

Grassland Ecosystem Guidelines

Landscape interpretation for planners and managers



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Landscape interpretation for planners and managers

Compiled by

Mandy Cadman, Charl de Villiers, Richard Lechmere-Oertel and Douglas McCulloch





This publication is
dedicated to the
memory of
Dr Rob Scott-Shaw,
whose knowledge of
grassland ecology
was an inspiration
to all.

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Preface



By Charl de Villiers

Much of the current conservation effort in South Africa's grasslands is focused on promoting land-use practices that reconcile development opportunities and spatial planning at a landscape scale with the over-arching goal of maintaining and increasing the resilience of ecosystems, especially in the face of climate change. This landscape approach involves working within and beyond the boundaries of protected areas to manage and mainstream biodiversity within a mosaic of land-uses.

A great deal of this effort needs to take place on privately or communally-owned land. This land may represent our main opportunity to ensure ecologically viable 'living landscapes' that can provide crucial services such as water provision, while being sufficiently robust to withstand the anticipated pressures and shocks of climate change. Therefore, even though such land does not form part of formally proclaimed national parks or nature reserves, it can – literally – be of irreplaceable importance for biodiversity and should be managed accordingly.

In practice, this means that people who do not necessarily have a background in biodiversity conservation are increasingly being called upon to manage land, plan for development, and make decisions with biodiversity in mind. Crucially, individuals and institutions who find themselves in this re-cast role as co-custodians of grassland biodiversity have to be equipped with reliable information. This information must be relevant to the decisions that they need to take in order to ensure that biodiversity is sufficiently considered – and safeguarded – in their plans and activities. These ecosystem guidelines were conceived precisely with this end in mind, namely, to provide a consistent benchmark and framework for addressing the biodiversity-related aspects of land-use planning, management and regulation in South Africa's grasslands. Until now, there has been no single document that brings the current state of knowledge about grasslands together, with the specific aim of providing non-scientists with easy-to-use, practical guidelines on how to take better account of biodiversity in land-use planning and decision-making. Envisaged users include land managers in the livestock, wool and game sectors, engaged environmental assessment practitioners and biodiversity specialists, agricultural extension officers, and officials responsible for land-use planning and regulation in the grasslands.

Experience has shown that ecosystem guidelines can be useful aids to inform development planning and land-use management when used in conjunction with systematic biodiversity plans and when formally built into the terms of reference for environmental assessments or municipal spatial planning projects. This is aided by training in the use of ecosystem guidelines in conjunction with related products and for application in different contexts (e.g. applications for mining rights or environmental authorisations, drafting a biodiversity-compatible grazing management plan, or developing an environmental management framework). The South African National Biodiversity Institute, the Departments of Environmental Affairs and Water Affairs, provincial environmental and agricultural departments, professional associations and institutions of higher learning represent some of the key roleplayers who can contribute to such training and capacity building.



In summary, ecosystem guidelines such as these for the grasslands are a key operational component in any 'mainstreaming' strategy which rests on the three pillars of:

- Enabling policies and institutions across sectors to address biodiversity in an integrated way.
- Providing accessible information about and interpretations of biodiversity priorities (e.g. Ecosystem Guidelines that interpret and guide use of knowledge in support of sustainable development).
- Assisting institutions and individuals throughout the value-chains of land-use and environmental planning and regulation, to integrate biodiversity meaningfully into their work.

The value of these ecosystem guidelines as a resource for promoting wise utilisation and conservation of grassland ecosystems will gradually become evident with time, and as the reputation of the guidelines grows, stimulating ever-wider use of the product and demands for training.

All those who are dedicated to the goals of sustainable development in the grasslands are encouraged to record their experiences of using these guidelines and to share this experience with SANBI and its partners. So doing, the grasslands implementation community should contribute to an ever-improving, increasingly effective integration of 'mainstreaming' theory and practice in support of securing ecosystem resilience and the inter-generational persistence of an exceedingly valuable component of South Africa's natural estate.

Box 1. The Grasslands Programme: conserving a working landscape

These Ecosystem Guidelines are part of a larger focus of work in grassland ecosystems, coordinated under the SANBI Grasslands Programme. The SANBI Grasslands Programme is a 20-year initiative to mainstream biodiversity into production practices in grasslands, thereby balancing biodiversity conservation and economic development imperatives in a landscape. Mainstreaming biodiversity means "incorporating biodiversity priorities into the policies, decisions and actions of a diverse range of people and organisations in various sectors" to increase awareness, minimise impact and mitigate risks to biodiversity and the ecosystem services that it supports. A large part of the Programme was made possible through an investment from the United Nations Development (UNDP) and the Global Environment Facility (GEF), with SANBI as the implementing agent. However, the Programme relies on multi-sector partnerships between government, business and civil society to mainstream biodiversity objectives into the major production sectors that operate in the Grasslands Biome, including agriculture, forestry, coal mining, and urban economies, as well as into the enabling environment.

The Grasslands Programme seeks to find solutions in which economic development is sustained by the ecological services provided by a healthy and well managed Grassland Biome. These Ecosystem Guidelines are part of a broader programme of action which has been put in place by the Grasslands Programme to respond to this challenge.

Contents



1	Introduction	1
1.1.	Grassland- a biodiversity asset underpinning South Africa's economy	2
1.2.	Grasslands under pressure	3
1.3.	Finding practical solutions- ecosystem guidelines for working in grassland landscapes	4



2	Grassland ecosystems and ecology	9
2.1.	Ecosystems, ecological infrastructure and ecosystem services	10
2.2.	Taking an ecosystem approach to planning and decision-making	11
2.3.	Grassland Ecosystems in South Africa	13



3	Planning a mosaic of land-uses in grassland ecosystems	17
3.1.	The landscape approach to conserving biodiversity in working landscapes	18
3.2.	Impacts on grasslands	18
3.3.	Approaches to planning in grasslands	19
3.4.	Taking a proactive approach in environmental assessment	24



4	Key issues in grassland management	25
4.1	Notes on fire	26
4.2	Notes on grazing	27
4.3	Notes on soil erosion	30
4.4	Notes on invasive alien species	32



5 Ecosystem Guidelines for Grasslands 33

5.1	Guidelines that apply to all grasslands	34
5.2	Dry Highveld Grassland	52
5.3	Mesic Highveld Grassland	58
5.4	High-Altitude Grassland	64
5.5	Sub-Escarpment Grassland	72
5.6	Coastal Grassland	78



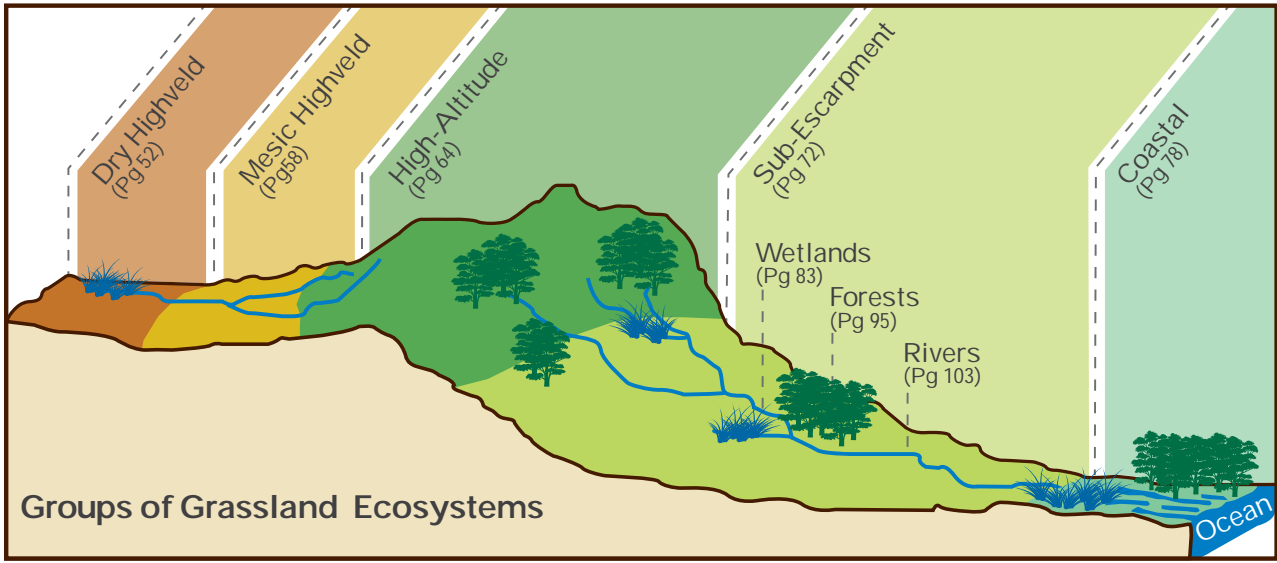
6 Ecosystem Guidelines for Wetlands 83



7 Ecosystem Guidelines for River Ecosystems 95



8 Ecosystem Guidelines for Forests 103





9	Useful Resources	109
9.1.	Glossary of Terms	110
9.2.	Grassland vegetation types and ecosystem threat status	117
9.3.	Proactive incorporation of biodiversity into pre-application screening	122
9.4.	Basic Terms of References for Biodiversity Assessment	135
9.5.	References and useful websites	137

Boxes, figures and tables

Boxes		
Box 1.	The Grasslands Programme: Conserving a working landscape	v
Box 2.	Grasslands at a glance	3
Box 3.	Grasslands and water	5
Box 4.	Broad categories of impacts on biodiversity	19
Box 5.	Principles of systematic biodiversity planning	21
Box 6.	Important systematic biodiversity planning products	23
Box 7.	What is ecosystem health and how can it be assessed?	39
Box 8.	Factors to be included in a fire management plan	40
Box 9.	Principles of the best practice for clearing invasive alien plants	44
Box 10.	WET-Health	89
Box 11.	Defining spatial biodiversity priority areas	116
Box 12.	The principle of 'no net loss' and biodiversity offsets	124
Box 13.	Economising biodiversity's slice of the landscape	125
Box 14.	Critical Biodiversity Area Maps, Bioregional Plans and Biodiversity Sector Plans	126
Box 15.	The Implimentation Manual for Freshwater Ecosystem Priority Areas	128
Box 16.	Frequently asked questions about CBA maps	132

Figures		
Figure 1.	Map showing the nine biomes of South Africa	2
Figure 2.	Summary of biodiversity mainstreaming tools available to assist planners and decision-makers working in grasslands	7
Figure 3.	Components of functioning ecosystems	10
Figure 4.	Landscape example of some ecosystem services provided by grasslands	11
Figure 5.	Ecosystem resilience and thresholds of change	12
Figure 6.	Map of South Africa showing location of five groups of grassland ecosystems	13
Figure 7.	Location of grassland ecosystems in a profile of the South African landscape	15
Figure 8.	The mitigation hierarchy for dealing with negative impacts on biodiversity	20
Figure 9.	Thresholds used to assess ecosystem threat status	22
Figure 10.	Illustration of some indicators that can be used to assess how effectively grassland biodiversity and associated ecosystem processes are being managed and conserved.	49
Figure 11.	Schematic drawing showing how the seven hydro-geomorphic classes of wetland relate to landscape setting	85
Figure 12.	Schematic drawing showing slope categories for rivers, one of three factors used to define river ecosystem types	96

Tables		
Table 1.	Vegetation Types and Threatened Ecosystems arranged according to the grassland ecosystem in which they occur	118

Acronyms

APO	Annual Plan of Operation
BGIS	Biodiversity-GIS website of SANBI (http://bgis.sanbi.org)
BotSoc	The Botanical Society of South Africa
CARA	Conservation of Agricultural Resources Act (Act 43 of 1983)
CBA	Critical Biodiversity Area
CBD	Convention on Biological Diversity
CR	Critically Endangered
CREW	Custodians of Rare and Endangered Wildflowers
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DWA	Department of Water Affairs
DEA	Department of Environmental Affairs
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EN	Endangered
ESA	Ecological Support Area
FEPA	Freshwater Ecosystem Priority Area
FPA	Fire Protection Association
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
KZN	KwaZulu-Natal (province of South Africa)
masl	metres above sea level
MAP	Mean annual precipitation
NBA	National Biodiversity Assessment
NBF	National Biodiversity Framework
NEMA	National Environmental Management Act (Act 107 of 1998)
NEM:BA	National Environmental Management: Biodiversity Act (Act 10 of 2004)
NFA	National Forests Act (Act 84 of 1998)
NEM:PAA	National Environmental Management: Protected Areas Act (Act 57 of 2003)
NFEPA	National Freshwater Ecosystem Priority Areas Project
NGO	Non-Governmental Organisation
NPAES	National Protected Area Expansion Strategy
NWA	National Water Act (Act 36 of 1998)
RHP	River Health Programme
RQO	Resource Quality Objective
SAIAB	South African Institute for Aquatic Biology
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
SASS	South African Scoring System
SDF	Spatial Development Framework
SEA	Strategic Environmental Assessment
VU	Vulnerable
WESSA	Wildlife and Environment Society of South Africa
WfW	Working for Water
WMA	Water Management Area
WoF	Working on Fire
WRC	Water Research Commission
WWF-SA	World Wide Fund for Nature, South Africa



1 Introduction



1. Introduction



Grasslands cover almost one third of South Africa's land surface, stretching from the Eastern Cape and KwaZulu-Natal, over the high escarpment and onto the central plateau of the country. They extend across the boundaries of seven provinces, spanning a complex array of socio-economic situations and land-use contexts. Although the bulk of grassland landscapes fall into the 'Grassland Biome' (see Figure 1), there are also patches of grassland vegetation that occur elsewhere in the country, forming a mosaic with other vegetation types in other biomes, such as the Indian Ocean Coastal Belt (along the coast of the Eastern Cape and KwaZulu-Natal). These Ecosystem Guidelines apply to all of these grassland landscapes.

1.1. Grassland - a biodiversity asset underpinning South Africa's economy

South Africa's grasslands are a remarkable and irreplaceable biodiversity asset of global significance. In South Africa, grassland plant diversity is second only to that of the Fynbos Biome and grassland ecosystems are home to a large number of the country's rare, endangered and endemic animal species (see Box 2). Grasslands are critically important water production landscapes (see Box 3) and also provide the natural resources and ecological infrastructure that supports most of South Africa's important economic activities, and millions of rural livelihoods.

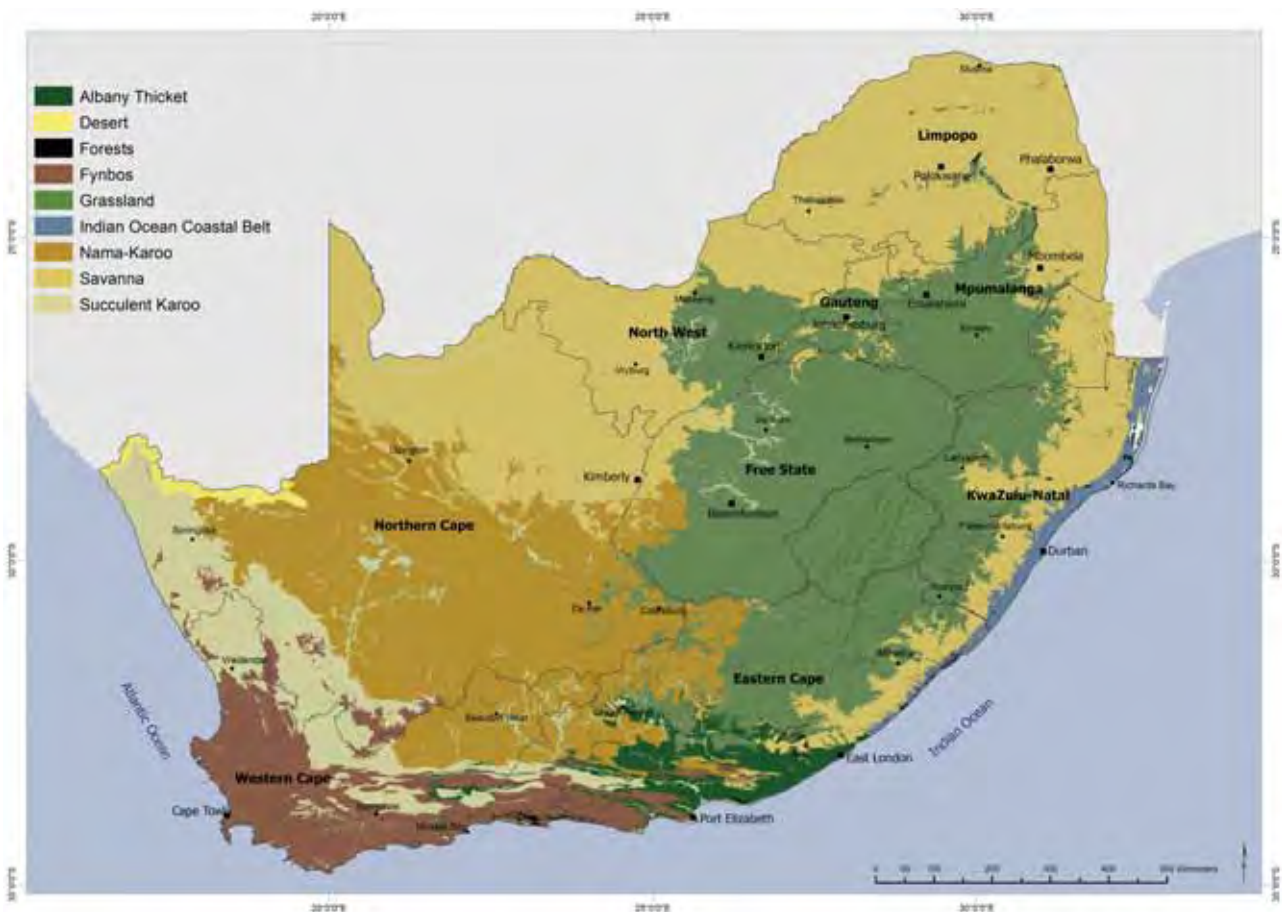


Figure 1. Map showing the nine biomes of South Africa



The conditions that prevail in grasslands make them highly suitable for human habitation, and many of the land-uses upon which food-production and other vital economic activities depend. For these reasons, some 40% of South Africans live and work in grasslands. These landscapes are also the location of large coal and gold deposits, agricultural lands and commercial forestry plantations, and include the heavily urbanised and industrialised province of Gauteng, which is considered to be the economic heartland of the country. These important activities form the backbone of the South African economy, but they also have impacts on the ecological infrastructure that underpins most of these economic activities.

1.2. Grasslands under pressure

For South Africa to meet its economic, job creation and social upliftment needs, it must increase agricultural production, and expand or intensify economic activities such as plantation forestry and mining to feed the important manufacturing and energy sectors. Grasslands provide a rich set of resources for addressing these challenges, but many of the current land-use practices in grasslands are already unsustainable and grassland ecosystems and resources are coming under increasing pressure from a variety of competing land-uses.

Box 2. Grasslands at a glance

The majority of South Africa's grassy vegetation types occur in the Grassland Biome, although 'grassland' is also found in small patches forming a mosaic with other vegetation types in other biomes. The Grassland Biome is:

- The second largest of South Africa's nine biomes, covering nearly 30% of the country's land surface area.
- A rich store of biodiversity assets, including 52 of South Africa's 122 important bird areas, almost one third of the country's 107 threatened butterflies, 15 of its endemic mammals and nearly 3,500 plant species.
- A region of global significance that is also home to three natural and cultural World Heritage Sites – the Cradle of Humankind, the Vredefort Dome and the uKhahlamba Drakensberg Park – and five Ramsar wetlands of international importance.
- An important water production landscape, containing 42 river ecosystems and most of the country's threatened wetland ecosystem types; five of South Africa's major river systems that have their headwaters in grasslands, including the Gariep, Vaal, Thukela, Mzimvubu and Kei Rivers; in addition, at least two of the flagship free-flowing rivers identified in the National Freshwater Ecosystems Priority Areas project arise in and flow through grasslands. Grassland areas receive the majority of South Africa's rainfall and constitute nearly half of the country's Strategic Water Source Areas.
- Home to South Africa's economic heartland: Grasslands support the cultivation of 60% of South Africa's commercial crops and 50% of subsistence croplands; 44% of the country's cattle and 32% of its sheep find their nourishment in grasslands; more than 40 % of all mining activities and 92 % of commercial plantation forestry takes place in grasslands, and 40% of the country's human population live in grassland landscapes.
- One of the most at-risk of South Africa's biomes: more than 40% of it has already been irreversibly modified, 60% of remaining grassland is considered to be threatened and less than 3% of it is under formal protection. Grassland is also considered to face the greatest risk of significant change due to climate change.

Grasslands are a valuable national asset, and their protection, enhancement and sustainable use should be a national priority. In addition to their own intrinsic value, grasslands are a valuable yet vulnerable source of natural solutions to the challenges posed by poverty, unemployment, and climate change. Their rich store of biodiversity, diverse ecosystems and abundant ecological infrastructure provides the foundation for economic growth, social development and human well-being.

For this potential to be realised, the country needs good scientific information that is effectively interpreted and made available to end-users; well-capacitated institutions that are responsible for effective management and governance of ecological infrastructure; and well-informed policies, legislation and leaders. These Ecosystem Guidelines for grasslands are one of a suite of tools that address these needs.



At least 40% of the Grassland Biome has been irreversibly modified and nearly 60% of remaining grassland areas are classified as threatened – this means that these ecosystems are losing vital aspects of their composition, structure and functioning. This, in turn, influences their ability to deliver essential services such as fresh water, soil formation, climate regulation and reduction of disaster risk. With less than 3% of grasslands under formal protection, remaining grassland landscapes and the biodiversity and ecosystems they support, are critically at risk. In these circumstances, it is clear that strategic and focussed action and a well-informed and cautious approach to development planning is of utmost importance.

Increasingly, people who do not necessarily have a background in biodiversity or conservation are being called upon to exercise decision-making powers in such a way that economic goals can be achieved whilst the health of ecosystems is maintained and the loss of threatened species or habitats is avoided. Ideally, all land-users and people who make decisions about the use of grassland resources should be aware of spatial biodiversity priorities within grassland landscapes and should understand their management requirements. This is so that they can proactively identify the ecological opportunities and constraints within a landscape, and use them to locate and manage infrastructural developments and other land-uses most appropriately.

1.3. Finding practical solutions - ecosystem guidelines for working in grassland landscapes

Individuals and institutions who work in grassland landscapes need to be equipped with reliable information that can help them take decisions to ensure that biodiversity is sufficiently considered – and safeguarded – in their decisions, plans and activities.

Although grasslands have been extensively studied and much scientific knowledge has been published about grassland ecology and management, this information is distributed across an array of publications spanning many years, and much of it is of a technical nature. Until now, there has been no single document that brings the current state of knowledge about grasslands together, with the specific aim of providing non-scientists with easy-to-use, practical guidelines on how to take better account of biodiversity in land-use planning and decision-making.

These guidelines have been developed to fill this gap.

What the Grassland Ecosystem Guidelines are

These guidelines are a practical guide that provides a consistent benchmark and framework for addressing the biodiversity-related aspects of land-use planning, landscape management and environmental regulation in South Africa's grasslands. The guidelines address key questions about grassland biodiversity that should be asked when planning or embarking on an activity in grassland. They bring together a consensus of scientifically reliable knowledge from a wide variety of sources and experts, and present it in a non-technical format that is accessible and relevant to non-specialists.

The Guidelines are intended to enable users to contextualize and interpret spatial biodiversity priority areas, such as those shown in systematic biodiversity plans. They should make it possible for the user to 'walk off the map', stand in a grassland landscape and, with the aid of suitably- informed maps:

- Correctly identify the broad ecosystem type they find themselves in.
- Understand broadly what drives this ecosystem in terms of ecological functioning.





- Understand what the limits of acceptable change are within that landscape, from a land-use and environmental perspective.
- Interpret how impacts need to be managed in that landscape, and how to monitor whether management is effective in securing biodiversity and ecosystem processes.

What the Grassland Ecosystem Guidelines are not

This document is not an exhaustive scientific reference work on grassland ecology or management, systematic biodiversity planning, environmental impact assessment, land-use planning or environmental legislation. Users requiring more information on these topics can refer to other resource materials, as recommended in the chapters and particularly in chapter 9.3.

These Guidelines are also not a substitute for more detailed scientific literature and 'best practice' guidelines, and they definitely do not replace the need for specialist studies of a site. They should be used in conjunction with other tools that are available, particularly systematic biodiversity plans that exist for the area of interest (see Chapter 3). Wherever possible, cross-reference is made to these tools throughout the text, and in the relevant appendices at the end of the book.

Box 3. Grasslands and water

Grasslands are critically important water production landscapes, playing a vital role in maintaining the quality and quantity of water entering rivers, streams and aquifers. The nature of the herbaceous vegetation in grasslands, both above and below ground, forms an effective substrate for capturing water, maximising infiltration, limiting erosive run-off and reducing soil loss. In this way, these ecosystems play a role in augmenting and regulating stream flow by holding water in the soil profile, or within wetlands, and slowly releasing it into rivers and streams, maintaining vital base flows into the dry seasons.

Grasslands account for more than half of the Strategic Water Source Areas of the country – areas that cover less than 5% of South Africa's land surface, but that receive the majority of its rainfall, and yield more than 80% of all water run-off. At least five major river systems have their headwaters in grasslands, and 34% of the country's remaining wetlands occur in grassland landscapes.

Wetlands and other freshwater ecosystems are essential for sustaining the ecology and economy of grasslands. The ecosystem services provided by wetlands include their ability to:

- Improve water quality (especially important in heavily industrialised parts of the biome).
- Regulate water flow (important in regulating flood levels and maintaining dry-season flows).
- Provide water, food and other natural products for human consumption or use.

Many wetlands are home to important biodiversity, and sites of cultural, recreational, educational or scientific value. The vital role played by many wetlands in agro-pastoral production systems and local livelihoods underpins the health and well-being of many rural communities. Wetlands represent high-value ecological infrastructure for gathering, managing and delivering water for human use – they are, however, the most threatened of South Africa's ecosystems.

The degradation of freshwater ecosystems (rivers and wetlands) is of great concern as South Africa is already a water-limited country. Water demand is expected to rise by some 50% over the next 20 years and unwise land-use practices, further loss of natural grassland habitat and the anticipated effects of climate change are expected to undermine water supplies even further.

In the face of these challenges, rehabilitation and maintenance of healthy grasslands and associated freshwater ecological infrastructure provides an effective natural solution for strengthening South Africa's water security. These Grassland Ecosystem Guidelines can be used to reduce further degradation and loss of grasslands and their associated wetlands, and to manage these ecosystems effectively for sustained water production.



How the Grassland Ecosystem Guidelines are structured

These Guidelines provide relevant information and guidance, based on six questions that should be addressed when contemplating the implications for biodiversity of land-use planning and decision-making in grasslands and associated ecosystems:

1. What are the main ecological characteristics of grassland?
2. What are the main issues, vulnerabilities and pressures in grassland?
3. What are the signs of healthy grassland?
4. What are the management best-practices and minimum ecological requirements in grassland?
5. What are the broad spatial guidelines for locating land-uses in grassland?
6. What indicators can be used to assess and monitor the impact of management on biodiversity in grassland?

The Guidelines include:

- An introduction to grasslands and key ecological concepts underpinning the ecosystem guidelines (Chapters 1 and 2).
- Practical guidelines on planning for a mosaic of land-uses in grasslands, including a brief explanation of systematic biodiversity planning and notes on the pro-active consideration of biodiversity in land-use planning and decision-making (Chapter 3).
- Notes on some key issues relating to conservation and management of grassland ecosystems in general (Chapter 4).
- Ecosystem guidelines for each of the grassland ecosystem groups (Chapter 5) and for wetland, river and forest ecosystems (Chapters 6, 7 and 8 respectively).
- Appendices of supplementary material that may be of additional interest to users, such as a glossary of terms (Chapter 9.1); a list of grassland vegetation types included in each ecosystem group and a list of threatened grassland ecosystems (Chapter 9.2); a special supplement for environmental assessment practitioners on how to incorporate biodiversity proactively into informed development planning, impact assessment and land management in grasslands (Chapter 9.3); and a terms of reference that should be used when commissioning a biodiversity assessment (Chapter 9.4); and additional references and useful websites (Chapter 9.5)

Who should use these guidelines

These Grassland Ecosystem Guidelines have been designed for use by a wide range of individuals and institutions whose activities take place in, or impact upon, grasslands. The most likely user groups include:

- decision-makers in national, provincial or local government and other regulators of land-use.
- spatial planners.
- environmental assessment practitioners.
- property developers.
- all industry or sector role-players whose work or activities take place in grasslands, or that rely on ecosystem services provided by grasslands (e.g. agriculture, mining, commercial forestry and so on)
- agriculture and conservation extension officers, and other specialist advisors.



When and how these guidelines should be used

The earlier these guidelines are used in the planning process the better. Ideally, their use should inform a plan or project up-front so that it is possible to work within the opportunities and constraints of these ecosystems, thus avoiding any potentially significant impacts on or delays in the development planning process later on. There are other sector-specific guidelines that provide more detailed information relating to particular types of land-use activities, or particular types of grassland ecosystems. Where these exist, they should be used in conjunction with these Grassland Ecosystem Guidelines, as described in Chapter 9.3. Figure 2 provides a summary of some of the key documents and tools that are available for practitioners working in grasslands.



Figure 2. Summary of biodiversity mainstreaming tools available to assist planners and decision-makers working in grasslands. This is not a comprehensive list, as it focuses on the guidelines and tools developed through the National Grasslands Biodiversity Programme; more information is available on the SANBI Grasslands Programme website (www.grasslands.org.za).





2 Grassland ecosystems and ecology



2. Grassland ecosystems and ecology



2.1. Ecosystems, ecological infrastructure and ecosystem services

Ecosystems are assemblages of living organisms, the interactions between them and between them and their physical environment. Each ecosystem is characterised by its composition (the living and non-living parts of which it is made), its structure (how the parts are arranged in time and space) and the ecological processes (functions such as nutrient cycling, water flows and dispersal) that maintain the composition and structure and keep it functioning as a unit (see Figure 3).

Ecological infrastructure is the stock of functioning ecosystems that provides a flow of essential system services to human communities – services such as the provision of fresh water, climate regulation and soil formation. Ecological infrastructure includes features such as healthy mountain catchments, rivers, wetlands, and nodes and corridors of natural grassland habitat which together form a network of interconnected structural elements within the landscape. If this ecological infrastructure is degraded or lost, the flow of ecosystem services will diminish and ecosystems will become vulnerable to shocks and disturbances, such as the impacts of climate change, unsustainable land use change and natural disasters like floods and droughts. It is important to note that when ecological infrastructure is degraded or fails, the direct monetary cost to society and government is often very high. Ecological infrastructure is, therefore, the nature-based equivalent of hard infrastructure, and is just as important for providing the vital services that underpin social development and economic activity.

