River (links Fynbos and Succulent Karoo biomes with coast)* *All rivers that are not irreversibly degraded should be included in biodiversity networks to assist in conserving ecological processes across landscapes*
	SAND MOVEMENT CORRIDORS	- The inland movement of marine sands represents a dynamic process that drives ecosystem functioning and determines biodiversity patterns. - Sand deposits create a complex sequence of sediments of various ages and chemistries associated with unique, soil-specific plant assemblages and diversification of species. - Sediment corridors can also be important links for coastal thicket - Sediment corridors can be important links in the seasonal replenishment of sand for bathing beaches	- The entire system, i.e. from source (input) to core and sink (outgoing) areas and adjacent habitat. These systems are often in the form of headland bypass dunes (i.e. cross a peninsula or headland that cuts across the prevailing wind direction) - Certain dune plumes may be as small as 10 ha, but many cover hundreds or even thousands of hectares - In the STEP planning domain, sand movement corridors were considered functional if less than 50% of each section had been transformed by agriculture and urbanisation. Dense alien stands can 'choke off' the movement of sediments between source and sink areas	*West Coast: Atlantis, south of Langebaan, north of Eland's Bay, extensive areas north of Lambert's Bay* *Cape Peninsula: Hout Bay-Sandy Bay (now largely destroyed), Witsand, Buffels Bay, Strandfontein coastline* *South Coast: Betty's Bay-Hanglip, Walker Bay, Quoin Point, Agulhas, Waenhuiskrans–De Hoop, Gouriqua, Kanon-Vleesbaai, Goukamma, Robberg Peninsula.*
VEGETATION BOUNDARIES	SOIL INTERFACES	- Maintain ecological diversification of plant and animal lineages in response to fine-scale gradients	- For the CAPE conservation planning programme, fine-scale edaphic gradients entailed ca.1 000 ha areas of juxtaposed and strongly contrasting edaphic habitats - These interfaces may be visible on the ground over a few metres, often as a staggered mosaic rather than as a purely linear divide, and are often marked by a change in topography, such as a break of slope	*There are numerous examples, e.g.:* *West Coast: Saldanha Strandveld (limestone or granite) abutting Atlantis, Cape Flats and Leipoldtville Sand Fynbos (acid sands); also between various Renosterveld types (alkaline shales, occasionally granites) and Sand Fynbos and Sandstone Fynbos types (acid sands)* *De Hoop: De Hoop Limestone Fynbos (limestone) and Potberg Sandstone Fynbos (acidic sands) and Rûens Shale Renosterveld (clay)* *Riversdale Plain: Canca Limestone Fynbos (limestone and calcrete), Mossel Bay Shale Renosterveld (clay), and Swellendam Silcrete Fynbos (silcrete) and Albertinia Sands Fynbos (acid sands)*
	UPLAND-LOWLAND INTERFACES AND BIOME BOUNDARIES (THICKET-FYNBOS)	- To maintain ecological diversification of plant and animal lineages. - To support faunal seasonal migration.	- Areas spanning upland-lowland gradients. - In STEP planning domain, identified as a 500 m wide buffer of untransformed habitat along interfaces between solid thicket and vegetation of the adjacent biome - These boundaries can also correspond with ecotones such as between sandstone fynbos-renosterveld-succulent karoo, or shale renosterveld-granite renosterveld-granite fynbos	*Upland-lowland vegetation boundaries, e.g.:* *Coastal plain/coastal mountain range (e.g. Riversdale Plain-Langeberg)* *Coastal range/interior basins (e.g. Langeberg-Little Karoo)* *Inland range/interior basins (e.g. Klein Swartberg-Moordenaarskaroo* *Inland range/Karoo basin (e.g. Roggeveld-Great Karoo)* *Biome boundaries: Interface of solid thicket and fynbos, grassland, succulent karoo or Nama karoo biomes.*

