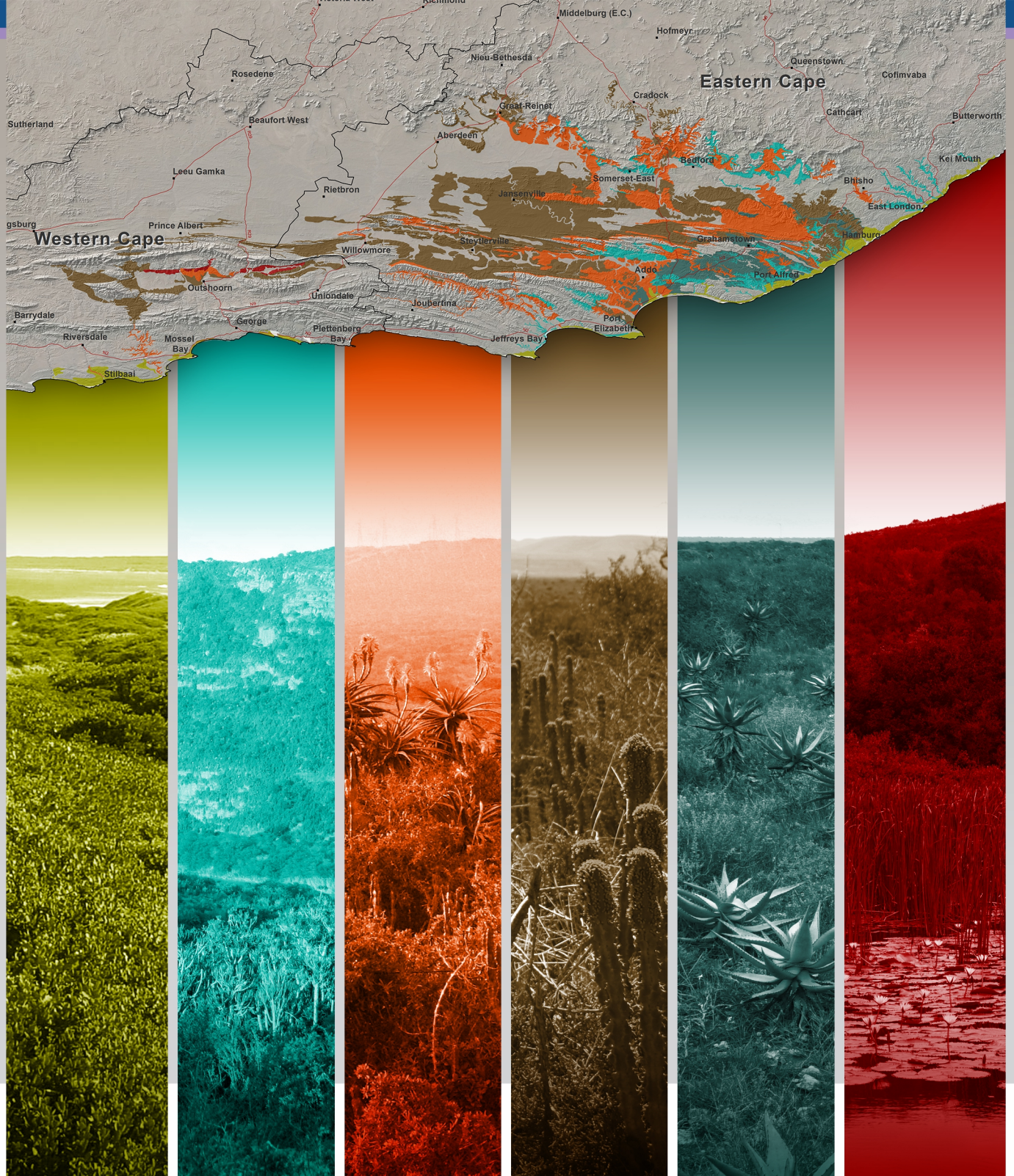




Ecosystem Guidelines for the **Albany Thicket Biome**



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forestry, fisheries
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Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

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Glossary of Terms

List of abbreviations, acronyms and initialisms

AENP	Addo Elephant National Park	ICLEI	International Council for Local Environmental Initiatives
AIP	Alien Invasive Plant	IDPs	Integrated Development Plans
ARC	Agricultural Research Council	IDZ	Industrial Development Zone
BCMM	Buffalo City Metropolitan Municipality	IPCC	Intergovernmental Panel on Climate Change
BRP	Bioregional Plan	IUCN	International Union for Conservation of Nature
BSP	Biodiversity Sector Plan	m.a.s.l	metres above sea level
BGIS	Biodiversity Geographic Information System	mm	millimetres
CAM	Crassulacean Acid Metabolism	NAEHMP	National Aquatic Ecosystem Health Monitoring Programme
CBA	Critical Biodiversity Area	NBA	National Biodiversity Assessment
CEN IEM	CEN Integrated Environmental Management	NBF	National Biodiversity Framework
CMPr	Coastal Management Programme	NDP	National Development Plan
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora	NEMA	National Environmental Management Act
CO ₂	Carbon Dioxide	NFEPA	National Freshwater Ecosystems Priority Areas
CSIR	Council for Scientific and Industrial Research	NMBM	Nelson Mandela Bay Metropolitan
DAFF	Department of Agriculture, Forestry and Fisheries (now DALRRD and DEFF)	NPP	Net Primary Productivity
DALRRD	Department of Agriculture, Land Reform and Rural Development	OSMP	Open Space Management Plan
DEA	Department of Environmental Affairs (now DEFF)	PA	Protected Area
DEDEAT	Department of Economic Development, Environmental Affairs and Tourism	PAES	Protected Area Expansion Strategy
DEFF	Department of Environment, Forestry and Fisheries	PES	Present Ecological State
Dept.	Department	REC	Recommended Ecological Category
DWA	Department of Water Affairs (now DWS)	REDZ	Renewable Energy Development Zones
DWAF	Department of Water Affairs and Forestry (these departments have now split and been grouped with other departments namely, DWA and DEFF)	REMP	River Eco-status Monitoring Programme
DWS	Department of Water and Sanitation	SACNASP	South African Council of Natural Scientific Professions
EAP	Environmental Assessment Practitioner	SAIIAE	South African Inventory of Inland Aquatic Ecosystems
ECBCP	Eastern Cape Biodiversity Conservation Plan	SANBI	South African National Biodiversity Institute
EI	Ecological Importance	SCC	Species of Conservation Concern
EIA	Environmental Impact Assessment	SDF	Spatial Development Framework
EIS	Ecological Importance and Sensitivity	SEA	Strategic Environmental Assessment
EMF	Environmental Management Framework	SIP	Strategic Integrated Projects
ES	Ecological Sensitivity	SPOT	<i>Satellite Pour l'Observation de la Terre</i> (Satellite for observation of the Earth)
ESA	Ecological Support Areas	STEP	Sub tropical Thicket Ecosystem Programme
FEPA	Freshwater Ecosystem Priority Area	SWSA	Strategic Water Source Area
FPA	Fire Protection Association	TOPS	Threatened or Protected Species
GIS	Geographic Information System	ToR	Terms of Reference
GTI	GEOTERRAIMAGE	UNESCO	United Nations Educational, Scientific and Cultural Organisation
HGM	Hydrogeomorphic	VEGMAP	The National Vegetation Map Project of South Africa, Lesotho and Eswatini SANBI
HI	Habitat Integrity	WfW	Working for Water
		WMA	Water Managements Area
		WRC	Water Research Council

Definitions

Abiotic: non-living, in this case taken to mean the non-living components of ecosystems (e.g. wind, temperature, geological features, precipitation, and so on).

Biodiversity: refers to the diversity of genes, species and ecosystems on Earth, and the ecological and evolutionary processes that maintain this diversity.

Biodiversity hotspot: an area characterised by high levels of biodiversity and endemism, and that faces significant threats to biodiversity.

Biodiversity offset: are conservation measures designed to remedy the residual negative impacts of development on biodiversity and ecological infrastructure, once the first three groups of measures in the mitigation sequence have been adequately and explicitly considered (i.e. to avoid, minimise and rehabilitate/ restore impacts). Offsets are the 'last resort' form of mitigation, only to be implemented if nothing else can mitigate the impact.

Biodiversity pattern: the compositional and structural aspects of biodiversity, at the species and ecosystem level.

Biodiversity planning: the process of developing a spatial plan that identifies one or more categories of biodiversity priority area, using the principles and methods of systematic biodiversity planning (see 'Systematic biodiversity planning').

Biodiversity priority areas: features in the landscape (or seascape) that are important for conserving a representative sample of ecosystems and species, for maintaining ecological processes, or for the provision of ecosystem services. These are identified using a systematic spatial biodiversity planning process, and include the following categories: Protected Areas, Critically Endangered and Endangered ecosystems, Critical Biodiversity Areas, Ecological Support Areas, Freshwater Ecosystem Priority Areas, Strategic Water Source Areas, Flagship free-flowing rivers, priority estuaries, focus areas for land-based Protected Area expansion, and focus areas for offshore protection.

Biodiversity Sector Plan: map of biodiversity priority areas (critical biodiversity areas and ecological support areas) accompanied by contextual information, land-use guidelines and supporting GIS information. The map must be produced using the principles and methods of systematic biodiversity planning, in accordance with nationally agreed guidelines. A biodiversity sector plan represents the biodiversity sector's input to planning and decision making in a range of other sectors. It may, but does not have to be, formally published in the Government Gazette as a bioregional plan.

Biodiversity stewardship: model for expanding protected areas in which the state conservation authority enters into legal agreements (contracts) with private and communal landowners to protect and manage land in biodiversity priority areas. Different categories of agreement confer varying degrees of protection on the land and hold different benefits for landowners and require different levels of restriction on permissible land uses. In this model, the landowner retains title to the land, and the primary responsibility for management remains with the landowner, with technical advice and assistance provided by the conservation authority.

Biodiversity target: quantitative targets, based on best available science – for ecosystems: that indicate the minimum proportion of each ecosystem type that should remain in a natural or near-natural state (or a good ecological condition) in order to maintain viable representative samples of all ecosystem types and the majority of species associated with them; for species: the minimum number of occurrences or populations that need to be kept extant (ideally with some form of protection) in order to ensure the persistence of the species, or the minimum amount of suitable habitat that needs to be kept in good ecological condition in order to ensure the persistence of a minimum viable population of the species.

Biodiversity threshold(s): a series of thresholds used to assess ecosystem threat status, expressed as a percentage of the original extent of an ecosystem type. The first threshold, for Critically Endangered ecosystems, is equal to the biodiversity target; the second threshold, for Endangered ecosystems, is equal to the biodiversity target plus 15%; and the third threshold, for Vulnerable ecosystems, is usually set at 60%.

Biome: an ecological unit of wide extent, characterised by complexes of plant communities and associated animal communities and ecosystems, and determined mainly by climatic factors and soil types. A biome may extend over large, more or less continuous expanses of land surface, or may exist in smaller, discontinuous patches.

Bioregion: terrestrial units defined on the basis of similar biotic and physical features and processes at a regional scale.

Bioregional Plan: a biodiversity sector plan that has been published in the Government Gazette in accordance with the National Environmental Management Biodiversity Act (Act No. 10 of 2004), and that has been produced in accordance with nationally agreed Guideline for the preparation and publication of Bioregional Plans as published in the National Biodiversity Framework (Notice No.291, Government Gazette No. 32006, March 2009). They are the

biodiversity sector's input into SDFs, EMFs, SEAs and EIAs. They are based on systematic biodiversity plans developed using best available science, and are intended to inform land-use planning, environmental assessment and natural resource management by a range of sectors whose policies and decisions impact on biodiversity, and to support and streamline environmental decision-making.

Biosphere Reserve: a term developed by UNESCO, given to ecosystems with plants and animals of unusual scientific and natural interest. The intention is to promote management, research and education in ecosystem conservation. The sustainable use of natural resources is included, e.g. fishing for human consumption in a manner that results in least damage to the ecosystem.

Biotic: Living, in this case taken to mean the living components of ecosystems (e.g. plant and animal species, micro-organisms and so on); also referred to as the 'biota' in an ecosystem.

Bush encroachment: refers to a decrease in palatable grasses and herbs caused by encroaching, often unpalatable, woody alien species, resulting in a decrease in the carrying capacity of the area.

Carbon sequestration: a biochemical process through which atmospheric carbon is absorbed and stored by living organisms including plants and soil micro-organisms, and involving the storage of carbon in soils, with the potential to reduce atmospheric carbon dioxide levels.

CBA Maps: a map of Critical Biodiversity Areas and Ecological Support Areas based on a systematic biodiversity plan.

Climate change: long term changes in the Earth's weather patterns, including temperature, wind and rainfall, especially as a result of the increase in temperature of the Earth's atmosphere resulting from the increased concentration of certain gases (the so-called 'greenhouse gases').

Community: is a group or association of populations of two or more different species (plants, animals, micro-organisms) occupying the same geographical area and in a particular time.

Conservation Area: an area of land or sea that is not protected in terms of the Protected Areas Act but is nevertheless managed as least partly for biodiversity conservation. Because there is no long-term security associated with conservation areas, they are not considered a strong form of protection. Conservation areas contribute towards the conservation estate but not the protected area estate.

Critical Biodiversity Areas: are areas required to meet biodiversity targets for ecosystems, species and ecological processes, determined by a systematic biodiversity plan. They may be terrestrial or aquatic, and are mostly (but not

always) in a good ecological state. These areas need to be maintained in a natural or near-natural state, and loss or degradation must be avoided. If these areas were to be modified, biodiversity targets could not be met.

Cultivation: a form of intensive agriculture. Includes field crops and horticulture. Includes dryland and irrigated crops. Can be for commercial or subsistence purpose.

Development: a broad socio-economic goal, encompassing social and economic factors.

Ecological condition: an assessment of the extent to which the composition, structure and function of an area or biodiversity feature has been modified from a reference condition of natural.

Ecological infrastructure: naturally functioning ecosystems that generate or deliver valuable ecosystem services – i.e. nature's equivalent of built infrastructure. Examples include mountain catchment areas, wetlands and soils.

Ecological process: the functions and processes that operate to maintain and generate biodiversity. In order to include ecological processes in a biodiversity plan, their spatial components need to be identified and mapped.

Ecological Support Areas: an area that must be maintained in at least fair ecological condition (semi-natural/moderately modified state) in order to support the ecological functioning of a CBA or protected area, or to generate or deliver ecosystem services, or to meet remaining biodiversity targets for ecosystem types or species when it is not possible or not necessary to meet them in natural or near-natural areas. One of five broad categories on a CBA map, and a subset of biodiversity priority areas.

EcoStatus: the overall PES or current state of the resource. It represents the totality of the features and characteristics of a river and its riparian areas or wetland that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services. The EcoStatus value is an integrated ecological state made up of a combination of various PES findings from component EcoStatus assessments (such as for invertebrates, fish, riparian vegetation, geomorphology, hydrology and water quality).

Ecosystem: an assemblage of living organisms, the interactions between them and their physical environment.

Ecosystem approach: a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It attempts to balance biodiversity conservation, resource use, and the level of human activity across the entire landscape.

Ecosystem resilience: the ability of an ecosystem to maintain its functions (biological, chemical, and physical) in the

face of disturbance or to recover from external pressures. A climate-resilient ecosystem would retain its functions in the face of climate change. Ecosystem-based adaptation will require measures to maintain the resilience of ecosystems under new climatic conditions, so that they can continue to supply essential services.

Ecosystem Services: the benefits that people obtain from ecosystems, including provisioning services (such as food and water), regulating services (such as flood control), cultural services (such as recreational benefits), and supporting services (such as nutrient cycling, carbon storage) that maintain the conditions for life on Earth.

Ecosystem Threat Status: a measure of how threatened an ecosystem is, based on how much of the ecosystem's original area remains intact relative to three different thresholds or 'tipping points'. These thresholds indicate the points at which it is estimated that the ecosystem would undergo fundamental change, either in terms of biodiversity pattern or ecological processes. Ecosystems are categorised as Critically Endangered, Endangered, Vulnerable or Least Threatened.

Endemic: restricted or exclusive to a particular geographic area and occurring nowhere else. Endemism refers to the occurrence of endemic species.

Forbs: herbaceous plants with soft leaves and non-woody stems.

Geology: the study of the Earth's crust and its rock formations.

Geophyte: perennial plant(s) having underground perennating organs such as bulbs, tubers or corms

Habitat: the area or environment occupied by a species or groups of species, due to the particular set of environmental conditions that prevails there.

Habitat loss: conversion of natural habitat in an ecosystem to a land use or land cover class that results in irreversible change in the composition, structure and functional characteristics of the ecosystem concerned.

Indicator species: a species that describes a characteristic or the ecological condition of the environment in which it occurs.

Invertebrate: animals without backbones.

Keystone species: a species that has a disproportionately large effect on its environment relative to its abundance.

Mitigation: measures to reduce negative impacts on the environment from land-use activities; in terms of climate change, measures to reduce greenhouse gas emissions into the atmosphere, and enhance greenhouse gas sinks.

National Freshwater Ecosystem Priority Areas: a biodiversity planning project that identified a set of freshwater ecosystem priorities for meeting biodiversity targets for rivers, wetlands and freshwater fish species of special concern.

Persistence: a principle of systematic biodiversity planning, referring to the need to maintain the ecological and evolutionary processes that enable ecosystems and species to persist over time.

Plantations: forestry plantations, almost always of exotic species.

Present Ecological State: a term for the current ecological condition of the aquatic resource. This is assessed relative to the deviation from the Reference State. Reference State/Condition is the natural or pre-impacted condition of the system. The reference state is not a static condition, but refers to the natural dynamics (range and rates of change or flux) prior to development. The PES is determined per component - for rivers and wetlands this would be for the drivers: flow, water quality and geomorphology; and the biotic response indicators: fish, macroinvertebrates, riparian vegetation and diatoms. PES categories for every component would be integrated into an overall PES for the river reach or wetland being investigated. This integrated PES is called the EcoStatus of the reach or wetland.

Protected Area: an area of land or sea that is protected in terms of the Protected Areas Act and managed mainly for biodiversity conservation.

Ramsar site: a wetland site designated to be of international importance under the Ramsar Convention. The Convention on Wetlands, known as the Ramsar Convention, is an intergovernmental environmental treaty established in 1971 by UNESCO, and came into force in 1975.

Red List of species: a publication that provides information on the conservation and threat status of species, based on scientific conservation assessments.

Refugia: an area in which a population of organisms can survive through a period of unfavourable conditions.

Reserve: the quantity and quality of water needed to sustain basic human needs and ecosystems (e.g. estuaries, rivers, lakes, groundwater and wetlands) to ensure ecologically sustainable development and utilisation of a water resource. The Ecological Reserve pertains specifically to aquatic ecosystems.

Succulent: plants that have some parts that are more than normally thickened and fleshy, usually to retain water in arid climates or soil conditions.

Species of special/conservation concern: species that have particular ecological, economic or cultural significance, including but not limited to threatened species.

Strategic water source area: an area that supplies a disproportionate amount of mean annual runoff to a geographical region of interest. In South Africa, SWSAs are the 10% of the land area that delivers 50% of mean annual run-off.

Systematic biodiversity/conservation planning: scientific methodology for determining areas of biodiversity importance involving: mapping biodiversity features (such as ecosystems, species, spatial components of ecological processes); mapping a range of information related to these biodiversity features and their condition (such as patterns of land and resource use, existing protected areas); setting quantitative targets for biodiversity features, analysing the information using software linked to GIS; and developing maps that show spatial biodiversity priorities. Systematic biodiversity planning is often called ‘systematic conservation planning’ in the scientific literature.

Threatened ecosystems: an ecosystem that has been classified as Critically Endangered, Endangered or Vulner-

able, based on an analysis of ecosystem threat status. A threatened ecosystem has lost, or is losing, vital aspects of its structure, composition or function. The Biodiversity Act makes provision for the Minister of Environmental Affairs, or a provincial MEC of Environmental Affairs, to publish a list of threatened ecosystems.

Threatened species: a species that has been classified as Critically Endangered, Endangered or Vulnerable, based on a conservation assessment (Red List of Species), using a standard set of criteria developed by the IUCN for determining the likelihood of a species becoming extinct. A threatened species faces a high risk of extinction in the near future.

Umbrella species: a species selected for making conservation-related decisions as its protection indirectly ensures the protection of many other species.

Ungulate: animal with hooves.

1

Introduction

1.1. Overview of the Albany Thicket Ecosystem Guidelines

Ecosystem guidelines have been developed for a number of biomes in South Africa. They represent the collective knowledge from a range of stakeholders and researchers, and incorporate the best available science. The guidelines aim to communicate complex and technical information in a non-technical format in order to make the information accessible to non-scientists. The guidelines also provide contextual information about the ecosystem types in the biome and supply step-by-step guidelines in terms of what ecosystem features and characteristics, key drivers of the ecosystems which are important to consider, and provide recommendations about how the ecosystems should be assessed or managed.

Although the Albany Thicket Biome is one of the smallest biomes in South Africa, intact thicket provides valuable resources and vital ecosystem services. It provides natural areas important for nature-based tourism and medicinal industries, protects soils from erosion, provides and helps purify water, and captures carbon (Reyers et al., 2009; Pierce & Skowno, 2009). In addition, thicket is valued for its intrinsic nature; for example, the local, traditional *Xhosa* people view thicket as sacred (Cocks et al., 2012). Relative to other vegetation types, thicket vegetation has faster growth rates under current and increasing carbon dioxide (CO₂) levels. Climatic extremes, including droughts, floods and heat waves, have little impact on thicket vegetation. Where thicket occurs in mosaics with other vegetation types, it provides an important buffer against climatic disturbances. It is therefore critically important for the persistence of non-thicket ecosystem types.

Major pressures to the Albany Thicket Biome currently include urban settlements (mostly around Nelson Mandela Metropole and the corridor from Buffalo City to the Amatola Mountains), agriculture (including cultivation and overgrazing by goats), afforestation, and alien vegetation infestation. There is an escalation in clearing of thicket for pastures in the Alexandria area and citrus in the Sundays and Gamtoos Valleys. Clearing of thicket for citrus is taking

place on the border of the Addo Elephant National Park (AENP), impacting on designated buffer areas and regional connectivity with other natural areas beyond the protected area. Existing pressures and risks are placing increasing and cumulative pressure on the environment, mostly through competition for space and consumptive use of biodiversity.

Ongoing land cover change and habitat loss to meet the needs of a growing population is placing enormous pressure on ecosystems, so that most have been influenced or modified to some extent by human activity. When natural systems are not considered, land-use change can impact negatively on ecological infrastructure and ecosystem services. Current pressures and impacts on biodiversity in the Albany Thicket Biome are described in **Chapter 4** (p. 102).

Careful land-use planning, and effective ecosystem management are critical to allow for responsible and sustainable development that provides socio-economic needs, without compromising the integrity and functionality of the very biodiversity that all citizens need for a safe and healthy existence. It is important that good decisions are made in the environmental assessment process, particularly through proactive land-use planning to retain key biodiversity assets and the ecosystem services they provide, for current and future generations.

These Ecosystem Guidelines are designed to support the reader in assessing land-use change proposals and making decisions on how best to sustain and manage biodiversity in the Albany Thicket Biome for the long-term benefit of all.

These Ecosystem Guidelines should be used in conjunction with other existing biodiversity plans and guidelines (see **Appendix 5.2** for a list of available references).

1.2. Albany Thicket: a diverse and valuable natural resource

The geographic scope of these Ecosystem Guidelines is defined by the boundary of the Albany Thicket Biome as

reflected in the Vegetation Map of South Africa (SANBI, 2018) (which will now be referred to as the SA VEGMAP). The Albany Thicket Biome is predominantly distributed in the semi-arid Eastern Cape but extends into the Western Cape (Figure 1). It occurs from the Great Kei Local Municipality in the east to the Hessequa Local Municipality (Western Cape) in the west, transitioning with ecosystem types of the Grassland, Savanna, Fynbos, Nama Karoo, Succulent Karoo and Forest Biomes. Small strips of the Albany Thicket Biome extend into the fynbos-dominated Western Cape in the Eden and Central Karoo District Municipalities. The Albany Thicket Biome covers only a small part of the land area of South Africa (approximately 32 000 km², i.e. 2.2%) (Vegetation Map of South Africa (VEGMAP), 2018), but is considered unique in terms of its origins, structure, diversity and relationship to other vegetation in South Africa. It stretches along the coastal region from the Kei River to Still Bay and an almost equal distance inland.

The Albany Thicket Biome occurs in a transitional area between summer and winter rainfall regions, with a coastal inland gradient and complex geology, the combination of which has produced a wide variation in elevation, topography, aspect, geomorphology, substrate, temperature and rainfall. This physical variation provides background to the development of complex vegetation patterns and floristic diversity. The general region is a convergence zone for most of the biomes in South Africa. With the exception of the Desert Biome, the Albany Thicket Biome borders onto, and intergrades with, all other biomes.

There are also areas of thicket vegetation that occur extensively up the east coast of South Africa, as well as down towards Cape Town, but these are not part of the Albany Thicket Biome as reflected in the national biome and VEGMAP (2018) because they occur under different climatic conditions¹ (see **Appendix 5.1** for further information). These thickets are not mapped in the Albany Thicket Ecosystem Guidelines.

These Ecosystem Guidelines divide the Albany Thicket Biome into seven ecosystem groups: six terrestrial and one inland aquatic; which share similar ecological drivers, characteristics, and have similar management requirements. The geographic distribution of the Albany Thicket Biome across municipal boundaries, with an indication of which ecosystem group can be found on a local municipality

level, is provided in **Appendix 5.1.4**. The document is supported by a spatial dataset with boundaries of each of the groups. The reader should check the location of their area of interest to determine if the guidelines have applicability, and if so, which ecosystem group applies.

The varied physical environment and complex vegetation patterns in the biome makes management decisions multifaceted, requiring a comprehensive understanding of each area. These Ecosystem Guidelines are a tool that can be used by the reader to understand how thicket functions, what its 'drivers' (things that maintain the composition, structure and function of thicket) are, and how it should best be managed.

The Albany Thicket Biome forms part of the Albany Centre of Plant Endemism and is also part of the internationally recognised Maputaland-Pondoland biodiversity 'hotspot', one of earth's biologically richest terrestrial ecosystems (Mittermeier et al., 2004). The biome forms the core of the Albany Centre of Endemism and has the highest number of endemic species of all biomes in the Eastern Cape (over 1 500 species, of which over 300 are endemics) giving weight to the importance of biodiversity conservation (Lubke et al., 1986). The biome is renowned globally for its high diversity of endemic succulents. Thicket vegetation within the biome is thought to be the most species-rich formation of woody vegetation in South Africa, exceeding that of temperate forests in the country which have by far the highest tree richness of any of the world's temperate forests.

The rich and unique biodiversity is a valuable asset; providing valuable goods and services to all people. Some key ecosystem services provided by the Albany Thicket Biome are nature-based tourism (including hunting), domestic small stock forage (especially angora goats and sheep), irrigated horticulture and carbon storage (Department of Environmental Affairs (DEA), 2015). Thicket forms the backbone of much of the province's agricultural activities. Most stock and game farming in the region make use of indigenous vegetation (much of which is in thicket) and the long-term success of these operations depends on well-managed biodiversity and functional ecosystems². Therefore, it is important to develop a good understanding on how best to manage thicket, and plan and implement land-use practices that do not compromise biodiversity or ecosystem services.

¹ Thicket vegetation also occurs in patches in association with vegetation in the Grassland, Savanna and Nama-Karoo Biomes. In these areas, a different set of climatic factors drive a distinctive flora with different origins and dynamics to vegetation in the Albany Thicket Biome

² In these guidelines, a functional ecosystem refers to an ecosystem, irrespective of its ecological condition, in which ecological processes operate and where the ecosystem is still capable of providing ecosystem services (e.g. erosion protection, water delivery). To determine if an ecosystem is still functional, the reader must identify the physical processes operating (or that would have operated) at the site and on a landscape level and assess if these are still in place.

Box 1: Albany Thicket at a glance

The Albany Thicket Biome:

- Is one of the smallest biomes in the country, comprising ~2.2% of South Africa's land surface.
- Intergrades with, and borders on all of the other biomes in the country other than the Desert Biome.
- Has exceptional diversity, and:
 - Is found within the Maputaland–Pondoland–Albany hotspot and forms the core of the Albany Centre of Endemism;
 - Is considered to be the most species-rich formation of woody vegetation in South Africa;
 - Is globally renowned for its high diversity of endemic succulents; and
 - Includes a wide range of growth forms, including leaf and stem, deciduous and semi-deciduous woody shrubs and dwarf shrubs, geophytes, annuals and grasses.
- Shows little annual fluctuation in its relatively high perennial cover, despite climate variability.
- Is generally drought resistant.
- Is not a fire-driven system (except in mosaics with other fire-driven vegetation types e.g. Fynbos).
- Provides an important buffer against climatic disturbances when found in a mosaic with other vegetation types.
- Has vegetation with high carbon sequestration potential.

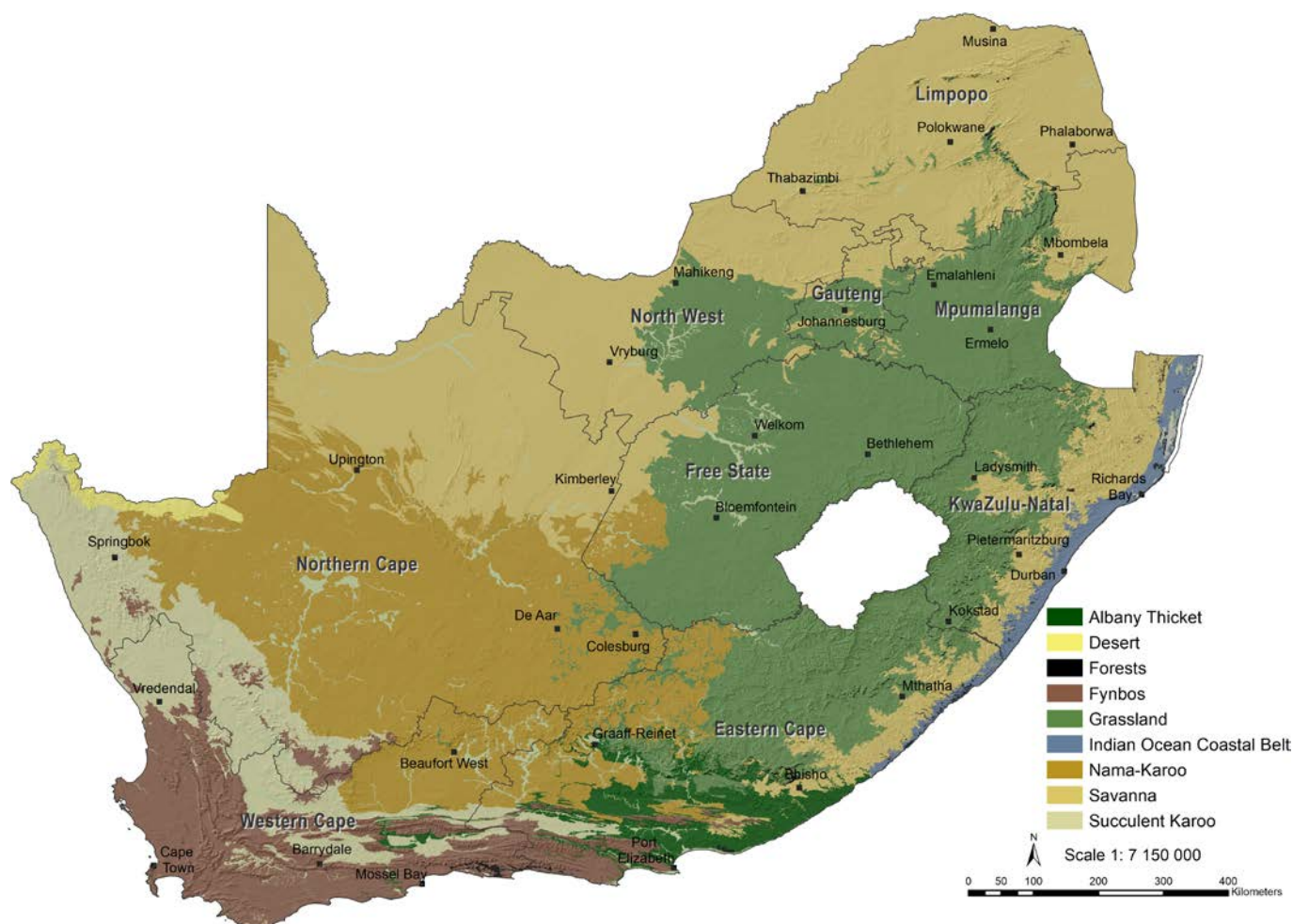


FIGURE 1.—The nine biomes of South Africa (Vegetation Map of South Africa (SA VEGMAP), 2018).

1.3. Ecosystem Groups of the Albany Thicket Biome

Vegetation types, which form the basis of terrestrial ecosystem types, that were identified in the STEP (Vlok & Euston-Brown, 2002; Vlok et al., 2003), and more recently in the SA VEGMAP (SANBI, 2018), have been clustered together to form ecosystem groups. The 112 vegetation types in the STEP map, and 44 types in the VEGMAP (2018) are too detailed to be used as ecosystem groups in these Ecosystem Guidelines. Rather, a system of classifying the various vegetation types into management units needed to be devised. The vegetation types in the STEP/VEGMAP thus needed to be summarised at a higher hierarchical level. The approach taken for this classification is described below and is used as the basis for defining ecosystem groups of the Albany Thicket Biome.

In these guidelines, thicket is broadly divided into solid thicket and thicket in a mosaic with other vegetation types. The Ecosystem Guidelines are based on the division of the Albany Thicket Biome into seven Ecosystem Groups: six terrestrial and one inland aquatic. Terrestrial Groups are divided into four solid thicket forms, i.e. Dune Thicket, Mesic Thicket, Valley Thicket, and Arid Thicket; and two mosaic groups

where thicket forms a mosaic with surrounding vegetation types, namely Thicket Mosaic with Savanna/Grassland, and Thicket Mosaic with Fynbos/Renosterveld (see Figure 2). The vegetation types combined in the six terrestrial Ecosystem Groups share similar ecological drivers, floristic and functional characteristics, and management requirements. There are various mosaics between thicket and surrounding vegetation types (i.e. mosaics with grassland, savanna, fynbos, renosterveld, and Nama and succulent karoo).

Mosaic-types are distinguished based on fire, where fire-free mosaics (i.e. forest and karoo types) are combined with solid thicket types. Dune vegetation mosaics also occur, and these are grouped with solid Dune Thicket, because the over-riding drivers are coastal processes.

Wetlands and watercourses occurring in association with terrestrial ecosystem groups in the Albany Thicket Biome are grouped as 'Inland Aquatic Ecosystems'. These occur throughout all ecosystem groups. **Chapter 3** (p. 15) elaborates on the selection, distribution, characteristics, functioning and management requirements of the seven groups.

A map showing the distribution of the terrestrial Ecosystem Groups across the biome is given in Figure 2. Table 1 describes the key features of the various groups and motivates their designation.

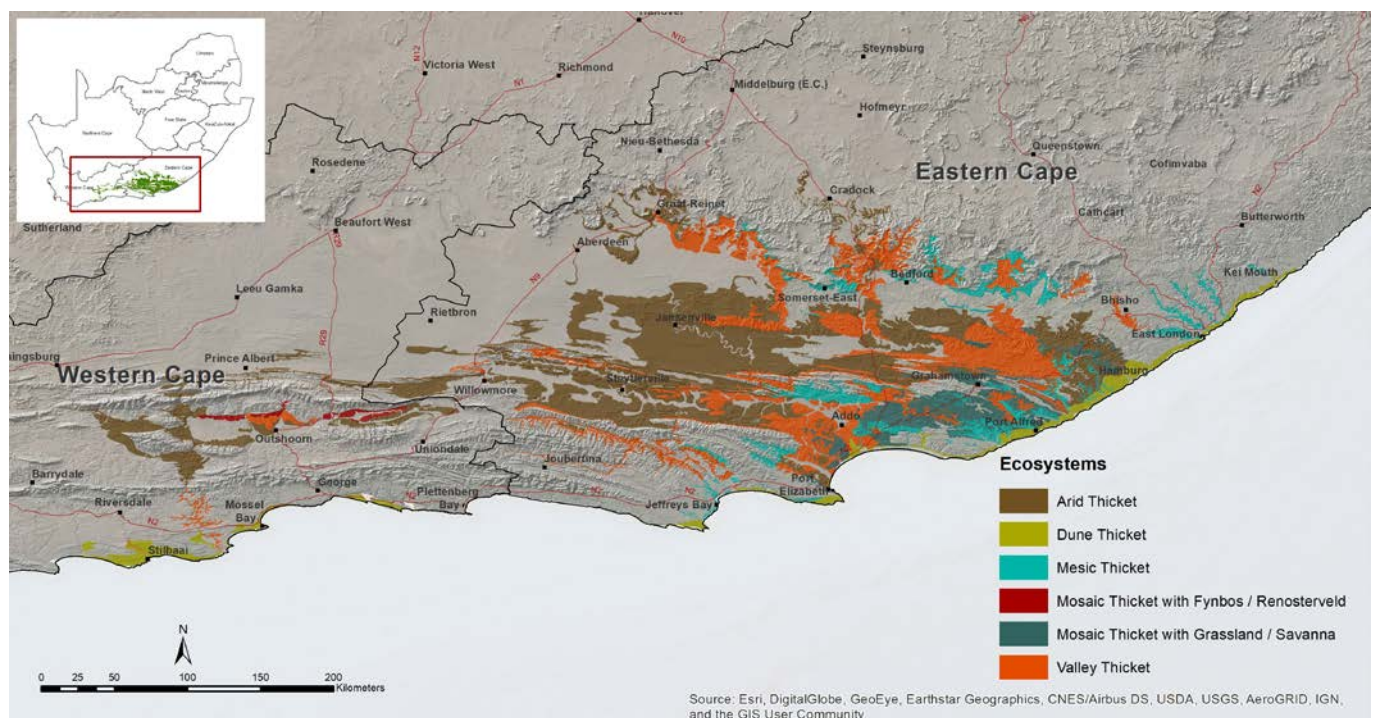


FIGURE 2.—Terrestrial Ecosystem Groups of the Albany Thicket Biome.

TABLE 1.—Ecosystem Groups of the Albany Thicket Biome.

Ecosystem Group	Description	Justification	Distinguishing Features
1 Dune Thicket (including Dune Thicket mosaics)	Thicket occurring in a narrow strip on coastal dunes and/or in close proximity to the coast. It includes any mosaics of thicket and other vegetation types, where these occur within the coastal and/or dune environment.	Most Dune Thicket occurs as narrow strips and/or localised clumps that border on other vegetation types across most of their distribution. Mosaic units are not much different, having a close spatial relationship to other vegetation types. In both solid and mosaic units, the overriding processes determining patterns are coastal.	- Occurs in coastal dunes or in close proximity to the coast. - There is a strong successional relationship between Dune Thicket and coastal forest, and in places it is displaced by coastal forest. - It often forms a mosaic with grassland, savanna or fynbos, with local patterns that are the result of fire dynamics. - It tends to have higher rainfall and a lower incidence of frost than the adjacent inland thicket, therefore it is a mesic thicket with a low proportion of succulent species.
2 Mesic Thicket (including all Thicket-Forest mosaics)	Thicket on flat, undulating or steep terrain, but with the highest moisture conditions of all the Albany Thicket types. It includes any areas where there is a transition to or mosaic with forest-type vegetation.	Mesic Thicket and Forest have similar ecology and processes, and both occur in areas with high moisture conditions.	- Occurs on flat, undulating or steep terrain. - In moist conditions. - In areas there is a transition to or mosaic with forest especially at the bottom of slopes, in kloofs or at other fire-protected sites. - Well-developed woody tree and shrub component, but succulents and spinescent species are less prominent than in Valley Thicket.
3 Valley Thicket	Thicket on steep slopes of main valley systems with intermediate moisture conditions.	Core, typical thicket with much internal floristic and environmental variation.	- Steep slopes of main valley systems. - Intermediate moisture conditions and higher temperatures than in Mesic Thicket. - Well-developed woody tree and shrub component, and succulents and spinescent species are a prominent feature. - Includes areas where <i>Portulacaria afra</i> (spekboom) may or may not be prominent.
4 Arid Thicket (including any thicket mosaics with Nama-Karoo or Succulent Karoo)	Thicket in hotter, dryer areas with the lowest moisture conditions. It also includes areas on the northwestern side of the core part of the biome in which there is a mosaic of thicket and karoo vegetation types.	Thicket in arid areas, including mosaics with karoo-type vegetation, which also occur in arid areas. In 'solid' and mosaic forms there is seldom a closed canopy over extended distances, and both occur under similar ecological conditions.	- Hot and dry areas; lowest moisture conditions. - Poorly-developed woody tree and shrub component, sparse and rarely exceeding 2 m in height. - Succulents are prominent.
5 Thicket Mosaic with Grassland and/or Savanna	Areas on the northeastern side of the core thicket areas in which there is a mosaic of thicket with grassland and/or savanna vegetation.	Grassland and savanna mosaics have been grouped here into a single unit, both of which are fire-driven ecosystems on the summer rainfall side of the Albany Thicket Biome.	- Northeastern side of the biome. - Mostly summer rainfall, although rain can occur at any time of the year. - Occurs within the broad river basins of the major river systems. - Valley bottoms and slopes are generally covered by thicket, whereas the tops of the slopes and slopes with a gentle gradient generally give way to grassland or thornveld-type savanna. - Thicket is restricted to fire-protected sites in the dissected valleys within matrix grassland/savanna areas.



TABLE 1.—Ecosystem Groups of the Albany Thicket Biome (continued).

Ecosystem Group	Description	Justification	Distinguishing Features
6 Thicket Mosaic with Fynbos and Renosterveld	Areas on the western side of the core thicket areas in which there is a mosaic of thicket and fynbos vegetation.	Fynbos and Renosterveld are on the winter rainfall side of the Albany Thicket Biome. Thicket/fynbos relationships are often successional and fire-driven. Below 600 mm/year, differences between fynbos and renosterveld are based on soil fertility.	• Western side of the biome, mostly winter rainfall. • Linear stretches of thicket occur where steeply dissected drainage valleys intersect smoother slopes, within matrix fynbos areas. • Each vegetation structural component exists within a specific part of the landscape, fynbos or renosterveld in the upper parts and thicket in the valleys. • In deep ravines, thicket may blend with forest species.
7 Inland Aquatic Ecosystems	Watercourses and wetlands occurring across the biome in association with all terrestrial ecosystem groups	Aquatic ecosystems	• There are no specific distinguishing features associated with aquatic ecosystems within Albany Thicket.

1.4. What the guidelines are

- ✓ The guidelines provide simple, concise information of key characteristics of ecosystems in the Albany Thicket Biome, based on the best available science, which deliver a practical understanding of the biome in order to inform land-use planning and decision-making. The guidelines include ecological information on: dominant species, main drivers, maintenance requirements for ecosystem viability and function, non-negotiables and possible trade-offs.
- ✓ The guidelines provide best management practice for biodiversity in the Albany Thicket Biome, which should be used during the planning and assessment of land-use change.
- ✓ The guidelines identify and describe the major risks, pressures and threats to biodiversity in the Albany Thicket Biome. They provide management recommendations to prevent critical thresholds being exceeded and avoid irreversible modification and collapse of the system.

1.5. What the guidelines are not

- ✗ The guidelines are NOT an exhaustive scientific reference work on biodiversity, ecosystem services, environmental impact assessment, ecosystem management, land-use planning or environmental legislation.
- ✗ The guidelines do NOT provide exhaustive instructions to land-use planners and environmental assessment practitioners (EAPs) (or other users). They are not prescriptive 'how to' guidelines and cannot answer all possible questions for all sites. Therefore, the guidelines are broad and must be used in combination with site-specific information and/or other available references, where required.
- ✗ The guidelines are NOT a substitute for making site visits or for involving biodiversity (or other) specialists in the environmental assessment process.

1.6. When and how the guidelines should be used

The guidelines should be used:

- Early in the planning process: these guidelines should be referred to in the pre-application, screening or feasibility

stage of a potential development or activity, to identify important biodiversity issues that need to be considered.

- As a decision support tool for land-use change applications: these guidelines can assist in making informed decisions as to the suitability of the proposed land-use change, taking into account potential effects on the receiving environment, and whether biodiversity management has been given adequate consideration.
- In conjunction with applicable legislation³: The application of relevant legislation is one of the underlying principles of these guidelines.
- In conjunction with other guidelines and tools: the guidelines provide an indication of available and applicable information and tools on biodiversity and land-use planning. It is important for the reader to check for any updates since this document was published, and to use the most recent and relevant information for the particular site or area.
- With the 'ecosystem approach' in mind: the 'ecosystem approach' helps to assess interdependencies between people and nature, identifies impacts and risks, and facilitates good decision making.

1.7. Who should use the guidelines

The Ecosystem Guidelines have been developed to provide scientifically defensible and practical information which can be used to make an informed decision on how best to manage biodiversity within the Albany Thicket Biome. The guidelines have application to a wide range of users, from regulatory authorities, to Environmental Assessment Practitioners (EAPs) in the impact assessment process, to private land users and/or commercial operators in the Albany Thicket Biome. Generally, the guidelines should be of use to all persons or entities whose activities have the potential to impact on the Albany Thicket Biome, and/or who may be affected by these activities.

1.8. Structure of the guidelines

Chapter 1: Introduction. An overview of the Albany Thicket Biome, geographic scope of the Ecosystem Guidelines, and how the guidelines should be used.

Chapter 2: Planning for a mosaic of land uses in a living landscape within the Albany Thicket Biome.

³ A synopsis of applicable legislation, policies, guidelines and tools that have relevance to environmental management in the Albany Thicket Biome is given in **Appendix 5.2**.

Chapter 3: Ecosystem guidelines for ecosystem groups identified in the Albany Thicket Biome.

Chapter 4: Planning for, and managing risks, pressures, restoration, species and conservation in the Albany Thicket Biome.

Chapter 5: Appendices.

Chapter 6: References.



2

Planning for a mosaic of land uses in a living landscape

2.1. Why are Ecological Process Areas Important?

Biodiversity pattern refers to biodiversity, in terms of composition and structure, at the genetic, species or ecosystem level.

Ecological processes refer to the functions and processes that operate to maintain and generate biodiversity. This includes interactions between species and abiotic components of the environment.

Biodiversity pattern and ecological processes (Figure 3) are inextricably linked: if sufficient habitat is not conserved to ensure that ecological processes are maintained, then the

biodiversity pattern will be lost. Similarly, loss of biodiversity may cause ecological processes to collapse. Both need to be considered during land-use planning processes to ensure that the location of land uses in the broader landscape will not result in irreparable damage or loss of irreplaceable biodiversity.

2.2. Spatial Components of Ecological Process Areas

Ecological processes can be hard to observe in time and space. This makes the task of measuring, quantifying and mapping them difficult. Some ecological processes are



FIGURE 3.—Biodiversity pattern, and fixed and flexible ecological processes.

mapped by selecting specific features that represent these processes. Spatial features may include physical linkages, boundaries, and gradients in the landscape (e.g. coastal or river corridors and migration pathways, vegetation types and/or altitudinal changes and contours).

Spatial features may be **fixed** in the landscape, such as an escarpment or a coastal corridor, and as such are clearly defined physical features (Figure 3). **Flexible** features include migration routes or corridors for achieving connection in the landscape, which may not be geographically constrained. Mapping these spatial components at appropriate scales enables conservation of ecological processes in biodiversity plans by including them in ecological corridors, which form part of the network of Critical Biodiversity Areas and Ecological Support Areas.

A number of ecological processes occur at different scales: hydrological processes or animal migration routes operate across large landscapes, whereas other ecological processes, e.g. pollination, operate at far smaller scales. Not all spatial components of ecological processes are therefore reflected in biodiversity plans, given different scales and conservation priorities. In general, it is mostly the large-scale ecological processes, considered important to meet biodiversity targets at the broad biome level, which have been mapped in biodiversity plans. Ecological corridors or vegetation boundaries representative of localised and equally important ecological processes within local catchments may not have been mapped. The identification of these important local-scale ecological processes is generally the responsibility of the EAP and/or ecological specialist.

In the land-use planning and environmental assessment process, it is important that each area is investigated to determine what ecological processes are required for biodiversity persistence, and what their spatial components are. The absence of a biodiversity plan for the area or the lack of an identified corridor within available plans does not preclude consideration of this aspect. The size of the area, the landscape features, the types of management being applied, and the nature and ecological state of the area must all be considered to conserve ecological processes. Each situation must be assessed on a case-by-case basis.

Fragmentation of natural areas and creating isolated 'islands of biodiversity' must be prevented as fragmentation disrupts the ecological processes needed to maintain functional ecosystems and intact biodiversity. It is important that connectivity between biodiversity in Protected Areas (PA) and biodiversity priority areas, also known as Critical Biodiversity Areas (CBAs), outside of the PA network, are maintained. CBA maps and biodiversity plans are extremely useful in providing a basis for connecting areas across the landscape and maintaining ecological processes that operate at a broad scale.

2.3. Planning ahead: Incorporating biodiversity pattern and ecological processes into the Environmental Assessment of project development

2.3.1. A proactive approach

The NEMA EIA Regulations impose tight timeframes on the Environmental Impact Assessment processes. Engagement with the environmental authority, conservation agencies and key biodiversity stakeholders, as well as the involvement of specialists prior to submission of the application, is therefore crucial. Early identification of potential biodiversity issues, impacts and risks allows the proponent to adjust and shape the land-use proposal in such a way as to avoid these impacts and minimise the risks associated with the development application.

The range of spatial biodiversity information readily available allows for early identification of constraints and risks associated with biodiversity and ecosystem services. In some cases, early intervention can enable proponents to avoid triggering the need for environmental authorisation (e.g. by avoiding or minimising modification of indigenous vegetation). Where natural habitat would be affected by a proposed land use, specialist biodiversity input is strongly advised. The proponent and/or appointed Environmental Assessment Practitioner (EAP) should engage an appropriate ecologist (i.e. a terrestrial, freshwater, wetland, estuarine or coastal ecologist) to identify potential biodiversity- and ecosystem services-related issues. By doing so, the ecologist can influence the proposal in such a way as to avoid or prevent significant negative impacts and risks, and optimise opportunities.

2.3.2. The Mitigation hierarchy

The mitigation of negative impacts on biodiversity and ecosystem services is a legal requirement in terms of NEMA. The principles in Section 2 of NEMA require that impacts be avoided and, where they cannot altogether be avoided, are minimised and remedied. Figure 4 outlines the mitigation hierarchy, where the priority is always on impact avoidance. Where impacts cannot be avoided and would result in an unacceptably high negative impact on the biophysical and/or social environment, the activity must not take place. With specific reference to biodiversity, the 'no go' option must

MITIGATION HIERARCHY	Avoid or prevent	Refers to considering options in project location, siting, scale, layout, technology, and phasing to avoid impacts on biodiversity, associated ecosystem services and people. This is the best option, but is not always possible. Where environmental and social factors give rise to unacceptable negative impacts, the proposed activity/development should not take place. In such cases, reliance on the later steps in the hierarchy to remedy impacts is not appropriate and is unlikely.
	Minimise	Refers to considering alternatives in the project location, siting, scale, layout, technology and phasing that would minimise impacts on biodiversity and ecosystem services. In cases where there are environmental and social constraints, every effort should be made to minimise impacts.
	Rehabilitate	Refers to the rehabilitation of areas where impacts are unavoidable and measures are provided to return impacted areas to near-natural state or an agreed land use. Although rehabilitation is important and necessary, unfortunately rehabilitation may fall short of replicating the diversity and complexity of a natural system.
	Offset	Refers to measures over and above rehabilitation to compensate for the residual negative effects on biodiversity. After every effort has been made to avoid, minimise and the rehabilitate impacts, biodiversity offsets can provide a mechanism to compensate for the residual impacts on biodiversity.

Mitigation hierarchy: Strive to avoid disturbance of ecosystems and loss of biodiversity. Where impacts cannot be avoided altogether, then minimise, rehabilitate and offset significant residual negative impacts on biodiversity.

FIGURE 4.—Mitigation hierarchy (adapted from Mining and Biodiversity Guideline, DEA 2013).

be selected where a proposed activity would lead to loss of irreplaceable biodiversity and/or irreversible ecological impacts. Where unavoidable impacts are not unacceptably high, mitigation measures must be applied to reduce the significance of the impact to acceptable levels by applying alternatives. After measures to avoid and minimise impacts have been incorporated into the proposal, and where negative impacts remain, rehabilitation measures are applied.

2.3.3. A step-by-step guide to considering biodiversity pattern and ecological processes in the Environmental Assessment

The EIA process has been developed and legislated to manage the impact of land-use change on biodiversity and ecological processes. The emphasis on proactive consideration of biodiversity to prevent ongoing biodiversity loss is a defining principle of international best practice in environmental assessment. The principle can be applied to other planning and decision-making processes that may impact on biodiversity and ecosystems, such as the development of SDFs and EMFs. Determining the context within which a

new land use is being proposed allows for a more informed analysis of the need and desirability of a project to be made, both in terms of its 'fit' with environmental opportunities and constraints, and its ecological sustainability.

Referring to these Ecosystem Guidelines and information in biodiversity plans during the initial stages of project planning, allows for the early identification of any limitations, risks and impacts, and can help avoid impacts and resolve problems in the formal application process.

The EIA process is often activity and site-specific which can be at the cost of a broader ecosystem perspective. This should be addressed through the use of biodiversity plans, and comprehensive biodiversity assessments. Guidance on how to plan for and undertake assessments is given below. Generic Terms of Reference (ToR) for terrestrial and aquatic biodiversity specialist studies are provided in **Appendix 5.3** and **5.4**, respectively. These ToR should be used in conjunction with the Albany Thicket Biome Ecosystem Guidelines and other available resources, such as the Department of Environment, Forestry and Fisheries (DEFF): Protocol for the Assessment and Reporting of Environmental Impacts on Terrestrial Biodiversity, to ensure proactive consideration of biodiversity in the pre-application stage of project development and throughout the EIA process.



Six steps for the early identification of biodiversity issues in land-use planning:

Step 1.

Prepare for the site visit by:

- Synthesising relevant and available biodiversity information to determine the sensitivity rating of the site, and if biodiversity priority areas occur (the web-based Environmental Screening Tool (<https://screening.environment.gov.za/screeningtool/>) must be used here). Read background information in Technical Documents of Biodiversity Sector Plans, Biodiversity Conservation Plans and Bioregional Plans and download the spatial data (which can be accessed at <http://bgis.sanbi.org/>) to understand the reason for identification of an area as a CBA, ESA, or threatened ecosystem. Should the reader not be able to access or interpret web-based information, they must consult the local competent authority for further clarification.
- Research characteristic floral species expected in the vegetation type listed for the area. For example, the VEGMAP describes vegetation types across the country, and provides a list of floral species that may be found in the area. Vegetation maps and descriptions may be available at a finer scale in Provincial or municipal Biodiversity/Bioregional Plans.
- Consult available point locality data for plants, and locality data available for animals at an appropriate scale (depending on the species and their range). Atlases and/or floral and faunal species data listed for the quarter degree square in which the site occurs can be accessed to determine what species and SCCs may be found. Quarter degree square data is at a coarse scale and may only be useful for large mammals and birds that have big ranges. Determine whether expected floral species need to be flowering or fruiting for identification, and if fauna is migratory as these are important aspects for planning the timing of the site survey. Data can be requested from the competent authority in the area. Plant species lists can be accessed on SANBI's 'Plants of southern Africa' (POSA) site at <http://newposa.sanbi.org/>. Plant locality data will be available for areas with high environmental sensitivity status on the Environmental Screening Tool at a fine scale. The confirmed habitat of range-restricted and threatened plant species will be mapped for areas with very high environmental sensitivity status.
- If wetlands and watercourses are expected, access information on the type of aquatic habitats in the area, how they function, and what their flow requirements are.
- Review recent aerial or satellite images (and where possible, historical images to track land-use change) and contour maps to determine the nature of the area, surrounding land-use types, landforms, land cover, drainage patterns, topography, slope etc.
- Physical factors are critical drivers of change, and need to be investigated on a landscape level, and in micro-siting. A useful resource is LandType maps developed by the DALRRD (formerly known as DAFF). The reader starts by identifying where the site is situated in relation to the national LandType map and refers to the detailed information available for the specific land type. A general profile of the area is given, with associated terrain, slope and soil types. This information is key to describing biodiversity change/patchiness/mosaics across an area, and in making decisions on how biodiversity needs to be managed, and what needs to be addressed in rehabilitation.
- Consider the numerous processes and impacts across a range of spatial and temporal scales that have bearing on the ecosystem pattern on site (i.e. do not limit ecosystem assessment to immediate time and local scale processes). This will help understand what shaped the current biodiversity status, and how the land-use change may impact on the ecosystem. It will also assist later in the assessment process in deciding what interventions should be used for biodiversity management, and at what scale to apply them.
- Read ecosystem guidelines available for the biome to understand what the ecological drivers of the relevant ecosystem group(s) are.

**Step 2.**

- Visit the site and do a site sensitivity verification (SSV). The purpose of the SSV is to confirm the actual use of the land on the ground versus that which has been identified by the screening tool. The SSV will confirm or refute the need to employ the various specialists as identified in the screening report. The SSV report does not form part of the specialist report but is to be submitted together with the relevant assessment reports. In addition, the purpose of the SSV is to establish if the site has been irreversibly modified. It will also bring attention to those features that have not been mapped and which therefore do not appear in the screening report. Refer to the DEFF Protocols for guidance on the assessment and reporting requirements for consistency of approach.

Step 2 (continued)

- During the site survey, the following aspects must be mapped and described: the extent and status of areas that are irreversibly modified, biodiversity features and ecological processes, and the location of SCCs and special habitats. The ecological condition must be assessed and described, and the reason for the identification and extent of any biodiversity priority areas (e.g. CBAs and ESAs) understood. If a discrepancy is noted between what available data specifies for the area and what is observed on site (e.g. the vegetation type on site does not match the description in VEGMAP), the entity responsible for compiling the data should be alerted. For variances in terrestrial vegetation, the VEGMAP team should be alerted to the problem via their online survey at: <https://docs.google.com/forms/d/e/1FAIpQLSeMAbFF3jgb-HErPUYD0hiQaTjTkb9KAm5ec2SBQd2jCYG7ooA/viewform> or via email: vegmap@sanbi.org.
- Note that biodiversity plans are generally updated on a five-year basis. A lot can change on the ground in this time, and the reader therefore needs to consider the current status of biodiversity in the area using a combination of a site assessment, available biodiversity plans and information, and by investigating the land-use history of the site. Remote sensing using the best available satellite or aerial imagery could be used to assist with mapping current and historical site condition. The importance of a detailed biodiversity site assessment, in conjunction with available spatial biodiversity tools, cannot be emphasised enough.
- The Species Environmental Assessment Guidelines (to be gazetted) read together with the Protocols for the assessment and reporting of environmental impact on: 3(c) Terrestrial Animal Species and 3(d) Terrestrial Plant Species (also to be gazetted), must be utilised. The guidelines provide both the background and context to the minimum assessment and reporting criteria contained within the Animal (3c) and Plant (3d) Species Protocols. It also provides guidance on sampling and data collection methodologies for the different taxonomic groups that are represented in the respective Protocols.

**Step 3.**

- Develop a map that shows biodiversity priority areas and other environmentally sensitive areas, and apply required buffers (for example to wetlands, rivers and SCCs). Maintain and accommodate clear vegetation boundaries (i.e. biome boundaries, riverine corridors, soil interfaces, etc.) as open spaces. Overlay the development footprint and ensure that biodiversity priority areas and sensitive areas are avoided. Be sure to check for connectivity on a local- and landscape level, and that sufficient space has been designated for ecological processes to operate.

**Step 4.**

- Identify and assess probable impacts of the proposed land use on biodiversity and ecological processes and determine whether, and how, impacts can be avoided by considering all feasible alternatives. Apply the mitigation hierarchy rigorously to biodiversity impacts, ensuring that reasonable and feasible alternatives have been given due consideration and the least impact option has been selected. Refer to the section on impact avoidance and the mitigation hierarchy in Section 2.3.2.

**Step 5.**

- Identify opportunities to conserve or restore biodiversity.

**Step 6:**

- Use biome Ecosystem Guidelines to identify best practice management methods for biodiversity persistence, considering local and larger-scale ecological processes and connectivity. Refer to **Chapter 3** for recommendations on the best spatial approaches to take for maintaining functional ecosystems at a landscape scale in the various ecosystem groups in the biome.



In order to ensure that an appropriate approach is used to include ecological processes in the environmental assessment process, the following is recommended:

- Further loss of habitat within mapped spatial components of ecological processes should be avoided.
- Where irreversible loss of habitat cannot be avoided or mitigated, offsets should be considered, according to the relevant biodiversity offsets guidelines or policy.
- Where there are clear opportunities in the natural landscape for linking fragments of the same ecosystem type, and/or linking different ecosystems to maintain corridors and connectivity, these opportunities should be explored and integrated into the spatial plan or project proposal. Setting aside natural habitat which is not connected to other natural or semi-natural areas could be of limited conservation value in the long term.
- Consult the relevant ecosystem guidelines for the biodiversity pattern and ecological process requirements of specific ecosystems (e.g. Mesic Thicket) when undertaking environmental assessments for projects that may impact on ecological process areas.
- Prioritise restoration and clearing of invasive alien species in degraded habitat linkages that would otherwise be lost if neglected.
- Narrow corridors such as riverine and sand movement corridors should be buffered to maintain their integrity within a spatial plan or project proposal.
- Consult CapeNature or DEDEAT for input into environmental assessments or biodiversity studies involving spatial components of ecological processes.

3

Ecosystem guidelines of the Albany Thicket

3.1. Using the guidelines

In this chapter, ten aspects are addressed in each ecosystem group. These aspects should be considered when contemplating the implications of land-use change on biodiversity in each of the ecosystem groups:

1. General characteristics
2. Conservation and land-use pressures
3. Key ecological drivers maintaining ecosystem function and biodiversity pattern
4. Main pressures, risks and threats
5. Non-negotiables
6. Best spatial approaches to avoid or minimise impacts and risk

7. Critical things to maintain for biodiversity to persist
8. Indicators to assess and monitor ecological condition
9. Reversibility of impacts within 5 to 10 years
10. Acceptable compensation measures or offsets for biodiversity loss

3.1.1. Stepwise approach to applying these guidelines

A suggested stepwise approach to using the information in this chapter when doing an EIA and/or making decisions on how to best manage an area, is given below:

Step 1 Locate site in relevant Ecosystem Group: use available shapefiles/locality maps of the ecosystem groups and locate your erf/farm within the relevant group.

Step 2 Read Appendix 5.2 of these guidelines to check what legislation, plans, guidelines, and spatial tools apply to the site and the current/proposed land use.

Step 3 Do a desktop screening exercise using DEFF's online Screening Tool (<https://screening.environment.gov.za/screeningtool>) to determine environmental sensitivity of the area. Use this information to check for biodiversity priority areas and identify any fatal flaws to the proposed land-use change and/or current management practices early in the process. This can also help identify what specialists need to be approached to assist with the detailed site assessment in Step 4, and what method should be used in the assessment process.

Step 4 Do a site inspection and biodiversity assessment. If you do not have the expertise, consult a specialist ecologist (terrestrial or aquatic, depending on the area). When conducting the site visit and subsequent site assessments, the utilisation of the Species Environmental Assessment Guidelines and the associated Species Protocols is required. Aspects to cover in the assessment include:

a Determine the biodiversity characteristics/patterns/features:

- i Does the site match the description for the area when consulting vegetation maps and reports? Check if there is a reference site in the vicinity that can be used as a benchmark of the natural biodiversity of the particular area.

- ii If not, what is the reason for the difference? Have land-use practices caused a change in the original biodiversity, or could it be an issue of scale where local variances are not depicted in available maps and classification systems?

b What drivers are required for biodiversity on site to persist (local and regional)?

- i Are these drivers operating at the site and in the greater area?
- ii If yes, what measures must be put in place to ensure they continue to operate?
- iii If no, how can they practically be re-instated?
- iv If not possible to re-instate, what does this mean for biodiversity persistence and management in the medium and long term; i.e. will the site remain viable and maintain its current biodiversity, or is loss of biodiversity inevitable over time?

c Is the site connected to other natural or near-natural areas and/or is it part of an important ecological corridor in the landscape? Do the biodiversity and ecological processes play a role in maintaining functional ecosystems beyond the site?

d What risks and pressures are currently experienced, and what additional risks/pressures to biodiversity are expected in the future?

- i For how long have these risks and pressures been applied to the site/area (ask the landowner, consult historic aerial images)?
- ii What are the impacts of the risks/pressures on the receiving ecosystems, and at what scales do these operate?
- iii Can the risks/pressures be removed/stopped or reduced?
- iv If they cannot be removed/stopped or reduced, what does this mean for biodiversity persistence and management in the medium and long term? For instance, will the site remain viable and maintain its current biodiversity, or is loss of biodiversity inevitable over time?