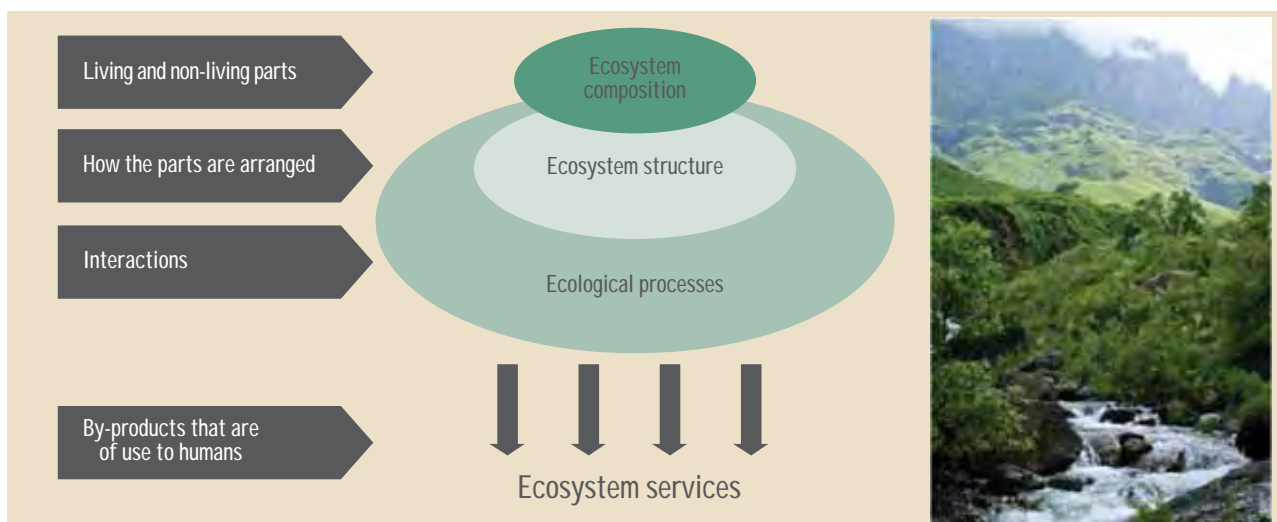


Ecosystem services provided by grasslands

Grassland ecosystems provide many essential ecosystem services, underpinned by rich biodiversity and diverse ecosystem processes. It is difficult to put a price on the benefits that South African society derives from these ecosystem services, but their contribution to economic activities has been estimated at some R9.7 million per annum. Some of the most important ecosystem services provided by grasslands include:

- Water production, water purification and flood attenuation (see Box 3).
- Good quality forage for animal production.
- Nutrient-cycling and carbon sequestration and storage.
- Pollination services.
- Support for livelihoods such as thatching and weaving.
- Medicinal and food plants.
- Cultural, heritage & recreational amenities, often with significant tourism value.
- Deep, nutrient-rich soils.

Figure 3. Components of functioning ecosystems



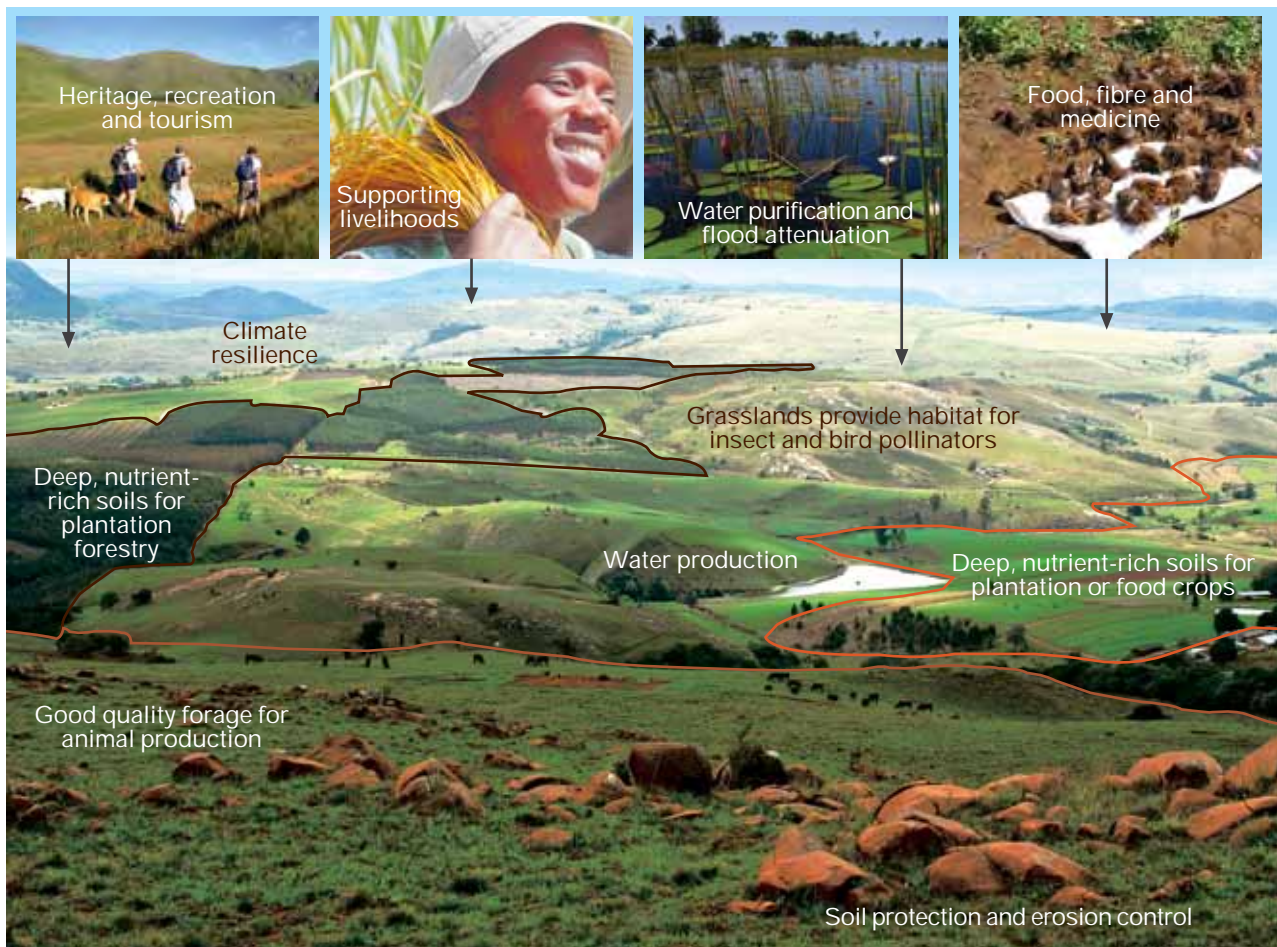
2.2. Taking an ecosystem approach to planning and decision-making

Ecosystems can be defined in different ways and at different scales. A useful way of defining them is to use vegetation types as surrogates for ecosystems, and this is the approach adopted in much of the biodiversity planning that is practiced in South Africa today. This has been possible largely because of the existence of a recently updated national vegetation map, and maps of river ecosystems and wetland types that provide consistent coverage of the whole country at an appropriate scale (1:250,000). These Grassland Ecosystem Guidelines have taken a broad ecosystem approach, treating clusters of grassland vegetation types as groups of ecosystems (similar to what has been defined as bioregions in Mucina and Rutherford, 2006) that have similar ecological characteristics, and share similar management requirements. This approach reduces the complexity of working across large and diverse landscapes involving many different vegetation types and land-use sectors, to a set of basic but reliable pointers that can guide responsible and appropriately informed land-use planning and decision-making about ecosystems and the biodiversity they support.

Taking a broad ecosystem approach to planning, management and conservation means that:

- Action can be focused on ecological processes that operate across a range of geographic scales and areas that are important for ecosystem-based adaptation to climate change, and not only on individual species as often was the case in the past.
- Best environmental assessment practice can be achieved by addressing issues at the appropriate ecological scale, as opposed to site-based decision-making, which often fails to consider the ecological value of a site within its broader landscape and regional context.

Figure 4. Landscape example of some ecosystem services provided by grasslands

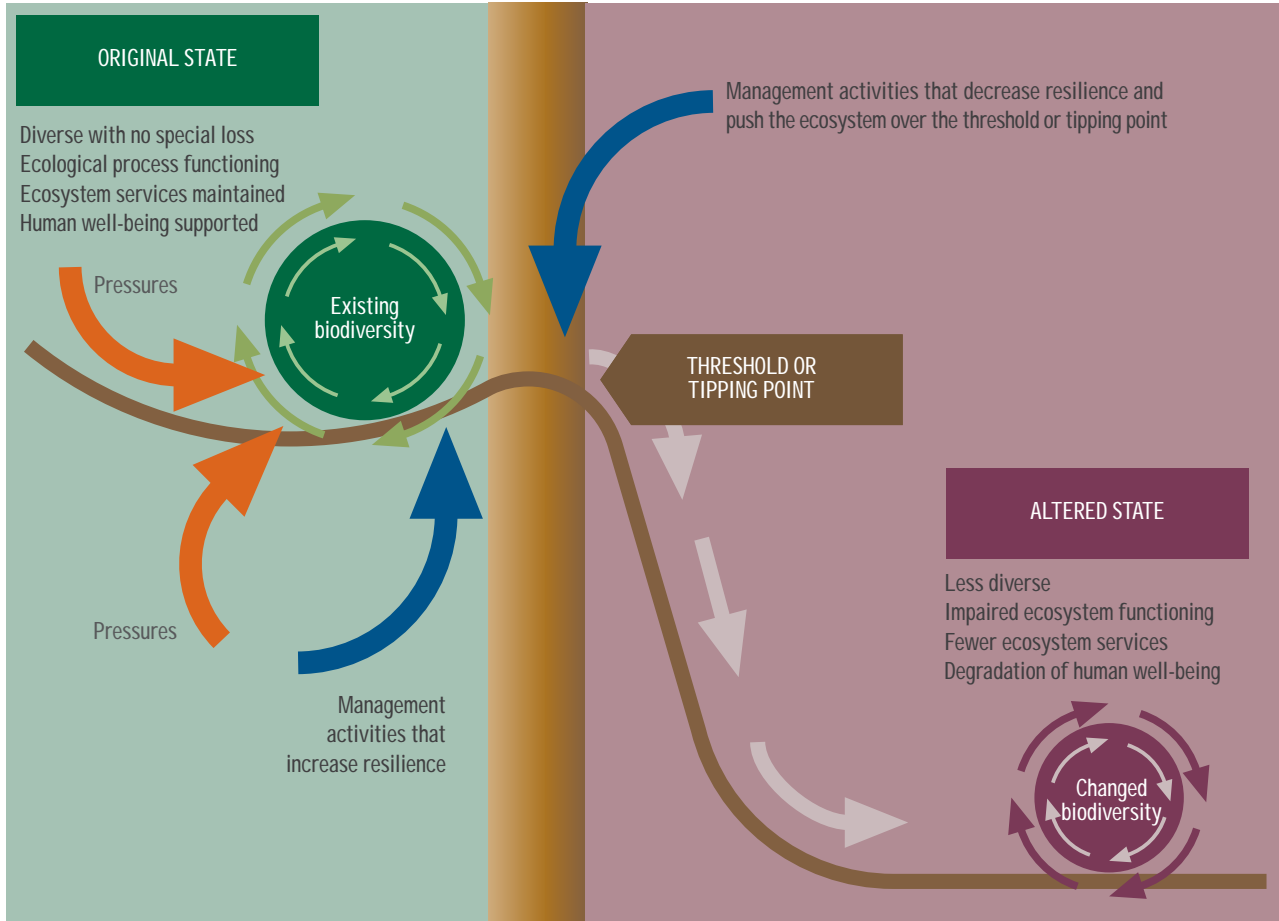




Change in ecosystems

Ecosystems are dynamic and undergo both natural and artificially induced changes all the time. All ecosystems can handle a certain amount of change yet still remain functional – this is the concept of resilience, and some ecosystems are more resilient than others. But there are points at which the ecosystem is pushed beyond a threshold after which it undergoes fundamental and irreversible change. Having passed this “tipping point” or threshold, the ecosystem becomes something different in terms of its composition, structure and functioning, and this could affect the ecosystem services it can provide (See Figure 5). If people are relying on the ecosystem services (e.g. water security or grazing production) for their livelihoods, then the resilience of the ecosystem is an important factor for them, whether they know it or not. Managing ecosystems to maintain resilience to undesirable change is an important natural solution to coping with the impacts of climate change and unsustainable land use change.

Figure 5. Ecosystem resilience and thresholds of change





2.3. Grassland Ecosystems in South Africa

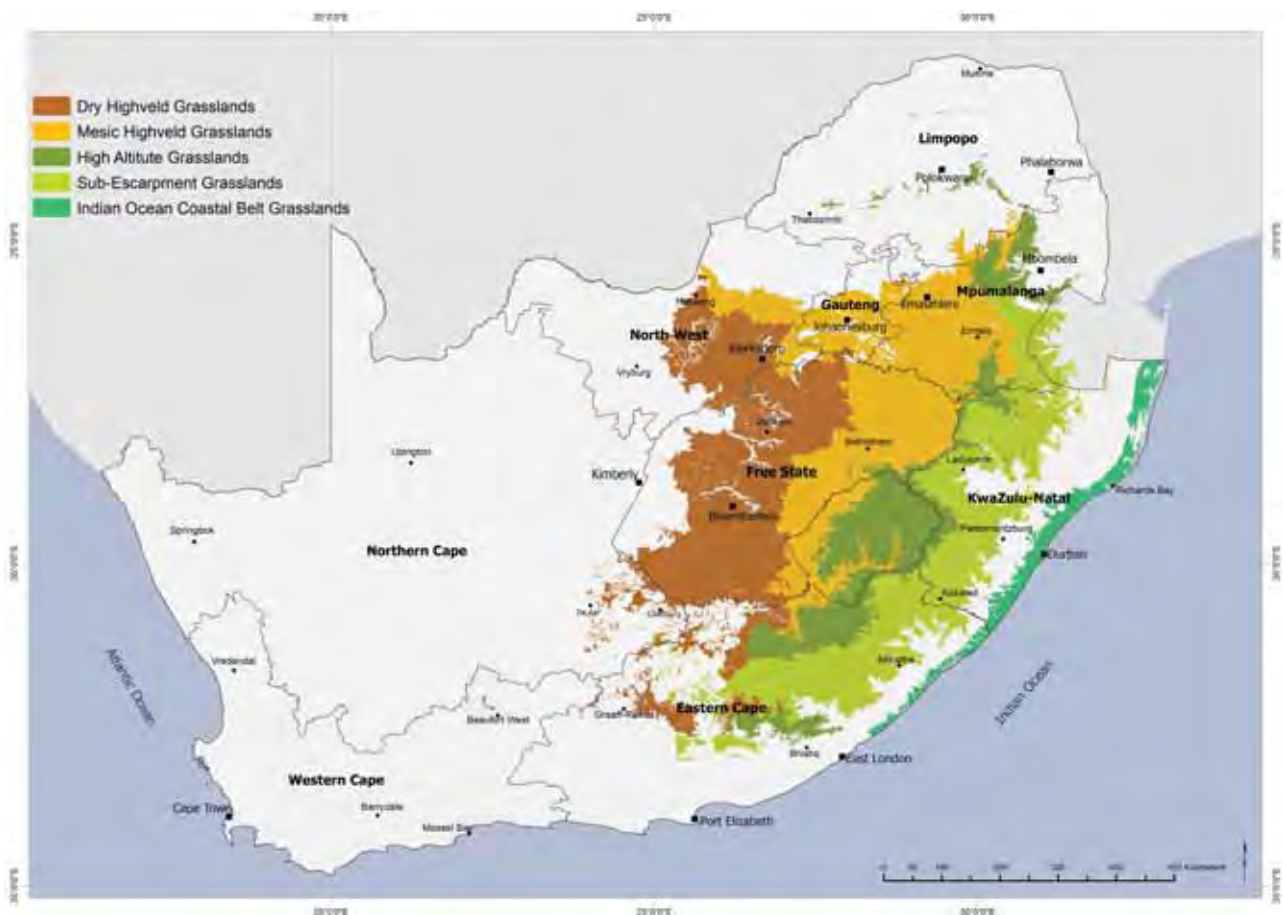
There are two broad, climatically determined types of grassland:

- Temperate inland grasslands, that make up the 'Grassland Biome', occurring over much of the eastern escarpment and sub-escarpment areas, and are the central, high plateau of the country.
- Subtropical grasslands that occur along the coastal belt of KwaZulu-Natal and the Eastern Cape and the interior immediately adjacent to this coastal belt. These form part of the Indian Ocean Coastal Belt Biome, but have been included in these Guidelines as the 'Coastal Grassland' group of ecosystems.

The Grassland Biome includes 72 nationally recognised grassland vegetation types, differentiated from each other by shifts in species composition that result from the interplay of environmental variables such as climate (temperature, frost and precipitation), topography and geology (Mucina & Rutherford, 2006). These environmental patterns influence other processes that shape these ecosystems, such as grazing and fire. The particular combination of abiotic factors determines the species richness and life history traits of the vegetation, and defines the ecological characteristics of the landscape.

Biomes are defined at a very broad scale. Although the Grassland Biome includes the majority of grassland vegetation types, there are also a small number of grassy vegetation types that fall into other biomes. These often occupy relatively small areas and are highly mixed amongst other types of vegetation, but still need to be managed as grassland. This document is intended to guide planning and decision-making in all landscapes that need to be treated as grassland from a management perspective, hence the inclusion of grasslands that fall outside the formal boundaries of the Grassland Biome.

Figure 6. Map of South Africa showing location of five groups of grassland ecosystems





Visually and structurally, grasslands are dominated by species of indigenous grass. However, in terms of species composition, grasslands are more diverse than they appear. Only one in every six species is a grass. Other plant species, especially bulbs and forbs (the collective name for soft-leaved herbaceous plants) make up $\frac{5}{6}$ of the plant species composition in the grasslands. Scattered trees or tree clumps may be present in some grasslands or in particular locations (e.g. on rocky ridges), but their canopy cover within a particular landscape rarely exceeds two per cent. Grassland landscapes span an altitudinal range from sea level to more than 3,000 m above sea level, and include highly varied topography – from sandy coastal plains and rolling hills, to the steep slopes, valleys and ridges of the sub-escarpment, up onto the peaks and plateaus of the high escarpment and the rolling plains of the Highveld.

Grassland ecosystem groups

In these guidelines, grassland vegetation types have been arranged into five broad groups of ecosystems based on their species composition, community structure, abiotic (i.e. 'non-living') environmental factors, ecological characteristics and management requirements. These ecosystem groups include:

- Dry Highveld Grassland.
- Mesic Highveld Grassland (excluding the north-eastern escarpment areas of Mpumalanga).
- High-Altitude Grassland (including the 'Drakensberg Grasslands' as defined in Mucina & Rutherford, 2006, the escarpment along the KwaZulu-Natal/Free State border and the north-eastern escarpment areas of Mpumalanga).
- Sub-Escarpment Grassland.
- Coastal Grassland (grassy vegetation types embedded within the Indian Ocean Coastal Belt Biome).

These five groups of ecosystems are similar to those recognised in Mucina & Rutherford (2006), with a few minor differences (described above) based on expert knowledge of the ecological characteristics and management requirements of these ecosystems.

A 'snapshot' of each of these groups of ecosystems is provided under the relevant section in Chapter 6. The geographic distribution of these grassland ecosystems is illustrated in Figure 6, and their spatial location within landscapes is shown in Figure 7. Chapter 9.2 indicates to which of the five ecosystem groups each grassland vegetation type belongs, along with its current ecosystem threat status.

Within each of the five broad grassland ecosystem groups, the plant communities share similar structure and species composition, and are maintained by similar ecological processes. This means that they can be expected to respond similarly to the land-uses that take place within them and so have similar planning and management requirements (described in Chapter 5).

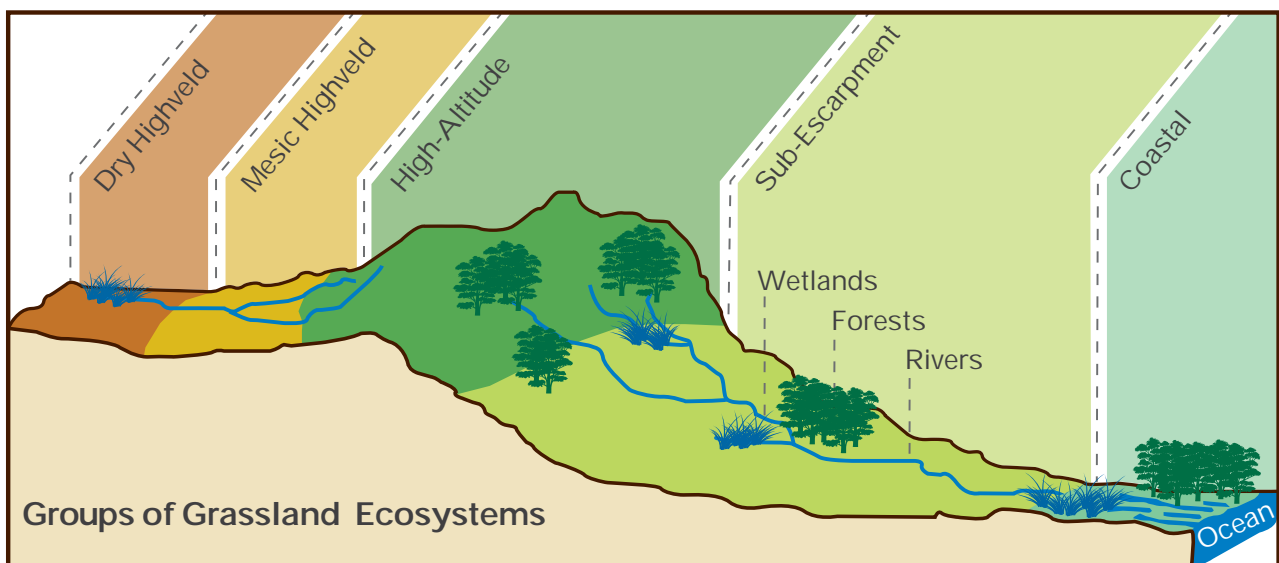


In addition to the five grassland ecosystem groups, the guidelines include three allied ecosystems that are present as a mosaic within the grassland landscape. These are:

- Wetlands.
- River ecosystems.
- Indigenous forest.

These ecosystems form an integral part of the grassland landscapes in which they occur, playing an important role in certain cross-cutting ecological processes that are responsible for maintaining grasslands. The general guidelines provided in Chapters 6 – 8 for wetlands, rivers and forest patches should assist practitioners in giving these ecosystems appropriate consideration as an integral part of the grassland landscape. If more detailed information for wetlands, rivers or forests is required, then references specific to these ecosystems should be consulted – for example, the WET-Management Series (Water Research Commission Reports, see www.wrc.org.za) can be consulted for advice on wetlands, or the Implementation Manual for Freshwater Ecosystem Priority Areas (Driver *et al.* 2011) can be used to guide land-use planning and practice in all freshwater ecosystems.

Figure 7. Location of grassland ecosystems in a profile of the South African landscape







3 Planning a mosaic of land-uses in grassland ecosystems



3. Planning a mosaic of land-uses in grassland ecosystems



Grasslands are in urgent need of conservation for their intrinsic value as a global and national biodiversity asset, and because the ecosystem services they provide are vital for economic growth and social development. In particular, land-based management of grasslands has important impacts on water production. The challenge lies in incorporating biodiversity priorities proactively into land-use planning and decision-making, so that the interconnected issues faced by grassland biodiversity and South African society can be addressed in an integrated and sustainable way.

3.1. The landscape approach to conserving biodiversity in working landscapes

In these guidelines a 'landscape approach' to conserving grasslands is promoted. This recognises the need for an inclusive approach that balances biodiversity conservation with resource utilisation and sustainable development across the entire landscape – this is achieved by using a range of management tools that can be implemented beyond the boundaries of formal protected areas. In this approach, protected areas (declared in terms of the National Environmental Management: Protected Areas Act 57 of 2003) are viewed as one part of a mosaic of land-uses in which biodiversity management objectives are built into the strategies, production practices and decisions of all land and resource users. Although some grassland areas may be identified as priorities for the establishment of formal protected areas, it is neither feasible nor desirable to meet all grassland biodiversity conservation targets through the creation of formal protected areas alone, especially in areas where the landscape is also suitable for some form of production.

Conservation action should focus on maintaining functional ecosystems across large areas of economically productive land, securing both the biodiversity patterns (species assemblages) and ecological processes that are supported by these ecosystems. This means that areas important for biodiversity conservation can be maintained and managed in a natural or near-natural state throughout the landscape. It also means that connectivity can be created between natural and near-natural areas across the landscape, allowing for the maintenance of ecological processes that operate at a large scale.

The landscape approach recognises that:

- Almost all ecosystems are already influenced or modified to some extent by human activity.
- People and their livelihood activities are an integral part of landscapes.
- Not all land-uses are compatible with biodiversity conservation, although some are.
- There are thresholds or levels of change, beyond which the ability of the landscape to sustain life and productivity is seriously diminished.
- Management actions must be carried out at the environmental scale suited to the issue being addressed.

3.2. Impacts on grasslands

Grasslands are old, stable and resilient ecosystems, in which most of the plants are long-lived, and can withstand repeated defoliation or disturbance by fire, frost and low to moderate levels of grazing. However, many land-use activities and other agents of change place pressure on South African grasslands. These activities can be broadly divided into those that cause degradation (changes in composition, structure or functioning) and those that result in a complete and irreversible modification (sometimes referred to as 'transformation') of the habitat, mostly through complete removal of the vegetation, or loss, turning or hardening of the soil.



Degradation can be caused by a variety of factors, but those of greatest importance in grasslands are:

- the incorrect application of fire and/or inappropriate grazing regimes.
- unsustainable utilisation of grassland resources.
- disturbance of the soil through activities such as ploughing for cultivation, or compaction of the soil for development.
- severe soil erosion.
- infestation by invasive alien or indigenous species.
- increased habitat fragmentation caused by various land-uses.

In most of these examples listed, the larger and more acute the degradation the higher the likelihood that this will result in modification. Irreversible modification is caused by outright loss of the original vegetation, typically due to a major land-use change due to one or more of the following:

- cultivation – commercial and subsistence planting of fields.
- mining.
- plantation forestry.
- infrastructure development, which can include building of roads, dams, houses and other hard infrastructure.

Impacting activities can have direct, indirect or cumulative effects (See Box 4).

Some grasslands can be distinguished from each other based on the extent of modification they have undergone. Primary grasslands are those that have not been significantly modified from their original state; even though they may no longer have their full complement of naturally-occurring species, they have not undergone significant or irreversible modification and still retain their essential ecological characteristics. Secondary grasslands are those that have undergone extensive modification and a fundamental shift from their original state (e.g. to cultivated areas), but have then been allowed to return to a 'grassland' state (e.g. when old cultivated lands are re-colonised by a few grass species). Although secondary grasslands may superficially look like primary grasslands, they differ markedly with respect to species composition, vegetation structure, ecological functioning and the ecosystem services they deliver.

3.3. Approaches to planning in grasslands

Because so many impacting activities take place in grasslands, adequate planning must be carried out to manage and locate land-uses appropriately, and to mitigate against inappropriate development so that the many benefits of grasslands are not lost.

Box 4. Broad categories of impacts on biodiversity

Direct impacts: directly linked to the land-use activity at the site (e.g. ploughing of grassland, extraction of water).

Indirect impacts: resulting from the land-use activity, but occurring beyond the boundaries of the land-use site (e.g. reduced water flows downstream of the site, or migration of pollutants).

Induced impacts: not related directly to the land-use activity, but anticipated to occur because of it (e.g. the development of associated industries or settlements).

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

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



Figure 8. The mitigation hierarchy for dealing with negative impacts on biodiversity, with biodiversity offsets to compensate for the residual negative impacts on biodiversity as the 'last resort'.

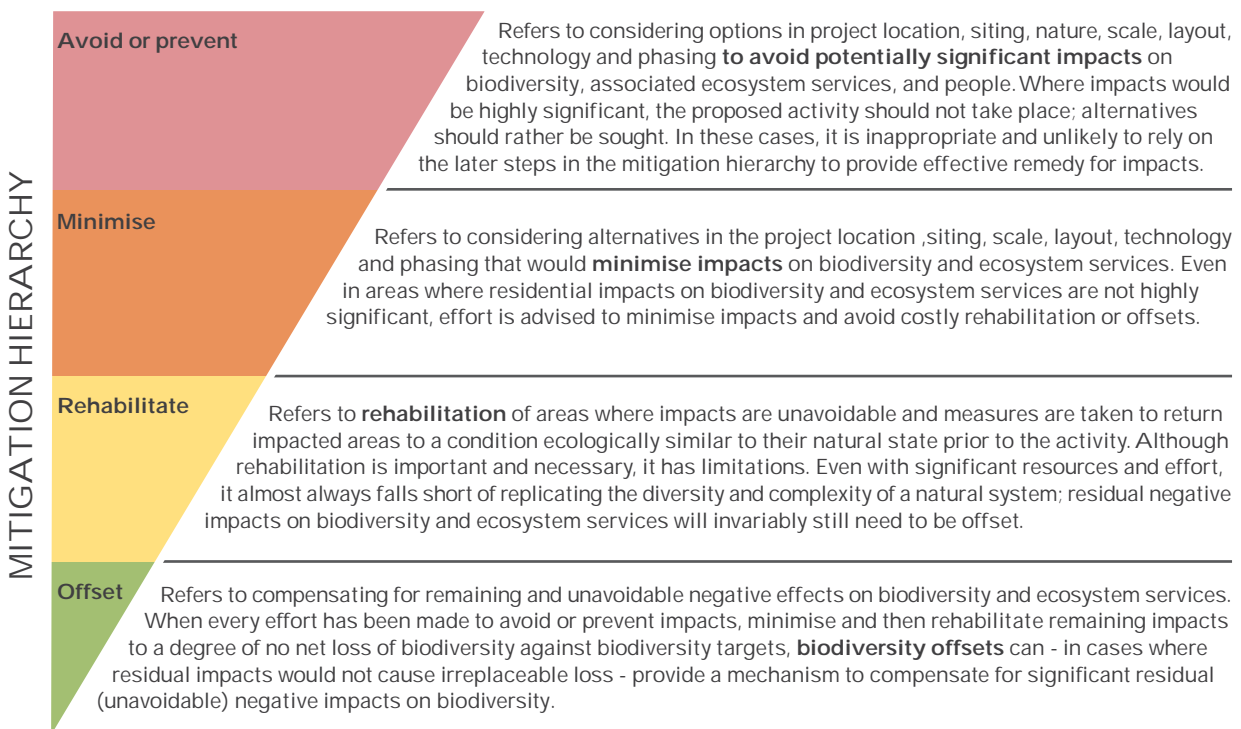
A precautionary approach to working in grasslands is recommended, following these general principles:

- Apply the law.
- Use the best biodiversity and other environmental information available.
- Engage all relevant stakeholders.
- Use best practice in EIA, particularly in terms of finding the best practicable alternative to avoid unsustainable loss of grasslands and ecological functioning (see Chapter 9.4 for more detail).
- Apply the mitigation hierarchy (i.e. deliberately aim to avoid unsustainable loss of grasslands and, where this cannot be reasonably avoided, mitigate impacts and rehabilitate disturbed areas to an ecologically acceptable condition, as required by law).
- Ensure effective implementation of biodiversity sector plans, bioregional plans, Environmental Management Plans and other similar planning tools.