- Look for obvious landscape features that may serve as ecological corridors or vegetation boundaries (e.g. watercourses, ridges or juxtaposed soil types). Aim to accommodate such corridors or vegetation boundaries in development plans, and manage them soundly to ensure their persistence.
- Look for opportunities to:
  - secure topographical and habitat linkages both between and within different ecosystems, vegetation types and ecological communities;
  - accommodate these corridors and vegetation boundaries within a spatial plan or project proposal;
  - minimize fragmentation of natural habitat - in general, small isolated patches of natural habitat are much less able to support ecological functioning than larger areas of natural habitat that remain connected to each other.
- Refer to the relevant ecosystem guidelines and determine what the "drivers" of the systems are (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 spatial components of ecological processes would be 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;
- Setting targets for the conservation of habitat within spatial components of ecological processes that have been mapped;
- Explicit incorporation of mapped corridors and vegetation boundaries in Spatial Development Frameworks;
- Integrating biodiversity priorities, including spatial components of ecological processes, in LandCare Area Wide Planning; and, where appropriate,
- Assigning appropriate management status to ecological corridors and/or vegetation boundaries (e.g. through stewardship agreements or proclamation as Protected Environments).

To this end, guidance is given on environmental assessment procedures for working in spatial components of ecological processes, and land-use guidelines for development within ecological corridors and vegetation boundaries.

6 *Environmental assessment procedures for working in spatial components of ecological processes*

As a broad yardstick for ensuring an appropriate approach, and level of rigour, for environmental assessment in spatial components of ecological processes, it is suggested that:

- Further loss of habitat within mapped spatial components of ecological processes should be avoided.
- Where irreversible loss of habitat cannot be avoided or mitigated, off-sets should emphasised.
- Generally, think in terms of functional networks: where there are clear opportunities in the natural landscape for linking fragments of the same ecosystem, 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 have limited value to biodiversity conservation.
- Consult the relevant ecosystem guidelines for the pattern and functional requirements of specific

ecosystems (e.g. Granite Fynbos, Limestone Fynbos-Sand Fynbos mosaics or wetlands) when undertaking environmental assessments for projects that may impact on spatial components of ecological processes.

- Prioritise restoration and alien clearance in degraded habitat linkages that would otherwise be lost if neglected.
- Attempt to align transformed areas "with the grain" of the ecological corridor or vegetation boundary that is being conserved, i.e. avoid severing habitat linkages in ecological corridors or destroying indigenous vegetation along the entire front of a soil interface.
- Where there are obvious vegetation boundaries which reflect soil interfaces, upland-lowland interfaces or, in the Thicket Biome, solid thicket-non thicket boundaries, these interfaces should be maintained and accommodated within a spatial plan or project proposal.
- Similarly, riverine corridors and sand movement corridors should be buffered, conserved and accommodated within a spatial plan or project proposal.
- Consult CapeNature for input into environmental assessments or biodiversity studies in spatial components of ecological processes.

JAN VLOK

Aim to accommodate vegetation boundaries and ecological corridors within projects.