Step 5 Considering the above steps, determine the biodiversity status/ecological condition of the site and set a management objective.

a Is the biodiversity status/ecological condition:

- i Intact and functional?
- ii Modified but still functional?
- iii Modified and having lost most of its functions?

b What is the desired management objective?

- i Maintain or revert to intact functional thicket.
- ii Allow the ecosystem to be functional and provide important ecosystem services, but not necessarily to return to intact thicket, i.e. where land-use change continues but in a manner that does not impact on ecological processes and ecosystem services.
- iii Maintain the site in its current condition, accepting that it is degraded. Implement management measures that do not result in further deterioration in its condition, or impact beyond the site boundary.
- iv Reconnect the site with natural or near-natural areas in the wider landscape. Although the site is in poor ecological condition, it plays an important role in connectivity with areas beyond the site and is part of a greater conservation network. Consider what measures must be implemented to rehabilitate/restore biodiversity on site and in potential ecological links or corridors.

3.1.2. Managing thicket as forest in terms of the National Forest Act

Mesic forms of Albany Thicket are considered to be a serial successional stage between grassland and forest. Mesic Thicket often intergrades with forest, especially in the bottom of slopes, in kloofs or at other fire-protected sites. Mosaics with forest are addressed in the Mesic Thicket Ecosystem Group in these guidelines.

Based on the high biomass and forest-like dynamics of the vegetation types that fall within the Mesic Thicket Group, these ecosystems, as mapped in the SA VEGMAP (SANBI, 2018), should be treated as forest with regards to legislated restrictions pertaining to management and use thereof. Forest is clearly defined in terms of the National Forest Act, and the management and protection thereof is the jurisdiction of DEFF (Forestry). While these guidelines provide management recommendations for thicket/forest mosaic areas, where forest occurs (as defined in the Act), cognisance must be taken of the prescriptions of the Act and Policies. Also, note that patches of forest may be found occurring within all of the ecosystem groups in valleys and deep ravines. Relevant sections for the Act are inserted below for reference:

In terms of the Forests Act, 'forest' includes: (a) a natural forest, a woodland and a plantation; (b) the forest produce in it; and (c) the ecosystems which it makes up. 'Natural forest' refers to a group of indigenous trees (a) whose crowns are largely contiguous; or (b) which have been declared by the Minister to be a natural forest under section 7(2). 'Woodland' refers to a group of indigenous trees which are not a natural forest, but whose crowns cover more than five per cent of the area bounded by the trees forming the perimeter of the group.

Forests are recognised as being of high conservation priority (and afforded a high level of protection on a national level under the National Forest Act, due to their 'conservation significance, especially due to their exceptional biodiversity

and ecosystem services, their dynamic nature and sensitivity to disturbance', and the strong development pressure forests are under (DWAF, 2007, now known as DEFF). The Act states, as a decision-making principle, that 'natural forests must not be destroyed save in exceptional circumstances where, in the opinion of the Minister, a proposed new land use is preferable in terms of its economic, social or environmental benefits'. The Policy principles and guidelines for control of development affecting natural forests outlined by DWAF (now DEFF) (2007) states that the aforementioned principle 'must be applied in a strict and conservative manner, aimed at protecting forests as a rare and sensitive biome'. Exceptional circumstances, in the context of this principle, refer to 'capital projects of national and provincial strategic importance'. Where forests are affected by such projects, it must first be proven beyond doubt that these are in the strategic national or provincial interest, and secondly that no feasible alternative is available (such as an alternative site or route).

In addition to preventing the destruction of 'natural forests' due to development, as a whole, the National Forest Act prohibits the destruction of any species of/individual trees occurring in natural forests:

Section 7(1) No person may (a) cut, disturb, damage or destroy any indigenous tree in a natural forest; or (b) possess, collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any tree, or any forest product derived from a tree contemplated in paragraph (a), except in terms of (i) a licence issued under subsection (4) or section 23.

It also protects a specified list of Protected Trees published each year, regardless of their location within or outside natural forests:

Section 15(1) No person may (a) cut, disturb, damage or destroy any protected tree; or (b) possess, collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any protected tree, or any forest product derived for a protected tree, except (i) under a licence granted by the Minister.

3.2. Dune Thicket

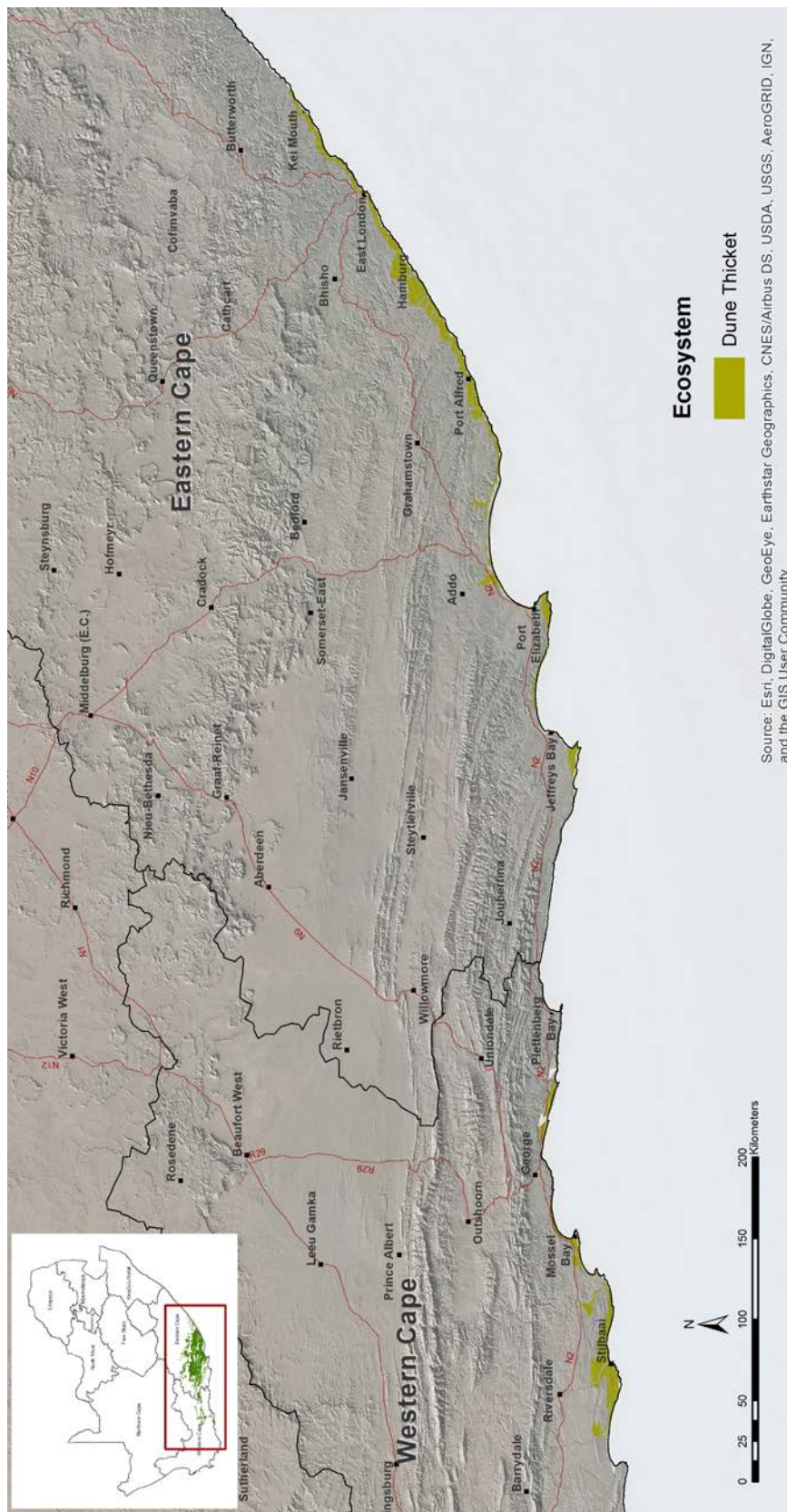


FIGURE 5.—Locality map of the Dune Thicket Ecosystem Group.

3.2.1. General characteristics

Dune Thicket is coastal vegetation (Figure 5), found mostly on aeolian substrates (i.e. quaternary sands along the coastline), as well as in fire- and frost-protected valleys that extend inland for a short distance from river mouths along the coastline. On coastal dunes, dune successional dynamics are important processes in the formation of Dune Thicket, and they tend to occur in a narrow strip in areas protected from salt-laden winds from the sea and from periodic fires from terrestrial habitats.

There is a strong successional relationship between Dune Thicket and coastal forest, and in places it is displaced by coastal forest. Dune Thicket often forms a mosaic with vegetation of the Grassland, Savanna or Fynbos Biomes, with local patterns the result of fire dynamics. Coastal areas tend to have higher rainfall and a lower incidence of frost than thicket in adjacent inland sites. The Dune Thicket Ecosystem Group is therefore a mesic thicket with a low proportion of succulent species.

Where Dune Thicket is mapped as a mosaic with other vegetation types, the thicket component often occurs in fire-protected sites, such as on riverbanks and in drainage valleys. The distribution is contained by water, rocks or sands on the downslope side and by shallower slopes on the upslope side that are more exposed to wind (and thus to fire).

Dominant and characteristic species in Dune Thicket vegetation include: *Allophylus natalensis*, *Anthospermum aethiopicum*, *Brachylaena discolor*, *Cordia caffra*, *Cotyledon adscendens*, *Erythrina caffra*, *Eugenia capensis*, *Grewia occidentalis*, *Gymnosporia capitata*, *Harpephyllum caffrum*, *Lycium cinereum*, *Mimusops caffra*, *Morella cordifolia*, *Mystroxydon aethiopicum*, *Phoenix reclinata*,



Plate 1.—Dune Thicket vegetation in the Cape Recife area in the NMBM (Source: Prof Richard Cowling).

Plate 2.—Dune Thicket vegetation in a protected valley in a mosaic with coastal fynbos vegetation in the Tsitsikamma area (Source: CEN IEM Unit).



TABLE 2.—Vegetation Types (VEGMAP, 2018) found in the Dune Thicket Ecosystem Group and their Ecosystem Threat Status and Ecosystem Protection Level (Skowno, 2018; Skowno et al., 2019).

Dune Thicket Vegetation Types	Veg Code	Ecosystem Threat Status	Ecosystem Protection Level	Extent (ha)	% decline 1750–2014
Kasouga Dune Thicket	AT41	Least Concern	Moderately Protected	30 810	3.51
Hamburg Dune Thicket	AT56	Least Concern	Poorly Protected	69 040	3.79
Goukamma Dune Thicket	AT36	Least Concern	Well Protected	8 684	2.88
Hartenbos Dune Thicket	AT40	Least Concern	Poorly Protected	64 956	1.78
St Francis Dune Thicket	AT57	Least Concern	Poorly Protected	26 019	3.70

Pterocelastrus tricuspidatus, *Sideroxylon inerme*, *Searsia crenata*, *Strelitzia nicolai*, *Schotia afra*, *Tarchonanthus camphoratus* and *Vachellia karroo*.

Dune Thicket is comprised of five vegetation types (SA VEGMAP, 2018) all of which are mosaics, as listed in Table 2 below, with an indication of the ecosystem threat status and ecosystem protection level (Skowno et al., 2019). The ecosystem threat status of all vegetation types in the ecosystem group is 'Least Concern' (Skowno et al., 2019).

The predominant vegetation types are Hamburg Dune Thicket and Hartenbos Dune Thicket, comprising ~65% of the area.

Based on the habitat modification assessment done as part of the NBA (Skowno, 2018), the dominant land cover type within this ecosystem group is 'natural' (includes rangelands), followed by 'croplands' on the eastern side of the group, and 'built-up areas' on the western side. Plantations are prevalent in Goukamma Dune Thicket, making up just less than 10% of the area covered by this vegetation type. Approximately 23.97% of the group has been modified.

3.2.2. Key ecological drivers maintaining ecosystem function and biodiversity pattern

- **Wind:** Dune ecosystems are wind-driven and affected by changes in wind speed, as well as the seasonal change in direction of prevailing winds.
- **Sand movement and stabilisation:** Seasonal cycles of sand deposition and erosion are critically important for maintaining ecosystem structure and function in dune ecosystems. Stabilisation of sand by perennial vegetation provides a stable environment for Dune Thicket to persist. Sand mobility can expose or bury existing vegetation, as well as create new habitat for thicket colonisation. Dune Thicket cannot persist in conditions of high sand mobility.
- **Deposition and decomposition of organic material:** Organic detritus deposited at the high-water mark of the sea provides an important source of organic material for maintaining nutrient cycles and food webs in dune ecosystems. More importantly in Dune Thicket, leaf litter and decomposition of vegetation matter provide an important source of organic carbon for improving the soil nutrient status, which provides improved conditions for the establishment of additional species, which promotes species diversity.
- **Dune successional dynamics:** The succession from pioneer to 'climax' vegetation on dunes is an important process leading to the establishment of Dune Thicket. This results in the initial establishment of Dune Thicket, as well as the re-establishment of vegetation in areas where it may have been lost (by natural or human causes).
- **Seed dispersal:** Many thicket species are bird or animal dispersed. The establishment of pioneer thicket communities or the diversification of existing thicket are critically dependent on dispersal of propagules by birds and animals.
- **Spatial linkages to other vegetation.**
- **Fire:** Thicket is generally fire-resistant, but any alteration to the natural fire regime can have harmful effects on Dune Thicket ecosystems, especially when in a mosaic with other vegetation types that are fire prone. Fire in adjacent habitats, such as in the Grassland, Savanna or Fynbos Biomes, are important for maintaining the thicket boundaries. Vegetation structural composition can influence the probability and/or intensity of fire. Invasion by AIPs can increase the frequency and intensity of fires, with harmful effects on thicket vegetation.
- **Rainfall:** The amount of annual rainfall, as well as the season in which it occurs are important factors in determining thicket characteristics. In coastal areas, this effect is enhanced by the proximity of the sea, which brings in more constant moisture. The season of rainfall is important and leads to a gradual change in floristic composition along the coastline with distance from the southwest to the northeast, with a corresponding increase in the proportion of subtropical species.

3.2.3. Conservation, land-use pressures and risks

Approximately 5% of the Dune Thicket Ecosystem Group is currently protected in nature reserves, as well as within the Alexandria section of the AENP. There are also various conservation areas.

Dune Thicket outside PAs is exposed to pressure from coastal urban development, industrial and mining activities and invasion by AIPs, any of which may result in complete loss and/or degradation of thicket habitat. Climate change and indirect effects that alter the stability of dune ecosystems are also serious threats. The Integrated Coastal Management Act governs the management of coastal areas, and the principles of the Act should be applied in land-use planning and decision making in the coastal zone.

3.2.4. Main pressures, risks and threats

- **Establishment of urban and industrial settlements and infrastructure on dune systems:**

Residential and industrial developments are common and widespread in dune ecosystems of the Albany Thicket Biome. The largest urban centre is Port Elizabeth in the NMBM, followed by East London in the Buffalo City Metropolitan Municipality (BCMM), both of which have port developments with adjacent IDZs. Other than these major urban and industrial centres, many small settlements and tourism facilities are scattered along the entire coastline of the biome. This has led to loss and fragmentation of habitat, changes to sand movement dynamics along coastlines leading to further changes to ecosystems, and general disturbance that affects biodiversity and vegetation patterns. Coastal village establishment in dune/fynbos mosaic vegetation precludes fires which are needed to maintain fynbos diversity and functioning, and often leads to encroachment of woody thicket species at the expense of fynbos. A good example of this is in St Francis Bay, in the Kouga Local Municipality in the Eastern Cape.

- **Invasion by woody alien plants:**

There are a wide array of woody AIP species that readily invade dune ecosystems (e.g. *Acacia cyclops* and *Cestrum laevigatum*). They have various effects on dune ecosystems, including stabilising mobile dunes, destabilising palaeo-dunes, altering soil nutrient status, displacing indigenous vegetation and altering natural fire regimes (invasive species are more prone to burning, whereas indigenous Dune Thicket seldom burns). There are significant parts of Dune Thicket ecosystems that are moderately to severely invaded by AIPs.

- **Climate change:**

Climate change has the potential to modify ambient rainfall, temperature and prevailing wind conditions, all

of which can lead to changes in species composition and vegetation structure. An increase in coastal storm intensity and frequency can be expected. This may result in small to significant changes in local dune dynamics and coastal erosion, which can lead to local loss or change in ecosystem characteristics and biodiversity patterns.

- **Coastal pollution:**

Pollution in coastal areas occurs largely as a result of sewage effluent from urban settlements (e.g. from point source discharges from wastewater treatment plants, diffuse runoff from areas with no formal sanitation treatment, or seepage from individual home systems such as septic tanks), stormwater runoff and poorly managed solid waste. There are also relatively large areas along the coast where agriculture occurs in thicket, especially dairy, and further inland large areas of citrus farming. Runoff from these areas to the coast may contain pesticides and fertilisers with high organic loads. Intact thicket vegetation provides an important buffer and filtration system for runoff from terrestrial habitats to the coast.

- **Groundwater abstraction:**

Groundwater is abstracted for domestic and agricultural use in coastal areas. Unregulated and/or over-abstraction of groundwater can have negative impacts on coastal waters and habitats, as these systems and their biota require freshwater inputs and nutrients. Saltwater intrusion into aquifers can also occur from over-abstraction, which results in a deterioration in groundwater quality. The synergies and relationships between Dune Thicket and surrounding coastal, aquatic and geohydrological processes must be considered.

- Harvesting of flora and fauna for rural livelihoods and commercial purposes are caused by the following resource uses:

- Animals for food, e.g. bush meat, edible insects.
- Animals for traditional/cultural use and medicine, e.g. leopard skins.
- Plants for food, cultural use and medicine. At least 38 plant species harvested in the Eastern Cape for medicinal trade purposes are from the Albany Thicket Biome, including species such as baboon grape, wart plant, *rooistam/kleefgras*, dwarf gasteria/*klein-beestong* and *ibhucu/kopiva/waterpypie/wildekopiva* (Sims-Castley, 2002). Approximately 30% of the plants harvested in the Eastern Cape are used exclusively for cultural purposes (for example iyeza lokuhlamba or ritual washing) (Cocks et al., 2003).
- Wood from trees is burnt for energy; used for building material for fencing and kraals; used in rituals and stockpiled to show status in the community (Cocks et al., 2003).
- Grass and reeds are used for thatching and to make brooms and mats.
- Legal and illegal hunting/poaching of animals, e.g. poaching of white and black rhinoceros.
- Harvesting of thicket species is taking place on a wide scale directly or indirectly by larger companies. An



estimated 156 tonnes of thicket plants are also traded annually in the Eastern Cape, generating an income of R7 million/year (Sims-Castley, 2002).

- Legal and illegal collection of plants for ornamental trade and medicines, e.g. poaching of cycads for illegal horticultural trade, collecting rare and endemic succulent species in the Arid Thicket Ecosystem Group for ornamental trade, harvesting sap from bitter aloe for the pharmaceutical and cosmetic industry.

3.2.5. Non-negotiables

- No construction on, or disturbance of dune systems, whether vegetated or not. All infrastructure and activities should be placed inland of secondary dunes, outside of areas deemed to be sensitive in Coastal Management Programmes (where available) and/or landward of coastal management lines determined in terms of the Integrated Coastal Management Act.
- The use of off-road vehicles on beaches is strictly regulated and should include a rigorously enforced ban (that includes management vehicles) on driving in dune systems above the high-water mark on beaches.
- Access to the beach should be controlled by establishing designated access points.
- Mined or previously disturbed areas should be properly rehabilitated.
- Sand-movement processes must be permitted, and sand-movement corridors protected. Hard structures and infrastructure must not be placed in the path of migrating dune fields and/or dynamic coastal process areas.
- Fragmentation of coastal habitats, including coastal-inland linkages, must be avoided.
- Restoration of degraded thicket should be a mandatory condition for authorisation of any application for land-use change in this at-risk biome. Never underestimate the restoration potential and importance of thicket in areas where it used to occur.
- Avoid any negative impacts on biodiversity priority areas.
- Avoid disturbance to rocky outcrops, geological/soil type boundaries and 'islands' in the landscape where thicket vegetation is present.
- Protect rare habitats, such as rocky outcrops, where range-restricted species occur.
- Avoid disturbance to riparian areas, steep slopes and valleys.
- Avoid the introduction of extra-limital, non-thicket game species (and remove extra-limital species where they have previously been introduced).
- Avoid uncontrolled aerial spraying of unregistered herbicides to destroy thicket.
- Avoid overstocking of domestic livestock and game on farms, especially goats.
- Avoid fragmenting patches of intact thicket. Where fragmentation has occurred, set aside corridor areas to reconnect the patches and/or implement measures to rehabilitate/restore corridors.
- Buffer zones around PAs should be retained in as natural a state as possible.
- Avoid allowing land uses to impact on transitional or boundary areas where thicket adjoins or forms mosaics with other vegetation types associated with other biomes. These areas accommodate the highest levels of biodiversity and require special conservation measures.

- Retain appropriate grazer-browser ratios in game species, as well as the required fire regime, for maintaining the vegetation in an optimum ecological state. Many of the mosaic thicket vegetation types are maintained by a fine balance between specific fire and grazing regimes.
- Both surface water and groundwater abstraction should be monitored where there is a risk of negative impacts on biodiversity and ecosystem function.

3.2.6. General recommendations

- Never rely on desktop information only to make decisions on the current status of biodiversity on a particular site. Always conduct a detailed biodiversity assessment on site, with the assistance of relevant specialists, where required.
- Areas identified as CBAs and ESAs, and/or threatened ecosystems in biodiversity plans are to be regarded as important biodiversity areas and must be prioritised for conservation/restoration/rehabilitation. No new development should be allowed in these areas before adequate investigation of the specific site by independent biodiversity specialists. Specialist investigations of the site and the surrounding landscape must be done to determine flora and fauna biodiversity, presence of threatened or protected flora and fauna species, and special or protected habitats, as well as any ecological corridors which facilitate landscape connectivity with other natural areas beyond the site and enable biodiversity to persist.
- Ecological corridors must be established and maintained between natural areas, especially between PAs and biodiversity priority areas outside of the PA network. Spatial linkages across the landscape between different thicket habitats must be in place and functional. Corridors must be designated and managed to allow species to track changing environmental conditions and must incorporate climate and biodiversity refugia. When identifying and delineating ecological corridors and connectivity across the landscape, make sure that these linkages follow major environmental gradients correlated to plant composition and that drive turnover in species composition across a wide range of spatial and temporal scales (Beta-diversity). Ensure that corridors are wide enough to incorporate variations in landform and physical processes (Jewitt et al., 2017).
- Restoration/rehabilitation efforts should focus on ecological corridors that provide spatial linkages across the landscape.
- Make sure that physical features, microhabitats and the 'patchiness' in the landscape (i.e. a mosaic of different habitats) are regarded as important aspects required for biodiversity persistence and management.
- Watercourses and wetlands are protected in terms of the National Water Act and are regarded as special habitats. Avoid activities that alter hydrological flow, or that impact on freshwater requirements of other users/habitats (e.g. estuaries and nearshore marine environments need freshwater for biodiversity and productivity).
- Do not consider the terrestrial environment in isolation; recognise and consider relationships between the land, surface water and groundwater components of the environment.
- Buffer areas around National Parks that are designated in Park Management Plans signed by the Minister must be considered when land-use change is planned on areas adjacent to these parks (and within buffer areas).
- Buffers must be implemented around PAs, conservation areas, known locations of SCCs, forested areas, and aquatic ecosystems.
- The carrying capacity of land used for livestock and game farming, and in PAs and conservation areas must be determined by a qualified specialist. Overstocking and overgrazing/browsing must be prevented. This is especially important in areas that are fenced. It is not possible to recommend stocking rates per ecosystem group in these guidelines, as rates will vary across sites depending on local conditions, land-use type, historical management etc. General guidelines can be gleaned from maps produced by the Agricultural Research Council (ARC), but they must be supported by a specialist who looks at local conditions that would impact on sustainable grazing and browsing practices.
- Rehabilitation relevant to all Albany Thicket types:
 - When government funds are made available for rehabilitation, PAs should be prioritised for rehabilitation efforts as there is less chance of conflicting land uses in these areas in future. Within PAs, the focus should be on areas that are outside of high impact zones (e.g. areas used/accessed by African elephants).
 - Disrupting soil structure and drainage has significant impact on thicket, and its restoration potential. For this reason, it is important to consider how and where the land has been disturbed in order to inform the approach to rehabilitation. Physical attributes of the area (i.e. terrain and soil information) must be investigated so that the correct measures can be used to re-instate processes required by local biodiversity.
 - Land Types (terrain/soil information) must be used when deciding what type of rehabilitation action is necessary. Sometimes active measures like ripping can create more damage through disruptions to the soil profile and drainage.
 - The impact of pesticides and herbicides on soil quality must be considered in rehabilitation potential. Pesticides/herbicides have the potential to harm soil biota, reduce soil quality and contaminate groundwater. Areas where pesticides/herbicides have been

used, especially where these have hyper-accumulated, may be less likely to recover if measures to improve soil quality are not addressed.

- **The removal and control of invasive alien vegetation must be prioritised.** Landowners must get advice from suitable specialists on which AIP species should be targeted, as some are more problematic in certain areas than others. Different species also respond differently to different control methods. The legal responsibilities of landowners for controlling different category species must also be taken into account. Areas in proximity to commercial plantations are particularly at risk of alien plant invasion, and plantation companies should assist landowners in managing invasive alien vegetation on their properties.
- **Land-use guidelines/recommendations given in available biodiversity plans and tools must be consulted and applied early in the land-use planning process (refer to Appendix 5.2).**
- On a strategic level, the seven principles discussed by Biggs et al. (2012) for building resilience in ecosystem services must be considered and applied especially in provincial and municipal planning processes.
- **Resilience of natural ecosystems to the impacts of climate change must be maintained** by making sure that ecological corridors are protected, thicket and mosaic boundaries are managed, management maintains diverse and functional ecosystems, and areas of climate refugia for persistence of species are identified and conserved. Dune Thicket is probably most at risk in the short term from the more immediate climate change risks associated with storm surges, changes to winds and impacts on sediment dynamics and dune corridors in the coastal zone.
- **Permeable fencing should be used**, especially in the growing number of game farms, to allow movement of animals. The impact of electric fencing on ground dwelling species must be avoided.
- A centrally managed database must be compiled where land managers, landowners, EAPs, conservation agencies, PA managers etc. can share data on AIPs (distribution, species, interventions, success rates) and fire (occurrence of controlled and uncontrolled burns, cause of fire, climate conditions prior to and during the burn, ecological monitoring records pre- and post-fire). This will greatly assist in developing an understanding of contributing factors, and best practice management in different areas. The information could be hosted on SANBI's BGIS site. A framework or template for data collection and reporting by persons on the ground would need to be developed for consistency purposes and robustness of data.

3.2.7. Best spatial approaches to avoid or minimise impacts and risk in Dune Thicket

- **Locate infrastructure and buildings so as to avoid damage from coastal processes** and, where possible, to avoid the need for physical defences against potential damage resulting from natural coastal processes.
- **Municipal planning decisions should include phased retreat of infrastructure along the coast**, where possible.
- **Permanent infrastructure should not be established on sandy beaches, close to river mouths or in dynamic or mobile dune systems.**
- **Land-use guidelines in biodiversity plans applicable to Dune Thicket should be considered**, especially where land-use change in CBAs and ESAs is proposed, to determine what types of activities are compatible with biodiversity persistence. Allow for protection of CBAs and ESAs to facilitate biodiversity persistence.
- **Coastal management lines** (previously called 'development setback lines'), must be developed for all coastal municipalities, and rigorously enforced in land-use change proposals in coastal areas. Coastal management lines identify high risk areas that need to be considered in development planning (i.e. they influence how and where development may proceed and how existing infrastructure should be maintained). The delineation of coastal management lines must be carried out in accordance with the provisions of the Integrated Coastal Management Act, the NEMA EIA Regulations, as well as any CMPr and SDFs.
- **From an ecological perspective, the delineation of coastal management lines needs to take into account, as a minimum:**
 - the need to protect infrastructure from coastal processes by allowing for: absorption of the impacts of severe storm sequences, shoreline movement, global sea level rise and increased storm surges, the fluctuation of natural coastal processes, and any combination of these factors;
 - the ecological requirements for maintaining biodiversity pattern and ecological processes, in combination with factors such as biodiversity and ecosystem requirements, landscape, seascape, visual amenity, indigenous and cultural heritage, public access, recreation, and safety to lives and property;
 - the need to treat the coast as a continuous and indivisible system; and
 - the need to establish and maintain a buffer of contiguous indigenous vegetation between the inland boundary of the youngest fixed dune trough and the seaward boundary of any impacting land-use activity (the exact set-back will depend on the biophysical

characteristics and requirements of the area, and the type and scale of the infrastructural development).

- The determination of coastal management lines also needs to take into account socio-economic elements, as it is this dimension that ultimately has an impact on these natural systems and, therefore, is an aspect that needs to be carefully managed.
- Ideally, avoid placing any infrastructure below the high-water mark, but, where this is unavoidable, adhere rigorously to the precautionary principle and ensure elements of flexibility are drawn into the design of the structure
- Prohibit all driving on sandy beaches above the high-water mark or in dune systems. The ban on driving should be maintained at popular bathing beaches, on beaches that support important breeding, feeding or roosting sites for shorebirds, and in the coastal zone of coastal protected areas (except on already-proclaimed roads).
- Prevent further fragmentation of thicket and, where possible, reconnect intact expanses of thicket.
- Modification of thicket habitat should never be allowed to sever corridors between intact thicket patches.
- Rehabilitate degraded ecological corridors connecting important thicket patches.
- Boundaries or transition areas between thicket and non-thicket biomes must be maintained by avoiding artificial disturbances in these areas, but natural disturbance regimes, such as those related to herbivory and fire, should be maintained.
- Manage grazing carefully (with attention paid to stocking rates and rotation) and ensure that grazing management is well co-ordinated with fire management, clearing of AIPs and other aspects of land management (such as measures for avoiding soil erosion) across the landscape. This is critically important for effective conservation of thicket habitats.
- The boundaries of conservancies and other land management initiatives should be designed to incorporate the natural fire zone, or broader ecosystem or habitat unit for that particular region.
- Habitat modification for urban or agricultural areas should be concentrated in nodes, allowing key ecological corridors across the landscape to be maintained. In this respect, available biodiversity plans and CBA maps should be used to guide land-use planning and change.

3.2.8. Critical things to maintain for biodiversity to persist

- Maintain indigenous vegetation structure and successional dynamics, including that of surrounding primary, foredunes and dune slacks.
- Protect thicket in sheltered areas that would be precluded from fire. Alternatively, ensure adequate fire management in areas where it may naturally occur and be needed for thicket diversity (e.g. in more northeastern areas). Where thicket occurs in a mosaic with other vegetation that needs fire (e.g. fynbos), apply management measures to avoid thicket encroachment.
- Respect and make allowance for dynamic coastal processes.



- **Maintain physical connectivity** (parallel to the coast, as well as from the coast to inland) and linkages to adjacent vegetation (e.g. to coastal forest and to Valley Thicket in river valleys).
- **Maintain soil nutrient status for nutrient-poor soils**, especially in areas with greater percentage of summer rainfall, by avoiding the use of inorganic fertilisers, and preventing contamination from sewage effluent for example
- **Consider other habitats that depend on intact thicket for their persistence**, for example inter-dune wetlands and depressions, rivers and estuaries. The status/functioning of these systems is related to the ecological condition of adjacent thicket habitat, where linkages occur between surface water and groundwater flow, sediment processes, and water quality.
- **Use a catchment approach in land-use management to prevent pollution of coastal environments**. Retain thicket to act as a buffer and filter for coastal protection.
- **Improve monitoring and surveillance of coastal areas** to identify and manage areas that are informally mined and/or poorly managed. Enforce rehabilitation of mined areas.
- **Consider synergies between surface water flow and groundwater, and how they relate to thicket composition and functioning, and the coastal environment**. Do not over-abstract groundwater for domestic or agricultural use.
- **Maintain all remaining intact thicket fragments across the range of thicket vegetation types to help buffer against the impacts of climate change**, especially those that occur in biodiversity priority areas.
- **Remaining stands of viable intact thicket in developed areas** (e.g. urban or peri-urban areas) should be retained as far as possible, as they provide useful ecosystem services to surrounding communities. For biodiversity in remnant thicket to persist, the identified drivers need to be operating. Consideration should be given to how these remnant tracts of thicket could be connected to viable corridors, and measures implemented accordingly.
- **Rehabilitate corridors that connect isolated patches of intact thicket**. Corridors are especially effective measures for conserving thicket because they enable the persistence of natural patterns of seed dispersal (in bird-dispersed species) and herbivore migration. Ecological corridors identified in biodiversity plans must be prioritised for ecological management and rehabilitation, especially in areas that are at risk of urban expansion and where there is a high probability of isolating thicket clumps across the landscape (which would ultimately result in areas of poor ecological condition in the absence of the required ecological drivers).
- **Maintain natural mosaic patterns and minimum viable patch sizes**. Establishing the minimum viable patch size and acceptable isolation distances between thicket patches, or the structure and maintenance of the mosaic pattern, all require detailed, on-site assessments at a minimum scale of 1:5 000. Only fine-scale, detailed analysis of present and past thicket distribution patterns can determine minimum viable patch sizes. A thorough understanding of physical factors shaping mosaic patterns is key, with reference to changes in soil type and slope, drainage patterns, and the location of microhabitats in the area under investigation.
- **Maintain natural disturbance regimes through integrated management of fire, grazing and drought**. Current climate trends might allow thicket to encroach into and displace less-resilient neighbouring vegetation types, so maintaining the mosaic patterns will become increasingly important to preserve biodiversity patterns at the landscape scale.
- **Certain patches of thicket, especially solid, non-mosaic vegetation types, require total protection from fire**. Fire and infestations of AIPs must, therefore, be managed in the adjacent, non-thicket ecosystems. Never allow adjacent 'fire-adapted' vegetation types (such as fynbos) to remain unburnt for longer than what is required based on the fynbos type in the area, or to become infested with woody AIPs.
- **Maintain the appropriate fire regime in terms of fire frequency and seasonality in fire-prone thicket types**.
- **Keep thicket patches and their surrounds free of invasive alien vegetation**. This requires controlling existing invasions, as well as the prevention of future invasion.
- **Ensure that planting of spekboom (*Portulacaria afra*) (as a restoration measure) only happens in areas where this species occurs (or occurred) naturally**. Consult with an experienced plant ecologist to obtain this information. If introduced in an incorrect area, spekboom could have a negative impact on other naturally-occurring species.
- **Degraded areas should be prioritised for rehabilitation/restoration**.

3.2.9. Indicators to assess and monitor ecological condition

- **Density and extent of indigenous and alien vegetation cover**: a low density of invasive alien vegetation is indicative of ecosystems in good ecological condition. The presence and density of AIP species should be monitored.
- **Functional coastal processes**, i.e. sand movement corridors, intact dune systems, connectivity along the coast and to inland ecosystems, and lack of coastal erosion.



These processes must be operating at a local and landscape level in functional Dune Thicket.

- **The canopy characteristics:** assess whether the thicket canopy is closed and continuous. In most cases, solid thicket vegetation consists of a closed, dense canopy consisting of an impenetrable tangle of shrubs and low trees. An open and/or fragmented canopy can be indicative of degradation or damage to the original vegetation. Changes could be monitored over time using a method such as fixed-point photography.
- **Structural elements:** determine whether the vegetation contains all the expected structural components for the site being assessed, including low trees, shrubs and woody lianas, accompanied by a sparse understorey of herbs consisting of geophytes, succulents, C₃ and C₄ grasses and others. The presence of emergent species, especially succulents, such as aloes and euphorbias, may also be characteristic for the site. If any of these components are lacking it may indicate degradation.
- **Presence and health of keystone species.**
- **Standing biomass:** thicket has a characteristically high standing biomass. Sparse vegetation or low biomass, except in more arid areas, may be a sign of degradation due to overgrazing or to some other factor.
- **Survival of structurally important species:** monitor mortality rate of adult trees during drought periods. Death of adult trees during drought periods indicates thicket that is in poor ecological condition.
- **Changes in species composition and vegetation structure:** species composition and vegetation structure relative to expected conditions can be monitored. The expectation can be based on historical information, baseline data collection or reference sites in similar ecological conditions to the target site. Changes may indicate habitat degradation or else provide information on successional dynamics. Functional type composition can also be a useful measure of favourable or detrimental changes. Botanical reserves could be a useful benchmark; however, they do not represent an entirely natural state since mega-herbivores have been removed. Species composition can also be measured as a baseline prior to an intervention and then monitored over time at fixed points to determine whether any changes are occurring. Similarly, monitoring can be used to determine whether a project is having continuous impacts on nearby vegetation or not.
- **Overall species diversity:** this indicator may change significantly due to natural environmental variation over time or space; for example, the amount of rainfall during the previous season or between one habitat and another. However, a reduction in species diversity may give an indication of deteriorating ecological condition.
- **Thicket growth and spread:** monitor encroachment of thicket into the surrounding matrix vegetation in thick-et-mosaic vegetation types. The presence of a distinct boundary between thicket patches and the adjacent vegetation types (such as Grassland, Savanna, Forest, Fynbos or Nama Karoo Biomes) will indicate ecosystems

in good ecological condition. Thicket clumps should only coalesce and displace adjacent vegetation types in prescribed areas where solid thicket previously occurred and not in areas where mosaic vegetation types are found.

- **A measure of fragmentation, continuity or vegetation connectedness**, as well as various other landscape ecology parameters: measures of these parameters may provide useful insight into identifying areas most in need of intervention or other areas that are intact. These parameters can be measured using aerial photographs, satellite images or SPOT images. In addition to measuring the current status, the effect of proposed clearing on an area of thicket vegetation can also be assessed using a similar approach.
- **Invasion by woody species**: the presence and density of AIPs, or the extent of invasion by weedy but indigenous woody species such as sweet thorn (*Vachellia karroo*), should be monitored, with a low density (or absence) of these species indicative of an ecosystem in good ecological condition.
- **SCCs**: persistence/stable population parameters of SCCs are a sign of ecosystems in good ecological condition. Other population parameters such as rates of recruitment, or the presence of seedlings or saplings, could provide information on population health.
- **Soil health**: parameters such as retention of the litter layer, with associated nutrients, can provide a good indication of ecological condition. The presence and severity of soil erosion features can provide a similar indication of general ecological condition; for example, the presence of sheet or gully erosion may be associated with a loss of vegetation cover.
- **Fire frequency and intensity**: in thicket-mosaic vegetation types, monitor signs that appropriate fire intervals and management are being applied. If fire is absent from mosaic vegetation types for longer than the prescribed period, then targeted burning will be required to prevent a deterioration in ecological condition.
- **The presence of a browse line can be used to indicate overbrowsing** (for example goats and browse lines in *Pappea capensis* in Arid Thicket).
- **The functionality of systems** (e.g. carbon sequestration): a number of methods can be used to do this, including easy to access new generation products (e.g. remote sensing), and making use of mass information readily available on the internet. Field measurements of net primary production can also be done.
- **Changes in the landscape**: remote sensing can be used to detect heterogeneity in the landscape, to indicate change, and to detect bush encroachment. It is important to note that while these technologies are available

and extremely useful, it takes a fair amount of skill and training to be able to use and apply these tools.

3.2.10. Reversibility of impacts within a period of 5 to 10 years

- **Impacts may be reversible in areas where rainfall is higher**, but the restoration process is likely to be slow and costly.
- **Rehabilitation of areas where vegetation has been destroyed is slow**, as vegetation must go through several successional phases to reach maturity. In most cases, especially in drier regions, recovery to the mature phase will take longer than ten years.
- **Damage is irreversible if dune environments are destroyed** as a result of land-use activities or if sand transport corridors are permanently impeded or obstructed.

3.2.11. Acceptable compensation measures or offsets for biodiversity loss

- **The coastline constitutes an important ecological corridor and plays an important role as key ecological infrastructure**. Since the corridor is geographically confined to the coast, development of Dune Thicket may permanently sever and fragment the corridor. Therefore, there are no acceptable compensation measures in coastal dune ecosystems.
- **Where Dune Thicket is degraded, restoration should be a mandatory condition for authorisation** of any application for land-use change.
- **Where residual negative impacts on Dune Thicket are unavoidable** and there are no alternatives to the proposed development (i.e. it is of overriding public importance), then **coastal corridors** must be integrated into the development layout and **biodiversity offsets** should target the securing and protection of core areas of Dune Thicket in good ecological condition, and provide for their effective management in the long term.
- **Where degraded, coastal processes should be restored** and the causes of loss of ecological condition removed, if possible.
- **Offsets must never be proposed as a mitigation measure for the destruction of unique and/or irreplaceable habitats**; lower impact alternatives that avoid impacts on these areas must be sought.
- **An offset area must be identified, planned and secured in line with the principals and requirements of presiding regulations and policy on offsets.**



3.3. Mesic Thicket

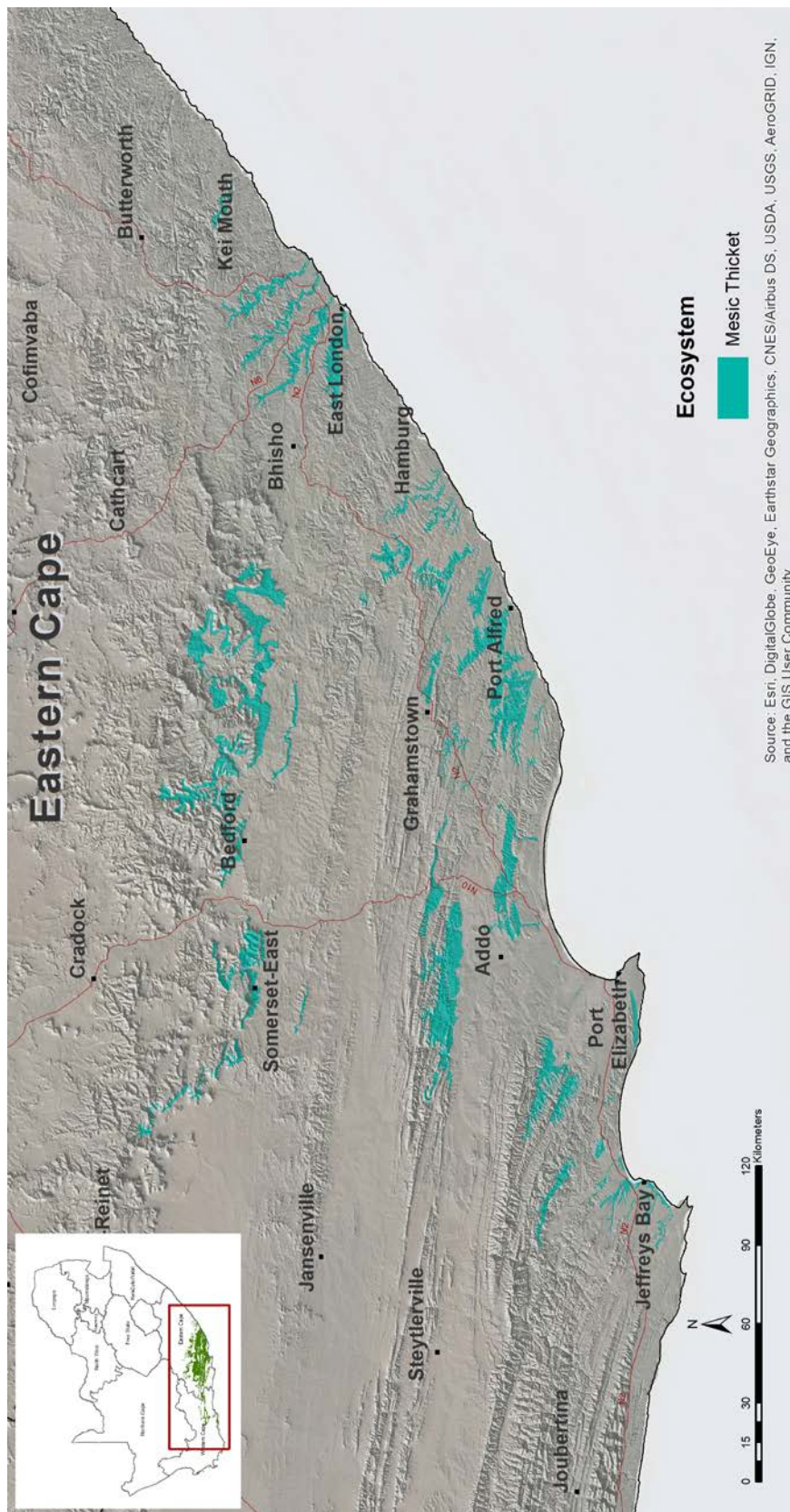


FIGURE 6.—Locality Map of the Mesic Thicket Ecosystem Group.

3.3.1. General characteristics

Mesic Thicket is an inland ecosystem group, occurring on the southern coastal lowlands and East London coastal hinterland, as well as within the south-eastern parts of the Cape Fold Mountains and along the foot of the Great Escarpment east of Somerset East (Figure 6). In the folded belt, it usually occurs on more nutrient-poor soils or, where it occurs on better soils, in areas with higher, more predictable rainfall than surrounding areas in which Valley Thicket occurs. It is a moist form of thicket, having the highest rainfall figures, compared to Valley Thicket and Arid Thicket, or else occurs on moist microsites. It has a well-developed woody tree and shrub component, but succulents and spinescent species are less prominent than in Valley Thicket. It often intergrades with forest, especially in the bottom of slopes, in kloofs or at other fire-protected sites.

Dominant and characteristic species include: *Allophylus decipiens*, *Aloe barberae*, *A. ferox*, *Brachylaena elliptica*, *Buddleja saligna*, *Canthium inerme*, *Cordia rudis*, *Combretum kraussii*, *Cussonia spicata*, *Elaeodendron zeyheri*, *Euphorbia triangularis*, *Flueggea verrucosa*, *Harpephyllum caffrum*, *Hippobromus pauciflorus*, *Olea europaea* subsp. *africana*, *Pappia capensis*, *Pittosporum viridiflorum*, *Plumbago auriculata*, *Ptaeroxylon obliquum*, *Schotia latifolia*, *Scutia myrtina*, *Searsia lucida*, *S. pallens* and *Vachellia karroo*.

Mesic Thicket is comprised of five solid thicket vegetation types, and five thicket/forest mosaic types (VEGMAP, 2018) as listed in Table 3 below with an indication of the ecosystem threat status and ecosystem protection level (Skowno et al., 2019).

The predominant vegetation types in the ecosystem group are Escarpment Mesic Thicket, Albany Mesic Thicket,



Plate 3.—A view of an area where thicket forms a mosaic with forest on a south-facing slope (Source: Prof Richard Cowling).

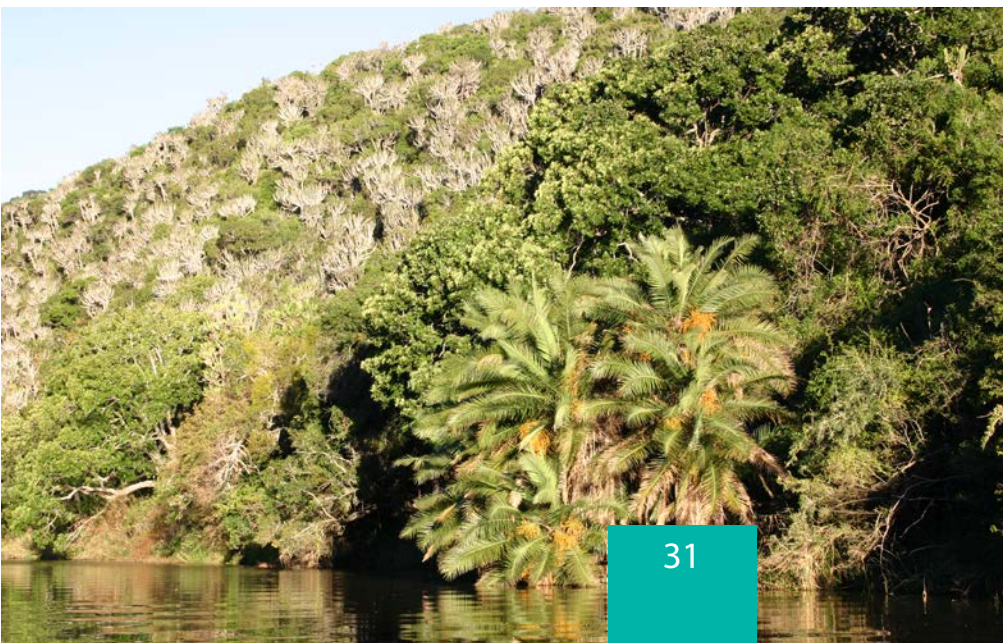


Plate 4 and 5.—Mesic Thicket in the Fish River Valley (top) and Kap River area (bottom) (Source: Prof Richard Cowling).

TABLE 3.—Vegetation Types (VEGMAP, 2018) found in the Mesic Thicket Ecosystem Group and their Ecosystem Threat Status and Ecosystem Protection Level (Skowno, 2018; Skowno et al., 2019).

Mesic Thicket Vegetation Types	Veg Code	Ecosystem Threat Status	Ecosystem Protection Level	Extent (ha)	% decline 1750–2014
Mesic Thicket					
Albany Mesic Thicket	AT17	Least Concern	Moderately Protected	70 922	2.05
Buffels Mesic Thicket	AT21	Least Concern	Poorly Protected	38 472	1.76
Escarpment Mesic Thicket	AT28	Least Concern	Poorly Protected	103 046	0.73
Fish Mesic Thicket	AT31	Least Concern	Poorly Protected	23 918	0.40
Sundays Mesic Thicket	AT50	Least Concern	Well Protected	57 810	1.42
Mesic Thicket with Forest Mosaics					
Sardinia Forest Thicket	AT48	Vulnerable	Not Protected	2 526	1.70
Thorndale Forest Thicket	AT52	Least Concern	Poorly Protected	4 359	3.66
Umtiza Forest Thicket	AT53	Critically Endangered	Moderately Protected	2 710	9.84
Van Stadens Forest Thicket	AT54	Least Concern	Well Protected	18 776	0.28
Elands Forest Thicket	AT26	Least Concern	Poorly Protected	3 963	4.75

Sundays Mesic Thicket, and Buffels Mesic Thicket. These vegetation types comprise ~80% of the ecosystem group.

Based on the habitat modification assessment done as part of the NBA (Skowno, 2018), the dominant land cover type within this ecosystem group is 'natural' (which includes rangelands), followed by 'croplands' in solid thicket, and 'croplands' and 'built-up areas' in mosaics with forest. The rate of decline of vegetation in the Mesic Thicket Ecosystem Group is moderate to low, only 13.90% of the group has been modified. It must be noted that although Sardinia Forest Thicket and Umtiza Forest Thicket occupy the smallest proportion of this ecosystem group, these vegetation types have the greatest extent of modified areas, mostly due to 'built-up areas'. The ecosystem threat status of these vegetation types is 'Vulnerable' and 'Critically Endangered' (Skowno et al., 2019). Van Stadens Forest Thicket is almost entirely natural (i.e. 98.60% natural land cover type listed). However, current risks currently occur from AIP invasion and too frequent fires, both of which can degrade thicket.

3.3.2. Key ecological drivers maintaining ecosystem function and biodiversity pattern

- **Rainfall:** Mesic Thicket occurs in landscapes with high amounts of annual rainfall, where the rain falls at any time of the year, the proportion of winter to summer rainfall is approximately even and where other (topographic and/or hydrological) factors promote high local

soil moisture conditions, for example valley bottoms in steep landscapes on mesic sides of mountains.

- **Climatic variability:** Due to the high, all-year-round rainfall and/or high local moisture conditions, the climatic variability in Mesic Thicket tends to be low.
- **Herbivory:** Less important in Mesic Thicket.
- **Fire:** Mesic Thicket tends to be associated with topographically-determined fire refugia (fire-safe places such as deep kloofs, cliffs and scree slopes). Invasion by woody AIP species can increase the frequency and intensity of fires, with harmful effects on vegetation in the group. Albany Thicket is considered to be a serial successional stage between grassland and forest, with Mesic Thicket occurring at the moist, fire-free end of the scale.
- **Soil nutrient dynamics:** Organic detritus, such as leaf litter and fallen branches, increases the soil organic content and creates a layer of humus. In dense Mesic Thicket this leads to conditions similar to what is found on the floor of forests and may be an important process in the development of forest at certain sites within thicket.
- **Seed dispersal:** Many thicket species bear fleshy fruits that are bird or animal dispersed. Dispersal of these fruits and seeds by animals, especially birds, results in the development of bush clumps around solitary perch sites such as pioneer trees and termite mounds. Bush clumps enlarge and, depending on local site conditions, eventually coalesce into dense thickets. The establishment of pioneer thicket communities or the diversification of existing thicket is therefore critically dependent on dispersal of propagules by animals.

- **Topography, geology and soil type:** Variations in these factors also drive diversity patterns and the distribution of thicket vegetation. Mesic Thicket is found in more mesic microsites than neighbouring Valley or Arid Thicket. It also tends to occur on more nutrient-poor soils or, where the soil nutrient status is similar, is found in areas with higher annual rainfall.
- **Spatial linkages to other vegetation.**

3.3.3. Conservation, land-use pressures and risks

Just over 10% of the ecosystem group is currently protected in Nature Reserves and conserved in various conservation areas.

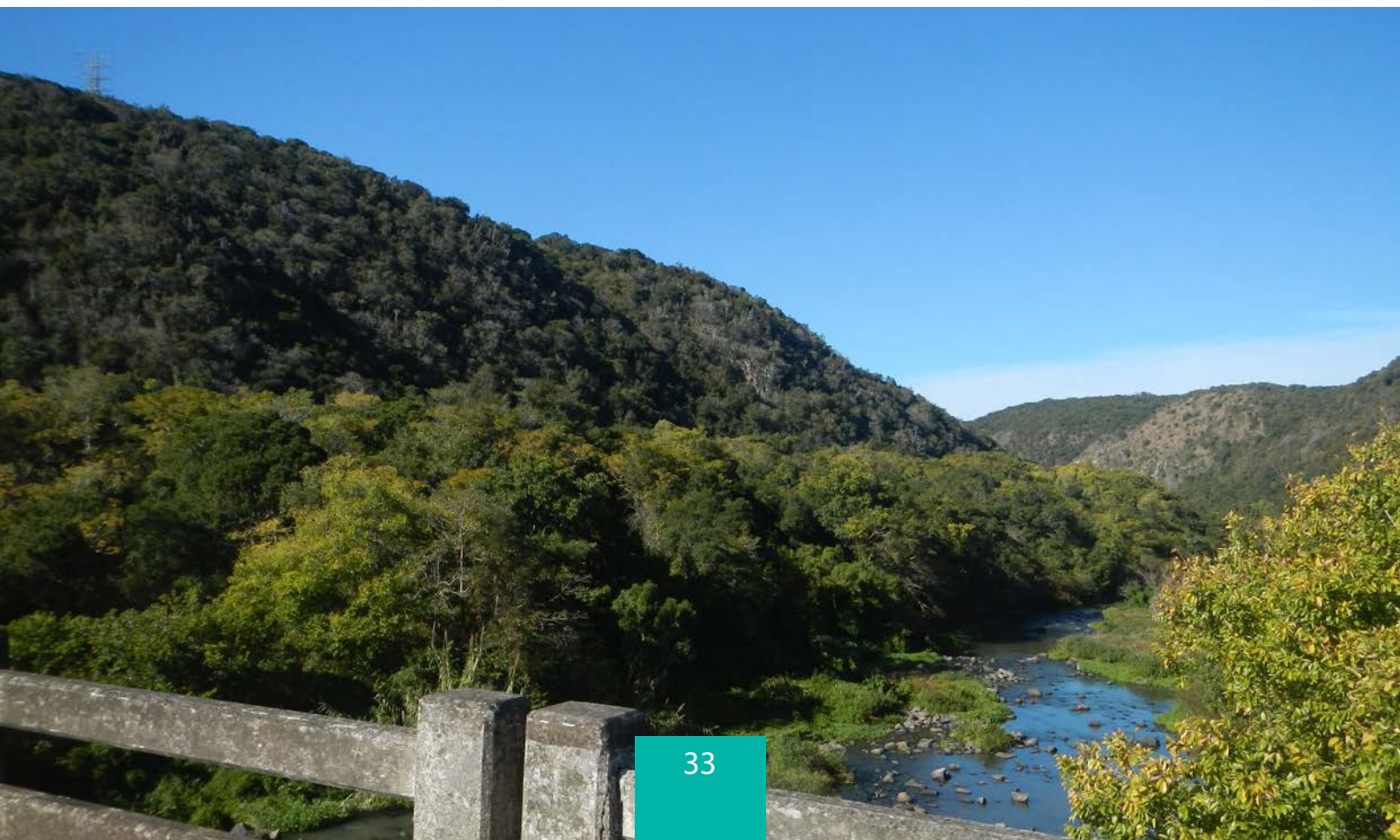
3.3.4. Main pressures, risks and threats

- **Clearing of thicket vegetation to make way for cultivation and grazing:**

Large tracts of thicket vegetation have been cleared for cultivation of various crops, particularly in linear strips along fertile river valleys; and for grazing of domestic animals. Some examples of areas at risk are in the vicinity of Kirkwood, where clearing takes place for citrus orchards and fodder crops, and in the area between Colchester and Alexandria, where large-scale clearing of thicket takes place for grazing areas for dairy farming. Clearing results in direct loss of thicket habitat, and

fragmentation, with a subsequent loss of connectivity between remaining patches of intact thicket habitat. Issues of particular concern are that:

- The loss of connectivity of thicket patches affects ecosystem function. This is especially important in this thicket type that occurs within river valleys, that has a linear distribution where clearing of thicket breaks the linear pattern of connectivity. Historically, thicket was more connected across the landscape than it is now. Habitat loss has resulted in a fragmented pattern that reduces resilience to environmental change and causes isolation of gene pools and the loss of gene flow within and between patches. Isolation due to human-induced fragmentation may result in some species losing their adaptive potential, increasing the risk of species or varieties becoming extinct.
- Due to historical patterns of clearing of thicket patches to make way for agriculture, Mesic Thicket, especially in linear valley systems, may now provide the only connectivity between thicket habitats that occur in inland-trending valleys. Infrastructure, especially linear infrastructure that crosses areas of thicket, threatens to sever these surviving linkages.
- **Overgrazing/browsing:**
Most thicket landscapes are used by commercial and subsistence farmers as rangelands for domestic stock, especially cattle and goats. Overstocking, combined with a lack of appropriate grazing/browsing management techniques over extended periods, has resulted in a large proportion of thicket landscapes becoming overutilised and degraded, with many negative consequences, including severe soil erosion and loss of certain



species. Aspects of grazing/browsing that are of particular concern include that:

- In the more mesic areas, conditions of poor fire regimes and the exclusion of mega-herbivore browsing pressure result in bush encroachment by indigenous woody shrubs such as sweet thorn and Karoo honey thorn (*Vachellia karroo* and *Lycium oxycarpum*).
- In the more arid areas, overgrazing/browsing and wildfires in hot, dry conditions present a significant threat to thicket. Although intact thicket does not readily burn, overgrazing/browsing results in the ecosystem becoming vulnerable to encroachment by woody shrubs (such as *Searsia* spp.) and C_4 grasses. Encroached areas become more flammable, meaning that fires can then penetrate vegetation that otherwise would not have been exposed to fire (at least not in recent times). This can result in the elimination of fire-intolerant thicket species.
- Livestock farmers actively burn thicket, or clear it, to improve the grazing potential of the land. In some cases, this is associated with the clearing of Albany Thicket to make way for grazing, in other instances these activities may be associated with clearing woody components that have encroached into grasslands. Being able to distinguish between these scenarios is critical in terms of applying these guidelines.
- **Invasion by woody AIPs:**
Invasive species disturb ecological processes and biodiversity patterns in thicket vegetation. Infestation by woody invasive alien species occurs in disturbed areas. These species outcompete the indigenous flora and increase fuel loads. The presence of invasive woody species increases the severity of fires and the likelihood of fires penetrating thicket at the interface between thicket and other vegetation types. Invasive trees and shrubs in Mesic Thicket include *Acacia cyclops* (in areas close to the coast), *A. dealbata*, *A. longifolia*, *A. mearnsii*, *A. melanoxylon*, *A. saligna*, *Agave americana*, *Casuarina cunninghamiana*, *Cestrum laevigatum*, *Eucalyptus camaldulensis*, *Lantana camara*, *Melia azedarach*, *Nicotiana glauca*, *Pinus halepensis*, *P. pinaster*, *P. radiata*, *Populus × canescens*, *Psidium guajava*, *Opuntia aurantiaca*, *O. ficus-indica*, *Ricinus communis*, *Salix babylonica*, *Schinus molle*, *Senna didymobotrya*, *Sesbania punicea* and *Solanum mauritianum*. There are many other AIP species that could occur within the thicket vegetation, but the ones listed here are most likely to change the structure and fire-dynamics of the vegetation and therefore lead to serious ecological changes.
- **Game farms:**
There has been a substantial increase in the number of game farms in the Eastern Cape, including in areas where Mesic Thicket occurs. While game farms have the potential to contribute towards thicket conservation if properly managed, there are several risks that they present. Overstocking of faunal species in fenced areas results in overgrazing/browsing; and subsequent impacts on thicket species composition and resilience. The introduction of extra-limital species creates competition with indigenous species, some of which may be outcompeted. Extra-limital species impact on flora through different browsing strategies. There is generally a lack of consistent management across game farms, with little control over fire management, fencing, grazing practices etc. Fencing prevents migration/movement of faunal species, and electric fences kill ground-dwelling species. Game farms are generally associated with nature-based eco-tourism, and the development of required infrastructure such as hotels, lodges, access (e.g. roads, airfields) and services. These aspects can result in visual impacts, and deteriorating environmental quality associated with poor waste management and disposal.
- **The use of herbicides to destroy thicket to create grazing for cattle and game species has been reported in the Alexandria and Addo areas.** Uncontrolled use of unregulated herbicides presents risks to thicket and other natural habitats in the surrounding area, as they are often applied using aerial sprays which prevents direct application to the target area only. A lack of understanding of how the herbicide works may lead to overapplication, with detrimental impacts on soil quality and rehabilitation potential for many years.
- **Poaching of flora, particularly *Cycad* species:**
This has the effect of removing a particular floristic component from the vegetation but can also cause localised disturbance in the areas where targeted species are removed.
- **Harvesting of flora and fauna for rural livelihoods and commercial purposes** are caused by the following resource uses:
 - Animals for food, e.g. bush meat, edible insects.
 - Animals for traditional/cultural use and medicine, e.g. leopard skins.
 - Harvesting of wood, medicinal and forage plants – this can result in the removal of keystone species from the vegetation, especially trees with hard woods that are highly suitable for firewood, structural elements, or can be used for wood carvings.
 - Plants for food, cultural use and medicine – at least 38 plant species harvested in the Eastern Cape for medicinal trade purposes are from the Albany Thicket Biome, including species such as baboon grape, wart plant, *rooistam/kleefgras*, dwarf gasteria/*klein-beestong* and *ibhucu/kopiva/waterpypie/wildekopiva* (Sims-Castley, 2002). Approximately 30% of the plants harvested in the Eastern Cape are used exclusively for cultural purposes (for example *iyeza lokuhlamba* or ritual washing) (Cocks et al., 2003).
 - Wood from trees is burnt for energy; used for building material for fencing and kraals; used in rituals and stockpiled to show status in the community (Cocks et al., 2003).
 - Grass and reeds are used for thatching and to make brooms and mats.



- Legal and illegal hunting/poaching of animals, e.g. poaching of white and black rhinoceros.
- Harvesting of thicket species is taking place on a wide scale directly or indirectly by larger companies. An estimated 156 tonnes of thicket plants are also traded annually in the Eastern Cape, generating an income of R7 million/year (Sims-Castley, 2002).
- Legal and illegal collection of plants for ornamental trade and medicines, e.g. poaching of cycads for illegal horticultural trade, collecting rare and endemic succulent species in the Arid Thicket Ecosystem Group for ornamental trade, harvesting sap from bitter aloe for the pharmaceutical and cosmetic industry.