Mitigation of impacts

The early identification and assessment of impacts on biodiversity provides an opportunity to implement appropriate plans and actions that reduce direct, indirect, induced and/or cumulative risks to biodiversity, people and business. The mitigation of negative impacts on biodiversity and ecosystem services is a legal requirement that takes on different forms depending on the significance of the impact and the area affected. Mitigation requires proactive planning that is enabled by the mitigation hierarchy, illustrated in Figure 8. Its application strives to avoid, minimise or offset disturbance of ecosystems and loss of biodiversity. Where biodiversity impacts are expected to be severe, the guiding principle should always be 'anticipate and prevent' rather than 'assess and repair'.

This approach integrates relevant biodiversity information into planning and decision-making at every stage of the project life cycle. In essence, better choices can be made with the early inclusion of biodiversity information into decision-making, and the bottom line is that 'prevention is better than cure.'





Identifying areas of biodiversity importance in grasslands

Valuable biodiversity is found throughout South Africa's grasslands, but it is not evenly distributed across the landscape. Because of this, and due to limited resources and other practical constraints, it makes sense to prioritise areas in terms of biodiversity importance, so that conservation action can be focussed strategically on areas of greatest biodiversity importance; similarly, other forms of land-use (such as mining, human settlement and agriculture) can be located where their impact on biodiversity can be minimised.

In South Africa, spatial biodiversity priorities are identified using systematic biodiversity planning, a method that aims to find the most efficient way to conserve enough biodiversity to ensure that it persists (See Box 5 for principles of systematic biodiversity planning). The results include maps, showing where the highest priority areas are within a broader landscape (enabling decision-makers to focus their attention on these) and land-use guidelines that indicate what land-uses are compatible with maintaining biodiversity in these priority areas.

How are systematic biodiversity plans developed?

Systematic biodiversity planning involves the following steps:

- Step 1. Map a wide range of information about biodiversity features and patterns of land and resource use, to show what is located where.
- Step 2. Set biodiversity targets that show how much of each ecosystem is needed to conserve it (see discussion below).
- Step 3. Develop a biodiversity assessment using systematic biodiversity planning software – this indicates what needs to be prioritised and where, highlighting the most efficient options for meeting all biodiversity targets, as well as other possible (less efficient) alternatives.
- Step 4. Interpret the biodiversity assessment and use it to generate a biodiversity priority areas map and land-use guidelines.

An important step is setting the biodiversity targets for each vegetation type (i.e. each ecosystem). To do this, each ecosystem is assigned to an ecosystem threat status category – this is a measure of how much of the ecosystem remains intact relative to a set of thresholds, and how at risk it is of undergoing further degradation or loss (see Figure 9). The thresholds, which are worked out using the best available science, indicate the points at which it is estimated that the ecosystem will pass from being under least threat, to being vulnerable, endangered and then critically endangered.

Box 5. Principles of systematic biodiversity planning

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

- The need to conserve a representative sample of biodiversity pattern, such as species and habitats (the principle of representation).
- The need to conserve the ecological and evolutionary processes that allow biodiversity to persist over time (the principle of persistence).
- The need to set quantitative biodiversity targets or thresholds that tell us how much of each biodiversity feature should be conserved in order to maintain functioning landscapes. Biodiversity targets are based on best available science and may be refined as new information becomes available. Biodiversity targets provide a basis for monitoring the effectiveness of the planning and management efforts.

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

- Efficiency, or striving to meet biodiversity targets in the smallest area possible. Efficiency goes together with complementarity, which is the extent to which an area contributes biodiversity features not represented elsewhere.
- Transparency, or documenting a clear rationale for decisions, enabling them to be repeated and/or critically reviewed.



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

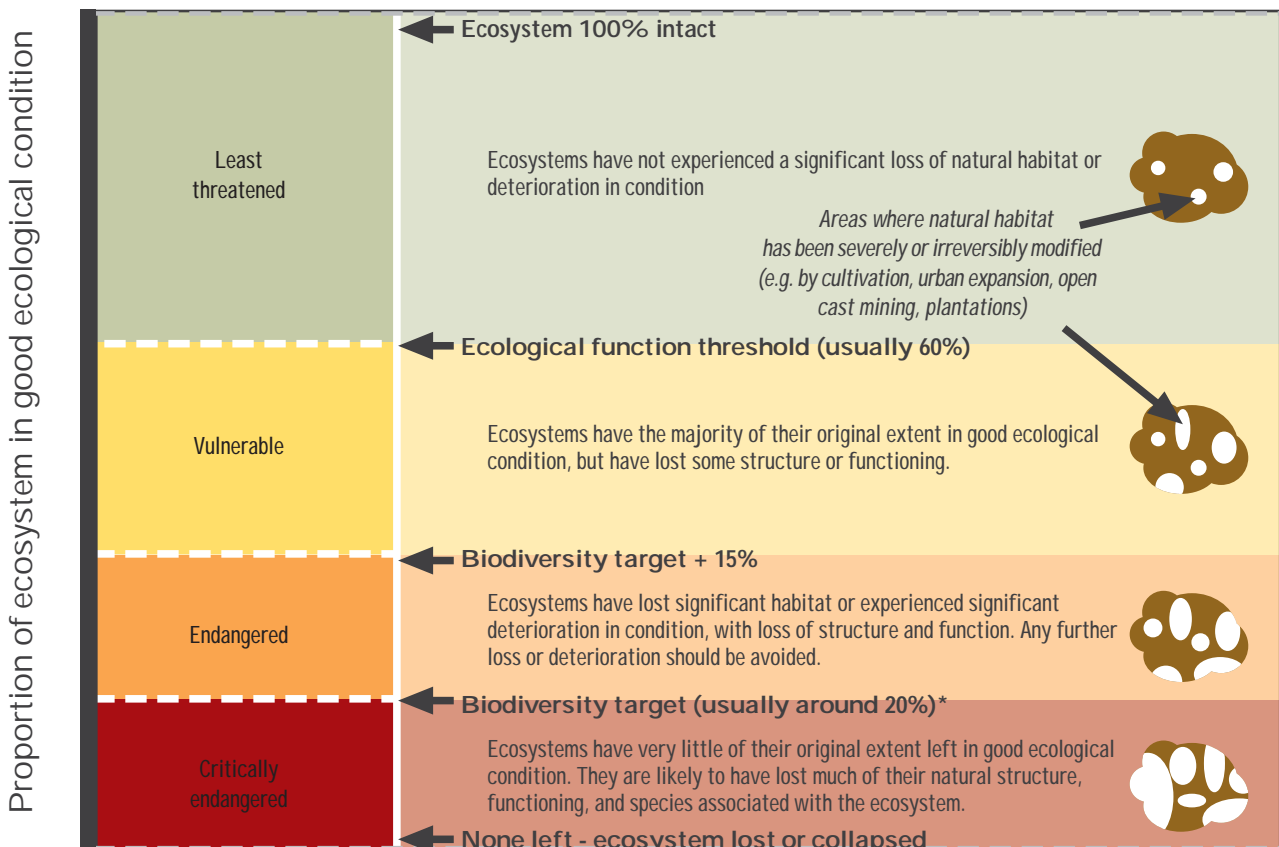
Threatened ecosystems that are gazetted in terms of Section 52 of the National Environmental Management: Biodiversity Act 10 of 2004 can be a trigger for environmental authorisation in terms of the national environmental impact assessment regulations. A list of threatened grassland vegetation types is provided in Appendix 2 of these Ecosystem Guidelines.

The products of systematic biodiversity planning:

The main products of systematic biodiversity planning are maps showing where the critical biodiversity areas (CBAs) and ecological support areas (ESAs) are located, and a set of guidelines explaining how these should be managed. Critical biodiversity areas are all the areas required to meet biodiversity targets - if these areas were to be modified in some way, then the biodiversity targets for them could not be met. CBAs need to be maintained in a natural or near-natural state and ideally include ecological corridors that maintain connections between them. Ecological support areas (ESAs) are needed to maintain the ecological functionality of the landscape by supporting the functioning of the critical biodiversity areas, and by delivering ecosystem services. These areas need to be kept in a near-natural state and need to remain functional, but some loss of biodiversity pattern can be tolerated.

Figure 9. Thresholds used to assess ecosystem threat status. These relate to the proportion of any ecosystem type that remains in good ecological condition. * Biodiversity target is the threshold for representation of biodiversity pattern (see glossary).

A summary of some recently published systematic biodiversity planning products is provided in Box 6.



Box 6: Important systematic biodiversity planning products



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

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

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



The Freshwater Ecosystem Priority Areas (FEPAs) and the FEPA Implementation Manual: The National Freshwater Ecosystem Priority Areas (NFPEA) project was a 3-year collaboration between the CSIR, SANBI, the Department of Water Affairs, the Water Research Commission, SANParks, SAIAB, the WWF and DEAT (now the Department of Environment Affairs). Its purpose was to identify a national network of freshwater priority areas that would be necessary to conserve a representative sample of the diversity of species and inland water ecosystems in which they occur, as well as the processes that generate and maintain diversity.

NFPEA map products provide strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. These strategic spatial priorities are known as Freshwater Ecosystem Priority Areas, or FEPAs. FEPAs were determined through a process of systematic biodiversity planning based on a range of criteria that are described in detail in the NFPEA Technical Report. The FEPA maps are published in the Atlas of Freshwater Ecosystem Priority Areas, which is accompanied by an Implementation Manual that provides detailed, practical guidelines for managing land-uses and their impacts in the freshwater priority areas. The NFPEA products can all be downloaded from the BGIS website.



Biodiversity Sector Plans

A biodiversity sector plan provides a map of areas that are important for conserving biodiversity and ecological processes (i.e. Critical Biodiversity Areas and Ecological Support Areas), together with contextual information on biodiversity and land-use guidelines. It is based on a fine-scale systematic biodiversity plan (1:50 000 or finer), and has boundaries aligned with administrative boundaries, such as a district or local municipality. Biodiversity Sector Plans usually take the form of a booklet or handbook, accompanied by wall maps as well as electronic versions of these.

The primary purpose of a biodiversity sector plan is to provide the biodiversity sector's input into a range of multi-sectoral planning and assessment processes to inform land-use planning and decision-making (e.g. provincial and municipal integrated development plans and spatial development frameworks, environmental management frameworks and environmental management programmes). A biodiversity sector plan can be the precursor to a Bioregional Plan which can be gazetted in terms of Chapter 3 of the NEM: Biodiversity Act.

Biodiversity Sector plans exist for several of the district municipalities in the Grasslands Biome and can be accessed via the BGIS website or from the local conservation agency/environmental department.

Bioregional Plans

A bioregional plan is a map showing Critical Biodiversity Areas for a municipality or group of municipalities, with accompanying land- and resource-use guidelines, which has been published in terms of the Biodiversity Act. A bioregional plan must meet the requirements that are laid down in the Guideline for Bioregional Plans (DEAT 2009). It must be based on a systematic biodiversity plan and serves the same purpose as a biodiversity sector plan. Municipalities must be consulted in the process of publishing a bioregional plan and after its publication the bioregional plan must be taken into account in all future planning by a municipality.



3.4. Taking a proactive approach in environmental assessment: Including biodiversity considerations in pre-application project planning

One of the key tasks of both environmental assessment and spatial planning is to determine the context within which a new project is being contemplated, and against which its impacts need to be assessed. This makes possible a more informed analysis of the need for (or desirability of) a project, both in terms of its 'fit' with environmental opportunities and constraints, and its ecological sustainability.

Activity-specific environmental impact assessment is inclined to focus on site-specific impacts, often at the cost of a broader ecosystem perspective. Systematic biodiversity plans, used in conjunction with these ecosystem guidelines, provide an excellent starting point for evaluating the suitability and potential impacts of a development proposal in relation to its broader biodiversity context. For this reason, these tools play an important role in providing a more ecologically-attuned perspective to environmental assessment.

Up-front reference to systematic biodiversity plans also indicates whether habitat modification in a particular place will contribute to cumulative impacts by reducing the chances of meeting biodiversity targets for specific ecosystems (vegetation types), or by contributing to habitat fragmentation and degradation of ecological processes. Critical Biodiversity Areas, Freshwater Ecosystem Priority Areas and Threatened Ecosystems provide a proactive and scientific basis for gauging the potential impacts of developments on grassland ecosystems; they can, therefore, help identify the most suitable options for siting land-uses.

There are six basic steps that should be followed to determine the biodiversity context of a proposed development and to identify potential 'red flags' that may need closer investigation, or that should inform the revision of project plans and alternatives. In summary, the steps cover:

- Step 1: Preparation for the site visit with reference to relevant biodiversity maps.
- Step 2: The site visit and how biodiversity considerations should inform project planning.
- Step 3: What to do if a project will not have a significant effect on biodiversity.
- Step 4: The importance of identifying opportunities to conserve biodiversity.
- Step 5: What to do if significant impacts on biodiversity cannot be avoided
- Step 6: How biodiversity considerations can be written into recommendations.

Chapter 9.4 provides a more detailed explanation of these steps. It also explains how use of these Grassland Ecosystem Guidelines can be integrated with use of SANBI's Biodiversity GIS website (<http://bgis.sanbi.org>) in pre-application biodiversity screening. Chapter 9.5 provides a basic terms of reference for biodiversity assessment for use by environmental assessment practitioners and others involved in development planning and decision-making.



4 Key issues in grassland management



4. Key issues in grassland management



This chapter provides a brief introduction to key cross-cutting issues in grassland management, including fire, grazing, invasive alien species and soil erosion. Fire and grazing are two of the most important ecological drivers in grassland. Any land-use change that results in reduced ability to manage fire or grazing in remaining natural areas will have significant implications for grassland biodiversity. Invasive alien species and soil erosion are two of the most pervasive management issues affecting all grassland ecosystems and are key indicators that the limits of acceptable change have been exceeded.

The objective of this chapter is not to provide detailed guidelines for the management of fire, grazing, invasive alien species or soil erosion, as this information can be found in other documents. Provided here is enough information to understand the dynamics of these issues in grassland and to interpret this information from a land-use planning perspective. Ecosystem-specific information relating to these issues is provided under the relevant sections in Chapter 5.



4.1. Notes on fire

Planners should understand enough about fire ecology to predict what the effects on the fire regime will be of any land-use change. Grasslands are both fire-prone and fire-dependent, requiring fire to maintain their biodiversity patterns and ecological processes. Fire is, therefore, critical for maintaining the health of grassland ecosystems and is also one of the most practical means of manipulating large areas of grassland for different management objectives.

Some of the ecological benefits of fire in grasslands include:

- Enhancement of primary productivity by stimulating new growth.
- Removal of dead and moribund plant material that will shade out the next season's growth.
- Release of nutrients and organic material back into the soil.
- Providing an opportunity for the species-rich forb component of the grasslands to flourish.
- Control of woody invasive alien species and indigenous weeds.
- Increased habitat diversity, by forming a mosaic of structurally-differing habitats within the grassland landscape – for example, a mix of tall and recently-burnt short grass provides habitat for different animals.
- Limiting the establishment of woody species and the possibility of a shift towards a more dominant woody component (such as in savanna or woodland).

Fire management

Management of fire is governed by law in South Africa and there are legal implications to negligence in the management of fire. All landholders are required by law to draw up and implement an appropriate fire management plan that should be approved by the local Fire Protection Association.



Natural fire cycles in South African landscapes have become severely disrupted mostly because of misconceptions about the valuable role fire plays, increased habitat fragmentation and because of the risks associated with managing fire in a production landscape. Unplanned or poorly-timed fires can be detrimental, affecting natural habitats, damaging ecosystem functioning, endangering life and destroying property. Pro-active fire management through planned and controlled burning, however, is an essential part of wise landscape management in grasslands.

Grassland species and ecosystems respond differently to varying fire regimes, especially when the effects of fire are considered in conjunction with the grazing regime to which the grassland might be subjected. The incorrect application of fire can result in a shift in species composition, encroachment by invasive alien or indigenous woody species, a decline in basal cover and an associated increase in soil erosion. Excluding fire for extended periods can result in permanent damage to the grassland.

The decision on how to burn a portion of grassland must always be founded on a clearly articulated set of management objectives for the land, and knowledge of the nature of the ecosystem (e.g. its productivity and life-history characteristics) and its ecological requirements. Fire can be used proactively as a management tool by manipulating the frequency, intensity and season of burn, in accordance with the requirements and tolerance of the particular grassland ecosystem, and the use to which it is being put. It is important to note that the use of fire as a management tool becomes increasingly important in regions with higher rainfall.

4.2. Notes on grazing

Along with fire, grazing is the single biggest factor that can influence the ecology of grasslands. From a planning perspective, any change in land-use that results in a change in the grazing regime will probably have a significant impact on grassland vegetation. These notes unpack the likely impacts of grazing on biodiversity so that planners can understand the implications of grazing-related land-use change. It is important to keep in mind, however, that it is neither possible nor meaningful to separate out the effects of grazing and fire, as these two factors work closely together with many subtle interactions.





Grazing is the removal of above-ground plant matter by animals, either indigenous or domestic. It acts as an important agent of disturbance, introducing habitat diversity into the system both spatially and over time. Many grassland species show life-history traits that are compatible with some grazing pressure, and it is generally understood that grazing can play a positive role in maintaining the ecological character of some, though not all, grassland ecosystems.

The positive effects of appropriate grazing include that it:

- Stimulates biomass production and removes dead or dying (moribund) plant biomass that might limit new growth.
- Introduces habitat variation through localised disturbance, which results in higher species richness and a greater abundance of small grassland animals.
- Breaks up the soil surface due to hoof action, allowing better infiltration of rainfall (this is particularly important in areas where hardening of the soil surface has occurred).
- Redistributes nutrients through animal dung.

Inappropriate grazing practices (such as over-grazing) can have negative effects including significant changes in species composition, especially when combined with inappropriate use of fire. This results in dominance by a few, unpalatable species (e.g. wire grasses such as *Aristida junciformis*) or leads to increased invasion by weedy species and soil erosion. This comes at the cost of both grassland biodiversity and productivity and is highly undesirable.

Factors determining appropriate grazing regimes

As with the fire, the appropriateness of any particular grazing regime will be determined by many factors, including the management objectives for the land, the productivity and life-history characteristics of the ecosystem and its ecological requirements, and the impact that the grazers have on the vegetation and landscape. Grazing pressure from indigenous fauna under natural conditions is generally much lower than that resulting from domestic livestock that are being farmed commercially, and indigenous fauna have different impacts from domestic livestock. However, the impact of grazing is multi-faceted, irrespective of whether it is indigenous game or domestic livestock doing the grazing. This means that if game animals such as blesbok are stocked at 'commercial' densities, then they will have similar impacts to domestic livestock.

The most important factors influencing the impact of grazing are: type of grazer, stocking density in relation to carrying capacity of the grassland ecosystem, and the type of grazing system employed.

Type of grazer:

Different animals graze in different ways, and this will result in different outcomes in the grassland. The basic differentiation is between concentrate (or selective) and bulk grazers:

- **Concentrate or selective grazers** are very picky about what they eat and generally nibble their way through the grassland, focusing on particular species that they find most palatable. Good examples include small buck, horses, goats and sheep. Concentrate grazers will have a significant impact on species composition if stocking rate is high.
- **Bulk grazers** are less fussy and generally 'mow' their way through grassland eating whatever is available. Good examples include eland, rhinos, buffaloes and cattle. Bulk grazers such as cattle generally have a lower impact on grassland than the equivalent number of selective grazers, as they do not crop the plants close to the ground and are less selective in what they eat.





Palatability has to do with the nutritional value of the grass, which is basically related to genetic variations but is also affected by variations in altitude, soils and rainfall and rangeland management practices.

Grasslands are categorised into three types in terms of palatability for grazing, namely:

- **Sourveld** exists in high rainfall (mesic) regions with frosty winters and highly leached soils. In these grasslands, animal production off the veld is only possible for six months of the year, before lower temperatures and dry winters result in a significant decline in forage quality. Sourveld plants withdraw their nutrients from their leaves, starting in early autumn, resulting in the leaves being unpalatable during winter.
- **Sweetveld** is found in the semi-arid, warm regions of the country where, due to lower rainfall and decreased leaching, soils are nutrient-rich and forage quality is maintained throughout the year. Sweetveld grasses tend to have lower fibre content and are palatable to livestock throughout the year, leading to year-round animal production off the veld. The quantity of forage available is limited by rainfall.
- **Mixed veld** includes grasses that retain their palatability for a longer period than sourveld grasses. This extends the grazing season in this type of grassland to approximately nine months.

Management for beef production generally favours the growth of palatable grass species at the expense of the forbs, although, in some cases, cattle are known to favour eating certain forb species too. It is in the forb community that the species richness of these ecosystems lies, and although grassland forbs are well-adapted to fire, they are often less able to cope with sustained grazing pressure. This means that the impact of grazing on the forb component of grasslands is important to monitor and that, in general, light to moderate grazing by livestock is advisable if grasslands are being managed to retain biodiversity.





Stocking rate:

The number of animals grazing on a given area of land for a given time is the stocking rate. This is one of the most important factors determining rangeland condition and the impact of grazing on biodiversity. The appropriate stocking rate is determined by the carrying capacity of the particular grassland ecosystem – this is the number of animal units per year that the ecosystem can support without undergoing detrimental changes. Increasing the stocking rate beyond a certain threshold reduces total primary productivity and lowers the vigour of palatable species. Different grassland ecosystems can support different types of grazers to a certain capacity. A few grassland ecosystems are adapted to withstanding sustained grazing pressures at the level of commercial livestock production, but the majority are not.

Grazing systems:

Effective management of the stocking rate is also determined by how the stock are moved across the landscape in what is called a ‘grazing system’ – this is the way in which the distribution of grazers is managed spatially and over time. There are many possible permutations of grazing systems, although they all tend to be variations of three basic types, namely continuous, rotational (conventional) and high intensity grazing. There is much debate about the likely impact of each grazing system on grassland productivity and diversity, and few generalisations can be drawn. Recent research suggests that high intensity grazing systems have a greater impact on biodiversity than continuous or conventional grazing systems, especially in the mesic grasslands, primarily because of the intense trampling effect of the confined herd. High intensity systems are, therefore, not encouraged in intact grasslands unless there is a specific management objective in mind, such as forcing a change in grassland species composition.

There are many options when it comes to rotating the impact of grazing from one part of the grassland to another, and a similar number of opinions as to which is best for both animal production and the vegetation. Different ecosystems will respond in different ways, but almost all grasslands respond well to a long period (e.g. a full growing season) of rest between bouts of grazing, and this should be built into all grazing plans. Many grassland landscapes have been subjected to high levels of grazing pressure over many decades, resulting in significant biodiversity loss. In many instances, grasslands have already lost much of their original biodiversity, although they continue to provide adequate or even good grazing. This emphasises the need to manage remaining representative grasslands with great care, adopting the precautionary principle whenever there is doubt about the possible impacts of a management decision.

4.3. Notes on soil erosion

A cross-cutting problem in grasslands is soil erosion, which is caused by loss of basal cover and poorly managed run-off. The main implications of soil erosion are:

- Loss of the topsoil, which has most of the organic matter and nutrients needed to promote plant growth.
- Increased sediment loads in downstream water bodies, leading to increased eutrophication and decreased storage capacity as dams silt up.
- Permanent loss of grazing lands, and with this, the long-term food provision potential that these resources represent.

There are two main forms of erosion in grasslands: gully and sheet erosion. These often occur as a result of the same management neglect, but require different approaches to prevent or solve.



Gully or donga erosion

Substantial volumes of soil can be lost through gully erosion. In some instances, gullies (or 'dongas') have been present for decades and it may even appear as if they are a natural part of the landscape. More often than not, though, gullies appear because of some kind of land management problem and, when this is the case, active intervention is required. In addition to measures which can be taken to stabilise the donga (See Chapter 5, question 4), the root cause of the problem must also be treated – i.e. it is important to know why the gully is forming and adjust the land management accordingly. The stabilisation work must always start at the upper end or 'head cut' of a donga or gully, as this is a site of active erosion.

Sheet erosion

Sheet erosion generally occurs when the vegetation becomes sparser, with increasingly larger spaces between individual plants. This allows water to move over a bare soil surface and for erosion to accelerate. The reduction in topsoil reduces the likelihood of new plants establishing from seed. Over time, and especially if the same number of livestock remain on the land, consuming ever-fewer plants, large areas of soil are exposed and erode down to the lower soil horizons, which are hard and compacted. This makes rehabilitation extremely difficult. Some soils are particularly vulnerable to sheet erosion. Measures for preventing and rehabilitating sheet erosion are provided in Chapter 5.





4.4. Notes on invasive alien species

Infestation by invasive alien species compromises the ecological integrity of grassland ecosystems, affecting their species composition, vegetation structure and ecological processes. Poor grassland management, particularly over-grazing and the incorrect application or exclusion of fire, leads to infestation by woody invasive alien species (such as black wattle), as well as shrubs (such as bramble). As the ecosystem becomes depressed through poor management, so its natural resilience to infestation by invasive alien species is reduced and this can ultimately lead to a complete modification of the grassland into a stand of woody invasive alien plants. Certain indigenous woody species that have weedy tendencies (for example the sweet-thorn, *Acacia karo*) can also invade grasslands that have been subject to poor management, with similar results.

It should be noted that land owners/users are required by law to control the invasive alien vegetation on their properties. Further guidelines for managing invasive alien species in different ecosystems are provided in Chapters 5 – 8.





5 Ecosystem Guidelines for Grasslands



5. Ecosystem Guidelines for Grasslands



This chapter provides answers to six key questions that are designed to get to the heart of understanding grassland ecosystems and the issues that impact on them, what it takes to locate land-use within them and manage them so that biodiversity loss is avoided or minimised and ecological processes are kept intact.

The questions are:

1. What are the main ecological characteristics of grassland?
2. What are the main issues, vulnerabilities or pressures in grassland?
3. What are the signs of healthy grassland?
4. What are the management best-practices and minimum ecological requirements in grassland?
5. What are the broad spatial guidelines for locating land-uses in grassland?
6. What indicators can be used to assess and monitor the impact of management on biodiversity in grassland?

The answers to these questions are provided below, in six sections as follows:

- Section 5.1 provides generic answers that apply to any grassland ecosystem
- Sections 5.2 to 5.6 are separate sections for each of the five grassland ecosystem groups, in which ecosystem-specific responses are provided.

Within each of the five grassland ecosystems, the plant communities share similar structure and species composition, and are maintained by similar ecological processes. This means that they can be expected to have similar planning and management requirements. Adopting a broad ecosystem approach means that the ecological function of a site can be considered within its broader landscape and regional context. In some cases, it has not been possible to provide ecosystem-specific answers to all of the questions simply because of a lack of suitable information, and in these cases the general guidelines should be applied.

5.1. Guidelines that apply to all grassland ecosystems

1 What are the main ecological characteristics of grassland?

Climate and fire are the primary factors giving grasslands their character, influencing the typical community structure, life history characteristics and primary productivity of each grassland ecosystem. Grazing, soil types and nutrient status are also important ecological drivers. The influence of these factors on the grassland is subtle and subject to many interactions, making it difficult to draw generalisations.

- **Climate:** The interplay of rainfall (both the annual average and variability), frost (severity and duration), temperature and altitude affects the length of the growing season and the build-up of biomass in the grassland; this affects the ability of the grassland to respond to both natural and artificial disturbances.
- **Life-history characteristics:** The life-histories of grassland plants influence how they respond to disturbances such as fire and grazing, as well as impacts resulting from different land-uses. Life-history strategies of grasses fall into one of two main categories: those in which re-sprouting and vegetative reproduction are the only or main forms of persistence and replacement, or those in which a significant amount of reproduction (i.e. replacement of individual plants) also takes place through seed. In almost all cases, individual grass plants (in perennial species) are long-lived, regardless of how much reproduction also takes place through seeds.



- **Fire:** Grasslands are fire-prone and fire-dependent, requiring fire to maintain their biodiversity patterns and ecological processes – this means that fire is an essential component of good grassland management. Grassland species and ecosystems respond differently to fire, especially if the effects of fire are considered in conjunction with the prevailing grazing regime.
- **Grazing:** Most grassland species can withstand some grazing pressure, and it is generally understood that grazing plays an important role in maintaining the ecological character of grassland ecosystems. It is neither possible nor meaningful to separate out the effects of grazing and fire as these two factors work closely together, with many subtle interactions.

2 What are the main issues, vulnerabilities or pressures in grassland?

There are several pressures that are generic to all grassland ecosystems, although the finer details may differ in specific ecosystems. The main issues, vulnerabilities and pressures are:

- **Increased habitat fragmentation:** The ecological processes that maintain the 'health' of grassland ecosystems often operate at a large spatial scale. This means that large, contiguous and linked blocks of intact grassland habitat (i.e. corridors) are needed to allow ecological processes such as fire, grazing, dispersal and pollination to operate effectively. Some land-uses may isolate and fragment the habitat into small, isolated (or disconnected) patches, leading to a breakdown in ecological processes. Some of the main causes of habitat fragmentation are:
 - o **Expansion of farming operations** (including commercial timber plantations, sugar cane fields and grain crops for human consumption, animal feeds or biofuels): As farmers attempt to improve production and profitability, there is a general trend for farming operations to use more land, either for grazing or arable fields or both. This sometimes results in primary grasslands being converted to cultivated fields to meet this demand and this places significant pressure on the remaining grasslands.
 - o **Injudicious or unplanned urban development:** the expansion of urban infrastructure contributes significantly to habitat fragmentation and biodiversity loss if it is not carefully planned with biodiversity priorities and ecosystem processes in mind. In rural areas, sprawling settlements are the main issues of concern, especially where they have been allowed to grow along main access routes, leading to ribbon rather than nodal development – this has many indirect, induced and cumulative impacts. The loss of natural green belts and high priority grasslands in urban nodes, and the establishment of urban infrastructure outside of the urban edge also results in fragmentation and loss of grassland habitat.
- **Habitat modification and loss:** Complete removal of natural habitat, and turning or hardening of soil, typically result from major land-use change as a result of mining, agriculture, plantation forestry, urban and peri-urban development and the construction of dams or other large infrastructure projects. These activities can have direct, indirect, induced and cumulative impacts on grassland ecosystems. As much of South Africa's mineral wealth is located beneath grasslands, expansion of mining activities in biodiversity priority areas poses a significant risk to remaining grasslands, particularly in Mpumalanga and KwaZulu-Natal.