7 *Land-use guidelines for spatial components of ecological processes*

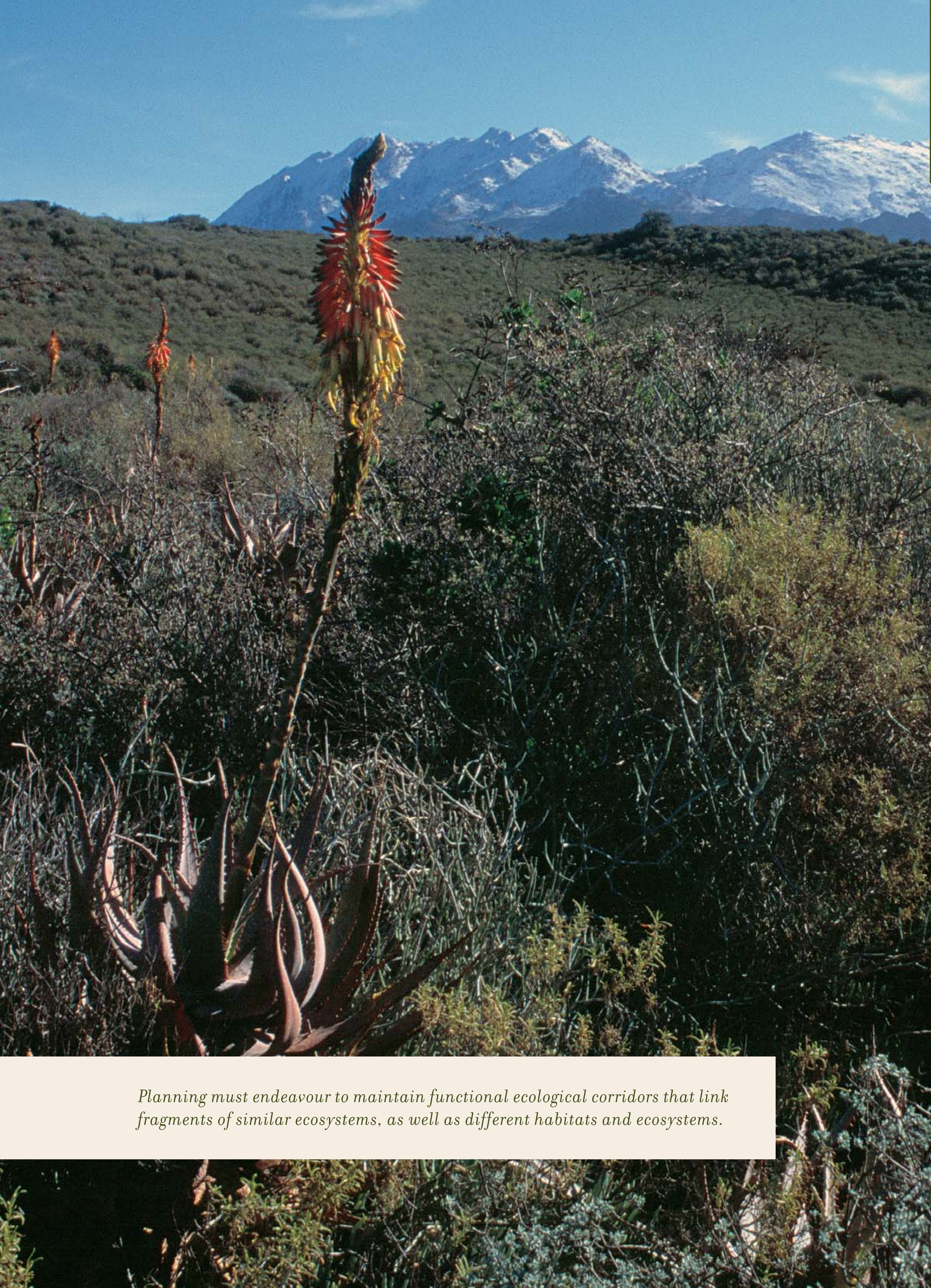
The following low-intensity land-uses may, subject to the appropriate biodiversity assessments and environmental management, be compatible with maintaining healthily functioning ecological corridors and vegetation boundaries:

- Biodiversity conservation
- Recreational infrastructure (hiking, mountain biking, horse trails, 4X4 tracks)
- Game farming
- Grazing
- Ecologically sustainable harvesting of natural vegetation
- Cultivation that avoids irreversible impairment of ecosystem functioning (e.g. strip cultivation rather than centre-pivot irrigation).

Sprawling urban and township development and resorts should be discouraged, especially alienation of land units through any form of subdivision, sectional title, share block or similar schemes.

CONSULT THE RELEVANT ECOSYSTEM GUIDELINES FOR MORE DETAILED RECOMMENDATIONS ABOUT DEVELOPMENT PLANNING IN SPECIFIC ECOSYSTEMS

COLIN PATERSON-JONES



Planning must endeavour to maintain functional ecological corridors that link fragments of similar ecosystems, as well as different habitats and ecosystems.

REFERENCES & RESOURCES

There is a wealth of scientific and other information about the ecology and management of ecosystems in the Western Cape, far too much to be listed here.

References cited in these guidelines are presented below, as well as a number of suggested readings and websites that can serve as useful points of departure for contextualising, and understanding the complexity and conservation requirements of, biodiversity in the Western Cape.

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www.zoo.upe.ac.za *(TERU, STEP)*
http://bgis.sanbi.org *(SA National Biodiversity Institute GIS Unit)*
http://www.capegateway.gov.za/eng/your_gov/406
(Department of Environmental Affairs and Development Planning provincial EIA guidelines)
http://www.capenature.co.za/index.php?fSectionId=37
(CapeNature Scientific Services - Western Cape State of Biodiversity reports)
http://www.biodiv.org/programmes/socio-eco/impact/search.aspx *(Convention on Biological Diversity)*