3.3.5. Non-negotiables

- No disturbance to riparian areas, steep slopes and valleys where thicket vegetation is present. It is especially important to avoid exposing the taller inner core of Mesic Thicket.
- Avoid clearing that leads to severe fragmentation, especially across linear features and in ecological corridors, such as narrow valley systems.
- Restoration of degraded thicket should be a mandatory condition for authorisation of any application for land-use change in this at-risk biome. Never underestimate the restoration potential and importance of thicket in areas where it used to occur.
- Avoid any negative impacts on biodiversity priority areas.
- Avoid disturbance to rocky outcrops, geological/soil type boundaries and 'islands' in the landscape where thicket vegetation is present.
- Protect rare habitats, such as rocky outcrops, where range-restricted species occur.
- Avoid disturbance to riparian areas, steep slopes and valleys.
- Avoid the introduction of extra-limital, non-thicket game species (and remove extra-limital species where they have previously been introduced).
- Avoid uncontrolled aerial spraying of unregistered herbicides to destroy thicket.
- Avoid overstocking of domestic livestock and game on farms, especially goats.
- Avoid fragmenting patches of intact thicket. Where fragmentation has occurred, set aside corridor areas to reconnect the patches and/or implement measures to rehabilitate/restore corridors.
- Buffer zones around PAs should be retained in as natural a state as possible.
- Avoid allowing land uses to impact on transitional or boundary areas where thicket adjoins or forms mosaics with other vegetation types associated with other biomes. These areas accommodate the highest levels of biodiversity and require special conservation measures.
- Retain appropriate grazer-browser ratios in game species, as well as the required fire regime, for maintaining the vegetation in an optimum ecological state. Many of

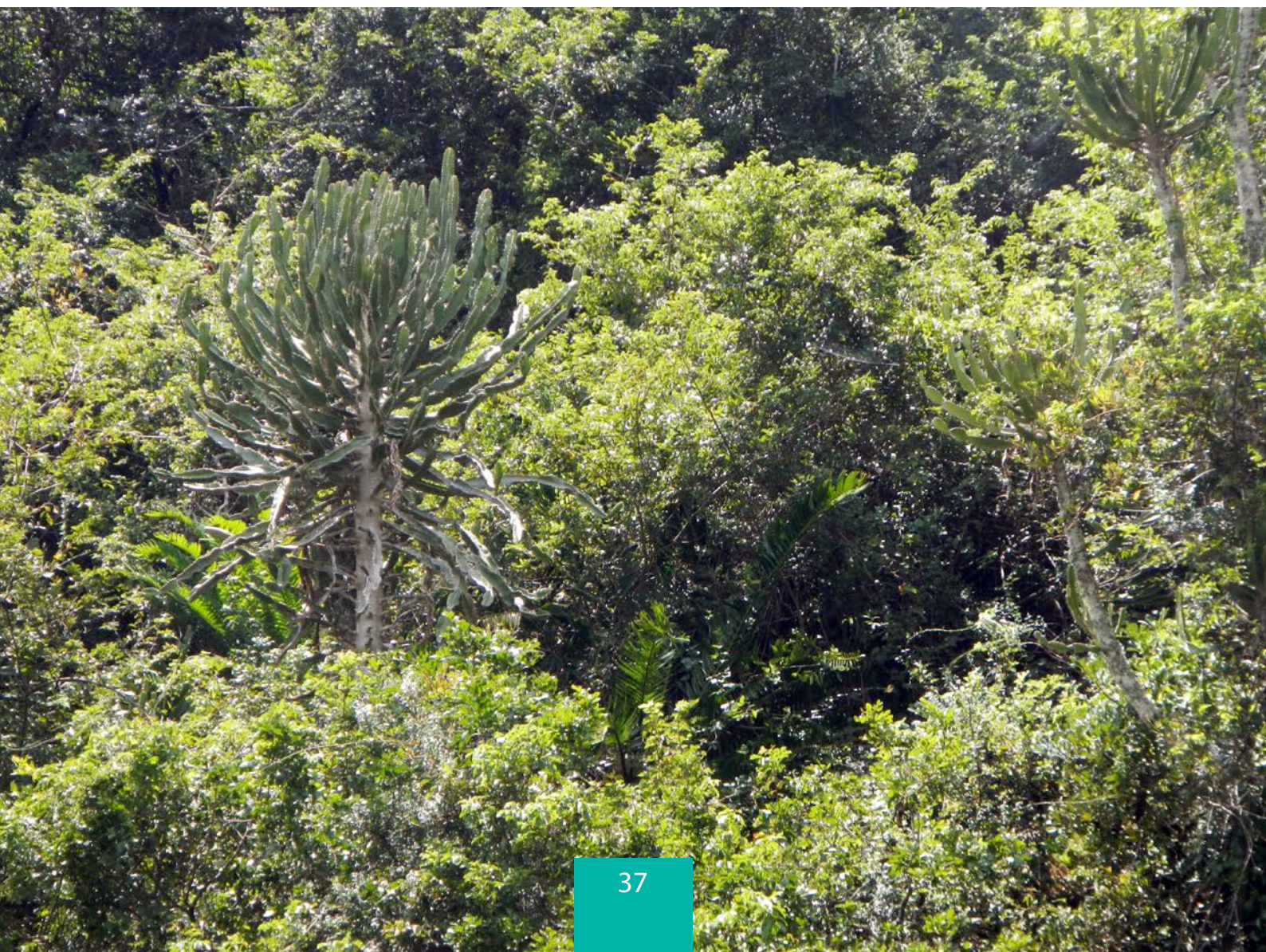
the mosaic thicket vegetation types are maintained by a fine balance between specific fire and grazing regimes.

- Both surface water and groundwater abstraction should be monitored where there is a risk of negative impacts on biodiversity and ecosystem function.

3.3.6. General recommendations

- Never rely on desktop information only to make decisions on the current status of biodiversity on a particular site. Always conduct a detailed biodiversity assessment on site, with the assistance of relevant specialists, where required.
- Areas identified as CBAs and ESAs, and/or threatened ecosystems, in biodiversity plans are to be regarded as important biodiversity areas and must be prioritised for conservation/restoration/rehabilitation. No new development should be allowed in these areas before adequate investigation of the specific site by independent biodiversity specialists. Specialist investigations of the site and the surrounding landscape must be done to determine flora and fauna biodiversity, presence of threatened or protected flora and fauna species, and special or protected habitats, as well as any ecological corridors which facilitate landscape connectivity with other natural areas beyond the site and enable biodiversity to persist.
- Ecological corridors must be established and maintained between natural areas, especially between PAs and biodiversity priority areas outside of the PA network. Spatial linkages across the landscape between different thicket habitats must be in place and functional. Corridors must be designated and managed to allow species to track changing environmental conditions and must incorporate climate and biodiversity refugia. When identifying and delineating ecological corridors and connectivity across the landscape, make sure that these linkages follow major environmental gradients correlated to plant composition and that drive turnover in species composition across a wide range of spatial and temporal scales (Beta-diversity). Ensure that corridors are wide enough to incorporate variations in landform and physical processes (Jewitt et al., 2017).
- Restoration/rehabilitation efforts should focus on ecological corridors that provide spatial linkages across the landscape.
- Make sure that physical features, microhabitats and the 'patchiness' in the landscape (i.e. a mosaic of different habitats) are regarded as important aspects required for biodiversity persistence and management.
- Watercourses and wetlands are protected in terms of the National Water Act and are regarded as special habitats. Avoid activities that alter hydrological flow, or that impact on freshwater requirements of other users/habitats (e.g. estuaries and nearshore marine environments need freshwater for biodiversity and productivity).
- Do not consider the terrestrial environment in isolation; recognise and consider relationships between the land, surface water and groundwater components of the environment.
- Buffer areas around National Parks that are designated in Park Management Plans signed by the Minister must be considered when land-use change is planned on areas adjacent to these parks (and within buffer areas).
- Buffers must be implemented around PAs, conservation areas, known locations of SCCs, forested areas, and aquatic ecosystems.
- The carrying capacity of land used for livestock and game farming, and in PAs and conservation areas must be determined by a qualified specialist. Overstocking and overgrazing/browsing must be prevented. This is especially important in areas that are fenced. It is not possible to recommend stocking rates per ecosystem group in these Guidelines, as rates will vary across sites depending on local conditions, land-use type, historical management etc. General guidelines can be gleaned from maps produced by the Agricultural Research Council (ARC), but they must be supported by a specialist who looks at local conditions that would impact on sustainable grazing and browsing practices.
- Rehabilitation relevant to all Albany Thicket types:
 - When government funds are made available for rehabilitation, PAs should be prioritised for rehabilitation efforts as there is less chance of conflicting land uses in these areas in future. Within PAs, the focus should be on areas that are outside of high impact zones (e.g. areas used/accessed by African elephants).
 - Disrupting soil structure and drainage has significant impact on thicket, and its restoration potential. For this reason, it is important to consider how and where the land has been disturbed in order to inform the approach to rehabilitation. Physical attributes of the area (i.e. terrain and soil information) must be investigated so that the correct measures can be used to re-instate processes required by local biodiversity.
 - Land Types (terrain/soil information) must be used when deciding what type of rehabilitation action is necessary. Sometimes active measures like ripping can create more damage through disruptions to the soil profile and drainage.
 - The impact of pesticides and herbicides on soil quality must be considered in rehabilitation potential. Pesticides/herbicides have the potential to harm soil biota, reduce soil quality and contaminate groundwater. Areas where pesticides/herbicides have been used, especially where these have hyper-accumulated, may be less likely to recover if measures to improve soil quality are not addressed.

- **The removal and control of invasive alien vegetation must be prioritised.** Landowners must get advice from suitable specialists on which AIP species should be targeted, as some are more problematic in certain areas than others. Different species also respond differently to different control methods. The legal responsibilities of landowners for controlling different category species must also be taken into account. Areas in proximity to commercial plantations are particularly at risk of alien plant invasion, and plantation companies should assist landowners in managing invasive alien vegetation on their properties.
- **Land-use guidelines/recommendations given in available biodiversity plans and tools must be consulted** and applied early in the land-use planning process (refer to Appendix 5.2).
- On a strategic level, the seven principles discussed by Biggs et al. (2012) for building resilience in ecosystem services must be considered and applied especially in provincial and municipal planning processes.
- **Resilience of natural ecosystems to the impacts of climate change must be maintained** by making sure that ecological corridors are protected, thicket and mosaic boundaries are managed, management maintains diverse and functional ecosystems, and areas of climate refugia for persistence of species are identified and conserved. Dune Thicket is probably most at risk in the short term from the more immediate climate change risks associated with storm surges, changes to winds and impacts on sediment dynamics and dune corridors in the coastal zone.
- **Permeable fencing should be used,** especially in the growing number of game farms, to allow movement of animals. The impact of electric fencing on ground dwelling species must be avoided.
- A centrally managed database must be compiled where land managers, landowners, EAPs, conservation agencies, PA managers etc. can share data on AIPs (distribution, species, interventions, success rates) and fire (occurrence of controlled and uncontrolled burns, cause of fire, climate conditions prior to and during the burn, ecological monitoring records pre- and post-fire). This will greatly assist in developing an understanding of contributing factors, and best practice management in different areas. The information could be hosted on SANBI's BGIS site. A framework or template for data collection and reporting by persons on the ground would





need to be developed for consistency purposes and robustness of data.

3.3.7. Best spatial approaches to avoid or minimise impacts and risk in Mesic Thicket

- Consider land-use guidelines in biodiversity plans applicable to Mesic Thicket, especially where land-use change in CBAs and ESAs is proposed, to determine what types of activities are compatible with biodiversity protection. Allow for protection of biodiversity priority areas to facilitate biodiversity persistence.
- Prevent further fragmentation of thicket and, where possible, reconnect intact expanses of thicket.
- Modification of thicket habitat should never be allowed to sever corridors between intact thicket patches.
- Rehabilitate degraded ecological corridors connecting important thicket patches.
- Boundaries or transition areas between thicket and non-thicket biomes must be maintained by avoiding artificial disturbances in these areas, but natural disturbance regimes, such as those related to herbivory and fire, should be maintained.
- Manage grazing carefully (with attention paid to stocking rates and rotation) and ensure that grazing management is well co-ordinated with fire management, clearing of AIPs and other aspects of land management (such as measures for avoiding soil erosion) across the landscape. This is critically important for effective conservation of thicket habitats.
- The boundaries of conservancies and other land management initiatives should be designed to incorporate the natural fire zone, or broader ecosystem or habitat unit for that particular region.
- Habitat modification for urban or agricultural areas should be concentrated in nodes, allowing key ecological corridors across the landscape to be maintained. In this respect, available biodiversity plans and CBA maps should be used to guide land-use planning and change.

3.3.8. Critical things to maintain for biodiversity to persist

- Maintain all remaining intact thicket fragments across the range of thicket vegetation types to help buffer against the impacts of climate change, especially those that occur in biodiversity priority areas.
- Remaining stands of viable intact thicket in developed areas (e.g. urban or peri-urban areas) should be retained

as far as possible, as they provide useful ecosystem services to surrounding communities. For biodiversity in remnant thicket to persist, the identified drivers need to be operating. Consideration should be given to how these remnant tracts of thicket could be connected to viable corridors, and measures implemented accordingly.

- Rehabilitate corridors that connect isolated patches of intact thicket. Corridors are especially effective measures for conserving thicket because they enable the persistence of natural patterns of seed dispersal (in bird-dispersed species) and herbivore migration. Ecological corridors identified in biodiversity plans must be prioritised for ecological management and rehabilitation, especially in areas that are at risk of urban expansion and where there is a high probability of isolating thicket clumps across the landscape (which would ultimately result in areas of poor ecological condition in the absence of the required ecological drivers).
- Maintain natural mosaic patterns and minimum viable patch sizes. Establishing the minimum viable patch size and acceptable isolation distances between thicket patches, or the structure and maintenance of the mosaic pattern, all require detailed, on-site assessments at a minimum scale of 1:5 000. Only fine-scale, detailed analysis of present and past thicket distribution patterns can determine minimum viable patch sizes. A thorough understanding of physical factors shaping mosaic patterns is key, with reference to changes in soil type and slope, drainage patterns, and the location of microhabitats in the area under investigation.
- Maintain natural disturbance regimes through integrated management of fire, grazing and drought. Current climate trends might allow thicket to encroach into and displace less-resilient neighbouring vegetation types, so maintaining the mosaic patterns will become increasingly important to preserve biodiversity patterns at the landscape scale.
- Certain patches of thicket, especially solid, non-mosaic vegetation types, require total protection from fire. Fire and infestations of AIPs must, therefore, be managed in the adjacent, non-thicket ecosystems. Never allow adjacent 'fire-adapted' vegetation types (such as fynbos) to remain unburnt for longer than what is required based on the fynbos type in the area, or to become infested with woody AIPs.
- Maintain the appropriate fire regime in terms of fire frequency and seasonality in fire-prone thicket types.
- Keep thicket patches and their surrounds free of invasive alien vegetation. This requires controlling existing invasions, as well as the prevention of future invasion.
- Ensure that planting of spekboom (*Portulacaria afra*) (as a restoration measure) only happens in areas where this species occurs (or occurred) naturally. Consult with an experienced plant ecologist to obtain this information. If

introduced in an incorrect area, *P. afra* could have a negative impact on other naturally-occurring species.

- **Degraded areas should be prioritised for rehabilitation/restoration.**

3.3.9. Indicators to assess and monitor ecological condition

- **The canopy characteristics:** assess whether the thicket canopy is closed and continuous. In most cases, solid thicket vegetation consists of a closed, dense canopy consisting of an impenetrable tangle of shrubs and low trees. An open and/or fragmented canopy can be indicative of degradation or damage to the original vegetation. Changes could be monitored over time using a method such as fixed-point photography.
- **Structural elements:** determine whether the vegetation contains all the expected structural components for the site being assessed, including low trees, shrubs and woody lianas, accompanied by a sparse understorey of herbs consisting of geophytes, succulents, C₃ and C₄ grasses and others. The presence of emergent species, especially succulents, such as aloes and euphorbias, may also be characteristic for the site. If any of these components are lacking it may indicate degradation.
- **Presence and health of keystone species:** for example, the presence and percentage cover of *P. afra* is an important indicator of ecological condition in areas where this species would naturally occur.
- **Presence and health of succulent species:** changes in the presence and density of succulent species, especially in drier forms of thicket vegetation types, indicate a change in ecosystem condition. A decline in the proportion of succulents may indicate declining ecological condition, usually as a result of persistent overgrazing.
- **Standing biomass:** thicket has a characteristically high standing biomass. Sparse vegetation or low biomass, except in more arid areas, may be a sign of degradation due to overgrazing or to some other factor.
- **Survival of structurally important species:** monitor mortality rate of adult trees during drought periods. Death of adult trees during drought periods indicates thicket that is in poor ecological condition.
- **Changes in species composition and vegetation structure:** species composition and vegetation structure relative to expected conditions can be monitored. The expectation can be based on historical information, baseline data collection or reference sites in similar ecological conditions to the target site. Changes may indicate habitat degradation or else provide information on successional dynamics. Functional type composition can also be a useful measure of favourable or detrimental changes. Botanical reserves could be a useful benchmark; however, they do not represent an entirely natural state since mega-herbivores have been removed. Species composition can also be measured as a baseline prior to an intervention and then monitored over time at fixed points to determine whether any changes are occurring. Similarly, monitoring can be used to determine whether a project is having continuous impacts on nearby vegetation or not.
- **Overall species diversity:** this indicator may change significantly due to natural environmental variation over time or space; for example, the amount of rainfall during the previous season or between one habitat and another. However, a reduction in species diversity may give an indication of deteriorating ecological condition.
- **Thicket growth and spread:** monitor encroachment of thicket into the surrounding matrix vegetation in thicket-mosaic vegetation types. The presence of a distinct boundary between thicket patches and the adjacent vegetation types (such as Grassland, Savanna, Forest, Fynbos or Nama Karoo Biomes) will indicate ecosystems in good ecological condition. Thicket clumps should only coalesce and displace adjacent vegetation types in prescribed areas where solid thicket previously occurred and not in areas where mosaic vegetation types are found.
- **A measure of fragmentation, continuity or vegetation connectedness, as well as various other landscape ecology parameters:** measures of these parameters may provide useful insight into identifying areas most in need of intervention or other areas that are intact. These parameters can be measured using aerial photographs, satellite images or SPOT images. In addition to measuring the current status, the effect of proposed clearing on an area of thicket vegetation can also be assessed using a similar approach.
- **Invasion by woody species:** the presence and density of AIPs, or the extent of invasion by weedy but indigenous woody species such as sweet thorn (*Vachellia karroo*), should be monitored, with a low density (or absence) of these species indicative of an ecosystem in good ecological condition.
- **SCCs:** persistence/stable population parameters of SCCs are a sign of ecosystems in good ecological condition. Other population parameters such rates of recruitment, or the presence of seedlings or saplings, could provide information on population health.
- **Soil health:** parameters such as retention of the litter layer, with associated nutrients, can provide a good indication of ecological condition. The presence and severity of soil erosion features can provide a similar indication of general ecological condition; for example, the presence of sheet or gully erosion may be associated with a loss of vegetation cover.
- **Fire frequency and intensity:** in thicket-mosaic vegetation types, monitor signs that appropriate fire intervals and management are being applied. If fire is absent from

mosaic vegetation types for longer than the prescribed period, then targeted burning will be required to prevent a deterioration in ecological condition.

- The presence of a browse line can be used to indicate overbrowsing (for example goats and browse lines in *Pappea capensis* in Arid Thicket).
- The functionality of systems (e.g. carbon sequestration): a number of methods can be used to do this, including easy to access new generation products (e.g. remote sensing), and making use of mass information readily available on the internet. Field measurements of nett primary production can also be done.
- Changes in the landscape: remote sensing can be used to detect heterogeneity in the landscape, to indicate change, and to detect bush encroachment. It is important to note that while these technologies are available and extremely useful, it takes a fair amount of skill and training to be able to use and apply these tools.

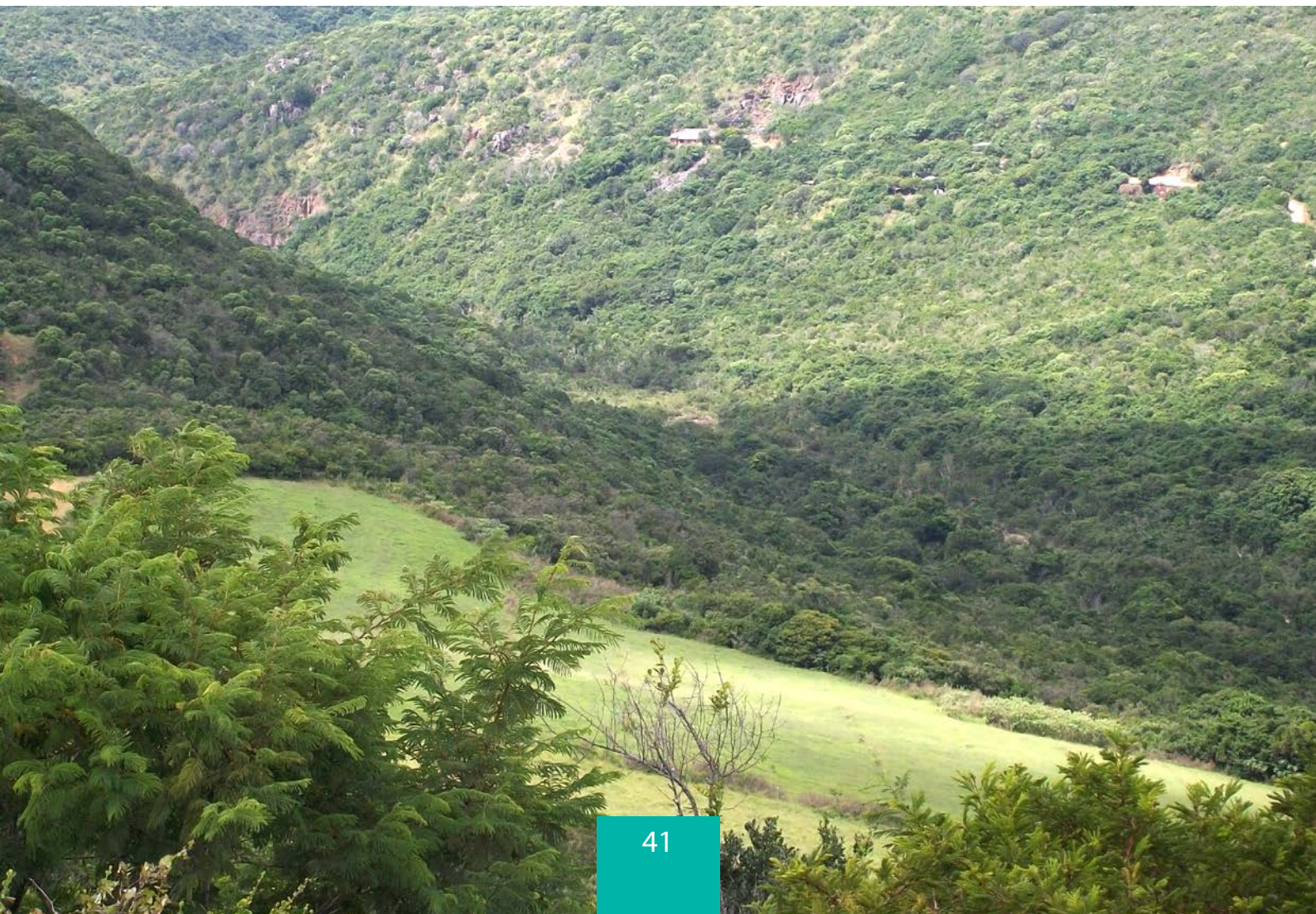
3.3.10. Reversibility of impacts within a period of 5 to 10 years

- Impacts may be reversible in areas where rainfall is higher, but the restoration process is likely to be slow and costly.

- Rehabilitation of areas where vegetation has been destroyed is slow, as vegetation must go through several successional phases to reach maturity. In most cases, recovery to the mature phase will take longer than ten years.

3.3.11. Acceptable compensation measures or offsets for biodiversity loss

- Where residual negative impacts on Mesic Thicket are unavoidable and there are no alternatives to the proposed development (i.e. it is of overriding public importance), then **biodiversity offsets** should target the securing and formal protection of core areas of Mesic Thicket in good ecological condition, and provide for their effective management in the long term.
- Offsets must never be proposed as a mitigation measure for the destruction of unique and/or irreplaceable habitats; lower impact alternatives that avoid impacts on these areas must be sought.
- An offset area must be identified, planned and secured in line with the principals and requirements of presiding regulations and policy on offsets.



3.4. Valley Thicket

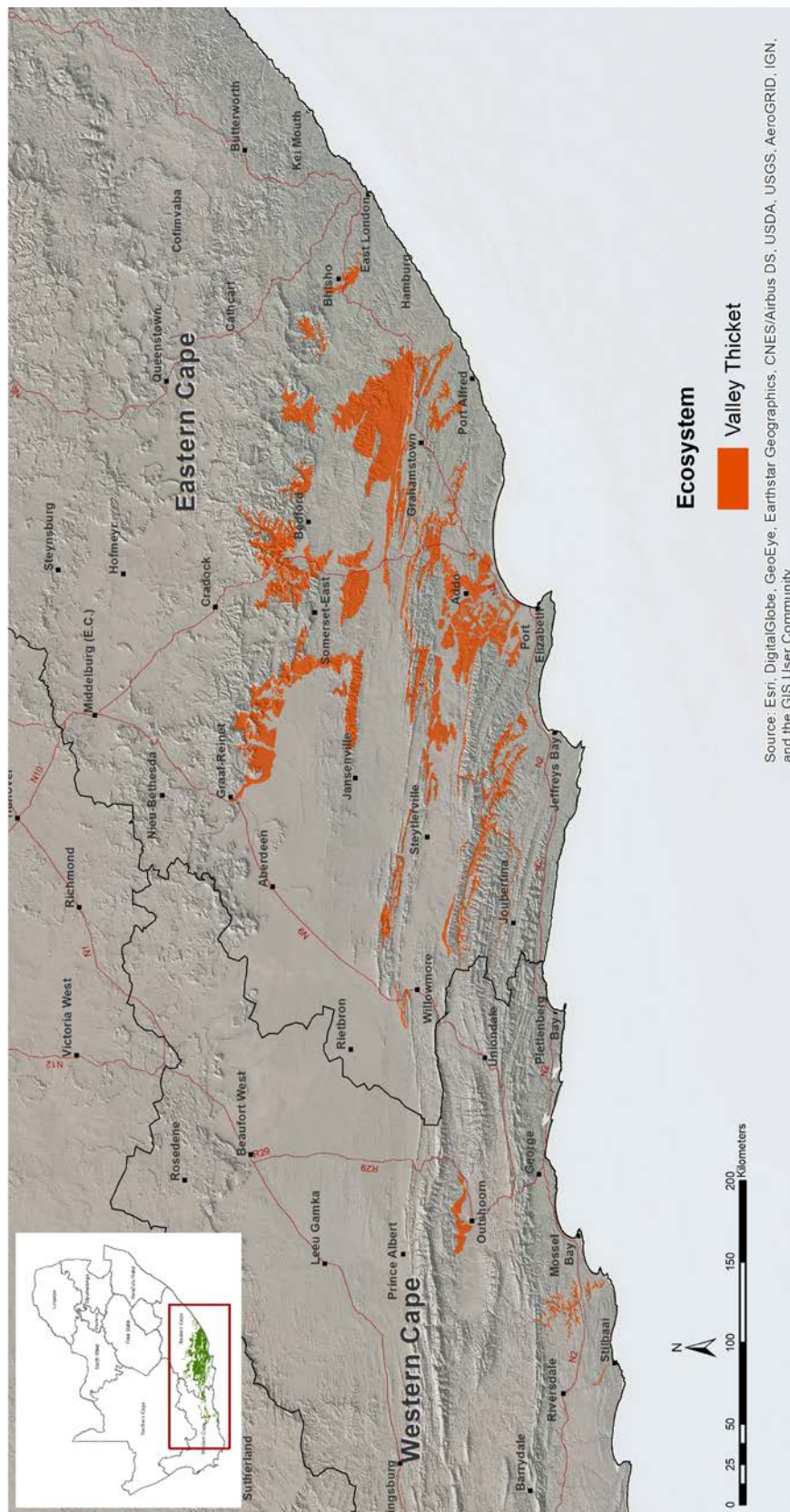


FIGURE 7.—Locality Map of the Valley Thicket Ecosystem Group.

3.4.1. General characteristics

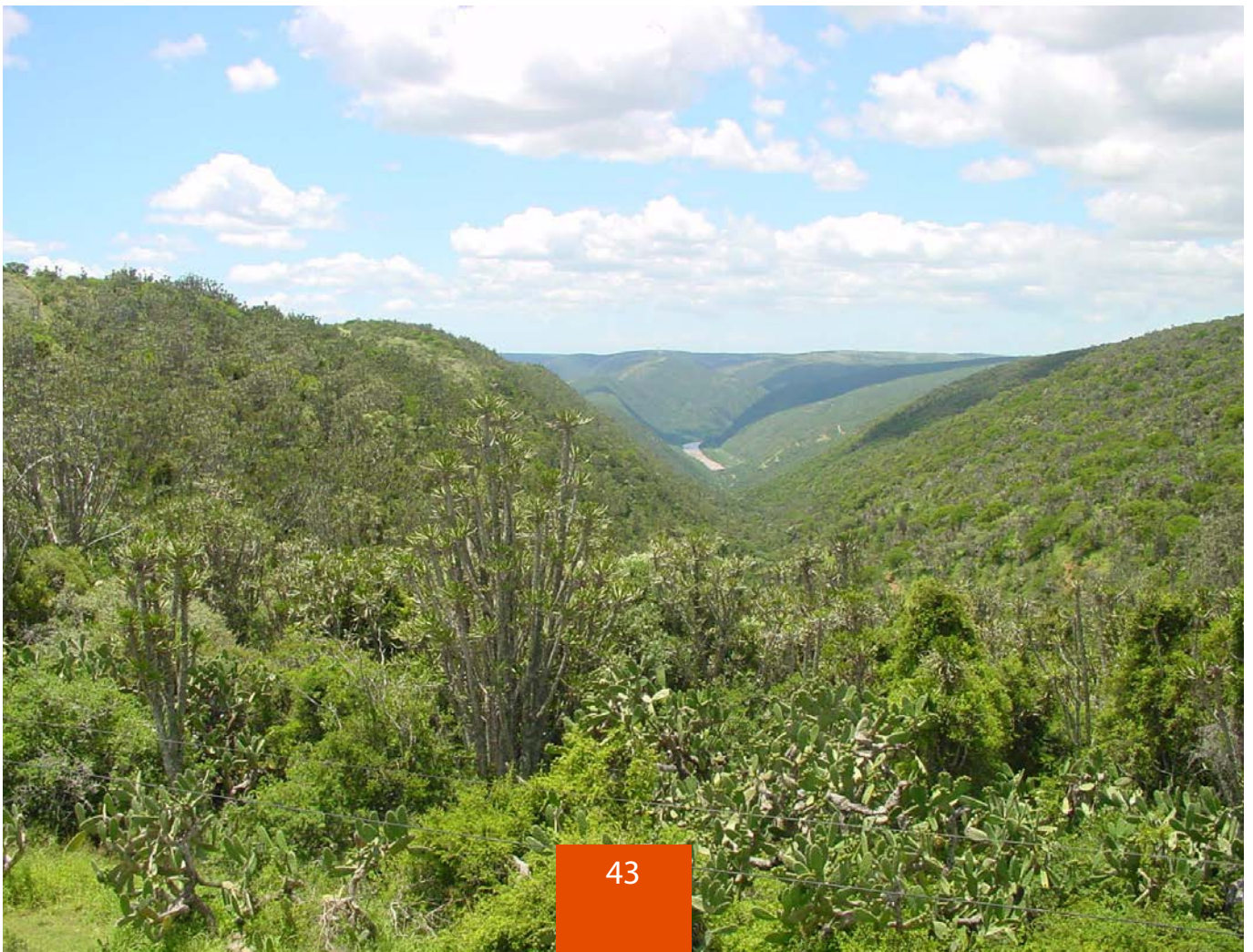
Valley Thicket is the most widespread thicket type commonly found in the core part of the Albany Thicket Biome. It is an inland ecosystem group, occurring in the major river valleys (Kei–Gouritz), as well as the lower slopes of the Cape Fold Mountains and the Great Escarpment (Figure 7). It is usually found on steep slopes with deep soils, but also on shallow, rocky soils. Where Valley Thicket occurs, there is usually less annual rainfall and higher mean maximum temperatures than in surrounding Mesic Thicket units. It has a well-developed woody tree and shrub component, and succulents and spinescent species are a prominent feature of the vegetation.

Dominant and characteristic species include: *Adromischus cristatus*, *Aloe africana*, *A. arborescens*, *A. ferox*, *A. microstigma*, *A. speciosa*, *A. striata*, *Asparagus subulatus*, *Azima tetraantha*, *Boscia oleoides*, *Bulbine frutescens*, *Cadaba aphylla*, *Capparis sepiaria*, *Carissa bispinosa*, *C. haematocarpa*, *Cotyledon orbiculata*, *C. velutina*, *Crassula cordata*, *C. latibracteata*, *C. orbicularis*, *C. ovata*, *C. perfoliata*, *C. perforata*, *C. rogersii*, *C. rup-estris*, *Cussonia gamtoosensis*, *C. spicata*, *C. thyrsoflora*, *Ehretia rigida*, *Elaeodendron croceum*, *Euclea undulata*, *Euphorbia atrispina*, *E. curvirama*, *E. grandidens*, *E. ledienii*, *E. mammillaris*, *E. mauritanica*, *E. polygona*, *E. tetragona*, *Gasteria bicolor*, *G. brachyphylla*, *G. carinata*, *Gloveria integrifolia*, *Grewia occidentalis*, *G. robusta*, *Gymnosporia buxifolia*, *G. nemorosa*, *G. polyacantha*, *Harpephyllum caffrum*, *Harworthia* spp., *Hippobromus pauciflorus*, *Kalanchoe rotundifolia*, *Lycium cinereum*, *L. ferocissimum*, *Maerua cafra*, *Nymanica capensis*, *Ozoroa mucronata*, *Pappea capensis*, *Pegolettia baccharidifolia*, *Peltargonium peltatum*, *P. tetragonum*, *Pit-tosporum viridiflorum*, *Plectranthus mada-gascariensis*, *Plumbago auriculata*, *Portu-lacaria afra*, *Ptaeroxylon obliquum*, *Putter-lickia pyracantha*, *Rhigozum obovatum*,



Plate 6.—Valley Thicket vegetation in the Swartkops River Valley in Nelson Mandela Bay Municipality (Source: CEN IEM Unit).

Plate 7.—Fish Valley Thicket (Source: Prof Richard Cowling).



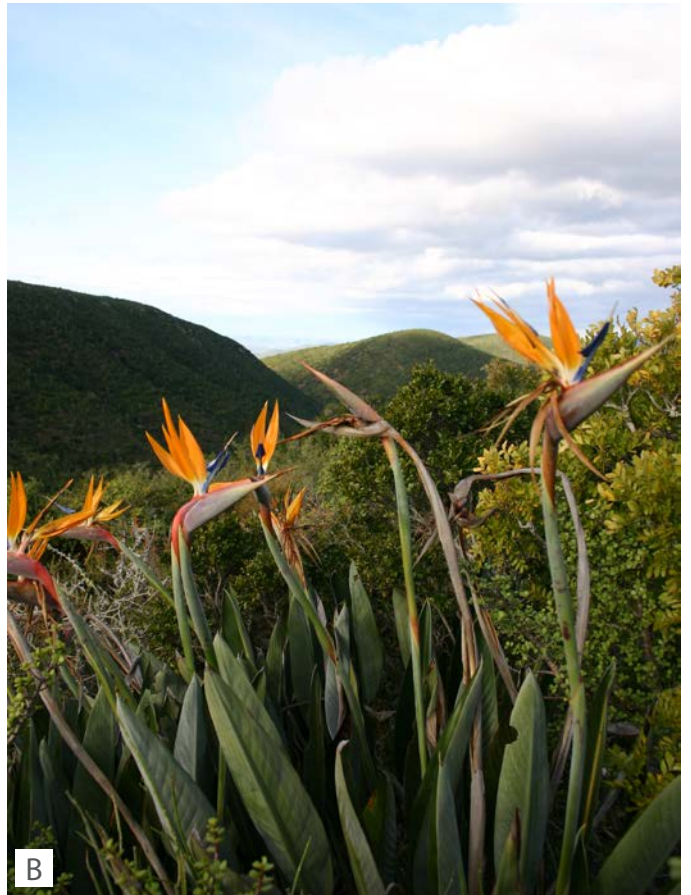
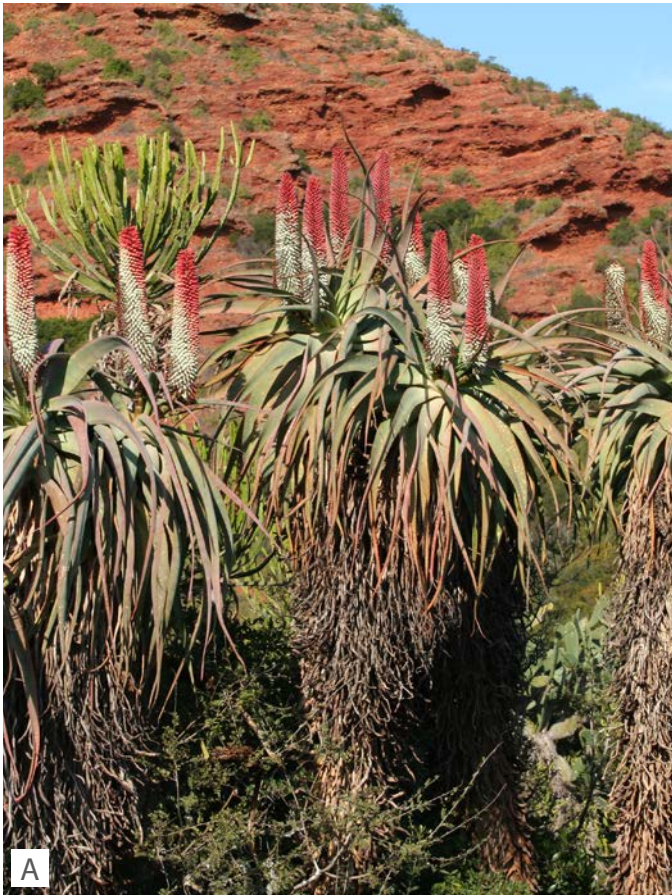


Plate 8.—Floral species (A, *Aloe speciosa*; B, *Strelitzia reginae*; C, *Cotyledon velutina*; D, *Pelargonium peltatum*) found in the Valley Thicket Ecosystem Group (Source: Prof Richard Cowling).

Rhoicissus digitata, *Rhoicissus tridentata*, *Sansevieria hyacinthoides*, *Sarcostemma viminale*, *Schotia afra*, *S. brachypetala*, *Scolopia mundii*, *S. zeyheri*, *Scutia myrtina*, *Searsia glauca*, *S. longispina*, *S. lucida*, *S. pterota*, *Senegalia caffra*, *Sideroxylon inerme*, *Tarchonanthus camphoratus*, *Tecomaria capensis* and *Tylecodon paniculatus*.

Vegetation in the Valley Thicket Ecosystem Group is divided into two broad types: those in which *Portulacaria afra* (spekboom) is prominent (one vegetation type), and those without *P. afra* (seven vegetation types) (VEGMAP, 2018). Table 4 below lists the vegetation types, with an indication of the ecosystem threat status and ecosystem protection level (Skowno et al., 2019).

Based on the habitat modification assessment done as part of the NBA (Skowno, 2018), the dominant land cover type within this ecosystem group is 'natural' (includes range-lands), followed by 'croplands'. The rate of modification of vegetation in the ecosystem group is low, with an estimated total modified area of 7.72%. The ecosystem threat status of all vegetation types in the ecosystem group is 'Least Concern', other than Buffels Valley Thicket and Escarpment Valley Thicket, which are classified as 'Critically Endangered' and 'Near Threatened', respectively. Although Buffels Valley Thicket only occupies approximately 1% of this ecosystem group, it must be noted that it is showing the highest rate of modification. Only 45% of Buffels Valley Thicket is 'natural' land cover, with 'croplands' occupying 22% and 'built up' areas occupying 18% of this vegetation type. 'Croplands' are also becoming a growing concern for biodiversity loss in Gouritz Valley Thicket, Sundays Valley Thicket and Gamka Valley Thicket, however their ecosystem threat status is still of 'Least Concern' (Skowno et al., 2019).

3.4.2. Key ecological drivers maintaining ecosystem function and biodiversity pattern

- **Herbivory**
- **Fire**
- **Rainfall**
- **Climatic variability:** Climatic extremes, including droughts, floods and heat waves, have little impact on thicket vegetation. This means that where thicket occurs in mosaics with other vegetation types (such as Grassland, Fynbos, Renosterveld and Nama Karoo), it provides an important buffer against these climatic disturbances. Thicket vegetation has, relative to other vegetation types, faster growth rates under current and increasing CO₂ levels, with Arid Thicket probably showing the highest resilience to climate change (though it is also the most vulnerable to overgrazing or heavy browsing). Relative to other biomes, Albany Thicket is probably one of the most resilient to climate change, which means that it is critically important for the persistence of non-thicket ecosystems. It also means that, under predicted climate change scenarios, thicket has the potential, with time, to displace and encroach into neighbouring vegetation.
- **Soil nutrient dynamics**
- **Ecosystem engineers:** *Portulacaria afra* is a common and sometimes dominant constituent of Valley Thicket. It has recently been referred to as an 'ecosystem engineer' because of the critically important role it plays in thicket restoration and promoting the recruitment of other thicket species. This characteristic thicket plant also resists droughts and floods and encroachment by fire from neighbouring landscapes dominated by Grassland

TABLE 4.—Vegetation Types (VEGMAP, 2018) found in the Valley Thicket Ecosystem Group and their Ecosystem Threat Status and Ecosystem Protection Level (Skowno, 2018; Skowno et al., 2019).

Valley Thicket Vegetation Types	Veg Code	Ecosystem Threat Status	Ecosystem Protection Level	Extent (ha)	% decline 1750–2014
Vegetation types with no <i>P. afra</i>:					
Albany Valley Thicket	AT18	Least Concern	Moderately Protected	117 563	1.05
Baviaans Valley Thicket	AT19	Least Concern	Well Protected	107 760	0.14
Buffels Valley Thicket	AT22	Critically Endangered	Not Protected	21 545	10.57
Escarpment Valley Thicket	AT29	Near Threatened	Well Protected	78 461	0.19
Fish Valley Thicket	AT32	Least Concern	Moderately Protected	359 630	0.63
Gouritz Valley Thicket	AT37	Least Concern	Poorly Protected	1 109	6.60
Sundays Valley Thicket	AT51	Least Concern	Moderately Protected	195 804	3.38
Vegetation types with prominent <i>P. afra</i>:					
Gamka Valley Thicket	AT34	Least Concern	Not Protected	33 150	3.42

and Savanna. The importance of *P. afra* lies in its ability to accumulate biomass in excess of what would be predicted by rainfall levels in the area. The species does this through the physiological decoupling of production from water availability. Where it does not occur, this role is played by a combination of other woody plant species.

- **Seed dispersal**
- **Topography, geology and soil type:** Variations in these factors drive diversity patterns and the distribution of different forms of thicket vegetation. Shales are found in large areas of Valley Thicket, resulting in low moisture availability to vegetation.
- **Spatial linkages to other vegetation**

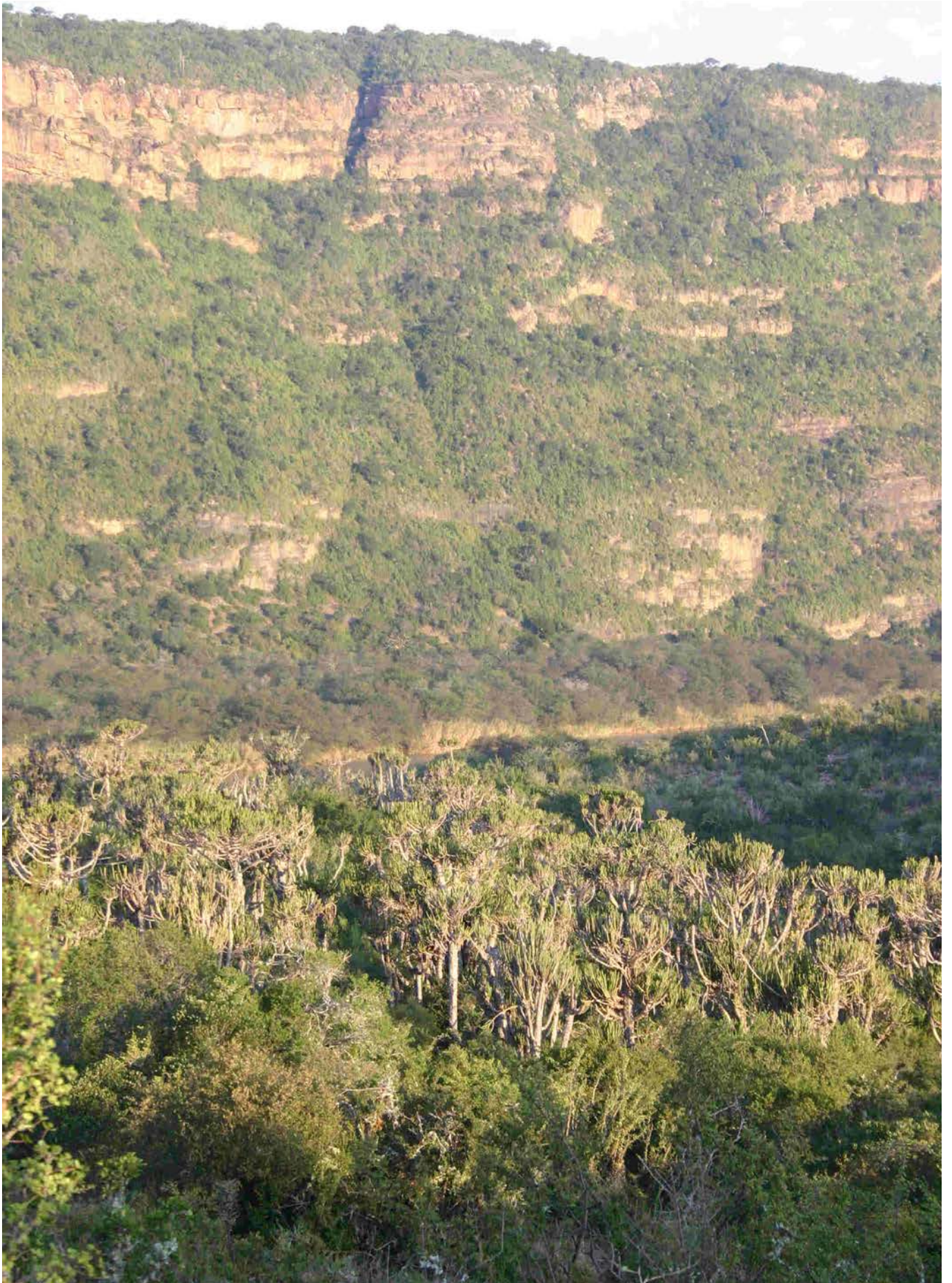
3.4.3. Conservation, land-use pressures and risks

Just over 12% of the ecosystem group is currently protected in the AENP and in Nature Reserves (e.g. Great Fish River Nature Reserve).

The most prominent current and future risks within the Valley Thicket Ecosystem Group are cultivation and expansion of urban settlements. The group has also been highly degraded through livestock overgrazing and browsing, which together with the incorrect application of fire, changes the original thicket into a secondary thornveld or grassland dominated by AIPs.

3.4.4. Main pressures, risks and threats

- **Urban expansion:** Residential and industrial developments are common and widespread in the Albany Thicket Biome. The largest urban centre is Port Elizabeth, but there are smaller settlements throughout the area occupied by Valley Thicket, including King William's Town and Bhisho, Bedford, Adelaide and Uitenhage. Major urban settlements and industrial development in the Port Elizabeth and Uitenhage areas in NMBM, and some smaller urban centres near King William's Town and Graaff-Reinet have led to loss and fragmentation of habitat, and general disturbance that affects biodiversity and vegetation patterns.
- **Overgrazing/browsing:** Most thicket landscapes are used by commercial and subsistence farmers as rangelands for small domestic stock, especially cattle and goats. Overstocking, combined with a lack of appropriate grazing/browsing management techniques over extended periods, has resulted in a large proportion of thicket landscapes becoming overutilised and degraded, with many negative consequences, including severe soil erosion and loss of certain species. Aspects of overgrazing/browsing that are of particular concern include that:
 - In the more mesic areas, conditions of persistent overgrazing result in the invasion of thicket by indigenous woody shrubs such as sweet thorn and Karoo honey thorn (*Vachellia karroo* and *Lycium oxycarpum*). In drier areas, persistent overgrazing leads to the loss of desirable succulents, especially species such as spekboom (*Portulacaria afra*), with many knock-on effects. The effect of *P. afra* removal by goat grazing is noticeable in farms in the Kleinpoort area northeast of Uitenhage.
 - *P. afra* is an essential component of some vegetation types in Valley Thicket. It plays a critical role in ecological succession processes, buffers habitats against the impacts of fire and is highly favoured by browsers. In some thicket habitats, it is often the dominant species. Overbrowsing, especially by goats, in combination with drought, leads to loss of *P. afra*, with multiple impacts including the loss of other plant species, loss of aerial cover and subsequent soil erosion. The loss of *P. afra* from the boundaries of thicket bush clumps lowers the resilience of the ecosystem to fire.
 - Overgrazing and wildfires in hot, dry conditions represent a significant threat to Valley Thicket. Although intact thicket does not readily burn, overgrazing of the succulent component (particularly *P. afra*) results in the ecosystem becoming vulnerable to encroachment by woody shrubs such as Karoo honey thorn, *Searsia* and C_4 grasses. Encroached areas become more flammable, meaning that fires can then penetrate vegetation that otherwise would not have been exposed to fire (at least not in recent times). This can result in the elimination of fire-intolerant thicket species.
 - Many stock farmers actively burn thicket (or clear it) to improve the grazing potential of the land. This has reduced the extent and abundance of thicket patches in the landscape, especially those that occur in mosaics with other vegetation on deeper and less nutrient-poor soils.
- **Game farms:** There has been a substantial increase in the number of game farms in the Eastern Cape, including areas where Valley Thicket occurs (e.g. in the areas around Bathurst and Grahamstown). While game farms have the potential to contribute to thicket conservation if properly managed, there are several risks that they present. Overstocking of faunal species in fenced areas results in overgrazing/browsing; and subsequent impacts on thicket species composition and resilience. Fencing prevents migration/movement of faunal species, and electric fences kill ground-dwelling species.
- **Aerial application of herbicides** impacts on non-target areas and reduces rehabilitation potential of the land.
- **Clearing of thicket vegetation to make way for cultivation:** Large tracts of thicket vegetation have been cleared for cultivation of various crops, particularly in linear strips



along fertile river valleys (e.g. in the Sundays River Valley, where large-scale clearing takes place for citrus orchards and fodder crops). In some areas, clearing of thicket has taken place within the buffer areas of National Parks (as indicated in Park Management Plans). Narrow strips of thicket vegetation are left on the borders of farms and PAs, creating unviable corridors. This results in direct loss of thicket habitat and fragmentation, with a subsequent loss of connectivity between remaining patches of intact thicket habitat. Issues of particular concern are that:

- The loss of connectivity of thicket patches affects ecosystem function. Historically, thicket was more connected across the landscape than it is now. Habitat loss has resulted in a fragmented pattern that reduces resilience to environmental change and causes isolation of gene pools and the loss of gene flow within and between patches. Isolation due to human-induced fragmentation may result in some species losing their adaptive potential, increasing the risk of species or varieties becoming extinct.
- Removal of thicket in river valleys and floodplains increases the intensity of floods and damage to infrastructure.
- **Damming of watercourses for irrigation** impacts on stream flow and freshwater requirements downstream.
- **Invasion by AIPs:**
Invasive species disturb ecological processes and biodiversity patterns in thicket vegetation. Infestation by woody AIP species occurs in disturbed areas. These species outcompete the indigenous flora and increase fuel loads. The presence of invasive woody species increases the severity of fires and the likelihood of fires penetrating thicket at the interface between thicket and other vegetation types.
- **Harvesting of flora and fauna for rural livelihoods and commercial purposes** are caused by the following resource uses:
 - Animals for food, e.g. bush meat, edible insects.
 - Animals for traditional/cultural use and medicine, e.g. leopard skins.
 - Plants for food, cultural use and medicine. At least 38 plant species harvested in the Eastern Cape for medicinal trade purposes are from the Albany Thicket Biome, including species such as baboon grape, wart plant, *rooistam/kleefgras*, dwarf gasteria/*klein-beestong* and *ibhucu/kopiva/waterpypie/wildekopiva* (Sims-Castley, 2002). Approximately 30% of the plants harvested in the Eastern Cape are used exclusively for cultural purposes (for example *iyeza lokuhlamba* or ritual washing) (Cocks et al., 2003).
 - Wood from trees is burnt for energy; used for building material for fencing and kraals; used in rituals and stockpiled to show status in the community (Cocks et al., 2003).
 - Grass and reeds are used for thatching and to make brooms and mats.

- Legal and illegal hunting/poaching of animals, e.g. poaching of white and black rhinoceros.
- Harvesting of thicket species is taking place on a wide scale directly or indirectly by larger companies. An estimated 156 tonnes of thicket plants are also traded annually in the Eastern Cape, generating an income of R7 million/year (Sims-Castley, 2002).
- Legal and illegal collection of plants for ornamental trade and medicines, e.g. poaching of cycads for illegal horticultural trade, collecting rare and endemic succulent species in the Arid Thicket Ecosystem Group for ornamental trade, harvesting sap from bitter aloe for the pharmaceutical and cosmetic industry.
- **Alternative energy development**, especially wind and solar energy projects in the areas surrounding Cookhouse, Middleton and Somerset East, and on the northern flats of the NMBM. The required road infrastructure, where not already existing, for wind energy projects is particularly damaging to habitats since it results both in loss of habitat and fragmentation of remaining habitat. This typically occurs over wide areas over which wind energy facilities are distributed. Solar energy projects usually require almost total removal of vegetation, but within a more localised footprint.

3.4.5. Non-negotiables

- **Avoid overgrazing/browsing in Valley Thickets**, as these ecosystems are at risk of being irretrievably lost if unsustainable grazing pressure persists. The effects of goats on Valley Thicket are especially problematic.
- **Restoration of degraded thicket should be a mandatory condition for authorisation** of any application for land-use change in this at-risk biome. Never underestimate the restoration potential and importance of thicket in areas where it used to occur.
- **Avoid any negative impacts on biodiversity priority areas.**
- **Avoid disturbance to rocky outcrops, geological/soil type boundaries and 'islands'** in the landscape where thicket vegetation is present.
- **Protect rare habitats, such as rocky outcrops, where range-restricted species occur.**
- **Avoid disturbance to riparian areas, steep slopes and valleys.**
- **Avoid the introduction of extra-limital, non-thicket game species** (and remove extra-limital species where they have previously been introduced).
- **Avoid uncontrolled aerial spraying of unregistered herbicides** to destroy thicket.
- **Avoid overstocking of domestic livestock and game on farms**, especially goats.

- **Avoid fragmenting patches of intact thicket.** Where fragmentation has occurred, set aside corridor areas to reconnect the patches and/or implement measures to rehabilitate/restore corridors.
- **Buffer zones around PAs** should be retained in as natural a state as possible.
- **Avoid allowing land uses to impact on transitional or boundary areas where thicket adjoins or forms mosaics with other vegetation types** associated with other biomes. These areas accommodate the highest levels of biodiversity and require special conservation measures.
- **Retain appropriate grazer-browser ratios in game species, as well as the required fire regime,** for maintaining the vegetation in an optimum ecological state. Many of the mosaic thicket vegetation types are maintained by a fine balance between specific fire and grazing regimes.
- **Both surface water and groundwater abstraction should be monitored** where there is a risk of negative impacts on biodiversity and ecosystem function.

3.4.6. General recommendations

- **Never rely on desktop information only to make decisions** on the current status of biodiversity on a particular site. Always conduct a detailed biodiversity assessment on site, with the assistance of relevant specialists, where required.
- **Areas identified as CBAs and ESAs, and/or threatened ecosystems, in biodiversity plans are to be regarded as important biodiversity areas** and must be prioritised for conservation/restoration/rehabilitation. No new development should be allowed in these areas before adequate investigation of the specific site by independent biodiversity specialists. Specialist investigations of the site and the surrounding landscape must be done to determine flora and fauna biodiversity, presence of threatened or protected flora and fauna species, and special or protected habitats, as well as any ecological corridors which facilitate landscape connectivity with other natural areas beyond the site and enable biodiversity to persist.
- **Ecological corridors must be established and maintained between natural areas, especially between PAs and biodiversity priority areas outside of the PA network.** Spatial linkages across the landscape between different thicket habitats must be in place and functional. Corridors must be designated and managed to allow species to track changing environmental conditions and must incorporate climate and biodiversity refugia. When identifying and delineating ecological corridors and connectivity across the landscape, make sure that these linkages follow major environmental gradients correlated to plant composition and that drive turnover in species composition across a wide range of spatial and temporal scales (Beta-diversity). Ensure that corridors are wide enough to incorporate variations in land-form and physical processes (Jewitt et al., 2017).
- **Restoration/rehabilitation efforts should focus on ecological corridors** that provide spatial linkages across the landscape.
- **Make sure that physical features, microhabitats and the 'patchiness' in the landscape (i.e. a mosaic of different habitats) are regarded as important** aspects required for biodiversity persistence and management.
- **Watercourses and wetlands are protected in terms of the National Water Act and are regarded as special habitats.** Avoid activities that alter hydrological flow, or that impact on freshwater requirements of other users/habitats (e.g. estuaries and nearshore marine environments need freshwater for biodiversity and productivity).
- **Do not consider the terrestrial environment in isolation; recognise and consider relationships between the land, surface water and groundwater components of the environment.**
- **Buffer areas around National Parks** that are designated in Park Management Plans signed by the Minister must be considered when land-use change is planned on areas adjacent to these parks (and within buffer areas).
- **Buffers must be implemented around PAs, conservation areas, known locations of SCCs, forested areas, and aquatic ecosystems.**
- The carrying capacity of land used for livestock and game farming, and in PAs and conservation areas must be determined by a qualified specialist. **Overstocking and overgrazing/browsing must be prevented.** This is especially important in areas that are fenced. It is not possible to recommend stocking rates per ecosystem group in these guidelines, as rates will vary across sites depending on local conditions, land-use type, historical management etc. General guidelines can be gleaned from maps produced by the Agricultural Research Council (ARC), but they must be supported by a specialist who looks at local conditions that would impact on sustainable grazing and browsing practices.
- **Rehabilitation relevant to all Albany Thicket types:**
 - When government funds are made available for rehabilitation, PAs should be prioritised for rehabilitation efforts as there is less chance of conflicting land uses in these areas in future. Within PAs, the focus should be on areas that are outside of high impact zones (e.g. areas used/accessed by African elephants).
 - Disrupting soil structure and drainage has significant impact on thicket, and its restoration potential. For this reason, it is important to consider how and where the land has been disturbed in order to inform the approach to rehabilitation. Physical attributes of the area (i.e. terrain and soil information) must be



investigated so that the correct measures can be used to re-instate processes required by local biodiversity.

- Land Types (terrain/soil information) must be used when deciding what type of rehabilitation action is necessary. Sometimes active measures like ripping can create more damage through disruptions to the soil profile and drainage.
- The impact of pesticides and herbicides on soil quality must be considered in rehabilitation potential. Pesticides/herbicides have the potential to harm soil biota, reduce soil quality and contaminate groundwater. Areas where pesticides/herbicides have been used, especially where these have hyper-accumulated, may be less likely to recover if measures to improve soil quality are not addressed.
- The removal and control of invasive alien vegetation must be prioritised. Landowners must get advice from suitable specialists on which AIP species should be targeted, as some are more problematic in certain areas than others. Different species also respond differently to different control methods. The legal responsibilities of landowners for controlling different category species must also be taken into account. Areas in proximity to commercial plantations are particularly at risk of alien plant invasion, and plantation companies should assist landowners in managing invasive alien vegetation on their properties.
- Land-use guidelines/recommendations given in available biodiversity plans and tools must be consulted and applied early in the land-use planning process (refer to Appendix 5.2).
- On a strategic level, the seven principles discussed by Biggs et al. (2012) for building resilience in ecosystem services must be considered and applied especially in provincial and municipal planning processes.
- Resilience of natural ecosystems to the impacts of climate change must be maintained by making sure that ecological corridors are protected, thicket and mosaic boundaries are managed, management maintains diverse and functional ecosystems, and areas of climate refugia for persistence of species are identified and conserved. Dune Thicket is probably most at risk in the short term from the more immediate climate change risks associated with storm surges, changes to winds and impacts on sediment dynamics and dune corridors in the coastal zone.
- Permeable fencing should be used, especially in the growing number of game farms, to allow movement of animals. The impact of electric fencing on ground dwelling species must be avoided.
- A centrally managed database must be compiled where land managers, landowners, EAPs, conservation agencies, PA managers etc. can share data on AIPs (distribution, species, interventions, success rates) and

fire (occurrence of controlled and uncontrolled burns, cause of fire, climate conditions prior to and during the burn, ecological monitoring records pre- and post-fire). This will greatly assist in developing an understanding of contributing factors, and best practice management in different areas. The information could be hosted on SANBI's BGIS site. A framework or template for data collection and reporting by persons on the ground would need to be developed for consistency purposes and robustness of data.

3.4.7. Best spatial approaches to avoid or minimise impacts and risk in Valley Thicket

- Consider land-use guidelines in biodiversity plans applicable to Valley Thicket, especially where land-use change in CBAs and ESAs is proposed, to determine what types of activities are compatible with biodiversity protection. Allow for protection of CBAs and ESAs to facilitate biodiversity persistence. Critical things to maintain for biodiversity to persist.
- Prevent further fragmentation of thicket and, where possible, reconnect intact expanses of thicket.
- Modification of thicket habitat should never be allowed to sever corridors between intact thicket patches.
- Rehabilitate degraded ecological corridors connecting important thicket patches.
- Boundaries or transition areas between thicket and non-thicket biomes must be maintained by avoiding artificial disturbances in these areas, but natural disturbance regimes, such as those related to herbivory and fire, should be maintained.
- Manage grazing carefully (with attention paid to stocking rates and rotation) and ensure that grazing management is well co-ordinated with fire management, clearing of AIPs and other aspects of land management (such as measures for avoiding soil erosion) across the landscape. This is critically important for effective conservation of thicket habitats.
- The boundaries of conservancies and other land management initiatives should be designed to incorporate the natural fire zone, or broader ecosystem or habitat unit for that particular region.
- Habitat modification for urban or agricultural areas should be concentrated in nodes, allowing key ecological corridors across the landscape to be maintained. In this respect, available biodiversity plans and CBA maps should be used to guide land-use planning and change.

3.4.8. Critical things to maintain for biodiversity to persist

- Remove goats entirely from biodiversity priority areas that are required to meet conservation targets.
- The Swartkops River Valley in the NMBM has been highlighted as an area of high biodiversity importance that is under significant pressure from urban and industrial development. The area has exceptional diversity in terms of species composition and habitat types and is a crucial ecological process area. Management of this area must be prioritised, and further destruction of the area prevented wherever possible.
- Maintain all remaining intact thicket fragments across the range of thicket vegetation types to help buffer against the impacts of climate change, especially those that occur in biodiversity priority areas.
- Remaining stands of viable intact thicket in developed areas (e.g. urban or peri-urban areas) should be retained as far as possible, as they provide useful ecosystem services to surrounding communities. For biodiversity in remnant thicket to persist, the identified drivers need to be operating. Consideration should be given to how these remnant tracts of thicket could be connected to viable corridors, and measures implemented accordingly.
- Rehabilitate corridors that connect isolated patches of intact thicket. Corridors are especially effective measures for conserving thicket because they enable the persistence of natural patterns of seed dispersal (in bird-dispersed species) and herbivore migration. Ecological corridors identified in biodiversity plans must be prioritised for ecological management and rehabilitation, especially in areas that are at risk of urban expansion and where there is a high probability of isolating thicket clumps across the landscape (which would ultimately result in areas of poor ecological condition in the absence of the required ecological drivers).
- Maintain natural mosaic patterns and minimum viable patch sizes. Establishing the minimum viable patch size and acceptable isolation distances between thicket patches, or the structure and maintenance of the mosaic pattern, all require detailed, on-site assessments at a minimum scale of 1:5 000. Only fine-scale, detailed analysis of present and past thicket distribution patterns can determine minimum viable patch sizes. A thorough understanding of physical factors shaping mosaic patterns is key, with reference to changes in soil type and slope, drainage patterns, and the location of microhabitats in the area under investigation.
- Maintain natural disturbance regimes through integrated management of fire, grazing and drought. Current climate trends might allow thicket to encroach into and displace less-resilient neighbouring vegetation types, so maintaining the mosaic patterns will become

increasingly important to preserve biodiversity patterns at the landscape scale.

- Certain patches of thicket, especially solid, non-mosaic vegetation types, require total protection from fire. Fire and infestations of AIPs must, therefore, be managed in the adjacent, non-thicket ecosystems. Never allow adjacent 'fire-adapted' vegetation types (such as fynbos) to remain unburnt for longer than what is required based on the fynbos type in the area, or to become infested with woody AIPs.
- Maintain the appropriate fire regime in terms of fire frequency and seasonality in fire-prone thicket types.
- Keep thicket patches and their surrounds free of invasive alien vegetation. This requires controlling existing invasions, as well as the prevention of future invasion.
- Ensure that planting of spekboom (*Portulacaria afra*) (as a restoration measure) only happens in areas where this species occurs (or occurred) naturally. Consult with an experienced plant ecologist to obtain this information. If introduced in an incorrect area, *P. afra* could have a negative impact on other naturally-occurring species.
- Degraded areas should be prioritised for rehabilitation/restoration.