- **Misapplication of fire:** Incorrect application of fire can result in a shift in species composition, infestation by invasive alien species and bush encroachment, an increase in densely-tufted or annual grass species, a decline in basal cover and an associated increase in soil erosion. Incorrect application of fire includes using the incorrect frequency, seasonality, or type of fire, or the complete exclusion of fire. This is particularly problematical when changes in land-use (e.g. introduction of a timber plantation or housing estate in part of a grassland landscape) result in remaining grassland being burnt too infrequently, or not at all, in an attempt to manage fire risk. The impacts of incorrect use of fire are made worse when the land is also subjected to poorly-managed grazing.
- **Inappropriate grazing practices:** Unsustainable stocking rates and continuous over-grazing lead to a reduction in total vegetation cover (i.e. basal and aerial cover); accelerated soil erosion; changes in species composition with replacement of nutritious perennial grasses by non-palatable annual grasses and weeds; and a loss of productivity. When combined with the incorrect application of fire, these impacts are often worsened.
- **Invasive alien species:** Invasive alien species threaten grassland biodiversity by taking up space that would otherwise be occupied by indigenous grassland species – invasive alien plants alter ecosystem processes by changing the structural composition (e.g. impacting the aerial or basal cover) or disturbance response (e.g. increasing the flammability of the system).
- **Bush encroachment:** Bush encroachment occurs when the cover of grasses and forbs is replaced in time by increasingly dense stands of indigenous woody plants, either trees or shrubs. The causes of bush encroachment are complex, but seem to be worsened by over-utilisation of the grassland (which depresses the fuel load and thus reduces the intensity of fires that would normally have killed the woody plant seedlings). Global climate change, with increased temperatures and carbon dioxide levels, may also make the problem more severe.
- **Over-harvesting of natural resources:** There are many plant species in grasslands that have medicinal or cosmetic properties and are harvested to some degree, sometimes commercially. Some species that have a high market value are being harvested to the point of local extinction (e.g. 'Stork's Bill' or *Pelargonium luridum*, which is prized for its essential oils). In many instances, the extent and value of the trade is unknown and there are real risks that key species could go locally extinct through non-permitted commercial harvesting
- **Hunting and wildlife trade:** Uncontrolled hunting with dogs and the informal wildlife trade are placing some important grassland mammal species, such as Oribi, at risk. These activities also depress populations of non-threatened species, particularly in the peri-urban areas close to human settlements.

3 What are the signs of healthy grassland?

As a quick rule of thumb, the indicators of healthy grassland ecosystems are:

- High basal cover, which binds the soil and so prevents erosion.
- A high diversity of growth forms (e.g. soft-leaved herbaceous plants – or forbs, bulbs, etc in addition to grasses).
- A high diversity of grass species, rather than dominance by any single species.
- Topsoil that is intact, rich in organic matter and uncompacted, with lots of evidence of soil-turning through the action of various animals.
- An even grass sward, rather than tussocked veld – tussocked veld is an indicator that all the palatable species have been eaten, leaving big tufts of unpalatable species.



- An absence of invasive alien plants or areas with heavy bush encroachment; note, however that in some grasslands indigenous woody species may occur naturally (e.g. stands of protea trees on southern slopes in sub-escarpment grasslands), but these should be present in naturally-occurring low densities or isolated patches (or small forest patches or bush-clumps where fire is naturally excluded).

A few notes on how to assess each of these indicators are provided below:

- **Basal Cover:** This is one of the most obvious features of grassland, and in a healthy system the basal cover should be high. Basal cover is a measure of how much of the soil is covered by the bases of the plants. At first glance, it may appear that there is a solid cover of vegetation, but a closer inspection at ground level shows that there is space between the bases of individual plants. The less space there is, the higher the basal cover. Loss of basal cover increases the vulnerability of grassland to soil erosion. This is a particular problem where there are steep slopes and multiple drainage lines, and where a large proportion of soil lost originates from the eroding faces of dongas.
- **Growth form diversity:** Walking along a 50 m or 100 m-long line through the centre of the grassland, and describing the growth forms of every plant encountered, will give a good measure of growth (or life) form diversity. In healthy grasslands, there should be a high diversity of different growth or life forms, other than grasses – this includes bulbs, forbs, woody shrubs, sedges, small trees, ferns, succulents and so on. If these other growth forms are absent, or their diversity is low, then this is generally a sign that the grassland is not healthy. Grasses are generally better able to withstand disturbance by fire and grazing than other growth forms, such as forbs. So, if grasslands are dominated by grass plants with very few forbs or geophytes, it may be due to misapplication of fire or over-grazing. If the grassland has lost those growth forms that have underground storage organs, such as bulbs and tubers (often identified by colourful flowering forms), then it is a sign that the area has probably been ploughed or subject to some other soil disturbance in the past, even if it still looks like an intact grassland.
- **Grass species diversity:** Healthy grasslands typically show high levels of grass species diversity. The dominance or absence of certain grass species can reveal a lot about the condition of the grassland, as different species respond to usage and management in different ways. In areas where grazing has occurred for a long time, it is not uncommon to encounter grasslands that look healthy because they have high basal cover, but an assessment of diversity might show that they are dominated by only one or a few grass species or by unpalatable species such as Wire Grass (*Aristida junceiformis*) and Taaipol (*Eragrostis plana*) – these would not be healthy grasslands. It is relatively easy for a trained person to measure species diversity by walking down a line of known distance (i.e. a transect) and measuring how many of each species are seen. Even if it is not possible to identify the species by name, in many instances it is not difficult to separate one grass species from another visually, especially if they are flowering, and they could be called simply Species A, B, C, and so on – it is important to ensure that one grass is not confused with another.
- **Soil surface features:** In a healthy grassland, the soil surface should:
 - o Be 'rough' with generally darker top soil and more organic matter than the subsoil. If the soil surface is exposed for any length of time, it is prone to accelerated erosion and to surface hardening, neither of which is desirable. If the topsoil and organic matter have been eroded away, it leaves a 'smoother' and lighter-coloured subsoil layer.



- o Show lots of evidence of soil being turned over by the activity of animals such as earthworms, porcupines, meerkats, moles and so on (look for evidence of mounds, burrows, holes and worm-casts). Soil-turning plays an important role in aeration and nutrient re-distribution in the soil. If the animals that perform this function are absent from the grassland, it probably indicates that it is highly disturbed and unhealthy.
- **Invasive alien plants (IAPs):** If invasive alien plants are emerging in a grassland landscape, it is normally a sign that its condition has deteriorated, particularly if the invasive plants are emerging throughout the grassland as opposed to being isolated in a few scattered clumps (the latter can occur if there has been localised disturbance, for example a small land slip). Ideally, there should be no invasive alien species (or only very few) in a healthy grassland.
- **Indigenous weedy plants:** Some indigenous plants may also behave as weeds; species that would normally be absent from grassland or present only in very low numbers, may become dominant if the resource use or management is inappropriate. For example, slangbos (*Seriphium plumosum*) may become dominant in grasslands that are chronically overgrazed, or woody tree species, such as Sweet Thorn (*Acacia karoo*), may encroach into grasslands and outcompete the grasses if fire is excluded from the landscape.

Box 7 explains what ecosystem health is and how it can be assessed. Can health be restored to damaged grassland ecosystems? The answer to this question depends on the nature and extent of the degradation or modification the grassland has suffered under previous management. The following general points apply:

- It is possible to 're-vegetate' damaged grasslands, but this is only possible at a small spatial scale and if the grassland still retains at least some obvious elements of health (e.g. some topsoil is still intact and all the natural vegetation has not been removed). Such re-building requires intensive and expensive interventions that focus on restoring topsoil and active planting of a range of species, and ensuring that they survive. It also usually requires careful and deliberate manipulation of fire and grazing (in particular, periods of rest from grazing).
- Removal of the primary vegetation cover, such as by ploughing, is often irreversible, especially in the mesic grasslands due to the slow rate of recruitment. Although it is possible to re-vegetate damaged grasslands (see above), it is very difficult if not impossible to restore them fully to their former state. If managed correctly, basal cover and some grassland ecosystem processes may be restored within five to ten years. This requires a process of intentionally establishing a sward of hardy indigenous grasses to act as "pioneers" in the succession process, using a mix of annual and sub-climax species. It should be noted, though, that the original species composition will not recover naturally – even over a long period (20-100 years) – because the long-lived, slow-growing species are very slow to colonise a denuded area. Primary grassland species, particularly in mesic grassland, show poor ability to re-colonise and they are quickly out-competed by fast-growing annual weeds that appear when primary vegetation has been removed. This is made even worse if the topsoil has been lost, as it will have to be replaced by natural regeneration, which is a decades-long process.
- Changes in species composition and structure resulting from poor rangeland management are generally reversible in the short to mid-term (5-20 years), especially if the primary grassland species (forbs and grasses) are still scattered across the grassland, even in low numbers. Different ecosystems will respond within different time frames. For example, Dry Highveld ecosystems will generally recover more quickly than mesic ones as they are dominated by plants that recruit more often from seeds stored in the seed bank, depending on rainfall. Mesic Highveld often show low levels of seedling recruitment and rely on plants being long-lived for their persistence.



- How quickly a grassland might show natural recovery is determined by the following:
 - Is there enough protective cover to allow seedlings to establish?
 - Is the topsoil still in place or has it, and the seed bank, been eroded away?
 - Have invasive alien plants and indigenous woody species become dominant to the point that they will exclude new seedlings?
- Management actions that maintain basal cover and reduce soil erosion are important tools for restoring and maintaining healthy grasslands.

4 What are the management best practices and minimum ecological requirements in grasslands?

Best-practices and minimum ecological requirements for managing grassland for biodiversity are presented below under four broad headings:

- managing fire
- managing grazing
- managing habitats and species
- managing soil erosion and physical disturbance.

Managing fire

An introduction to fire in grasslands has been provided in Chapter 4 and readers are referred there for general information. Please note: The guidelines provided here are general recommendations that are aimed at promoting biodiversity in grassland ecosystems, or at least achieving a compromise between biodiversity and other land-use objectives.



Box 7. What is ecosystem health and how can it be assessed?

Different land-users may have different concepts of what constitutes 'healthy' grassland. Therefore, the first question to ask is what is the purpose (or anticipated use) of the grassland? For example, a cattle farmer may be delighted with fields dominated exclusively by Rooigras (*Themeda triandra*) or by some other grass species kept in a highly productive state (e.g. thatching grass or *Hyparrhenia* species), but this may concern a nature conservationist. Or, a water catchment protection agency might be satisfied with fields of unpalatable wire grass that hold the soil together and provide reasonable water infiltration, but this would be very unproductive for grazing.

In these guidelines, the health of the ecosystem is judged in terms of optimising biodiversity patterns and ecological processes in support of productive and resilient ecosystems.

From an ecological perspective, 'healthy' grassland ecosystems are characterised by various indicators, some of which would be obvious to a non-specialist, and others of which may require a more trained assessment. The indicators listed here are those that would be obvious to a non-specialist who needs to make sound judgements about the state of the grassland in question. The technical detail of how to measure or assess grassland health will not be covered here, though a few pointers are provided for how to make quick assessments of certain indicators:

- It is useful to compare the grassland being assessed to one nearby that is from the same ecosystem group, and that is known to be reasonably healthy. This area can be used as a reference point for the aspects of ecosystem health given below, and then can be compared with the project site. The comparison can either be done by 'eye' (accepting that that this may be prone to some inaccuracy) or with some comparative measurements (if there is the capacity to carry these out).
- It is not useful to compare one grassland ecosystem type to another, as what is considered 'healthy' in one ecosystem may be different in another. For example, healthy basal cover in Sub-Escarpment Grassland is significantly higher than that for healthy Dry Highveld Grassland, and a direct comparison of this indicator between these systems would leave the assessor with an erroneous conclusion.
- The timing of assessment is very important as grasslands enter a state of dormancy over winter and are likely to lose their floristic components, which assist in distinguishing grass species from one another. For the most part, the non-grass species will also not be in evidence during winter. Therefore, it is very difficult to assess grassland health (other than basal cover) in winter (especially after a fire) or after a period of heavy grazing, as there will not be much to look at! Assessments of ecosystem health should, therefore, be made in summer.



These general rules of thumb include:

- **Promote habitat heterogeneity:** This can be achieved by maintaining a mosaic of areas with different fire regimes i.e. frequency, season, extent, intensity, type and time since last burn. Variability in time and space is the key – avoid doing the same thing year after year in the same place, as different components of the grassland will respond differently.
- **Do not withhold fire:** One of the biggest risks of permanently damaging grassland comes from the prolonged (> 5 years) absence of fire. The annual accumulation of unburnt, dead plant material forms a dense canopy that shades out the new growth, killing plants in a few years. Over time the soil is exposed leading to a loss of topsoil and the seed bank. It is very difficult to restore grassland that has been damaged in this way.
- **Burn according to a plan:** An appropriate burning regime is an essential management tool in grasslands, and it must be articulated in the form of a coherent, intentional fire management plan. Box 8 lists the main factors that should be included in a Fire Management Plan.
- **Do not use herbicides or hoeing in the creation of firebreaks:** The use of herbicides or hoeing for putting in the tracer lines for firebreaks kills the plants and leaves a bare soil strip that is highly susceptible to erosion – ultimately this will lead to the formation of large gullies across the grassland. Instead, use mowing, brush-cutting or spraying with a frosting agent to create tracer lines.
- **Do not force fire into natural fire refugia:** Fire refugia (i.e. bush clumps and rocky areas that don't burn easily) provide habitats that allow fire-sensitive species to escape from and survive through fires.

In addition to these general guidelines, some more specific recommendations are made under Question 4 in the section on each ecosystem group. For detailed guidance on the management of fire in grasslands, consult an expert or burning guidelines that have been developed specifically for the area in question.

Box 8. Factors to be included in a fire management plan

- **Safety:** Meet legal and practical requirements to ensure that burning only takes place when it is safe to do so (the District Fire Officer or local Fire Protection Association or Officer should be consulted for guidance).
- **Management objectives for the land:** In practice, where the land is being used for commercial livestock production, some level of compromise will need to be struck between burning the veld to promote biodiversity, and managing it to support economically viable animal production. As an example, fodder requirements for livestock and game must be considered so that there is always enough unburnt vegetation for animals in the area to survive until the burnt grass has re-grown.
- **The nature of the particular ecosystem:** This includes its life-history characteristics and productivity, as these determine how the grassland will respond to fire.
- **Ecological and biodiversity considerations:** The most obvious of these is to introduce as much habitat variability (in space and time) as is practically possible, by manipulating the fire regime.
- **Annual adaptation of the fire plan:** The fire management plan must be adapted to local conditions every year. In other words, deciding what, when and how to burn will be influenced by the past season's fires (including unplanned fires), rainfall and vegetation growth, grazing intensity (previous and proposed), infestation by invasive alien plants or bush encroachment, or any other variables that change every year. This means the fire management plan is adapted every year so that it is a flexible system that is sensitive to the current condition of the grassland. Once the ecosystem requirements and management outcomes and prevailing conditions are clearly understood, then the fire regime can be manipulated by adjusting the frequency, seasonality and type of fire.
- **Frequency of burning:** There is no set rule that can be prescribed regarding the frequency of burning; the decision should rather be based on the land-use objective, the need for burning according to the structure and condition of the grassland, and the amount of fuel that is present.
 - o Timing of burning (season): When choosing the season of burning, consider factors such as the state of dormancy of the grass, the need for fire protection, the time interval between burns, time until the start of the new growing season (i.e. how long will the soil surface remain exposed before sufficient re-growth occurs?), and prevailing weather conditions.
 - o Type of burn: The two most common factors to influence in a fire are the temperature of the fire and the speed at which it moves.



Managing grazing

Best practice or minimum ecological requirements for managing grazing in grassland ecosystems include:

- **Grazing must be implemented according to an intentional, coherent grazing plan:** The most important thing to remember about grazing (especially in combination with fire) is that there is no single or simple 'one-size-fits-all' solution. A grazing plan should pay attention to the choice of animal (bulk or selective grazers), stocking rates, rotation and resting, numbers of animals, proposed fire management, history of grazing and fire, and the sustainability of the grazing regime. Detailed information can be obtained from a variety of sources (such as the National Grazing Guidelines, Lechmere-Oertel 2013), or extension officers, experienced farmers or other experts who can help with the development of a well-informed grazing plan. Recognition should also be given to the skill of how to 'read the veld' and to having a management system flexible enough to respond to changes in the veld condition:
 - If economic return is not the primary objective, grassland should be grazed continuously at light stocking rates. The selective grazing associated with this will create a mosaic of vegetation structures and niches for a variety of plant and animal species to exploit. Appropriate use of fire should overcome any long-term changes in species composition brought about by selective grazing.
 - For livestock production systems, grazing should conform strictly to national stocking rate norms, stocking rates should be monitored and incentives provided for farmers who follow best practice. The stocking rate should be flexible and variable, corresponding with factors such as annual rainfall and above mentioned factors for the grazing management plan, and should be conservative.
 - Prevent overgrazing by educating land-owners and managers, promoting biodiversity stewardship on land of high conservation value and investigating certification options to incentivise good rangeland management.
- **Take care with the provision of water and licks:** The concentration of animals around water points and licks can lead to substantial localised damage to the vegetation, ultimately giving rise to an erosion problem. The exact solution will depend on the specific conditions and there are several agricultural manuals that can provide detailed options.
- **Take the pressure off natural rangelands where possible:** This could be done by providing pastures in areas that have already been irreversibly modified.
- **Maintain populations of naturally-occurring smaller herbivores:** It is important to ensure that grazing is taking place at a variety of spatial scales, as this will help maintain biodiversity. Small herbivores such as rodents, tortoises and smaller antelope are, therefore, important to maintain the health of grassland ecosystems.

In addition to the general best practice guidelines described above, there are more detailed guidelines that are given under under Question 4 for each group of ecosystems.



Managing habitats and species

Best practices and minimum ecological requirements for managing habitats and species in grassland ecosystems include:

- **Grasslands should be kept free of invasive alien species:** Clearing of invasive alien species needs to be approached systematically according to an invasive alien species management plan – a haphazard approach will almost certainly make matters worse. Basic principles of best practice for clearing invasive alien species are included in Box 9. It is advisable, however, to obtain specialist advice when drafting an invasive alien management plan, from programmes such as Working for Water (visit their website at <http://www.wfw.gov.za>) or from specialists in this field.



- **Bush encroachment must be controlled:** Appropriate management of fire and grazing can be used to avoid or limit bush encroachment. Where grasslands have already become encroached by woody species, specialist advice should be obtained on how to clear the area of encroaching species.
- **Basal cover must be maintained and soil erosion reduced:** Loss of basal cover increases the vulnerability of the grassland to infestation by invasive alien species and to soil erosion. This is a particular problem in escarpment and sub-Escarpment areas with their steep slopes and multiple drainage lines.
- **Promote the persistence of habitats with high species diversity and endemism:** Within broader grassland landscapes managed for animal production, there are islands or patches of very high diversity and endemism, and other habitats where species of special concern occur. These require specific management approaches that focus exclusively on the biodiversity features, compelling the need to:
 - Obtain ecological advice as to the most appropriate fire regime that will allow the key species to persist.
 - Protect rocky ridges from grazers, even though they are more or less naturally protected by their location.
- **Monitor populations of species of special interest:** Request the regional conservation authorities, relevant conservation NGOs or civil society interest groups (such as CREW – Custodians of Rare and Endangered Wildflowers) to initiate a programme to monitor the populations of important species.
- **Protect localities that are home to threatened species:** There are several threatened species, such as cranes, cycads and oribi that should be protected. Where such species occur, it is important that the appropriate conservation body (either the provincial authorities or affected conservation NGOs) be contacted and invited to offer advice and practical assistance to ensure the persistence of these individuals. The Red Data List can also provide information and guidance on how to deal with these species (see <http://redlist.sanbi.org/>).
- **Manage the grassland to optimise seasonal water flows:** Maintain grassland diversity, structure and condition by keeping escarpment and Sub-Escarpment areas in a natural state as possible, as this will optimise seasonal flows and improve the security of supply. In these areas, maintaining seasonal water-flows should be promoted as the primary land-use. Treating wetlands and their catchments as part of the grassland matrix is important (see Chapter 6 on Wetlands for more detailed treatment of this topic). Particular attention should be given to the following:
 - Invasive alien plants should be strictly controlled.
 - Point-source discharges (such as road drains) should be dispersed to avoid the formation of gullies.
 - Excessive grazing and hoof damage to wetland banks should be avoided.
 - Wetlands should be periodically burned, based on expert advice.
- **Limit economic activity in intact primary grassland to biodiversity-compatible land-uses:** Land-uses such as grazing (under sustainable stocking rates), catchment management for water production and sustainable eco-tourism would pose minimal risk to the long-term health of primary grasslands.
- **Regulate harvesting, hunting and trade in grassland species:** Although hunting and the trade in indigenous wildlife and protection of indigenous species is controlled by provisions of the Biodiversity Act, this is not always easy to enforce, especially in rural areas. Harvesting and hunting (including the use of dogs), should be regulated and take place within a legal framework based on sustainable off-take rates. Active management and close monitoring is essential to ensure that protected species are not placed at risk by unsustainable or unregulated off-take.



- **Wild-harvesting of grassland plants:** This must be regulated and, in areas where populations have been depressed, prevented. The assistance of the relevant conservation bodies should be sought to monitor and record what is being collected, where from and in what quantities. Attention should also be given to investigating the viability of replacing the wild supply with commercial, small-scale production of medicinal plant species.

Managing soil erosion and physical disturbance

Best practices for managing soil erosion and physical disturbance include:

- **Manage soil erosion by identifying and treating the root cause:** In general, the best way of combating erosion is to prevent it from happening. Alternatively, early detection and rehabilitation are the best options. When treating soil erosion, it is important to know what is causing it, and the land-use or land management must be adjusted accordingly – it is not enough simply to treat the erosion itself, without dealing with the root cause.
- **Implement measures for combating erosion, including:**
 - o A donga rehabilitation programme: a large proportion of soil lost in escarpment and sub-escarpment systems originates from the eroding faces of dongas, and dongas must be treated as soon as they are noticed. It is critically important to understand what is causing the formation of the dongas, so that timely and appropriate intervention can be made. Stabilisation of dongas and gullies can be achieved using 'hard options' (such as building gabions – wire cages filled with rocks) or 'soft' alternatives such as sloping, silt-traps and re-vegetation.
 - o Maintenance of roads, footpaths, stock tracks and tracer lines (old ones as well as those still in use): this is an important part of an erosion-control programme, as roads, footpaths and stock tracks pose a potentially serious erosion risk. Ensure adequate drainage through regular placement of soil humps or transverse furrows ('afkeerwallejtjies'), which direct water away from roads and paths, as well as preventing water from gathering enough momentum to cause significant erosion.
 - o Preventing sheet erosion: monitor the environment in which livestock are grazing and adjust the management strategy if necessary. Where sheet erosion has already happened, rehabilitate the eroded area by:
 - Slowing down the movement of water over exposed soil by creating barriers such as brush-lines and rock packs, and mulching; mulching holds multiple benefits as it also adds organic matter to the soil, shields the soil from temperature extremes and provides a habitat for soil microfauna.
 - Establishing a new grass sward through active planting of indigenous pioneer species that are suited to the area; this can be done through hydro-seeding, scattering of seed, or planting of plugs or tufts.
 - Removing livestock from the rehabilitation area, so that the vegetation can recover; in other cases it may be beneficial to bring cattle into the area briefly, if hoof action is needed to break up compacted soil; dung could provide a useful source of nutrients and organic matter.
- **Obtain expert advice:** Obtain the advice of experts who understand the particular grassland ecosystem in question and ensure there is sufficient budget and materials to do the rehabilitation work properly, as this will save time and money in the long run.



5 What are the broad spatial guidelines for locating land-uses in grassland ecosystems?

- **Use systematic biodiversity plans to identify areas best suited for conservation and other land-uses:** Systematic biodiversity plans should be used to prioritise all areas that are to be secured for formal protection or other forms of conservation management (e.g. sensitive habitats such as forest patches, wetlands, remaining portions of primary grassland, all critical biodiversity areas) and to design a system of corridors that link protected areas and other natural areas throughout the landscape. Systematic biodiversity plans can also be used to identify other areas of biodiversity importance (e.g. ecological support areas) in which biodiversity-compatible land-uses can take place, and areas where less compatible development should be located. This makes it possible for planners to be proactive in locating land-uses in areas that are best suited to them, and avoiding inappropriate development in sensitive areas. The local conservation authority or SANBI's BGIS website can be consulted to find out if any systematic biodiversity plans are available for a particular area (visit: <http://bgis.sanbi.org>). Also see SANBI's Biodiversity Advisor for on-line biodiversity information at <http://biodiversityadvisor.sanbi.org/>

Box 9. Principles of best practice for clearing invasive alien plants

The objective of any programme to control invasive alien plants should be to eliminate all undesirable species from a property within a specific time-frame (with 5 years considered to be sufficient), with provisions made for follow-up to maintain an alien-free state.

- Invasive alien plants should be tackled on a species by species basis, as a single approach is unlikely to be effective for all species.
- The management programme for each species must include pre-treatment, initial treatment, and follow-up treatment/s and there must be an adequate budget for all treatment phases, especially in the follow-up or maintenance phase. This will require a 5-10 year budget cycle – neglecting this will make the problem worse.
- Priority species (the ones most likely to expand into other areas) should be addressed first.
- Outlier and expanding populations should be dealt with first as they contribute the most to the rate of invasion.
- Exotic and indigenous invasive species should be removed by mechanical means, but the cleared material should not be left stacked in the grassland, as this poses a fire risk.
- A sound and effective rehabilitation plan should be implemented immediately following clearing in those areas where clearing is likely to result in large patches of bare soil, especially on steep slopes or adjacent to streams. Cleared areas should be re-vegetated with locally-occurring indigenous pioneer species to 'kick start' rehabilitation. Stumps can be treated with herbicide and left in place on steep slopes where erosion may be a problem, and before indigenous vegetation has had a chance to re-establish itself.
- Use of herbicides is appropriate, but chemical use must conform to the highest environmental standards as specified by the many public and private sector invasive plant control programmes currently underway.
- Burning stacks of cut material is not recommended because high temperatures can result in long-term damage to the soil. If it is necessary to remove the cut material (e.g. where it poses a fire risk or access problem) then it is best to select one or a few 'sacrificial' areas where the material can be burnt. Areas that are not likely to erode and that are already damaged should be selected for this purpose.
- Larger branches and trunks should be cut into logs and removed from the site – revenue could be generated from their sale as firewood. Burning them on site may pose a fire risk from smouldering logs which can also damage the soil.
- Management actions that maintain basal cover and reduce soil erosion are important tools for maintaining grasslands and keeping them free of invasive species.



- **Avoid any damaging land-use in remaining patches of primary grassland:** Wherever possible, primary grasslands should be kept in a natural or near-natural state and should be managed to avoid degradation. Many grassland ecosystems have been highly modified and fragmented, and this means that the remaining intact grassland in these ecosystems becomes important to conserve. To prevent habitat loss passing thresholds of concern, the following should be considered when planning land-use in intact primary grasslands:
 - Find alternative sites wherever possible; position impacting land-uses in areas that have been previously modified, e.g. old fields.
 - Avoid placing developments within the last remaining large expanses of grassland: where there are several options for siting a development, choose the habitat that is already more fragmented or locate development at the edge of large, intact areas.
- **Avoid those parts of the landscape that are either species-rich, or particularly vulnerable to disturbance:** In these areas, avoid land-uses that may cause irreversible habitat loss or degradation of grassland ecosystems. Particular attention should be paid to:
 - Steep slopes and land-slide zones: these are vulnerable to disturbance and erosion. The risk of erosion increases with the gradient of a slope and erosion of part of a slope can affect all areas down-slope of the eroded area. In these situations (for example, the construction of telecommunications infrastructure and access roads), planning and project design must pay particular attention to preventing erosion and slope failure (both of which, in turn, can facilitate infestation by invasive alien plants).
 - Ridges, soil interfaces and rocky or naturally moist areas: these areas often retain higher levels of habitat and species diversity and should not undergo land-use change if they are still in a natural state. Advice should be obtained from a biodiversity specialist or the provincial conservation agency if a project is being planned in such areas.
 - High water-production areas and catchments in priority river systems (as determined by provincial biodiversity plans, NFEPA and other related products): these should be protected from any land-uses that will harm catchment functioning.
 - Wetlands and riverine areas: these should be protected by low-impact buffer zones and kept in a natural or near-natural state, as they are key corridors for animal movement and play a critical role in regulation of water flows and groundwater recharge; they also serve as valuable breeding sites for certain species.
- **Minimise bird strikes when siting power line corridors and wind farms:** Power lines and wind turbines may impact on large birds, and organisations such as the Endangered Wildlife Trust and BirdLife Africa should be consulted when designing power line corridors to ensure that new power lines don't coincide with known bird flight paths. This also applies to the selection of sites for wind farms.
- **Consolidate land-use activities within a property or landscape:** Nodal development is preferred to situations in which developments or land-uses are scattered across the landscape. Land-use activities or infrastructural development should be consolidated and clustered towards the periphery of a site (where possible); contiguous blocks of grassland in a natural state should be maintained within the development footprint. Management burns are also less risky and controversial when developments are clustered instead of being spread out through a landscape.
- **Link natural and near-natural areas by means of corridors:** No impacting land-uses should be planned within corridors. These corridors should be as wide as possible, to provide cover for larger animals. Ridges, mountains and rivers with intact riverine vegetation can provide effective natural corridors. Any current, regional systematic biodiversity plan should be consulted when planning the network of corridors in the landscape.



- **Avoid ribbon development along roadways:** The routing of roads needs to be carefully planned to minimise fragmentation or loss of intact grassland habitats through ribbon development.
- **Pay special attention to wetlands, riverine areas and forests,** using the guidelines for these ecosystems provided in Chapter 6, 7 and 8.