APPENDIX 1

SOUTH AFRICAN VEGETATION TYPES GROUPED ACCORDING TO ECOSYSTEMS DEALT WITH IN THESE GUIDELINES

COASTAL ECOSYSTEMS

Arid Estuarine Salt Marshes	VU
Blombos Sand Strandveld	LT
Cape Coastal Lagoons	N/A
Cape Estuarine Saltmarshes	VU
Cape Flats Dune Strandveld	EN
Cape Seashore Vegetation	LT
Groot Brak Dune Strandveld	EN
Lambert's Bay Strandveld	VU
Langebaan Dune Strandveld	VU
Namaqualand Seashore Vegetation	LT
Namaqualand Strandveld	LT
Overberg Dune Strandveld	LT
Saldanha Flats Strandveld	EN
Saldanha Granite Strandveld	EN
Saldanha Limestone Strandveld	EN
Southern Cape Dune Fynbos	LT
Southern Coastal Forest	LT

LOWLAND FYNBOS ECOSYSTEMS

Agulhas Limestone Fynbos	LT
Agulhas Sand Fynbos	VU
Albertinia Sand Fynbos	VU
Atlantis Sand Fynbos	EN
Breede Sand Fynbos	EN
Canca Limestone Fynbos	LT
Cape Flats Sand Fynbos	CR
Cape Lowland Alluvial Vegetation	CR
Cape Lowland Freshwater Wetlands	VU
Cape Vernal Pools	CR
De Hoop Limestone Fynbos	LT
Elim Ferricrete Fynbos	EN
Freshwater Lakes	N/A
Hangklip Sand Fynbos	VU
Hopefield Sand Fynbos	EN
Kynsna Sand Fynbos	EN
Leipoldtville Sand Fynbos	EN
Namaqualand Sand Fynbos	LT
Southern Coastal Forest	LT

MIDLAND-UPLAND FYNBOS ECOSYSTEMS

Bokkeveld Sandstone Fynbos	LT
Boland Granite Fynbos	EN
Breede Alluvium Fynbos	EN
Cape Inland Salt Pans	EN
Cape Winelands Shale Fynbos	EN
Cederberg Sandstone Fynbos	LT
Central Coastal Shale Band Vegetation	LT
Central Inland Shale Band Vegetation	LT
Breede Quartzite Fynbos	LT
Breede Shale Fynbos	VU
Ceres Alluvium Fynbos	EN
Eastern Coastal Shale Band Vegetation	EN
Eastern Inland Shale Band Vegetation	LT
Elgin Shale Fynbos	CR
Garden Route Granite Fynbos	EN
Garden Route Shale Fynbos	EN
Greyton Shale Fynbos	VU
Graafwater Sandstone Fynbos	VU
Grootrivier Quartzite Fynbos	LT
Haweqas Sandstone Fynbos	LT
Kamiesberg Mountains Shrubland	LT
Kango Conglomerate Fynbos	LT
Klawer Sandy Shrubland	LT
Kogelberg Sandstone Fynbos	LT
Kouebokkeveld Shale Fynbos	EN
Kouga Sandstone Fynbos	LT
Loerie Conglomerate Fynbos	LT
Lourensford Alluvium Fynbos	CR
Matjiesfontein Quartzite Fynbos	LT
Matjiesfontein Shale Fynbos	LT
Montagu Shale Fynbos	LT
North Hex Sandstone Fynbos	LT
North Kammanassie Sandstone Fynbos	LT
North Langeberg Sandstone Fynbos	LT
North Outeniqua Sandstone Fynbos	LT
North Rooiberg Sandstone Fynbos	LT
North Sonderend Sandstone Fynbos	LT
North Swartberg Sandstone Fynbos	LT
Northern Shale Band Vegetation	LT
Olifants Sandstone Fynbos	LT
Overberg Sandstone Fynbos	LT
Peninsula Granite Fynbos	EN
Peninsula Sandstone Fynbos	LT
Piketberg Sandstone Fynbos	LT
Potberg Ferricrete Fynbos	EN
Potberg Sandstone Fynbos	LT
Robertson Granite Fynbos	LT
South Hex Sandstone Fynbos	LT
South Kammanassie Sandstone Fynbos	LT
South Langeberg Sandstone Fynbos	LT
South Outeniqua Sandstone Fynbos	VU
South Rooiberg Sandstone Fynbos	LT
South Sonderend Sandstone Fynbos	LT
South Swartberg Sandstone Fynbos	LT
Southern Afrotemperate Forest	LT
Swartberg Altimontane Sandstone Fynbos	LT
Swartberg Shale Fynbos	LT
Swartland Alluvium Fynbos	CR
Swartruggens Quartzite Fynbos	LT
Swellendam Silcrete Fynbos	EN
Tsitsikamma Sandstone Fynbos	VU
Western Altimontane Sandstone Fynbos	LT
Western Coastal Shale Band Vegetation	LT
Winterhoek Sandstone Fynbos	LT