3.4.9. Indicators to assess and monitor ecological condition

- The canopy characteristics: assess whether the thicket canopy is closed and continuous. In most cases, solid thicket vegetation consists of a closed, dense canopy consisting of an impenetrable tangle of shrubs and low trees. An open and/or fragmented canopy can be indicative of degradation or damage to the original vegetation. Changes could be monitored over time using a method such as fixed-point photography.
- Structural elements: determine whether the vegetation contains all the expected structural components for the site being assessed, including low trees, shrubs and woody lianas, accompanied by a sparse understorey of herbs consisting of geophytes, succulents, C₃ and C₄ grasses and others. The presence of emergent species, especially succulents, such as aloes and euphorbias, may also be characteristic for the site. If any of these components are lacking it may indicate degradation.
- Presence and health of keystone species: for example, the presence and percentage cover of *P. afra* is an important indicator of ecological condition in areas where this species would naturally occur. Most Valley Thicket types should have a relatively high cover of *P. afra* when they are in good ecological condition. In particular, thicket patches that are in good ecological condition should have *P. afra* present at their boundaries, as this protects

the vegetation within the bush clumps from fire. The absence of *P. afra*, usually as a result of poor browsing practices, indicates poor ecological condition.

- **Presence and health of succulent species:** changes in the presence and density of succulent species, especially in drier forms of thicket vegetation types, indicate a change in ecosystem condition. A decline in the proportion of succulents may indicate declining ecological condition, usually as a result of persistent overgrazing.
- **Standing biomass:** thicket has a characteristically high standing biomass. Sparse vegetation or low biomass, except in more arid areas, may be a sign of degradation due to overgrazing or to some other factor.
- **Survival of structurally important species:** monitor mortality rate of adult trees during drought periods. Death of adult trees during drought periods indicates thicket that is in poor ecological condition.
- **Changes in species composition and vegetation structure:** Species composition and vegetation structure relative to expected conditions can be monitored. The expectation can be based on historical information, baseline data collection or reference sites in similar ecological conditions to the target site. Changes may indicate habitat degradation or else provide information on successional dynamics. Functional type composition can also be a useful measure of favourable or detrimental changes. Botanical reserves could be a useful benchmark; however, they do not represent an entirely natural state since mega-herbivores have been removed. Species composition can also be measured as a baseline prior to an intervention and then monitored over time at fixed points to determine whether any changes are occurring. Similarly, monitoring can be used to determine whether a project is having continuous impacts on nearby vegetation or not.
- **Overall species diversity:** this indicator may change significantly due to natural environmental variation over time or space; for example, the amount of rainfall during the previous season or between one habitat and another. However, a reduction in species diversity may give an indication of deteriorating ecological condition.
- **Thicket growth and spread:** monitor encroachment of thicket into the surrounding matrix vegetation in thicket-mosaic vegetation types. The presence of a distinct boundary between thicket patches and the adjacent vegetation types (such as Grassland, Savanna, Forest, Fynbos or Nama Karoo Biomes) will indicate ecosystems in good ecological condition. Thicket clumps should only coalesce and displace adjacent vegetation types in prescribed areas where solid thicket previously occurred and not in areas where mosaic vegetation types are found.
- **A measure of fragmentation, continuity or vegetation connectedness, as well as various other landscape ecology parameters:** measures of these parameters may provide useful insight into identifying areas most in need of intervention or other areas that are intact. These parameters can be measured using aerial photographs, satellite images or SPOT images. In addition to measuring the current status, the effect of proposed clearing on an area of thicket vegetation can also be assessed using a similar approach.
- **Invasion by woody species:** the presence and density of AIPs, or the extent of invasion by weedy but indigenous woody species such as sweet thorn (*Vachellia karroo*), should be monitored, with a low density (or absence) of these species indicative of an ecosystem in good ecological condition.
- **SCCs:** persistence/stable population parameters of SCCs are a sign of ecosystems in good ecological condition. Other population parameters such rates of recruitment, or the presence of seedlings or saplings, could provide information on population health.
- **Soil health:** parameters such as retention of the litter layer, with associated nutrients, can provide a good indication of ecological condition. The presence and severity of soil erosion features can provide a similar indication of general ecological condition; for example, the presence of sheet or gully erosion may be associated with a loss of vegetation cover.
- **Fire frequency and intensity:** in thicket-mosaic vegetation types, monitor signs that appropriate fire intervals and management are being applied. If fire is absent from mosaic vegetation types for longer than the prescribed period, then targeted burning will be required to prevent a deterioration in ecological condition.
- **The presence of a browse line can be used to indicate overbrowsing** (for example goats and browse lines in *Pappea capensis* in Arid Thicket).
- **The functionality of systems** (e.g. carbon sequestration): a number of methods can be used to do this, including easy to access new generation products (e.g. remote sensing), and making use of mass information readily available on the internet. Field measurements of nett primary production can also be done.
- **Changes in the landscape:** remote sensing can be used to detect heterogeneity in the landscape, to indicate change, and to detect bush encroachment. It is important to note that while these technologies are available and extremely useful, it takes a fair amount of skill and training to be able to use and apply these tools.

3.4.10. Reversibility of impacts within a period of 5 to 10 years

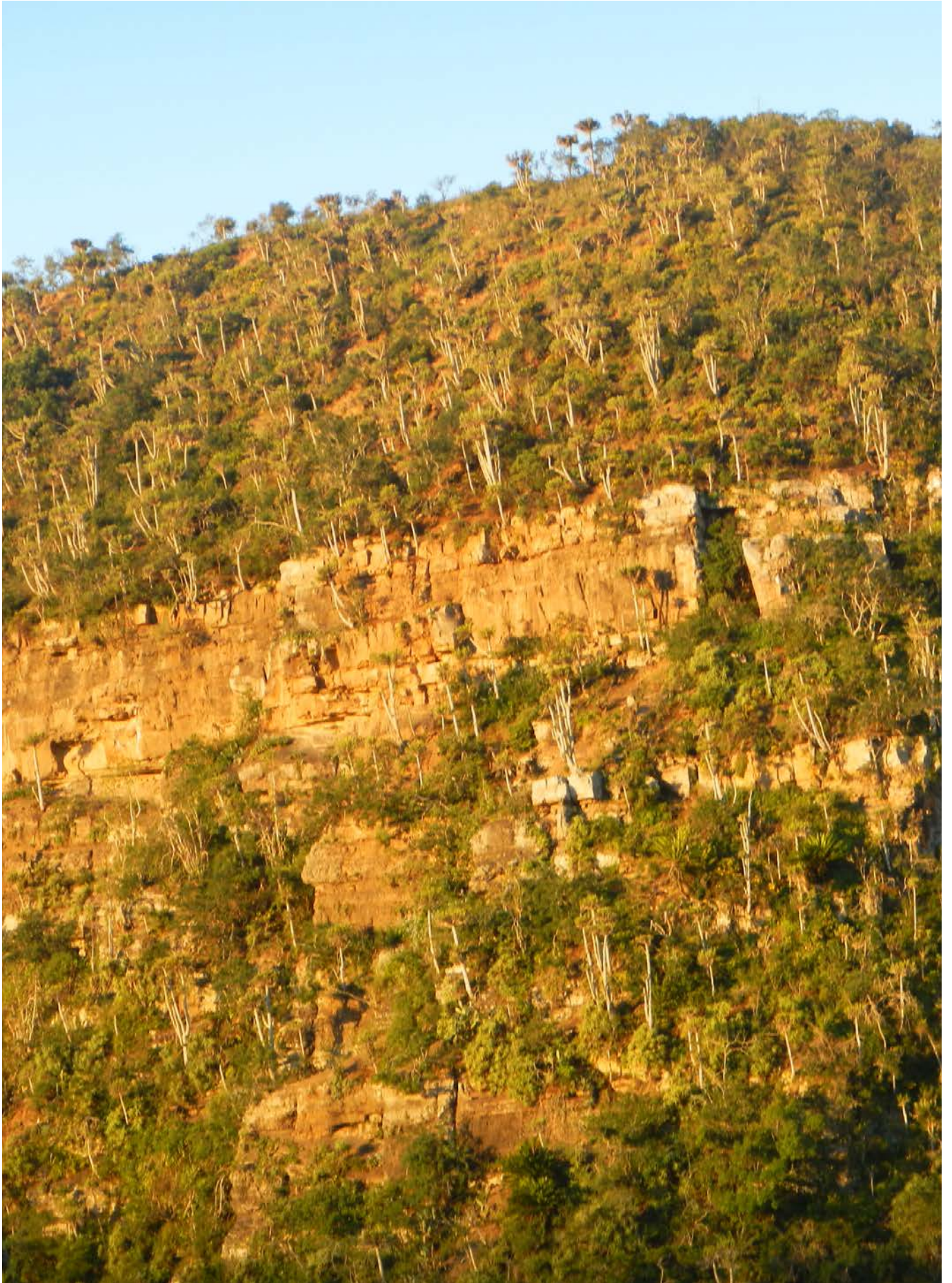
- **Loss of Valley Thicket vegetation is probably irreversible in human timescales.** The prevailing ecological

theory on the origins of thicket vegetation indicates that it developed under a different climate regime to what currently occurs. This suggests that it would be virtually impossible to restore thicket vegetation in a form that resembles the original composition and structure.

- Where small patches of thicket have been lost within an intact extent of Valley Thicket, it is possible that the remaining thicket could spread into the disturbed area, if active management of the process takes place.
- Rehabilitation of areas where vegetation has been destroyed is slow, as vegetation must go through several successional phases to reach maturity. In most cases, recovery to the mature phase will take a lot longer than ten years.
- Restoration by planting rows of spekboom (*Portulacaria afra*) truncheons across large areas (of about 3 500 ha) have been done in the past. It is possible that in the long term this could promote thicket recovery.

3.4.11. Acceptable compensation measures or offsets for biodiversity loss

- Where residual negative impacts on Valley Thicket are unavoidable and there are no alternatives to the proposed development (i.e. it is of overriding public importance), then biodiversity offsets should target the securing and formal protection of core areas of Valley Thicket in good ecological condition, and provide for their effective management in the long term.
- Offsets must never be proposed as a mitigation measure for the destruction of unique and/or irreplaceable habitats; lower impact alternatives that avoid impacts on these areas must be sought.
- An offset area must be identified, planned and secured in line with the principals and requirements of presiding regulations and policy on offsets.



3.5. Arid Thicket

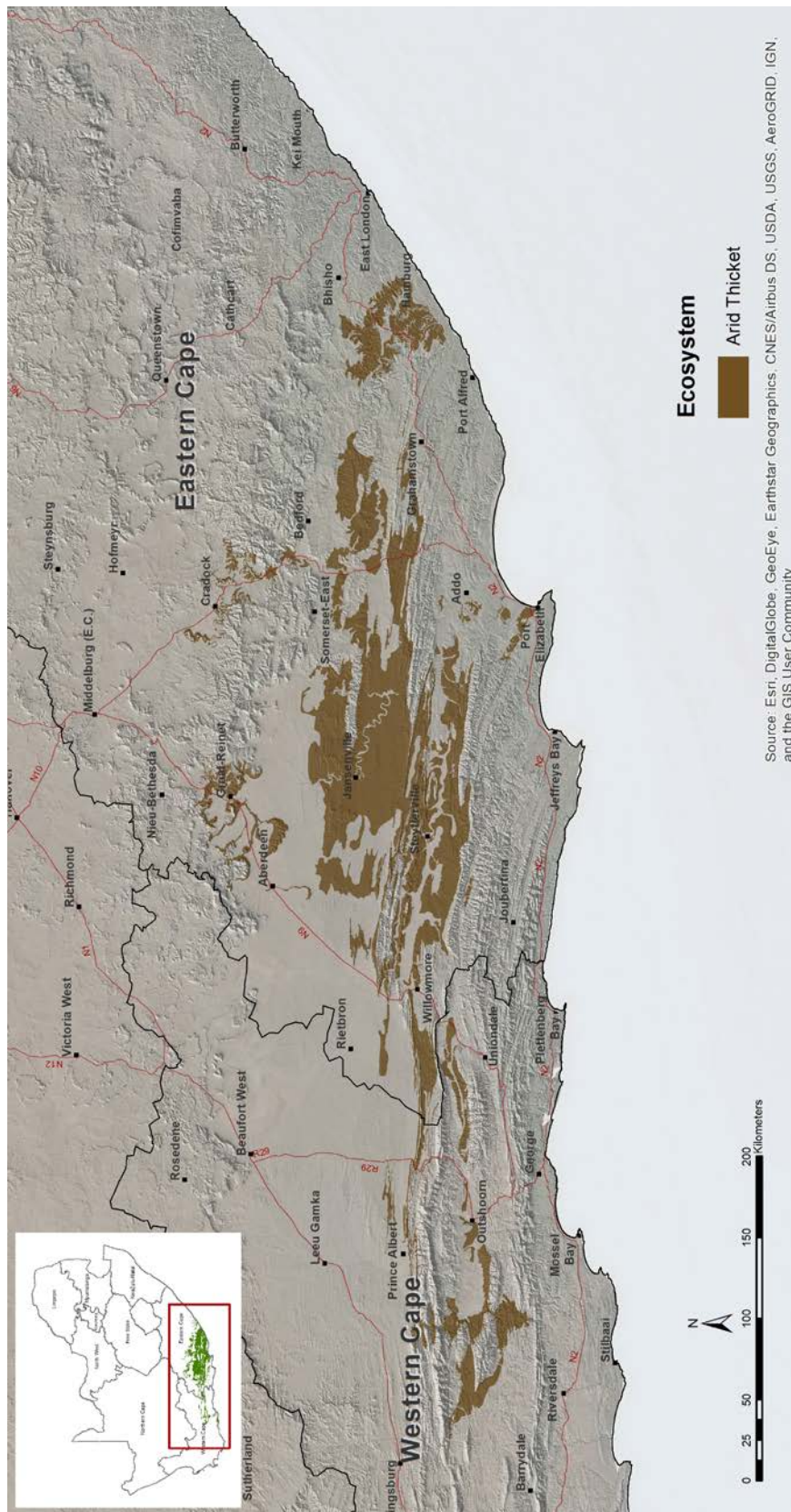


FIGURE 7.—Locality Map of the Valley Thicket Ecosystem Group.

3.5.1. General characteristics

Arid Thicket is an inland vegetation group occurring mostly on the coastal hinterland area of the biome, as well as within the eastern Cape Fold Mountains, along the foot of the Great Escarpment, especially associated with the foot slopes of steep topography in the Graaff-Reinet and Aberdeen area, and in scattered patches inland of the Great Escarpment near Cradock (both Escarpment Arid Thicket) (Figure 8). The largest region of Arid Thicket is found on the plains centred on Jansenville (Sundays Arid Thicket). Other significant patches are to the north of Grahamstown in the Great Fish River Valley (Fish Arid Thicket), between Willowmore and Kirkwood, centred on Steytlerville in the Groot River Valley, and on the plains centred on Oudtshoorn and Calitzdorp (Gamka Arid Thicket). There is a large area of Arid Thicket on the plains south of Ladismith, but this exists as a mosaic with Renosterveld and Succulent Karoo.

Arid Thicket is the driest form of thicket, having the lowest rainfall figures (200–300 mm), compared to other ecosystem groups, or it is restricted to particularly arid sites. In the escarpment zone, frost is a regular occurrence in Arid Thicket, whereas this is not the case in any other parts of the biome.

Arid Thicket has a poorly-developed woody tree and shrub component, sparse and rarely exceeding two metres in height, but succulents are a prominent component of the vegetation. Large woody trees are rare. Arid Thicket occurs on shallow, loamy-clayey soils to heavy clay soils. Due to relatively low fuel loads, Arid Thicket has a low likelihood of burning. Fire does not easily penetrate arid basins.



Plate 9.—Arid Thicket with *Euphorbia* sp. in the foreground (Source: Prof Richard Cowling).



Plate 10.—Succulent plants (*Crassula rupestris* in the foreground in the image on the left, and *Aloe striata* in the image on the right) are a prominent component of the vegetation in the Arid Thicket Ecosystem Group (Source: Prof Richard Cowling).

Dominant and characteristic species include: *Aloe africana*, *A. ferox*, *A. microstigma*, *A. speciosa*, *Astroloba foliolosa*, *Boscia oleoides*, *Cadaba aphylla*, *Carissa haematocarpa*, *Cotyledon orbiculata*, *Crassula ovata*, *Euclea undulata*, *Euphorbia atrispina*, *E. bothae*, *E. caerulescens*, *E. ferox*, *E. pentagona*, *E. tetragona*, *Gloveria integrifolia*, *Gymnosporia polyacantha*, *G. szyszyłowiczii*, *Nymaniania capensis*, *Pappea capensis*, *Pegoletia baccharidifolia*, *Portulacaria afra*, *Ptaeroxylon obliquum*, *Rhigozum obovatum*, *Sarcostemma viminale*, *Schotia afra*, *Searsia longispina* and *Vachellia karroo*.

Arid Thicket is comprised of five vegetation types in solid thicket, and ten thicket mosaics with Nama Succulent Karoo vegetation types (VEGMAP, 2018) as listed in Table 5 with an indication of the ecosystem threat status and ecosystem protection level (Skowno et al., 2019).

The predominant vegetation type is Sundays Arid Thicket, followed by Doubledrift Karroid Thicket which together make up ~50% of the group.

Based on the habitat modification assessment done as part of the NBA (Skowno, 2018), ~4% of this group is modified. Most of the ecosystem group is considered 'natural' (includes rangelands). The land cover 'croplands' is the main land use, followed by urban settlement of the NMBM, where Motherwell Karroid Thicket and Bethelsdorp Bontveld occur (and 'built' areas cover large areas of the vegetation types). The rate of modification is generally low across all vegetation types other than Motherwell Karroid Thicket, where 'built' areas comprise 41% of the vegetation type, and where the percentage rate of modification between 1990 and 2014 was 17.49%. Despite the low modification levels,

TABLE 5.—Vegetation Types (VEGMAP, 2018) found in the Arid Thicket Ecosystem Group and their Ecosystem Threat Status and Ecosystem Protection Level (Skowno, 2018; Skowno et al., 2019).

Arid Thicket Vegetation Types	Veg Code	Ecosystem Threat Status	Ecosystem Protection Level	Extent (ha)	% decline 1750–2014
Arid Thicket					
Albany Arid Thicket	AT15	Least Concern	Poorly Protected	1 460	0
Escarpment Arid Thicket	AT27	Least Concern	Moderately Protected	123 993	0.10
Fish Arid Thicket	AT30	Least Concern	Well Protected	67 404	0.64
Gamka Arid Thicket	AT33	Least Concern	Poorly Protected	49 183	0.15
Sundays Arid Thicket	AT49	Vulnerable	Moderately Protected	564 706	0.20
Arid Thicket in a mosaic with Nama Succulent Karoo					
Koedoeskloof Karroid Thicket	AT42	Least Concern	Not Protected	5 986	1.51
Saltaire Karroid Thicket	AT47	Least Concern	Poorly Protected	91 054	0.29
Albany Bontveld	AT16	Least Concern	Poorly Protected	5 377	0.26
Bethelsdorp Bontveld	AT20	Vulnerable	Not Protected	3 548	5.20
Doubledrift Karroid Thicket	AT24	Least Concern	Poorly Protected	297 378	0.56
Motherwell Karroid Thicket	AT44	Critically Endangered	Not Protected	16 333	17.49
Oudtshoorn Karroid Thicket	AT46	Least Concern	Well Protected	57 190	0.25
Eastern Gwarrieveld	AT25	Least Concern	Poorly Protected	212 877	0.05
Willowmore Gwarrieveld	SKv12	Least Concern	Not Protected	225 231	0.15
Western Gwarrieveld	SKv9	Least Concern	Poorly Protected	76 037	0.38

degradation by poor livestock management is a significant threat to biodiversity in Arid Thicket. Management measures are required to ensure grazing and browsing takes place in suitable areas and to prevent loss of key ecosystem species.

The ecosystem threat status of Motherwell Karroid Thicket is 'Critically Endangered', and Sundays Arid Thicket and Bethelsdorp 'Vulnerable' (Skowno et al., 2019).

3.5.2. Key ecological drivers maintaining ecosystem function and biodiversity pattern

- **Herbivory:** Arid Thicket has relatively low growth rates, and defoliation (browsing) by herbivores has been an integral part of thicket evolution. In Arid Thicket this has led to the common occurrence of spiny plants alongside the dominant succulent flora. Arid Thicket in good ecological condition is a drought tolerant, reliable and enduring food source, but overgrazing leads to rapid degradation. Large herbivores (such as African bush elephant, black rhinoceros and some of the larger ungulates) were probably historically important for maintaining the matrix habitat between thicket bush clumps, but this is probably only currently true for species such as the greater kudu.

Small herbivores such as tortoises play an important role in influencing the abundance of low-growing succulents and geophytes through selective herbivory.

- **Rainfall:** The amount of annual rainfall, as well as the season in which it occurs, are important factors in determining thicket characteristics. Arid Thicket occurs in landscapes with the lowest amounts of annual rainfall or in areas where topography or soil type create local aridity.
- **Climatic variability:** Arid Thicket probably shows the highest resilience to climate change (though it is also the most vulnerable to overgrazing or heavy browsing).
- **Ecosystem engineers:** *Portulacaria afra* (spekboom) has recently been referred to as an 'ecosystem engineer' because of the critically important role it plays in thicket restoration and promoting the recruitment of other thicket species. This characteristic thicket plant also resists droughts and floods and encroachment by fire from neighbouring landscapes dominated by grassland and savanna.
- **Seed dispersal**
- **Topography, geology and soil type:** Variations in these factors also drive diversity patterns and the distribution of thicket vegetation. Arid Thicket is found in more arid microsites than neighbouring Valley Thicket.
- **Spatial linkages to other vegetation**



Plate 11.—Browsers in thicket: African bush elephant (top) and greater kudu (bottom) (Source: Prof Richard Cowling).

3.5.3. Conservation, land-use pressures and risks

Approximately 10–15% of the ecosystem group is conserved in PAs, mostly in sections of the Addo Elephant National Park in the area east and west of Jansenville and the Camdeboo National Park near Graaff-Reinet. Arid Thicket has been highly degraded through livestock grazing and browsing, which has changed the original thicket into a scrubby karroid dwarf shrubland. Once keystone species, such as *Portulacaria afra* have been lost, it is difficult for them to re-establish naturally. Broad management of grazing and browsing pressure is therefore required to limit future degradation of this ecosystem group.

3.5.4. Main pressures, risks and threats

- **Overgrazing/browsing:**
Most thicket landscapes are used by commercial and subsistence farmers as rangelands for domestic stock (especially sheep and goats). Overstocking, combined with a lack of appropriate grazing/browsing management techniques over extended periods, has resulted in a large proportion of thicket landscapes becoming overutilised and degraded, with many negative consequences, including severe soil erosion and loss of certain species. Aspects of overgrazing/browsing that are of particular concern include:
 - In the drier areas, persistent overgrazing leads to the loss of desirable succulents, especially species such as *Portulacaria afra*, with many knock-on effects. Core areas of Arid Thicket are very sensitive to severe grazing/browsing impact and once the canopy cover of these areas becomes fragmented, the vegetation is rapidly and irreversibly altered to a depauperate form of Nama Karoo. Degraded or modified arid thicket rarely actively expands or re-establishes where it has been impacted or lost. Under persistent heavy grazing, species loss eventually leads to rapid soil erosion.
 - *P. afra* is an essential component of Arid Thicket. It plays a critical role in ecological succession processes, buffers habitats against the impacts of fire and is highly favoured by browsers. In some thicket habitats, it is often the dominant species. Overgrazing/browsing, especially by goats, in combination with drought, leads to loss of *P. afra*, with multiple impacts including the loss of other plant species, loss of aerial cover and subsequent soil erosion. The loss of *P. afra* from the boundaries of thicket bush clumps lowers the resilience of the ecosystem to fire.
- **The introduction of non-indigenous and extra-limital game species** may also have negative impacts on thicket vegetation, as the introduction of these species may upset the natural grazer/browser ratios, thus subjecting the habitat to excessive grazing or browsing pressure.

- **Urban expansion:**

Expansion of the built environment is prominent in the NMBM, in Motherwell Karroid Thicket and Bethelsdorp Bontveld vegetation types.

- **Arid Thicket is at risk of desertification** from changes in environmental variables expected with climate change.
- **'Fracking' is a possible future threat** that may result in loss and fragmentation of thicket habitat, and deterioration of groundwater quality.
- **Arid Thicket is cleared in the Steytlerville, Willowmore and Oudtshoorn areas to make way for pivots.** Dams in valleys to provide water for pivots impact on hydrology.
- **Linear infrastructure, such as roads and power corridors, result in loss and fragmentation of thicket.** Fauna are particularly at risk from collisions with vehicular traffic and power lines (avifauna).
- **Harvesting of flora and fauna for rural livelihoods and commercial purposes** are caused by the following resource uses:
 - Animals for food, e.g. bush meat, edible insects.
 - Animals for traditional/cultural use and medicine, e.g. leopard skins.
 - Harvesting of ornamental plant species, especially succulents (many of which are SCCs), takes place in this ecosystem group.
 - Plants for food, cultural use and medicine. At least 38 plant species harvested in the Eastern Cape for medicinal trade purposes are from the Albany Thicket Biome, including species such as baboon grape, wart plant, *rooistam/kleefgras*, dwarf gasteria/*klein-beestong* and *ibhucu/kopiva/waterpypie/wildekopiva* (Sims-Castley, 2002). Approximately 30% of the plants harvested in the Eastern Cape are used exclusively for cultural purposes (for example *ieyeza lokuhlamba* or ritual washing) (Cocks et al., 2003).
 - Wood from trees is burnt for energy; used for building material for fencing and kraals; used in rituals and stockpiled to show status in the community (Cocks et al., 2003).
 - Grass and reeds are used for thatching and to make brooms and mats.
 - Legal and illegal hunting/poaching of animals, e.g. poaching of white and black rhinoceros.
 - Harvesting of thicket species is taking place on a wide scale directly or indirectly by larger companies. An estimated 156 tonnes of thicket plants are also traded annually in the Eastern Cape, generating an income of R7 million/year (Sims-Castley, 2002).
 - Legal and illegal collection of plants for ornamental trade and medicines, e.g. poaching of cycads for illegal horticultural trade, collecting rare and endemic succulent species in the Arid Thicket Ecosystem Group for ornamental trade, harvesting sap from bitter aloe for the pharmaceutical and cosmetic industry.

3.5.5. Non-negotiables

- **Avoid overgrazing/browsing in Arid Thicket**, as these ecosystems are at risk of being irretrievably lost if unsustainable grazing/browsing pressure persists.
- **Restoration of degraded thicket should be a mandatory condition for authorisation** of any application for land-use change in this at-risk biome. Never underestimate the restoration potential and importance of thicket in areas where it used to occur.
- **Avoid any negative impacts on biodiversity priority areas.**
- **Avoid disturbance to rocky outcrops, geological/soil type boundaries and 'islands' in the landscape where thicket vegetation is present.**
- **Protect rare habitats, such as rocky outcrops, where range-restricted species occur.**
- **Avoid disturbance to riparian areas, steep slopes and valleys.**
- **Avoid the introduction of extra-limital, non-thicket game species** (and remove extra-limital species where they have previously been introduced).
- **Avoid uncontrolled aerial spraying of unregistered herbicides to destroy thicket.**
- **Avoid overstocking of domestic livestock and game on farms, especially goats.**
- **Avoid fragmenting patches of intact thicket.** Where fragmentation has occurred, set aside corridor areas to reconnect the patches and/or implement measures to rehabilitate/restore corridors.
- **Buffer zones around PAs should be retained** in as natural a state as possible.
- **Avoid allowing land uses to impact on transitional or boundary areas** where thicket adjoins or forms mosaics with other vegetation types associated with other biomes. These areas accommodate the highest levels of biodiversity and require special conservation measures.
- **Retain appropriate grazer-browser ratios in game species, as well as the required fire regime**, for maintaining the vegetation in an optimum ecological state. Many of the mosaic thicket vegetation types are maintained by a fine balance between specific fire and grazing regimes.
- **Both surface water and groundwater abstraction should be monitored** where there is a risk of negative impacts on biodiversity and ecosystem function.

3.5.6. General recommendations

- **Never rely on desktop information only to make decisions** on the current status of biodiversity on a particular site. Always conduct a detailed biodiversity assessment

on site, with the assistance of relevant specialists, where required.

- Areas identified as CBAs and ESAs, and/or threatened ecosystems, in biodiversity plans are to be regarded as important biodiversity areas and must be prioritised for conservation/restoration/rehabilitation. No new development should be allowed in these areas before adequate investigation of the specific site by independent biodiversity specialists. Specialist investigations of the site and the surrounding landscape must be done to determine flora and fauna biodiversity, presence of threatened or protected flora and fauna species, and special or protected habitats, as well as any ecological corridors which facilitate landscape connectivity with other natural areas beyond the site and enable biodiversity to persist.
- Ecological corridors must be established and maintained between natural areas, especially between PAs and biodiversity priority areas outside of the PA network. Spatial linkages across the landscape between different thicket habitats must be in place and functional. Corridors must be designated and managed to allow species to track changing environmental conditions and must incorporate climate and biodiversity refugia. When identifying and delineating ecological corridors and connectivity across the landscape, make sure that these linkages follow major environmental gradients correlated to plant composition and that drive turnover in species composition across a wide range of spatial and temporal scales (Beta-diversity). Ensure that corridors are wide enough to incorporate variations in landform and physical processes (Jewitt et al., 2017).
- Restoration/rehabilitation efforts should focus on ecological corridors that provide spatial linkages across the landscape.
- Make sure that physical features, microhabitats and the 'patchiness' in the landscape (i.e. a mosaic of different habitats) are regarded as important aspects required for biodiversity persistence and management.
- Watercourses and wetlands are protected in terms of the National Water Act and are regarded as special habitats. Avoid activities that alter hydrological flow, or that impact on freshwater requirements of other users/habitats (e.g. estuaries and nearshore marine environments need freshwater for biodiversity and productivity).
- Do not consider the terrestrial environment in isolation; recognise and consider relationships between the land, surface water and groundwater components of the environment.
- Buffer areas around National Parks that are designated in Park Management Plans signed by the Minister must be considered when land-use change is planned on areas adjacent to these parks (and within buffer areas).
- Buffers must be implemented around PAs, conservation areas, known locations of SCCs, forested areas, and aquatic ecosystems.
- The carrying capacity of land used for livestock and game farming, and in PAs and conservation areas must be determined by a qualified specialist. Overstocking and overgrazing/browsing must be prevented. This is especially important in areas that are fenced. It is not possible to recommend stocking rates per ecosystem group in these guidelines, as rates will vary across sites depending on local conditions, land-use type, historical management etc. General guidelines can be gleaned from maps produced by the Agricultural Research Council (ARC), but they must be supported by a specialist who looks at local conditions that would impact on sustainable grazing and browsing practices.
- Rehabilitation relevant to all Albany Thicket types:
 - When government funds are made available for rehabilitation, PAs should be prioritised for rehabilitation efforts as there is less chance of conflicting land uses in these areas in future. Within PAs, the focus should be on areas that are outside of high impact zones (e.g. areas used/accessed by African elephants).
 - Disrupting soil structure and drainage has significant impact on thicket, and its restoration potential. For this reason, it is important to consider how and where the land has been disturbed in order to inform the approach to rehabilitation. Physical attributes of the area (i.e. terrain and soil information) must be investigated so that the correct measures can be used to re-instate processes required by local biodiversity.
 - Land Types (terrain/soil information) must be used when deciding what type of rehabilitation action is necessary. Sometimes active measures like ripping can create more damage through disruptions to the soil profile and drainage.
 - The impact of pesticides and herbicides on soil quality must be considered in rehabilitation potential. Pesticides/herbicides have the potential to harm soil biota, reduce soil quality and contaminate groundwater. Areas where pesticides/herbicides have been used, especially where these have hyper-accumulated, may be less likely to recover if measures to improve soil quality are not addressed.
- The removal and control of invasive alien vegetation must be prioritised. Landowners must get advice from suitable specialists on which AIP species should be targeted, as some are more problematic in certain areas than others. Different species also respond differently to different control methods. The legal responsibilities of landowners for controlling different category species must also be taken into account. Areas in proximity to commercial plantations are particularly at risk of alien plant invasion, and plantation companies should assist landowners in managing invasive alien vegetation on their properties.

- Land-use guidelines/recommendations given in available biodiversity plans and tools must be consulted and applied early in the land-use planning process (refer to Appendix 5.2).
- On a strategic level, the seven principles discussed by Biggs et al. (2012) for building resilience in ecosystem services must be considered and applied especially in provincial and municipal planning processes.
- Resilience of natural ecosystems to the impacts of climate change must be maintained by through making sure that ecological corridors are protected, thicket and mosaic boundaries are managed, management maintains diverse and functional ecosystems, and areas of climate refugia for persistence of species are identified and conserved. Dune Thicket is probably most at risk in the short term from the more immediate climate change risks associated with storm surges, changes to winds and impacts on sediment dynamics and dune corridors in the coastal zone.
- Permeable fencing should be used, especially in the growing number of game farms, to allow movement of animals. The impact of electric fencing on ground dwelling species must be avoided.
- A centrally managed database must be compiled where land managers, landowners, EAPs, conservation agencies, PA managers etc. can share data on AIPs (distribution, species, interventions, success rates) and fire (occurrence of controlled and uncontrolled burns, cause of fire, climate conditions prior to and during the burn, ecological monitoring records pre- and post-fire). This will greatly assist in developing an understanding of contributing factors, and best practice management in different areas. The information could be hosted on SANBI's BGIS site. A framework or template for data collection and reporting by persons on the ground would need to be developed for consistency purposes and robustness of data.
- Rehabilitate degraded ecological corridors connecting important thicket patches.
- Boundaries or transition areas between thicket and non-thicket biomes must be maintained by avoiding artificial disturbances in these areas, but natural disturbance regimes, such as those related to herbivory and fire, should be maintained.
- Manage grazing carefully (with attention paid to stocking rates and rotation) and ensure that grazing management is well co-ordinated with fire management, clearing of AIPs and other aspects of land management (such as measures for avoiding soil erosion) across the landscape. This is critically important for effective conservation of thicket habitats.
- The boundaries of conservancies and other land management initiatives should be designed to incorporate the natural fire zone, or broader ecosystem or habitat unit for that particular region.
- Habitat modification for urban or agricultural areas should be concentrated in nodes, allowing key ecological corridors across the landscape to be maintained. In this respect, available biodiversity plans and CBA maps should be used to guide land-use planning and change.

3.5.7. Best spatial approaches to avoid or minimise impacts and risk in Arid Thicket

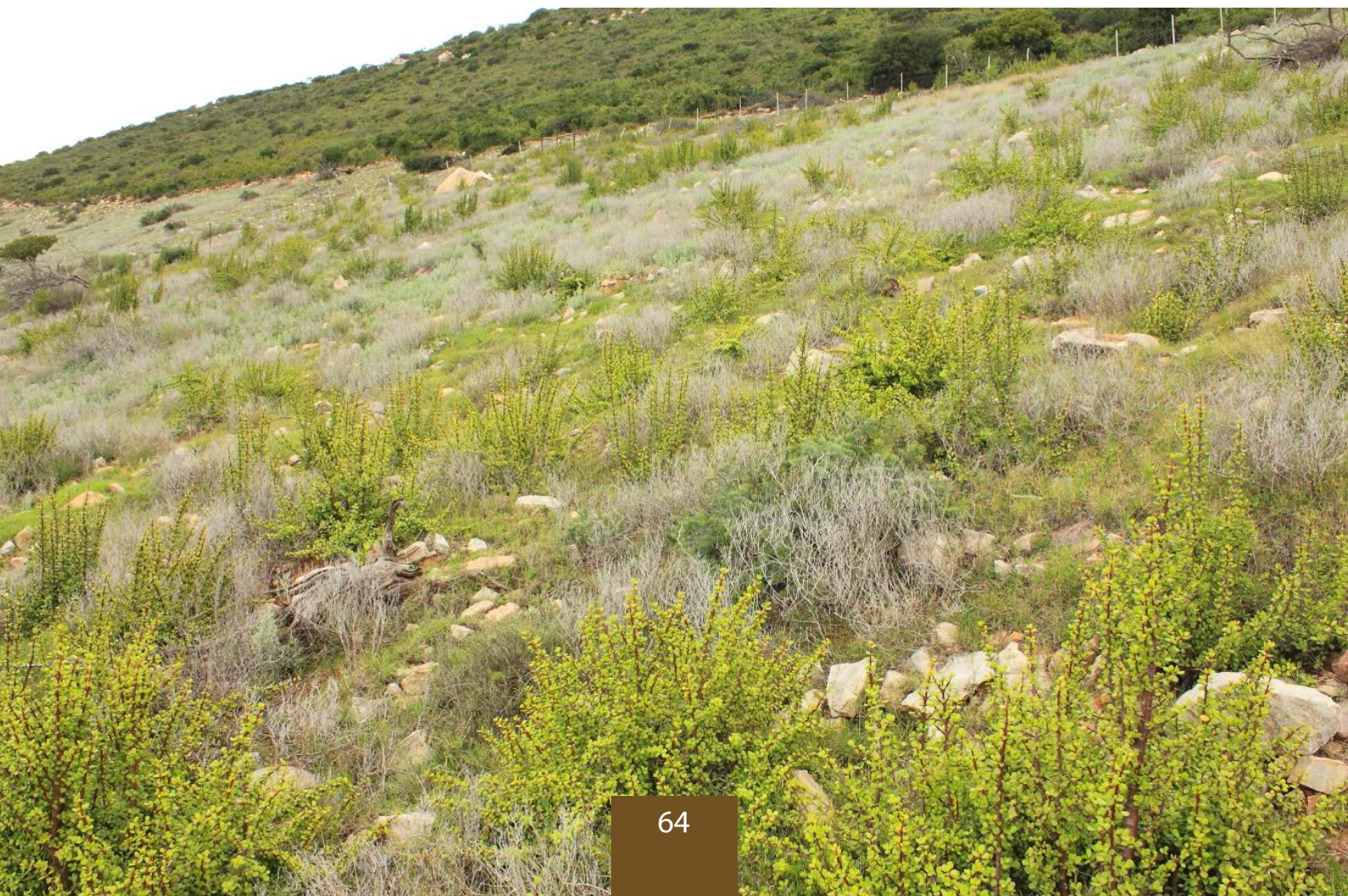
- Consider land-use guidelines in biodiversity plans applicable to Arid Thicket, especially where land-use change in CBAs and ESAs is proposed, to determine what types of activities are compatible with biodiversity protection. Allow for protection of CBAs and ESAs to facilitate biodiversity persistence.
- Prevent further fragmentation of thicket and, where possible, reconnect intact expanses of thicket.
- Modification of thicket habitat should never be allowed to sever corridors between intact thicket patches.
- Maintain all remaining intact thicket fragments across the range of thicket vegetation types to help buffer against the impacts of climate change, especially those that occur in biodiversity priority areas.
- Remaining stands of viable intact thicket in developed areas (e.g. urban or peri-urban areas) should be retained as far as possible, as they provide useful ecosystem services to surrounding communities. For biodiversity in remnant thicket to persist, the identified drivers need to be operating. Consideration should be given to how these remnant tracts of thicket could be connected to viable corridors, and measures implemented accordingly.
- Rehabilitate corridors that connect isolated patches of intact thicket. Corridors are especially effective measures for conserving thicket because they enable the persistence of natural patterns of seed dispersal (in bird-dispersed species) and herbivore migration. Ecological corridors identified in biodiversity plans must be prioritised for ecological management and rehabilitation, especially in areas that are at risk of urban expansion and where there is a high probability of isolating thicket clumps across the landscape (which would ultimately result in areas of poor ecological condition in the absence of the required ecological drivers).
- Maintain natural mosaic patterns and minimum viable patch sizes. Establishing the minimum viable patch size

and acceptable isolation distances between thicket patches, or the structure and maintenance of the mosaic pattern, all require detailed, on-site assessments at a minimum scale of 1:5 000. Only fine-scale, detailed analysis of present and past thicket distribution patterns can determine minimum viable patch sizes. A thorough understanding of physical factors shaping mosaic patterns is key, with reference to changes in soil type and slope, drainage patterns, and the location of microhabitats in the area under investigation.

- Maintain natural disturbance regimes through integrated management of fire, grazing and drought. Current climate trends might allow thicket to encroach into and displace less-resilient neighbouring vegetation types, so maintaining the mosaic patterns will become increasingly important to preserve biodiversity patterns at the landscape scale.
- Certain patches of thicket, especially solid, non-mosaic vegetation types, require total protection from fire. Fire and infestations of AIPs must, therefore, be managed in the adjacent, non-thicket ecosystems. Never allow adjacent 'fire-adapted' vegetation types (such as fynbos) to remain unburnt for longer than what is required based on the fynbos type in the area, or to become infested with woody AIPs.
- Maintain the appropriate fire regime in terms of fire frequency and seasonality in fire-prone thicket types.
- Keep thicket patches and their surrounds free of invasive alien vegetation. This requires controlling existing invasions, as well as the prevention of future invasion.
- Ensure that planting of spekboom (*Portulacaria afra*) (as a restoration measure) only happens in areas where this species occurs (or occurred) naturally. Consult with an experienced plant ecologist to obtain this information. If introduced in an incorrect area, *P. afra* could have a negative impact on other naturally-occurring species.
- Degraded areas should be prioritised for rehabilitation/restoration.

3.5.9. Indicators to assess and monitor ecological condition

- The presence and density of AIP species, most importantly Lindley's saltbush (*Atriplex lindleyi*), or the extent of invasion by weedy but indigenous woody species should be monitored. A low density (or absence) of these species is indicative of intact thicket ecosystems.
- The canopy characteristics: assess whether the thicket canopy is closed and continuous. In most cases, solid thicket vegetation consists of a closed, dense canopy consisting of an impenetrable tangle of shrubs and low trees. An open and/or fragmented canopy can be indicative of degradation or damage to the original vegetation.



Changes could be monitored over time using a method such as fixed-point photography.

- **Structural elements:** determine whether the vegetation contains all the expected structural components for the site being assessed, including low trees, shrubs and woody lianas, accompanied by a sparse understorey of herbs consisting of geophytes, succulents, C₃ and C₄ grasses and others. The presence of emergent species, especially succulents, such as aloes and euphorbias, may also be characteristic for the site. If any of these components are lacking it may indicate degradation.
- **Presence and health of keystone species:** for example, the presence and percentage cover of *P. afra* is an important indicator of ecological condition in areas where this species would naturally occur.
- **Presence and health of succulent species:** changes in the presence and density of succulent species, especially in drier forms of thicket vegetation types, indicate a change in ecosystem condition. A decline in the proportion of succulents may indicate declining ecological condition, usually as a result of persistent overgrazing.
- **Standing biomass:** thicket has a characteristically high standing biomass. Sparse vegetation or low biomass, except in more arid areas, may be a sign of degradation due to overgrazing or to some other factor.
- **Survival of structurally important species:** monitor mortality rate of adult trees during drought periods. Death of adult trees during drought periods indicates thicket that is in poor ecological condition.
- **Changes in species composition and vegetation structure:** species composition and vegetation structure relative to expected conditions can be monitored. The expectation can be based on historical information, baseline data collection or reference sites in similar ecological conditions to the target site. Changes may indicate habitat degradation or else provide information on successional dynamics. Functional type composition can also be a useful measure of favourable or detrimental changes. Botanical reserves could be a useful benchmark; however, they do not represent an entirely natural state since mega-herbivores have been removed. Species composition can also be measured as a baseline prior to an intervention and then monitored over time at fixed points to determine whether any changes are occurring. Similarly, monitoring can be used to determine whether a project is having continuous impacts on nearby vegetation or not.
- **Overall species diversity:** this indicator may change significantly due to natural environmental variation over time or space; for example, the amount of rainfall during the previous season or between one habitat and another. However, a reduction in species diversity may give an indication of deteriorating ecological condition.
- **Thicket growth and spread:** monitor encroachment of thicket into the surrounding matrix vegetation in thicket-mosaic vegetation types. The presence of a distinct boundary between thicket patches and the adjacent vegetation types (such as Grassland, Savanna, Forest, Fynbos or Nama Karoo Biomes) will indicate ecosystems in good ecological condition. Thicket clumps should only coalesce and displace adjacent vegetation types in prescribed areas where solid thicket previously occurred and not in areas where mosaic vegetation types are found.
- **A measure of fragmentation, continuity or vegetation connectedness, as well as various other landscape ecology parameters:** measures of these parameters may provide useful insight into identifying areas most in need of intervention or other areas that are intact. These parameters can be measured using aerial photographs, satellite images or SPOT images. In addition to measuring the current status, the effect of proposed clearing on an area of thicket vegetation can also be assessed using a similar approach.
- **Invasion by woody species:** the presence and density of AIPs, or the extent of invasion by weedy but indigenous woody species such as sweet thorn (*Vachellia karroo*), should be monitored, with a low density (or absence) of these species indicative of an ecosystem in good ecological condition.
- **SCCs:** persistence/stable population parameters of SCCs is a sign of ecosystems in good ecological condition. Other population parameters such rates of recruitment, or the presence of seedlings or saplings, could provide information on population health.
- **Soil health:** parameters such as retention of the litter layer, with associated nutrients, can provide a good indication of ecological condition. The presence and severity of soil erosion features can provide a similar indication of general ecological condition; for example, the presence of sheet or gully erosion may be associated with a loss of vegetation cover.
- **Fire frequency and intensity:** in thicket-mosaic vegetation types, monitor signs that appropriate fire intervals and management are being applied. If fire is absent from mosaic vegetation types for longer than the prescribed period, then targeted burning will be required to prevent a deterioration in ecological condition.
- **The presence of a browse line can be used to indicate overbrowsing** (for example goats and browse lines in *Pappea capensis* in Arid Thicket).
- **The functionality of systems** (e.g. carbon sequestration): a number of methods can be used to do this, including easy to access new generation products (e.g. remote sensing), and making use of mass information readily available on the internet. Field measurements of nett primary production can also be done.

- **Changes in the landscape:** remote sensing can be used to detect heterogeneity in the landscape, to indicate change, and to detect bush encroachment. It is important to note that while these technologies are available and extremely useful, it takes a fair amount of skill and training to be able to use and apply these tools.

3.5.10. Reversibility of impacts within a period of 5 to 10 years

- In Arid Thicket vegetation types, impacts such as overgrazing or browsing are essentially considered to be irreversible over short to long timescales. These impacts could be partially reversible at a 100-year timescale.
- Revegetation of areas where vegetation has been destroyed is likely to be extremely slow and costly, and the original species composition is unlikely to be recovered.
- Restoration by planting rows of spekboom (*Portulacaria afra*) truncheons across large areas (of about 3 500 ha) has been done in the past. It is possible that in the very long term, under certain conditions, this could promote thicket recovery.

3.5.11. Acceptable compensation measures or offsets for biodiversity loss

- There are few if any acceptable compensation measures or offsets for biodiversity loss in Arid Thicket ecosystems. Restoration of degraded thicket should be a priority recommendation in land-use change application, assessment, and decision-making processes.
- Where residual negative impacts on Arid Thicket are unavoidable and there are no alternatives to the proposed development (i.e. it is of overriding public importance), then **biodiversity offsets** should target the securing and protection of core areas of Arid Thicket in good ecological condition, and provide for their effective management in the long term.
- Offsets must never be proposed as a mitigation measure for the destruction of unique and/or irreplaceable habitats; lower impact alternatives that avoid impacts on these areas must be sought.
- An offset area must be identified, planned and secured in line with the principals and requirements of presiding regulations and policy on offsets.



3.6. Thicket Mosaics: Grassland and/or Savanna



FIGURE 9.—Locality Map of Thicket Mosaics with Grassland and/or Savanna.

3.6.1. General characteristics

In fire-prone ecosystems, thicket forms mosaics with grassland and/or savanna. Grassland and savanna mosaics have been grouped here into a single unit, both of which are fire-driven ecosystems in the summer-rainfall, northeastern side of the Albany Thicket Biome.

This group has a fairly extensive geographical extent, stretching from the core part of the biome near Port Elizabeth, all the way through to the summer rainfall side of the biome near East London. Across this range, it intergrades with savanna and grassland, and is largely replaced by Mesic Thicket towards East London. With the exception of the Great Kei River Valley, vegetation types within this ecosystem group may extend down to 80 km from the coastline.

The mosaic thicket vegetation occurs within the broad river basins of the major river systems. Valley bottoms and slopes are generally covered by solid thicket, whereas the tops of the slopes, and slopes with a gentle gradient, generally give way to grassland or thornveld-type savanna, thus forming a mosaic pattern. Solid thicket is therefore restricted to fire-protected sites in the dissected valleys within matrix grassland/savanna areas. As an example, in Grass Ridge Bontveld, the distinction between thicket and other surrounding vegetation is substrate-driven but is maintained by fire dynamics.

The ecosystem group occurs with a tendency towards having mostly summer rainfall, although being in the Albany Thicket Biome, rainfall may still fall at any time of the year. These mosaic ecosystems occur at elevations from near sea level to around 600 m.a.s.l., although they extend to around 1 000 m.a.s.l. in the upper reaches of the Great Kei River Valley.



Plate 12.—Grass Ridge Bontveld on a hilltop north of the Coega Industrial Development Zone in Nelson Mandela Bay Municipality (Source: CEN IEM Unit).

Plate 13.—Grahamstown Grassland Thicket (Source: Prof Richard Cowling).



TABLE 6.—Vegetation Types (VEGMAP, 2018) found in the Thicket Mosaics with Grassland/Savanna Ecosystem Group and their Ecosystem Threat Status and Ecosystem Protection Level (Skowno, 2018; Skowno et al., 2019).

Thicket Mosaic with Grassland/Savanna Vegetation Types	Veg Code	Ecosystem Threat Status	Ecosystem Protection Level	Extent (ha)	% decline 1750–2014
Crossroads Grassland Thicket	AT23	Least Concern	Moderately Protected	31 118	0.67
Geluk Grassland Thicket	AT35	Least Concern	Well Protected	3 015	4.11
Grahamstown Grassland Thicket	AT38	Least Concern	Poorly Protected	129 083	4.29
Grass Ridge Bontveld	AT39	Least Concern	Moderately Protected	24 592	1.47
Nanaga Savanna Thicket	AT45	Least Concern	Moderately Protected	69 703	3.12

The main thicket type forming a mosaic with grassland and savanna is Mesic Thicket (and Mesic Thicket with Forest mosaics) in the bottom of major valleys, but it may form mosaics with any of the solid thicket ecosystem groups. Mesic Thicket is sensitive to fire frequency and intensity and forms mosaics with surrounding vegetation outside of fire-protected sites, or else forms a serial successional stage between grassland or savanna and forest. A key factor affecting the relationship to fire is the degree of summer drought, which increases from the central part of the biome towards the perimeters.

Dominant and characteristic species will depend on the thicket type but could be similar to that found in Arid Thicket, Mesic Thicket, Valley Thicket or Dune Thicket.

Five vegetation types occur within the ecosystem group (VEGMAP, 2018) as listed in Table 6 with an indication of the ecosystem threat status and ecosystem protection level (Skowno et al., 2019). The predominant vegetation type in this group is Grahamstown Grassland Thicket, followed by Nanaga Savanna Thicket.

Based on the habitat modification assessment done as part of the NBA (Skowno, 2018), ~29% of this ecosystem group has been modified. Besides 'natural' (includes rangelands) areas, 'croplands' is the dominant land cover type in this group. Grahamstown Grassland Thicket is the predominant vegetation type, and also has the highest percentage decline in vegetation.

The ecosystem threat status of all vegetation types in the group is 'Least Concern' (Skowno et al., 2019). However, large areas have been degraded. Correct management of alien invasive vegetation and grazing and browsing is required to prevent further degradation in this group.

3.6.2. Key ecological drivers maintaining ecosystem function and biodiversity pattern

- **Fire:** Fire in adjacent habitats, such as grassland or savanna, is important for maintaining thicket boundaries and

also leads to the formation of mosaics with surrounding vegetation. Heavy grazing can reduce fuel loads, resulting in less intense, more slow-moving fires that allow the establishment and spread of thicket clumps. Vegetation structural composition can influence the probability and/or intensity of fire. Invasion by woody AIPs can increase the frequency and intensity of fires, with harmful effects on thicket vegetation.

- **Soil nutrient dynamics**
- **Seed dispersal**
- **Topography, geology and soil type:** Variations in these factors also drive diversity patterns and the distribution of thicket vegetation.
- **Spatial linkages to other vegetation**
- **Herbivory**
- **Climatic variability:** Climatic extremes, including droughts, floods and heat waves, have little impact on thicket vegetation. This means that where thicket occurs in mosaics with other vegetation types (such as Grassland, Fynbos, Renosterveld and Nama Karoo), it provides an important buffer against these climatic disturbances.

3.6.3. Conservation, land-use pressures and risks

A relatively small portion of this ecosystem group is within PAs, and mostly occurs in the AENP. There are various conservation areas that include components of these ecosystems.

The most prominent risks within this ecosystem group are due to cultivation and expansion of urban settlements, both of which are a continued future risk. The urban areas of East London, Mdantsane, King William's Town/Bhisho, Kei Road, Komga, Butterworth, Grahamstown, Paterson, Alicedale and Bathurst all occur within this group. There are extensive areas of cultivation, many in proximity to the urban centres, but also in more rural areas. Significant parts of this ecosystem group occur within previous homeland areas (e.g. Ciskei), and degradation has occurred from subsistence and communal farming.

This ecosystem group has also been highly degraded through livestock grazing and browsing, which changes the original thicket into a secondary thornveld, or grassland dominated by indigenous invasive or weedy species.

3.6.4. Main pressures, risks and threats

- **Clearing of thicket vegetation to make way for agriculture:**

Large tracts of thicket vegetation have been cleared for cultivation of various crops and for pastures for grazing animals. This results in direct loss of thicket habitat and fragmentation, with a subsequent loss of connectivity between remaining patches of intact thicket habitat. Issues of particular concern are that:

- The loss of connectivity of thicket patches affects ecosystem function. Historically, thicket was more connected across the landscape than it is now. Habitat loss has resulted in a fragmented pattern that reduces resilience to environmental change and causes isolation of gene pools and the loss of gene flow within and between patches. Isolation due to human-induced fragmentation may result in some species losing their adaptive potential, increasing the risk of species or varieties becoming extinct.

- **Several game farms have established in this ecosystem group between Colchester and Grahamstown in particular, and in the Port Alfred and Bathurst areas. Overstocking of faunal species** in fenced areas results in overgrazing/browsing; and subsequent impacts on thicket species composition and resilience. **The introduction of extra-limital species** creates competition for indigenous species, some of which may be outcompeted. Extra-limital species impact on flora through different grazing/browsing strategies. There is generally a lack of consistent management across game farms, with little control over fire management, fencing, grazing practices etc. **Game fences prevent some animal and plant species from migrating**, and may ultimately place their survival at risk.

- **Urban areas:**

Residential and industrial developments are common and widespread in Thicket Mosaic areas with Grassland and Savanna. The largest urban/industrial centre is in NMBM near Motherwell, and the Coega IDZ. Numerous small settlements occur within most of the vegetation types in the group. This has led to loss and fragmentation of habitat, changes to successional dynamics leading to further changes to ecosystems, and general disturbance that affects biodiversity and vegetation patterns.

- **Fire:**

In most vegetation types in this group, especially closer to rural-residential settlements, fire is used by landowners as a tool to remove thicket vegetation to favour the growth of palatable grasses. A high fire frequency, in combination with subsequent overgrazing, may lead to

a loss of the original thicket species to be replaced by grassland or thornveld-type Savanna. Along drainage lines, where fire would seldom occur under natural conditions, thicket vegetation is opened up to be replaced by thorny shrubs and small trees, such as sweet thorn (*Vachellia karroo*). A too high fire frequency therefore leads to a change in vegetation structure and composition to the detriment of local biodiversity.

- **Invasion by woody alien plants:**

Invasive species disturb ecological processes and biodiversity patterns in thicket vegetation. Infestation by woody AIPs occurs in disturbed areas. These species out-compete the indigenous flora and increase fuel loads. The presence of invasive woody species increases the severity of fires and the likelihood of fires penetrating thicket at the interface between thicket and other vegetation types.

- **Overgrazing:**

Most thicket landscapes are used by commercial and subsistence farmers as rangelands for domestic stock (especially goats and cattle). Overstocking, combined with a lack of appropriate grazing/browsing management techniques over extended periods, has resulted in a large proportion of thicket landscapes becoming overutilised and degraded, with many negative consequences, including severe soil erosion and loss of certain species. Aspects of overgrazing/browsing that are of particular concern include that:

- Persistent overgrazing results in the invasion of thicket by indigenous woody shrubs, such as sweet thorn and Karoo honey thorn (*V. karroo* and *Lycium oxycarpum*).
- Overgrazing and wildfires in hot, dry conditions represent a significant threat to thicket, especially when in a mosaic with fire-prone vegetation types (since the likelihood of fire occurring in these areas is greater). Although intact thicket does not readily burn, overgrazing of the succulent component results in the ecosystem becoming vulnerable to encroachment by woody shrubs and C₄ grasses. Encroached areas become more flammable, meaning that fires can then penetrate vegetation that otherwise would never have been exposed to fire (at least not in recent times). This can result in the elimination of fire-intolerant thicket species.

- **Wind farms result in clearing of thicket**, fragmentation of habitats, and may cause bird and bat strikes. Bird and bat deaths may further impact on seed dispersal, and result in an increase in scavengers in the area.

- **Harvesting of flora and fauna for rural livelihoods and commercial purposes** are caused by the following resource uses:

- Animals for food, e.g. bush meat, edible insects.
- Animals for traditional/cultural use and medicine, e.g. leopard skins.

- Plants for food, cultural use and medicine. At least 38 plant species harvested in the Eastern Cape for medicinal trade purposes are from the Albany Thicket Biome, including species such as baboon grape, wart plant, *rooistam/kleefgras*, dwarf gasteria/*klein-beestong* and *ibhucu/kopiva/waterpypie/wildekopiva* (Sims-Castley, 2002). Approximately 30% of the plants harvested in the Eastern Cape are used exclusively for cultural purposes (for example *ieyeza lokuhlamba* or ritual washing) (Cocks et al., 2003).
- Wood from trees is burnt for energy; used for building material for fencing and kraals; used in rituals and stockpiled to show status in the community (Cocks et al., 2003).
- Grass and reeds are used for thatching and to make brooms and mats.
- Legal and illegal hunting/poaching of animals, e.g. poaching of white and black rhinoceros.
- Harvesting of thicket species is taking place on a wide scale directly or indirectly by larger companies. An estimated 156 tonnes of thicket plants are also traded annually in the Eastern Cape, generating an income of R7 million/year (Sims-Castley, 2002).
- Legal and illegal collection of plants for ornamental trade and medicines, e.g. poaching of cycads for illegal horticultural trade, collecting rare and endemic succulent species in the Arid Thicket Ecosystem Group for ornamental trade, harvesting sap from bitter aloe for the pharmaceutical and cosmetic industry.
- Avoid the introduction of extra-limital, non-thicket game species (and remove extra-limital species where they have previously been introduced).
- Avoid uncontrolled aerial spraying of unregistered herbicides to destroy thicket.
- Avoid overstocking of domestic livestock and game on farms, especially goats.
- Avoid fragmenting patches of intact thicket. Where fragmentation has occurred, set aside corridor areas to reconnect the patches and/or implement measures to rehabilitate/restore corridors.
- Buffer zones around PAs should be retained in as natural a state as possible.
- Avoid allowing land uses to impact on transitional or boundary areas where thicket adjoins or forms mosaics with other vegetation types associated with other biomes. These areas accommodate the highest levels of biodiversity and require special conservation measures.
- Retain appropriate grazer-browser ratios in game species, as well as the required fire regime, for maintaining the vegetation in an optimum ecological state. Many of the mosaic thicket vegetation types are maintained by a fine balance between specific fire and grazing regimes.
- Both surface water and groundwater abstraction should be monitored where there is a risk of negative impacts on biodiversity and ecosystem function.

3.6.5. Non-negotiables

- No burning of thicket vegetation within valleys as this can lead to permanent changes in the species composition and structure of these areas.
- Retain appropriate grazer-browser ratios in game species, as well as the required fire regime, for maintaining the vegetation in an optimum ecological state. Many of the Thicket Mosaic vegetation types are maintained by a fine balance between specific fire and grazing regimes.
- Restoration of degraded thicket should be a mandatory condition for authorisation of any application for land-use change in this at-risk biome. Never underestimate the restoration potential and importance of thicket in areas where it used to occur.
- Avoid any negative impacts on biodiversity priority areas.
- Avoid disturbance to rocky outcrops, geological/soil type boundaries and 'islands' in the landscape where thicket vegetation is present.
- Protect rare habitats, such as rocky outcrops, where range-restricted species occur.
- Avoid disturbance to riparian areas, steep slopes and valleys.

3.6.6. General recommendations

- Never rely on desktop information only to make decisions on the current status of biodiversity on a particular site. Always conduct a detailed biodiversity assessment on site, with the assistance of relevant specialists, where required.
- Areas identified as CBAs and ESAs, and/or threatened ecosystems, in biodiversity plans are to be regarded as important biodiversity areas and must be prioritised for conservation/restoration/rehabilitation. No new development should be allowed in these areas before adequate investigation of the specific site by independent biodiversity specialists. Specialist investigations of the site and the surrounding landscape must be done to determine flora and fauna biodiversity, presence of threatened or protected flora and fauna species, and special or protected habitats, as well as any ecological corridors which facilitate landscape connectivity with other natural areas beyond the site and enable biodiversity to persist.
- Ecological corridors must be established and maintained between natural areas, especially between PAs and biodiversity priority areas outside of the PA network. Spatial linkages across the landscape between different thicket habitats must be in place and functional. Corridors must

be designated and managed to allow species to track changing environmental conditions and must incorporate climate and biodiversity refugia. When identifying and delineating ecological corridors and connectivity across the landscape, make sure that these linkages follow major environmental gradients correlated to plant composition and that drive turnover in species composition across a wide range of spatial and temporal scales (Beta-diversity). Ensure that corridors are wide enough to incorporate variations in landform and physical processes (Jewitt et al., 2017).

- Restoration/rehabilitation efforts should focus on ecological corridors that provide spatial linkages across the landscape.
- Make sure that physical features, microhabitats and the 'patchiness' in the landscape (i.e. a mosaic of different habitats) are regarded as important aspects required for biodiversity persistence and management.
- Watercourses and wetlands are protected in terms of the National Water Act and are regarded as special habitats. Avoid activities that alter hydrological flow, or that impact on freshwater requirements of other users/habitats (e.g. estuaries and nearshore marine environments need freshwater for biodiversity and productivity).
- Do not consider the terrestrial environment in isolation; recognise and consider relationships between the land, surface water and groundwater components of the environment.
- Buffer areas around National Parks that are designated in Park Management Plans signed by the Minister must be considered when land-use change is planned on areas adjacent to these parks (and within buffer areas).
- Buffers must be implemented around PAs, conservation areas, known locations of SCCs, forested areas, and aquatic ecosystems.
- The carrying capacity of land used for livestock and game farming, and in PAs and conservation areas must be determined by a qualified specialist. Overstocking and overgrazing/browsing must be prevented. This is especially important in areas that are fenced. It is not possible to recommend stocking rates per ecosystem group in these guidelines, as rates will vary across sites depending on local conditions, land-use type, historical management etc. General guidelines can be gleaned from maps produced by the Agricultural Research Council (ARC), but they must be supported by a specialist who looks at local conditions that would impact on sustainable grazing and browsing practices.
- Rehabilitation relevant to all Albany Thicket types:
 - When government funds are made available for rehabilitation, PAs should be prioritised for rehabilitation efforts as there is less chance of conflicting land uses in these areas in future. Within PAs, the focus should be on areas that are outside of high impact zones (e.g. areas used/accessed by African elephants).
 - Disrupting soil structure and drainage has significant impact on thicket, and its restoration potential. For this reason, it is important to consider how and where the land has been disturbed in order to inform the approach to rehabilitation. Physical attributes of the area (i.e. terrain and soil information) must be investigated so that the correct measures can be used to re-instate processes required by local biodiversity
 - Land Types (terrain/soil information) must be used when deciding what type of rehabilitation action is necessary. Sometimes active measures like ripping can create more damage through disruptions to the soil profile and drainage.
 - The impact of pesticides and herbicides on soil quality must be considered in rehabilitation potential. Pesticides/herbicides have the potential to harm soil biota, reduce soil quality and contaminate groundwater. Areas where pesticides/herbicides have been used, especially where these have hyper-accumulated, may be less likely to recover if measures to improve soil quality are not addressed.
- The removal and control of invasive alien vegetation must be prioritised. Landowners must get advice from suitable specialists on which AIP species should be targeted, as some are more problematic in certain areas than others. Different species also respond differently to different control methods. The legal responsibilities of landowners for controlling different category species must also be taken into account. Areas in proximity to commercial plantations are particularly at risk of alien plant invasion, and plantation companies should assist landowners in managing invasive alien vegetation on their properties.
- Land-use guidelines/recommendations given in available biodiversity plans and tools must be consulted and applied early in the land-use planning process (refer to Appendix 5.2).
- On a strategic level, the seven principles discussed by Biggs et al. (2012) for building resilience in ecosystem services must be considered and applied especially in provincial and municipal planning processes.
- Resilience of natural ecosystems to the impacts of climate change must be maintained by making sure that ecological corridors are protected, thicket and mosaic boundaries are managed, management maintains diverse and functional ecosystems, and areas of climate refugia for persistence of species are identified and conserved. Dune Thicket is probably most at risk in the short term from the more immediate climate change risks associated with storm surges, changes to winds and impacts on sediment dynamics and dune corridors in the coastal zone.
- Permeable fencing should be used, especially in the growing number of game farms, to allow movement of

animals. The impact of electric fencing on ground dwelling species must be avoided.