6 What indicators can be used to assess and monitor the impact of management on grassland biodiversity?

Monitoring can be carried out for different purposes and at different scales by different people and institutions. At the landscape scale, it would usually be the regulatory authorities (e.g. provincial government departments or their agencies) who would be responsible for monitoring, whereas at site level it would be the specific land manager or user who would most likely be involved. Monitoring can be carried out to:

- Evaluate capacity to plan for and manage grasslands, i.e. find out if the resources and capacity are available to do what is required for best practice.
- Assess planning and management activity, i.e. establish if the management objectives are being achieved.
- Understand trends in land-use change using landscape-level indicators.
- Monitor the biodiversity health of the grassland itself, i.e. establish how the landscape is responding to management.

Intentional management of grassland implies that there is some desired state or goal that the land manager is aiming towards. It is vital to have a monitoring programme in place that provides feedback so that the management plan can be adapted as time goes on. In the planning environment, the biodiversity targets are set during the systematic biodiversity planning process.

Monitoring capacity

It is important to monitor the willingness and capacity to plan properly for the sustainable future of grasslands. Indicators that can be used to assess capacity and willingness include:

- Capacity, commitment and budget to produce reasonable land-use plans.
- Willingness of managers to make decisions in favour of protecting grasslands from poor land-use decisions if it is justifiable.
- Capacity to design and implement a comprehensive management plan and implement any changes that are indicated by monitoring.
- Management effectiveness.

Monitoring the planning activity per management authority

Many management authorities are not equipped with even the most basic of planning systems and often do not have qualified staff to advise the planning processes. An assessment every five or so years should identify whether there are gaps in the human resources and systems in the planning authority.

Monitoring the landscape integrity of grasslands

Monitoring should be carried out at the scale of provinces, district and local municipalities so that it is easy to identify where the greatest rates of change are occurring and whether there are problems in the decision-making process in that sphere of administration.

Simple landscape-level indicators include:

- Changes in land cover.
- How much natural grassland remains unmodified.
- Which areas have the greatest rates of change?

Measures of the decision-making process include:

- The number of applications for land-use change received and approved.
- The area of land undergoing land-use change.
- The number and area of illegal or unplanned land-use changes.





Monitoring the biodiversity integrity of grasslands

As with any biological ecosystem, it is possible to monitor ecological aspects of grasslands that tell a story of what is happening 'under the hood'. The aim of biodiversity monitoring is to understand whether the grassland is being compromised by some management or land-use activity, such as grazing and burning. Some general guidelines for monitoring biodiversity in grasslands include:

- **Monitor over time:** It can be difficult to measure change without having a series of measurements over time that shows the direction of change starting from a baseline assessment. The baseline may not be the ideal, but it is the starting point, and later measurements will show whether the system is deteriorating or improving under the current land-use practice and management. Grassland systems change relatively slowly (in a 5-25 year time frame), so there has to be commitment to ongoing monitoring for long periods of time.
- **Monitor at the right time:** Biodiversity surveys should be carried out during the summer months when most annuals and bulbs are flowering, and follow-up surveys should be carried out at more or less the same time of year.
- **Use comparisons with grassland known to be in good condition:** In an ideal situation, it is very helpful to have a near-perfect, 'intact' portion of grassland nearby (that is of the same type) that can be used as a reference point against which to measure change in the 'managed' or impacted grassland. However, in most grassland there has been a long history of grazing, and there are very few places where there are substantial portions of intact grassland remaining. In such areas, start with a baseline assessment of the current condition of the grassland and measure future change against this.
- **Select indicators carefully:** It is important to have indicators that are:
 - Simple and inexpensive to measure, i.e. do not require specialists.
 - Measureable and sensitive to change so that a small change in the management drivers will be reflected in the indicator.
 - Reliable, so that they always respond in the same way to the same drivers.
 - Targeted, meaning that they are specific to land-use change drivers so that the indicator will only respond to the driver and not to the many other influences, such as climate change.



Biodiversity indicators that can be used in all grassland ecosystems:

In general, monitoring the impact of management actions on grassland ecosystems has focused on plant and soil indicators, and not animals due to the difficulty in drawing conclusions from animal presence or absence – animals are generally very mobile, and in many cases require specialists to identify them. There has, however, been some promising work on the use of key bird species and dragonflies as indicators of ecosystem health, but this will not be covered here.

Easily-measured indicators that respond readily to changes in management, and that can be used in all grassland ecosystems, can be divided into two groups:

- Plant species and growth forms that appear or disappear under poor management.
- Vegetation structure, soil and water indicators that reflect changes in the whole ecosystem.



‘Decreasers’ and ‘increasers’: Many of the plants in grasslands are sensitive to the pressures of inappropriate grazing and burning and are quickly lost from the ecosystem (over 5-15 years or so) if the conditions are not right – this has been the subject of much scientific research. All grass species have been classified either as ‘decreasers’ or ‘increasers’, depending on whether they come or go under different land-use practices or management regimes – decreasers are the palatable species that decrease or disappear in response to high grazing pressure, and increasers are the unpalatable species that become more dominant as grazing pressure increases (lists of these species can be accessed in any textbook or manual on grassland science). Loss of palatable species from the ecosystem is a sign of degradation.

Forbs and bulbs: The group of non-woody and non-grass plants called forbs, are generally susceptible to inappropriate grazing and burning and, with few exceptions, will start to decrease under poor management. Any grassland that shows any of the following characteristics is showing signs of stress and the management should be adjusted to relieve grazing or burning pressure:

- Very few species of forbs or bulbous plants (geophytes).
- A decrease in the proportion of forbs and bulbs relative to the grasses.
- Dominance by only one or a few forb species.

Invasive alien species and weedy indigenous species: Intact, healthy grasslands are usually resistant to infestation by invasive plants or non-grassland species, but not under conditions of inappropriate grazing and burning. The types of changes that take place include:

- Infestation by invasive alien species such as wattle, pine, triffid weed and bramble.
- Increasing dominance of indigenous tree species such as various types of *Acacia* (e.g. Sweet Thorn) or Ouhout (*Leucosidea sericea*) - this is typically called bush encroachment.
- Increasing dominance of woody karroid shrubs or other weedy indigenous species such as slangbos (*Seriphium plumosum*) and bracken fern (*Pteridium aquilinum*).



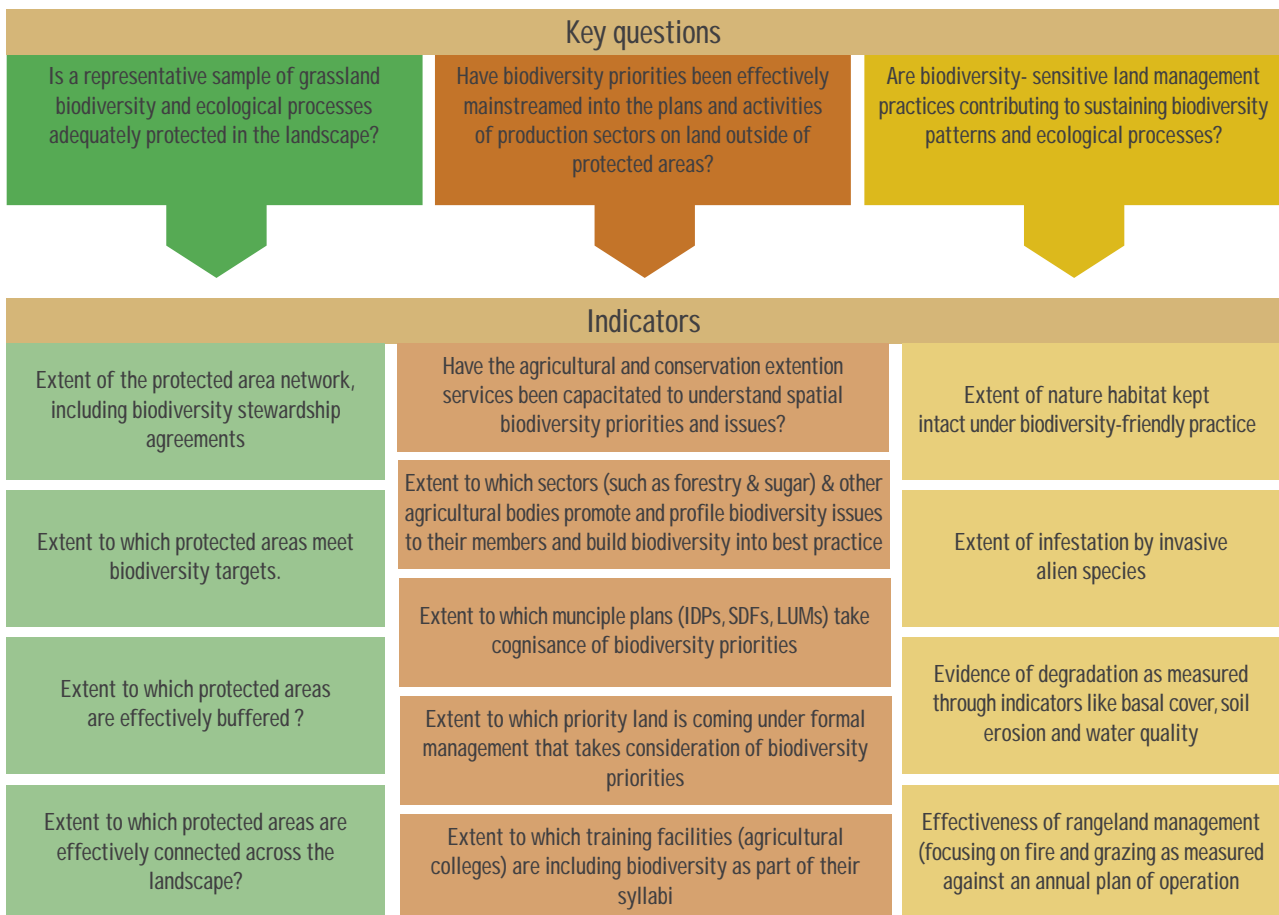
When such changes become apparent in grassland, it is already past time to act and an immediate response is required. It is important to note that the encroaching woody plants are not the cause of the problem, but the result of inappropriate management. Although scientists do not all agree on the role of increased atmospheric carbon dioxide and climate change in increasing woody plants in grasslands, there is little debate that inappropriate management can worsen the situation.



Vegetation structure, soil and water indicators: Changes in species and growth forms are associated with more long-term changes in the structure of the ecosystem. These changes are usually more difficult to notice and are harder to reverse. When they are noticed, it is a clear signal for immediate action, mainly by reducing stocking rates, and adapting other components of the existing grazing and fire management regimes. The most important signals are:

- The extent of modification of individual vegetation types, protected area buffers and areas designated as biodiversity priority areas in systematic biodiversity plans.
- Loss of large, unfragmented areas of intact grassland and ecological corridors.
- Changes in vegetation structure (as indicated by fixed point photography), such as a shift from an even sward (healthy) to tussock veld (degraded).
- Visible signs of accelerated soil erosion and increased sedimentation in rivers and streams.
- Decrease in aerial and basal cover.
- Declining water quality in rivers and the water emerging from wetlands.
- Changes in flow patterns, including the amount of water, or changes to base flows.

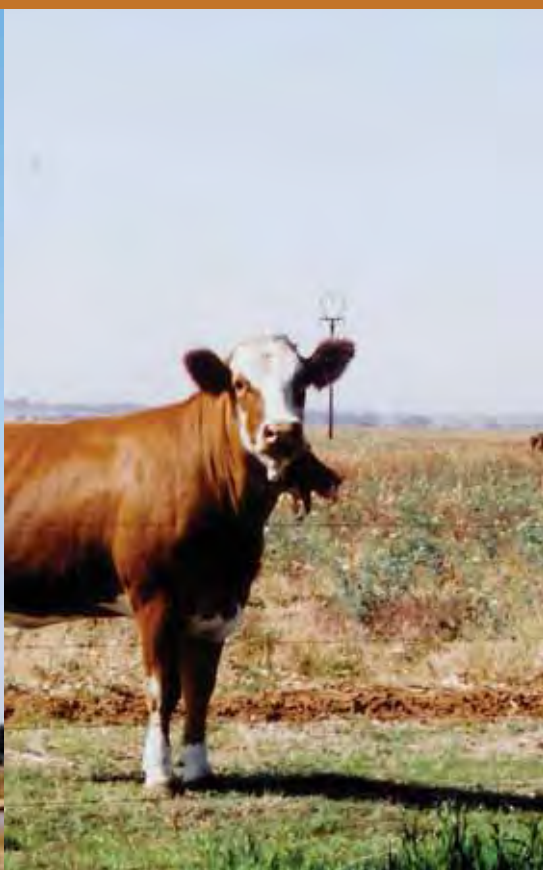
Figure 10. Illustration of some indicators that can be used to assess how effectively grassland biodiversity and associated ecosystem processes are being managed and conserved.







5.2. Dry Highveld Grassland



5.2. Dry Highveld Grassland

Snapshot of Dry Highveld Grassland

General characteristics of this group of ecosystems are that they:

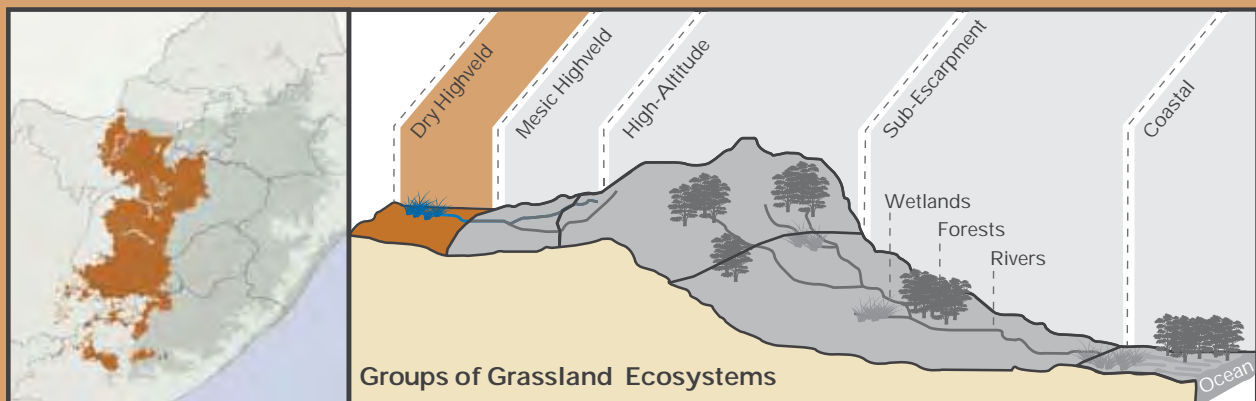
- Occupy the central plateau of the country, extending over much of the Free State, and into the North West Province, with smaller areas in the Eastern and Northern Cape as well as Gauteng.
- Comprise 14 national vegetation types, but are dominated spatially by Central Free State Grassland and Vaal-Vet Sandy Grassland (see Chapter 9.2 for full list), and include some shrublands on rocky koppies and slopes.
- Are dominated by semi-arid sweetveld that is drought-adapted and shows a significant amount of reproduction from seed; plants persist vegetatively from year to year but new plants establish after droughts from dormant seeds.
- Occur at mid-altitudes of 1 300 -1 600 masl, where the topography is mostly flat to undulating, broken occasionally by rocky ridges, small outcropping mountains and river valleys.
- Are adapted to a climate that is temperate, with a moderate to high frequency of frost (20 – 50 frost days per year) in winter.
- Occur where rainfall is strongly seasonal, falling mainly in summer, with low mean annual precipitation (400 – 550 mm); drier parts of the region (towards the west) show greater variability in rainfall.
- Underlying geology is dominated by sandstones and mudstones, giving rise to deep, red soils; dolerite sheets are associated with shallower, stony soils, whilst in the west, shallow red sands over layers of calcrete occur.

Conservation:

- Includes 5 threatened vegetation types (see Chapter 9.2).
- Little is under formal protection, and much has already been irreversibly modified.

Socio-economic importance:

- Important for agriculture (particularly maize), rangeland (sheep and cattle) and mining (gold).



1 What are the main ecological characteristics of Dry Highveld grassland?

- **Climate:** Dry Highveld grasslands are fundamentally different from all of the other grassland ecosystems, largely due to their significantly different climate. Even though the winters are cold and frosty, the defining climatic difference is the low and highly variable summer rainfall. In this semi-arid ecosystem, water and not the duration and temperature of the growing season is the limiting factor to growth.
- **Grazing:** The unpredictable semi-arid climate, combined with nutrient-rich (unleached) soils, results in nutritious sweetveld; although this grassland is slow-growing (due to low rainfall), it can support animal production year-round. Grazing is an important 'driver' in these systems,



- **Plant life-histories:** The life-histories of plant species in this ecosystem are driven primarily by adaptation to drought. Most of the species are perennial and long-lived, persisting vegetatively over long periods. However, a significant amount of reproduction also takes place through seed production. This means that plants are able to persist in the form of dormant seeds in the seed bank through periods of drought, and this has important implications for veld management. It also allows for interesting cyclical shifts in species composition, such as when Karoo-like (karroid) shrubs spread into the more arid (western) parts of these grasslands during drier cycles, but are replaced by grasses again when periods of higher rainfall return. Because seeds can lie dormant for some time, these grasslands are quite resilient to impacts over a short-term (five-year) period, and may be expected to recover from inappropriate management within the course of several growing seasons, if topsoil has not been lost.
- **Fire:** This plays an important role in maintaining these sweetveld grasslands, but it is not as important as grazing. Because sweetveld grasslands have slow growth rates they recover slowly after fire events, although the fuel load rarely has the chance to build up enough to result in regular, intense fires.
- **Encroachment by invasive woody species:** Bush encroachment is largely limited by fire, coupled with the effects of low rainfall and the occurrence of frost – tree seedlings are either killed by fire or stunted by successive, severe frosts and/or lack of water. If the grass biomass is reduced by sustained grazing or decreased fire intensity, bush encroachment by trees such as *Acacia karoo*, or woody karroid shrubs (such as *Pentzia* and *Felicia* species) can occur.
- **Underlying geology:** This is an important determinant of biodiversity patterns and ecological processes. In particular, the presence of dolerite sheets gives rise to ecologically sensitive plant communities that show high levels of species richness and endemism.



2 What are the main issues, vulnerabilities or pressures in Dry Highveld Grassland?

Of particular concern in these systems is overgrazing, expansion of commercial cultivation and mining; quarrying and urban sprawl have more localised impacts in certain areas:

- **Overgrazing:** These nutritious sweetveld grasslands are highly susceptible to overgrazing and have undergone some of the worst denudation of any grassland ecosystem in South Africa. This vulnerability stems from the fact that that sweetveld maintains high nutrient content year-round and is therefore often used for grazing without any rest; also, the slow growth rate of the vegetation means that Dry Highveld Grassland recovers slowly from the impacts of grazing.
- **Commercial cultivation of grain crops:** Because large expanses of Dry Highveld Grassland have been modified through cultivation of crops, only small, disconnected fragments of natural grassland remain.
- **Loss of habitat due to gold mining:** In the West Rand and Welkom areas, mining and its associated industries have resulted in irreversible modification of large areas of Dry Highveld Grassland, although fragments of Vaal-Vet Sandy Grassland do remain intact between the various mines.
- **Acid mine drainage:** This impacts on the streams and rivers that drain catchments of the West Rand area.
- **Quarrying:** Along most of the municipal, provincial and national routes, borrow-pits and quarries occur. Most of these quarries are smaller than about 2 ha and are usually close to roads, which means that their impacts are quite localised; however, their cumulative and induced impacts need to be monitored.



- **Urban sprawl:** Certain vegetation types in and around Mangaung are significantly impacted by urban expansion, although this poses less risk elsewhere.

3 What are the signs of healthy Dry Highveld Grassland?

In addition to the general signs of healthy grassland given in Section 5.1, healthy Dry Highveld Grassland is characterised by:

- Undulating plains characterised by stands of Red Grass (*Themeda triandra*). In the higher rainfall areas Finger Grass (*Digitaria eriantha*) should also be prevalent and, in areas of lower rainfall and sandy soils, Borseltjie Grass (*Antheophora pubescens*) should be abundant.
- Few or no karroid shrubs, although the shrubby component of these grasslands can vary naturally with topography (with shrubby species common on south-facing ridges) and in response to seasonal variation in rainfall. If the number or extent of karroid shrubs keeps increasing, then this is an indicator that the grassland is becoming degraded.

4 What are the management best-practices and minimum ecological requirements in Dry Highveld Grassland?

In addition to the general management best practices and minimum ecological requirements described in Section 5.1, the following ecosystem-specific recommendations apply in Dry Highveld Grassland:

- **Burning:** Because rainfall and productivity are unpredictable, it is difficult to set out burning frequency rules for Dry Highveld Grassland; in general, and in the absence of more specific information, the following rules of thumb can be applied:
 - These semi-arid systems should only be burnt when the build-up of the grass sward reaches a predetermined point, as measured with a pasture disk meter, and when there is a clear reason for burning.
 - A burning interval of approximately 10 years should be applied.
 - Burning should take place in late winter, and only in seasons that have been wet enough to ensure enough biomass to support an intense fire.
- **Grazing:** Small animals are as important as the bulk grazers in maintaining the vegetation structure, habitat diversity and nutrient cycles that give these systems their character. These grasslands should be managed to maintain the habitat diversity that allows a range of natural herbivores to persist. (The natural grazing regime of these systems would have included grazing impacts at a wide range of spatial scales, ranging from individual grass plants grazed by small animals like insects or small rodents, through patches grazed by tortoises or solitary antelope, to large tracts of land grazed episodically by herds of springbok or buffalo).

Other general recommendations for managing grazing include that:

- These grasslands can be grazed commercially, but require a 'responsive' management system that can be adapted to the high level of climatic variability found in these systems.
- Rotational grazing systems are recommended for commercial animal production; grazing intensity should be manipulated by adjusting camp numbers, the stocking rate and periods of stay/rest.





5 What are the broad spatial guidelines for locating land-uses in Dry Highveld Grassland?

In addition to the general spatial guidelines described for all grassland ecosystems in Section 5.1., the following recommendations are made for Dry Highveld Grassland:

- **Vegetation types on dolerite and sandstone should be maintained in a natural state:** Dolerite sheets supporting Bloemfontein Karroid Grassland and sandstone outcrops should be kept in a natural state – they should be treated as ‘no go’ areas for land-uses that result in habitat loss or degradation.
- **Avoid habitat loss in threatened grassland vegetation types:** Threatened vegetation types such as Bloemfontein Dry Grassland and Vaal-Vet Sandy Grassland are highly fragmented and there should be no further habitat loss, or ploughing, in these vegetation types without proper impact assessments.



6 What indicators can be used to assess and monitor the impact of management on biodiversity in Dry Highveld Grassland?

Beyond the broad guidelines provided in the answer to this question in Section 5.1, there are a few specific guidelines for monitoring in Dry Highveld Grassland, as follows:

- **Changes in species composition and dynamics:** These changes can indicate habitat degradation. Plant surveys should be carried out to assess species composition, and the data should be compared with a reference site to determine the extent of degradation taking place. Degraded grasslands are characterised by an absence of Red Grass, Finger Grass and Borseltjie Grass, and dominance by unpalatable species such as wire grass (*Aristida*) and some species of *Eragrostis* (*E. lehmaniana*).
- **Endangered animal species:** A decline in populations of endangered animals such as Sungazer Lizards (*Cordylus giganteus*), and grassland birds such as bustards, korhaans, larks and pipits, is a sign that the ecosystem is becoming degraded.





5.3. Mesic Highveld Grassland



5.3. Mesic Highveld Grassland

Snapshot of Mesic Highveld Grassland

General characteristics of this group of ecosystems are that they:

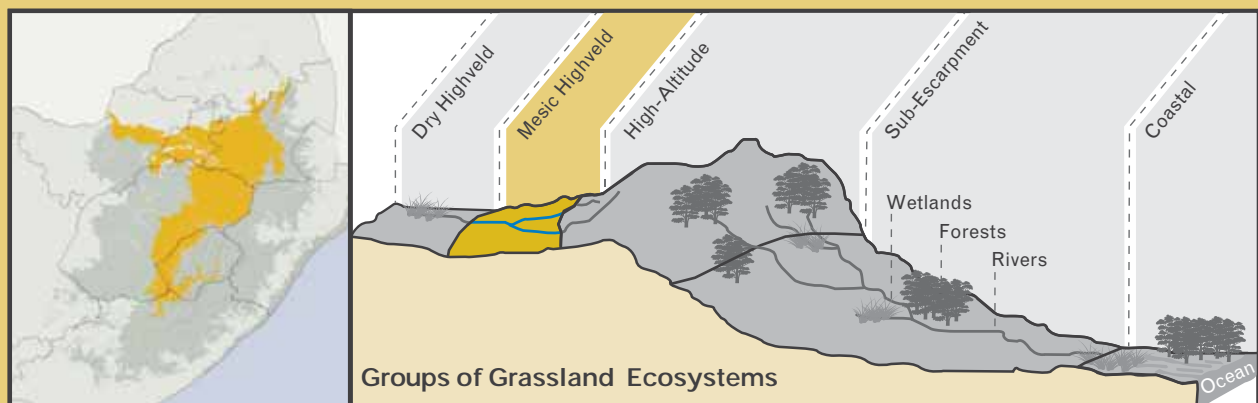
- Are located in the eastern, higher rainfall parts of the Highveld, covering much of Gauteng, the Eastern Free State, much of Mpumalanga and extending slightly into neighbouring parts of the Eastern Cape, and Lesotho.
- Comprise 17 national vegetation types (see Chapter 9.2).
- Are made up of highly productive sourveld grasslands characterised by long-lived grasses that favour re-sprouting, and other plants that show a tendency to store carbohydrates in specialised underground storage organs; plants withstand above-ground disturbance by being long-lived with only occasional replacement from seed.
- Are adapted to a climate characterised by high summer rainfall (700 – 1 200 mm mean annual precipitation), combined with warm summer temperatures and cool to cold winters with a moderate to high incidence of frost.
- Occur at mid-altitudes (1 300 – 1 800 m) in varied landscapes that include extensive flat or undulating plains broken by low hills and 'tafelbergs, rocky outcrops, steep boulder-strewn slopes and deep river valleys.
- Occur on soils that are generally deep, fertile and free-draining but can have impervious layers of hardpan or 'oukclip' (impervious soil layers, often infused with minerals such as calcium carbonate or iron oxide). The diversity of soil types is influenced by the underlying geology which includes base layers of sedimentary rock (shales, mudstones and sandstones), cut through by dykes and ridges of dolerite, quartzite and gabbro.

Conservation:

- A high proportion of vegetation types in Mesic Highveld Grassland are considered to be threatened and this ecosystem group is generally poorly protected (see Chapter 9.2).

Socio-economic importance:

- Many key economic activities take place in this grassland ecosystem – mining, grazing, cultivation, plantation forestry and urban settlement; Mesic Highveld grasslands are key water production landscapes – many wetlands and pans and five major river systems have their origin in these grasslands.

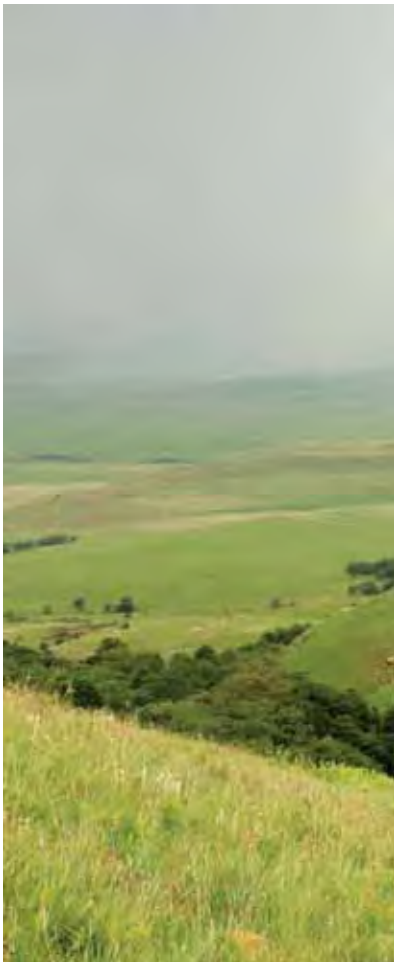


1 What are the main ecological characteristics of Mesic Highveld Grassland?

- **The climate** is characterised by warm, wet summers and cool, dry winters; this, combined with the effects of altitude, results in:
 - A long growing season (centred over summer) lasting about six to seven months, alternating with unproductive winter and early spring seasons.
 - High primary productivity leading to rapid build-up of biomass, resulting in a high fuel load and potentially intense fires.
- **High natural incidence of fire:** Summer weather is characterised by frequent storms, and lightning strikes, which cause natural fires. The natural occurrence of fire, combined with the effects of frost and hail storms, maintains the open, largely treeless character of these grasslands (except on rocky ridges, which support natural shrublands because the surface topography favours the growth of woody species over grasses).



- **Grazing:** Mesic Highveld Grassland is reasonably well adapted to grazing pressure under low to moderate stocking rates with adequate rest periods.
- **Life-history strategies:** The combined summer grazing/winter burning disturbance regime has resulted in vegetation dominated by plants that are perennial and long-lived, and that reproduce mostly by vegetative growth with only occasional replacement from seed. There are few annual species found in mesic grassland. This means that these ecosystems do not recover well when areas are cleared, as the newly-disturbed ground is rapidly colonised by other annual weeds that out-compete slower-growing, perennial grasses.
- **Hydrological characteristics:** Mesic Highveld grasslands are located in high rainfall regions and are vitally important for water production. The characteristically dense vegetation cover traps surface water, slowing run-off and allowing more time for water to drain vertically through the porous soil profile; this water is then stored as sub-surface water by the impermeable rock layers that lie beneath the subsoil. This sub-surface water drains slowly as clean water into the many wetland systems that occur throughout this ecosystem (as a result of its flattish topography), replenishing streams and rivers almost year-round. The supply of good quality water from these ecosystems is important for domestic, agricultural, industrial and commercial water users both in South Africa and neighbouring countries.
- **Underlying geology:** The diverse geology underlying Mesic Highveld Grassland correlates closely with high levels of plant species richness and endemism. The soils derived from the diverse types of parent rock vary in texture from sandy to clayey and the sandier soils tend to support lower basal cover but higher plant species diversity than less sandy ones.



2 What are the main issues, vulnerabilities or pressures in Mesic Highveld Grassland?

Any activity that disrupts the hydrology in Mesic Highveld Grassland, such as reducing vegetation cover, disrupting the soil profile, and modifying water runoff or filtration through the soil, is likely to have far-reaching impacts for these ecosystems, the services they deliver and the people and economic activities that depend on them.