RENOSTERVELD ECOSYSTEMS

Baviaanskloof Shale Renosterveld	LT
Breede Alluvium Renosterveld	EN
Breede Shale Renosterveld	VU
Cape Vernal Pools	CR
Central Mountain Shale Renosterveld	LT
Central Rûens Shale Renosterveld	CR
Ceres Shale Renosterveld	VU
Eastern Rûens Shale Renosterveld	CR
Humansdorp Shale Renosterveld	EN
Kango Renosterveld	LT
Langkloof Shale Renosterveld	EN
Matjiesfontein Shale Renosterveld	LT
Montagu Shale Renosterveld	LT
Mossel Bay Shale Renosterveld	EN
Namaqualand Granite Renosterveld	LT
Nieuwoudtville Shale Renosterveld	EN
Nieuwoudtville-Roggeveld Dolerite Bulb Veld	LT
Peninsula Shale Renosterveld	CR
Robertson Granite Renosterveld	LT
Roggeveld Shale Renosterveld	LT
Rûens Silcrete Renosterveld	CR
Swartberg Shale Renosterveld	LT
Swartland Alluvium Renosterveld	EN
Swartland Shale Renosterveld	CR
Swartland Silcrete Renosterveld	CR
Uniondale Shale Renosterveld	LT
Vanrhynsdorp Shale Renosterveld	LT
Western Rûens Shale Renosterveld	CR
Swartland Granite Renosterveld	CR
Hantam Plateau Dolerite Bulb Veld	LT

SUCCULENT KAROO ECOSYSTEMS

Agter-Sederberg Succulent Shrubland	LT
Central Knersvlakte Vygieveld	LT
Citrusdal Vygieveld	VU
Doringrivier Succulent Karoo	LT
Eastern Little Karoo	LT
Hantam Karoo	LT
Kamiesberg Mountains Shrubland	LT
Knersvlakte Dolomite Vygieveld	LT
Knersvlakte Quartz Vygieveld	LT
Knersvlakte Shale Vygieveld	LT
Koedoesberg-Moordenaars Succulent Karoo	LT
Little Karoo Quartz Vygieveld	LT
Muscadel Alluvial Vegetation	EN
Namaqualand Arid Grassland	LT
Namaqua Heuweltjieveld	LT
Namaqualand Blomveld	LT
Namaqualand Inland Duneveld	LT
Namaqua Klipkoppe Shrubland	LT
Namaqualand Riviere	LT
Namaqualand Spinescent Grassland	LT
Northern Knersvlakte Vygieveld	LT
Platbakkies Succulent Shrubland	LT
Prince Albert Succulent Karoo	LT
Robertson Karoo	LT
Roggeveld Karoo	LT
Rooiberg Quartz Vygieveld	LT
Rosyntjieberge Mountain Succulent Shrubland	LT
Swartruggens Sandstone Karoo	LT
Tanqua Escarpment Succulent Shrubland	LT
Tanqua Karoo	LT
Tanqua Riviere	LT
Vanrhynsdorp Gannabosveld	VU
Western Gwarrieveld	LT
Western Little Karoo	LT
Piketberg Quartz Succulent Shrubland	CR

THICKET ECOSYSTEMS

Gamka Thicket	LT
Groot Thicket	LT
Eastern Gwarrieveld	LT

APPENDIX 2

RECOMMENDED TERMS OF REFERENCE FOR THE CONSIDERATION OF BIODIVERSITY IN ENVIRONMENTAL ASSESSMENT AND DECISION-MAKING

Botanical Society of SA Conservation Unit, Private Bag X10, Claremont, 7735
Tel: 27-21-799-8824 Fax: 27-21-761-5983
Inquiries: Paisley@botanicalsociety.org.za

1. Provide a general overview of the affected area in terms of connectivity, corridors, and ecological viability of the affected area.