- A centrally managed database must be compiled where land managers, landowners, EAPs, conservation agencies, PA managers etc. can share data on AIPs (distribution, species, interventions, success rates) and fire (occurrence of controlled and uncontrolled burns, cause of fire, climate conditions prior to and during the burn, ecological monitoring records pre- and post-fire). This will greatly assist in developing an understanding of contributing factors, and best practice management in different areas. The information could be hosted on SANBI's BGIS site. A framework or template for data collection and reporting by persons on the ground would need to be developed for consistency purposes and robustness of data.

3.6.7. Best spatial approaches to avoid or minimise impacts and risk in this Thicket Mosaic

- Consider land-use guidelines in biodiversity plans applicable to Thicket Mosaics with Grassland/Savanna, especially where land-use change in CBAs and ESAs is proposed, to determine what types of activities are appropriate for biodiversity protection. Allow for protection of CBAs and ESAs to facilitate biodiversity persistence.
- Prevent further fragmentation of thicket and, where possible, reconnect intact expanses of thicket.
- Modification of thicket habitat should never be allowed to sever corridors between intact thicket patches.
- Rehabilitate degraded ecological corridors connecting important thicket patches.
- Boundaries or transition areas between thicket and non-thicket biomes must be maintained by avoiding artificial disturbances in these areas, but natural disturbance regimes, such as those related to herbivory and fire, should be maintained.
- Manage grazing carefully (with attention paid to stocking rates and rotation) and ensure that grazing management is well co-ordinated with fire management, clearing of AIPs and other aspects of land management (such as measures for avoiding soil erosion) across the landscape. This is critically important for effective conservation of thicket habitats.
- The boundaries of conservancies and other land management initiatives should be designed to incorporate the natural fire zone, or broader ecosystem or habitat unit for that particular region.
- Habitat modification for urban or agricultural areas should be concentrated in nodes, allowing key ecological

corridors across the landscape to be maintained. In this respect, available biodiversity plans and CBA maps should be used to guide land-use planning and change.

3.6.8. Critical things to maintain for biodiversity to persist

- Fire and infestations of invasive alien plants must be managed in mosaic ecosystems. Never allow adjacent 'fire-adapted' vegetation types (such as grasslands or savannas) to remain unburnt for longer than the time required by the specific vegetation type in the area under investigation, or to become infested with woody AIP species.
- Maintain the appropriate fire regime in terms of fire frequency and seasonality in fire-prone thicket types.
- Maintain all remaining intact thicket fragments across the range of thicket vegetation types to help buffer against the impacts of climate change, especially those that occur in biodiversity priority areas.
- Remaining stands of viable intact thicket in developed areas (e.g. urban or peri-urban areas) should be retained as far as possible, as they provide useful ecosystem services to surrounding communities. For biodiversity in remnant thicket to persist, the identified drivers need to be operating. Consideration should be given to how these remnant tracts of thicket could be connected to viable corridors, and measures implemented accordingly.
- Rehabilitate corridors that connect isolated patches of intact thicket. Corridors are especially effective measures for conserving thicket because they enable the persistence of natural patterns of seed dispersal (in bird-dispersed species) and herbivore migration. Ecological corridors identified in biodiversity plans must be prioritised for ecological management and rehabilitation, especially in areas that are at risk of urban expansion and where there is a high probability of isolating thicket clumps across the landscape (which would ultimately result in areas of poor ecological condition in the absence of the required ecological drivers).
- Maintain natural mosaic patterns and minimum viable patch sizes. Establishing the minimum viable patch size and acceptable isolation distances between thicket patches, or the structure and maintenance of the mosaic pattern, all require detailed, on-site assessments at a minimum scale of 1:5 000. Only fine-scale, detailed analysis of present and past thicket distribution patterns can determine minimum viable patch sizes. A thorough understanding of physical factors shaping mosaic patterns is key, with reference to changes in soil type and slope, drainage patterns, and the location of microhabitats in the area under investigation.
- Maintain natural disturbance regimes through integrated management of fire, grazing and drought. Current

climate trends might allow thicket to encroach into and displace less-resilient neighbouring vegetation types, so maintaining the mosaic patterns will become increasingly important to preserve biodiversity patterns at the landscape scale.

- **Certain patches of thicket, especially solid, non-mosaic vegetation types, require total protection from fire.** Fire and infestations of AIPs must, therefore, be managed in the adjacent, non-thicket ecosystems. Never allow adjacent 'fire-adapted' vegetation types (such as fynbos) to remain unburnt for longer than what is required based on the vegetation type in the area, or to become infested with woody AIPs.
- **Keep thicket patches and their surrounds free of invasive alien vegetation.** This requires controlling existing invasions, as well as the prevention of future invasion.
- **Ensure that planting of spekboom (*Portulacaria afra*) as a restoration measure only happens in areas where this species occurs (or occurred) naturally.** Consult with an experienced plant ecologist to obtain this information. If introduced in an incorrect area, *P. afra* could have a negative impact on other naturally-occurring species.
- **Degraded areas should be prioritised for rehabilitation/restoration.**

3.6.9. Indicators to assess and monitor ecological condition

- **The canopy characteristics:** assess whether the thicket canopy is closed and continuous. In most cases, solid

thicket vegetation consists of a closed, dense canopy consisting of an impenetrable tangle of shrubs and low trees. An open and/or fragmented canopy can be indicative of degradation or damage to the original vegetation. Changes could be monitored over time using a method such as fixed-point photography.

- **Structural elements:** determine whether the vegetation contains all the expected structural components for the site being assessed, including low trees, shrubs and woody lianas, accompanied by a sparse understorey of herbs consisting of geophytes, succulents, C₃ and C₄ grasses and others. The presence of emergent species, especially succulents, such as aloes and euphorbias, may also be characteristic for the site. If any of these components are lacking it may indicate degradation.
- **Presence and health of keystone species:** for example, the presence and percentage cover of *P. afra* is an important indicator of ecological condition in areas where this species would naturally occur.
- **Presence and health of succulent species:** changes in the presence and density of succulent species, especially in drier forms of thicket vegetation types, indicate a change in ecosystem condition. A decline in the proportion of succulents may indicate declining ecological condition, usually as a result of persistent overgrazing.
- **Standing biomass:** thicket has a characteristically high standing biomass. Sparse vegetation or low biomass, except in more arid areas, may be a sign of degradation due to overgrazing or to some other factor.
- **Survival of structurally important species:** monitor mortality rate of adult trees during drought periods. Death of



adult trees during drought periods indicates thicket that is in poor ecological condition.

- **Changes in species composition and vegetation structure:** species composition and vegetation structure relative to expected conditions can be monitored. The expectation can be based on historical information, baseline data collection or reference sites in similar ecological conditions to the target site. Changes may indicate habitat degradation or else provide information on successional dynamics. Functional type composition can also be a useful measure of favourable or detrimental changes. Botanical reserves could be a useful benchmark; however, they do not represent an entirely natural state since mega-herbivores have been removed. Species composition can also be measured as a baseline prior to an intervention and then monitored over time at fixed points to determine whether any changes are occurring. Similarly, monitoring can be used to determine whether a project is having continuous impacts on nearby vegetation or not.
- **Overall species diversity:** this indicator may change significantly due to natural environmental variation over time or space; for example, the amount of rainfall during the previous season or between one habitat and another. However, a reduction in species diversity may give an indication of deteriorating ecological condition.
- **Thicket growth and spread:** monitor encroachment of thicket into the surrounding matrix vegetation in thicket-mosaic vegetation types. The presence of a distinct boundary between thicket patches and the adjacent vegetation types (such as Grassland, Savanna, Forest, Fynbos or Nama Karoo Biomes) will indicate ecosystems in good ecological condition. Thicket clumps should only coalesce and displace adjacent vegetation types in prescribed areas where solid thicket previously occurred and not in areas where mosaic vegetation types are found.
- **A measure of fragmentation, continuity or vegetation connectedness, as well as various other landscape ecology parameters:** measures of these parameters may provide useful insight into identifying areas most in need of intervention or other areas that are intact. These parameters can be measured using aerial photographs, satellite images or SPOT images. In addition to measuring the current status, the effect of proposed clearing on an area of thicket vegetation can also be assessed using a similar approach.
- **Invasion by woody species:** the presence and density of AIPs, or the extent of invasion by weedy but indigenous woody species such as sweet thorn (*Vachellia karroo*), should be monitored, with a low density (or absence) of these species indicative of an ecosystem in good ecological condition.
- **SCCs:** persistence/stable population parameters of SCCs is a sign of ecosystems in good ecological condition. Other population parameters such as rates of recruitment, or the presence of seedlings or saplings, could provide information on population health.
- **Soil health:** parameters such as retention of the litter layer, with associated nutrients, can provide a good indication of ecological condition. The presence and severity of soil erosion features can provide a similar indication of general ecological condition; for example, the presence of sheet or gully erosion may be associated with a loss of vegetation cover.
- **Fire frequency and intensity:** in thicket-mosaic vegetation types, monitor signs that appropriate fire intervals and management are being applied. If fire is absent from mosaic vegetation types for longer than the prescribed period, then targeted burning will be required to prevent a deterioration in ecological condition.
- **The presence of a browse line can be used to indicate overbrowsing** (for example goats and browse lines in *Pappea capensis* in Arid Thicket).
- **The functionality of systems** (e.g. carbon sequestration): a number of methods can be used to do this, including easy to access new generation products (e.g. remote sensing), and making use of mass information readily available on the internet. Field measurements of net primary production can also be done.
- **Changes in the landscape:** remote sensing can be used to detect heterogeneity in the landscape, to indicate change, and to detect bush encroachment. It is important to note that while these technologies are available and extremely useful, it takes a fair amount of skill and training to be able to use and apply these tools.

3.6.10. Reversibility of impacts within a period of 5 to 10 years

- **Impacts may be reversible in areas where rainfall is higher,** but the restoration process is likely to be slow and costly.
- In mosaics with more Arid Thicket vegetation types, impacts such as overgrazing or cultivation are essentially considered to be irreversible over short to long timescales. These impacts could be partially reversible at a 100-year timescale.
- Rehabilitation of areas where vegetation has been destroyed is extremely slow and costly, as vegetation must go through several successional phases to reach maturity. In most cases, recovery to the mature phase will take far longer than ten years (possibly even up to 100 years in some areas).
- Restoration by planting rows of *P. afra* truncheons across large areas (of about 3 500 ha) have been done in the past. It is possible that in the very long term this could promote thicket recovery.

3.6.11. Acceptable compensation measures or offsets for biodiversity loss

- Where residual negative impacts on Thicket Mosaic are unavoidable and there are no alternatives to the proposed development, i.e. it is of overriding public importance, then **biodiversity offsets** should target the securing and formal protection of core areas of Thicket

Mosaic in good ecological condition, and provide for their effective management in the long term.

- Offsets must never be proposed as a mitigation measure for the destruction of unique and/or irreplaceable habitats; lower impact alternatives that avoid impacts on these areas must be sought.
- An offset area must be identified, planned and secured in line with the principals and requirements of presiding regulations and policy on offsets.

3.7. Thicket Mosaics: Fynbos and/or Renosterveld

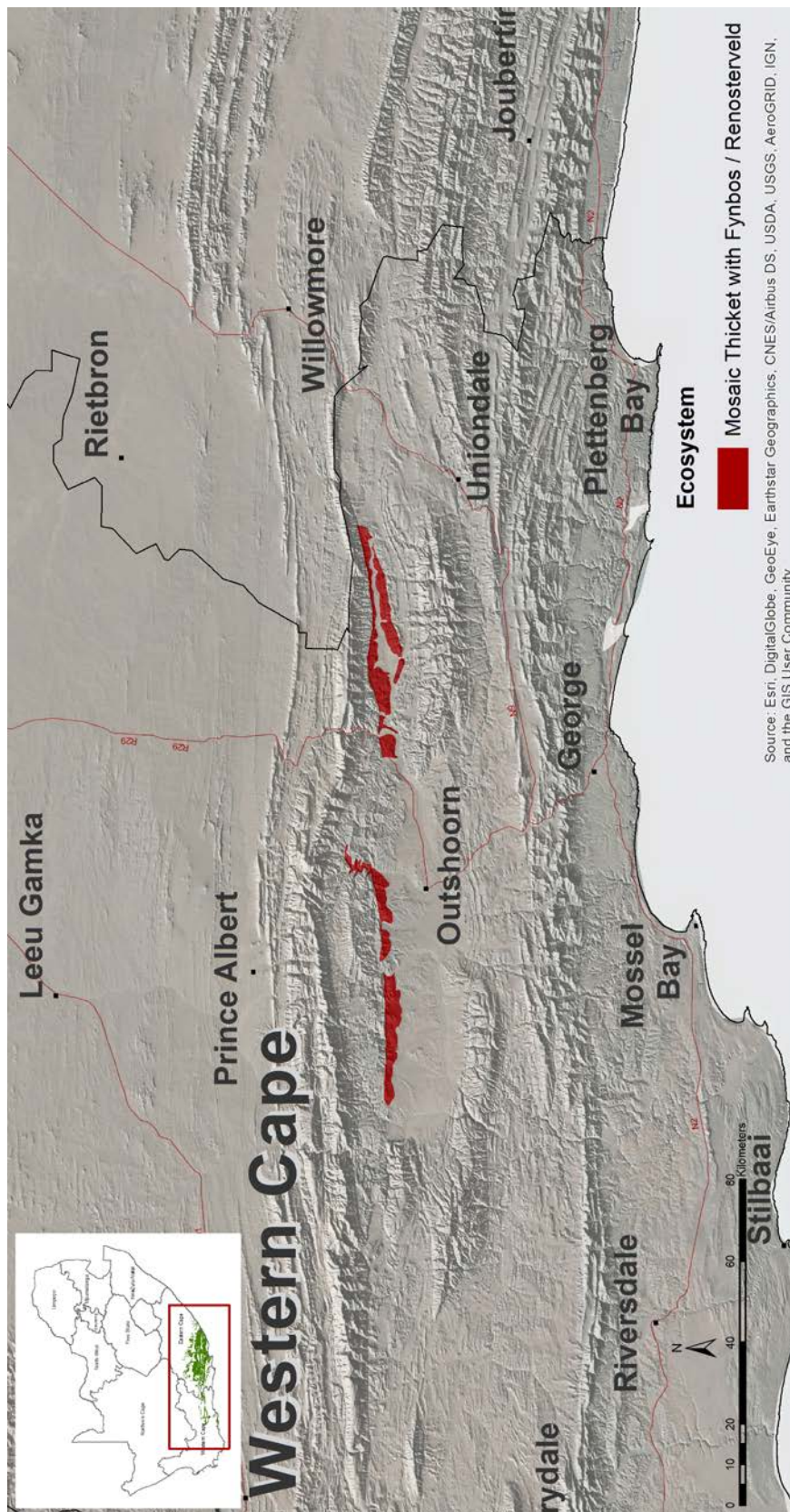


FIGURE 10.—Locality Map of Thicket Mosaics with Fynbos and/or Renosterveld.

3.7.1. General characteristics

This ecosystem group has limited geographical extent, stretching along the southern foothills of the Swartberg to the north of Oudtshoorn. However, there are also various places (outside the Albany Thicket Biome) where thicket is mapped as branching linear features running upriver valleys within Fynbos or Renosterveld vegetation from near the coast at Jeffrey's Bay, westwards and inland past Humansdorp through the Baviaanskloof Mountains and along the southern flank of the Kouga Mountains. Thicket occurring in close proximity to Fynbos or Renosterveld in these areas should therefore be managed as if it were a mosaic. There are also some smaller scattered outlying patches at various locations, including at Cango Caves, two sites directly north and directly west of Uitenhage, at Kirkwood, directly east of Alicedale, and in an east-west running narrow band to the north of Alexandria. These linear stretches of thicket occur in parts of the landscape in which steeply dissected drainage valleys intersect smoother slopes. Thicket is restricted to fire-protected sites in the dissected valleys within matrix fynbos areas. Each vegetation structural component exists within a specific part of the landscape, Fynbos or Renosterveld in the upper parts and Thicket in the valleys. In deep ravines, thicket may blend with forest species. Although not mapped as mosaic vegetation types in the Albany Thicket Biome in VEGMAP (2018) (and not captured in the boundaries of the ecosystem groups shown in this report), management of these areas would be the same as for other mosaic areas.

Dominant and characteristic species in the ecosystem group include *Aloe africana*, *Atalaya capensis*, *Buddleja saligna*, *Calpurnia intrusa*, *Diospyros scabrida*, *Euphorbia grandidens*, *Loxostylis alata*, *Olea europaea* subsp. *africana*, *Osyris*

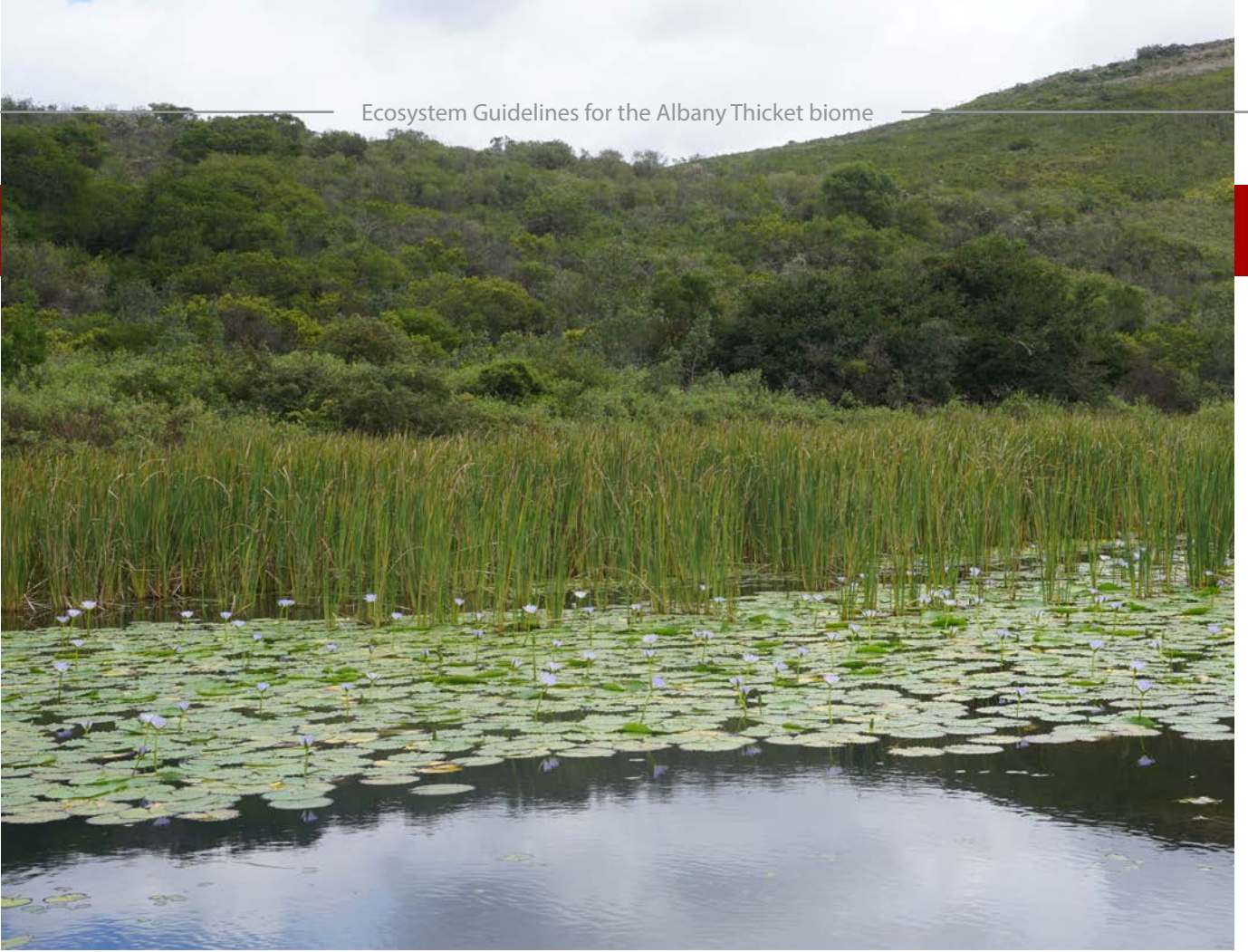


Plate 14.—Thicket occurring on lower slopes and in drainage valleys with Fynbos/Renosterveld on surrounding hills (Source: CEN IEM Unit).

Plate 15.—Thicket mosaic with Renosterveld in the Gamtoos Valley (Source: Prof Richard Cowling).



TABLE 7.—Vegetation Types (VEGMAP, 2018) found in the Thicket Mosaics with Fynbos/Renosterveld Ecosystem Group and their Ecosystem Threat Status and Ecosystem Protection Level (Skowno, 2018; Skowno et al., 2019).

Thicket Mosaics with Fynbos/Renosterveld Vegetation Types	Veg Code	Ecosystem Threat Status	Ecosystem Protection Level	Extent (ha)	% decline 1750–2014
Mons Ruber Fynbos Thicket	AT43	Least Concern	Not Protected	28 620	0.71
Vegetation types in the Fynbos Biome where thicket mosaics occur					
Kouga Sandstone Fynbos	FFs27	Least Concern	Well Protected	240 298	0.65
Kouga Grassy Sandstone Fynbos	FFs28	Least Concern	Well Protected	405 217	0.81
Humansdorp Shale Renosterveld	FRs19	Vulnerable	Not Protected	37 205	8.53
Loerie Conglomerate Fynbos	FFt2	Least Concern	Poorly Protected	21 117	0.58
Baviaanskloof Shale Renosterveld	FRs18	Least Concern	Well Protected	11 872	0.01
Mossel Bay Shale Renosterveld	FRs14	Critically Endangered	Not Protected	86 654	13.19
Swellendam Silcrete Fynbos	FFc1	Endangered	Poorly Protected	86 851	11.55

compressa, *Portulacaria afra*, *Pterocelastrus tricuspidatus*, *Searsia lucida*, *Smelophyllum capense*, *Sterculia alexandri* and *Tarchonanthus camphoratus*.

Only one vegetation type, Mons Ruber Fynbos Thicket, occurs in this ecosystem group (within the Albany Thicket Biome) (VEGMAP, 2018). However, seven vegetation types listed under the Fynbos Biome occur as mosaics with thicket vegetation (as described above). Table 7 lists vegetation types, and their ecosystem threat status and ecosystem protection level (Skowno et al., 2019).

Based on the habitat modification assessment done as part of the NBA (Skowno, 2018), the rate of decline and extent of modification of the Mons Ruber Vegetation Type is low. 'Natural areas' is the predominant land cover type, with 'croplands' accounting for 3.34% of the area. Overall, modification in the vegetation types where thicket occurs in mosaics with fynbos within the Fynbos Biome is comparatively high, mostly as a result of 'croplands'. For example, in Mossel Bay Shale Renosterveld, Humansdorp Shale Renosterveld and Swellendam Silcrete Fynbos, where the extent of 'croplands' is equal to or greater than 'natural areas'. The ecosystem threat status of these vegetation types is 'Critically Endangered', 'Vulnerable', and 'Endangered', respectively.

3.7.2. Key ecological drivers maintaining ecosystem function and biodiversity pattern

- **Rainfall:** The amount of annual rainfall, as well as the season in which it occurs, are important factors in determining thicket characteristics. Thicket Mosaics with Fynbos and/or Renosterveld occur on the winter rainfall side of the biome and where rainfall seasonality is stronger than in the core areas of the biome. This seasonality enhances the probability of natural fire. In mountainous areas, orographic rainfall causes slopes facing prevailing

winds to have more moisture, which affects vegetation composition.

- **Topography:** Thicket occurs in a particular part of the landscape; in ravines cut into the landscape, in gulleys and on foot slopes, which are all fire-protected locations. The surrounding fynbos and/or renosterveld occurs on more open landscape, where fire is more likely to spread. This is an important factor shaping the character of this ecosystem group. At a broader scale, it occurs on the southern slopes of mountain ranges, which are cooler and moister than the northern sides of the mountain ranges.
- **Fire:** Fire in adjacent habitats, such as fynbos, is important for maintaining the thicket boundaries. Vegetation structural composition can influence the probability and/or intensity of fire. Invasion by woody AIPs can increase the frequency and intensity of fires, with harmful effects on thicket vegetation. Too high fire-frequency can reduce recruitment through seeding species and favour resprouters.
- **Grazing:** Grazers remove biomass of palatable species, especially grasses. This can lead to an increase in cover of less desirable species, such as *Elytropappus rhinocerotis*. More importantly, palatable grasses are an important step in the successional change from fire-burnt sites back towards matrix fynbos or renosterveld, and then to thicket. Overgrazing can arrest this process and re-direct it towards an alternative stable state in which thicket and/or fynbos is unlikely to re-develop.
- **Spatial linkages to other vegetation**
- **Seed dispersal**

3.7.3. Conservation, land-use pressures and risks

A significant proportion of this ecosystem group is within the greater Baviaanskloof Mountain area, and parts are

protected within the Baviaanskloof Nature Reserve. There are also various other conservation areas that contribute to biodiversity management in this group.

The main risks/pressures in the group occur in the region between Patensie and Jeffrey's Bay, where arable soils have been cultivated. There also tends to be a change in fire regimes closer to human settlement, which can have various detrimental impacts on thicket mosaics. Pressure from urban expansion is mostly in the Jeffrey's Bay and Humansdorp areas. Invasion by AIPs, resulting in complete loss and/or degradation of natural habitat, has the potential to be a serious threat within this group. Climate change is also a potential threat, although this is ameliorated by the location of much of this group within mountainous areas and the fact that the core areas are mostly unfragmented (i.e. landscape corridors are in place and appear to be functional).

3.7.4. Main pressures, risks and threats

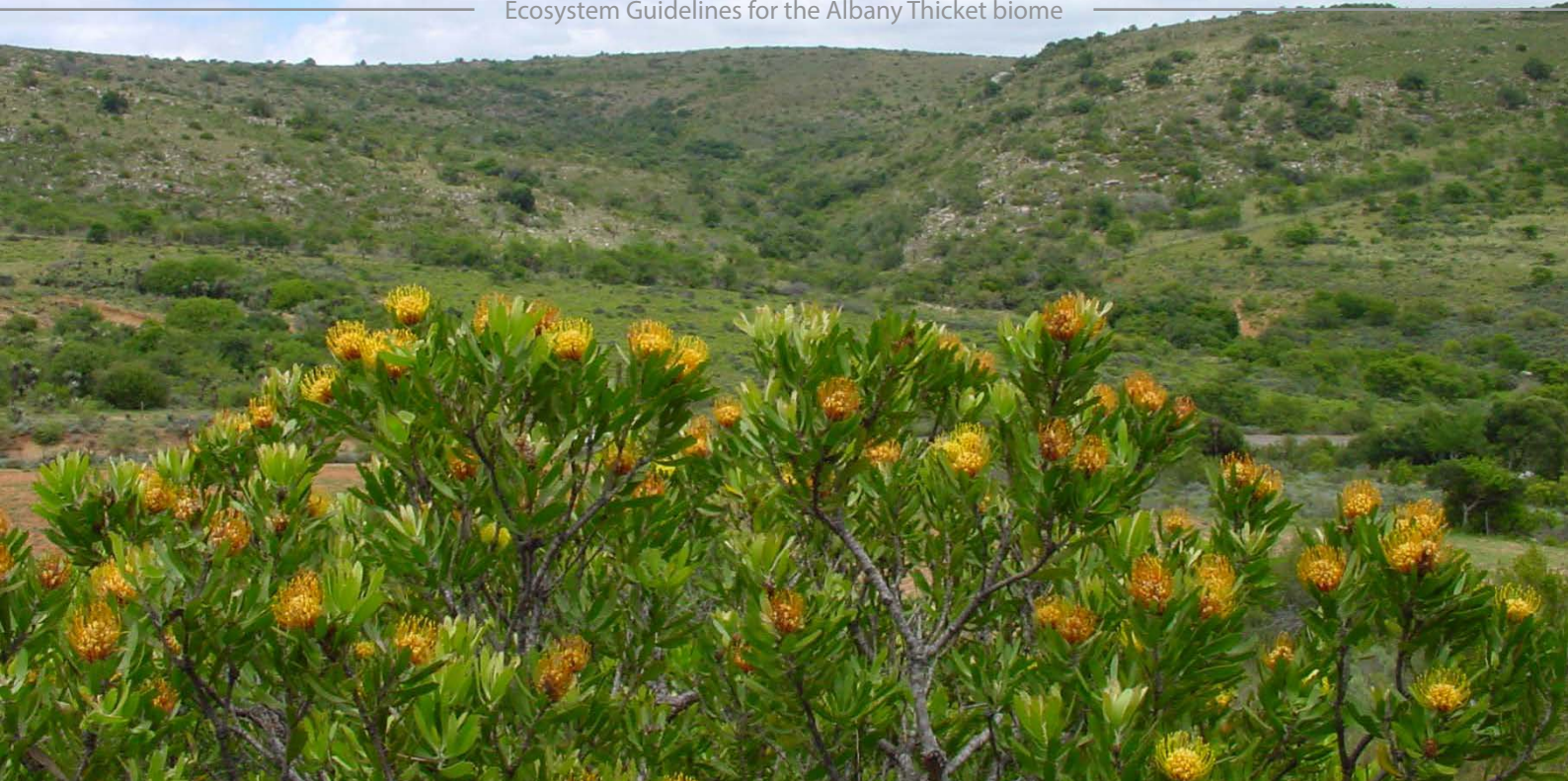
- **Clearing of thicket vegetation to make way for agriculture** (but to a limited extent):
In areas occupied by Thicket-Fynbos/Renosterveld Mosaics, agriculture has occurred primarily in the area closer to Jeffrey's Bay, whereas further northwest into the Baviaanskloof Mountain area, the vegetation is in a natural state. Currently, clearing within this group occurs from the southern side and has caused little fragmentation of core areas within the Baviaanskloof area.
- **Invasion by woody AIPs:**
There are a wide array of invasive alien (exotic) woody species that readily invade fynbos ecosystems. These have various effects on fynbos ecosystems, including altering soil nutrient status, displacing indigenous vegetation and altering natural fire regimes. Invasion by AIPs is more prevalent at the southeastern end of the area occupied by Thicket-Fynbos Mosaics than further into the Baviaanskloof Mountains, where conservation efforts and the less-impacted landscape are not as affected by alien invasions (although riparian areas and wide floodplains are heavily invaded by *Acacia* species).
- **Fire:**
In some parts of this group, especially closer to Jeffrey's Bay, fire is used by landowners as a tool to remove thicket vegetation to favour the growth of palatable grasses. A high fire frequency, in combination with subsequent overgrazing, may lead to an increase in density of renostervos. Along drainage lines, where fire would seldom occur under natural conditions, thicket vegetation is opened up to be replaced by weedy shrubs, such as glossy currant (*Searsia lucida*), and within the matrix fynbos vegetation, resprouting shrubs replace reseeder. A too-high fire frequency therefore leads to a change in vegetation structure and composition to the detriment of local biodiversity.
- **Urban settlements in the coastal areas between Jeffrey's Bay and Oyster Bay, and inland in Humansdorp, Hankey and Patensie.**
- **Climate change:**
Climate change has the potential to modify ambient rainfall, temperature and prevailing wind conditions, all of which can lead to changes in species composition and vegetation structure. This may result in small to significant changes in local vegetation dynamics, which can lead to local loss or change in ecosystem characteristics and biodiversity patterns. To some extent, the location of much of this unit within a mountainous area is likely to buffer it from climate-change effects.
- **Overgrazing:**
Most thicket landscapes are used by commercial and subsistence farmers as rangelands for small domestic stock (especially goats). Overstocking, combined with a lack of appropriate grazing management techniques over extended periods, has resulted in a large proportion of thicket landscapes becoming overgrazed, with many negative consequences, including severe soil erosion and loss of certain species.
- **Harvesting of flora and fauna for rural livelihoods and commercial purposes** are caused by the following resource uses:
 - Animals for food, e.g. bush meat, edible insects.
 - Animals for traditional/cultural use and medicine, e.g. leopard skins.
 - Plants for food, cultural use and medicine. At least 38 plant species harvested in the Eastern Cape for medicinal trade purposes are from the Albany Thicket Biome, including species such as baboon grape, wart plant, *rooistam/kleefgras*, dwarf gasteria/*klein-beestong* and *ibhucu/kopiva/waterpypie/wildekopiva* (Sims-Castley, 2002). Approximately 30% of the plants harvested in the Eastern Cape are used exclusively for cultural purposes (for example *ieyeza lokuhlamba* or ritual washing) (Cocks et al., 2003).
 - Wood from trees which includes uses such as: burning for energy; used for building material for fencing and kraals; used in rituals and stockpiled to show status in the community (Cocks et al., 2003).
 - Grass and reeds are used for thatching and to make brooms and mats.
 - Legal and illegal hunting/poaching of animals, e.g. poaching of white and black rhinoceros.
 - Harvesting of thicket species is taking place on a wide scale directly or indirectly by larger companies. An estimated 156 tonnes of thicket plants are also traded annually in the Eastern Cape, generating an income of R7 million/year (Sims-Castley, 2002).
 - Legal and illegal collection of plants for ornamental trade and medicines, e.g. poaching of cycads for illegal horticultural trade, collecting rare and endemic succulent species in the Arid Thicket Ecosystem Group for ornamental trade, harvesting sap from bitter aloe for the pharmaceutical and cosmetic industry.

3.7.5. Non-negotiables

- No construction or disturbance of vegetation within PAs or conservation areas, especially the Baviaanskloof PA.
- Avoid overgrazing in mosaic thickets, as these ecosystems are at risk of being irretrievably altered if unsustainable grazing pressure persists.
- Retain the required fire regime for maintaining the vegetation in an optimum ecological state. Thicket mosaic vegetation types are maintained by a fine balance between specific fire and grazing regimes.
- Restoration of degraded thicket should be a mandatory condition for authorisation of any application for land-use change in this at-risk biome. Never underestimate the restoration potential and importance of thicket in areas where it used to occur.
- Avoid any negative impacts on biodiversity priority areas.
- Avoid disturbance to rocky outcrops, geological/soil type boundaries and 'islands' in the landscape where thicket vegetation is present.
- Protect rare habitats, such as rocky outcrops, where range-restricted species occur.
- Avoid disturbance to riparian areas, steep slopes and valleys.
- Avoid the introduction of extra-limital, non-thicket game species (and remove extra-limital species where they have previously been introduced).
- Avoid uncontrolled aerial spraying of unregistered herbicides to destroy thicket.
- Avoid overstocking of domestic livestock and game on farms, especially goats.
- Avoid fragmenting patches of intact thicket. Where fragmentation has occurred, set aside corridor areas to reconnect the patches and/or implement measures to rehabilitate/restore corridors.
- Buffer zones around PAs should be retained in as natural a state as possible.
- Avoid allowing land uses to impact on transitional or boundary areas where thicket adjoins or forms mosaics with other vegetation types associated with other biomes. These areas accommodate the highest levels of biodiversity and require special conservation measures.
- Retain appropriate grazer-browser ratios in game species, as well as the required fire regime, for maintaining the vegetation in an optimum ecological state. Many of the mosaic thicket vegetation types are maintained by a fine balance between specific fire and grazing regimes.
- Both surface water and groundwater abstraction should be monitored where there is a risk of negative impacts on biodiversity and ecosystem function.

3.7.6. General recommendations

- Never rely on desktop information only to make decisions on the current status of biodiversity on a particular site. Always conduct a detailed biodiversity assessment on site, with the assistance of relevant specialists, where required.
- Areas identified as CBAs and ESAs, and/or threatened ecosystems, in biodiversity plans are to be regarded as important biodiversity areas and must be prioritised for conservation/restoration/rehabilitation. No new development should be allowed in these areas before adequate investigation of the specific site by independent biodiversity specialists. Specialist investigations of the site and the surrounding landscape must be done to determine flora and fauna biodiversity, presence of threatened or protected flora and fauna species, and special or protected habitats, as well as any ecological corridors which facilitate landscape connectivity with other natural areas beyond the site and enable biodiversity to persist.
- Ecological corridors must be established and maintained between natural areas, especially between PAs and biodiversity priority areas outside of the PA network. Spatial linkages across the landscape between different thicket habitats must be in place and functional. Corridors must be designated and managed to allow species to track changing environmental conditions and must incorporate climate and biodiversity refugia. When identifying and delineating ecological corridors and connectivity across the landscape, make sure that these linkages follow major environmental gradients correlated to plant composition and that drive turnover in species composition across a wide range of spatial and temporal scales (Beta-diversity). Ensure that corridors are wide enough to incorporate variations in landform and physical processes (Jewitt et al., 2017).
- Restoration/rehabilitation efforts should focus on ecological corridors that provide spatial linkages across the landscape.
- Make sure that physical features, microhabitats and the 'patchiness' in the landscape (i.e. a mosaic of different habitats) are regarded as important aspects required for biodiversity persistence and management.
- Watercourses and wetlands are protected in terms of the National Water Act and are regarded as special habitats. Avoid activities that alter hydrological flow, or that impact on freshwater requirements of other users/habitats (e.g. estuaries and nearshore marine environments need freshwater for biodiversity and productivity).
- Do not consider the terrestrial environment in isolation; recognise and consider relationships between the land, surface water and groundwater components of the environment.



- Buffer areas around National Parks that are designated in Park Management Plans signed by the Minister must be considered when land-use change is planned on areas adjacent to these parks (and within buffer areas).
- Buffers must be implemented around PAs, conservation areas, known locations of SCCs, forested areas, and aquatic ecosystems.
- The carrying capacity of land used for livestock and game farming, and in PAs and conservation areas must be determined by a qualified specialist. Overstocking and overgrazing/browsing must be prevented. This is especially important in areas that are fenced. It is not possible to recommend stocking rates per ecosystem group in these guidelines, as rates will vary across sites depending on local conditions, land-use type, historical management etc. General guidelines can be gleaned from maps produced by the Agricultural Research Council (ARC), but they must be supported by a specialist who looks at local conditions that would impact on sustainable grazing and browsing practices.
- Rehabilitation relevant to all Albany Thicket types:
 - When government funds are made available for rehabilitation, PAs should be prioritised for rehabilitation efforts as there is less chance of conflicting land uses in these areas in future. Within PAs, the focus should be on areas that are outside of high impact zones (e.g. areas used/accessed by African elephants).
 - Disrupting soil structure and drainage has significant impact on thicket, and its restoration potential. For this reason, it is important to consider how and where the land has been disturbed in order to inform the approach to rehabilitation. Physical attributes of the area (i.e. terrain and soil information) must be investigated so that the correct measures can be used to re-instate processes required by local biodiversity
- Land Types (terrain/soil information) must be used when deciding what type of rehabilitation action is necessary. Sometimes active measures like ripping can create more damage through disruptions to the soil profile and drainage.
- The impact of pesticides and herbicides on soil quality must be considered in rehabilitation potential. Pesticides/herbicides have the potential to harm soil biota, reduce soil quality and contaminate groundwater. Areas where pesticides/herbicides have been used, especially where these have hyper-accumulated, may be less likely to recover if measures to improve soil quality are not addressed.
- The removal and control of invasive alien vegetation must be prioritised. Landowners must get advice from suitable specialists on which AIP species should be targeted, as some are more problematic in certain areas than others. Different species also respond differently to different control methods. The legal responsibilities of landowners for controlling different category species must also be taken into account. Areas in proximity to commercial plantations are particularly at risk of alien plant invasion, and plantation companies should assist landowners in managing invasive alien vegetation on their properties.
- Land-use guidelines/recommendations given in available biodiversity plans and tools must be consulted and applied early in the land-use planning process (refer to Appendix 5.2).
- On a strategic level, the seven principles discussed by Biggs et al. (2012) for building resilience in ecosystem

services must be considered and applied especially in provincial and municipal planning processes.

- **Resilience of natural ecosystems to the impacts of climate change must be maintained** by making sure that ecological corridors are protected, thicket and mosaic boundaries are managed, management maintains diverse and functional ecosystems, and areas of climate refugia for persistence of species are identified and conserved. Dune Thicket is probably most at risk in the short term from the more immediate climate change risks associated with storm surges, changes to winds and impacts on sediment dynamics and dune corridors in the coastal zone.
- **Permeable fencing should be used**, especially in the growing number of game farms, to allow movement of animals. The impact of electric fencing on ground dwelling species must be avoided.
- A centrally managed database must be compiled where land managers, landowners, EAPs, conservation agencies, PA managers etc. can share data on AIPs (distribution, species, interventions, success rates) and fire (occurrence of controlled and uncontrolled burns, cause of fire, climate conditions prior to and during the burn, ecological monitoring records pre- and post-fire). This will greatly assist in developing an understanding of contributing factors, and best practice management in different areas. The information could be hosted on SANBI's BGIS site. A framework or template for data collection and reporting by persons on the ground would need to be developed for consistency purposes and robustness of data.

3.7.7. Best spatial approaches to avoid or minimise impacts and risk in this Thicket Mosaic

- **Consider land-use guidelines in biodiversity plans applicable to Thicket Mosaics with Fynbos/Renosterveld Mosaic**, especially where land-use change in CBAs and ESAs is proposed, to determine what types of activities are compatible with biodiversity protection. Allow for protection of CBAs and ESAs to facilitate biodiversity persistence.
- **Prevent further fragmentation of thicket** and, where possible, reconnect intact expanses of thicket.
- **Modification of thicket habitat should never be allowed to sever corridors** between intact thicket patches.
- **Rehabilitate degraded ecological corridors** connecting important thicket patches.
- **Boundaries or transition areas between thicket and non-thicket biomes must be maintained** by avoiding artificial disturbances in these areas, but natural

disturbance regimes, such as those related to herbivory and fire, should be maintained.

- **Manage grazing carefully** (with attention paid to stocking rates and rotation) and ensure that grazing management is well co-ordinated with fire management, clearing of AIPs and other aspects of land management (such as measures for avoiding soil erosion) across the landscape. This is critically important for effective conservation of thicket habitats.
- The boundaries of conservancies and other land management initiatives should be designed to incorporate the natural fire zone, or broader ecosystem or habitat unit for that particular region.
- **Habitat modification for urban or agricultural areas should be concentrated in nodes**, allowing key ecological corridors across the landscape to be maintained. In this respect, available biodiversity plans and CBA maps should be used to guide land-use planning and change.

3.7.8. Critical things to maintain for biodiversity to persist

- **Fire and infestations of AIPs must be managed in mosaic ecosystems.** Certain patches of thicket, especially solid, non-mosaic vegetation types, require total protection from fire. Fire and infestations of AIPs must, therefore, be managed in the adjacent, non-thicket ecosystems. Never allow adjacent 'fire-adapted' vegetation types (such as fynbos) to remain unburnt for longer than what is required based on the fynbos type in the area, or to become infested with woody AIPs.
- **Maintain the appropriate fire regime in terms of fire frequency and seasonality in fire-prone thicket types.**
- **Maintain all remaining intact thicket fragments** across the range of thicket vegetation types to help buffer against the impacts of climate change, especially those that occur in biodiversity priority areas.
- **Remaining stands of viable intact thicket in developed areas (e.g. urban or peri-urban areas) should be retained as far as possible**, as they provide useful ecosystem services to surrounding communities. For biodiversity in remnant thicket to persist, the identified drivers need to be operating. Consideration should be given to how these remnant tracts of thicket could be connected to viable corridors, and measures implemented accordingly.
- **Rehabilitate corridors that connect isolated patches of intact thicket.** Corridors are especially effective measures for conserving thicket because they enable the persistence of natural patterns of seed dispersal (in bird-dispersed species) and herbivore migration. Ecological corridors identified in biodiversity plans must be prioritised for ecological management and rehabilitation, especially in areas that are at risk of urban expansion and where

there is a high probability of isolating thicket clumps across the landscape (which would ultimately result in areas of poor ecological condition in the absence of the required ecological drivers).

- **Maintain natural mosaic patterns and minimum viable patch sizes.** Establishing the minimum viable patch size and acceptable isolation distances between thicket patches, or the structure and maintenance of the mosaic pattern, all require detailed, on-site assessments at a minimum scale of 1:5 000. Only fine-scale, detailed analysis of present and past thicket distribution patterns can determine minimum viable patch sizes. A thorough understanding of physical factors shaping mosaic patterns is key, with reference to changes in soil type and slope, drainage patterns, and the location of microhabitats in the area under investigation.
- **Maintain natural disturbance regimes through integrated management of fire, grazing and drought.** Current climate trends might allow thicket to encroach into and displace less-resilient neighbouring vegetation types, so maintaining the mosaic patterns will become increasingly important to preserve biodiversity patterns at the landscape scale.
- **Keep thicket patches and their surrounds free of invasive alien vegetation.** This requires controlling existing invasions, as well as the prevention of future invasion.
- **Ensure that planting of spekboom (*Portulacaria afra*) as a restoration measure only happens in areas where this species occurs (or occurred) naturally.** Consult with an experienced plant ecologist to obtain this information. If introduced in an incorrect area, *P. afra* could have a negative impact on other naturally-occurring species.
- **Degraded areas should be prioritised for rehabilitation/restoration.**

3.7.9. Indicators to assess and monitor ecological condition

- **The canopy characteristics:** assess whether the thicket canopy is closed and continuous. In most cases, solid thicket vegetation consists of a closed, dense canopy consisting of an impenetrable tangle of shrubs and low trees. An open and/or fragmented canopy can be indicative of degradation or damage to the original vegetation. Changes could be monitored over time using a method such as fixed-point photography.
- **Structural elements:** determine whether the vegetation contains all the expected structural components for the site being assessed, including low trees, shrubs and woody lianas, accompanied by a sparse understorey of herbs consisting of geophytes, succulents, C₃ and C₄ grasses and others. The presence of emergent species, especially succulents, such as aloes and euphorbias, may

also be characteristic for the site. If any of these components are lacking it may indicate degradation.

- **Presence and health of keystone species:** for example, the presence and percentage cover of *P. afra* is an important indicator of ecological condition in areas where this species would naturally occur.
- **Presence and health of succulent species:** changes in the presence and density of succulent species, especially in drier forms of thicket vegetation types, indicate a change in ecosystem condition. A decline in the proportion of succulents may indicate declining ecological condition, usually as a result of persistent overgrazing.
- **Standing biomass:** thicket has a characteristically high standing biomass. Sparse vegetation or low biomass, except in more arid areas, may be a sign of degradation due to overgrazing or to some other factor.
- **Survival of structurally important species:** monitor mortality rate of adult trees during drought periods. Death of adult trees during drought periods indicates thicket that is in poor ecological condition.
- **Changes in species composition and vegetation structure:** species composition and vegetation structure relative to expected conditions can be monitored. The expectation can be based on historical information, baseline data collection or reference sites in similar ecological conditions to the target site. Changes may indicate habitat degradation or else provide information on successional dynamics. Functional type composition can also be a useful measure of favourable or detrimental changes. Botanical reserves could be a useful benchmark; however, they do not represent an entirely natural state since mega-herbivores have been removed. Species composition can also be measured as a baseline prior to an intervention and then monitored over time at fixed points to determine whether any changes are occurring. Similarly, monitoring can be used to determine whether a project is having continuous impacts on nearby vegetation or not.
- **Overall species diversity:** this indicator may change significantly due to natural environmental variation over time or space; for example, the amount of rainfall during the previous season or between one habitat and another. However, a reduction in species diversity may give an indication of deteriorating ecological condition.
- **Thicket growth and spread:** monitor encroachment of thicket into the surrounding matrix vegetation in thicket-mosaic vegetation types. The presence of a distinct boundary between thicket patches and the adjacent vegetation types (such as Grassland, Savanna, Forest, Fynbos or Nama Karoo Biomes) will indicate ecosystems in good ecological condition. Thicket clumps should only coalesce and displace adjacent vegetation types in prescribed areas where solid thicket previously occurred and not in areas where mosaic vegetation types are found.

- **A measure of fragmentation, continuity or vegetation connectedness, as well as various other landscape ecology parameters:** measures of these parameters may provide useful insight into identifying areas most in need of intervention or other areas that are intact. These parameters can be measured using aerial photographs, satellite images or SPOT images. In addition to measuring the current status, the effect of proposed clearing on an area of thicket vegetation can also be assessed using a similar approach.
- **Invasion by woody species:** the presence and density of AIPs, or the extent of invasion by weedy but indigenous woody species such as sweet thorn (*Vachellia karroo*), should be monitored, with a low density (or absence) of these species indicative of an ecosystem in good ecological condition.
- **SCCs:** persistence/stable population parameters of SCCs is a sign of ecosystems in good ecological condition. Other population parameters such as rates of recruitment, or the presence of seedlings or saplings, could provide information on population health.
- **Soil health:** parameters such as retention of the litter layer, with associated nutrients, can provide a good indication of ecological condition. The presence and severity of soil erosion features can provide a similar indication of general ecological condition; for example, the presence of sheet or gully erosion may be associated with a loss of vegetation cover.
- **Fire frequency and intensity:** in thicket-mosaic vegetation types, monitor signs that appropriate fire intervals and management are being applied. If fire is absent from mosaic vegetation types for longer than the prescribed period, then targeted burning will be required to prevent a deterioration in ecological condition.
- **The presence of a browse line can be used to indicate overbrowsing** (for example goats and browse lines in *Pappea capensis* in Arid Thicket).
- **The functionality of systems** (e.g. carbon sequestration): a number of methods can be used to do this, including easy to access new generation products (e.g. remote sensing), and making use of mass information readily available on the internet. Field measurements of net primary production can also be done.

- **Changes in the landscape:** remote sensing can be used to detect heterogeneity in the landscape, to indicate change, and to detect bush encroachment. It is important to note that while these technologies are available and extremely useful, it takes a fair amount of skill and training to be able to use and apply these tools.

3.7.10. Reversibility of impacts within a period of 5 to 10 years

- **Impacts such as overgrazing or cultivation are essentially considered to be irreversible over short to long timescales.** These impacts could be partially reversible at a 100-year timescale.
- **Revegetation of areas where vegetation has been destroyed is likely to be extremely slow and costly** and the original species composition is unlikely to be recovered.
- **Where the original vegetation has been lost, vegetation recovery will probably require a lengthy successional series of changes from pioneer vegetation to fynbos and eventually to a thicket mosaic.**

3.7.11. Acceptable compensation measures or offsets for biodiversity loss

- **Where residual negative impacts on Thicket Mosaics with Fynbos/Renosterveld are unavoidable and there are no alternatives to the proposed development, i.e. it is of overriding public importance, then biodiversity offsets should target the securing and formal protection of core areas of the ecosystem group in good ecological condition, and provide for their effective management in the long term.**
- **Offsets must never be proposed as a mitigation measure for the destruction of unique and/or irreplaceable habitats; lower impact alternatives that avoid impacts on these areas must be sought.**
- **An offset area must be identified, planned and secured in line with the principals and requirements of presiding regulations and policy on offsets.**



3.8. Inland Aquatic Ecosystems

3.8.1. General characteristics

Inland freshwater aquatic ecosystems located within the biome vary in type and extent. This is due to the spatial scale and geographic positioning of the biome, coupled with the fact that the biome ranges from warm temperate to tropical coastal regions and extends into warm dry inland areas across a wide variety of landscape settings, namely valley floors, slopes, plains and/or benches. From an aquatic perspective, the biome reaches far inland to the drier Drought Corridor Ecoregion in the north, to the Southern and Eastern Coastal Belt Ecoregions that experience higher rainfall.

Inland aquatic ecosystems are classified based on their hydrological processes or responses and geomorphological features and experience no tidal variation. This Hydrogeomorphic (HGM) approach of classifying wetlands (Ollis et al., 2014) has been widely adopted. Van Deventer et al., (2020) have updated the National Wetland Inventory as part of the NBA. The NBA has classified known rivers and wetlands into various HGM units. The HGM approach allows for the identification of key hydrological processes, related to ecological function over time, which can then be related to past/present land use, impact identification and conservation needs or requirements.

Based on the available spatial data (South African Inventory of Inland Aquatic Ecosystems (SAIIAE Wetland Inventory Version 5.2), the following natural aquatic freshwater ecosystems are found in the Albany Thicket Biome:

- Rivers and streams
- Floodplain Wetlands
- Channelled Valley Bottom Wetlands
- Unchannelled Valley Bottom Wetlands
- Wetland flats
- Pans/Depressions
- Estuaries (tidal and not inland systems)

Where more detailed information is available, several sub-units have also been included in the database and those found in this biome, include:

- Springs
- Seeps
- Peatlands
- Oxbow lakes: The oxbow lakes identified in the SAIIAE Inventory are solar salt works, sand mining operations of relic floodplains. Only two small oxbow areas associated with the Coega River are known presently.

With regard watercourses (rivers and streams), the biome covers two of the nine Water Management Areas (WMAs) of South Africa, which are defined by the catchments of major rivers or water resources. These WMAs are as follows:

- Breede-Gouritz
- Mzimvubu-Tsitsikamma

Importantly the biome covers significant portions of the Great Kei, Great Fish, Buffalo and Kouga/Gamtoos River catchments, which are important water resources within the Eastern Cape.

3.8.2. Key ecological drivers maintaining ecosystem function and biodiversity pattern

Climate (rainfall and temperate), catchment geomorphology and geology (including soils) are the key ecological drivers within inland waterbodies and wetlands, and how these act or interact is summarised as follows:

- **Climate:** Ambient temperature, precipitation, evaporation, solar radiation and the duration and direction of winds have a direct impact on the temporal and spatial availability of water to the ecosystem.
- **Catchment geomorphology:** The landscape setting of an aquatic ecosystem is defined by the topographical shape of the catchment influenced by the following factors:
 - Change in altitude, i.e. cooler ambient temperatures are expected at higher altitudes.
 - The diversity of aquatic ecosystems and wetland types is related the changes in relief or shape of a catchment.
 - Slope form and gradient determines if the catchment is convex or concave and in turn determines where soil moisture will accumulate, such as at the foot of a slope.
- **Geology:** The underlying catchment geology impacts on the types of soils or sediment that are formed and the resultant soil chemistry, i.e. acidic or nutrient rich.

Landscape scale conditions exert an influence over the form and functioning of inland aquatic systems, as follows (Ollis et al. 2013):

- **Substrate** (soils/sediment): Catchment geomorphology and geology have a strong influence over the type, depth, degree of wetness, and chemistry of the substrate within an inland aquatic system. Wetlands, and the lower reaches of most rivers, tend to have substrata with a coarse to fine texture (sand, silt, clay), while the upper and middle



reaches of rivers tend to have unconsolidated, rocky substrata, such as boulders, cobbles, pebbles and gravel. Substrate type, in turn, influences the vegetation and faunal composition within rivers, wetlands and open waterbodies, and the biological functions they can perform. Natural processes of erosion and deposition are amongst the most important processes forming and shaping wetlands and rivers

- **Water sources and hydrological regime:** The form and functioning of an inland aquatic ecosystem are influenced by the source and amount of water flowing into, through and out of that system. Wetlands, rivers and open waterbodies essentially evolve as a result of a surplus of water at or near the ground surface. Water can enter an aquatic system from a river upstream, from diffuse surface or overland runoff from the catchment, or as lateral subsurface seepage (also referred to as interflow) through the surrounding soils. Some aquatic ecosystems may be wholly or partially groundwater-fed.
 - The hydrological regime (i.e. the timing, frequency, magnitude and duration of base flow or floods) of flowing systems such as rivers, or the hydroperiod (i.e. the timing and duration of saturation or inundation) of standing systems such as wetlands and open waterbodies, directly affects their physical, chemical and biological characteristics and overall functioning. For example, the flushing out of accumulated fine sediments is essential for maintaining the shape of the river channel. Similarly, the frequency and duration of inundation and saturation of a wetland will determine its soil morphology and chemistry (for example, level of oxygenation, build-up of carbon and nutrient cycling), and, thus, will also determine the types of vegetation growing within the wetland.
- **Water quality:** Along with water sources and the hydrological regime, water quality is a major driver of ecosystem functioning in aquatic ecosystems. These ecosystems act as 'sinks' for the accumulation of materials mobilised and transported within the catchment, either through natural processes or human activities. Inland aquatic ecosystems are particularly vulnerable to land-use practices throughout the catchment that may have an impact on the quality of either surface or subsurface water. It is important to protect the health of inland aquatic ecosystems from the risks of water quality impairment, and to ensure that these systems continue to provide critically important water quality-related ecosystem services (e.g. nutrient cycling, primary production) and habitat for biotic communities.
- **Biota and biological processes:** All of the drivers described above play a role in determining the form and functioning of inland aquatic systems, and in shaping the biotic communities and processes characterising each ecosystem. For instance, vegetation strongly influences geomorphological processes by slowing down water flow and capturing sediment, and in determining the chemistry of the water draining the catchment.

- Aquatic organisms (biota) occur in the zone where conditions are optimal for productivity. For example, plant species that prefer saturated soil conditions year round will be found in the permanently saturated or inundated zone of a wetland, whereas those that prefer seasonally saturated conditions will occur around the edges of the wettest zone, or only in seasonally saturated wetlands. The kinds of plants occurring in each zone provide visual evidence of wetland presence, even enabling wetland assessors to delineate the permanent, seasonal and temporary zones within a wetland. In rivers, plants and animals occur in the optimal biotope, which is a combination of habitat (mainly substrate and water depth) and flow type (fast or slow).
- Some of the biological processes that may influence the form and functioning of inland aquatic systems include nutrient cycling, evapotranspiration, decomposition, succession, primary productivity, grazing, predation and competition. For example, some plant species such as bulrush (*Typha capensis*) and common reed (*Phragmites australis*), grow particularly well in permanent waterbodies, especially where there is some nutrient enrichment. These species outcompete an often more diverse community of plants (such as sedges and restios) that would naturally occur in the wetland or stream, leading to mono-specific stands that inhibit the free flow of water.

3.8.3. Conservation, land-use pressures and risks

Inland aquatic ecosystems in the Albany Thicket Biome, as with all the other biomes, are generally highly threatened ecosystems, with most systems in the coastal regions range classified between Endangered and Vulnerable (Eastern Cape and KwaZulu-Natal) (Nel et al., NSBA 2004).

Based on the Present Ecological State (PES) rating information on a subquaternary basis for the country (DWS, 2014), most of the biome's mountain streams, upper foothill rivers and wetlands in mountain catchments are in a good ecological condition (PES = largely Natural to Moderately Modified). However, coupled with an increase in development (towns, cities, industry, mining and agriculture), when moving into the lower-lying inland ecosystems, pressures have resulted in the mainstem systems being degraded (i.e. most were rated as Largely Modified). Rivers and wetlands near mining areas and large industrial cities were rated as 'Seriously modified' or 'Critically/Extremely modified'. This is where the loss of natural habitat, biota and basic ecosystem functions is extensive, and modifications have reached a critical level (i.e. the system has been modified completely with an almost complete loss of natural habitat and biota). In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible, a result of either over abstraction, canalisation or excessive water quality changes.

TABLE 8: Description of A–F, ecological categories based on Kleynhans & Louw (2007).

Ecological category	Ecological description	Management perspective
A	Unmodified, natural.	Protected systems; relatively untouched by human hands; no discharges or impoundments allowed.
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	Some human-related disturbance, but mostly of low impact potential.
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	Multiple disturbances associated with need for socio-economic development, e.g. impoundment, habitat modification and water quality degradation.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred.	
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	Often characterised by high human densities or extensive resource exploitation. Management intervention is needed to improve health, e.g. to restore flow patterns, river habitats or water quality.
F	Critically/Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	

Furthermore, the PES assessment (DWS, 2014) highlighted that afforestation, agriculture (land use and water quality/quantity impacts), habitat fragmentation (dams and weirs), bush encroachment, loss of riparian continuity, invasive plants and fish, were also significant pressures within the inland systems.

3.8.4. Main pressures, risks and threats

Inland aquatic systems receive runoff, which not only includes water but also sediment and pollutants from the surrounding landscape and are thus particularly sensitive to activities in the catchment, even those operating some distance away. Poor and/or inappropriate land-use practices within the catchment of an inland aquatic system are largely responsible for the deterioration or loss of freshwater habitat and/or freshwater biodiversity.

Inland aquatic ecosystems are also particularly vulnerable to climate change, as this leads to long-term changes in the hydrological regimes of surface and groundwater, temperature regimes and ultimately the biota associated with these systems. Wetlands are especially sensitive to climate change as they are delicately balanced between terrestrial and aquatic influences, where species may already find refuge from desiccation.

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

and threats in the Inland Aquatic Ecosystems in the Albany Thicket Biome are:

- **Changes in natural disturbance regimes:** this includes alterations to the natural frequency or severity of bush encroachment, flooding, erosion, sedimentation and grazing within inland aquatic ecosystems and their catchments.
- **Land-use change and development:** land uses such as agriculture, mining or the establishment of urban infrastructure result in catchment hardening, excavation, loss of organic-rich soils and the drainage and infilling of wetlands, rivers and floodplains.
- **Invasive alien plants and animals:** the presence of invasive alien species can have severe impacts on locally indigenous aquatic flora and fauna, and can upset the natural balance of an inland aquatic system. Invasive alien trees in particular can result in large-scale changes to river and wetland ecosystems, altering the flow regime and promoting down-cutting, channelisation and severe erosion.
- **Pollution and changes in water quality:** pollution from both point and non-point sources, salinisation (i.e. an increase in the concentration of dissolved salts), nutrient enrichment, and alkalisation (i.e. an increase in the pH, leading to a decrease in the acidity). Excessive and/or inappropriate use of fertilisers, herbicides and/or pesticides is particularly problematic, as is the discharge of mining effluents directly or indirectly into inland aquatic systems.

- **Changes in the flow regime:** this occurs in flowing-water systems such as rivers and riverine wetlands, as a result of water abstraction, diversion of flows, interbasin water transfers, impoundment, canalisation, channelisation, irrigation, and poorly managed stormwater flows.
- **Changes in inundation or saturation patterns:** this happens in wetlands and open waterbodies such as lakes and dams, because of changes within the ecosystem itself or due to activities in the catchment that affect runoff patterns.
- **Changes in groundwater quality or quantity:** the quality or quantity of groundwater is affected by over-use or inappropriate use or land-based practices, such as the infiltration of sewage effluent or other contaminated waste from surface sources into the groundwater, or intensive irrigation, or the kinds of impacts that could result from mining.
- **Changes in the sediment regime:** the amount of sediment entering or leaving inland aquatic ecosystems can be affected by changes in the natural cycles of erosion or deposition within the ecosystem (or its catchment), as a result of activities such as poor ploughing practices that lead to the constant mobilisation of sediments.
- **Fragmentation:** this is caused by a loss of connectivity between:
 - Different parts of an inland aquatic system (e.g. the loss of upstream-downstream linkages through poor planning of roads, pipelines etc.).
 - Geographically separate systems that were hydrologically or biologically connected in their natural state.
 - Between inland aquatic systems and the adjacent/surrounding terrestrial ecosystems (such as from extensive clearing of natural vegetation within the catchment, or from the construction of levees).
- **Encroachment into inland aquatic systems and/or their buffers:** activities such as infilling and excavation, inappropriate grazing (too close to, or overgrazing of wetlands), and removal of naturally-occurring indigenous vegetation (directly, such as occurs for the cultivation of crops or plantations, or indirectly, as a result of desiccation, for example,) lead to degradation in many inland aquatic ecosystems.
- **Over-exploitation of biota in inland aquatic systems:** over-exploitation of riparian trees, wetland plants, and indigenous fish, for subsistence or commercial use, represents a significant pressure in many inland aquatic ecosystems.
- **No further degradation should be permitted in inland aquatic ecosystems that are designated as being of moderate to high conservation importance,** as assessed by an appropriate specialist.
- **All inland aquatic ecosystems must be appropriately buffered.** Buffers must be provided for, such that they:
 - Are adequate for the protection of the ecosystem from the pressures identified above.
 - Maintain the ecosystem in a desired or attainable ecological condition.
 - Allow for future rehabilitation or restoration.
- **Human activities that will impact directly (e.g. encroachment) or indirectly (e.g. diffuse pollution) on a river, wetland or open waterbody, and/or its buffer, must be assessed by a suitably qualified and experienced specialist,** and the ecosystems groundtruthed as part of any land-use change application, environmental assessment or licensing process both under NEMA and the National Water Act.