The main concerns in these grasslands arise from the expansion of activities such as coal-mining, commercial agriculture and unplanned urban development.

- **Mining and associated activities:** Coal mining, especially strip-mining (which is expanding rapidly in Mpumalanga), removes the primary vegetation and modifies the soil profile. In addition to local impacts, these activities are likely to affect hydrology and water production at a landscape level. Deep, underground coal mining penetrates the water table and can lead to widespread subsidence, although the implications and knock-on effects of this are not well-understood. Other mining-related impacts include:
 - o Pollution of water bodies: deep acid saturation from coal mines is having negative impacts on the health of wetlands and river ecosystems, and affects the ability of these systems to produce clean water. This is made worse by increasing pollution from other point and non-point sources, examples being an influx of nutrients, dissolved salts and other undesirable substances from under-performing urban sewerage treatment plants or intensive agriculture. This holds serious implications for the health of people who rely on this water, both in South Africa and Mozambique where rivers are fed from catchments in Mesic Highveld Grassland.
 - o Acid rain associated with industry and coal-fired power stations increases soil pH and nitrogenous inputs into primary grasslands, which has a negative effect on grass species important for grazing, such as Rooigras (*Themeda triandra*).



- **Commercial crop production:** The footprint of cultivated lands in mesic grasslands is currently stable, but it is possible that increasing demand for biofuels may lead to expansion of the land under large-scale, commercial cultivation. Also, as more and more agricultural lands are mined, the demand for additional land for cultivation increases, and relatively under-developed communal areas may be targeted for expansion of commercial crop production. If so, planners and decision-makers should work together to ensure an integrated approach to land-use planning and development, to ensure that critical grassland ecosystems are not lost in favour of agriculture on marginal lands, where the viability of such activities would be questionable.
- **Urban sprawl:** Mesic Highveld grasslands happen to be home to some of the major urban and economic centres of the country, such as Johannesburg in Gauteng. The trend of rapid urbanisation, and its associated growth in demand for infrastructure, can cause increasing habitat loss and fragmentation of landscapes if it is not carefully planned. In many instances, the growth is associated with extensive informal peri-urban sprawl and undesirable ribbon development along main roads.

3 What are the signs of healthy Mesic Highveld Grassland?

In addition to general signs of healthy grassland ecosystems provided in Section 5.1, indicators of health in Mesic Highveld grasslands include:

- The presence of numerous geophytes.
- A high diversity of flowering plants other than grasses.
- Low frequency or occurrence of *Hyparrhenia* and related grasses.
- Intact, healthy wetlands and river ecosystems.
- Healthy populations of grassland animals, especially birds and butterflies.



4 What are the management best-practices and minimum ecological requirements in Mesic Highveld Grassland?

In addition to the general management best practices and minimum ecological requirements described in Section 5.1 above, the following ecosystem-specific recommendations apply to Mesic Highveld Grassland:

- **There should be no further loss of habitat in this ecosystem group:** In particular, all large remnants of Mesic Highveld Grassland need to be maintained in a natural state and should be carefully managed for the persistence of biodiversity; large areas of natural habitat are needed for the many species of birds, plants and numerous wetlands that Mesic Highveld Grassland supports.
- **Burning:** In general, the burning requirements and responses of all mesic grassland types (Mesic Highveld, Sub-Escarpment and High-Altitude ecosystems) are similar, but differ markedly from those of Dry Highveld and Coastal ecosystems. In addition to the general burning guidelines provided in Section 5.1, the following should be noted:
 - o The diversity of fire-tolerant wild flowers in mesic grasslands will be promoted by including a range of fire frequencies that are more diverse than the agriculturally-advocated biennial spring burns.
 - o Patch mosaics of predominantly two to three year fire intervals (although longer burn intervals should also be included) appear to be the best-practice for promoting plant diversity in mesic grasslands
 - o Fuel load is the main determinant of when to burn. Burning should take place between May and August (depending on biomass, rainfall, wind patterns and other safety factors).



- **Grazing management should be flexible in response to the condition of the veld and prevailing conditions.** It should be noted that:
 - Mesic Highveld Grassland can sustain commercial grazing, but stocking rates must remain within agricultural norms.
 - Both the grass and forb communities in these ecosystems are well-adapted to relatively frequent above-ground disturbance, for example through grazing and fire, but they are vulnerable to any disturbance that kills the plant, such as ploughing or intense grazing that damages the roots, as re-establishment from seed is rare.
- **Mesic Highveld Grassland should be managed as water-production landscapes:** All wetlands and their catchments are important. Both land-based management and direct management of wetlands should focus on avoiding activities that may interfere with water flow, infiltration or groundwater recharge. All land-use applications should include an accurate, ground-truthed map of wetlands in the landscape as part of any EIA scoping procedure – the scoping assessment should include wetlands that fall within the site of the proposed land-use as well as any off-site wetlands that may be affected by the proposed activities.

5 What are the broad spatial guidelines for locating land-uses in Mesic Highveld Grassland?

In addition to the general guidelines for all grassland ecosystem groups provided in Section 5.1, the following recommendations are made for Mesic Highveld Grassland:

- **Avoid any further fragmentation of primary grasslands:** Wherever possible, infrastructure development, or other impacting activities, should be directed towards existing disturbed lands (unless these have been earmarked for rehabilitation) and should be directed away from grassland containing habitats or species of special concern.
- **Maintain connectivity between natural areas across the landscape:** Establish corridors of natural grassland that can be connected throughout the landscape to maintain populations of birds and mammals, and to allow ecological processes that operate at large scale to function.
- **Establish and respect buffers around protected areas, wetlands and rivers:** In areas such as the Chrissiesmeer Panveld, these buffers need to be at least 200 m wide and mining should not be allowed – the area is unique because of its number of freshwater pans (many other pans are brackish); furthermore, the underlying geology shows high potential for acid mine drainage, which would result in acidification of the pans (as they have no free-flowing outlets).
- **Direct impacting activities away from grasslands on dolomitic substrates:** Land-uses other than biodiversity conservation should be directed away from grasslands on dolomites, especially around Gauteng – these contain large karst cave systems and lowering of the water table by extractive land-uses may lead to increased subsidence of soils and the formation of sinkholes.
- **Mitigate the impact of urban sprawl:** Best practices for mitigating the impact of urban sprawl include the establishment and maintenance of strong urban edges, well-planned open space systems that incorporate biodiversity priority areas, and a strong enabling environment for planning, managing and monitoring these areas.





6 What indicators can be used to assess and monitor the impact of management on biodiversity in Mesic Highveld Grassland?

The general indicators described under Question 6 in Section 5.1 for all grassland ecosystems, can be applied reliably to monitor the impact of management on biodiversity in Mesic Highveld Grassland. However, of particular importance in this group of ecosystems are:

- Any indicators that signal deterioration in the health of rivers and wetlands: These indicators include changes in the structure or function of wetlands, loss of wetland or riverine habitat, any deterioration in the quantity or quality of water entering or leaving wetlands and rivers and any increase in the presence of invasive alien species.
- Any signs of increased soil erosion or disruption of the soil profile (see Section 5.1 for details).
- A decline in populations of rare, endemic and threatened species, such as Rudd's Lark, the African Grass Owl, Giant Sungazer lizards, and antbears.





5.4. High-Altitude Grassland



5.4. High-Altitude Grassland

Snapshot of High-Altitude Grassland

General characteristics of these ecosystems are that they:

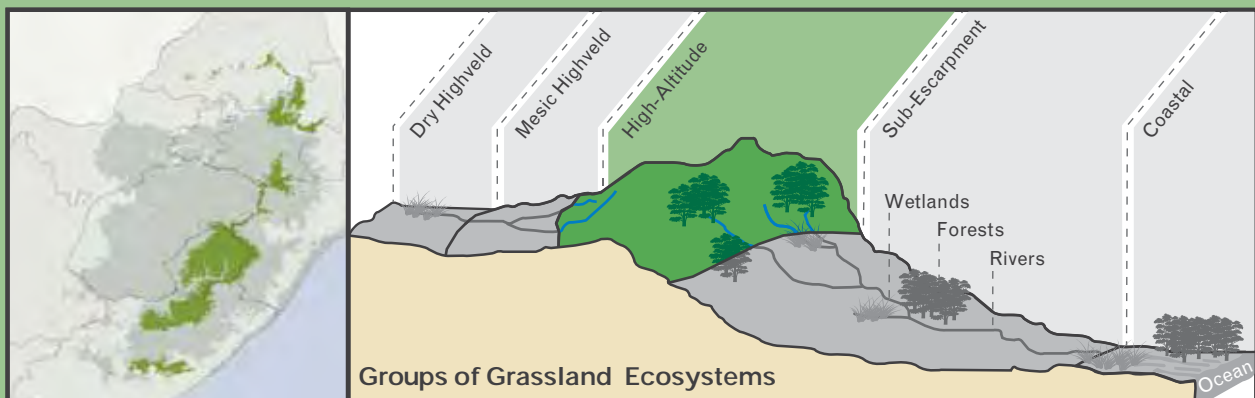
- Are one of seven centres of endemism that have been identified in South Africa, (i.e. a large proportion of the species in this group of ecosystems is found nowhere else).
- Comprise 22 national vegetation types, with Lesotho Highland Basalt Grassland covering the largest area (see Chapter 9.2).
- Are made up of high altitude, sourveld grasslands (mostly) dominated by slow-growing grasses that favour re-sprouting rather than reproducing by seed, and show a low tolerance for disturbance. Some parts of the Mpumalanga escarpment (e.g. Northern Escarpment Quartzite Sourveld) show faster growth rates, due to higher rainfall, slightly lower altitudes and less frost than is experienced in other high-altitude areas.
- Two broad sub-units are identified based on altitude:
 - Escarpment grasslands (1 400 – 1 800 masl), incorporating the highlands of the Eastern Cape, the escarpment of KwaZulu-Natal and Lesotho, the KwaZulu-Natal/Free State border and up into the highlands of Mpumalanga.
 - Alpine grasslands (>1 800 masl), concentrated in the Eastern Cape highlands, the high escarpment of KwaZulu-Natal and Lesotho, and with northern outliers on the summits of mountains in Mpumalanga (such as Long Tom Pass, Steenkampsberg and Mariepskop).
- Occur in areas with topography that includes high-altitude plateaus, mountain peaks and slopes, hills incised by gorges and deep river valleys and undulating plains.
- Are adapted to high precipitation due to snow, frost and mist and rainfall that occurs mostly in summer; in some parts of the escarpment, mean annual precipitation varies from 1 200 – 1 500 mm, with peaks in excess of 2 500 mm occurring at about three year intervals.
- Occur in areas of cool to very cold climate, with a high proportion of frost nights per year, although some parts of the Mpumalanga escarpment experience slightly milder climate with few frost night per year.
- Occur on alkaline soils derived from volcanic basalt rock, leached of nutrients due to high rainfall. The underlying geology includes basalt interspersed with dolerite, dolomite, quartzite and shale, each of which support specialised plant communities.
- Exhibit high levels of endemism in both plant and animals species, and a very rich forb component to the vegetation.

Conservation:

- This grassland ecosystem exhibits high levels of endemism in both plant and animal species (i.e. many species occur only in this grassland). Beyond the boundaries of the Maloti-Drakensberg World Heritage Site few of the vegetation types enjoy any kind of formal protection.

Socio-economic importance:

- High-Altitude grasslands include some of our most important Strategic Water Source Areas and so are of importance for South Africa's water security. The Maloti-Drakensberg catchments represent the single most important source of water for South Africa's industrial and mining heartland of Gauteng. Other key catchments along the escarpment play a similar water provisioning role, and an energy-generation role through pump storage schemes.
- Many rural communities are dependent on these grasslands for grazing for their livestock.





1 What are the main ecological characteristics of High-Altitude Grassland?

- **Climate:** This is the primary ecological driver in these ecosystems, with temperature (not water availability) the most important factor limiting growth, especially in the alpine zones. High-Altitude grasslands are well-adapted to a harsh climatic environment characterised by cool to very cold temperatures, a high incidence of severe frost, and high levels of precipitation (in the form of rainfall, snow and mist), with rainfall occurring mostly in summer. The effects of this are:
 - A relatively short growing season (< 4 months), although some vegetation types occurring on quartzites at lower altitudes, and the whole of the escarpment, zone shows a longer growing season (up to six months).
 - Predominance of vegetation communities that are relatively slow-growing and favour vegetative growth and re-sprouting rather than reproducing by seed.
 - Lowered primary productivity and relatively low leaf mass; at lower altitudes (in the escarpment zone) productivity is increased particularly on richer dolomite soils.
 - Soils with a high humic content.
- **Primary productivity:** Low primary productivity and relatively low leaf height (and mass) limits animal production in alpine grasslands to four or fewer months of the year. Historically, it is unlikely that grazing animals would have lived in any significant numbers in the alpine or escarpment zones and the vegetation is not well adapted to grazing at pressures anything other than minimal.
- **Life-history strategies:** Escarpment vegetation communities are long-lived, slowly accumulating resources in underground storage organs. They respond slowly to disturbance particularly if the plant root stock is disturbed, or if resources are lost too rapidly – under these circumstances plants cannot easily recover and are likely to die.
- **Topography:** The topography is generally steep resulting in shallow rocky soils and high rates of water run-off, with a high risk of soil erosion. This means that once plant cover has been lost (through over-grazing or ploughing), there is a high risk of erosion and almost no possibility of natural recovery without costly intervention.
- **Underlying geology:** This is an important determinant of species composition; in the alpine zones much of the area is underlain by basalt, interspersed with other rock types including quartzites and dolomites; in the escarpment zones, quartzites, shales, diabase and dolomites dominate.
- **Soils:** These are mostly nutrient-rich, despite the high rainfall and potential for leaching, as the escarpment zone is mostly underlain by volcanic rocks that break down to form nutrient-rich soils. As a result, the plant forage is generally of good quality during the growing season. In the harsh winters the plants move all nutrients from the leaves to the roots, leaving very poor quality forage (sourveld). This means the escarpment zone can only be grazed during the growing season and livestock will have to be moved elsewhere during winter. (Note: in some High-Altitude grasslands of Mpumalanga, the soils are coarse, shallow and nutrient-poor, as they are mostly derived from quartzites).

2 What are the main issues, vulnerabilities or pressures in High-Altitude Grassland?

There are several issues of concern in these grassland ecosystems, including: an increase in shifting subsistence agriculture, mining, poor range management, infestation by invasive alien species, increased off-road driving, changes in land-use patterns and a loss of formal land management. In the escarpment areas of Mpumalanga, afforestation in unsuitable areas is also a concern. These issues are explained below in the context of the vulnerability of these ecosystems to impacts and the pressures they place on biodiversity:



- **Shifting subsistence cultivation:** In the past, most cultivation was confined to below the escarpment due to topographic and climatic factors that limited where crops could be grown. More recently, there has been an emergence of shifting agriculture in the escarpment and sub-escarpment zones as lower fields have become exhausted and insufficient, and as short-season crop cultivars have been developed. In some areas, the main crop is the illegal plant *Cannabis*, which is planted in areas that are unlikely to be easily detected. The small fields are generally ploughed by oxen and are often on relatively steep slopes, making them vulnerable to erosion once the crop is harvested. *Cannabis* crops are grown for a few seasons, until the soil is exhausted, and then a new area is ploughed. The old fields do not recover their natural species diversity due to poor recruitment.
- **Poor rangeland management:** These grasslands are sensitive to overgrazing by goats, sheep and cattle, primarily because their recovery rate is very slow, especially after heavy utilization. The combination of too-frequent fire followed immediately by grazing results in ever-diminishing grass production and increasing pressure on the remaining plants and, eventually, encroachment by non-palatable karroid woody species – this can be a problem in both communal and commercial rangelands. Issues of particular concern are:
 - **Communal grazing:** In areas subject to communal grazing, where there is usually no single management authority, herders attempt to stimulate green-flushes in the grassland by burning two to three times per year, whenever a fire will carry through the grass. This leads to reduced plant vigour and tuft-size, and increased soil erosion. This highly detrimental practice quickly reduces productive grassland to unproductive karroid shrubland. Although the shrubs can be an important source of fuel for local communities, when they are removed the soil is exposed leading to extensive erosion – entire valleys can be devastated in this way. The Lesotho mountains and Drakensberg of the north-Eastern Cape are particularly affected by this issue due to the nature of the communal ‘management’ of the rangeland; there is no easy solution to this complex problem which is deeply rooted in local leadership and governance issues.
 - **Commercial grazing:** High-Altitude grasslands are not adapted to extensive or extended grazing by large herds of grazers (especially selective grazers like sheep). They are sensitive to over-stocking, and have to be carefully managed if they are to sustain economically viable livestock numbers. Agricultural advice has generally focused on sustaining the productive grasses, such as Rooigras (*Themeda triandra*), and has under-emphasised the species-rich forb component. Although the forbs are well-adapted to fire, they are less able to cope with sustained grazing pressure.
- **Localised encroachment by invasive alien plant species:** Several species of invasive alien plants are becoming a problem, largely as a result of poor management of fire and grazing (the climate at higher altitudes would normally keep woody invasive species in check). The most important invasive species in these areas are American Bramble (*Rubus cuneifolius*), Black Wattle (*Acacia mearnsii*) and Gum (*Eucalyptus* species), with Bugweed (*Solanum mauritianum*), *Acacia melanoxylon* and *Acacia dealbata* also becoming a problem.
- **Off-road driving by tourists:** With the increased interest in adventure tourism, foot and animal paths in the highlands of the Eastern Cape, Lesotho and Mpumalanga are increasingly being used as vehicle tracks. This is leading to severe, localised soil erosion due to the steep slopes and shallow, fragile soils. Northern Escarpment Quartzite Sourveld is especially unable to withstand the impacts of vehicles, or any other disturbance, due to the high humic content of the soils. Vehicle tracks leave long-lasting scars in these landscapes.



- **A loss of formal land management:** Complex socio-political and socio-economic issues such as stock-theft, declining security on farms and challenging economic conditions, have led some commercial farmers to abandon their land. This has been the case in the remote border areas of KwaZulu-Natal and the Eastern Cape. The management vacuum that results in the latter case can lead to the problems described under 'communal grazing' above.
- **Afforestation:** Commercial timber plantations occur in many parts of the landscape and represent an important economic activity. In some cases, afforestation has taken place in unsuitable areas, such as Northern Escarpment Dolomite Grassland in which the loss of ground water as a result of afforestation has resulted in a decreased flow of water to karst cave systems.



3 What are the signs of healthy High-Altitude Grassland?

In addition to the general signs of healthy grassland ecosystems described in Section 5.1, signs of healthy High-Altitude Grassland include:

- The presence of abundant geophytes and life forms other than grasses.
- Low occurrence of *Hyparrhenia* and other unpalatable grasses.
- High plant species diversity, as indicated by a variety of coloured forms in the grassland.
- Low occurrence or absence of invasive alien species.
- No obvious signs of soil erosion (such as dongas, sheet erosion or leaf litter and loose soil accumulating in lower-lying areas).
- The abundant presence of naturally-occurring animals of various types.

4 What are the management best-practices and minimum ecological requirements in High-Altitude Grassland?

In addition to the general management best-practices and minimum ecological requirements described in Section 5.1, the following ecosystem-specific recommendations apply in High-Altitude Grassland:

- **Burning must be carried out according to an integrated fire management plan that takes account of the following:**
 - High-Altitude grasslands generally have slow growth rates (due to the climate) and they should be burnt less frequently as the altitude increases.
 - The tension between burning and grazing needs to be carefully balanced, so that enough time is given for the sward to recover after burning events – if fire is applied too frequently, or at the wrong time (e.g. spring, just as new growth is starting), it leads to reduced vigour and tuft-size, and increased soil erosion either by sheet erosion or landslides. It is recommended that patch burning be applied, using a variety of intervals between burns.
 - The periodicity of burns should be 5-7 years in alpine areas, and 2-4 years in escarpment areas – the higher the altitude, the lower the frequency of burning (although this does not apply to the escarpment grasslands of Mpumalanga).
 - Burning should take place in late winter; burning in August should be avoided due to the prevalence of hot berg winds that can increase the risk of dangerous runaway fires.
 - Areas to be burnt should be divided into burning blocks using natural features such as rivers and ridges.
 - High altitude, sourveld grasslands should not be grazed for 6–8 weeks after being burnt.
 - Sweetveld grasslands on the Stormberg plateau (north of Molteno and Dordrecht in the Eastern Cape) should only be burned in seasons when grass growth has exceeded grazing demand.





- **Grazing should be carefully managed**, as follows:
 - Only light to moderate grazing by livestock (preferably by bulk rather than selective grazers) should be permitted if these grasslands are being managed for the persistence of biodiversity.
 - Careful animal management is required to prevent over-utilisation and its associated soil erosion; stocking rates and rest periods need to be closely managed.
 - In sourveld areas (much of the High-Altitude region) stick to low stocking rates, with continuous grazing over very large areas, with long periods of rest (at least a full season).
 - In sweetveld areas (e.g. the Stormberg plateau in the Eastern Cape) rotational grazing at low stocking rates is acceptable, but camps should be rested for long enough (up to 10 weeks) to allow seed-fall.
- **Pay particular attention to species of special concern:** Detailed ecological studies following the minimum standards for EIAs in sensitive areas are essential before any land-use application can be approved – these grasslands are extremely diverse and contain the highest number of threatened and endemic species of all of the grassland ecosystem groups; many of the endemics have highly restricted distributions and could easily be irretrievably lost by inappropriate land-use at a single site.
- Invasive alien species should be controlled as matter of priority.

5 What are the broad spatial guidelines for locating land-uses in High Altitude Grassland?

In addition to the general guidelines provided in Section 5.1, the following recommendations for High-Altitude Grassland are made:

- Sites with threatened and endemic animal and plant species should be maintained in a natural state, with no further habitat loss as a result of changes in land-use; detailed spatial guidelines for dealing with these species of special concern can be found in the Red Data List (<http://redlist.sanbi.org/>).
- Blue swallow nesting sites should be buffered and excluded from any kind of impacting land-use.
- Avoid any further fragmentation of natural grassland areas.
- No further afforestation should be permitted on dolomitic grasslands; these have already been extensively modified and the remaining areas harbour endemic plant species and several threatened species of bats.
- Establish buffers around rivers and wetlands, following the recommendations given in Chapters 6 and 7.
- Incorporate mountain summits, ridges and peat bogs into ecological corridors that are kept in a natural state and managed for biodiversity. These corridors should be identified using current systematic biodiversity plans, and should be aligned to include migration routes and sensitive habitats, amongst other things.
- In alpine zones, where endemism is very high, the siting of any infrastructure, such as radio masts, needs to be informed by careful surveys carried out during the flowering season (which is very short due to the cold climate).

6 What indicators can be used to assess and monitor the impact of management on biodiversity in High-Altitude Grassland?

The general indicators described under Question 6 in Section 5.1 for all grassland ecosystems, can be applied reliably to monitor the impact of management on biodiversity in High-Altitude Grassland. However, of particular importance in this group of ecosystems are:

- **The status of populations of endemic and rare species:** High-Altitude grasslands show very high levels of endemism; a loss of endemic species from the ecosystem indicates the need to adjust management of fire and grazing.



- **Changes in species abundance:** Single species dominating the landscape is a sure sign of degradation as is the loss of palatable species from the ecosystem.
- **Infestation by invasive alien species:** One of the biggest risks posed by these species is that they occupy habitat that would otherwise be available for naturally-occurring species, thus causing degradation.
- **Groundwater levels and base flows:** With these grasslands being such important water production landscapes, it is important to monitor catchment-level impacts of land-use change on groundwater levels and base flows.
- **Obvious signs of soil erosion:** Features such as hard-capping, the pedestal effect (grass clumps growing on raised pedestals of soil separated by scoured out areas), and the accumulation of loose soil in lower lying areas are all signs of degradation as a result of inappropriate management.





5.5. Sub-Escarpment Grassland



5.5. Sub-Escarpment Grassland

Snapshot of Sub-Escarpment Grassland

General characteristics of this group of ecosystems are that they:

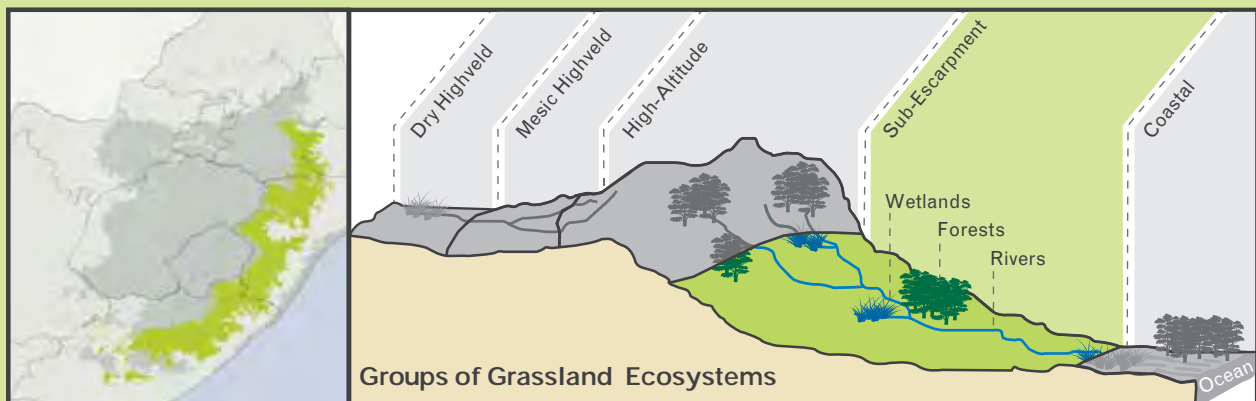
- Are mesic grasslands occurring at mid-altitudes (760 – 1 800 masl) at the base of the escarpment of KwaZulu-Natal and the Eastern Cape.
- Comprise 20 national vegetation types (see Chapter 9.2 for a full list).
- Are made up of long-lived grasses and forbs that are adapted to frequent above-ground disturbance mostly due to fire, after which they re-sprout using carbohydrates stored in underground storage organs.
- Reproduce only infrequently through seedlings and seeds are generally viable only for short periods; plants persist for many years and replacement takes place vegetatively as new tillers emerge.
- Occur in areas with topography dominated by flat plains, rolling hills with gentle to steep slopes rising to the base of the escarpment, and traversed by deep river valleys; the heterogeneity of the topography influences the prevailing fire regime.
- Are adapted to a climate that is characterised by warm, wet summers with high rainfall (mean annual precipitation >600 mm), and dry, temperate winters that are cool to cold with a moderate to heavy frost regime; the rising topography results in orographic precipitation and frequent formation of mist.
- Soils are depleted of nutrients as a result of leaching and generally support sourveld; they form a mosaic made up of shallow and poorly-drained soils from sedimentary rocks (shales, sandstones and mudstones), interspersed with deep, well-drained soils from igneous rocks (such as basalt and dolerite).

Conservation status:

- All of the vegetation types are inadequately protected, with two thirds of them classified as threatened.
- Mistbelt grasslands have undergone extensive modification due to commercial forestry operations, row-cropping and urban sprawl. Only eight vegetation types have undergone relatively little modification.

Socio-economic importance:

- These grasslands are important as rangelands and are favoured for afforestation and other cropping activities. They are also important water-production landscapes, and are the catchment for important rivers such as the Mngeni, Mzimvubu and the Umtamvuna.



1 What are the main ecological characteristics of Sub-Escarpment Grassland?

- **Climate:** In Sub-Escarpment Grassland the climate is more moderate than in escarpment and alpine areas, with warm, wet summers and cold winters. This results in a longer growing season and higher grassland productivity, producing taller and heavier plants; as these grasslands still experience a cold winter with frost, they are sourveld, with poor winter grazing. Frost plays an important role in reducing grazing and 'curing' the grass, increasing its suitability for burning.



- **Fire:** Sub-Escarpment grasslands are well-adapted to fire, and this is the most important ecosystem process that can be managed to maintain biodiversity and productivity in these ecosystems. The rapid biomass build-up influences fire behaviour and results in increased fire frequency and intensity.
- **Soils:** These are generally deeper than in escarpment areas, and well-drained, but can become leached due to the high rainfall.
- **Grazing:** These grasslands are not well suited to high intensity grazing on an ongoing basis. Historically, they were subjected to light levels of selective grazing by herbivores that range in size from oribi to eland. It is unlikely that herds of bulk grazers would have come into this zone except on occasions when grazing was limited elsewhere.
- **Life-history strategies:** The plants in these grasslands persist mainly through being long-lived, sporadically replacing themselves through seeds or vegetative reproduction. Many species have adapted to the frequent disturbance by fire and frost by storing carbohydrates in a variety of underground storage organs, from which they re-sprout after the disturbance.

2 What are the main issues, vulnerabilities or pressures in Sub-Escarpment Grassland?

The issues in Sub-Escarpment Grassland are similar to those described for High-Altitude Grassland, although they present themselves in slightly different ways and produce different levels of pressure in these ecosystems. Of particular concern is expansion of various types of cultivation, heavy grazing, changes in other commercial land-use patterns (relating to mining, urban and peri-urban sprawl and sub-division of land) and encroachment by invasive alien species, as described below:

- **Habitat loss due to expanding cultivation:**
 - **Commercial plantation forestry:** Due to the emergence of new tree cultivars and changing economics, commercial forestry is becoming viable in areas previously considered to be unsuitable for afforestation, particularly in the Eastern Cape, and in the mistbelt areas of KwaZulu-Natal. Decisions are sometimes made to plant up areas that are unsuitable for plantations, often in a poorly-informed attempt to address the needs of impoverished rural communities. In some areas, landowners have also shifted to timber cultivation as an alternative form of income, because rampant stock theft has made farming with livestock un-economical.
 - **Expansion of dairy pastures, potato and sugar-cane fields:** Dairy farmers need to expand their production systems to maintain profitability, which results in more primary grasslands being used for grazing or placed under pasture. Potato farmers keep expanding their operations into primary grassland because it is free of eelworm, which otherwise affects the marketability of the potato crop. And the development of new cultivars of sugarcane has made it possible to cultivate this crop in areas that were previously considered marginal (e.g. Richmond in southern KwaZulu-Natal).
 - **Shifting subsistence cultivation and a lack of formal land management:** as for High-Altitude Grassland.
- **Invasive alien species:** The problem with invasive alien species is similar to that in High-Altitude Grassland, although the more moderate climate in Sub-Escarpment regions makes them more vulnerable to infestation by woody invasive species. One of the greatest risks posed by invasive alien species is that they occupy available habitat for indigenous species, thereby degrading and modifying grassland habitats.