2. In terms of biodiversity pattern, identify or describe:

2.1 Community and ecosystem level

a. The main vegetation type[1], its aerial extent and interaction with neighbouring types, soils or topography.
b. The types of plant communities that occur in the vicinity of the site.
c. Threatened or vulnerable ecosystems (cf. new SA vegetation map/National Spatial Biodiversity Assessment[2], conservation plans http://cpu.uwc.ac.za, WCNCB State of Biodiversity Report.http://www.capenature.org.za).
d. The types of animal communities (fish, invertebrates, avian, mammals, reptiles, etc).

2.2 Species level

a. Red Data Book species (give location, if possible using GPS).
b. The viability of and estimated population size of the RDB species that are present (include the degree of confidence in prediction based on availablitiy of information and specialist knowledge, i.e. High=70-100% confident, Medium 40-70% confident, low 0-40% confident).
c. The likelihood of other RDB species, or species of conservation concern, occurring in the vicinity (include degree of confidence).

2.3 Other pattern issues

a. Any significant landscape features or rare or important vegetation/faunal associations such as seasonal wetlands, alluvium, seeps, quartz patches or salt marshes in the vicinity.
b. The extent of alien plant cover of the site, and whether the infestation is the result of prior soil disturbance such as ploughing or quarrying (alien cover resulting from disturbance is generally more difficult to restore than infestation of undisturbed sites).
c. The condition of the site in terms of current or previous land uses.

1. Mucina L, Rutherford MC and Powrie LW (eds)(2004) *Vegetation map of South Africa, Lesotho and Swaziland*: Shapefiles of basic "mapping units". Beta version 4.0, February 2004, National Botanical Institute, Cape Town. Obtainable from SA National Biodiversity Institute, Ph (021) 799 8800 or parenzee@sanbi.org. Conditions apply.
2. <ftp://ftp.nbi.ac.za> Go to "Incoming", go to "NSBA Vol 1 Terrestrial Component Oct 04 Appendix A&B.pdf"

3. In terms of biodiversity process, identify or describe:

a. The key ecological "drivers" of ecosystems on the site and in the vicinity, such as fire.

b. Any spatial component of an ecological process that may occur at the site or in its vicinity (i.e. corridors such as watercourses, upland-lowland gradients, migration routes, coastal linkages or inland-trending dunes, and vegetation boundaries such as edaphic interfaces, upland-lowland interfaces or biome boundaries).

c. Any possible changes in key processes, e.g. increased fire frequency or drainage/artificial recharge of aquatic systems.

d. The condition and functioning of rivers and wetlands (if present) in terms of: possible changes to the channel, flow regime (surface and groundwater) and naturally-occurring riparian vegetation.

e. Would the conservation of the site lead to greater viability of the adjacent ecosystem by securing any of the functional factors listed in (1)?

4. Would the site or neighbouring properties potentially contribute to meeting regional conservation targets for both biodiversity pattern and ecological processes?

For information on conservation and biodiversity targets, contact the SANBI B-GIS Unit, <BGISHelp@sanbi.org> or http://bgis.sanbi.org or the CapeNature Land Use Advisory Unit, Ph (021) 866-8000.

5. Is this a potential candidate site for conservation stewardship?

Contact CapeNature at Ph (028) 314-0173 for information on the stewardship programme.

6. What is the significance of the potential impact of the proposed project, alternatives and related activities - with and without mitigation - on biodiversity pattern and process (including spatial components of ecological processes) at the site, landscape and regional scales?