All rivers, wetlands and open waterbodies have some ecological importance or value. This may not necessarily be for the conservation or maintenance of biodiversity pattern and/or ecological processes, but in terms of functional value and the provision of ecosystem services. For example, inland aquatic ecosystems generally provide water retention capacity, which is an important function in the catchment.

Previously no accepted aquatic buffer distances were provided by the national or provincial authorities and until such a system was developed, it was typically recommended that a 50 m buffer be set for all-natural wetlands. More recently a buffer model system described by Macfarlane & Bredin (2017) for rivers, estuaries and wetlands respectively has been developed. These buffer models are based on the condition of the waterbody, the state of the remainder of the site/catchment, coupled to the type of development that is being proposed, as well as the proposed alteration of hydrological flows. Based then on the information known a site-specific buffer model (Excel-based spreadsheet) provides a buffer distance for the construction and operational phases of a development, and a final buffer distance. Simply stated, the greater potential impact near an intact system, the larger the proposed buffer distance will be. This method of assigning buffers has been widely accepted by a number of authorities and is becoming a requirement for inclusion in aquatic specialist assessments.

3.8.6. General recommendations

- **Never rely on desktop information only to make decisions** on the current status of biodiversity on a particular site. Always conduct a detailed biodiversity assessment on site, with the assistance of relevant specialists, where required.

3.8.5. Non-negotiables

- **The hydrological regime and water quality of a river, wetland or open waterbody must be adequate to maintain the ecosystem in a desired or attainable condition.**

- Areas identified as CBAs and ESAs, and/or threatened ecosystems, in biodiversity plans are to be regarded as important biodiversity areas and must be prioritised for conservation/restoration/rehabilitation. No new development should be allowed in these areas before adequate investigation of the specific site by independent biodiversity specialists. Specialist investigations of the site and the surrounding landscape must be done to determine flora and fauna biodiversity, presence of threatened or protected flora and fauna species, and special or protected habitats, as well as any ecological corridors which facilitate landscape connectivity with other natural areas beyond the site and enable biodiversity to persist.
- Ecological corridors must be established and maintained between natural areas, especially between PAs and biodiversity priority areas outside of the PA network. Spatial linkages across the landscape between different thicket habitats must be in place and functional. Corridors must be designated and managed to allow species to track changing environmental conditions and must incorporate climate and biodiversity refugia. When identifying and delineating ecological corridors and connectivity across the landscape, make sure that these linkages follow major environmental gradients correlated to plant composition and that drive turnover in species composition across a wide range of spatial and temporal scales (Beta-diversity). Ensure that corridors are wide enough to incorporate variations in landform and physical processes (Jewitt et al., 2017).
- Restoration/rehabilitation efforts should focus on ecological corridors that provide spatial linkages across the landscape.
- Make sure that physical features, microhabitats and the 'patchiness' in the landscape (i.e. a mosaic of different habitats) are regarded as important aspects required for biodiversity persistence and management.
- Watercourses and wetlands are protected in terms of the National Water Act and are regarded as special habitats. Avoid activities that alter hydrological flow, or that impact on freshwater requirements of other users/habitats (e.g. estuaries and nearshore marine environments need freshwater for biodiversity and productivity).
- Do not consider the terrestrial environment in isolation; recognise and consider relationships between the land, surface water and groundwater components of the environment.
- Buffer areas around National Parks that are designated in Park Management Plans signed by the Minister must be considered when land-use change is planned on areas adjacent to these parks (and within buffer areas).
- Buffers must be implemented around PAs, conservation areas, known locations of SCCs, forested areas, and aquatic ecosystems.



- The carrying capacity of land used for livestock and game farming, and in PAs and conservation areas must be determined by a qualified specialist. Overstocking and overgrazing/browsing must be prevented. This is especially important in areas that are fenced. It is not possible to recommend stocking rates per ecosystem group in these guidelines, as rates will vary across sites depending on local conditions, land-use type, historical management etc. General guidelines can be gleaned from maps produced by the Agricultural Research Council (ARC), but they must be supported by a specialist who looks at local conditions that would impact on sustainable grazing and browsing practices.
- Rehabilitation relevant to all Albany Thicket types:
 - When government funds are made available for rehabilitation, PAs should be prioritised for rehabilitation efforts as there is less chance of conflicting land uses in these areas in future. Within PAs, the focus should be on areas that are outside of high impact zones (e.g. areas used/accessed by African elephants).
 - Disrupting soil structure and drainage has significant impact on thicket, and its restoration potential. For this reason, it is important to consider how and where the land has been disturbed in order to inform the approach to rehabilitation. Physical attributes of the area (i.e. terrain and soil information) must be investigated so that the correct measures can be used to re-instate processes required by local biodiversity
 - Land Types (terrain/soil information) must be used when deciding what type of rehabilitation action is necessary. Sometimes active measures like ripping can create more damage through disruptions to the soil profile and drainage.
 - The impact of pesticides and herbicides on soil quality must be considered in rehabilitation potential. Pesticides/herbicides have the potential to harm soil biota, reduce soil quality and contaminate groundwater. Areas where pesticides/herbicides have been used, especially where these have hyper-accumulated, may be less likely to recover if measures to improve soil quality are not addressed.
- The removal and control of invasive alien vegetation must be prioritised. Landowners must get advice from suitable specialists on which AIP species should be targeted, as some are more problematic in certain areas than others. Different species also respond differently to different control methods. The legal responsibilities of landowners for controlling different category species must also be taken into account. Areas in proximity to commercial plantations are particularly at risk of alien plant invasion, and plantation companies should assist landowners in managing invasive alien vegetation on their properties.
- Land-use guidelines/recommendations given in available biodiversity plans and tools must be consulted and applied early in the land-use planning process (refer to Appendix 5.2).
- On a strategic level, the seven principles discussed by Biggs et al. (2012) for building resilience in ecosystem services must be considered and applied especially in provincial and municipal planning processes.
- Resilience of natural ecosystems to the impacts of climate change must be maintained by through making sure that ecological corridors are protected, thicket and mosaic boundaries are managed, management maintains diverse and functional ecosystems, and areas of climate refugia for persistence of species are identified and conserved. Dune Thicket is probably most at risk in the short term from the more immediate climate change risks associated with storm surges, changes to winds and impacts on sediment dynamics and dune corridors in the coastal zone.
- Permeable fencing should be used, especially in the growing number of game farms, to allow movement of animals. The impact of electric fencing on ground dwelling species must be avoided.
- A centrally managed database must be compiled where land managers, landowners, EAPs, conservation agencies, PA managers etc. can share data on AIPs (distribution, species, interventions, success rates) and fire (occurrence of controlled and uncontrolled burns, cause of fire, climate conditions prior to and during the burn, ecological monitoring records pre- and post-fire). This will greatly assist in developing an understanding of contributing factors, and best practice management in different areas. The information could be hosted on SANBI's BGIS site. A framework or template for data collection and reporting by persons on the ground would need to be developed for consistency purposes and robustness of data.

3.8.7. Best spatial approaches to avoid or minimise impacts and risk of inland aquatic ecosystems

All inland aquatic ecosystems in the broader sub-catchment should be taken into account in any environmental assessment. For example, connectivity up- and downstream, between inland aquatic systems, and the associations with the terrestrial landscape must be considered.

Wetlands and riparian areas should be accurately delineated at site level using a minimum mapping scale of 1:10 000 as 1:50 000 scale is too coarse. For wetlands, delineation should ideally take place in the wet season, but, if it must be done at other times of the year, a level of confidence in the delineation should be assigned to the results. Nationally approved wetland and riparian zone identification and delineation methodologies should be followed in wetland delineation and identification, to allow comparison between specialist studies. These are set out in the DWS requirements in terms of GN 267 (40713) of March



2017, which have detailed the minimum requirements (Table of Contents) for a wetland/aquatic assessment, as well as listed the appropriate delineation manuals/methods.

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

As described above, buffers through the use of detailed modelling systems have been established for all inland aquatic ecosystems, based on the knowledge that a one size fits all approach is not appropriate (Macfarlane & Bredin, 2017). Thus, the determination of a buffer size has taken into account the type, desired ecological condition and likely functions of the ecosystem, together with the spatial requirements of species that are dependent on the ecosystem for all or part of their life cycle, and the nature of the impacts of the proposed land-use activity. Buffers must also accommodate the potential capacity of the site to cope with unexpected events such as fires, potential river migration areas, and other natural processes, as well as not foreclosing on opportunities for future restoration and/or rehabilitation.

Land-use change proposals and applications should be informed by assessments that adequately describe the key landscape drivers that may be affected by the land-use

activity. Inland aquatic systems, particularly wetlands, are maintained by processes that often extend or originate well beyond the protection that can be afforded by a conventional buffer.

Inland aquatic ecosystems in the broader sub-catchment and the linkages between ecosystems from source to sea should be taken into account in any environmental assessment. For example, the continuation of a particular wetland beyond the project area or site should be acknowledged. The current and historical connectivity up- and downstream and between inland aquatic ecosystems should be taken into consideration, as well as the associations with the surrounding terrestrial landscape.

3.8.8. Critical things to maintain for biodiversity to persist

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

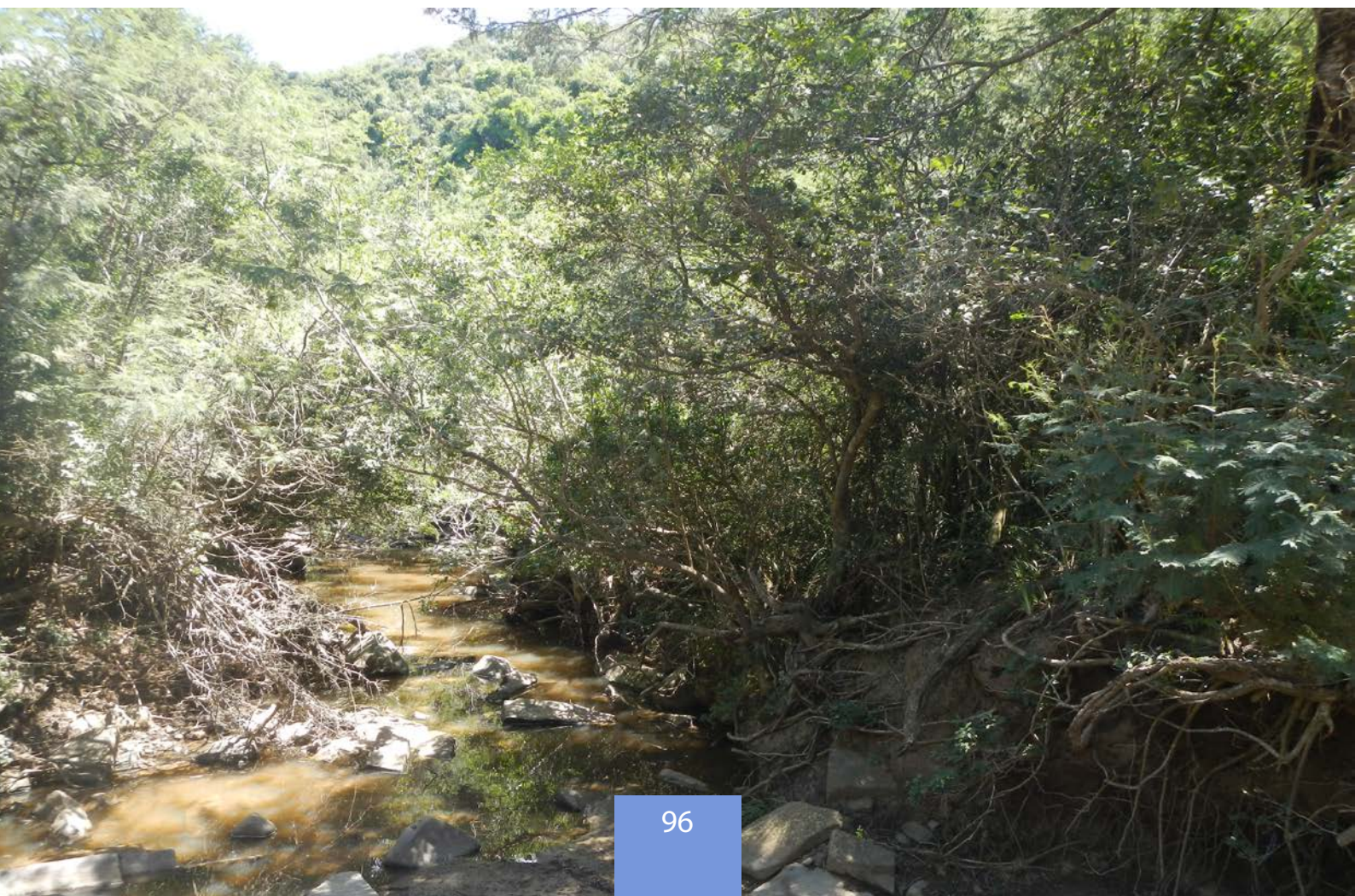
- **Natural geomorphological processes (erosion and deposition):** activities or land uses that affect these processes can modify habitat type and trigger knock-on effects such as flooding (for example, as a result of sediment 'islands' being formed in the channel, especially if AIPs are present) and wetland drainage (as a result of down-cutting/eroding of streams and wetlands). Even seemingly minor alterations can affect geomorphological processes

by changing the slope of the riverbed or wetland, or the availability and deposition of sediment. Sedimentation may also encourage invasion by alien plants, as the seeds of some alien trees grow well on sand banks formed in channels as a result of upstream erosion. Once established, the trees stabilise these areas resulting in channel shrinkage.

- **Natural hydrological regime (flow or hydroperiod):** too-frequent floods result in disturbance levels that exceed recovery potential. Changing a river from a seasonal to a perennial river, or vice versa, results in dramatic changes to riverine biodiversity, with perennial flows in a seasonal ecosystem often promoting invasion by pest species such as *Typha capensis*.
- **Natural water quality:** freshening an aquatic ecosystem (i.e. making it less salty) can have as big an impact as making it too saline, and can result in dominance by nuisance, disturbance-tolerant species, rather than by natural communities adapted to natural water quality conditions. Maintenance of nutrient availability is also critical for biodiversity. Changes (usually increases) affect plant competition, with nuisance, often invasive alien species outcompeting indigenous ones, resulting in major biodiversity changes.
- **Natural physical habitat structure:** most of the changes outlined above also bring about changes in physical habitat, for example by promoting plant growth that invades into previously open water habitat, increasing

shading and adding to the rate of production of organic detritus on wetland floors or in riverine pools. Changes in structure of the physical habitat affect habitat quality and availability, and can create conditions that favour alien species at the expense of indigenous ones. This is particularly evident in destabilised river channels where habitat diversity is reduced as a result of erosion and the deposition of loose boulders and cobbles that are not optimal for the establishment of aquatic plants and invertebrates.

- **Naturally-occurring biotic communities:** some human activities have a high potential for the accidental or deliberate import of alien or invasive species or even taxa from other catchments that may have a slightly different genetic makeup to those occurring naturally. Imported species may have a competitive advantage over those occurring naturally, leading to a loss of natural biodiversity. Although some naturally-occurring species may be a nuisance to humans (e.g. midges, mosquitoes, bulrushes, reeds), such organisms often play important roles in biodiversity maintenance (e.g. midge larvae feed on wetland sediments, support aquatic invertebrate and fish predators and, when they emerge as adults, birds, bats and insect predators). Maintenance of natural growth forms (e.g. a range of juvenile to mature plant species, providing a range of habitat types, rather than a neatly trimmed lawn) is also important, both from the perspective of habitat type, and to maintain biological processes.



- **Biological processes:** natural patterns of succession, productivity, competition and predation are important in biodiversity maintenance. These may be affected by activities or land uses occurring outside of the wetland or river, e.g. loss of habitat for predators or prey of fauna that require aquatic habitats for only part of their life cycles, such as frogs and insects. Changes in habitat types (e.g. as a result of nutrient enrichment) may change competitive interactions between species, resulting in potentially nuisance species (e.g. bulrushes and midges) dominating at the expense of more diverse communities.
- **Natural ecological and hydrological linkages:** corridors that allow for longitudinal movement up- and down river systems or laterally, between aquatic and terrestrial habitats, may be critical for the long-term survival of the taxa that rely on these migration routes to complete breeding cycles, find food sources or maintain genetic diversity. Maintenance of hydrological connectivity is equally important, allowing for natural surface flows into and out of rivers and wetlands, and also allowing infiltration of surface water into areas of recharge that may be important for the maintenance of wetlands or rivers elsewhere.

3.8.9. Indicators to assess and monitor ecological condition

Several aquatic health assessment tools have been developed by the DWS and partners from the early 2000s, to firstly assist with the standardisation of the various approaches but also develop a rating system that is easily understood. These include the following:

Habitat Integrity (HI) or Present Ecological State (PES) Assessments:

These assessments, which should be carried out with the involvement of a vegetation specialist, can be used to determine the state of the vegetation surrounding (or in) the aquatic ecosystem, and the physical condition of the river-bank or wetland boundary. A decline in the health of the ecosystem could be indicated by: changes in species composition or the absence of particular species, infestation by invasive alien species, signs of accelerated bank erosion or the presence of actively-eroding headcuts, and a decline in vegetation cover in relation to an ecosystem of the same kind that is known to be in a good ecological condition.

The PES of a river represents the extent to which it has changed from the reference or near pristine condition (Category A) towards a highly impacted system where there has been an extensive loss of natural habit and biota, as well as ecosystem functioning (Category E).

The PES scores have been revised for the country and based on the new models, aspects of functional importance, as well as direct and indirect impacts have been included (DWS, 2014). The new PES system also incorporates **Ecological Importance (EI)** and **Ecological Sensitivity (ES)** separately as opposed to Ecological Importance and Sensitivity (EIS) in the old model, although the new model is still heavily centred on rating rivers using broad fish, invertebrate, riparian vegetation and water quality indicators. The Recommended Ecological Category (REC) is still contained within the new models, with the default REC being B, when little or no information is available to assess the system or when only one of the above-mentioned parameters are assessed or the overall PES is rated between a C or D.

The South African Scoring System, Version 5 (SASS 5): which is a system for the rapid bio-assessment of water quality of rivers (using riverine macroinvertebrates). SASS 5 can also be used to monitor water quality in wetlands as long as it is the water leaving the wetland that is assessed.

WET-Health: which is a tool that has been developed for rapid assessment of wetland health based on hydrology, geomorphology and vegetation. Besides providing a replicable and explicit measure of wetland health, the WET-Health system also helps to diagnose the causes of degradation, so that these can be appropriately addressed. The services of an expert who has experience in assessing wetland health must be secured to use WET-Health effectively.

The River Eco-Status Monitoring Programme (REMP)⁴: This is a component of the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) and is managed by the DWS. The purpose of the REMP is to monitor the ecological condition of river ecosystems, as reflected by the system drivers and biological responses (instream and riparian).

These assessments make use of various indicators, such as:

- **Water chemistry variables** as indicators of water quality, particularly nutrients (such as phosphate, ammonia, nitrate, nitrite, potassium and sulphate), pH and conductivity levels, but also turbidity and conductivity. Assessments of water quality are complex and must involve a water quality specialist. They may include basic laboratory tests or other techniques that focus on the water itself, or the aquatic macroinvertebrate fauna of the water body (e.g. SASS 5 or WET-Health).
- **Algal biomass (as chlorophyll-a) and diversity** – the presence or absence of particular species (indicator organisms) can be used to detect species changes in environmental conditions, such as eutrophication, organic enrichment, salinisation or changes in pH.

⁴The REMP evolved from, and replaced, the River Health Programme in 2016

- **Plant diversity and community zonation** (changes in zonation and extent indicate changes in moisture levels or water quality).
- **The community structure of aquatic invertebrates**, their sensitivity to water quality and habitat changes can provide a time-integrated measure of prevailing conditions in river ecosystems (which is something that analyses of water chemistry cannot do). The absence of particular groups of invertebrates (e.g. dragonflies) can indicate a decline in the health of the ecosystem.
- **Soil type, soil moisture and signs of soil erosion.**
- **Depth to water table**, especially in systems that are largely groundwater-fed.

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

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

3.8.10. Reversibility of impacts within a period of 5 to 10 years

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

Impacts on water quantity are probably reversible in the short-term but may be associated with longer-term indirect and irreversible impacts. Such impacts may include decreases in water availability in the riparian zone leading to death of long-lived riparian trees or decreased flows and loss of floods leading to sedimentation of the river channel and stabilisation of instream sandbars by vegetation.

Impacts on water quality are generally reversible in a 5- to 10-year period, assuming that all contamination ceases.

However, some impacts may be long term and practically irreversible, such as nutrient enrichment that leads to the domination of a river channel by bulrushes.

Infestation by AIPs is often reversible if appropriate clearance methods are used, in conjunction with follow-up operations that ensure that the whole catchment has been cleared. If this is not the case, then sites are soon re-invaded by the same or other species. Note, however, that invasion by alien fish and their impacts on indigenous fish populations are difficult to reverse. It should be noted that

recovery from alien *Acacia* tree infestation may take as long as 1–20 years if severe channel incision has occurred within these areas.

3.8.11. Acceptable compensation measures or offsets for biodiversity loss

Impacts of very high significance (e.g. when the aquatic ecosystem is irreplaceable or particularly vulnerable) cannot be offset and must be avoided. Impacts of low significance may not need to be offset, but the mitigation hierarchy must still be applied.

The challenge for determining acceptable offsets for inland aquatic ecosystems is that they must contribute to meeting biodiversity objectives (species, communities and ecosystem processes), as well as water resource objectives, as guided by the National Water Act (i.e. National Water Resource Strategy and Resource Directed Measures). Acceptable offsets or compensatory measures are those that adhere to the principle of no effective net loss but preferably a net gain of inland aquatic ecosystem biodiversity and ecosystem functioning. Macfarlane et al. (2016) provides an offset 'calculator' that makes use of a clearly defined 'gains versus losses' accounting system.

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

In an effort to assist in the due care of wetlands on the municipal level, where most aquatic impacts take place through an increase in urban settlements, the Local Governments for Sustainability group (ICLEI) developed a wetland management guideline for municipalities (Edwards et al., 2018). The guideline provides detailed means to identify and prioritise wetland management issues within respective municipalities to strengthen the role of local government in protecting valuable aquatic/wetland systems. Noting that value is not only placed on conservation importance or biodiversity value, but also ecosystem services and socio-economic/cultural value (Edwards et al., 2018). The guideline therefore focuses on providing means to assist the municipality with developing a strategy to earmark wetlands for rehabilitation, methods to monitor outcomes, and where necessary develop offset strategies. These strategies then form part of future Land-use Schemes, SDFs and IDPs. This then serves as a useful resource to guide development on a municipal scale, where impacts on aquatic systems are avoided (rather than having to mitigate down the line by placing development in environmentally sensitive areas.

Offsets must never be proposed as a mitigation measure for the destruction of unique and/or irreplaceable habitats;



lower impact alternatives that avoid impacts on these areas must be sought. An offset area must be identified, planned and secured in line with the principals and requirements of presiding regulations and policy on offsets.

3.8.12. Notes on Strategic Water Source Areas

Strategic Water Source Areas (SWSAs) are the country's most important water sources, comprising surface and groundwater supply areas. SWSAs include areas that (a) supply a disproportionate (i.e. relatively large) quantity of mean annual surface water runoff in relation to their size and so are considered nationally important; or (b) have high groundwater recharge and where the groundwater forms a nationally important resource; or (c) areas that meet both criteria (a) and (b). SWSAs of surface water sources have high runoff that can support nationally important economic centres; and groundwater sources have high recharge rates and support high levels of groundwater use, often being the sole supply to towns, and supporting nationally important economic centres.

Recently, 22 priority surface water and 37 groundwater source areas were delineated in the country. These are areas that capture ~50% mean annual runoff from ~10% of the land. Land-use activities can alter water flows and water quality in both surface and groundwater areas. The management and protection of these areas have been developed with respect to sectors that are deemed to create significant impact on SWSAs:

- Forestry: predominantly water quantity impacts,
- Agriculture: water quantity and quality impacts,
- Mining: water quality impacts,
- Alien invasive plants: multiple impacts related to water quality and quantity.

The intention is for the maps and guidelines to be used in:

- Reactive decision-making on proposed developments,
- Proactive planning: National Water Resource Strategy, National Planning, Integrated Development Plans (IDPs), SDFs and zoning schemes,
- Proactive conservation and rehabilitation.

SWSAs mapped within the Albany Thicket Biome are shown in Figure 11. Important groundwater areas occur in the NMBM (predominantly in Valley Thicket), near Graaff-Reinet (in Arid Thicket) and to the west of Oudtshoorn (in Arid Thicket). Important surface water catchments are predominantly in Mesic and Valley Thicket, and in areas where Mesic Thicket merges with Dune Thicket along the coast.

Broad recommendations for these areas are as follows:

Groundwater:

- Avoid activities that would result in over-utilisation of groundwater and/or impact on groundwater recharge in SWSAs. Typical activities may include unsustainable abstraction of groundwater for domestic supply or agriculture use, increase in hard surface in reduced recharge of aquifers etc.
- Manage activities in SWSAs to prevent groundwater quality deterioration. Water quality impacts are broadly related to addition of chemical compounds and elements, sedimentation, and water-borne diseases. Maintaining good water quality is integral to the ability of the SWSA to supply groundwater to the local population/economy, and also the receiving environment and associated biota. Mining and agriculture have the potential to cause pollution via chemicals, pesticides, and fertilisers.

Surface Water:

- Avoid activities that would result in alteration of hydrological flow in Strategic Water Source Areas (SWSAs). Typical activities may include hardening of surfaces and accelerated flow, with resultant erosion and sedimentation; placing hard structures in riparian areas, modification of the bed or banks of rivers, alluvial mining, storm-water management etc.
- Manage activities in SWSAs to prevent water quality deterioration. Water quality impacts are broadly related to addition of chemical compounds and elements, sedimentation, and water-borne diseases. Maintaining good water quality is integral to the ability of the SWSA to supply water to the local population/economy, and also the receiving environment and associated biota. Mining and agriculture have the potential to cause pollution via chemicals, pesticides, and fertilisers. The replacement of natural vegetation with alien vegetation generally leads to soil destabilisation especially in high rainfall, which can cause sedimentation of rivers and streams.

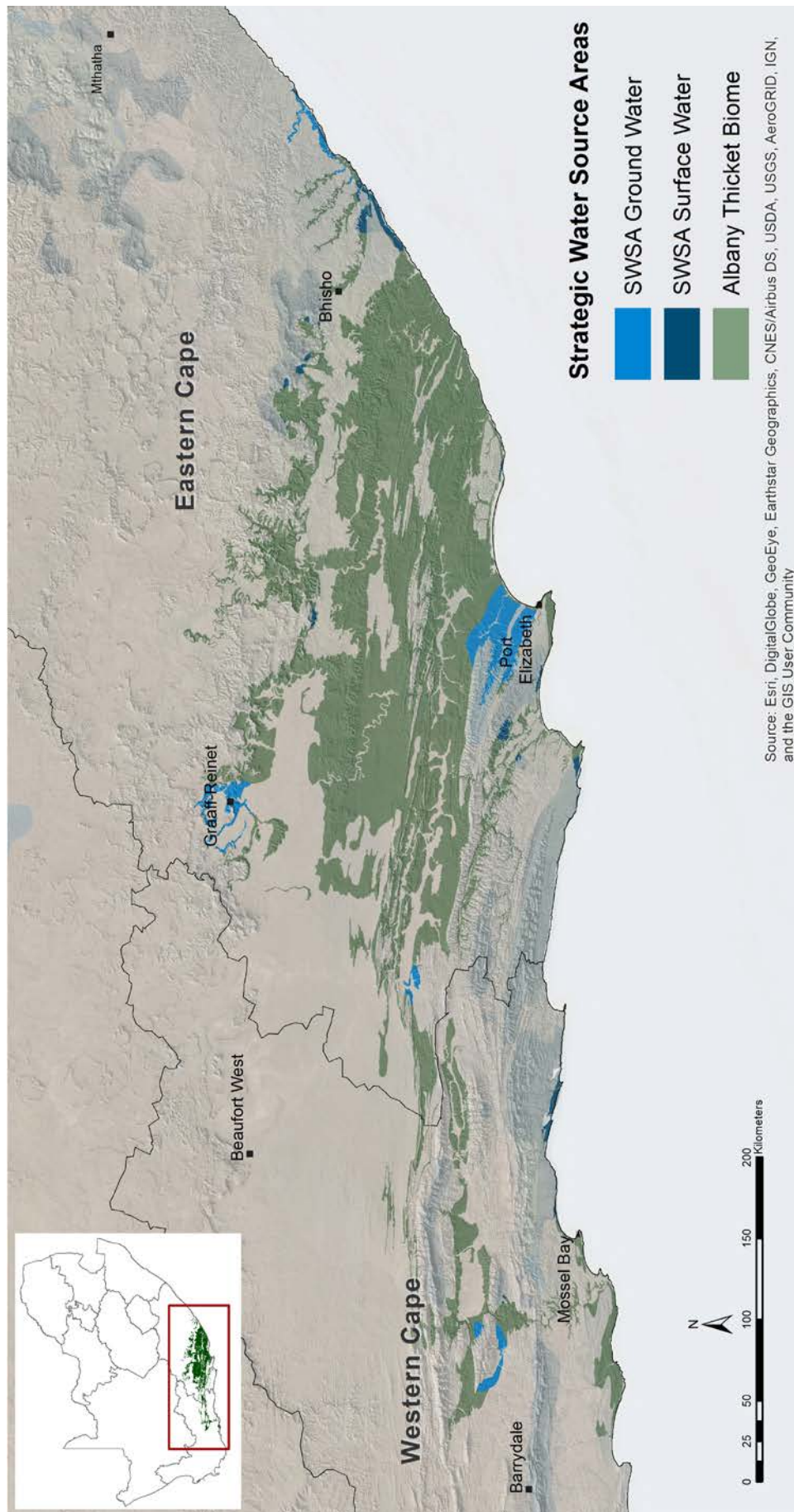


FIGURE 11.—Strategic Water Source Areas in the Albany Thicket Biome (WRC, 2017).

4

Planning for and managing risks and pressures, restoration, species and conservation

Land-use change is one of the biggest pressures leading to land cover change, habitat loss and degradation. Habitat loss affects ecosystem threat status and impacts on provisioning of ecosystem goods and services. Land-use pattern provides an important context for understanding land-use change and possible degradation, as well as future opportunities for biodiversity and land-use management. Figure 12 is a Land Cover Map (2014), showing land cover types in the Albany Thicket Biome.

SANBI has developed a land cover-based habitat modification layer in the NBA (Skowno et al., 2019), primarily using the 1990 and 2013/2014 national land cover products developed for DEFF by GEOTERRAIMAGE (GTI) in 2015. This information has been used to determine habitat loss over time (i.e. between the reference state in 1750, and subsequent states in 1990 and 2014) in different ecosystem types (and biomes), and the predominant land cover types responsible for the loss. The assessment shows that approximately 8.8% of ecosystems in the Albany Thicket Biome has been lost between the reference state (1750) and 2014; with ~1% being lost between 1990 and 2014. This loss is made up of the following land cover/land-use types (Skowno et al., 2019):

- Croplands ~4.6%;
- Secondary natural⁵ 2.2%;
- Built-up environment 1.5%;
- Plantations 1.5%;
- Artificial waterbodies 0.4%; and
- Mines and quarries 0.02%.

Note that the NBA 2018 habitat modification layer is based on a broad distinction of 'natural' versus 'not natural' areas

and does not include the full range of classes from areas in natural state to near-natural (rangelands), fair condition, poor condition; for example, degraded rangelands or areas with alien invasive plants are therefore mostly mapped into the 'natural' class. The habitat modification assessment therefore underestimates land-use pressures in the Albany Thicket Biome, which could mean there is an under-estimation of ecosystem threat status in some ecosystem types.

Different land-use activities pose different types and levels of risks/pressures to the Albany Thicket Biome with varying impacts and consequences:

Direct impacts are those impacts directly linked to the project. Intensive agriculture, urban development, industry, and mining may cause a direct risk to ecosystems by clearing of vegetation and habitat fragmentation; resulting in loss of habitat and species, and possibly affecting ecological processes.

Indirect or secondary impacts are those impacts resulting from the project that may occur beyond or downstream of the boundaries of the project site and/or after the project activity has ceased, and/or through complex impact pathways. Poorly managed agriculture may have indirect impacts on vegetation as a result of overgrazing/overbrowsing, inappropriate fire management, and uncontrolled use of pesticides and inorganic fertilisers for example. This may result in land degradation with a change in species composition and diversity, bush encroachment, spread of AIPs, deterioration of soil and water quality, erosion, etc.

Cumulative impacts are those impacts from the project combined with the impacts from past, existing and

⁵Secondary natural' areas are those that were classified as 'natural' in the 1990 and 2014 Land Cover map but are in fact old croplands that have been abandoned since the 1960s. While they may resemble natural areas, they are likely to have lost the majority of their native flora and fauna. In the 2018 land cover-based habitat modification analysis, these areas have been classified as 'secondary natural'

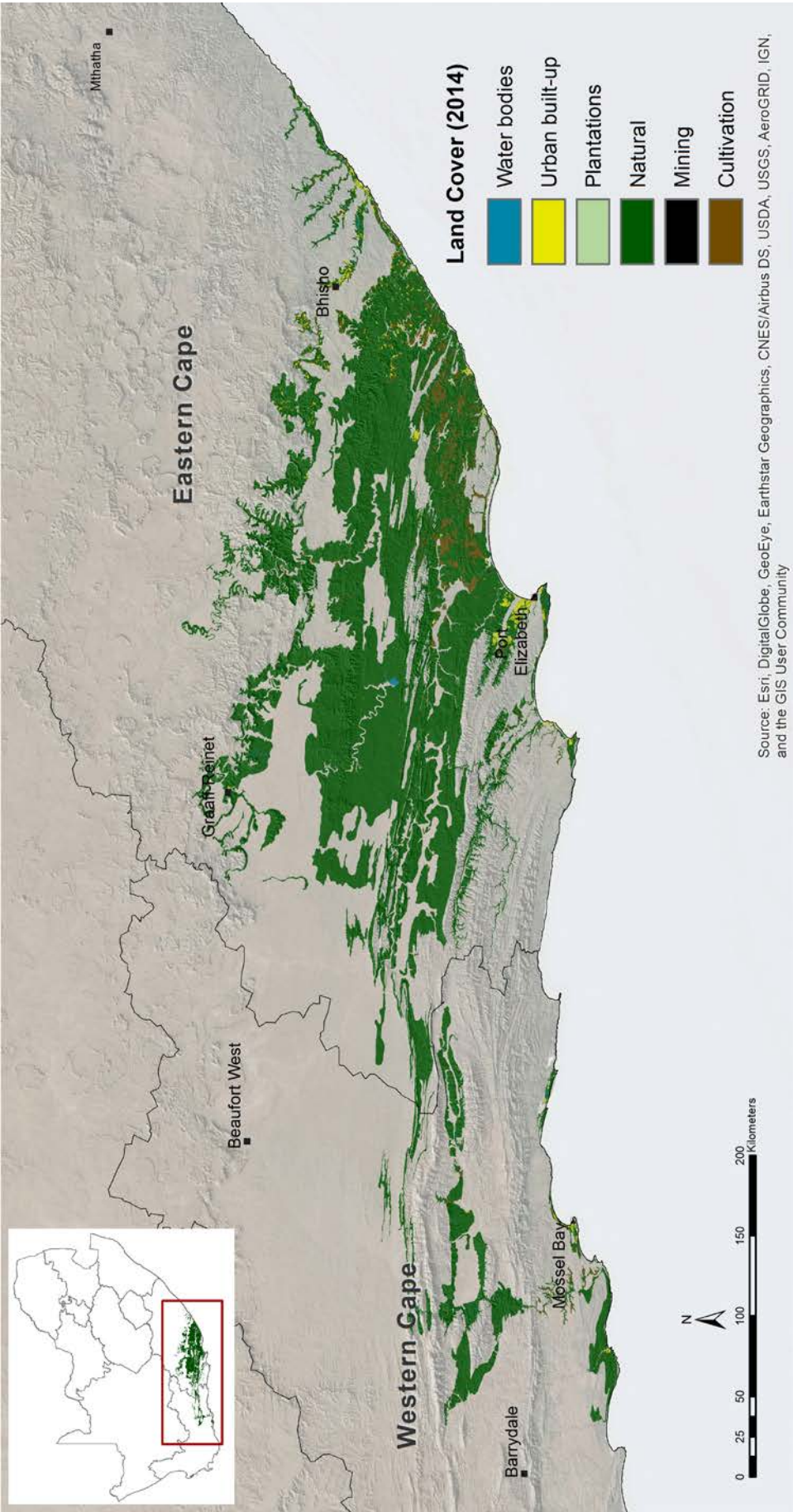


FIGURE 12.—National Land Cover Map in the Albany Thicket Biome (Land Cover Map, 2014).



reasonably foreseeable future projects that would affect the same biodiversity or natural resources.

Some activities pose higher risks than others, e.g. low-impact developments with sensitive designs and small footprints would require less clearing of vegetation than extensive urban developments; intensive agricultural practices may require more vegetation clearing and higher application rates and dosage of pesticides and fertilisers for monoculture crop production.

Activities that impact on the biome can be site specific, but may have local, regional, national or even global (e.g. climate change) consequences. Clearing vegetation on a site (local activity) that is part of a greater conservation corridor (e.g. an ESA in a provincial biodiversity plan) or biodiversity priority (e.g. CBAs in such a plan) can impact on regional or national biodiversity targets and landscape

level connectivity. Lack of control of AIPs on a farm (local activity) in the catchment area of a river can reduce base flow and impact on a distant town's water supply scheme (regional impact).

4.1. Managing Urban Development, Mining and Renewable Energy

Urban development, mining and renewable energy developments are land uses that are typically associated with permanent or severe modification of landscape. A description of associated threats and recommendations for maintaining ecological infrastructure for the continued delivery of ecosystem services is provided in Table 9.

TABLE 9.—Threats and recommendations for conserving ecological infrastructure for the delivery of ecosystem services.

Land-use activity	Threats	Ecological Infrastructure and Ecosystem Services
Urban Development		
Built-up areas used for residential and/or commercial and/or industrial activities associated with cities and towns.	Establishment of settlements.	Services provided by terrestrial and aquatic ecosystems are required for sustainable urban settlements:
Extent of urban settlements varies across the biome, with Nelson Mandela Bay and Buffalo City being two urban major centres in the Eastern Cape.	Urbanisation: increasing, especially with high poverty levels where people move to cities for work and establish in informal settlements often on the urban fringe, and also practice urban agriculture (with livestock and crops).	• Functional aquatic ecosystems (e.g. wetlands) protect settlements and infrastructure from flooding and filter runoff to improve water quality, intact/ diverse habitats filter air pollutants and improve air quality which is especially important in cities.
Game farming can be expanded to include the hunting and nature-based tourism industry.	Industrial development, with associated emissions (air, water).	• Maintaining ecological corridors of well-managed biodiversity in cities provides areas for the local community to enjoy for recreational/cultural/spiritual purposes. It makes cities less vulnerable to the impacts of climate change by regulating temperature, controlling pests, providing habitat for pollinators that is needed for urban agriculture, attenuating floodwaters etc.
	Rural-residential/peri-urban development such as smallholdings and 'lifestyle or eco-estates'. The latter is prevalent along the coastline.	
	Residential development in coastal areas, with risks to Dune Thicket.	
	The hunting and nature-based tourism industry is associated with the development of tourist infrastructure (e.g. lodges, hotels, airfields or helipads) which need access and services. There are some examples of structures that create a visual impact due to their position on ridges, and that pose an erosion risk because of access needed up steep slopes. This type of tourism infrastructure generally occurs in areas that are not serviced; where effluent treatment and disposal, solid waste management, as well as water availability and abstraction can pose risks.	
	The Coega Industrial Development Zone (IDZ) and Port of Ngqura is an 11 000 ha industrial development area in the NMBM, predominantly situated within the Albany Thicket Biome. An Open Space Management Plan (OSMP) has been done for the Coega IDZ, which allocates biodiversity priority areas within the planning area. However, development of the IDZ will still result in loss of thicket habitat, predominantly within the 'Thicket Mosaic with Grassland/ Savanna' Ecosystem Group.	
	The estuarine and terrestrial environments of the Swartkops River Valley in the NMBM provide an array of ecosystem services to the local population and hosts a diversity of habitats and species (many of which are threatened or protected). The majority of the valley is designated as a biodiversity priority area in the NMBM's BRP and falls within the Arid Thicket or Valley Thicket Ecosystem Group. The valley and floodplain are under continuous pressure from industrial development and urban expansion, and at risk from associated impacts.	
	Urban development requires services and connectivity, and a network of linear infrastructure (i.e. roads and service corridors for powerlines, sewage and water conveyance) have been positioned through thicket.	
	Development in floodplains and/or with insufficient buffers around watercourses.	
	Increase in hard surfaces and altered hydrological flow (volume and pattern).	
	Generation of effluent, emissions and solid waste.	
	Increased groundwater abstraction to provide potable water to people.	

TABLE 9.—Threats and recommendations for conserving ecological infrastructure for the delivery of ecosystem services (continued).

Land-use activity	Threats	Ecological Infrastructure and Ecosystem Services
Mining		
Mining and quarrying take place in a relatively small area of the biome (0.02%) is not currently considered to be a major risk. However, with increasing industrialisation and infrastructure development in the Eastern Cape, the need for materials is likely to grow in the long term. An increase in illegal sand mining along the eastern coastal extent of the biome in the Transkei area has been informally reported. Mining of sand, gravel and stones within riparian areas also takes place, for example in the Swartkops River near Uitenhage in the NMIBM. Calcrete mining occurs in the Patensie and Hankey areas, as well as in Bontveld mosaic vegetation in the northern sections of the NMIBM. Material from borrow pits is needed on an ongoing basis for linear and structural developments.	Establishment of mines. Emissions. Use of water. Risk varies according to the type of mining, the scale, duration and extent of mining, the environmental management approach used, and the ecological condition/biodiversity status of the area being mined. Different stages of mining can have different risks and impacts that vary in significance; increasing in severity as a mining project develops through reconnaissance, to prospecting and then mining. Upon closure, biodiversity impacts may be fully mitigated over time. Alternatively, and depending in part on the adequacy of closure and rehabilitation provisions (including sufficient financial provision) impacts may persist long after mine closure (e.g. acid mine drainage, erosion).	Services provided by terrestrial and aquatic ecosystems, related to mining: • Good quality and quantity of water in local resources. Depending on the type of mining activity, relatively large volumes of water are required. Mining can therefore impact on water availability to surrounding natural systems and people if placed incorrectly in the landscape (e.g. in SWSAs).
Renewable Energy Development		
Development of infrastructure identified as a job driver in the National Development Plan (NDP). Sixteen Strategic Integrated Projects (SIPs) identified to promote fast-tracked development and growth of social and economic infrastructure. Three of these SIPs are energy-related (i.e. SIP 8, 9 and 10). SIP 8 aims at facilitating the implementation of sustainable green energy initiatives. A SEA was done that identified Renewable Energy Development Zones (REDZs) and Power Corridors. A SEA is also underway for servitudes for a gas pipeline network to support South Africa's oil and gas sector.	Two REDZs have been identified in the Eastern Cape (i.e. Cookhouse and Stormberg areas) and two in the Western Cape (i.e. Komsberg and Overberg areas). Development of renewable energy projects and gas pipeline supply network in the Albany Thicket Biome.	N/A

4.2. Managing Climate Change

Climate changes have impacted on natural and human systems on a global scale. The fifth assessment report of the Intergovernmental Panel on Climate Change (IPCCC AR5) describes observed changes, impacts and mitigation of climate change impacts. Subsequently, a special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways has been developed by the IPCC (IPCC, 2018).

Irrespective of the cause, impacts are a result of observed climate change, highlighting the sensitivity of these systems thereto. Impacts on human systems are a function of climate change and socio-economic factors, which means they vary across geographic areas and are more easily detected at local levels. Notable existing impacts of climate change include:

- Altered hydrological systems and impacts on water quality and quantity.
- Shifting geographic ranges, seasonal activities, migration patterns, abundances and species interactions of several terrestrial, freshwater and marine species.
- Extinction of species: only a few species extinctions have been attributed to climate change in recent time. However, natural global climate change at rates slower than current anthropogenic climate change caused significant ecosystem shifts and species extinctions during the past millions of years.
- Increases in the frequency or intensity of ecosystem disturbances (e.g. droughts, windstorms, fires and pest outbreaks) have been noted in many areas and are attributed to climate change in some cases.
- Since 1950, changes in many extreme weather and climate events have been noted. Some of these have been linked to human influences, such as a decrease in cold temperature extremes, an increase in warm temperature extremes, an increase in extreme high sea levels and an increase in the number of heavy precipitation events in a number of regions.
- Negative impacts on crop yields have been assessed to be greater than positive impacts over many regions (other than high-latitude regions). Observed impacts relate mainly to production aspects of food security.
- The current burden of human ill-health from climate change is comparatively small and not well quantified. However increased heat-related mortality and decreased cold-related mortality due to warming has been detected in some areas. Local scale temperature and rainfall changes have changed the distribution of some water-borne illnesses and disease vectors.
- Damage to infrastructure and settlements.
- South Africa's National Climate Change Adaptation Strategy (Second Draft, October 2017) has reported that natural ecosystems are experiencing non-climate related pressures (e.g. land-use change, AIPs invasion, bush

encroachment and altered fire regimes) which directly and indirectly affect biodiversity and ecosystem services delivery. Climate change will exacerbate the effect of these pressures on ecosystems with direct consequences, in particular for the nature-based tourism industry and livestock agriculture. For example, bush encroachment impacts rangeland productivity and increased intensity and frequency of fires and more 'out-of-season' fires will affect the fire regime which is required for maintaining some ecosystems (e.g. the Savanna Biome).

The DEA (now the Dept. of Environment, Forestry and Fisheries (DEFF)) has developed 'Climate Change Adaptation Plans for South African Biomes' for the nine biomes in South Africa. The plan identifies and prioritises adaptation actions for the various landscapes and ecosystems, and the dependent economic activities. Understanding how the combined influences of non-climatic stressors and climate change impact on biomes is key to understanding changes to ecosystem services, and developing effective strategic adaptation responses (DEA, 2015).

To reduce climate change impacts at a biome level, four broad categories of adaptive actions can be applied:

- Spatial planning approaches: the type of activities taking place in a biome can change, or if required, cease altogether and introduce others;
- Management approaches: the way in which land uses are managed or implemented can be adjusted under a changing climate (e.g. changing the intensity of use);
- Ecosystem-based adaptation: this action aims to support the inherent ability of ecosystems, including their human inhabitants and organisms, to adapt to climate change, principally by reducing the other stresses which might impede that capacity, and restoring ecosystem function where it has been damaged. Functional natural systems are used to buffer human systems from negative climate change impacts, to build resilience and adaptive capacity. It is implemented through the protection and restoration of ecosystem services and the sustainable management of natural resources (IPCC, 2013); and
- Biodiversity stewardship programmes: these can be used to expand conservation areas on private land and promote sustainable land management through management agreements that can be used to form corridors to enhance the adaptive capacity outside of the PA network.

4.2.1. Climate-related changes and impacts expected in the Albany Thicket Biome

Climate-related changes and impacts expected in the Albany Thicket Biome include:

- The regional climate of the Albany Thicket Biome is projected to become 2–4°C hotter by the end of the 21st

century. Because of the proximity to the coast, warming will be lower than for biomes in the interior.

- The region is projected to be about 15% wetter, especially in summer. The reason for the expected increase in rainfall, and particularly the fraction falling in large storms, is that the low-pressure trough which channels moisture from the tropics strengthens under global warming scenarios.
- The biome is partly defined by climate, therefore the area it occupies is likely sensitive to a changing climate. However, the boundaries of the biome are determined more by the effects of climate on the fire regime, rather than directly by climate. Hotter, wetter conditions are likely to favour the spread of the Savanna Biome into the Albany Thicket Biome from the northeast, however the expansion of woody components (bush encroachment) associated with elevated CO₂ levels, may favour establishment of mesic thicket types. Biome modelling conducted by Guo et al. (2017) predict an expansion of Albany Thicket within in the Eastern Cape and Western Cape.
- The frequency of large rainfall events is projected to increase, which increases the risk of soil erosion, particularly in degraded thicket and on fine-textured soils.
- The viability of livestock-based land-use activities in the biome depends to a large degree on the Net Primary Productivity (NPP) of vegetation. The NPP under the expected climate change scenarios is likely to increase by about 10% (the increase due to rainfall and rising CO₂ will be slightly offset by higher temperatures). Any benefits to livestock production will be offset by the negative effects of extreme temperatures on animal performance.
- Succulent plants with a Crassulacean Acid Metabolism (CAM) are prominent in the Albany Thicket Biome. Compared to C₄ grasses and trees and forbs with a C₃ photosynthetic system, succulent species with CAM are least productive in response to rising CO₂ concentrations, while C₃ species respond best. Therefore, although succulent plants are well-adapted to high temperatures and drought, they may be outcompeted by trees and grass under combinations of higher rainfall, rising CO₂ and more frequent and intense fires.

4.2.2. Land-use adaptation responses to climate change

Livestock: The main pressure being applied to the Albany Thicket Biome is from land use, particularly from a long history of overstocking of animals. For any form of climate change adaptation to be effective in the biome, removing the sources of non-climate related degradation is paramount. Important decisions for adaptation must be made regarding the number and type of large animals present. Indigenous or exotic livestock will both continue to be suitable for the biome, as long as appropriate stocking densities are applied.

Crop cultivation:

- **Irrigation:** Water will be increasingly scarce and valuable in the future to meet future demands, and wasteful practices such as flood irrigation or overhead sprinklers operating during the daytime will be done away with.
- **Ploughing:** The fine-grained, shale- and mudstone-derived soils in the biome are prone to surface sealing and erosion, especially when the soil contains sodium. Exposure of unvegetated soils to high energy rainfall in severe storms will typically trigger erosion. The best adaptive action is to restore the vegetation cover. Revegetation is a more efficient rainwater harvesting technique than the building of more small, shallow dams, and helps to prolong the life and usefulness of large dams and the quality of water in the rivers.

4.2.3. Recommendations for biodiversity management in natural ecosystems

In order to enhance resilience and the persistence of biodiversity the following is recommended:

- For species to persist in natural environments, they will need to track climates that they are adapted to by moving through landscapes (which may be modified or fragmented); or where movement is not possible, they will need to adapt *in situ*. Corridors and network areas are needed to allow for movement of species between PAs, conservation areas and biodiversity priority areas (Jewitt et al., 2017).
- Identify, manage and protect important natural ecosystems and processes to promote ecosystem resilience to climate change:
 - Climatic refugia: these are locations which are considered to be buffered from climate change where biodiversity can retreat to, or persist in. Examples are areas with steep ecological gradients where the environment undergoes rapid spatial shifts between, for example, elevation, soil, temperature and rainfall. Wet areas, such as riparian zones and wetlands can act as climate refugia. Areas with microclimates are another example of climatic refugia and include areas close to water bodies and valleys (Morelli et al., 2016).
 - Biological refugia: these include biodiversity hot-spots; areas supporting high diversity of species with sufficient habitat to sustain a minimum viable population and promote *in situ* adaptation; local centres of endemism; and areas with high species richness along ecological gradients.
 - Incorporate areas where climatic and biological refugia have been identified through the investigation of climate change impacts on plant communities, into ecological corridors (especially between PAs) to maximise species persistence into the future (Jewitt et al., 2017).

- Appropriate management measures must be implemented on a case-by-case basis in climatic and biological refugia areas.
- Lower the risk of climate-related disturbances (i.e. floods, fires) and create additional refugia. Land managers (i.e. local authorities, landowners) could for example implement measures to reduce fuel loads of the area to lower the risk of fires (Morelli et al., 2016).
- If areas identified as important climatic and biological refugia areas are not currently protected, their formal protection should be prioritised (for example through the Protected Areas Act).
- Enhance regional and local connectivity across the landscape for biodiversity persistence:
 - Conserve movement corridors and protect priority corridors (e.g. biodiversity priority areas) for climate-change adaptation at the landscape scale.
 - Improve landscape connectivity by creating, maintaining, and/or protecting local-scale ecological corridors in good ecological condition.
 - When identifying and delineating ecological corridors and connectivity across the landscape, make sure that these linkages follow major environmental gradients correlated to plant composition and that it drives turnover in species composition across a wide range of spatial and temporal scales (β -diversity) (Jewitt et al., 2017).
 - Ensure that corridors are wide enough to incorporate variations in topography and resulting landforms that provide microrefugia sites in which species can persist and disperse along with changing climates (Jewitt et al., 2017).
 - The loss of biodiversity and/or restoration of degraded areas must be prioritised in corridors. In areas where habitat has been lost along environmental gradients, homogenisation occurs, resulting in decreased adaptive phenotypic diversity (Freedman et al. 2010). This may lead to a loss of diversity and reduces the ability of species to persist in changing environments. Protecting environmental gradients therefore protects the genetic diversity needed for adaptation and speciation (Beier & Brost, 2010), which is important

to prevent a dominance of generalist species at the expense of specialist species expected from rapid environmental change (Bowers & Harris, 1994).

- Corridors must allow for movement of faunal species across the landscape. Fencing, especially in biodiversity priority areas should be permeable.
- Planning of new structures and infrastructure must avoid these areas, and suitable buffers and setbacks must be implemented around important habitats and dynamic process areas.

The Albany Thicket Biome shows unusually high rates of carbon sequestration (Mills et al., 2005) and there is therefore a high potential for restoration projects (e.g. planting of spekboom) to take place through the use of carbon credits and other payments for ecosystem services (Mills & Cowling, 2006). Restoration of degraded areas presents an opportunity for biodiversity, water yield and job creation; in combination with climate change mitigation. Studies have shown that the ability of thicket species to store carbon is much higher in areas where thicket is intact and there is a high diversity of species. Where the natural vegetation is disturbed, the carbon sequestration potential is reduced. Intact thicket has an unusually high carbon stock per unit area, considering the relatively harsh climate, of ~30 tonnes carbon per hectare (C/ha) in the above and below-ground plant parts, and 800 tonnes C/ha in the soil. Conversely, degraded thicket has ~11 tonnes of plant biomass and 280 tonnes/ha of soil carbon. Large areas of degraded thicket are available for restoration projects, and there are multiple possible benefits. However, there are still a number of uncertainties regarding the costs and success rates of thicket restoration, the complete climate consequences of thicket restoration, the rate at which carbon is stored in the ecosystem and the vulnerability of the stored carbon to future loss if the thickets are not protected from overbrowsing remain unclear. This makes the degree to which restoration for carbon storage will be adopted on a large scale by landowners and carbon tracers uncertain (DEA, 2015).

Climate change acts as threat multiplier. Examples of how this may be considered in association with a range of land-use activities is provided in Table 10 below.

TABLE 10.—Climate change threat multipliers.

Land-use activity	Climate change as a threat multiplier
Subsistence Farming	An increase in intense rainfall events exacerbates erosion, especially in degraded thicket. Sediment-loaded runoff causes siltation of dams used for watering livestock or storing water for crop irrigation. Soil capping can also occur, resulting in reduced groundwater recharge (and reduced water availability). Wetter hotter conditions will likely favour woody trees over succulents and grasses, leading to bush encroachment, reducing grazing potential. Hotter temperatures will make dairy farming (and farming with other non-indigenous animals that are not adapted to hot conditions) unviable. Communities practising subsistence agriculture in communal areas and/or at the periphery of cities are more vulnerable to the threats of climate change as they depend on natural resources (partly or wholly) for their livelihoods and have less access to services (such as waste removal and sanitation treatment). The latter often results in poor environmental quality, especially of water sources that are needed for livelihoods.

TABLE 10.—Climate change threat multipliers (continued).

Land-use activity	Climate change as a threat multiplier
Commercial cultivation	An increase in intense rainfall events exacerbates erosion, especially in modified areas where natural ground cover is low or absent. Sediment-loaded runoff causes siltation of dams used for storing water for crop irrigation. Soil capping can also occur, resulting in reduced groundwater recharge and reduced water availability for crops. Hotter temperatures create heat stress for labour, impacting on health and well-being, and productivity. Optimal growing areas for field crops (such as barley, maize, sorghum, soybean, sugarcane and wheat) are likely to shift by 2050. The distribution of insect, plant and disease vectors are also likely to shift, which could impact negatively on crop production.
Plantations	Hotter, wetter temperatures and increased CO ₂ levels will favour the spread of woody AIPs, especially in degraded thicket. Plantations situated in catchments reduce stream flow/groundwater levels and availability of water to downstream users. Water demand is increasing, and the resource is already over-allocated to various sectors. An increase in the number of high rainfall events exacerbates the risk of erosion. Soils under plantations often have less groundcover and the root systems are less effective at stabilising/retaining soils under high runoff conditions. The risk of erosion is therefore greater under these conditions; further reducing soil quality and impacting on downstream water resources. Plantations are at risk of increased occurrence and intensity of wildfires. The increased survival and spread of insects and pathogens will also impact on plantations.
Commercial livestock farming	Wetter, hotter conditions and increased CO ₂ levels will likely favour woody trees over succulents and grasses, leading to bush encroachment, and reducing grazing potential. Climate and its impact on the fire regime plays a strong role in maintaining the boundaries of the Albany Thicket Biome. An increase in more intense or frequent fires, and bush encroachment may alter fire patterns and biome boundaries. Hotter temperatures will make farming with non-indigenous animals that are not adapted to hot conditions unviable. An increase in intense rainfall events exacerbates erosion, especially in degraded thicket. Sediment-loaded runoff causes siltation of dams used for watering livestock. Soil capping can also occur, resulting in reduced groundwater recharge and availability of water for stock. The distribution of insect, plant and disease vectors are also likely to shift, which could impact negatively on livestock production and animal health.
Game farming	Game farming, hunting and eco-tourism related ventures with indigenous animals are less susceptible to climate change impacts as the animals are adapted to hotter temperatures. However poor management and overstocking of species in fenced areas can cause land degradation, which is susceptible to erosion under high rainfall events. Siltation of dams and reduced groundwater recharge impacts on water availability for watering game species. Degraded land is more susceptible to bush encroachment by certain indigenous species and AIPs, which can impact on forage availability for game species. Increasing CO ₂ levels promotes the spread of woody plants, enhancing bush encroachment.
Urban Development:	Settlements inappropriately established in proximity to watercourses are at risk of flooding from an increase in the amount of extreme rainfall events. Informal settlements that are often established in floodplains are particularly at risk of flooding, and communities living in these circumstances are more susceptible to impacts of climate change because of their location and housing density, which makes emergency services difficult. Roads and infrastructure experience warping, wear and tear, physical damage from hotter temperatures and flooding. Hotter temperatures can impact on the power distribution network, making transmission less effective. An increase in sea level rise and storm surges places coastal settlements at greater risk of inundation, especially if incorrectly placed in dynamic coastal process areas and without suitable setbacks from the high-water mark of the sea or the estuarine functional zone.
Mining	Mining often requires relatively large amounts of water and can impact on water quality. Water demand is increasing, and the resource is already over-allocated to various sectors.

4.3. Managing Cultivation Agriculture

Cultivation agriculture is associated with the clearing of thicket for the planting of food crops, orchards, plantations and pastures. There is an escalation in clearing of thicket for pastures in the Alexandria area and clearing for citrus

in the Sundays and Gamtoos Valleys. There is a growing demand for land for plantations (with the risk of AIP invasion in surrounding areas and the associated negative impact on water resources and biodiversity).

A description of associated threats and recommendations for maintaining ecological infrastructure for the continued delivery of ecosystem services is provided in Table 11.

TABLE 11.—Cultivation agriculture threats and recommendations for conserving ecological infrastructure for the delivery of ecosystem services.

Land-use activity	Pressure	Ecological Infrastructure and Ecosystem Services
Subsistence Farming		
Crops grown typically include maize, bean types, potatoes and a variety of vegetables and herbs (ACB, 2017).	Clearing vegetation for crops results in: • Habitat modification. • Biodiversity loss. • Reduction in soil and water quality. • Deteriorating environmental conditions impact on biota.	Ecological Infrastructure and Ecosystem Services provided by terrestrial and aquatic ecosystems, required for sustainable subsistence farming: • Maintaining soil quality, structure and drainage is important for crop production. • Maintaining intact biodiversity corridors and/or buffers around agricultural areas will assist with pest control, fire protection, soil quality, pollination of food plants, drought resistance, and resilience to the impacts of climate change. • Managing aquatic ecosystems and water resources for water quality and availability are important for crop irrigation.
Increase in people living on the periphery of cities and associated urban agriculture.	Use of herbicides, pesticides and inorganic fertilisers.	
Commercial crops		
Crops, orchards, animal fodder	Removal of vegetation for crops, orchards and fodder crops (e.g. lucerne). Current high-risk areas are in the Sundays River Valley and Gamtoos Valley areas, where large areas of thicket are being cleared for citrus, fodder crops and vegetables (with a recent increase in farming under shade net and/or tunnels in the Gamtoos Valley). Generally involves the replacement of diverse natural vegetation with a single species, which increases the susceptibility to pests. Clearing vegetation and ploughing soils for crops alters soil profile, structure and drainage; and reduces natural enrichment. Soils become either waterlogged or well drained, and their nutrient status is affected, increasing the need for fertiliser inputs to maintain crop yield. Soils lose their viability, which impacts on the rehabilitation potential of the land. This is a particular risk in areas where lucerne or other fodder crops are planted and irrigated. This issue is illustrated in sections of the AENP where 'old lands' on farms purchased and incorporated into the National Park more than 30 years ago have not yet rehabilitated. Use of herbicides, pesticides and inorganic fertilisers. Abstraction of water (surface and groundwater) for irrigation. Damming of watercourses to collect water for irrigation. Growing crops in floodplains.	Ecological Infrastructure and Ecosystem Services provided by terrestrial and aquatic ecosystems, required for commercial cultivation: • Maintaining soil quality, structure and drainage is important for crop production and sustained quality of crops. • Managing aquatic ecosystems and water resources for water quality and availability – important for crop irrigation. • Diverse ecosystems are more resilient to the impacts of climate change and are less vulnerable to pest infestations. Therefore, maintaining ecological corridors in and around crops can act as a buffer and protect crops.
Plantations		
Although the majority of plantations in South Africa occur outside the biome, there is a growing demand for plantation expansion.	Removal of natural vegetation for plantations. Large areas are often planted with a single alien species.	Ecological Infrastructure and Ecosystem Services provided by terrestrial and aquatic ecosystems, related to plantations: • Good quality and quantity of water in local resources. Plant species in plantations typically require large volumes of water, and can impact on water availability to surrounding natural systems and people if placed incorrectly in the landscape (e.g. in SWSAs).

4.4. Managing Overgrazing/browsing

Modification and degradation of thicket as a result of unsustainable stocking rates and overgrazing/browsing is

primarily recognised through structural changes in the vegetation, and loss of biodiversity, biomass and soil carbon (Lechmere-Oertel et al., 2008).

A description of associated threats and recommendations for maintaining ecological infrastructure for the continued delivery of ecosystem services is provided in Table 12 below.

TABLE 12.—Livestock grazing/browsing threats and recommendations for conserving ecological infrastructure for the delivery of ecosystem services.