- **Heavy grazing:** These grasslands are heavily used as rangelands. Although they are reasonably resilient, they are not well-suited to extensive or extended grazing, because they are very slow to recover once they have been pushed beyond their carrying capacity. If they are being managed for commercial beef production, the growth of palatable grass species is favoured and this sometimes results in a decline in forbs (which account for much of the species richness in these ecosystems, and which are less able to withstand heavy grazing pressure). The impact of grazing on forbs in these ecosystems is not uniform however, so this is something that needs special attention in any grazing management plan.
- **Changes in other land-use patterns:** Various forms of land-use are placing more and more of these grasslands at risk of being lost (through irreversible modification) or degraded (through unsuitable management), either directly or through knock-on effects. Issues of greatest importance include:
 - Expansion of mining operations: New and expanded mining operations, particularly for coal and bauxite, are a major driver of land-use change in the northern parts of this ecosystem.
 - Increased sub-division of land: This drops the size of land-holdings below that which triggers the EIA process. Because many rare and threatened species in this ecosystem have highly localised distributions, they can be easily lost as the smaller properties on which they occur 'slip through' the EIA regulations.
 - Urban and peri-urban sprawl: Poorly planned residential development outside the urban edge is causing ongoing loss of Sub-Escarpment Grassland. The expansion of associated infrastructure, such as roads and water pipe-lines, causes fragmentation of habitat and changes the natural fire regime as the management focus shifts to fire protection.

3 What are the signs of healthy Sub-Escarpment Grassland?

In addition to the general signs of healthy grassland ecosystems described in Section 5.1., the following indicators apply in Sub-Escarpment Grassland:

- **The presence of persisting populations of endemic and grassland-specialist species:** Refer to O'Connor & Kuyler, 2005, for a list of these. These species are either rare or have a close connection with the health of the specific habitat in which they occur. A sharp decline in their numbers can signal poor management of the habitat, however it is important to first eliminate natural processes (e.g. climatic changes) as a cause of any population shifts.
- **Absence, or low numbers of invasive alien species:** Species of particular concern in these grassland ecosystems include wattle, pine and bramble or indigenous weedy species such as bracken fern.
- **Grassland areas free of bush encroachment:** Although healthy grassland ecosystems should be free of bush encroachment, healthy patches of forest or open woodland should occur in naturally appropriate locations within the landscape (for example, stands of *Protea* on southern slopes or forest patches in deep kloofs and valleys or along drainage lines).
- **Grassland that has the appearance of an even sward:** 'Tussock veld', as opposed to an even sward, is a sign of unhealthy Sub-Escarpment Grassland.
- **A high diversity of growth forms and species of grassland plants:** Complete dominance by one or only a few species is a sure sign of degradation.
- **Absence of dongas or other signs of soil erosion.**



4 What are the management best-practices and minimum ecological requirements in Sub-Escarpment Grassland?

In addition to the general management best-practices and minimum ecological requirements described in Section 5.1, the following ecosystem-specific recommendations apply:

- **Burn according to a fire management plan:** An appropriate burning regime is an essential management tool in these grasslands. As in the other mesic grassland ecosystems, Sub-Escarpment Grassland shows high levels of plant species diversity and this is best maintained when fire is applied using a range of fire frequencies that is more diverse than the often-advocated biennial spring burns. General recommendations regarding frequency and season of burn are:
 - Burn every 2 – 4 years, depending on rainfall and fuel load.
 - Burn in winter, but not too early.
 - No less than 30% and no more than 60% of an area should be burnt within any given year.
- **Manage grazing carefully and prevent overgrazing:** Grazing should be managed to maintain cover and the natural composition of palatable species. Wherever possible, natural herbivore assemblages (i.e. composition and numbers) should be promoted as these best replicate the disturbance regimes under which the biodiversity of these ecosystems developed. In particular, note the following:
 - Basal cover needs to be maintained at all costs in order to prevent soil erosion.
 - Sub-Escarpment Grasslands can be grazed commercially, but under strict management that recognises the poor ability of these ecosystems to recover once the limits of acceptable change have been passed. For cattle, rotational grazing involving adequate periods of rest is recommended.
 - If economic return is not the primary objective, grassland should be grazed continuously at light stocking rates. The selective grazing associated with this will create a mosaic of vegetation structures and niches for a variety of species to exploit. Regular burning (every two to four years) should overcome any long-term changes in species composition brought about by selective grazing.
- **Establish strategically located protected areas:** Areas of highest importance should be included in protected areas (including sites secured through biodiversity stewardship agreements) linked by a well-defined network of corridors.
- **Avoid any further loss of primary grassland:** Habitat loss should be avoided and economic activity in intact primary grassland should be directed towards land-uses that will not affect the long-term ecological integrity of these ecosystems (e.g. catchment management, carefully managed beef production or ecotourism).
- **Manage wild-harvesting of plants:** Wild-harvesting (for traditional medicines, bioprospecting or any other purpose) should be managed according to a conservative harvesting plan that is negotiated with the interested and affected parties; some compromise between conservation goals and resource use will likely need to be met.
- **Avoid impacts on wetlands:** Sub-Escarpment Grasslands occur in important catchment areas; healthy wetlands are essential to continued delivery of good quality water, so impacts on wetlands in these grasslands should be avoided at all costs (See Chapter 6 for more information on wetlands).
- **Manage wetland systems, rivers, ridges and valleys for biodiversity objectives:** Outside of protected areas these habitats should be managed in support of biodiversity objectives, particularly if they have been mapped as Critical Biodiversity Areas or Ecological Support Areas.



5 What are the broad spatial guidelines for locating land-uses in Sub-Escarpment Grassland?

In addition to the general guidelines provided in Section 5.1, the following recommendations for Sub-Escarpment Grasslands are made:

- **Natural and near-natural areas should be linked by means of corridors:** Within a commercial agricultural, forestry or mining landscape these corridors should be at least 200 m wide. Any current systematic biodiversity plan (such as provincial biodiversity plans or biodiversity sector plans) should be consulted when planning the network of corridors in the landscape, and, wherever possible, these should be aligned to include special habitats or species of special concern.
- **Establish buffers:** Buffers should be established around sensitive habitats (such as wetlands and forest patches) and species of special concern. Recommendations regarding buffer widths for species of special concern can be found in the Red Data List.

6 What indicators can be used to assess and monitor the impact of management on biodiversity in Sub-Escarpment Grassland?

The general indicators described under Question 6 in Section 5.1 for all grassland ecosystems, can be applied reliably to monitor the impact of management on biodiversity in Sub-Escarpment Grassland. However, of particular importance in this group of ecosystems are:

- **The distribution and integrity of forest patches:** Forests are a natural feature within the matrix of these grasslands, making a significant contribution to their diversity. Their distribution and extent is largely governed by burning practices and changes in their extent, if not intended, are a reliable indicator of poor fire management.
- **Species of special concern:** Any change or decline in the populations of rare, threatened or endemic, grassland specialist species that cannot be attributed to natural population cycles, is an indicator that the management needs to be adjusted.
- **Loss of palatable species:** A decline in the diversity and abundance of palatable grass species (decreasers) indicates the need for a change in grazing management.
- **Plant species composition and abundance** and both aerial and basal cover.
- **Levels of encroachment** by woody invasive species (either exotics or weedy indigenous species).





5.6. Coastal Grassland



5.6. Coastal Grassland

Snapshot of Coastal Grassland

General characteristics of this group of grassland ecosystems are that they:

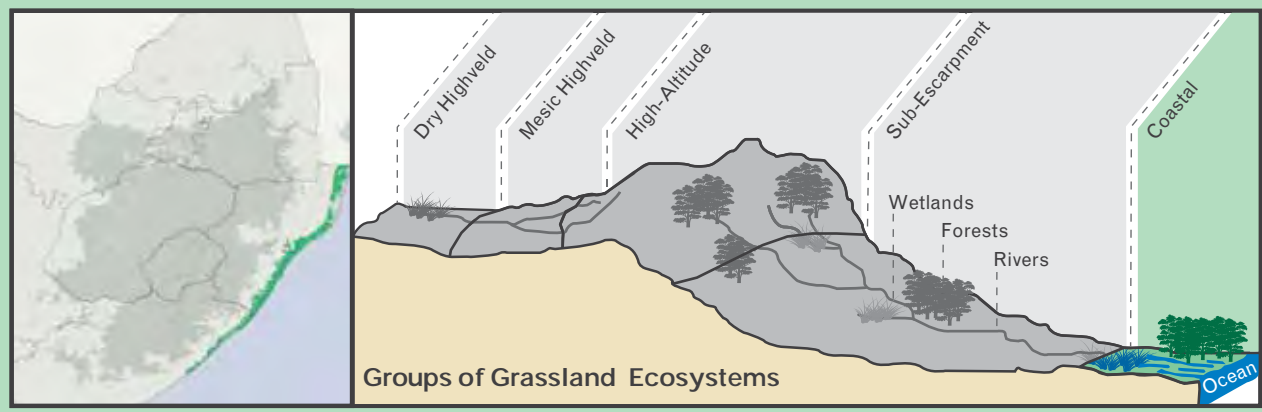
- Are classified as part of the Indian Ocean Coastal Belt Biome.
- Occur as patches forming a mosaic with pockets of other vegetation types (including coastal thicket and scrub, sand and swamp forests, evergreen forest, riparian habitats, wetlands and estuaries) occurring in a narrow strip extending from Maputaland in the north, southwards along the KwaZulu-Natal and Eastern Cape coastlines as far south as about East London.
- Are heterogeneous, and can be divided into two main types – the northern, more subtropical grasslands (occurring on old sandy dunes and coastal flats and reliant on a shallow water table); and the southern grasslands that occur at the transition from subtropical to more temperate systems. These occur on the rocky plateaus of coastal hills in landscapes that include coastal dunes, incised valleys, steep cliffs, rocky outcrops, and deep forested ravines.
- Occur at low altitudes (20 – 600 masl), and are adapted to a climate that is characterised by warm to hot, humid summers with high rainfall (1 000 mm), and mild winters with no frost.
- Are mesic grasslands, well-adapted to frequent above-ground disturbance largely due to fire, with well-developed capacity for re-sprouting.
- Comprise 5 national vegetation types, and contain two of the seven Centres of Endemism recognised in South Africa; one of these, the Pondoland-Ugu Centre of endemism, has the highest density of endemic species of all of the Centres.
- Are underlain by diverse geology and soils, resulting in high levels of species diversity and endemism, especially on sandstone outcrops.

Conservation:

- All of the vegetation types in this ecosystem are under-protected (except in Maputaland) and most are threatened, persisting mainly as fragments.
- Coastal Grassland is overall the most threatened of all the grassland ecosystem groups.
- Extensive habitat loss has been caused by various forms of cultivation (principally sugarcane and bananas), and sprawling urban settlement and in some areas overgrazing has led to degradation.

Socio-economic importance:

- These grassland areas are dominated by sugar-cane and banana farming. They provide a rich source of thatching grass and plants important in traditional medicine and they are important as grazing lands for livestock.



1 What are the main ecological characteristics of Coastal Grasslands?

- **Climate:** These grasslands are quite distinct from the other ecosystems, largely due to the significantly different climate in coastal regions. The hot summer temperatures and warm winters, combined with high summer rainfall and lack of any extended dry period, results in:
 - o A growing season that potentially spans the year, but is limited in winter by the slightly drier conditions.
 - o A rapid build-up of plant material that provides fuel for the many small-scale fires during winter; growth in this highly productive system can sometimes be limited by the poor nutrient conditions in the leached soils.



- **Complex geology and topography:** Coastal Grassland is underlain by diverse geology including basement sandstones, granites, gneisses and schists with basalt and dolomite intrusions and sedimentary marine strata. This results in a fine-scale patterning of hydrological and soil conditions that gives rise to a high degree of species turnover and diversity over short Coastal Grassland is particularly important from a species conservation perspective. Coastal Grassland on sandstones are especially diverse.
- **Fire:** This is one of the most important ecological processes maintaining the character of Coastal Grasslands. Due to the high fuel loads that build up over the long, wet growing season, these grasslands have historically been subjected to frequent fires, which affects both the vegetation structure and species composition in these ecosystems. They are characterised by a dynamic relationship with coastal forest and estuarine elements, and fire is critical in maintaining the open grassland areas within the grassland-forest mosaic.
- **Grazing:** Historically, these grasslands would have been subjected to grazing at a variety of spatial scales with herds of bulk grazers, such as buffalo or zebra, moving periodically through an area and removing a substantial amount of material, with smaller herbivores such as oribi or other antelope, removing particular plant parts on a small spatial scale.

2 What are the main issues, vulnerabilities or pressures in Coastal Grassland?

Dune and sand mining, infestation by invasive alien species, urban and peri-urban sprawl, the expansion of commercial cultivation and subsistence farming, and unsystematic or unplanned use of fire are the main issues in Coastal Grassland, as described below:

- **Dune Mining:** There is growing pressure to strip-mine titanium from sand dunes in Maputaland and Pondoland, in areas immediately adjacent to remaining Coastal Grassland. In addition to various direct and indirect impacts of this mining activity, the infrastructure and roads associated with mining will further fragment these grasslands. Sand-mining of dunes and river-beds creates similar problems.
- **Extensive urban sprawl:** The narrow coastal strip in which these grasslands occur is home to a large and growing city (Durban) and many other densely populated towns and coastal resorts; in the southern part of the range, dense rural settlement is also growing. Urban and peri-urban sprawl and residential development beyond the urban edge, is causing increased habitat fragmentation and loss. The proliferation of luxury residential golfing estates and similar holiday resorts is also placing pressure on remaining grasslands, as they lead to habitat loss and the use of large volumes of water, pesticides and herbicides that affect water quality and the underlying hydrology of remaining grassland patches.
- **Construction of new major roads:** Apart from habitat loss and the other direct impacts of this activity, the construction of new major roads (such as the N2 toll road between KwaZulu-Natal and the Eastern Cape) carries with it the risk of increased pressure from urban settlement – once a new major road is established, there tends to be a natural inclination for people to settle along this route, leading to ribbon rather than nodal development.





- **Infestation by invasive alien plants:** The coastal zone is particularly vulnerable to infestation by aggressive invasive alien species, such as trifid weed (*Chromolaena odorata*) and tick-berry (*Lantana camara*) due to the tropical climate and high-levels of localised disturbance. Bush and forest encroachment caused by the exclusion of fire is also a problem in some areas.
- **The expansion of commercial sugar-cane farming and plantation forestry:** The expansion of commercial sugar-cane farming (dryland) and plantation forestry (involving new cultivars), means that there is pressure for more Coastal Grassland to be allocated for these activities.
- **Inappropriate land-management:** Over-grazing and the unsystematic or injudicious use of fire, particularly in areas that are not formally managed, causes habitat degradation in these coastal ecosystems.

3 What are the signs of healthy Coastal Grassland?

In addition to the general signs of healthy grassland ecosystems described in Section 5.1., the following indicators apply in Coastal Grassland:

- **The distribution and integrity of forest patches:** Although healthy Coastal Grassland should be free from bush encroachment, forests patches are a natural feature within the matrix of these grasslands, making a significant contribution to their diversity. In particular, the forest ecotone should be intact, characterised by the presence of distinctive plant communities at the grassland-forest interface.
- **The presence of persisting populations of rare sandstone endemics and other rare, threatened or endemic species.**
- **An abundance and diversity of forbs and geophytes and a high diversity of grass species.**
- **Soils** with a high proportion of soil organic matter.
- **The absence of invasive alien species.**



4 What are the management best-practices and minimum ecological requirements in Coastal Grassland?

In addition to the general management best-practices and ecological non-negotiables described in Section 5.1 above, the following ecosystem-specific recommendations apply in Coastal Grassland:

- **Burning:** Fire is one of the most important ecological processes responsible for maintaining the open grassland areas in the grassland-forest mosaic that characterises these coastal regions. Due to the high rainfall and productivity in these ecosystems, they can support frequent fires. The diversity of fire-tolerant wild flowers in these mesic grasslands benefits from being exposed to a range of fire frequencies that is more diverse than the often-advocated biennial, spring burns. Fire management plans for Coastal Grassland should incorporate:
 - Patch mosaics of predominantly two to three year fire intervals (although longer burn intervals should be included to maximise plant diversity).
 - Burning that takes place in winter or spring, (depending on biomass accumulation) with no more than 30% of an area being burnt in any one year.
- **Grazing:** Coastal Grasslands naturally occur as small patches rather than extensive areas of connected grassland, and they have become even more extensively fragmented due to habitat loss caused by various land-uses. This influences the level of grazing pressure they can withstand. Although they can sustain commercial grazing, stocking rates must remain within agricultural norms and low rates are recommended.



5 What are the broad spatial guidelines for locating land-uses in Coastal Grassland?

In addition to the general spatial guidelines provided in Section 5.1, the following recommendations for Coastal Grassland are made:

- **Avoid any further fragmentation:** Coastal Grasslands are by nature patchy in their distribution, occurring as they do as part of a mosaic with forests and other vegetation types. Various land-uses have resulted in a high degree of fragmentation of these grassland-forest mosaics and there should be no further fragmentation in these ecosystems.
- **Maintain all remaining primary Coastal Grassland in a natural or near-natural state:** This is the most threatened of all the grassland ecosystem groups and all remaining areas of intact, primary grassland should be kept in a natural or near-natural state.

6 What indicators can be used to assess and monitor the impact of management on biodiversity in Coastal Grassland?

The general indicators described under Question 6 in Section 5.1 for all grassland ecosystems can be applied reliably to monitor the impact of management on biodiversity in Coastal Grassland. However, of particular importance in this group of ecosystems are:

- **The encroachment of woody species** into previously open grassland patches is a sign that fire is being used too infrequently, allowing woody species to out-compete grassland species.
- **Absence of distinctive forest-grassland ecotonal communities** indicates that fire is being used too often, or the fires are too hot, resulting in damage to the forest-grassland ecotone and the forest margin.
- **Increasing occurrence of invasive alien species**, either in the grassland itself, or at forest margins.





6 Ecosystem Guidelines for Wetlands



6. Ecosystem Guidelines for Wetlands



A large proportion of South Africa's wetland ecosystems occur in grassland landscapes. Wetlands are those parts of the landscape where water accumulates long enough and often enough to influence the characteristics of the soil and the composition of the plant and animal communities living there. These areas can be temporarily, seasonally or permanently wet. The Convention on Wetlands of International Importance (i.e. the Ramsar Convention) takes a broad view of wetlands that includes all aquatic freshwater systems, but South Africa's National Water Act (Act 36 of 1998) uses a narrower definition that applies to wetland types referred to commonly as bogs, pans, marshes and vleis. Wetlands are specialised ecosystems that deliver essential ecosystem services that are vital for human welfare and environmental sustainability. They are of strategic importance for ensuring water quality, regulating water flows, attenuating floods and for supporting agro-pastoral systems and the livelihoods of many rural people.

Wetlands do not all share the same ecological characteristics and functionality, and so cannot all be treated in the same way from a land-use planning, management or decision-making perspective. There are several different types of wetland ecosystems that can be identified based largely on where they occur within a landscape (e.g. on a slope, a plain or a valley floor), the wetland vegetation that characterises them and how they function (see Figure 11). What all wetlands have in common is that they occur on soils that have developed under prolonged periods of water-logging (i.e. the soils are hydromorphic).

The National Classification System for Wetlands (Ollis *et al.* 2013) recognises the following main categories of wetland, based on how they function:

- **Seeps:** (sometimes called 'sponges'): these are generally seasonal, small and widely scattered wetlands formed at valley heads or on hill-slopes, largely by the discharge of sub-surface water.
- **Valley-bottom Wetlands:** these occur in valley bottoms and are usually wetter for longer periods than seeps. They may be channelled (with at least one or more clearly defined stream channels, but lacking floodplain features), or un-channelled (with no clearly defined stream channel).
- **Floodplain Wetlands:** gently sloped, with floodplain features and a distinct stream channel.
- **Depressions and 'Flats':** areas that accumulate surface water (e.g. 'pans'), either in depressions, or extensive areas characterised by level, gently undulating or uniformly sloping land.

Important points about all wetlands:

- **They are part of a highly interconnected system;** this means that impacts on one wetland at a particular point in the landscape have implications for the state of other wetlands in that wetland system. Wetlands also provide critical areas of cover (corridors) providing refuge for animals to moving across a grassland landscape.
- **Wetlands are vulnerable to damage** and once damaged or degraded are difficult, though not impossible, to restore. Many wetlands have already been irreversibly lost, especially in urban and intensively cultivated areas, and those that remain are the most threatened of all of South Africa's ecosystems - 65% of them are classed as threatened, and 48% of these are critically endangered.
- **The pattern of water movement in the wetland** (i.e. the hydrological regime), and its relationship to the variety of soil types, gives rise to a variable mosaic of specialist habitats, contributing significantly to local biodiversity.
- **The moisture within wetlands generally gives rise to a more robust vegetation structure than that of the surrounding grassland.** This provides refugia for animals during times of disturbance, enhancing the potential for re-colonisation of nearby areas following disturbances such as fire.





- **The health of wetlands is inextricably linked to the land-uses within their catchments.** A large proportion of South Africa's wetlands occur in grasslands, which means that sound land-use planning and management of land-based impacts in grassland landscapes is essential to maintain the health of wetlands, and the ecosystem services they provide.

The guidelines given below are very generalised and are intended to serve as general pointers or 'red flags' for practitioners who are working in grassland landscapes that include wetlands. More detailed information and guidance can be obtained from several sources that focus on wetlands and other aquatic ecosystems, such as:

- The WET-Management Series, an integrated set of tools that assists users in achieving well-informed and effective wetland management and rehabilitation. These tools can be downloaded from the website of the Water Research Commission (www.wrc.org.za).
- The National Freshwater Ecosystem Priority Area Implementation Manual (Driver *et al.* 2011) which can be downloaded from SANBI's BGIS website (www.bgis.sanbi.org.za).
- The SANBI 'Biodiversity Advisor' at: http://biodiversityadvisor.sanbi.org/?home_items=planning-and-assessment.
- The National Wetland Classification System (Ollis *et al.* 2013).

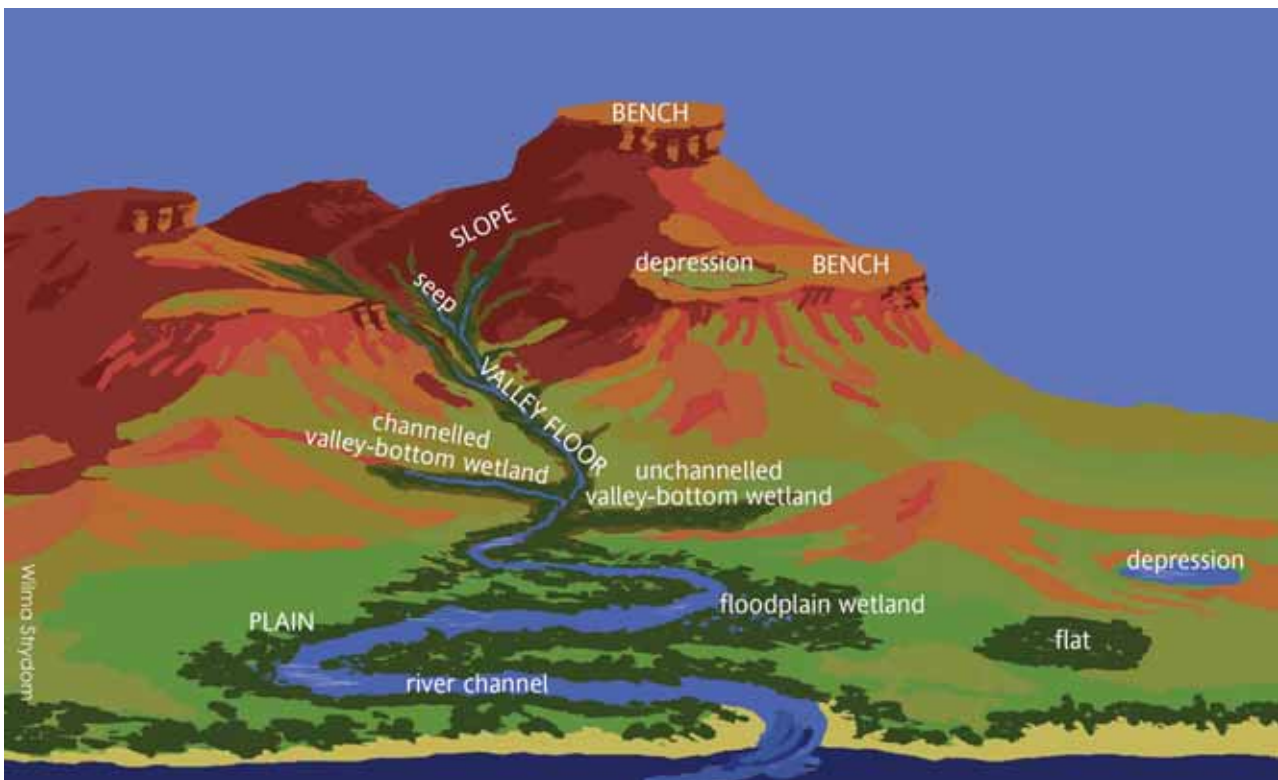


Figure 11. Schematic drawing showing how the seven hydro-geomorphic classes of wetland relate to landscape setting (taken from Driver *et al.* 2012).



1 What are the main ecological characteristics of wetlands?

The structure, composition and functioning of wetland ecosystems is determined by many interacting biophysical factors, including:

- **Geology and geomorphology:** Underlying rock type defines the shape of a landscape and the physical and chemical resource base of the wetland ecosystem. These differences influence the shape and gradient of the land surface, and, therefore, the distribution of water, sediment and nutrients within the wetland.
- **Hydrological regime:** The timing, duration and temporal sequencing of floods and the general movement of water within the wetland exert a strong influence over the plants and animals living in it, and over the physical and chemical characteristics of the ecosystem.
- **Water quality:** Along with water quantity, water quality is a major driver of biological responses within freshwater ecosystems. Some wetlands (e.g. those with catchments underlain by sandstone) are naturally low in nutrients, and support plants, and animals, particularly adapted to lower nutrient conditions, while others have an inherently higher nutrient status. Nutrient overload (i.e. eutrophication) of wetland ecosystems can lead to ecologically significant changes in vegetation structure and composition.
- **Water quantity and source:** The ecological character of a wetland will also be influenced by the amount and source of the water flowing through it – water can enter the wetland from a river upstream, via surface runoff from the catchment or as subsurface seepage through the adjacent soils in the catchment.
- **Climate:** This acts together with geology to influence other drivers (such as hydrology or sedimentation) that shape wetlands. Mean annual precipitation drives the hydrology of a wetland ecosystem, and permanently saturated wetland areas occur more extensively and more often under higher rainfall conditions. Temperature is the most important climatic driver influencing the biota in a wetland ecosystem.
- **Vegetation and other biota:** The presence or absence of wetland plants and animals can be a response to other ecological drivers (such as sedimentation), or can determine the characteristics of the wetland. Vegetation strongly influences wetland geomorphic process by slowing down water flows and capturing sediment; it is also the source of peat in peat-land systems.
- **Sedimentation:** The distribution of sediment within the wetland, as well as the type of mineral sediments (fine clay or coarse sand and gravel, chemical and organic sediments), are important determinants of its ecological character. In general, the amount of sediment entering a wetland is equal to or greater than the amount leaving it, so that there is a net accumulation of sediment in the system.

In addition to the biophysical drivers, there are several disturbance factors that naturally alter the structure and functioning of wetlands, including:

- **Fire:** Under natural or carefully managed conditions, fire is a normal, healthy part of wetland ecology. However, some wetlands (e.g. peat bogs and swamp forests) are susceptible to damage by fire and should be protected from it (i.e. where land-use changes around these wetlands have stripped the natural fire buffers away, active management is necessary to protect them).



- **Grazing:** Grazing influences the diversity of habitats in the wetland, and their ecological condition. Many wetlands have evolved under grazing pressure from indigenous animals such as buffalo, and, when in a healthy state, are able to support high seasonal concentrations of herbivores. Domestic livestock may have a similar (and positive) effect in maintaining habitat diversity, if grazing pressure is carefully managed.

Primary production in wetlands is a function of the interaction of all of the other drivers listed above. Primary production is highest where water is freely available throughout the year (i.e. the permanently wet zone in a wetland) and where nutrients and temperature are not severely limiting. Primary production is itself a key ecological driver in wetland ecosystems, because where it is very high (usually involving tall-growing, single species such as 'fluitjiesriet', *Phragmites australis*), fierce competition acts to exclude other species. This is important, as in these cases, disturbance 'creates space' for shorter-growing, less competitive species to co-occur with the more competitive ones.

2 What are the main issues, vulnerabilities or pressures in wetland ecosystems?

Several land-use practices and other pressures contribute to the loss and degradation of wetlands. Impacts can be direct, occurring at the wetland site, or indirect, in which case they are related to grassland management within the wider catchment of the wetland.

The main causes of direct impacts on wetlands are:

- **Cultivation** (e.g. of sugarcane, maize or other crops): The primary impacts of agriculture on wetlands include removal of natural vegetation and ploughing (especially on floodplains). This leads to erosion and changes in water flows, water availability on the surrounding land, and water quality, especially where fertilisers and other chemicals are in use. The type of crop planted, the need for drainage and the spatial extent of the cultivation are all important in determining the extent of impact on a wetland, but, in general, the impacts of cultivation in wetlands is overwhelmingly negative. For this reason, ploughing of wetlands is regulated by the Conservation of Agricultural Resources Act (CARA, Act 43 of 1983), the National Water Act (NWA, Act 36 of 1998) and NEMA.
- **Road crossings and road infrastructure:** When roads are built adjacent to, in or upstream of wetlands, it results in water flow being confined through culverts, resulting in head-cut erosion or channel-scouring and incision. Drainage from roads also confines flow, resulting in point-source discharges into the wetland and lateral erosion.
- **Impoundments** (dams, weirs, drains): The construction of any kind of impoundment influences the natural flow of water into and out of wetlands as well as the movement of sediment.
- **Poor grazing management:** Wetlands are generally well-adapted to grazing, and can benefit from it. It is possible, though, to over-utilise them, especially in winter when they may contain the only green forage in the area and animals concentrate on the wetland causing erosion of channels. This dries out indigenous vegetation, compromises the ability of the wetland to hold back floods, and can release large volumes of sediment into rivers that would otherwise be trapped by wetland plants.
- **Mining of peat:** Peat is used in the horticulture industry and in various industrial purification procedures; when it is mined (dug out of peat bogs), the structure of the wetland is fundamentally and significantly damaged. Peat mining in South Africa is currently unsustainable.