7. Indicate on a topographical map or orthomap (preferably at a scale ≥ 1:10 000):

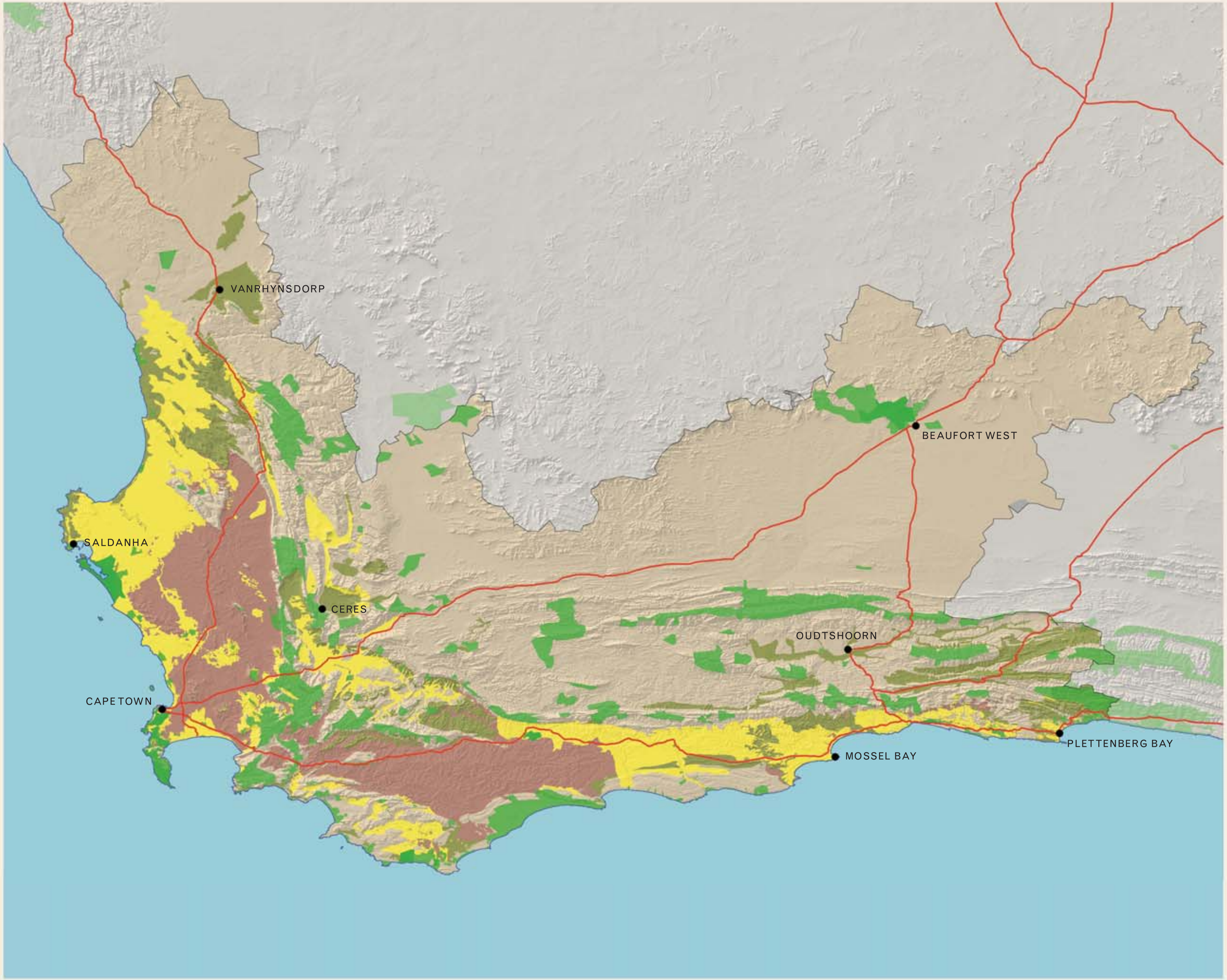
- The area that would be impacted by the proposed development;
- The location of vegetation, habitat and spatial components of ecological processes that should not be developed or otherwise transformed; and
- Areas, including the site and surrounds, that must remain intact as corridors or ecological "stepping stones" to maintain ecosystem functioning, including fires in fire-prone systems.

8. Recommend actions that should be taken to prevent or, if prevention is not feasible, to mitigate impacts and restore disturbed vegetation or ecological processes. Indicate how preventative and remedial actions will be scheduled to ensure long-term protection, management and restoration of affected ecosystems and biodiversity.

9. Indicate limitations and assumptions, particularly in relation to seasonality.

10. Indicate how biodiversity considerations have been used to inform socio-economic aspects of the proposed project, e.g. through changes to the location or layout of infrastructure, or retaining public access to biodiversity-related amenities or resources such as beaches or grazing.

ECOSYSTEM STATUS FOR THE WESTERN CAPE



MARCH 2007

30 Kilometers

Biodiversity G I S

LEGEND

ECOSYSTEM STATUS

- CRITICALLY ENDANGERED
- ENDANGERED
- VULNERABLE
- LEAST THREATENED
- PROTECTED AREAS
- ROADS

SOUTH AFRICAN national biodiversity institute SANBI

CAPE ACTION FOR PEOPLE AND THE ENVIRONMENT C.A.P.E

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