Land-use activity	Pressures	Ecological Infrastructure and Ecosystem Services
Subsistence Farming		
Keeping livestock (mostly goats and cattle, but sheep, pigs, chickens and donkeys are also kept). Prevalent in Kei River and Buffalo River, between the Buffalo River and Great Fish River (i.e. Peddie District) and in the Central Karoo. Influx of people into towns has also resulted in subsistence farming taking place on the periphery of urban areas.	Overgrazing/overbrowsing by livestock (particularly goats). Vegetation clearing for crops. Burning veld too frequently to increase grazing areas. Goat pastoralism and pressure on spekboom. Clearing thicket for urban subsistence agriculture. Lack of management of farming practices and severe biodiversity degradation, especially in Mesic Thicket Ecosystem Group where communal lands are used for grain fed agriculture (Lloyd et al., 2002).	Services provided by terrestrial and aquatic ecosystems, required for sustainable subsistence farming: • Maintaining soil quality, structure and drainage is important for crop production. • Maintaining intact biodiversity corridors and/or buffers around agricultural areas will assist with pest control, fire protection, soil quality, pollination of food plants, drought resistance, and resilience to the impacts of climate change. • Functional ecosystems are important for sustained and quality grazing for livestock.
Commercial livestock farming		
Large areas of the biome are used for livestock farming. Over the last 200 years, indigenous herbivores, particularly the mega herbivores (elephant and black rhinoceros), have been largely replaced by domestic herbivores (e.g. cattle and goats).	Overstocking of animals, poor land management practices, and overgrazing/browsing. Even though thicket vegetation is adapted to high levels of herbivory from indigenous species, it has been found to be particularly vulnerable to domestic herbivory, particularly by goats. The part of the Albany Thicket Biome occurring within the Little Karoo (Arid Thicket) has been shown to be particularly vulnerable to overgrazing (Hoffman & Cowling, 1990), causing 19.6% to be severely degraded, and 62.1% moderately degraded (Thompson et al., 2009). Continued development of new pastures for dairy and beef production, particularly in the Mesic Thicket Group. Large scale destruction of thicket can be seen in the districts of Bathurst, East London, Alexandria, Albany and Stutterheim (Lloyd et al., 2002). Illegal hunting and/or poisoning of carnivores (e.g. leopard, black-backed jackal and caracal) perceived to be 'damage-causing' is prevalent on commercial livestock farms to protect livestock. Aerial spraying of herbicides is used (often illegally) to destroy thicket and increase grazing areas for domestic livestock. Application appears to be unregulated with little to no control over who applies the herbicides, where spraying takes place, what chemicals are used, or the frequency of application.	Services provided by terrestrial and aquatic ecosystems, required for commercial livestock farming: • Functional ecosystems are important for sustained and quality biomass for livestock. • Maintaining spekboom in areas where they would naturally occur is key to sustaining large herbivores in semi-arid environments, as the plant plays a critical role in the maintenance of the ecosystem by facilitating the incorporation of organic matter into soil (Lechmere-Oertel et al., 2008). The subcanopy microclimate promotes the maintenance of high plant biomass, therefore spekboom-dominated thicket has the ability to support far higher densities of large herbivores than expected in the semi-arid environment (e.g. Mills et al., 2014). • Managing aquatic ecosystems and water resources for water quality and availability are important for watering of livestock.

TABLE 12.—Livestock grazing/browsing threats and recommendations for conserving ecological infrastructure for the delivery of ecosystem services.

Land-use activity	Pressures	Ecological Infrastructure and Ecosystem Services
Commercial livestock farming (continued)		
	Purchasing of domestic livestock farms by big corporations, where 'outsiders' have little understanding of what farming/management practices are being used. This makes it difficult for specialists and conservation authorities to advise on or control activities that may be impacting on thicket ecosystems.	
Game farming		
Thicket is able to support a high diversity and abundance of large browsing mammals (Mills et al., 2007). Since the 1980s a noticeable shift from stock farming to game farming has taken place in the Eastern Cape where some of the farmers have diversified to include both game and stock farming and others have focused only on game farming (Hamann & Tuinder, 2012).	Overstocking of game species and poor land management practices, causing overgrazing or overbrowsing (depending on game species). General lack of and/or inconsistency in management of game farms. Use of fences. Keeping extra-limital game species. Incorrect application of fire for grazing and/or to control bush encroachment. Illegal hunting and/or hunting of predators to protect game (e.g. leopard and black-backed jackal). As for livestock farming, application of herbicides to increase grazing areas. Poaching of animals (e.g. white rhinoceros, black rhinoceros). Note: impacts of game farming are not restricted to these primary activities but extend to those discussed under secondary activities 'urban development' below.	Services provided by terrestrial and aquatic ecosystems, required for game farming: • Functional ecosystems are important for sustained and quality grazing and browsing for game species. • Managing aquatic ecosystems and water resources for water quality and availability is important for watering of game species.

Plate 16.—Degradation of thicket vegetation in proximity to water holes in the AENP (Source: CEN IEM Unit).



4.5. Managing Alien Invasive Species

Alien and Invasive Plants (AIPs) refer to those plants occurring in areas where they are not naturally found, and which have the potential to spread into and invade the landscape at the expense of indigenous vegetation causing environmental, economic and social harm. AIPs are able to reproduce and spread without the direct assistance of people and the more aggressive invaders can occupy large areas. AIPs are considered major threats to most ecosystems. A list of some of the predominant species that may be found in the different Ecosystem Groups are listed in Table 13. Therefore, assessments and plans should take the following into consideration:

- AIPs impact both terrestrial and freshwater ecosystems in the Albany Thicket Biome, leading to displacement of indigenous species and habitat modification, loss of biodiversity pattern and disruption of ecological processes.
- The loss of diversity renders ecosystems less resilient to the impacts of climate change.
- Disruption of ecological processes, such as hydrological flow, fire regimes and nutrient cycling, impacts on land productivity and the provision of ecosystem services to society (Hoffman et al., 1999). For example: increased use of water by AIPs is a significant risk to water availability for natural ecosystems and for socio-economic use.
- Loss of ecosystem services has adverse economic implications. In 2008, the annual economic losses due to AIP invasions in South Africa was estimated as R6.7 billion. In the absence of the alien invasive control programme initiated by Working for Water (WfW), the estimated loss would have been R41.7 billion per year (Van Wilgen et al., 2012).

While not a listed alien species in terms of the Conservation of Agricultural Resources Act (CARA) or the Biodiversity Act

in the Eastern Cape, the century plant can spread rapidly and prevent re-establishment of thicket vegetation (Vlok & Euston Brown, 2002).

Different AIPs result in different levels and types of invasion risks and impacts to thicket, and control methods do not apply equally to all species in all areas. For example, jointed cactus is currently a significant risk to thicket in the Kabouga area in the AENP due to inaccessibility of the thicket vegetation combined with unfavourable conditions for biocontrol agents. Conversely, in intact thicket, prickly pear is considered less of a risk and is regarded as a 'guest plant'. But in degraded areas, it spreads over large areas and impedes thicket regeneration.

Where AIPs occur in an area, an alien invasive management programme should be put in place. In terms of the 'duty of care' principle under Section 28 of NEMA, the onus is on the landowner to initiate and implement the programme (with assistance from a suitable specialist) and control AIPs on his/her property.

Ideally, any control programme for alien vegetation must include the following three phases:

- Initial control: drastic reduction of existing population.
- Follow-up control: control of seedlings, root suckers and coppice growth.
- Maintenance control: sustain low alien plant numbers with annual control.

Best practice principles to implement in an alien clearing plan include:

- Clear from the top of a catchment down.
- Clear sparse infestations before dense.
- Do follow-up before new clearing.

TABLE 13.—Predominant alien invasive plants.

Albany Thicket Ecosystem Group	Main AIPs
Dune Thicket	Red-eyed wattle and <i>Eucalyptus</i> species are examples of AIPs threatening Dune Thicket vegetation. The introduction of alien species in dune fynbos vegetation areas, combined with a reduction in fire frequency, has been shown to favour the establishment of thicket clumps at the expense of natural dune fynbos vegetation. However, where dense stands of red-eyed wattle have established in areas of limestone fynbos, fire intensity increases, and the fire can spread and destroy established Dune Thicket (Vlok & Euston Brown, 2002). Additional prevalent AIP species include: guava and Port Jackson willow.
Arid Thicket	Lindley's salt bush is an example of an alien species invading the more Arid Thicket areas and, if established, can prevent the re-establishment of original thicket vegetation. Sisal and golden torch establish in disturbed areas.
Mesic Thicket	The umbra tree has displaced many indigenous forest trees along drainage lines. Additional prevalent AIP species include: eucalyptus, black wattle, syringa, bugweed and guava.
Valley Thicket	Prickly-pear and cactus species are a threat to the biodiversity of Valley Thicket units. Sisal and golden torch establish in disturbed areas.



Plate 17.—Prickly pear cochineal feeding on the sap of a prickly pear amongst thicket vegetation (Source: CEN IEM Unit).

Plate 18.—Jointed cactus under a thicket bush clump (Source: CEN IEM Unit).



- Consider the potential impact on environmentally sensitive areas (e.g. wetlands and watercourses, biodiversity priority areas).
- Ad hoc/piecemeal clearing is discouraged.

The programme must include post-intervention monitoring to test its success. Successful control of AIPs is generally a long-term process, and an adaptive management approach is needed.

Different methods are available to control or eradicate AIPs:

- Manual removal: physical removal by cutting, felling etc.,
- Chemical control: application of herbicides, and
- Biological control: releasing a biological control agent into the area that has been tested and approved for the target species.

The choice of method will depend on the species under consideration, and the area where control is to be implemented. The WfW guidelines on control methods should be consulted, and the advice of a specialist sought to determine the best method to use.

Manual control alone has had little success on AIPs. Biological control should be used in combination with manual control methods, or on its own, particularly where such control has already had notable success (Van Wilgen et al., 2012). If chemical control is also used, it must be used with caution and only target-specific herbicides should be used.

Depending on the nature of the receiving environment, some texts recommend that once an area has been cleared of AIPs, it should be control-burnt to promote germination of seeds. The heat from the burn ensures the germination of almost all seeds (Theron, 1978). If the second cohort of trees is cleared and treated before they produce seeds, the success of rehabilitation would be greater as the alien vegetation seedbank would be reduced. However, the risk of fire to surrounding areas must be considered (for example proximity to PAs, settlements) and it will not be suitable in all instances.

Note the following:

- It is the legal responsibility of landowners to control AIPs on their land and prevent them spreading to surrounding areas. Landowners must familiarise themselves with the classification of AIPs on their properties in terms of the Alien and Invasive Species Lists under the Biodiversity Act, and the associated management responsibilities.
- Commercially important AIPs will require a permit to be grown in terms of the Biodiversity Act. A risk assessment will need to be done to determine the possible impact of the species on the surrounding environment as part of the permit application process. The permit holder is

responsible to control any spread of the species beyond the boundaries of the property.

- Persons wishing to sell their property must notify the DEFF and potential purchasers, in writing, of the presence of AIPs on the property.

4.6. Managing Bush Encroachment

Bush encroachers are those indigenous woody species that invade overgrazed or disturbed land. They are especially evident in some of the semi-arid areas which have been grazed continuously by cattle, for example; but can occur throughout the biome in degraded areas. Areas where thicket forms mosaics with savanna or grassland are generally more prone to bush encroachment. Bush encroachment can also occur in areas where grazing is light and infrequent, and where processes such as fire are excluded; for example in Dune Thicket mosaic vegetation with fynbos, where the exclusion of fire results in encroachment of woody thicket species and a loss of the fynbos component.

Start off by establishing if bush encroachment is actually present on site. This can be done by:

- Checking a series of aerial photographs or images, and map areas where woody vegetation cover has increased.
- Determine what species are present. Bush encroachment is generally characterised by one of a few typical species.
- Look at the age structure: bush encroached areas generally have even-age cohorts.

Where there is evidence of bush encroachment or a risk of it occurring, a bush encroachment management programme must be developed and implemented, with assistance from a suitable specialist. The plan must include monitoring to test its effectiveness. The following should be considered in the compilation of a bush encroachment management programme:

1. **The pre-disturbance vegetation structure and composition** (i.e. what is the typical biodiversity pattern in a natural ecosystem?).
2. **The history of land-use type and change of the site to current time:** this will help determine what pressures may have led to bush encroachment, and if there were any specific trigger events; as well as how long the area has been encroached.
3. **The type, number and density of woody encroacher species** on the site.
4. If possible, determine **how long** it has taken for the current numbers of encroachers to become established on site.



Plate 19.—Signs of bush encroachment on overgrazed land in Arid Thicket (Source: CEN IEM Unit).

- Have the numbers increased rapidly in a short time span?
 - Have the numbers been increasing steadily over a longer time?
 - The time taken for woody encroachers to establish on site will provide insight into which drivers are resulting in the establishment of woody vegetation, and what control measures are required (for example, grazing management, fire management).
5. Consider the **rainfall conditions** of the area and any changes to patterns.
- What is the average rainfall of the area and current rainfall of the area?
 - Are drought conditions occurring?
 - Has the area experienced an increase in rainfall?
 - Rainfall is one driver responsible for woody species recruitment and encroachment. Seedling recruitment may take place during higher rainfall years, but during drier season the seeds may be dormant. Therefore, if dry conditions exist and the level of bush encroachment is low, bush encroachment may increase during periods of heavier rainfall if other contributing factors are present (e.g. overgrazing, poor fire management).
6. What **land uses** are taking place in the area and **how well managed are these**?
- Has the area been overgrazed by livestock or game?
 - Are there any browsers in the area, and if so, do they naturally occur there?
 - What is the carrying capacity of the area?
 - What is the current stock level?
 - Have additional watering points been provided in the area?

- If applicable, is rotational grazing practised?

Answering these questions will give an indication on the drivers leading to bush encroachment and what measures should be put in place to manage encroachers. For example, if only grazers are on site, then browsers that would naturally occur in the area could be introduced to assist with the suppression of the woody vegetation. The numbers of grazers may also need to be decreased as overgrazing will result in the removal of the herbaceous layer which will give rise to open patches allowing for the establishment of woody seedlings.

1. What grasses are on site?
 - The productivity of C_4 grasses is less positively responsive to rising CO_2 concentrations than trees and forbs with a C_3 photosynthetic system, giving woody trees an advantage under the current scenario of climate change.
 - Determine whether the grasses on site are perennial/annual and C_4/C_3 species. Most annual alien invasive grasses in South Africa (and some perennial species) are the C_3 type. Indigenous perennial C_4 type grasses can, however, outcompete C_3 grasses and also act as a suppressive factor over woody seedlings and plants.
2. When last did the area **burn**?
3. Assess the **restoration potential** of the site especially if it falls within a biodiversity priority area.
4. **Choose an appropriate method(s)** to control the woody vegetation whilst ensuring that damage to the environment is minimised.
 - Harvesting of woody encroacher species can aid in job creation, generate income from sale of the

products limit the effects of bush encroachment, and reduce pressure off trees that occur in the area under undisturbed conditions.

- Implement tree thinning rather than tree-clearing. Thin trees using manual methods and ensure the correct application of thinning so as not to reduce inter-tree competition.
- Consider the possibility of introducing browsers to hinder growth of unwanted woody species (Staver & Bond, 2014).
- Ensure the correct fire regime is in place.
- Introduce a rotational grazing system (if not already introduced) and manual removal of seedlings and saplings with occasional burning, to control woody encroachers.
- If tree arboricides are used, apply manually on targeted species to ensure non-target species are not adversely affected. Chemical control measures require a five to seven-year follow-up treatment (Van Rooyen, 2016).

4.7. Managing Harvesting and Poaching

Over 2 000 indigenous plant species have documented traditional medicinal uses, and just over a quarter of these are traded annually in the country (Williams et al., 2013). The majority of plant material is obtained from open access, communal lands in various provinces around the country. These resources are collected without any restrictions and can be for personal use, but most are transported to urban markets where they are sold to traders and traditional healers. Some 656 medicinal plant species are common in trade and many are unsustainably harvested, with 184 species declining due to unsustainable use (Child et al., 2017).

The past decade has seen the rise of the new emerging threat of international wildlife trafficking syndicates that are beginning to heavily impact on species desired for overseas markets, including black and white rhinoceros and pangolins. Expansion of human settlements, especially in areas bordering PAs has resulted in increased hunting intensity for bushmeat and/or traditional medicine and cultural regalia, as well as increasing the number of animals killed incidentally in snares, which impacts species ranging from African wild dog and leopard to Temminck's ground pangolin and mountain reedbuck. The mountain reedbuck has experienced significant declines resulting in it being up listed from Vulnerable to Endangered. There has been an increase in the scale of illegal sport hunting with dogs which directly threatens species, such as oribi. The increasing use of leopard skins for cultural ceremonies has resulted in the leopard being uplisted from Least Concern to Vulnerable. Six mammal species have increased in threat status between 2004 and 2016 as a result of direct persecution (Child et al., 2017).

4.8. Managing Fire

The Albany Thicket Biome occurs in the transitional area between summer rainfall areas (Savanna or Grassland Biomes) and winter rainfall areas (Forest and Fynbos Biomes). One of the key factors affecting the relationship with fire is the degree of summer or winter drought experienced within the biome, which generally increases from the central parts of the biome towards the periphery (outer edges). It is therefore generally the outer edges of the biome, which form a mosaic with Savanna, Grassland or Fynbos Biome vegetation, which are more prone to fire. Woody vegetation within some types of ecosystems in the Albany Thicket Biome can increase or decrease in density depending on the occurrence of disturbing mechanisms such as fire or herbivory (Vlok & Euston-Brown, 2002).

The vegetation occurring within the Albany Thicket Biome can be divided into fire-prone and non-fire-prone vegetation. Fire is generally not a driving factor in the moist forms of thicket vegetation, such as Valley Thicket and Mesic Thicket Groups, due to the high moisture content of the vegetation. The more Arid Thicket types are considered to be fire-refugia (safe) areas as the vegetation is simply too arid to support flammable vegetation. Thicket vegetation found on deep kloofs, cliffs and scree slopes are also considered to be fire-safe places.

Contributing factors to the risk and intensity of fires in the Albany Thicket Biome include herbivory and woody alien vegetation.

- Heavy grazing reduces fuel loads which in turn reduces the frequency and intensity of fires. Heavy grazing on the periphery of thicket mosaics with other vegetation types could therefore result in an expansion of thicket woody species.
- Overstocking of game and domestic livestock on farms may lead to a reduction in the succulent component of thicket, and replacement with a more flammable field layer which increases the risk of fire.
- Invasion of woody alien vegetation increases the fuel load which can increase the frequency and intensity of fires. In Dune Thicket and in Thicket Mosaic groups, the increase in fire intensity and frequency caused by woody plant invasion would have a harmful effect on the indigenous thicket vegetation at those locations.

4.8.1. Proactive Fire Management Plan

When compiling a fire management plan, consider the following:

1. Combine fire management with other management options, such as control of woody AIPs and proactive management of grazing and browsing.

2. The intensity and frequency of controlled fires should be matched to the type of Albany Thicket vegetation.
3. Mosaic types would require active fire management to maintain the structure at the edges of the biome.
4. Woody AIPs should be controlled to prevent unwanted fires and fires that burn at higher temperatures.
5. Grazing should be managed to ensure that fuel loads are reduced where required.
6. Browsing should be managed to ensure that the thicket vegetation is not stripped away completely in an area, thus making it prone to invasion by alien grass and woody species.
7. Where possible, the use of natural non-flammable vegetation should be considered as an alternative to clearing firebreaks, especially in biodiversity priority areas.

Law governs the management of fire (refer to the National Veld and Forest Fire Act No. 101 of 1998 that specifies the need for landowners to implement at least a 5 m fire break in areas where natural veld adjoins agricultural land or alien thickets). Negligence with regards to fire management has legal implications. Any person that owns and/manages property where fire is a risk must develop a fire management plan, with assistance from a suitable specialist. To carry out a burn in the prescribed season, a permit will need to be obtained from the relevant Fire Protection Association (FPA). A general rule is to plan for safe, managed burns and allow for wildfires.

Further information and advice can be obtained from:

- Working on Fire: www.workingonfire.org
- FireWise: www.firewisesa.org.za
- The local Fire Protection Association.

Plate 20.—Example of mosaic thicket (Grahamstown Grassland Thicket of the Mosaic Thicket with Grassland/Savanna Ecosystem Group) on periphery of Albany Mesic Thicket (Source: CEN IEM Unit).



4.9. Planning for species

4.9.1. Threatened and Protected Species

Threatened species are those that face a high risk of extinction in the near (or foreseeable) future and have been classified as Critically Endangered, Endangered or Vulnerable. The classification is based on a scientific conservation assessment (or Red Listing process), using a standardised set of criteria developed by the IUCN for determining the likelihood of a species becoming extinct.

A **Red Listed Species** is any species that has been assessed according to Red List criteria, whether or not the species is threatened or of conservation concern. IUCN Red List categories for species include Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Near Threatened, and Data Deficient. Additional categories in South Africa are Rare and Critically Rare.

Species of Conservation Concern (SCC): IUCN Red List Definition. Threatened species and other species of significant conservation importance: Extinct, Extinct in the Wild, Near Threatened, Data Deficient. In South Africa 'Rare' and 'Critically Rare' categories are added.

Protected species are species which are protected by international, national or provincial legislation. The translocation, hunting, owning, breeding or trading of faunal species is illegal without the applicable permits or licenses in place. Damage or removal of protected floral species and/or their habitat requires a permit issued by the relevant authorities (usually Provincial). Such a permit will only be issued after the collection of relevant field data and an analysis of the impacts associated with the removal.

TOPS-listed species: Species listed as threatened or protected in terms of Section 56 of the Biodiversity Act. Classified as Critically Endangered, Endangered, Vulnerable or Protected.

Lists of protected species published under different Acts, Regulations or Ordinances can be found at:

- List of Threatened or Protected Species published in terms of the Biodiversity Act;
- List of protected trees published under the Forest Act;
- International conventions (CITES); and
- Provincial ordinances.

For information on species listed on the Global IUCN Red List, visit: www.iucnredlist.org. To access information about a South African species' IUCN Red List status, CITES Appendix listing or the Biodiversity Act TOPS status visit: <http://sibis.sanbi.org>. Refer to **Appendix 5.2** for additional resources relating to threatened species.

4.9.2. Working in faunal habitats

The habitat requirements of animals must be given careful consideration in environmental assessments and management plans. The different kinds of animals occurring within the Albany Thicket Biome have different ecological requirements.

4.9.2.1. Faunal Diversity in the biome

Vegetation in the Albany Thicket Biome is nutritious and supports a diversity of herbivores, ranging from the blue duiker to elephant and black rhinoceros. Thicket plant communities seem to be well adapted to being browsed by herbivores and have the ability to resprout. Thicket can maintain forage production, even during times of drought, in a relatively good condition.

Birds are important for seed dispersal in thicket. In Dune Thicket Ecosystem Groups, mammals may be even more important dispersers than birds (Kerley et al., 1995).

Due to the impenetrability of thicket in some areas, domestic herbivores on livestock or game farms have not posed a threat to smaller indigenous herbivores and animals such as kudu, bushbuck, duiker, bushpig and Cape grysbok remain common in areas outside PAs.

Historical evidence shows a long-term presence of elephants in the thicket region. Removal of large herbivores (such as elephant and kudu) has been shown to lead to degradation of thicket. Elephants in thicket influence several processes, such as plant biomass, landscape patchiness, nutrient cycling and soil features (Kerley & Landman, 2006). Kudus are efficient seed dispersers (Sigwela, 1999), and elephants have a part in maintaining vegetation structure and vegetative recruitment in spekboom-dominated thicket (Stuart-Hill, 1992). Modification of vegetation and reduction of canopy height by elephants creates habitat for smaller vertebrates and allows access to forage by other browsers (Dawies et al., 2017). Where elephants are present, thicket modification should theoretically only occur where their densities exceed the carrying capacity of the area allocated to them (Landman et al., 2014).

4.9.2.2. Faunal Movement and the need for corridors

Fauna may require different habitats for feeding, breeding, shelter and accessing water. They need to be able to access these different habitats, adding value to the importance of connectivity of natural environments and considering animal movement patterns in ecological corridors.

When planning corridors required for fauna, consider the following:

1. Landscape-scale movement, i.e. the annual or seasonal migration.

2. Local-scale movement, i.e. the daily movements to search for food, water, shelter, nesting or breeding sites.
3. Size of the corridor, i.e. both the length and width (the longer the corridor the wider it needs to be).
4. Habitat requirements, i.e. are there specific interfaces, gradients, forage or niche areas that are required for different species.
5. Behavioural traits.
6. Land use within corridors and effects on target species.
7. Neighbouring land use/s and associated edge effects on the habitat.
8. Management constraints such as roads and fencing.

4.9.2.3. Managing Impacts on Fauna

Where impacts on fauna cannot be avoided or sufficiently minimised as set out in the mitigation hierarchy, the developer (with assistance from the EAP, relevant taxa specialist(s) and an offset specialist) must either find an alternative, lower-impact site for development, or offset the residual negative impacts on faunal species in such a way as to counterbalance loss to the affected population and species. Impacts on the habitat of CR species and local endemic species with highly restricted distributions should be avoided. When threatened or localised endemic species are impacted, the offset must cater explicitly for the habitat needs of the affected species and prevent any change (i.e. increase) in their threat status. A precautionary approach to determining the size of offset must be exercised in cases where threatened species are affected (Draft National Biodiversity Offset Policy, 2017). Refer to the latest version of the National Biodiversity Offset Policy for guidance on appropriate offset ratios based on species threat status.

Guidelines to avoid or minimise impacts of proposed land use on animals:

1. Access available data (e.g. species lists for quarter degree square areas) and check what fauna are expected to occur in the area. Understand their habitat requirements, and their daily and longer-term movement patterns. Determine whether a specialist survey is needed.
2. Consider potential impacts on fauna and their habitats early in the assessment process.
3. Cluster development in disturbed or modified areas to avoid habitat loss.
4. Minimise light pollution to avoid disruption of circadian rhythms and seasonal cues, attracting unwanted animals or scaring off animals.
5. Ensure lighting does not shine into areas of natural or near-natural vegetation.
6. Locate roads between developed areas and natural habitat to act as a fire break.
7. Avoid backing up houses against natural vegetation to prevent disturbance.
8. Design barrier walls and fencing to allow for the passage of small fauna. Avoid solid walls or include regular gaps in solid walls. Palisade fencing is permeable to most small fauna.
9. Do not place electric fencing strands below 15 cm above ground level.
10. Design drains and canals with angles of less than 45 degrees so they do not act as pitfall traps and animals can escape from the structures.
11. Swimming pools should be raised or surrounded by walls to prevent accidental drowning of fauna.
12. Design roadside curb stones with a gentle gradient, or to be less than 6 cm high, so small animals can move off roads and on to verges.
13. Manage and minimise the impacts of domestic pets. Pay attention to the impacts that some pets (e.g. cats) can have on faunal SCCs in the area.
14. Ensure specialist input is sought regarding the impact of stormwater flow and discharge into natural environments, and on biota in these systems (e.g. discharge of stormwater into wetlands).



15. Relocate target species where their habitat will be converted, and only if permits have been issued by the relevant authority. Fauna must be relocated to similar habitat conducive to their persistence, and where their introduction will not impact on existing biota in the area. Removal of fauna ahead of construction should be done as close to the time of construction as possible to prevent fauna moving back into the affected area.

4.9.2.4. Animal indicator species

Available information on specific faunal groups must be considered during the environmental assessment process. However, it is not always feasible to obtain full species lists of the animals occurring on site due to the relatively short timeframes of the EIA process and limited resources.

Faunal distribution lists per quarter degree square can be scanned to determine the likely/expected fauna in the area (e.g. Bird Atlas, Butterfly Atlas). References such as the 'Historical Incidence of the Larger Land Mammals in the Broader Eastern Cape' (Skead, 2007) can also be checked.

When detailed information is not available, the biodiversity assessment should focus on those species whose presence, absence or abundance can be used to measure faunal diversity or the ecological health of the ecosystem (see examples for the Albany Thicket Biome in the text box below).

4.9.3. In- and ex-situ conservation

The removal of a subpopulation and/or species of plants or animals from their natural habitat to an artificial environment

is referred to as '*ex-situ* conservation'. This is frequently used as a mitigation measure in land-use change proposals (especially in the EIA process) where impacts on natural ecosystems, and fauna and flora cannot be avoided. However, there are numerous drawbacks with this practice, and it must not be used as a conservation measure for SCCs. Similarly, translocation of subpopulations is an unacceptable conservation measure.

- *Ex situ* conservation may result in the erosion of genetic diversity and characteristics of the species and increase its extinction risk in the wild.
- Suitable receptor sites may not be available or may be limited.
- Translocations are expensive and are typically not successful.
- Even if they are successful, translocated individuals may harm other species in the receiving environment (e.g. the translocated individuals may transmit pathogens and/or parasites, and translocation may result in rapid changes in the species itself).
- Moving large numbers of individuals can lead to overpopulation and mortality of the species at the receptor site.
- AIP species could be introduced at the receptor site/s.
- The predator-prey balance could be disrupted at the receptor site/s.

In-situ conservation is vital and should be recommended as the only option for conserving SCCs.

In general, *ex-situ* conservation for SCCs is not an option available to developers. *Ex situ* conservation can only be

Keystone species: Species that play a unique and critical role in the way an ecosystem functions. The loss of a keystone species from an ecosystem will likely result in the loss of other species, the structure of the ecosystem will change which will alter or limit the functioning of the ecosystem. For example: Spekboom is a keystone plant species in Arid Thicket and plays a significant role in the carbon cycling of the ecosystem. Elephants are considered to be keystone species in relatively large areas of the biome that have been modified to settlements or other land cover types that are not suitable for mega-herbivores. In ecosystem assessments, the practicality of introducing and managing certain keystone species will need to be critically reviewed depending on the location.

Indicator species: The presence and abundance of indicator species serves as a measure of environmental conditions, the overall ecological condition or the state of an ecosystem. For example: dung beetles are sensitive

to habitat change (McGeoch, 2002) and some species tend to increase in abundance where there is increased shrub cover (Blaum et al., 2008). The abundance of dung beetles in certain areas could be used as a reliable indicator of ecosystem health. The presence of stone flies, dragonflies and damselflies indicates good water quality in aquatic ecosystems.

Umbrella species: Conserving umbrella species will indirectly result in the conservation of other species that occur in the same habitat. An umbrella species will usually occupy a habitat with a large range and populations of other species will occupy the same area although they are likely to have smaller distributional ranges. The presence of umbrella species indicates an ecosystem that is relatively intact and connected. For example: many of the top predators have large home ranges and can be used as umbrella species. Examples of umbrella species are honey badger and aardvark.

considered in situations where *in situ* conservation of threatened or protected species is already highly compromised before the land-use change takes place (for example in situations where there is extreme habitat fragmentation or severe degradation of the site to the point that there has been a loss of key ecological processes).

4.9.3.1. Search and Rescue of Flora

The translocation of 'rescued' plant material generally has a very low success rate and that material can be regarded as lost from the wild with high mortality rates to be expected. Search and rescue is not permitted for threatened plant species. However, for non-threatened plants, in instances where avoidance is not feasible, general guidance for search and rescue exercises is given below. Note that permits are required from the relevant authority before any threatened or protected species can be disturbed or removed.

1. The temporary storage of rescued plants in a nursery for future rehabilitation must be avoided if possible as this presents a risk of introducing exotic species and pathogens from nurseries into the wild. It is better to remove plants when they are dormant from the area to be disturbed and replant them immediately.
2. Thorough spatial demarcation of biodiversity priority areas, and other habitats that host threatened and/or protected species, as well as the location of the species during the pre-application and assessment phases should assist in developing a comprehensive understanding of what needs to be relocated.
3. A specialist botanical report must be prepared to provide detailed information regarding the rescue techniques, the preferred season of rescue and replanting, and suitable sites for relocation. This information should be used to appoint a contractor with the necessary skills to carry out the rescue operation.
4. A suitable receptor site must be identified and endorsed by the applicable conservation agency. The receptor site may be a site identified as part of the biodiversity offset, depending on the project in question and whether or not impacts have been avoided as per the mitigation hierarchy.
5. If a site will be disturbed and rehabilitated post-disturbance; focus on saving plants that are known to be successfully translocated (e.g. bulbs, succulents and aerial seed banks).
6. Mark bulbs in spring when they are in leaf or have flowers; transplant only once leaves have dried off.
7. Transplant bulbs in autumn (April–May).
8. Sow seed before the first heavy rains.
9. Transplant any other propagated material after the first heavy rains.
10. Prior to disturbance of an area, remove topsoil (at least the upper 150 mm) ideally with additional subsoil

(500 mm depth) during dry conditions. Do not work with wet soils.

11. Identify and avoid or minimise stressors to the relocated plant that would limit the success of its survival.
12. Replace topsoil as soon as disturbance in the area is complete, and plan for this to be done before the rainy season.
13. At recently burned sites, rescue seedlings by retaining soil sods ($\pm 30 \times 30 \text{ cm} \times 15 \text{ cm}$ deep) in trays, or transplant individual species into nursery bags.
14. Consider the viability of seeds over time.
15. Consider vegetation recruitment via the use of cuttings where possible.
16. Implement a three-year maintenance phase once topsoil/sods are translocated, to control AIPs that may thrive in response to the disturbance.
17. The best option for rescued plant material is to use it to rehabilitate or restore disturbed sites, or else remove them permanently to a botanical garden or nursery where continuous management measures can be applied to assist in their survival.

4.9.3.2. Search and Rescue of Animals

When a land-use activity will result in loss of habitat for fauna, the translocation of fauna will not mitigate the loss of natural habitat but could reduce the significance of the negative impacts of the impacting land-use activity. Search and rescue is not permitted for threatened fauna. However, for non-threatened fauna, the following recommendations are provided:

1. Search and rescue of non-threatened fauna can be supported if the operations are properly planned and implemented. In all cases, advice from suitable experts should be obtained to inform the search and rescue operation. Note that permits are required from the relevant authority before any threatened or protected species can be disturbed or removed.
2. General guidelines for planning of faunal search and rescue operations:
 - Move the animals to the closest, most suitable natural habitat. The habitat identified may form part of the biodiversity offset recommended to offset residual impacts.
 - Ensure that the receptor site consists of an adequate food supply (i.e. vegetation, invertebrates etc. as applicable to the rescued species) and water to avoid impacting the receptor site.
 - Suitable refugia for species must be available at the receptor site.
 - Ensure that breeding sites will be available for the translocated species.
 - Ensure that the site consists of a suitable number of predators and competitors to assist with population density control.

5

Appendices

5.1. Additional reading on the Albany Thicket Biome

5.1.1. Biogeography and description of Albany Thicket Biome

Definition

Subtropical Thicket, as found in the Albany Thicket Biome, is described by Vlok et al. (2003) as a 'dense canopy of largely evergreen shrubs and low trees (0.5–3.0 m) often straddled by woody lianas, and a sparse understorey of shade-tolerant herbs, mostly comprising geophytes and succulents, but also grasses. Large succulent shrubs may dominate the canopy (e.g. *Portulacaria afra* and *Crassula ovata*) or emerge from it (e.g. *Aloe* spp. and *Euphorbia* spp.). Overall, growth form diversity is very high.' In some areas thicket is so dense that it is impossible to walk through (solid thicket). Elsewhere it occurs as mosaic thicket where clumps of thicket vegetation are scattered within other kinds of vegetation. Vegetation clumping is a distinctive feature, strongly facilitated by below-ground animal activity. The vegetation structure is derived from an unusual combination of constituent growth forms, a co-dominance of large woody plants and dwarf shrubs which are often succulent.

Origin

Evidence suggests that thickets are extremely ancient, with the vast majority of the plant lineages characteristic of thicket vegetation probably emerging in the Eocene age (56–33 MYA) (Cowling et al., 2005), and include many floristic elements that are ancestors of the Cape and Succulent Karoo floras (Vlok et al., 2003). Subtropical thicket may have derived from the Tertiary forest flora of southern Africa that pre-dates the evolution of savanna and grassland. The biome is characterised by subtropical, semi-xeric conditions and it is thought that the typical Albany Thicket vegetation developed during the Eocene, when the climate was colder and drier than the current state. Evidence

suggests that the biome has existed in its current location for an uninterrupted geological period of time, although it may have expanded and contracted at various stages. The complexity of this relatively small geographical area with its characteristic plant species and long history makes this a region with some of the highest landscape-level diversity in the world. These factors make thicket a natural biogeographical laboratory and a flora of very high scientific interest.

Albany Thicket has unique climate, origins, dynamics, flora and vegetation which justifies its status as a biome. It is also in an area of climatic and environmental transition. The flora is therefore transitional across biomes that converge in the domain where the Albany Thicket Biome occurs. It has attracted scientific interest since the early days of botanical exploration in South Africa, but still remains enigmatic, with a scientific understanding of this region only beginning to emerge. The biome has undergone much conversion and degradation, and effective management of remaining areas is critically important to ensure its persistence and provisioning of ecosystem services.

Climate

Climatically it is a zone characterised by hot and humid summers and mild winters. Rainfall occurs throughout the year, with maxima in spring and autumn. There is no seasonal period of pronounced drought. Change to summer rainfall in a northeasterly direction corresponds with a shift to grassland and savannas; and to winter rainfall in a southwesterly direction to fynbos vegetation. Even with relatively high variation in rainfall and prolonged drought patterns, vegetation of the Albany Thicket Biome shows little annual fluctuation in its relatively high perennial cover; and is generally drought resistant. Thicket vegetation has high potential to capture and store carbon. The Albany Thicket Biome is defined on the basis of its unique climate and vegetation structural characteristics. It is largely associated with the non-seasonal rainfall zone of southern South Africa where copious rain or intense drought can occur at any time of the year, although spring and autumn are usually the high-rainfall periods. This lack of seasonality is very important in shaping the characteristics of the vegetation.

Biogeography

Albany Thicket has a unique phylogenetic and biogeographic origin, with thicket species having a strong subtropical Tongoland-Pondoland floristic affinity, but with transitional components with Cape, Karoo-Namib and Afromontane affinities (Cowling, 1984). Members of the Celastraceae, Ebenaceae and Anacardiaceae dominate the evergreen shrub component. There is relatively low regional endemism, comprising mainly succulent species of karroid affinity (Cowling, 1984). Vlok & Euston-Brown (2002), using a very narrowly-defined flora for the Albany Thicket Biome, calculated endemism at just over 20%, which they interpreted as supporting the definition of the subtropical thicket as a unique biome with its own intrinsic biodiversity. Levels of endemism within Albany Thicket are highest in Valley Thicket and the biome is globally renowned for its diversity of endemic succulents in the families Aizoaceae, Asphodelaceae, Crassulaceae, Euphorbiaceae and Apocynaceae.

Structure

Structurally, the vegetation is dominated by broad-leaved sclerophyllous shrubs, many of which have spines, and having a conspicuous woody vine and succulent component, especially in drier forms (Cowling, 1984). According to Vlok et al. (2003) the vegetation consists of a single stratum of woody plants and there is an absence of a well-developed grass component. Most canopy species regenerate by resprouting and the dominant canopy species are relatively shade-intolerant. Albany Thicket is associated with deepish, well-drained and relatively fertile soils (Cowling, 1984), although it is not limited to or restricted by any particular soil type.

Similar vegetation types

The Albany Thicket Biome is intermediate between the Forest Biome and the Savanna Biome, the vegetation having similarities to both. Thicket can be distinguished from savanna by the absence of a conspicuous grassy layer and from forest by being of lower height and lacking the many strata below the canopy. Savanna occurs where there is strong summer rainfall and a marked winter drought period, whereas thicket has a bimodal rainfall pattern and no strong seasonality, which is important for restricting the regular occurrence of fire. Forest occurs in very moist locations where it is completely protected from fire.

Globally there is vegetation with similar structure and climatic conditions that is analogous to that found in the Albany

Thicket Biome, and in southern Africa there is vegetation with similar structure, but different climatic conditions, that has been classified as distinct from Albany Thicket. It is important to understand what makes the subtropical thicket of the Albany Thicket Biome unique in comparison to these areas of similar vegetation:

- At least two other regions are analogous to the Albany Thicket Biome on a global scale, namely the thickets of the Chaco on the border between Argentina and Paraguay, and the spiny thickets of southern and south-western Madagascar, classified as 'deserts and xeric shrublands'. It has been suggested that other areas that could be considered to form part of a global subtropical succulent-rich biome may include Somali-Masai thickets (White, 1983), vine-thickets of Queensland in Australia (Webb, 1978) and succulent-rich thickets of northern Venezuela and Columbia (Matteucci, 1987).
- Thicket of the Eastern Cape is similar in structure to thicket found in the equatorial and tropical regions of Africa, but these are tropical and not subtropical vegetation types.
- There is other thicket vegetation in South Africa, typically the valley bushveld that occurs in the valleys of the east coast of South Africa, as well as Lowveld vegetation in northern KwaZulu-Natal and Swaziland that is similar to thicket from the Eastern Cape. The reasons thicket in the valleys to the northeast of the Great Kei River are not recognised as being part of the Albany Thicket Biome are that: a) there is a changeover at the Great Kei River from the characteristic bimodal to seasonal rainfall; b) there is a season of pronounced drought with dry winters that favours a regular fire regime typical of the Savanna and Grassland Biomes. This is accompanied by a change in species composition to the northeast to include typical winter-deciduous savanna species. The vegetation structure in these areas includes a distinct grassy field layer and vegetation dynamics are largely driven by fire, which is not the case with most forms of Albany Thicket.
- Other parts of South Africa where thicket is found include patches along the west coast and also embedded within the Grassland Biome in particular habitats. The thicket patches along the west coast of South Africa are in a winter rainfall region and they have their own distinctive flora, origins and dynamics, although they share some species with the Albany Thicket Biome. The karroid thickets occurring in patches within the Grassland and Nama-Karoo Biomes have a frost-tolerant, temperate flora that indicates a different origin to the Albany Thicket Biome.



Plate 21.—Key differences between vegetation of the Albany Thicket, Savanna and Forest Biomes (Source: CEN IEM Unit)

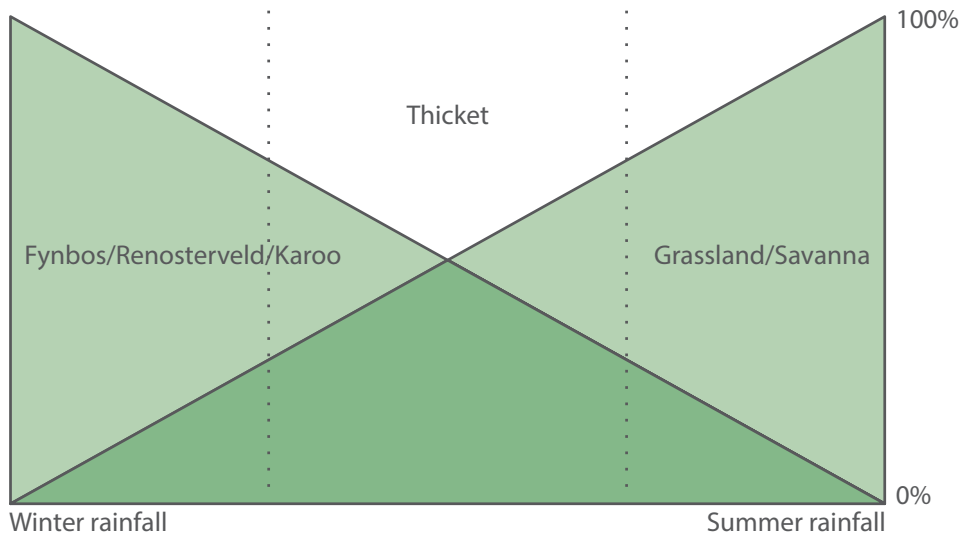


FIGURE 13.—Rainfall seasonality in relation to biome types (note that the diagram is conceptual, and ecosystems do not change in a linear or smooth manner as depicted by the straight lines).

5.1.2. Climate, Soils and Geology

Rainfall seasonality is a significant determining factor of thicket distribution. The biome occurs in a climatic interface between the winter rainfall region and the summer rainfall region. The rainfall in this area is bimodal but can occur at any time of the year. The balance between winter and summer rainfall never exceeds a ratio of 1:1 within the region (see Figure 13). Where more than 50% of the rain occurs in the winter, such as towards the western extreme of the biome, thicket becomes fragmented and displaced by renosterveld or fynbos. Where there is more than 60% summer rainfall in the northeastern part of the biome, there is similar fragmentation and a changeover to savanna or grassland. The climate is not the selective force for this pattern, but rather the fire regimes that accompany the seasonal precipitation.

Rainfall within the Albany Thicket Biome is unreliable and is one of the most important factors determining variance in vegetation patterns within the Albany Thicket Biome. The average coefficient of variation in annual rainfall is between 25 and 36%. It may be as low as 18% at the coast (more reliable) and as high as 40% in Gamka Thicket. Droughts of several months are common. Thicket species are strongly adapted to these conditions, with a high degree of succulence and sclerophylly (having hard leaves), deep-rooting in larger trees and shrubs, C_3 and Crassulacean Acid Metabolism (CAM), and storage organs being common.

Many species are slow-growing. At the coast, where rainfall is usually higher and more predictable, growth rates are higher, and there is less succulence and leaf sclerophylly. Rainfall may vary from about 200 mm on the inland fringes of Arid Thicket to a maximum of 1 050 mm in Dune Forest mosaics in the southeast. This means that within the Albany Thicket Biome, there is a strong gradient from highly arid to very moist.

The Albany Thicket Biome is a subtropical biome and is largely restricted to areas that do not experience frequent frost. The temperature regime is not extreme, except for

parts of the Arid Thicket Ecosystem Group, where absolute maximum summer temperatures may exceed 50°C. Frost is rare and lowest mean minima range between 1°C in the Escarpment region to 8°C in Arid Thicket. Subtropical thicket is seldom found above 1 000 m elevation, which is associated with a reduction in mean temperatures and an increased incidence of frost, the latter of which probably limits the occurrence of subtropical thicket.

Thicket grows on a variety of geological types, including quartzitic sandstones of the Cape system that usually generate highly infertile soils. Thicket is usually associated with nutrient-rich soils, but this may be more a consequence of plant-induced soil enrichment than parent material. Organic detritus from nutritious foliage, in combination with adequate moisture and an absence of fire, leads to soil enrichment.

5.1.3. Fire and Herbivory

There is a strong association with fire-protected sites (Vlok et al., 2003) and thicket is eventually lost in areas that are burnt at a high frequency. A combination of low availability of fuel and the high degree of succulence largely excludes fire from the biome (although this will not hold true for degraded thicket where a flammable field layer often replaces the non-flammable succulent component).

Fire is required periodically to open gaps on extensive stands of thicket vegetation, which is important for maintenance of biodiversity. In the wetter parts of the biome where the proportion of summer rainfall is at its highest, infrequent fire has led to displacement of grassland by woodland. Where fire intensity is low, but frequency high, only individual woody trees or shrubs survive within a matrix of grassland, so thicket consolidation does not occur. Where thicket vegetation occurs as a mosaic with other vegetation types, such as fynbos, grassland or savanna, it is strongly associated with fire-protected sites.

Herbivores play an important role in maintaining the richness of different growth forms. The Albany Thicket Biome can support a high diversity and density of herbivores, and herbivory has played an important role in shaping vegetation and ecosystem properties. Large herbivores are the major source of natural disturbance (Vlok et al., 2003). Without disturbance, thicket vegetation is relatively impenetrable, but large animals such as African bush elephant open up tracks that permit access to other animals. Elephants also encourage coppicing in woody shrubs and have a positive effect on the structure and growth of spekboom (*Portulacaria afra*), one of the keystone species of the biome. Indigenous herbivores are critically important for seed dispersal of thicket species. Clumping of vegetation appears to be strongly facilitated by below-ground animal activity, including termite mounds, mole-rat colonies, aardvark burrowing and earthworm activity.

Indigenous herbivores are important for maintaining the structure and diversity of thicket vegetation. Browsing by large herbivores encourages coppicing of shrubs, which maintains structure, composition and productivity of thicket vegetation. In contrast, domestic livestock, especially goats, damage the vegetation through grazing and browsing. The top-down feeding behaviour of African elephant encourages thicket shrubs, especially *Portulacaria afra*, to spread laterally through the formation of a 'skirt'. Goats tend to eat

into the vegetation from the side, opening it up and changing microclimatic conditions that then lead to deterioration of thicket patches. Goats are gregarious animals that have a high local impact in their feeding activities, whereas indigenous herbivores feed in a more diffuse pattern. Indigenous herbivores are important seed dispersers for a large variety of thicket species, unlike domestic livestock.

Thicket has a high standing biomass, but low annual production. It takes long periods for the main forage species to recover from the effects of over-utilisation by domestic livestock, up to 18 months to recover from 50% defoliation. This can be exacerbated by periods of drought, which are a common feature of the climate of the Albany Thicket Biome.

Important indigenous mammalian herbivores in the Albany Thicket Biome include African bush elephant, black rhinoceros, greater kudu, Cape buffalo, common eland and Cape bushbuck. Others that occur within thicket vegetation include blue duiker, bushpig and common duiker.

In places, there is strong clumping of vegetation, which is facilitated by below-ground animal activity, including termite mounds, mole rat (of the family Bathyergidae) colonies, aardvark burrows and earthworm activity. These clumps show elevated levels of carbon, nutrients, organic and moisture content in comparison with adjacent soils.

5.1.4. Geographical Distribution of the Albany Thicket Biome and ecosystem groups per municipality.

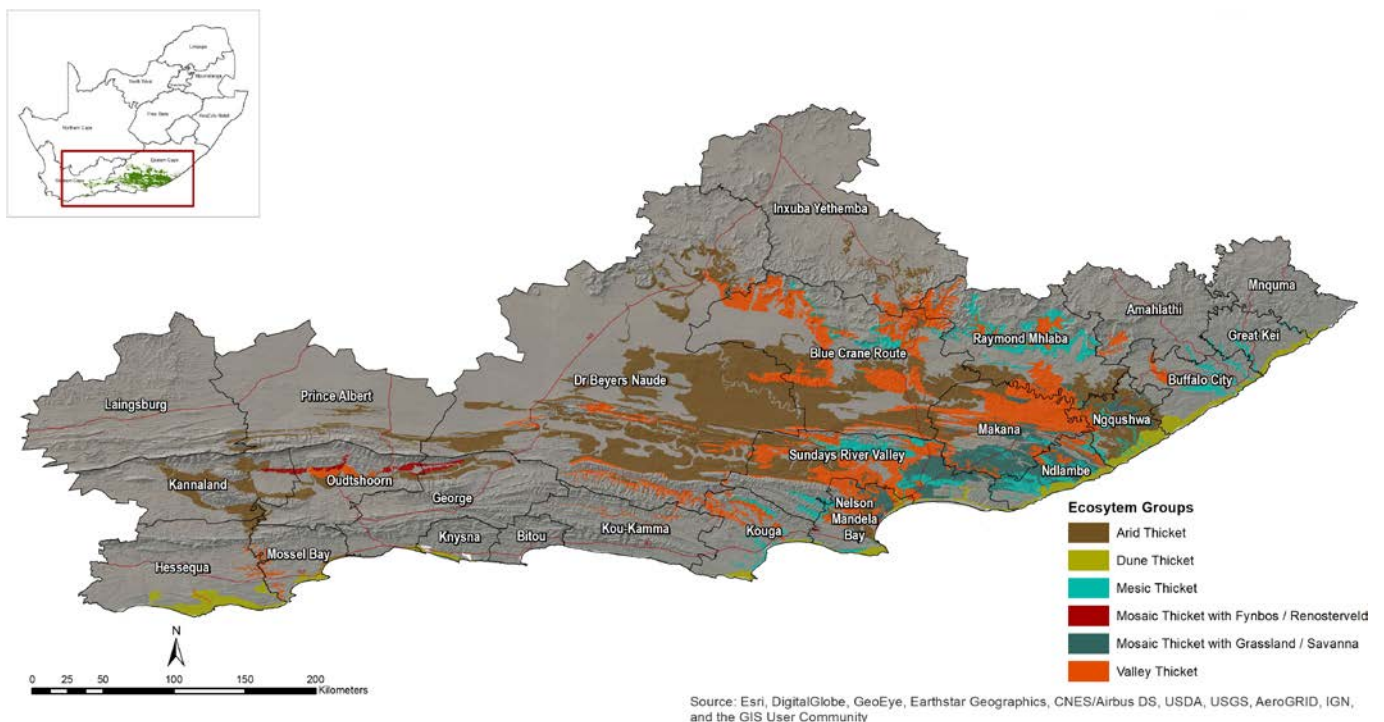


FIGURE 14.—All ecosystem groups per municipality.

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TABLE 14.—Ecosystem groups per Municipality (continued).

Province	District Municipality	Local Municipality	Applicable Ecosystem Groups
Eastern Cape	Amathole	Amahlati	Mesic Thicket Valley Thicket
		Raymond Mhlaba	Valley Thicket Mesic Thicket Arid Thicket Thicket–Grassland & Savanna Mosaics

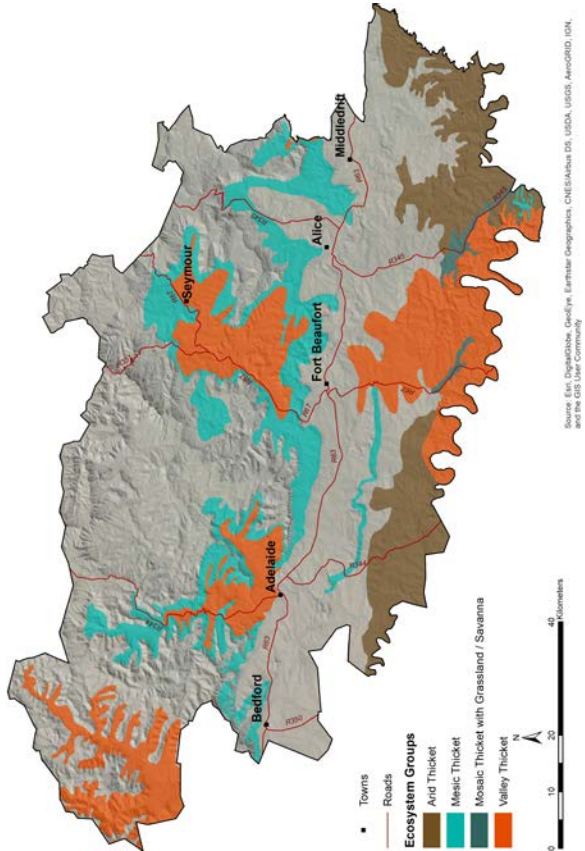
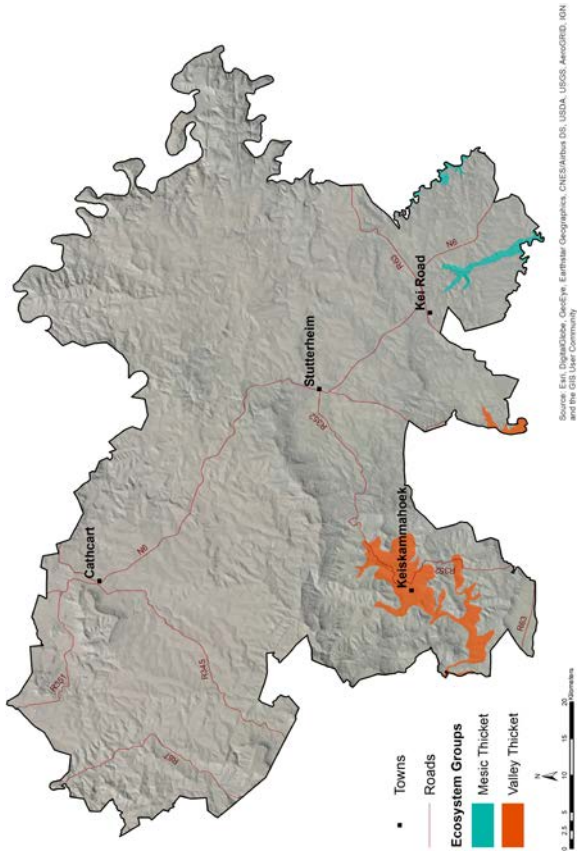


TABLE 14.—Ecosystem groups per Municipality (continued).

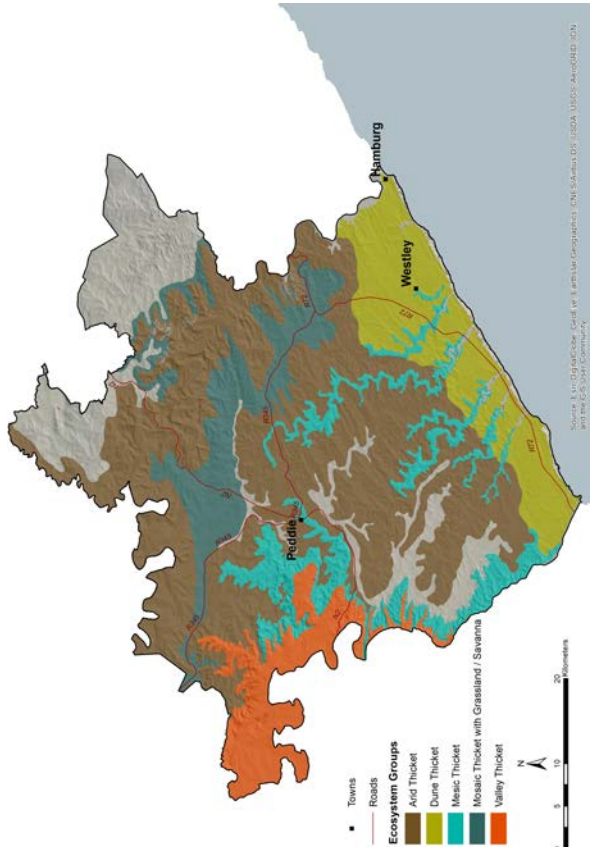
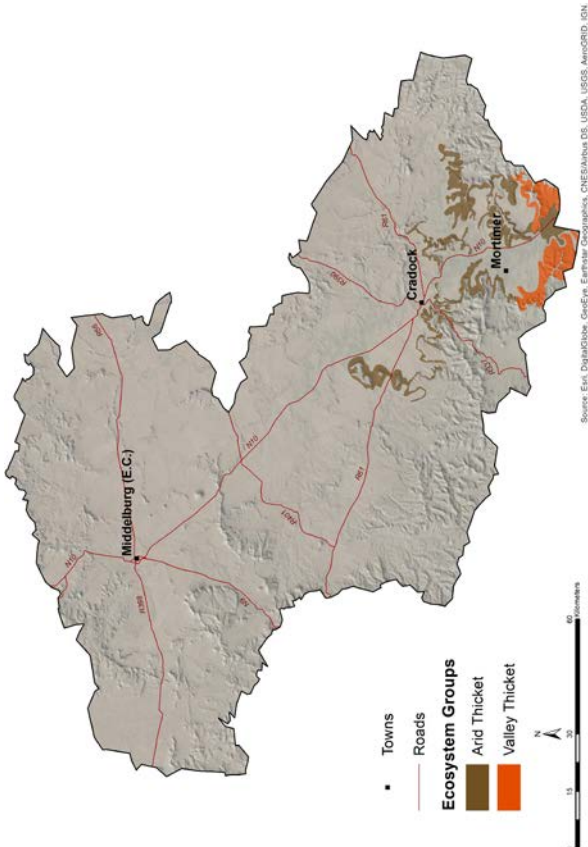
Province	District Municipality	Local Municipality	Applicable Ecosystem Groups
Eastern Cape	Amathole	Ngqushwa	Arid Thicket
			Thicket–Grassland & Savanna
			Mosaics
			Dune Thicket
			Mesic Thicket
			Valley Thicket
			
	Chris Hani	Inxuba Yethemba	Valley Thicket
			Arid Thicket
			

TABLE 14.—Ecosystem groups per Municipality (continued).

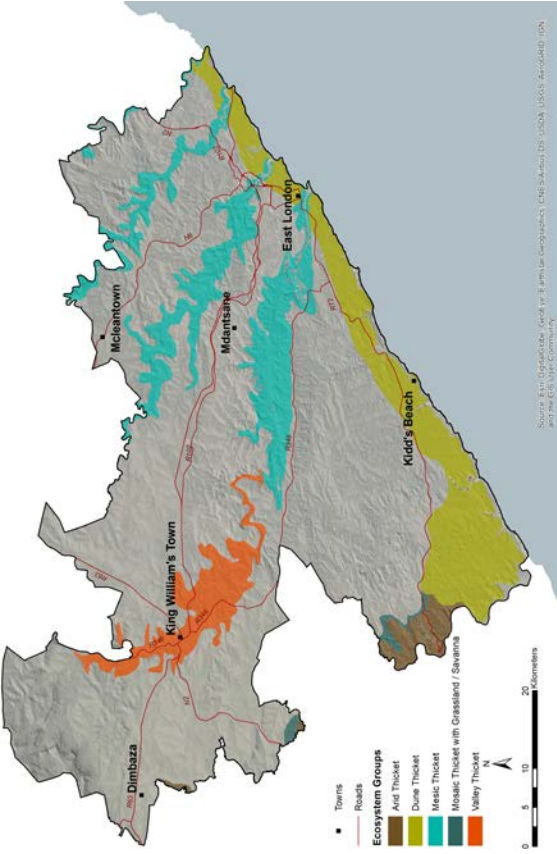
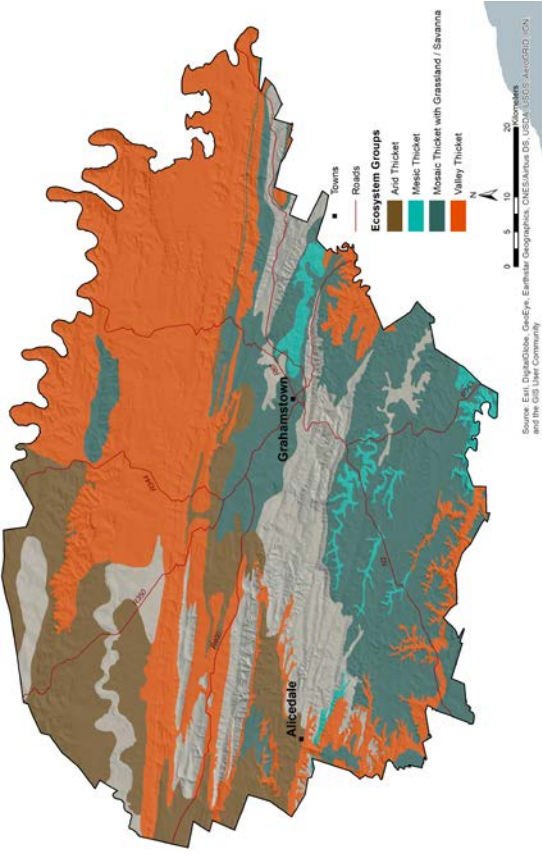
Province	District Municipality	Local Municipality	Applicable Ecosystem Groups
Eastern Cape	Buffalo City	Buffalo City	Dune Thicket Mesic Valley Thicket Arid Thicket Thicket–Grassland & Savanna Mosaics
			
	Makana	Cacadu/Sarah Baartman	Thicket–Grassland & Savanna Mosaics Mesic Thicket Valley Thicket Arid Thicket
			

TABLE 14.—Ecosystem groups per Municipality (continued).

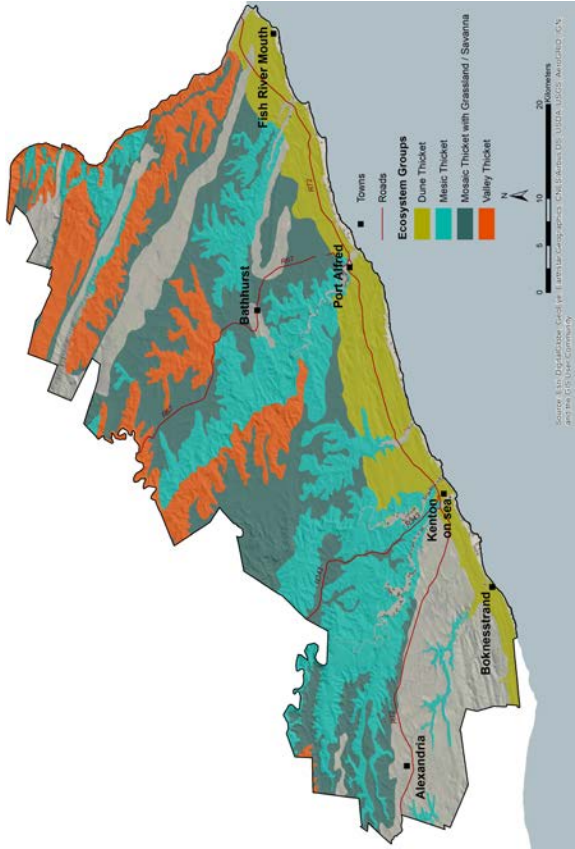
Province	District Municipality	Local Municipality	Applicable Ecosystem Groups
Eastern Cape	Cacadu/Sarah Baartman	Ndlambe	Valley Thicket Mesic Thicket Dune Thicket Thicket–Grassland & Savanna Mosaics
			
	Sundays River Valley		Mesic Thicket Thicket–Grassland & Savanna Mosaics Valley Thicket Dune Thicket Arid Thicket
			

TABLE 14.—Ecosystem groups per Municipality (continued).