- **Coal mining:** Coal provides most of South Africa's energy needs and earns valuable foreign exchange through exports, but coal mining poses a particular challenge for wetland health. Many shallow coal seams are located close to wetlands; this means that open-cast mining often damages wetlands, compromising the roles that wetlands play in water purification and flood prevention, and worsening problems with water quality that already exist in heavily-mined or utilised catchments. The impacts of coal-mining on wetlands can be catastrophic for wetland health. Such impacts include (but are not limited to): direct loss of wetland habitat; compaction of soils resulting in increased surface runoff; and acid mine drainage, which increases the pH of the receiving water (sulphur in coal spoils reacts with oxygen to form sulphuric acid, which leaches out over successive rainfall seasons before being expressed to the surface in wetlands and springs, and entering river systems).

The main causes of indirect impacts on wetlands are:

- **Disruption of the flow regime:** Wetlands rely heavily on their underlying hydrology to maintain them. Any land-use or management activity that changes the amount and timing of flows of freshwater into wetlands, or causes erosion or a drop in the water table, will have significant negative impacts.
- **Deterioration of water quality:** Wetlands are usually the lowest points in the grassland landscapes in which they occur, making them receivers of wastes, pollutants and sediment in run-off. This, combined with their high degree of connectivity, makes them susceptible to pollution caused by a variety of land-use practices. A change in water quality in streams and rivers as a result of polluting activities in the surrounding catchment will also impact on the quality of water reaching wetlands.
- **Changes in the sediment regime:** Any change in the amount of sediment entering or leaving a wetland will cause a change in the shape of the surface of the wetland and this will, in turn, influence the movement of water and nutrients through the system.
- **Poor grazing management or crop production practices:** If grazing or crop production in the wetland catchment are poorly managed, it can lead to decreased basal cover, accelerated erosion and the formation of gullies – these penetrate into wetlands, changing the character and functioning of the ecosystem and can ultimately lead to its destruction.
- **Changes in run-off characteristics associated with urban infrastructure:** Typically, the development of urban infrastructure changes natural run-off characteristics due to the hardening of surfaces and channelling of water. This leads to increased peak discharges and run-off volumes, increased frequency and severity of flooding, and a change in the characteristics of urban waterways from seasonal to perennial streams. The effects of additional water brought about by watering gardens in urban environs is also important - urban gardens often receive twice the amount of 'rainfall' through irrigation, resulting in increased run-off and erosion and more frequent and intense flooding.
- **Incorrect application of fire:** Wetlands are generally well adapted to fire. However, when they become degraded and denuded (from overgrazing, previous incorrect application of fire or other impacts as detailed above), fire can penetrate into the vegetation or peat layers and completely 'gut' the wetland. Burning too often is as bad as burning too infrequently, or excluding fire completely.
- **Encroachment by invasive alien plants:** Invasive alien plants (such as Brazilian Pepper trees, *Schinus terebinthifolius*) are not always easily recognised by non-specialists and can become very difficult to eradicate.



Some of these species can entirely out-compete the indigenous plants in the wetland, leading to changes in species composition, vegetation structure, water levels, response to fire and, eventually, the functioning of the wetland. Invasive alien tree species such as poplars and willows take up large volumes of water. Infestation by invasive alien plants can also lead to wetlands being separated from their floodplains, which is ecologically harmful and can contribute to more severe flooding. Floodplain wetlands are also prone to down-cutting and erosion if invasive alien plants constrict flows during floods.

3 What are the signs of healthy wetland ecosystems?

'Healthy' wetlands are those in which both the structure and function of the ecosystem are unmodified from a natural or near-natural state. The term 'wetland health' is used here to mean a measure of the extent to which human impacts have caused the wetland to deviate from its natural reference condition. The following general rules of thumb apply to assessing the health of wetlands:

- **Wetlands are naturally dynamic systems** and respond to external events at varying spatial and temporal scales. This means that not all changes will necessarily be bad, as they may be part of a natural cycle of change – it is, therefore, important to know the difference between acceptable and unacceptable changes in the state of a wetland.
- **Important indicators of wetland health** include changes in the distribution and timing of water flows; water retention; sediment inflows or outflows, structural and compositional changes in vegetation and other biota; and water quality.
- **Assessing wetland health is complex** and needs clearly-defined, quantifiable features that can be used as indicators when compared to a reference condition. There may be many methods for assessing wetland health, but we recommend using WET-Health, which is part of the WET-Management series. WET-Health (see Box 10), is a tool that has been developed for rapid assessment of wetland health using indicators based on hydrology, geomorphology and vegetation. Besides providing a replicable and explicit measure of wetland health, WET-Health also helps diagnose the causes of degradation so that these can be appropriately addressed. The services of an expert who has experience in assessing wetland health must be secured to use WET-Health effectively. WET-Health can be accessed via the website of the Water Research Commission (www.wrc.org.za).
- **Coupled with spatial information**, monitoring the health of wetlands (using WET-Health) can be used for guiding catchment-scale planning and decision-making. It can also be used by EIA practitioners for highlighting potential impacts of land-use alternatives on wetlands, and for guiding mitigation requirements.

Box 10: WET-Health

WET-Health assesses deviation in the ecological condition of a wetland from a natural or reference state using three components: hydrology, geomorphology and vegetation. These components are assessed separately to produce three scores that are then combined to give a cumulative score.

The WET-Health system uses:

- An impact-based approach for those activities that do not produce clearly visible responses in wetland structure and function (e.g. the impacts of water inputs of irrigation or afforestation in the catchment). This is the main approach used in the hydrological assessment.
- An indicator-based approach for activities that produce clearly visible responses in wetland structure and function (e.g. the presence of invasive aliens or erosion gullies). This approach is mainly used in the assessment of geomorphological and vegetation health.

An assessment is also made of the extent to which the wetland is likely to change, and of the causes of degradation. Visit www.wrc.org.za, click on 'Knowledge Hub' and search for 'WET-Health'.



Can damaged wetlands be rehabilitated? As a guiding principle, wetlands that are currently in a healthy state should remain so; those that are not in good condition should be rehabilitated to their best attainable ecological condition, wherever possible. The following general principles are relevant to wetland rehabilitation:

- Though wetlands are vulnerable to damage, they are generally more resilient than many other ecosystems and can be rehabilitated to at least a basic level of ecological and hydrological functioning, thus restoring ecosystem services such as water purification. Biotic diversity in the wetland, however, may be very difficult to restore, especially in drier wetlands in which it may never recover.
- How easily the system can be rehabilitated will depend on the type of wetland (how ecologically complex it is), and the causes and extent of the degradation. More complex habitats are more difficult to rehabilitate – impacts on these wetlands as a result of changes in water quality or the level of the water table may not be restorable. If the fundamental hydrological characteristics have been irreversibly altered, then the wetland will change accordingly and the shift is considered to be permanent.
- Rehabilitation can include interventions that restore ecosystem health to a degraded system by re-instating its natural ecological drivers such as seasonal flows or basic vegetation structure, or by preventing the further decline of a wetland that is in the process of degrading.
- Typically, interventions to restore degraded systems consist of re-instating the natural hydrological regime; this is achieved by using ‘plugs’ to physically repair drains in the wetland; interventions to maintain the health of a wetland, or to prevent its further decline, typically consist of management interventions such as removing invasive alien species, or managing grazing pressure or fire frequency.
- In designing a wetland rehabilitation plan it is important to remember that: (i) the objectives of the rehabilitation project must be clearly defined (i.e. not all wetlands can be restored to the same level); (ii) the causes of the degradation and not only the symptoms must be addressed; (iii) measurable indicators must be set to monitor the effectiveness of the rehabilitation interventions.

Note: Wetland rehabilitation is a complex process and has complex links with human usage. Assistance can be obtained from programmes that focus on the rehabilitation of wetlands, such as Working for Wetlands (see www.wetlands.sanbi.org.za). Much practical guidance in planning, implementing and evaluating wetland rehabilitation is also available through the WET-Management Series, published by the Water Research Commission. Visit the Water Research Commission website, www.wrc.org.za, click on “Knowledge Hub” and Search for ‘WET-Management Series; there are several tools available for guiding wetland rehabilitation.

4 What are the management best-practices and minimum ecological requirements for wetlands?

Land-use practices or activities that will lead to deterioration in the current condition of a wetland, or changes to the water flow or inundation regime of priority wetlands should be avoided. Land-use practices or activities that will make rehabilitation of a priority wetland difficult or impossible are also not desirable. General best practices for managing wetlands include:

- **Never interfere with base levels in wetland systems:** If the base level of a wetland is lowered, it will usually result in erosion. Raising the base level (e.g. through building a dam or impoundment of some sort) will encourage deposition and accumulation of sediments.



- **Maintain grassland biodiversity, structure and condition to maximise water flow:** Maintaining grasslands in as natural a state as possible will enhance the water resources obtained from them. In grassland areas, water production should be promoted as a primary land-use, especially in high-yield catchments.
- **Monitor water flows, water quality and habitat condition:** If any changes in these indicators are detected, make management decisions that respond to them as they arise.
- **Maintain hydrological connections between wetlands:** Wetlands cannot be treated as isolated systems, and hydrological connections must be maintained across the landscape.
- **Wise fire management is an essential part of wetland management:** Periodic burning of herbaceous wetlands (but NOT swamp forests and peatlands) is a beneficial practice – it removes top-growth and introduces heterogeneity to the vegetation structure. Generally wetlands are well-adapted to fire and can withstand most fire regimes within reason. Due to the availability of water, plant biomass accumulates rapidly and wetlands will carry fast and hot fires. Care needs to be taken with fire in hydrologically altered peatlands – in afforested landscapes these can be dried out and burn out completely. General guidelines for burning wetlands to maximise biodiversity are:
 - Adjust the periodicity of burning according to rainfall: In high rainfall regions the periods between burns can be shorter (2 to 3 years), and in lower rainfall areas the interval between burns should be longer (e.g. 4 to 5 years).
 - Always consider the specific circumstances at the site: The frequency of burning may be influenced by land-use practices at the site – for example, if the wetland is actively grazed by livestock then it may require less frequent burning.
 - The timing of the burn is important: Optimal timing of burns will be influenced by conditions in the wetland and the prevailing land-use practices, and there may be trade-offs between what is best for maximising biodiversity and meeting other land-use objectives.
 - Consider the spatial extent of the burn: It is not advisable to burn all of the wetlands in a given area at the same time, or, in the case of an individual wetland, to burn all of it at once – species that depend on the cover provided by wetland vegetation need to be catered for by leaving some wetlands (or parts of a wetland) unburnt at any particular time.
 - Consult a wetland specialist for assistance with devising an appropriate fire plan for the grassland landscape in which the wetlands occur.
- **A grazing plan is essential:** Grazing management needs to be adaptive and in line with the conditions in the wetland and the management objectives for the area in which the wetland occurs. Factors such as grazing intensity, timing, location in relation to sensitive areas and issues such as trampling and erosion all need to be built into an adaptive grazing management plan. Tools such as WET-Sustainable Use: a System for Assessing Sustainability of Wetland Use (downloadable from www.wrc.org.za) should be used to guide resource-use in wetlands.
- **Disperse point-source discharges:** Point-source discharges, such as road drains, cause gullies and should be dispersed by using attenuation ponds, or ensuring that there is a buffer of 20 m or more of vegetation between the outlet and the edge of the wetland.
- **Control invasive alien plants:** Programmes such as Working for Water or Working for Wetlands can be approached for advice.
- **Manage water quality.**



- **Management of the post-development landscape should focus on:**
 - Restoring or maintaining the pre-development hydrological regime, with emphasis on subsurface flow and low rates of through flow.
 - Responsible use and conservation of water resources as a primary objective.
 - Identification of the specific ecosystem services provided by the wetlands, and maintaining them under post-development conditions.

5 What are the broad spatial guidelines for locating land-uses in relation to wetlands?

Wetlands should be given priority in spatial planning because they are such a vital part of the overall grassland landscape, with many downstream influences. This means that planners should:

- **Delineate wetlands accurately in spatial plans:** This should be done at site level prior to planning new or changed land-uses in any given grassland landscape, and delineation should take place in the wet season.
- **Adopt a 'no net loss' approach towards wetland function on a property or catchment scale:** All wetlands have conservation significance and, wherever possible, should be excluded from development footprints. Where development is unavoidable, and the mitigation hierarchy has been demonstrably exhausted, consider identifying an appropriate biodiversity off-set – but this is always a last resort. The best practice guideline for wetland offsets published by SANBI (MacFarlane, 2012) provides useful guidance in this regard.
- **Design and implement a clearly defined and substantiated buffer strategy:** Buffers of intact natural vegetation provide a stable strip of protective, natural or near-natural terrestrial habitat around the wetland, to absorb some of the impacts of land-based activities. The width of the buffer will depend on many factors, and a national protocol for buffer determination around wetlands (and other aquatic ecosystems) has been developed to provide guidance on buffer widths (MacFarlane *et al.* 2010). The Water Research Commission can also provide guidance in this regard; the FEPA Implementation Manual (Driver *et al.* 2011) provides some general rules of thumb for buffer width for priority wetlands. In all cases, determining the width of a buffer to a reasonable level of confidence requires a site visit and collection of specific information. The wetland must be accurately delineated at site level, and a minimum mapping scale of 1:10 000 is recommended (1:50 000 is too coarse).
- **Maintain wetlands as important ecological corridors.**
- **Allow space for fires within the wetland:** This is important, even within an urban landscape where fire management can be complex.
- **Manage the impacts of road infrastructure on water flows carefully:**
 - Bridges and road crossings should make allowances for diffuse flow, with gaps beneath the crossing at least 20 m wide, depending on flows.
 - Pipe culverts must also provide for base flows, which means placing at least one pipe low enough in the channel bed so the flow of water is not impeded during drier periods.

Note: A suitably qualified wetland specialist should be consulted in all planning and decision-making regarding wetlands, including during the design phase of civil engineering and infrastructure projects. This is to ensure that the implications of various land-use options are correctly understood by planners and technical experts. A wetland specialist will also be needed to determine the delineation of the wetland boundary and buffer widths.



6 What indicators can be used to assess and monitor the impact of management on wetlands?

There are several publications that describe indicators that can be used to monitor the management of wetlands, so this information is not repeated here. Some of the main kinds of indicators that can be used include:

- **Water quality, water quantity, and habitat condition:** These can be monitored using reliable, measurable indicators, such as those outlined in WET-Health (see www.wrc.org.za).
- **Basic vegetation assessments over time:** These can give an indication of whether the vegetation in the wetland is changing.
- **Signs of soil erosion:** It is important to monitor all signs of soil erosion, and especially the presence of actively eroding head-cuts, as these would normally indicate a serious degradation problem.
- **Water quality:** Diatoms, nutrient status and conductivity levels are reliable indicators as are signs of sediment deposition within the hydro-geomorphic unit – the choice of indicator will depend on the management needs and monitoring questions being asked. SASS (Dickens & Graham, 2002) can be used to monitor water quality, if the water leaving the wetland is assessed.

Note: These guidelines for monitoring wetlands are generalised and additional indicators must be used, depending on the specific wetland type. Consult the FEPA Implementation Manual for more detailed guidelines on how to treat wetlands that are designated freshwater priority areas (FEPAs). Monitoring should be carried out by a specialist who has experience in assessing wetlands.





7 Ecosystem Guidelines for Rivers



7. Ecosystem Guidelines for Rivers



River ecosystems are vital for supplying water, which is South Africa's scarcest natural resource. Healthy river ecosystems support rural and urban economies, serve as critical ecological infrastructure and provide a range of important services to all South Africans. Grasslands, especially the Mesic Highveld, High-Altitude and Sub-Escarpment ecosystem groups, are critically important water-production landscapes, and sound land-based planning and management is vital for maintaining the health of the river ecosystems that run through them. Despite their critical importance, main-stem river ecosystems are generally in a very poor ecological state. Tributaries tend to be in better ecological condition than main rivers, so the proportion of threatened river ecosystem types is higher if only main rivers are assessed, with 65% of them classed as threatened, and 46% of them as critically endangered.

Rivers are affected by longitudinal, lateral and vertical processes and are sensitive to upstream and downstream activities. Because of the way in which river ecosystems integrate with their catchments through the hydrological cycle, there is a strong link between catchment health and river health. Rivers are both subject to and indicators of land-based catchment management practices.

Rivers and the land adjacent to them (i.e. the riparian zone), are important zones because they are at the ecological interface between terrestrial and freshwater elements of biodiversity. They perform an important role as natural ecological corridors, allowing movement of fauna and flora within the landscape, as well as providing many other ecosystem services. Riparian zones contribute to sustaining groundwater-driven base flows in perennial rivers, particularly during the dry season. This is important for sustaining biodiversity, meeting the ecological reserve (minimum daily flow volumes), the human reserve (drinking water), and water allocations (e.g. irrigation).

Riparian zones provide habitat and contribute to other biodiversity processes, including:

- Shading (buffering water temperature, especially in upper zones).
- Providing nesting areas for birds, and migration corridors.
- Serving as refugia and re-colonisation sources for more heavily-utilized main-stem rivers.
- Contribution of woody debris, providing food for microorganisms and aquatic insects, and cover for fish.

The main river types – determined by their steepness, location in the landscape and functioning – include:

- Mountain streams.
- Upper foothill rivers.
- Lower foothill rivers.
- Lowland rivers.

Each of these river types (see Figure 12) has specific management objectives relating to the availability and quality of water, sediment transport, and the quality and connectivity of riparian habitat.

Figure 12. Schematic drawing showing slope categories for rivers, one of three factors used to define river ecosystem types.





1 What are the main ecological characteristics of river ecosystems?

The ecology of riverine and riparian habitat is quite complex as it lies at the interface between terrestrial and aquatic ecosystems, and is influenced by drivers from both of these systems. The most important ecological drivers are:

- **Water quantity and hydrological flow regime:** The volume, distribution and seasonality of water-flows (including surface and groundwater sources) has a strong influence over the biological communities inhabiting the river ecosystem.
- **Upstream and catchment processes:** Rivers are linear ecosystems and are affected by ecological processes (such as disturbance by fire) and the effects of land-use practices throughout their catchments. Major impacts on the upper reaches of a river ecosystem have a cascading effect on the rest of the river ecosystem further downstream.
- **Natural erosion and sedimentation:** The natural erosive power of water, and the deposition of sediment in areas of slower-moving water, control the movement of the river banks and river bed material that provides habitat for aquatic animals. Rivers are prone to flooding and the riparian vegetation is regularly exposed to major natural disturbances that can completely re-shape the river banks and strip them of vegetation.
- **Connectivity of the river system:** Maintaining natural connectivity of the river ecosystem throughout the landscape is important as it allows for the re-establishment of natural riverine flora and fauna after flooding, movement of migratory species and other processes that depend on the natural connectivity of the system.



2 What are the main issues, vulnerabilities or pressures in river ecosystems?

River ecosystems are under severe pressure across the Grassland Biome, primarily due to cumulative human impacts and the expansion of intensive land-uses that either demand water or influence the hydrological cycle. Impacts can be both direct and indirect, and the consequences are far-reaching as rivers flow through the landscape, and impacts at one point may have knock-on effects elsewhere. A single poorly-informed decision in the upper catchment can affect the downstream ecology and all the downstream water users. Some of the main pressures on rivers include:

- **Infestation by invasive alien plants:** This includes infestation by trees such as wattles (*Acacia mearnsii*) in the riparian zone, and the introduction of aquatic invasive alien species (both plants and animals).
- **Direct channel modification:** Re-alignment of river channels and canalization leads to direct loss of aquatic habitat and changes in natural drainage patterns.
- **Sand-mining:** This activity causes structural damage to river banks and river beds and causes large volumes of sediment to be released into rivers.
- **Clearing of riparian vegetation:** Removal of riparian vegetation causes fragmentation and loss of natural connectivity along river corridors, and increases the volumes and rates of water runoff into rivers.
- **Impoundments:** Artificial barriers, such as small river dams and weirs, change the hydrology of the river, influence water temperature, turbidity and nutrient status, and form barriers to species migration. Regulated and unseasonal flow-releases, including the cumulative impacts of upstream catchment activities (eg. small farm dams) and over-abstraction from ground and surface water resources, interfere with natural cues and processes.
- **Pollution:** Primary causes of pollution include excessive faecal and nutrient loads (primarily phosphates), as well as chemical pollution entering rivers from industries such as mining, detergents from informal washing zones and solid waste and litter in the riverine zone. Pollution has significant impacts on water quality both at source and cumulatively downstream.



- **Injudicious ‘hard’ development within the catchment:** Activities such as building of roads and the establishment of hardened surfaces alters the hydrological regime of riverine areas causing channel modification, loss of natural vegetation at catchment level and changes in natural patterns of water flow.
- **Cumulative reduction in water flows:** Over-abstraction, inter-basin transfers within the catchment and loss of natural vegetation all contribute to stream-flow reduction. This impacts on the hydrology and flow regime of rivers as well as their ability to sustain winter base flows.
- **Increased sedimentation:** Increased sediment loads result from poor land-use management practices and increased erosion. This alters river habitats and affects water quality.
- **Degradation of wetland habitat:** Damage to wetlands contributes to increased sedimentation, larger flood peaks and destabilisation of downstream river reaches. This also affects the ability of the wetland to deliver important services such as flood attenuation and improved water quality.

3 What are the signs of healthy river ecosystems?

Healthy rivers are those that retain ecological characteristics and functioning similar to a natural, pre-disturbance state, and in which there is a sustainable balance between the ecological integrity of the river ecosystem and human use. In healthy river ecosystems:

- Flow regimes, water quality, channel characteristics and biota will be such that:
 - In the river and along its banks most of the plant and animal species will be indigenous; indigenous riparian vegetation is still dominant along the majority of the river’s length; and invasive alien species pose no significant threat.
 - Natural ecosystem processes are maintained.
 - Major natural habitat features are represented and are maintained over time.
 - Linkages between the river, the floodplain, associated wetlands and drainage lines are intact.
 - Natural migration routes of indigenous fish and other animals are intact.
 - Natural linkages with the sea or coastal lagoons are maintained and associated estuaries are productive ecosystems.
- The sensitivity to water quality and habitat preferences of macro-invertebrates (invertebrates large enough to be seen with the naked eye) can be used as an indicator of riverine habitat integrity. These indicators form the basis of the South African Scoring System (SASS, currently in Version 5) which is widely used for assessing water quality. For more information on SASS, refer to: Dickens and Graham, 2002 (details in reference list).
- Dragonflies (*Odonata*) should be present – they are an easily seen and easily understandable indicator of river health.

The River Health Programme (RHP), which is managed by the South African Department of Water Affairs, has a well-established set of indicators for assessing the health of rivers. Visit their website at www.dwaf.gov.za for more information.

Can damaged river ecosystems be rehabilitated? Although riverine habitats are prone to natural disturbance, they may be difficult to rehabilitate after damage, depending on the severity of the damage, and the starting condition of the river. The following factors should be considered when designing a river rehabilitation plan:



- **Stream rehabilitation may be either passive** (the disturbance is reduced and the system heals itself) **or active** (direct interventions in which specific repair procedures are applied). Many aspects of riverine recovery will take place passively, such as re-colonisation by invertebrates, which happens rapidly if substrate and nutrient requirements are met.
- **Invasion by alien plant species in the riparian zone is reversible**, but how easily it can be reversed depends on the severity of impact. Rehabilitation is not a once-off activity, but involves follow-up operations to clear new growth and to eliminate seedbanks over the long term. It is also costly due to the physical nature of the work. It is strongly recommended that landowners do not allow IAPs to get out of control in the first place, due to the significant costs of clearing and rehabilitating. For further advice on the removal of invasive alien species, contact Working for Water (www.dwaf.gov.za/wfw/) a government-led programme that focuses on the removal of invasive alien tree species from river catchments.
- **Invasion by alien fish species is very difficult to reverse** without costly and drastic measures such as poisoning entire stretches of rivers with a pesticide such as rotenone. Again, the best strategy is not to allow the introduction of any further alien fish species.

4 What are the management best-practices and minimum ecological requirements for river ecosystems?

Best practices for maintaining the health of river ecosystems include:

- **Ensure that management actions are consistent with the Resource Quality Objectives for the river:** Associated with the management class of water resource are a set of Resource Quality Objectives (RQOs) which set out the quantity, quality and pattern of water; assurance of instream flow; and character and condition of instream and riparian habitat and biota. RQOs are progressively being set as part of the classification of water resources by DWA under Chapter 3 of the National Water Act. Further information is available here: <http://www.dwaf.gov.za/rdm/>.
- **Keep grazers out of riparian habitats:** Riparian habitat should not be grazed, even if it is part of the grassland system. Livestock generally cause damage to the banks of rivers (from trampling) and the resulting erosion can be very difficult to fix. Where river water is the only option for the cattle to drink, a few access areas should be opened up and formally stabilised with rock packs, or other stabilisation measures, to prevent erosion. If there are indications that such an erosion problem is developing, an alternative may be to pipe water to a point away from the stream/river.
- **Aim for persistence of riverine biodiversity through the protection of ecological processes, including maintenance of:**
 - Natural flow regimes, including base flow, which is vital to managing water provision at a landscape scale.
 - Natural erosion and sedimentation regimes.
 - River connectivity (re-establishment of natural riverine fauna and riverine buffers).
 - Bank stability.
 - Habitat availability and accessibility.
 - Control of invasive alien plants and animals.
- **Implement a buffer system around all rivers:** Buffers are areas of natural vegetation that protect the ecological integrity of the receiving watercourse, protect the ecosystem from damaging impacts and allow for future rehabilitation. The width of river buffers should be determined using the guidelines in the FEPA Implementation Manual (see also Question 5, below).



- **Assess the impacts of any kind of land-use in the catchment on the volumes of surface flow entering riverine systems.** The emphasis should be on:
 - Maintaining the natural velocity and volumes of in-flow, or keeping these within a 10% variance after the introduction of a particular land-use.
 - Maintaining flood control functions, by keeping riparian vegetation intact.
 - Stability, with no increase in erosion or sediment deposition as a result of the land-use, either within the riverine zone or elsewhere in the catchment.
 - Replacing the natural capacity of the soil to hold water – once surfaces have been hardened (e.g. due to laying of concrete), artificial measures need to be introduced for storing water and feeding it gradually into the stream network.
- **Maintain migration pathways:** Indigenous migratory species must be able to move freely up- and down-stream. Any structure that obstructs or modifies the flow in the river should include a ‘fishway’ (or fish pass) that allows indigenous fish to move both upstream and downstream. This should only be done in rivers that are free of alien fish species (or alien fish species should be unable to use the fishpass). Hydraulic conditions within the fishway should suit the swimming capabilities of the migrating indigenous fish or other organisms.
- **Adopt a precautionary approach:** To protect the river system from the risks of water quality impairment, use the generic water quality boundary values that have been determined by the Department of Water Affairs for maintaining rivers in a healthy state. These values are used to determine acceptable deviations in physical or chemical variables away from a natural or reference condition.



5 What are the broad spatial guidelines for locating land-uses in relation to river ecosystems?

The National Freshwater Ecosystem Priority Areas Atlas (which can be accessed on SANBI’s BGIS website: www.bgis.sanbi.org) maps broad-scale strategic spatial priorities for conserving freshwater ecosystems and supporting sustainable use of water resources. The National Freshwater Ecosystem Priority Areas Atlas can be used to determine if a river ecosystem falls into a freshwater priority area or not. If it does, the guidelines in the FEPA Implementation Manual (Driver *et al.* 2011) should be used to guide planning and land-use in and around this river ecosystem. At the landscape scale, broad spatial guidelines for locating land-uses in relation to river ecosystems include:

- **Establish buffer zones on either side of the river ecosystem:** Buffers should be established to protect the riparian ecotone and the river itself from any impacting activities. Whilst the buffer might not protect the river system from changes to the local hydrology, or point-source discharge, it will provide the following benefits:
 - Maintenance of ecological connectivity across the landscape.
 - Protection of riparian vegetation. or promotion of its regeneration.
 - Stabilisation of the river banks.

The appropriate buffer width will depend on many factors and the national protocol for buffer determination should be used when available (MacFarlane *et al.* 2010). In the absence of specific data, buffer zones should never be less than 10 m wide on either side of the river, and ideally should be in excess of 30 m. In the case of rivers that are designated Freshwater Ecosystem Priority Areas, a generic buffer width of 100 m should be applied (although this may need to be modified to take into account the specific circumstances at particular sites or habitat requirements of certain species). The buffer should be designed to incorporate at least the primary and secondary floodplain zones, and, in upstream management areas they should be wide enough to ensure that water quality will not be affected downstream by any proposed land-uses.

- **Preserve the connectivity of the river ecosystem** and do not permit land-uses that lead to fragmentation of riparian zones.



6 What indicators can be used to assess and monitor the impacts of management on the biodiversity of river ecosystems?

To assess the impacts of management on river ecosystems, two key aspects should be monitored: (i) the ecological integrity of riverine habitats; and, (ii) water quality.

- **Habitat assessments:** These can be used to determine the state of the riparian vegetation and the physical condition of the river-bank. These assessments are easy to conduct and would sound obvious alarm bells if there are problems in the ecosystem. A vegetation specialist should be able to assist with habitat assessments. In such assessments, the following would indicate a decline in the health of the ecosystem:
 - Changes in species composition and vegetation structure.
 - Absence of dragonflies.
 - The presence of invasive alien plants.
 - Signs of accelerated erosion on the banks.
 - A decline in vegetation cover relative to areas that are known to be in good condition.
- **Assessments of water quality:** These are more complex and need to be carried out by a water quality specialist. The following aspects of water quality in streams that flow out of the riverine habitat should be assessed:
 - Basic laboratory analysis of the water can be used to measure turbidity, conductivity, pH, and levels of nutrients such as ammonia, phosphate, chloride, potassium, nitrate, nitrite and sulphate. This can be measured using a range of techniques that either focus on the water itself or the aquatic macro-invertebrate fauna of the stream (e.g. SASS 5).
 - The community structure of aquatic invertebrates, their sensitivity to water quality and habitat changes. This can provide a time-integrated measure of the prevailing river conditions, which is something water chemistry analyses cannot do. Given the lack of expertise on macro-invertebrate taxonomy at the species level, and the number of undescribed species, it would be pragmatic to focus on particular families of invertebrates, for example mayflies, caddisflies or blackflies.
 - Diatoms (unicellular algae) respond rapidly to specific physical or chemical conditions in aquatic ecosystems and are often the first indication of change. The presence or absence of indicator organisms can be used to detect specific changes in environmental conditions such as eutrophication, organic enrichment, salinisation and changes in pH. Diatom indices are generated from a list of the taxa present in a sample, along with a measure of their abundances.