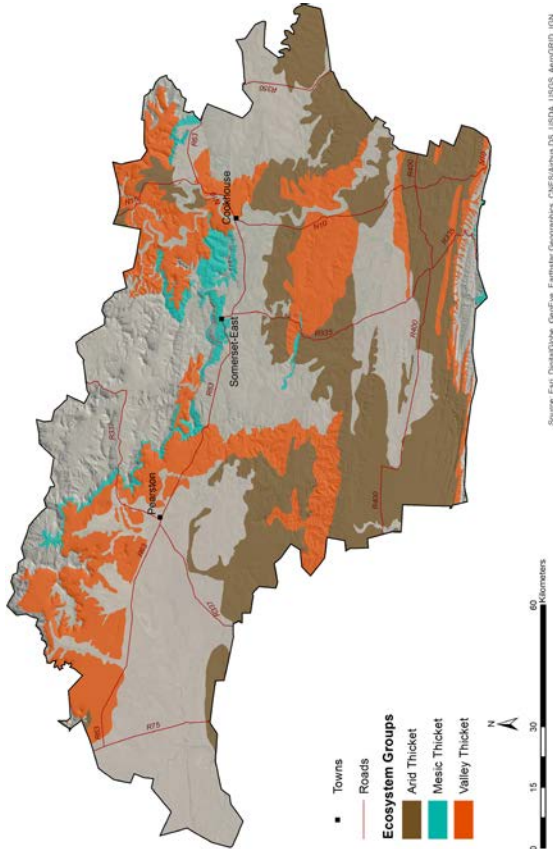
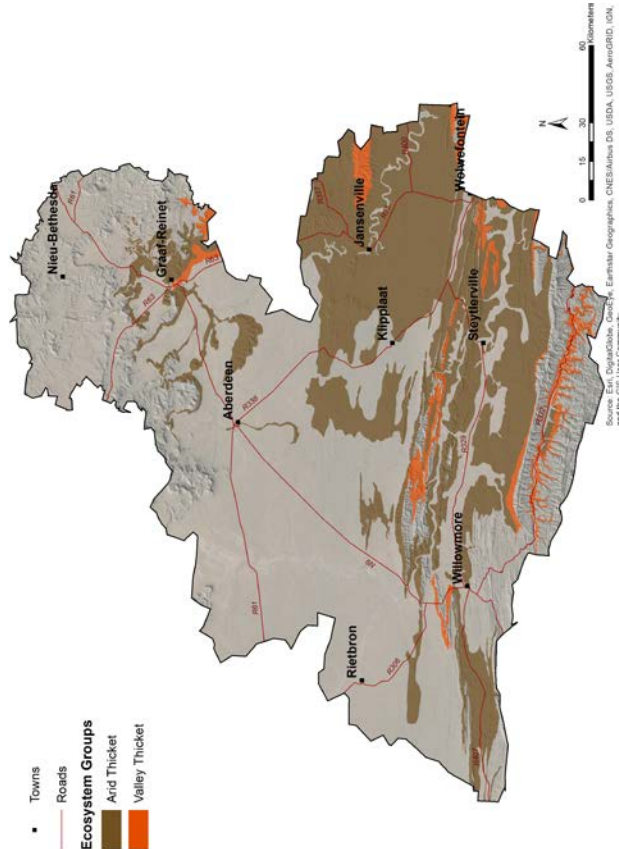
Province	District Municipality	Local Municipality	Applicable Ecosystem Groups
Eastern Cape	Cacadu/Sarah Baartman	Blue Crane Route	Mesic Thicket Thicket–Grassland & Savanna Mosaics Valley Thicket Arid Thicket
			 Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
	Dr Beyers Naude (previously iKwezi)		Valley Thicket Arid Thicket
			 Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

TABLE 14.—Ecosystem groups per Municipality (continued).

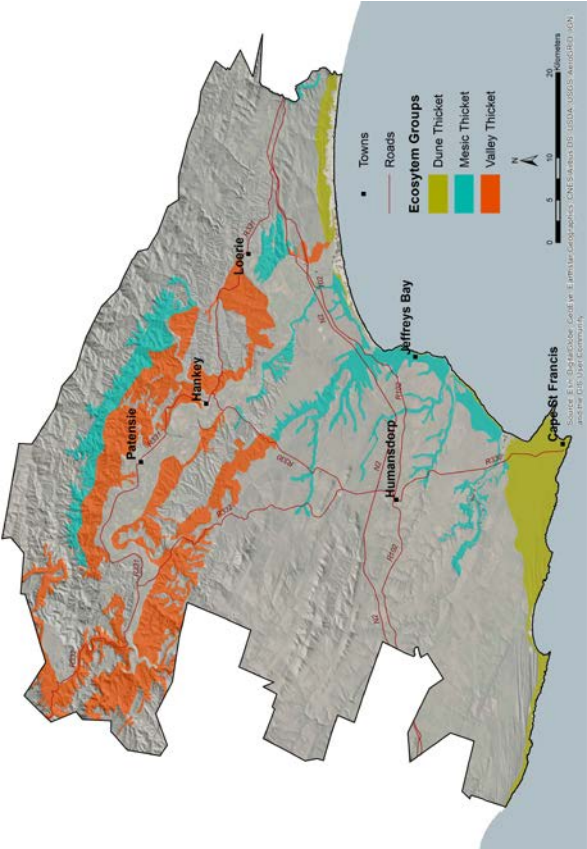
Province	District Municipality	Local Municipality	Applicable Ecosystem Groups
Eastern Cape	Cacadu/Sarah Baartman	Kouga	Mesic Thicket Valley Thicket Dune Thicket
			
	Kou-Kamma		Valley Thicket Dune Thicket
			

TABLE 14.—Ecosystem groups per Municipality (continued).

Province	District Municipality	Local Municipality	Applicable Ecosystem Groups
Eastern Cape	Nelson Mandela Bay	Nelson Mandela Bay	Thicket–Grassland & Savanna Mosaics
			Arid Thicket
			Mesic Thicket
			Valley Thicket
			Dune Thicket
Western Cape	Eden	Bitou	Dune Thicket
			Dune Thicket

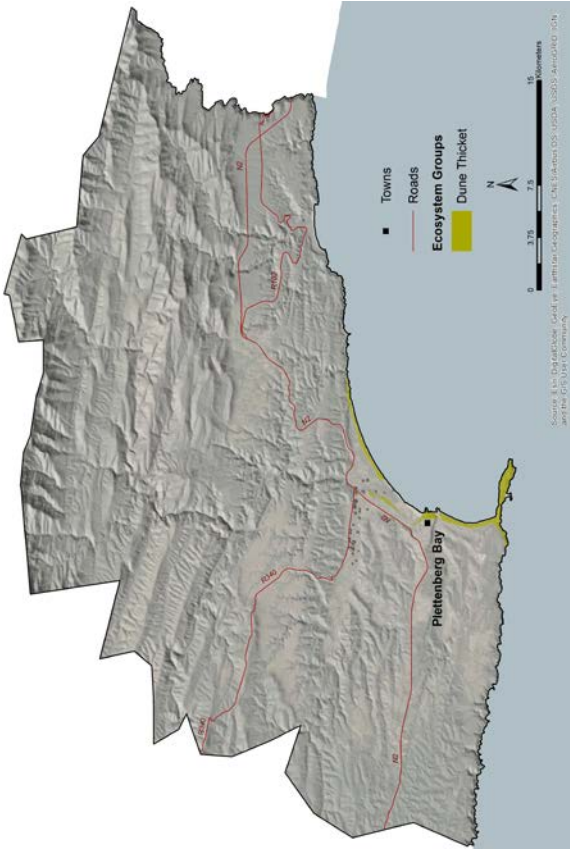
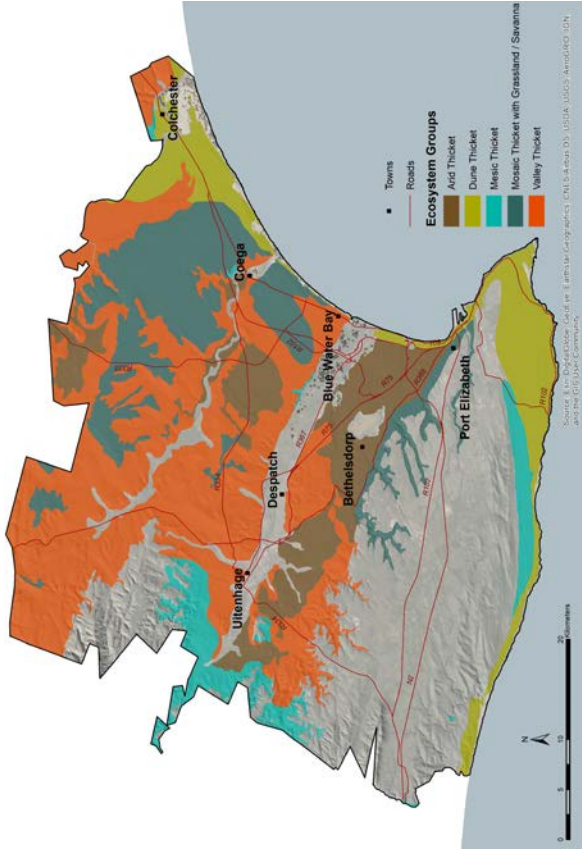


TABLE 14.—Ecosystem groups per Municipality (continued).

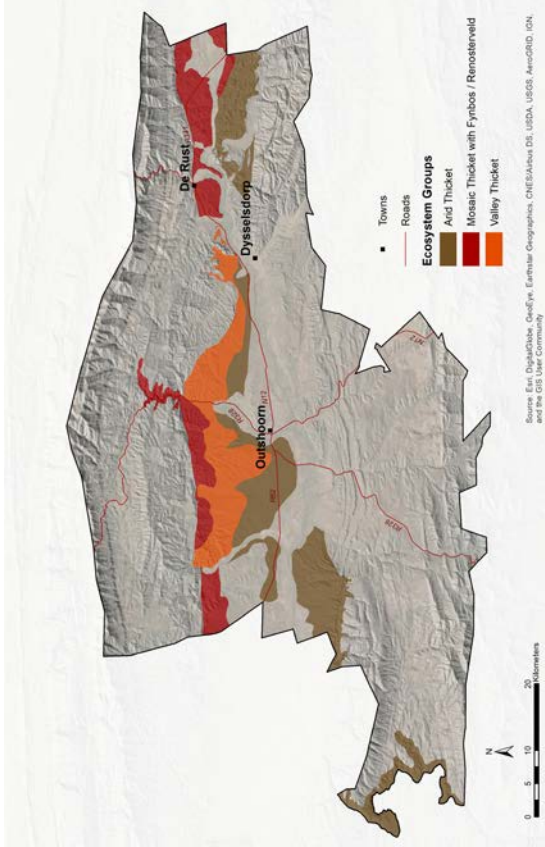
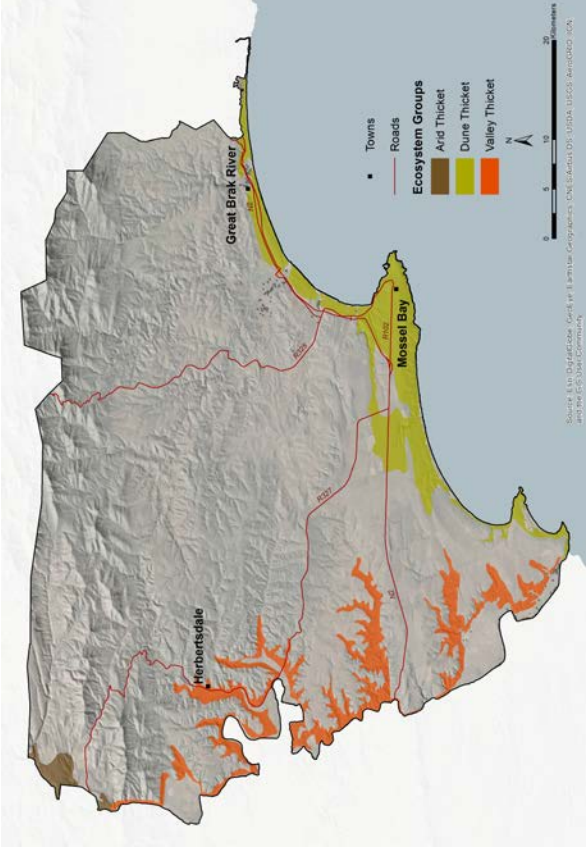
Province	District Municipality	Local Municipality	Applicable Ecosystem Groups
Western Cape	Eden	Oudtshoorn	Arid Thicket Valley Thicket Thicket-Fynbos Mosaic
			
		Mossel Bay	Arid Thicket Valley Thicket Dune Thicket
			

TABLE 14.—Ecosystem groups per Municipality (continued).

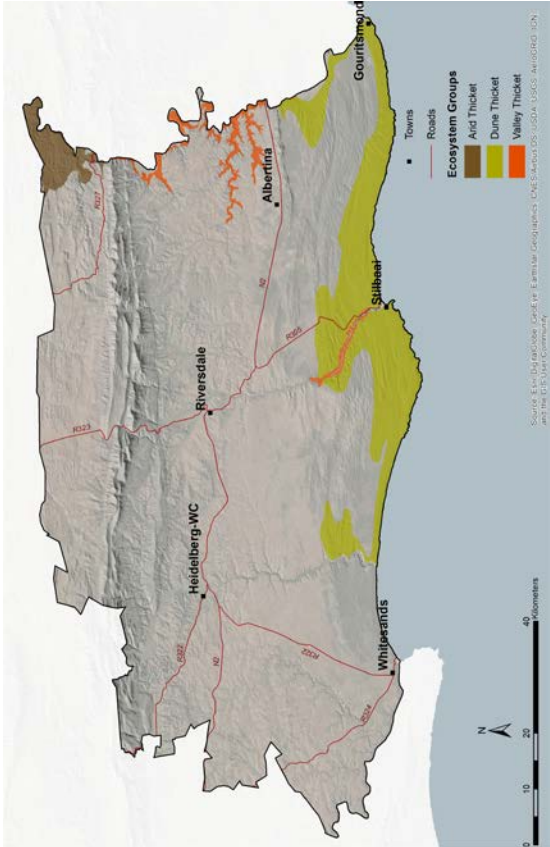
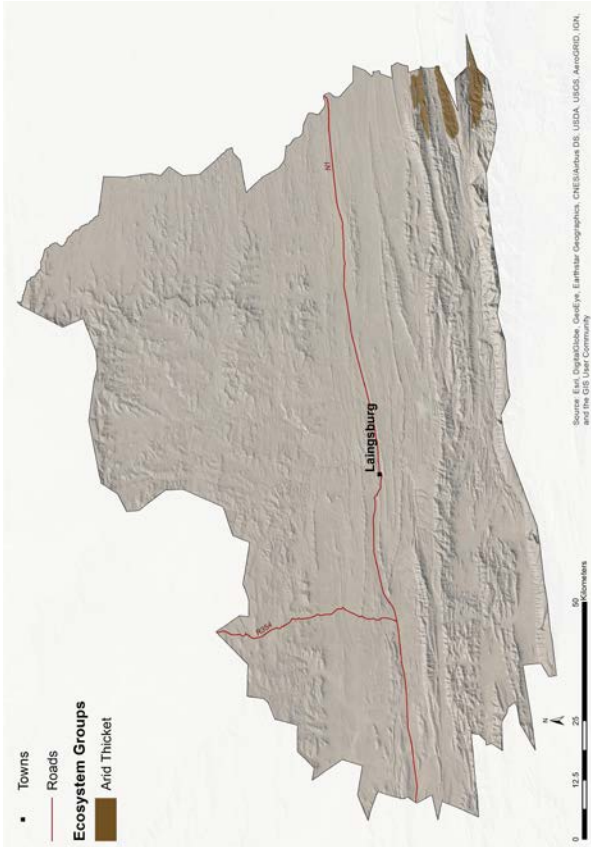
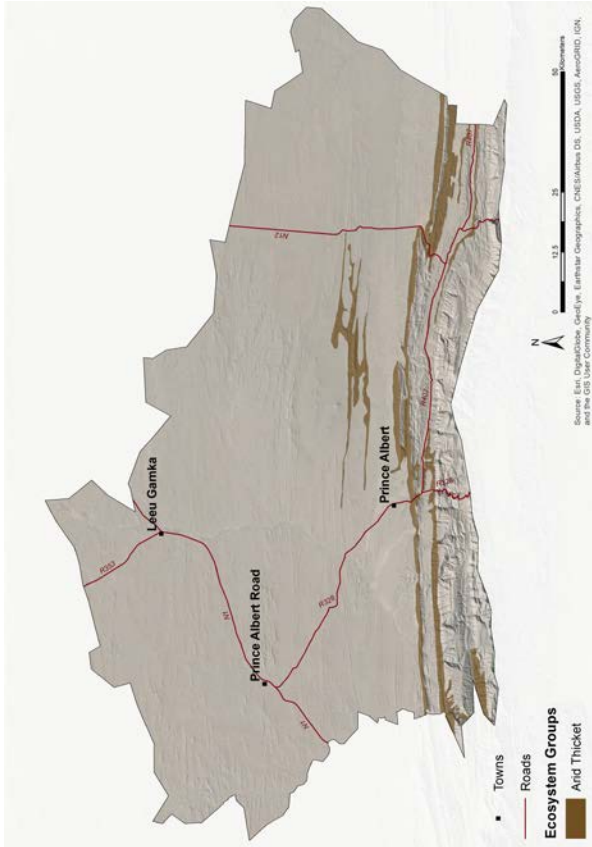
Province	District Municipality	Local Municipality	Applicable Ecosystem Groups
Western Cape	Eden	Kannaland	Arid Thicket Thicket–Fynbos Mosaic
			
Hessequa	Hessequa	Hessequa	Valley Thicket Dune Thicket
			

TABLE 14.—Ecosystem groups per Municipality (continued).

Province	District Municipality	Local Municipality	Applicable Ecosystem Groups
Western Cape	Central Karoo	Prince Albert	Arid Thicket
		Laingsburg	Arid Thicket



5.1.5. Summary of Ecological Drivers of Albany Thicket Ecosystem Groups

TABLE 15.—A summary of distinguishing features, and common ecological drivers, and general recommendations for the ecosystem group in the Albany Thicket Biome.

Ecological Drivers	Dune Thicket	Mesic Thicket	Valley Thicket	Arid Thicket	Thicket Mosaic with Grassland/ Savanna	Thicket Mosaic with Fynbos/ Renosterveld
Wind	✓					
Dune succession and sediment dynamics	✓					
Rainfall The amount of annual rainfall, as well as the season in which it occurs, are important factors in determining thicket characteristics. Thicket occurs in landscapes with widely differing amounts of annual rainfall, but only occurs in areas where the proportion of winter to summer rainfall is approximately even, or where the proportion of annual rainfall falling in winter (April to August) is at least equal to or greater than 20%. The season of rainfall is important and leads to a gradual change in floristic composition across the biome with distance from the southwest to the northeast, with a corresponding increase in the proportion of subtropical species. Increased summer rainfall increases the C ₄ grassy component of thicket, which can induce other changes, such as an increased likelihood of fire.	✓	✓	✓	✓	✓	✓
Seed Dispersal Many thicket species bear fleshy fruits that are bird or animal dispersed. Dispersal of these fruits and seeds by animals, especially birds, results in the development of bush clumps around solitary perch sites such as pioneer trees and termite mounds. Bush clumps enlarge and, depending on local site conditions, eventually coalesce into dense thickets. The establishment of pioneer thicket communities or the diversification of existing thicket are therefore critically dependent on dispersal of propagules by animals.	✓	✓	✓	✓	✓	✓
Landform (topography, geology, soils) Soil (structure and drainage) has a strong relationship with microhabitats, which are important drivers of thicket diversity. The variability in terrain and change in soils across the landscape has bearing on changes in thicket vegetation composition.	✓	✓	✓	✓	✓	✓
Herbivory Regular defoliation (browsing) by a wide range of herbivores has been an integral part of thicket evolution and is thought to have led, amongst other things, to the predominance of spiny plants that characterise most thicket vegetation types. Large herbivores (such as African elephant and black rhinoceros and some of the larger ungulates) are important for maintaining the matrix habitat between thicket bush clumps, whilst small herbivores such as tortoises play an important role in influencing the abundance of low-growing succulents and geophytes through selective herbivory. Herbivory is relatively less important in Mesic Thicket, for example, as growth rates are high and plants have the ability to outgrow the reach of herbivores.		✓	✓	✓	✓	✓

TABLE 15.—A summary of distinguishing features, and common ecological drivers, and general recommendations for the ecosystem group in the Albany Thicket Biome (continued).

Ecological Drivers	Dune Thicket	Mesic Thicket	Valley Thicket	Arid Thicket	Thicket Mosaic with Grassland/ Savanna	Thicket Mosaic with Fynbos/ Renosterveld
Fire (with herbivory and alien vegetation) Fire and its interplay with herbivory is an important driver in thicket ecosystems. Solid thicket is generally fire-resistant, but any alteration to the natural fire regime can have harmful effects on thicket ecosystems. Fire in adjacent habitats, such as grassland, savanna or fynbos, are important for maintaining the thicket boundaries and also lead to the formation of mosaics with surrounding vegetation. Solid or uniform thicket tends to be associated with topographically-determined fire refugia (fire-safe places such as deep kloofs, cliffs and scree slopes) or climatically-determined fire-refugia (which are those areas that are too arid to support flammable vegetation). Heavy grazing can reduce fuel loads, resulting in less intense, more slow-moving fires that allow the establishment and spread of thicket clumps. Overstocking of game and domestic livestock on farms may lead to a reduction in the succulent component of thicket, and replacement with a more flammable field layer which increases the risk of fire. Vegetation structural composition can influence the probability and/or intensity of fire. Invasion by woody invasive alien species can increase the frequency and intensity of fires, with harmful effects on thicket vegetation. Albany Thicket is considered to be a serial successional stage between grassland and forest, with transformation of grassland beginning when the fire frequency and intensity is lowered, possibly due to heavy grazing by domestic livestock. Fire is therefore an important ecological driver maintaining vegetation structure and pattern.	✓ Occurs in fire refugia areas. Can occur in a mosaic with fire-dependent vegetation types (e.g. fynbos)	✓ Occurs in fire refugia areas	✓ Occurs in fire refugia areas	✓ Occurs in fire refugia areas. Low likelihood of burning as fires do not penetrate arid basins	✓ Fire driven	✓ Fire driven
Soil nutrient dynamics Leaf litter and decomposition of vegetation matter provide an important source of organic carbon for improving the soil nutrient status, which provides conditions for the establishment of additional species. Retaining the leaf litter is of vital importance to retaining thicket vegetation, since this mulch layer has important water retaining properties, as well as allelopathic properties that prevent grasses from establishing under bush clumps, which would make fires more likely.	✓	✓	✓	✓	✓	✓
Deposition and decomposition of organic material Organic detritus, such as leaf litter and fallen branches, increases the soil organic content and creates a layer of humus. In dense thicket this leads to dynamics similar to what occurs on the floor of forests where litter falls on the ground and is decomposed and mineralised after which it becomes available again for uptake by plants. Leaf litter and decomposition of vegetation matter provide an important source of organic carbon for improving the soil nutrient status, which provides conditions that maintain the existing vegetation. Retaining the leaf litter is of vital importance to retaining thicket vegetation, since this mulch layer has important water retaining properties, as well as being an important carbon sink. Removal of thicket vegetation and conversion to other land uses, such as agriculture, often leads to the loss of this soil carbon and humus content, which then makes it difficult for thicket to become re-established.	✓	✓	✓	✓	✓	✓
Spatial linkages to other vegetation types There are various ecological processes that are dependent on linkages to other natural vegetation, including seed dispersal and pollination, as well as animal migration. Fragmentation can break these linkages and the artificial boundaries that are created can introduce various detrimental effects on thicket vegetation, including large changes in abiotic conditions. There is also a spatial relationship between thicket and surrounding vegetation in areas where thicket occurs as a mosaic.	✓	✓	✓	✓	✓	✓

TABLE 15.—A summary of distinguishing features, and common ecological drivers, and general recommendations for the ecosystem group in the Albany Thicket Biome (continued).

Ecological Drivers	Dune Thicket	Mesic Thicket	Valley Thicket	Arid Thicket	Thicket Mosaic with Grassland/ Savanna	Thicket Mosaic with Fynbos/ Renosterveld
Ecosystem engineers <i>Portulacaria afra</i> has recently been referred to as an ‘ecosystem engineer’ because of the critically important role it plays in thicket restoration and promoting the recruitment of other thicket species. This characteristic thicket plant also resists droughts and floods and encroachment by fire from neighbouring landscapes dominated by grassland and savanna. The importance of the plant lies in its ability to accumulate biomass in excess of what would be predicted by rainfall levels through the physiological decoupling of production from water availability.			✓	✓		

5.2. Overview of Key Biodiversity Plan and Relevant Legislation and Policy

TABLE 16.—Differentiation between Key Biodiversity Plans and their application.⁶

Tool/Plan	Scale	Application
National Biodiversity Assessment (NBA) 2018 http://nba.sanbi.org.za	National	The NBA assesses and reports on the state of biodiversity in the country which is important to understand trends and inform policy and decision-making. Genes, species and ecosystems are dealt with across terrestrial, freshwater, estuarine, coastal and marine realms. The assessment is spatially explicit and focusses on threat status and protection levels for ecosystems and species. Information is available as a set of technical reports for each realm and a summary synthesis report, with accompanying data, maps and metadata. These are publicly available on SANBI's Biodiversity Adviser and BGIS websites. The NBA is a key reference for scientists, consultants, decision-makers etc. and serves as a platform for information sharing in the biodiversity sector.
NEMBA List of Ecosystems that are threatened and in need of protection (GN 1002 of 2011) (Please note that steps are underway to replace this list with updated information in 2021. Always ensure that the most recent published list is referenced).	National	Listed Threatened Ecosystems are referenced in Listing Notice 3 of the Environmental Impact Assessment (EIA) Regulations of the National Environmental Management Act (NEMA).
Biodiversity Sector Plans (BSP)/ Provincial Conservation Plans/ Systematic Biodiversity Plans	Usually developed for a province, district or metro municipality, but can be for a local municipality	A map of Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) and supporting information in the form of land- and resource-use guidelines and GIS data. Maps and information are used in land-use planning, and environmental assessment to inform decisions around areas that should ideally be managed for biodiversity conservation and/or compatible land-use types (as per the suggested land-use guidelines). A BSP is the biodiversity sector's input into planning and decision-making in a range of other sectors. CBAs and ESAs are incorporated into municipal Spatial Development Framework (SDF) Plans and Integrated Development Plans (IDPs) for forward proactive planning. They can also be used in proactive conservation, for example to prioritise stewardship sites, protected areas expansion, and areas where alien vegetation clearing should be focused. CBAs and ESAs are frequently referenced in Listing Notice 3 of the EIA Regulations of NEMA.
Bioregional Plans (BRP)	Municipal	A BRP is usually developed for a district or metropolitan municipality but could be developed for a local municipality or group of local municipalities. It represents the biodiversity sector's input into planning and decision-making in a range of other sectors. A BRP is always based on an underlying systematic biodiversity plan. In order to be published as a BRP, the CBA map must go through a consultation process to ensure it is consistent with other relevant municipal plans and frameworks.
Ecosystem Guidelines	Area where the biome occurs	Consult guidelines to understand the characteristics and functioning of biodiversity in the area of interest, and to determine how best to manage biodiversity on a local and landscape scale. Ecosystem Guidelines to be used in conjunction with above biodiversity tools and plans to guide land-use planning, with biodiversity management in mind. At the time of finalising this document, Ecosystem Guidelines are available for Fynbos, Grassland, Albany Thicket and Savanna Biomes.

⁶ The reader must ensure they use the most up to date plans for assessment and decision making, as these will contain current/recent scientific literature and approaches.

5.2.1. Constitution of South Africa (1996)

Environmental Rights and the need for sustainable development are enshrined in Section 24 of the Constitution:

Section 24. Everyone has the right (a) to an environment that is not harmful to human health or well-being and (b) to have the environment protected for the benefit of present and future generations, through reasonable legislative and other measures that (i) prevent pollution and ecological degradation; (ii) promote conservation; and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

Modification to and loss/degradation of biodiversity priority areas would, for example, be in conflict with the

Constitutional requirement for 'ecologically sustainable development'.

5.2.2. Environmental legislation

South Africa is subject to numerous international obligations and commitments. Ratification becomes entrenched in national legislation and informs national priorities and programmes in the country. Examples include the Kyoto Protocol, acceded to by South Africa in 2002. The Protocol aims to reduce air pollution responsible for global warming and requires signatory countries to reduce their carbon dioxide (CO₂) and other greenhouse gas emissions with target percentages and dates. Other examples include the Convention on Biological Diversity (CBD) and the Convention on Wetlands (Ramsar Convention).

5.2.3. National environmental legislation

A list of relevant environmental legislation applicable to land-use planning and biodiversity management in South Africa is given below.

TABLE 17.—Environmental legislation relevant to land-use planning and biodiversity management.

National Environmental Management Act and the EIA Regulations	
National Environmental Management Act (Act No. 107 of 1998) (NEMA)	The NEMA is the framework to enforce Section 24 of the Constitution. The NEMA provides for co-operative environmental governance by establishing principles for decision-making on matters affecting the environment. These principles apply to the actions of all organs of state that may significantly affect the environment. The NEMA is the overarching piece of legislation dealing with environmental matters, from which other Acts that cover specific environments stem (i.e. Specific Environmental Management Acts (SEMA)). These are inserted below.
The EIA Regulations 2014, as amended (GN R 324, GN R 325, GN R. 327) published in terms of NEMA	The EIA process has been developed and legislated to manage the impact of development on the environment. The EIA regulations list activities and identify competent authorities under sections 24(2), 24(5) and 24D of the NEMA, where environmental authorisation is required prior to commencement of that activity.
NEMA Financial Provisioning Regulations 2015 (R1147)	Requires financial provision for management, rehabilitation and remediation of environmental impacts from prospecting, exploration, mining or production operations through the lifespan of such operations and latent or residual environmental impacts that may become known in the future.
Specific Environmental Management Acts (SEMA) Developed under NEMA, which means that NEMA and the principles of NEMA apply	
National Environmental Management: Protected Areas Act, 2003 (Act No. 57 of 2003), as amended, 2014 ('Protected Areas Act')	The Protected Areas Act provides for the protection of ecologically viable areas and the establishment of a national register of all protected areas (PAs) and for the management of those areas in accordance with national norms and standards. The types of PAs included: (a) special nature reserves, national parks, nature reserves (including wilderness areas), protected environments; (b) world heritage sites; (c) marine PAs; (d) specially protected forest areas, forest nature reserves and forest wilderness areas declared in terms of the National Forests Act, 1998 and (e) mountain catchment areas declared in terms of the Mountain Catchment Areas Act, 1970. PAs identified in terms of the Protected Areas Act are referred to in the NEMA 2014 EIA Regulations. The Protected Areas Act must be read in conjunction with the Biodiversity Act.

TABLE 17.—Environmental legislation relevant to land-use planning and biodiversity management (continued).

Specific Environmental Management Acts (SEMA) Developed under NEMA, which means that NEMA and the principles of NEMA apply (continued)	
National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004: 'Biodiversity Act')	The Biodiversity Act aims to provide for the management and conservation of South Africa's biodiversity within the framework of NEMA to give effect to ratified international agreements that are binding on South Africa, and the need to protect the ecosystem as a whole, including species that are not targeted for exploitation. The focus of this legislation is on the preservation of species and ecosystems that are threatened or in need of protection. A person may not carry out a restricted activity involving a specimen of a listed threatened or protected species without obtaining a permit (issued in terms of Chapter 7 of the Act). The Act provides for biodiversity planning through the development of a National Biodiversity Framework (NBF), BRPs, and Biodiversity Management Plans. The Alien and Invasive Species Lists and Regulations published in terms of the Biodiversity Act are used for the management of Listed Alien and Invasive Species.
National Environmental Management Waste Act, 2008 (Act No. 59 of 2008: 'Waste Act')	The Waste Act regulates waste management to prevent pollution and ecological degradation and provide for the licensing and control of waste management activities and the remediation of contaminated land.
National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004), as amended, 2014 ('Air Quality Act')	The Air Quality Act aims to reform the law regulating air quality, provide reasonable measures for the prevention of pollution and ecological degradation, secure ecologically sustainable development while promoting justifiable economic and social development, and provide national norms and standards regulating air quality monitoring, management and control by all spheres of government.
Other Relevant legislation	
National Water Act, 1998 (Act No. 36 of 1998: 'National Water Act')	The National Water Act provides the legal framework for the effective and sustainable management of our water resources. The National Water Act recognises that water is a scarce and precious resource, and the ultimate goal of water resource management is to achieve the sustainable use of water for the benefit of all South Africans.
National Forest Act, 1998 (Act No. 84 of 1998: 'Forest Act')	This act makes provision for sustainable forest management and special measures to protect forests and trees. Specially protected forest areas, forest nature reserves and forest wilderness areas declared in terms of this act are PAs in terms of the Protected Areas Act.
Mountain Catchment Areas Act, 1970 (Act No. 63 of 1970: 'Mountain Catchment Areas Act')	This act makes provision for the conservation, use, management and control of land situated in mountain catchment areas. Mountain catchment areas declared in terms of this act are PAs in terms of the Protected Areas Act.
Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983: 'CARA')	This act makes provision for the control over the utilisation of the natural agricultural resources to promote the conservation of soil, water sources and vegetation.
The Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002: 'MPRDA')	This act is the main piece of legislation governing all stages of the mining and petroleum production process in South Africa. The Act is part of a network of legislation geared towards sustainable development and the conservation and management of South Africa's biodiversity.
National Heritage Resources Act, 1999 (Act No. 25 of 1999: 'National Heritage Resources Act')	The National Heritage Resources Act sets out general principles for governing heritage resources management, including an integrated system for the identification, assessment and management of the heritage resources of South Africa. The South African Heritage Resources Agency (SAHRA) is the national administrative body responsible for the protection of South Africa's cultural heritage. World Heritage Sites are referred to in the EIA Regulations, (2014, as amended) and are PAs in terms of the Protected Areas Act.

5.2.4. Provincial environmental legislation

The restructuring of spheres of government in the first ten years of democracy and changes to administrative boundaries within South Africa has resulted in Provincial Ordinances being assigned to two or more provinces. New legislation is

emerging and may repeal such Ordinances. Amongst other things, Provincial Ordinances list protected and threatened species, and some list PAs – EAPs and others involved in the land-use planning and assessment process must make sure they contact the relevant provincial authority to obtain the list of threatened and protected species for the area in which they are working. These species require permits from the relevant authority prior to their disturbance, removal or relocation.

TABLE 18.—List of provincial environmental legislation listing threatened and protected species relevant to the Albany Thicket Biome.

Name	Administrative boundary
Cape Nature and Environmental Conservation Ordinance (Ordinance 19 of 1974).	Assigned to Eastern Cape and Western Cape.
Ciskei Nature Conservation Act (Act 10 of 1987).	Assigned to Eastern Cape.

5.2.5. Management Tools for Threatened Species, Red Listed Species, TOPS-Listed Species and Protected Species

TABLE 19.—Useful resources relating to protected/threatened/listed species.

Name	Description	Available at:
The IUCN Red List of Threatened Species™	Provides information on species listed on the Global IUCN Red List.	https://www.iucnredlist.org/
IUCN Red List Categories and Criteria	Provides information on the IUCN Red List Categories and Criteria.	www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria
IUCN Red List Regional Categories and Criteria	Provides information on the IUCN Red List Categories and Criteria at regional levels.	www.iucnredlist.org/documents/reg_guidelines_en.pdf
Red List of South African Plants	Provides up to date information on the national conservation status of South Africa's indigenous plants.	http://redlist.sanbi.org/
Red List of South African Species Note: at the time of writing these guidelines (February 2019), this was a new website and did not yet include mammal species.	Provides the most up to date Red List status for South Africa's indigenous animals.	http://speciesstatus.sanbi.org/
Red List of South African Mammals		https://www.ewt.org.za/reddata/reddata.html
SANBI Red List of South African Plants: Guidelines for Environmental Impact Assessment. 2009. Driver, M., Raimondo, D., Maze, K., Pfab, M.F. & Helme, N.A. (2009). Applications of the Red List for conservation practitioners. In: D. Raimondo, L. Von Staden, W. Foden, J.E. Victor, N.A. Helme, R.C. Turner, D.A. Kamundi & P.A. Manyama (Eds.). Red List of South African Plants. <i>Strelitzia</i> 25: 41–52. South African National Biodiversity Institute. Pretoria.	Guides EAPs on how botanical specialists should be chosen and when and how botanical surveys should be conducted. Guides botanical specialists on the recommendations that should be made if a species of conservation concern (SCC) is found on a site, as well as for the habitat conservation of such species. To mitigate deleterious edge effects, the guideline notes that a 200 m buffer needs to be instated around a population of an SCC where development is planned. The open space system in the development plan must be sufficient to enable pollinators to operate, and connectivity with natural vegetation in surrounding areas must be promoted.	http://redlist.sanbi.org/eiaguidelines.php

TABLE 19.—Useful resources relating to protected/threatened/listed species (continued).

Name	Description	Available at:
List of Protected Tree Species under the National Forest Act (G 40521, No 1602) 23 December 2016.	Criteria used to select tree species for inclusion in the protected tree list includes, Red List Status, Keystone Species Value, Sustainability of Use, Cultural/Spiritual Importance and whether a species is already adequately protected by other legislation.	https://cer.org.za/wp-content/uploads/1999/04/List-of-protected-tree-species.pdf
Threatened or protected species regulations published in terms of the Biodiversity Act (G 30568 No 1187) 14 December 2007; (G 38600, No 255 and No 256) of 2015 (Draft).	The species are listed in terms of section 56 of the Biodiversity Act and are currently categorised as Critically Endangered, Endangered, Vulnerable and Protected. The list focuses on species that are threatened by exploitation for human use and/or commercial purposes. Use of these species are prohibited without a permit.	2007 TOPS Regulations: https://www.environment.gov.za/sites/default/files/gazetted_notices/nemba_criticallyendangered_specieslist_g30568rg8801gon1187.pdf 2015 Draft TOPS Regulations: https://www.environment.gov.za/sites/default/files/legislations/nemba10of2004_topsregulations_0.pdf

Note that the removal and/or disturbance of threatened or protected species is not allowed in the absence of a permit from the relevant competent authority.

5.2.6. Biodiversity guidelines for terrestrial and aquatic environments applicable to the Albany Thicket Biome

A list of useful biodiversity-related guidelines for terrestrial and aquatic environments available to those living and working within the Albany Thicket Biome are provided below.

Note: This is not an exhaustive list. Users should check with the relevant Environmental Departments or SANBI to ensure that they are working with the most up-to-date editions of these documents.

TABLE 20.—Biodiversity-related guidelines for terrestrial and aquatic environments.

Name	Available at
The EIA and Biodiversity Related Guidelines	
Integrated Environmental Management Information Series: Overview of Integrated Environmental Management.	https://www.environment.gov.za/sites/default/files/docs/series0%20_overview.pdf
DEAT (2004) Overview of Integrated Environmental Management, Integrated Environmental Management, Information Series 0, Department of Environmental Affairs and Tourism (DEAT), Pretoria.	
National Environmental Management Act, 1998 (Act No. 107 of 1998): Publication of Public Participation Guideline. 2010.	https://www.environment.gov.za/sites/default/files/legislations/nema107of1998_publicparticipationguideline.pdf
Department of Environmental Affairs (2010), Public Participation 2010, Integrated Environmental Management Guideline Series 7, Department of Environmental Affairs, Pretoria, South Africa. ISBN: 978-0-9802694-2-0	
Guideline on Need and Desirability.	https://www.environment.gov.za/sites/default/files/legislations/needanddesirabilityguideline2017_0.pdf
DEA (2017), Guideline on Need and Desirability, Department of Environmental Affairs (DEA), Pretoria, South Africa.	
Draft National Biodiversity Offset Policy.	https://www.environment.gov.za/sites/default/files/legislations/nema107of1998_draftnationalbiodiversityoffsetpolicy_gn40733_0.pdf
Department of Environmental Affairs, National Environmental Management Act, 1998 (Act No. 107 of 1998) GN 276 in GG 40733 of 31 March 2017.	

TABLE 20.—Biodiversity-related guidelines for terrestrial and aquatic environments (continued).

Name	Available at
Generic Environmental Management Programme (EMPr) for the Development and Expansion of Infrastructure for the Overhead Transmission and Distribution of Electricity. Department of Environmental Affairs. 2018. Generic Environmental Management Programme (EMPr) for the Development and Expansion of Infrastructure for the Overhead Transmission and Distribution of Electricity. 72 pp.	https://www.environment.gov.za/sites/default/files/docs/generic_empr_overheadtransmissionanddistribution.pdf
Guideline for Involving Biodiversity Specialists in EIA Processes. 2005. Brownlie, S. Guideline for involving biodiversity specialists in EIA processes: Edition 1. Council for Scientific and Industrial Research (CSIR) Report No. ENV-S-C 2005 053 C. Republic of South Africa, Provincial Government of the Western Cape, Department of Environmental Affairs & Development Planning, Cape Town.	http://biodiversityadvisor.sanbi.org/wp-content/uploads/2012/04/Involving_Biodiversity_Specialists.pdf
Guidance Document on Biodiversity, Impact Assessment and Decision Making in Southern Africa. 2009. Brownlie, S., Walmsley, B. & Tarr, P. CBBIA-IAIA Guidance Series. Capacity Building in Biodiversity and Impact Assessment (CBBIA) Project, International Association for Impact Assessment (IAIA), North Dakota, USA.	http://biodiversityadvisor.sanbi.org/wp-content/uploads/2012/08/CBBIA-IAIA-Guidance-Documents-on-Biodiversity-Impact-Assessment-and-Decision-making-in-SA.pdf
South Africa's Bioprospecting, Access and Benefit-Sharing Regulatory Framework: Guidelines for Providers, Users and Regulators. Department of Environmental Affairs. 2012. South Africa's Bioprospecting, Access and Benefit-Sharing Regulatory Framework: Guidelines for Providers, Users and Regulators. 71 pp.	https://www.environment.gov.za/sites/default/files/legislations/bioprospecting_regulatory_framework_guideline.pdf
Alien Vegetation Guidelines	
Monitoring, Control and Eradication Plans. Guidelines for species listed as invasive in terms of section 70 of National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004) and as required by section 76 of this act.	https://www.environment.gov.za/sites/default/files/legislations/nemba_invasivespecies_controlguideline.pdf
Mining Guidelines	
Mining and Biodiversity Guideline: Mainstreaming biodiversity into the mining sector. Department of Environmental Affairs, Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity Forum, and South African National Biodiversity Institute. 2013. Mining and Biodiversity Guideline: Mainstreaming biodiversity into the mining sector. Pretoria. 100 pages. ISBN: 978-0-621-41747-0	https://www.environment.gov.za/sites/default/files/legislations/miningbiodiversity_guidelines2013.pdf
Mining and Impact Guide. 2008. Gauteng Department of Agriculture, Environment and Conservation, Digby Wells and Associates, Growth Lab and The Council for Geoscience, 2008.	http://www.gauteng.gov.za/government/departments/agriculture-and-rural-development/Documents/All%20Forms/MiningandEnvironmentallImpactGuide.pdf
South African Mine Water Atlas, 2017. Water Research Commission (2017). South African Mine Water Atlas. WRC Project No. K5/2234//3	http://www.wrc.org.za/programmes/mine-water-atlas/
Renewable Energy Guidelines	
EIA Guideline for Renewable Energy Projects. Department of Environmental Affairs (2015). EIA Guideline for Renewable Energy Projects. Department of Environmental Affairs, Pretoria, South Africa.	https://www.environment.gov.za/sites/default/files/legislations/EIA_guidelineforrenewableenergyprojects.pdf
Forestry Guidelines	
Policy Principles and Guidelines for Control of Development Affecting Natural Forests. Department of Agriculture Forestry and Fisheries. September 2009.	https://www.nda.agric.za/doaDev/sideMenu/ForestryWeb/webapp/Documents/PolicyGuideNaturalForestsDev.pdf

TABLE 20.—Biodiversity-related guidelines for terrestrial and aquatic environments (continued).

Name	Available at
Coastal Guidelines	
A summary guide to South Africa's Integrated Coastal Management Act Department of Environmental Affairs. A summary guide to South Africa's Integrated Coastal Management Act. 17 pp.	https://www.environment.gov.za/sites/default/files/docs/integrated_coastalmanagement_act_summaryguide.pdf
A User-Friendly Guide to the Integrated Coastal Management Act of South Africa Celliers, L., Breetzke, T., Moore, L. & Malan, D. 2009. A User-friendly Guide to South Africa's Integrated Coastal Management Act. The Department of Environmental Affairs and SSI Engineers and Environmental Consultants. Cape Town, South Africa.	https://www.environment.gov.za/sites/default/files/docs/guideto_icm_act.pdf

5.2.7. Planning tools and guidelines applicable to watercourses and wetlands

Many planning tools and guidelines related to the identification, classification, and assessment of, and offsetting of impacts on, aquatic ecosystems have been developed. Key planning tools and guidelines (and the 'Inland Aquatic

Ecosystems' Group in these Ecosystem Guidelines) for use in the EIA, are provided below. These must be referred to in conjunction with the Ecosystem Guidelines when wetlands occur in the area in question.

TABLE 21.—Planning tools and guidelines for wetlands and water courses.

Name/Description	Available at:
A practical field procedure for identification and delineation of wetland and riparian areas Edition 1. Department of Water Affairs and Forestry, Pretoria. Updated with amendments in 2008. Department of Water Affairs and Forestry. 2005.	https://www.solidaridadlibrary.org/en/node/3697
Manual for the Rapid Ecological Reserve Determination of Inland Wetlands M.W. Rountree, H.L. Malan & B.C. Weston (Eds). Fluvius Environment Consultants, University of Cape Town, Department of Water Affairs, Resource Directed Measures. 2013. Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Version 2.0). <i>WRC Report No. 1788/1/12</i> ISBN 978-1-4312-0356-7	http://www.wrc.org.za/Knowledge%20Hub%20Documents/Research%20Reports/1788-1-13.pdf
WET-Health is a tool that has been developed for rapid assessment of wetland health based on hydrology, geomorphology and vegetation. Besides providing a replicable and explicit measure of wetland health, the WET-Health system also helps to diagnose the causes of degradation, so that these can be appropriately addressed.	
Buffer Zone Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries. Macfarlane, D.M. & Bredin, I.P. 2017. Buffer Zone Guidelines for Rivers, Wetlands and Estuaries Part 1: Technical Manual. <i>WRC Report No. TT 715/1/17</i> , Water Research Commission, Pretoria.	http://www.wrc.org.za http://www.wrc.org.za/Knowledge%20Hub%20Documents/Research%20Reports/TT%20715-1-17.pdf
Wetland Offsets: A best practice guideline for South Africa. SANBI and Department of Water and Sanitation. Macfarlane, D., Holness, S.D., Von Hase, A., Brownlie, S., Dini, J.A. & Kilian, V.. 2016. WETLAND OFFSETS: A Best Practice Guideline for South Africa. <i>WRC Report No. TT 660/16</i> . Water Research Commission.	http://www.wrc.org.za/Knowledge%20Hub%20Documents/Research%20Reports/TT%20660%20-%20Jo_web.pdf

TABLE 21.—Planning tools and guidelines for wetlands and water courses (continued).

Name/Description	Available at:
WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. WET-EcoServices is designed for inland palustrine wetlands, i.e. marshes, floodplains, vleis and seeps. It has been developed to help assess the goods and services that individual wetlands provide to allow for more informed planning and decision-making. Marneweck, G.C., Batchelor, A.L., Lindley, D.S., Collins, N.B. & Kotze, D.C. 2007. WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. <i>WRC Report</i> No. TT 339/09, Water Research Commission, Pretoria.	http://www.wrc.org.za/Knowledge%20Hub%20Documents/Research%20Reports/TT%20339-09.pdf
A method for assessing cumulative impacts on wetland functions at the catchment or landscape scale. This tool enables assessment of the effects on wetland functionality of the cumulative impacts of human activities at a landscape scale. It uses two metrics: the land cover change impact metric and the loss of function metric to produce a functional effectiveness score that is translated to functional hectare equivalents. The difference between the functional hectare equivalents of a pristine catchment is compared with the current state to assess the cumulative impacts of human activities on wetland functionality. Ellery, W., Grenfell, S., Grenfell, M., Jaganath, C., Malan, H. & Kotze, D. 2010. A method for assessing cumulative impacts on wetland functions at the catchment or landscape scale. <i>WRC Report</i> No. TT437/09. Water Research Commission.	http://www.wrc.org.za/Knowledge%20Hub%20Documents/Research%20Reports/TT437-09%20Conservation%20of%20Water%20Ecosystems.pdf
National wetland vegetation database: classification and analysis of wetlands.	http://www.wrc.org.za/Knowledge%20Hub%20Documents/Research%20Reports/1980-1-14.pdf
High Risk Wetlands Atlas: Reference Guide to the Mpumalanga Mining Decision Support Tool. This report serves as a reference guide to the content and use of the High Risk Wetlands Atlas. The report aims to provide the required information for users to install the atlas and access the underlying spatial data, as well as to provide supporting information on the preparation and content of the spatial data. Holness, S.D., Dini, J.A., De Klerk, A. & Oberholster, P. 2016. High Risk Wetlands Atlas: Reference Guide to the Mpumalanga Mining Decision Support Tool. <i>WRC Report</i> No. TT 659/16. Water Research Commission.	http://www.wrc.org.za/Knowledge%20Hub%20Documents/Research%20Reports/TT%20659%20-16.pdf
Development of Decision-Support Tools for Assessment of Wetland Present Ecological Status. Provide interim decision-support tools to assist government agencies and wetland assessors in selecting appropriate wetland PES assessment methods and reporting the results in a transparent and consistent manner. This is in the process of being updated. Ollis, D.J., Day, J.A., Malan, H.L., Ewart-Smith, J.L. & Job, N.M. 2014. Development of Decision-support Tools for Assessment of Wetland Present Ecological Status (PES) Volume 2. Development of a decision-support framework for wetland assessment in South Africa and a decision-support protocol for the rapid assessment of wetland ecological condition. <i>WRC Report</i> No. TT 609/14. Water Research Commission.	http://www.wrc.org.za/Knowledge%20Hub%20Documents/Research%20Reports/TT%20609-14.pdf

5.2.8. CBA Maps, Provincial Biodiversity Plans, BSPs and BRPs currently available within the Albany Thicket Biome

TABLE 22.—Biodiversity Plan applicable to the Albany Thicket Biome.

CBA Maps/Provincial Biodiversity Plans/Biodiversity Sector Plans
Western Cape Biodiversity Spatial Plan, 2017
The Subtropical Thicket Ecosystem Planning project (STEP), 2006
Eastern Cape Biodiversity Conservation Plan (ECBCP), 2019 Note: the ECBCP is currently under revision and is planned for gazetting in 2019
Blue Crane Route Municipality Biodiversity Sector Plan, 2012
Ndlambe Municipality Biodiversity Sector Plan, 2012
Sundays River Valley Municipality Biodiversity Sector Plan, 2012
Ikwezi Municipality Biodiversity Sector Plan, 2012
Addo Biodiversity Sector Plan, 2012.
The Garden Route Biodiversity Sector Plan for the southern regions of the Kouga and Koukamma Municipalities, 2010.
Hessequa and Mossel Bay Municipalities Biodiversity Sector Plan, 2010
Biodiversity Assessment of the Central Karoo District Municipality, 2009.
Bioregional Plans
Nelson Mandela Bay Municipality Bioregional Plan, 2015

5.3. Generic Terms of Reference for Ecological Specialists

The references cited in the text are included in the general reference list in Chapter 6. The ToR is a combination of available Provincial Guidelines for Biodiversity Assessments/ Specialist studies, the Draft Procedures to be followed for the assessment and minimum criteria for reporting of identified environmental themes in terms of Section 24(5)(a) and (h) of NEMA when applying for environmental authorisation, and the Ecosystem Guidelines for Environmental Assessment in the Western Cape.

5.3.1. Introduction

An assessment of terrestrial ecosystems and biodiversity must be carried out by a suitably qualified and SACNASP

registered ecological (or terrestrial/ biodiversity) specialist. The specialist must have no financial or other vested interest in the proposed development.

In this section, guidance is provided for the drafting of project-specific ToR and can be used by Environmental Assessment Practitioners (EAPs) or ecological specialists. The ToR generally describes the scope of work to be carried out by a terrestrial ecologist or biodiversity specialist.

The steps typically followed for the assessment of terrestrial ecosystems includes:

- Step 1: Description of study area
- Step 2: Identify potentially significant impacts and risks typically associated with the project
- Step 3: Site visit and groundtruthing
- Step 4: Recommendations for mitigation
- Step 5: Biodiversity Impact Assessment reporting

Step 1: Description of Study Area

The report must provide a description of the broader landscape as well as patterns and processes operating in the landscape in order to place the terrestrial ecosystems in context. The description should aim to provide an understanding on the surrounding landscape (topography, hydrology, gradient, vegetation, and soils), how and why the ecosystem(s) came to be there (e.g. natural or anthropogenic) and what processes are occurring in and around the ecosystem that influence its function and form.

Good quality aerial photographs of the site and surrounding area and photographs of the terrestrial ecosystems on the site should be included in the report.

Collation of other potentially relevant biodiversity information available for the surrounding area or, at the very least, quaternary catchment, for example, Reptile Atlas data, Frog Atlas data.

The report must include the biodiversity importance of an area in the landscape. The biodiversity importance can be determined using available information:

- National Biodiversity Assessment (NBA),
- Bioregional plans and biodiversity sector plans (BSP) (and associated critical biodiversity area (CBA) maps),
- Freshwater Ecosystem Priority Areas (FEPAs) and accompanying fine-scale biodiversity plans,
- The provincial Protected Area Expansion Strategy (PAES).

Any likely biodiversity risks should be identified using the following:

- Areas of international importance:
 - Ramsar sites, World Heritage Sites, and/or their buffer zones,
 - UNESCO Biosphere Reserves.
- CBAs or Ecological Support Areas (ESAs) identified in bioregional or biodiversity sector plans,
- Protected areas and/or their buffer zones,
- PAES,
- FEPAs,

- Estuarine Functional Zones,
- Important climate-adaptation corridors,
- Sensitive areas in applicable Environmental Management Frameworks (EMFs),
- Coastal public property,
- Areas falling within the Coastal Protection Zone (CPZ),
- Key ecosystem services (e.g. water catchment areas), and
- Areas prone to flooding or other natural hazards/disasters.

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

- Identify the Ecosystem threat status of affected vegetation/areas (refer to the latest version of the National List of Threatened Terrestrial Ecosystems, and the relevant provincial updated statistics on Ecosystem Threat Status.
- Determine whether or not any threatened species or protected species could be negatively affected using Red Lists and/or Red Data Book information.
- Map the location of important bird areas (IBAs) in relation to the site (available from SANBI BGIS).
- Determine if there are unique/sensitive features such as wetland or mobile sand dunes that could present constraints to development using Google Earth, SPOT or other images.

If an assessment is carried out in support of an environmental authorisation application, it is required that the impact assessment be based on the results of an assessment carried out on the proposed development site, as well as alternative sites. The site contextualisation should therefore be carried out for the proposed and alternative sites.



Step 2: Potentially significant impacts and risks typically associated with the project

The nature and scale of the proposed development must be considered. The potentially significant impacts and risks that would typically be associated with the project must be identified.

Impacts should include:

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



Step 3: Site visit and groundtruthing

A site visit must be carried out to groundtruth biodiversity information.

Baseline surveys may be required to supplement the information base and inform the assessment.

The site assessment will entail:

- Describing the condition of the ecosystem on the preferred and alternative sites.
- Describing levels of degradation and infestation by alien invasive species, where applicable.
- Describing important biodiversity identified on the site(s) and in the wider landscape.

- Describing biodiversity patterns and ecological processes within or near the site.
- Describing landscape features or habitat types within or near the site.
- Mapping important biodiversity identified on site and in the wider landscape.
- Carrying out the site visit in the appropriate seasons applicable to the ecosystem being assessed and in terms of both pattern and ecological process perspectives.
- Identifying areas or features off site that could be indirectly impacted by the proposed land use, for example, groundwater-dependent ecosystems.
- Making note of inconsistencies between the NBA/biodiversity plans/CBA maps/FEPA maps and the 'on the ground' situation.



Step 4: Recommendations for mitigation

Once the site has been groundtruthed, features and areas of biodiversity significance that would be impacted or which may be at risk as a result of the proposed land use, can be identified.

Recommendations for mitigation to inform or influence the proposal must be compiled. Mitigation measures are to address spatial changes and the technology and/or management associated with the proposed development.

Key biodiversity stakeholders (e.g. SANBI, CREW) should be engaged with to clarify or obtain additional biodiversity information.

Tasks associated with recommendations for mitigation:

- All potential impacts (Step 2) must be taken into account.
- The mitigation hierarchy (avoid, minimise, rehabilitate, offset) must be applied.
- The desired management objectives for the specific biodiversity areas or features (CBA, ESA, FEPA, protected area, etc.) must be determined. The specialist must evaluate whether or not the likely impacts would compromise the desired management objectives of the identified biodiversity.
- Identify areas where any loss of biodiversity will be irreplaceable; this could include jeopardising the biodiversity targets or where a loss could lead to extinction of species. These areas must be retained and protected, and any potential impacts must be avoided or prevented.
- These areas generally comprise:
 - CBAs;
 - Critically Endangered ecosystems;
 - FEPAs;
 - special/unique habitats (that occur locally e.g. quartz patches);
 - areas with fixed (rather than flexible) ecological corridors across ecological gradients;
 - Habitat of known Critically Endangered species and/or areas containing biodiversity that underpins ecosystem services on which there is high dependency and for which there are no substitutes.
- Areas of high importance/sensitivity should be identified where impacts should be avoided or prevented or, where they cannot altogether be avoided, be minimised (e.g. through buffers or setbacks).
- These areas include:
 - Endangered ecosystems (emphasis should be on avoidance/prevention);
 - Vulnerable ecosystems;
 - ESAs;
 - Habitat of highly threatened species and/or concentrations of threatened species; and
 - Highly dynamic ecosystems (e.g. mobile sand dunes or watercourses).

- Identify areas where any loss of important ecosystem services would be irreversible and could not be substituted or would be extremely expensive to substitute. These include services which people are highly dependent on for livelihoods, health, safety or wellbeing. Examples include water supplies or flood buffers.
- Areas which pose a natural hazard to land-use activities which require development or management setbacks are to be identified.
- Key drivers of the affected ecosystems are to be addressed, for example, addressing the spatial/layout implications if burning is required.
- Areas known for biodiversity importance but are degraded/invaded by alien species and which require rehabilitation/restoration, must be identified. Include areas that could improve connectivity and reduce fragmentation in the landscape.
- Identify areas that would be worthy of protection (i.e. through biodiversity stewardship).
- Identify areas where impacts on biodiversity would be of low or negligible significance and where modifying land uses should be focused.
- Biodiversity offsets should be a last resort form of mitigation. Biodiversity offsets should only be considered once all reasonable and feasible alternatives have been duly considered and where significant negative impacts cannot be avoided. A biodiversity offset specialist should be recommended to design an appropriate and adequate offset in accordance with offset guidelines.



Step 5: Biodiversity Impact Assessment Reporting

Once the groundtruthing has taken place and recommendations to mitigate identified potential impacts have been compiled, the findings of the biodiversity assessment are captured in a specialist report.

The following should be included in the specialist report:

- A description of the site visit carried out including the season and any limitations.
- Assumptions and limitations, examples:
 - gaps in information;
 - inability to visit site; and
 - Inability to do seasonal sampling.
- Description and mapping of areas and features of biodiversity importance and their sensitivity to the proposed development.
- Reporting on whether groundtruthing presented any conflicts or inconsistencies with biodiversity information in biodiversity plans/maps; this is to be supported with evidence i.e. photographs.
- A description of how the Mitigation Hierarchy has been used to avoid/minimise potentially significant impacts that in turn have influenced or shaped the land-use proposal. This should also be done for any reasonable and feasible alternatives.
- Describe the protocol used to assess and evaluate the potential significance of negative impacts on biodiversity and ecosystem services, and levels of confidence in the assessment.
- For terrestrial CBA, list reasons why the ecosystem has been identified as a CBA and note if the development is consistent with regards to maintaining the CBA in its current state or achieving rehabilitation. Assess impacts on:
 - Species composition, structure of vegetation and indicate extent of site clearing;
 - Ecosystem threat status;
 - Subtypes of vegetation;
 - Overall species and ecosystem diversity on site;
 - Populations of SCCs;
 - Ecological functioning and processes; and
 - Ecological connectivity.

- A statement of impacts that could not be avoided or reduced sufficiently to ensure that they would be of low or negligible significance.
- A statement of any impacts would be irreversible and lead to loss of irreplaceable biodiversity, or loss of important ecosystem services on which there is high dependency.
- Areas that are not suitable for development and which must be avoided must be highlighted and described.
- Map(s) at a meaningful scale (preferably >1:10 000).
- Photographs to illustrate the biodiversity implications of the proposed project.
- Photographs to illustrate biodiversity implications of the amended proposal (considering recommended area based measures to avoid and minimise negative impacts).
- Description of all recommended measures that must be implemented during project phases (construction, operational) to avoid, minimise, rehabilitate, and/or compensate/offset biodiversity impacts.
- Statement of the required outcomes of these mitigation measures, to be incorporated in the Environmental Management Programme.
- Provide a reasoned opinion, based on the finding of the specialist assessment, regarding the acceptability of the development and if the development should receive approval, and any conditions to which the statement is subjected.
- Reference to all the sources of biodiversity information used or obtained.

5.4. Generic Terms of Reference for Aquatic Specialists

Note: The references cited in the text are included in the general reference list in Chapter 6.

5.4.1. Introduction

An assessment of aquatic ecosystems and biodiversity must be carried out by a suitably qualified and SACNASP registered aquatic specialist. Certain tasks will need to be

completed, depending on the scope of the study. In this section, guidance is provided for the drafting of project-specific ToR and can be used by EAPS or aquatic specialists.

The steps typically followed for the assessment of aquatic ecosystems include:

- Step 1: Contextualisation of type of assessment and study area
- Step 2: Identification, mapping (delineation) and classification of aquatic ecosystems
- Step 3: Assessment of inland aquatic ecosystems
- Step 4: Setting of management objectives
- Step 5: Monitoring

Step 1: Contextualisation of type of assessment and study area

1. Type of assessment

The type of assessment required will determine the level of detail required to be provided by the aquatic specialist. The specialist input may be required for a site scan, an analysis of constraints, an environmental authorisation, a water use license, strategic environmental assessments, or for rehabilitation or restoration of a system.

When an environmental authorisation is required for an activity that is proposed to take place on a site identified as being of 'very high sensitivity' for aquatic biodiversity (as per the national web-based environmental screening tool) an Aquatic Biodiversity Impact Assessment must be carried out and a report submitted to the competent authority which details the findings of the assessment. Similarly, should a water use authorisation be required, then an aquatic assessment will be required.

The Table below describes various assessment types and an indication of the steps (1–5) that should be carried out by the specialist in order to provide the relevant input.

Assessment Type	Steps				
Site scan	1	2	3	4	5
Specialist required to determine whether there is an inland aquatic ecosystem that could be affected by a proposed activity.	✓	✓			
Constraints analysis	1	2	3	4	5
This entails a rough delineation/mapping of inland aquatic ecosystems and recommended buffers, to show constraints on activities in and around the affected aquatic ecosystems.	✓	✓	✓		
The specialist may be required to provide an opinion on the suitability of the proposed activities and propose mitigation measures to reduce the potential negative impacts on aquatic ecosystems to acceptable levels. Constraints analysis generally goes hand-in-hand with a site scan.					
Environmental authorisation	1	2	3	4	5
The Environmental Impact Assessment (EIA) Regulations promulgated by National Environmental Management Act (Act 107 of 1998) (NEMA), specify activities that require environmental authorisation before they may proceed. Authorisation requires carrying out a systematic process of identifying, assessing and reporting on potential environmental impacts associated with an activity. This is done as either a Basic Assessment or as a Scoping and EIA, depending on the type of activity proposed.	✓	✓	✓	✓	

Assessment Type	Steps				
Water use authorisation	1	2	3	4	5
The National Water Act (Act 36 of 1998) regulates a number of consumptive and non-consumptive water uses. Depending on the type and volume of use, these water uses must be registered and/or authorised by the Department of Water and Sanitation, except if the proposed water use falls within the limits of the permissible water uses set out in Schedule 1 of the National Water Act. Authorisation is obtained either as a Water Use Licence (WUL), or as General Authorisation (GA), if the water use falls within the conditions and limits of a gazetted GA. A Water Use Licence requires the determination of the 'Reserve' for the relevant catchment.	✓	✓	✓	✓	✓
Strategic environmental assessment, environmental management framework, river management plan, biodiversity plan, etc.	1	2	3	4	5
These types of studies generally apply to a wider geographical area than those described above and will address broader objectives.	✓	✓	✓	✓	
Rehabilitation or restoration of degraded aquatic ecosystems	1	2	3	4	5
Specialist input may be required at various levels of the rehabilitation/restoration process. Input could include the definition of objectives, determination of the best method for achieving the objectives, assessment of the condition and importance of the affected ecosystem (both before and after intervention), and in designing a monitoring programme looking at the effectiveness of the intervention.	✓	✓	✓	✓	

2. Site contextualisation

The report must provide a description of the broader landscape as well as patterns and processes operating in the landscape in order to place the inland aquatic ecosystems in context. This description should aim towards a better understanding of:

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

If an assessment is carried out in support of an environmental authorisation application, it is required that the aquatic impact assessment be based on the results of an assessment carried out on the proposed development site as well as alternative sites. The site contextualisation should therefore be carried out for the proposed and alternative sites.

Site contextualisation could include:

- Good quality aerial photograph of the site and surrounding area;
- Photographs of the inland aquatic ecosystems on the site;
- Desktop delineation of the boundaries of the subcatchment of the ecosystem and the surrounding quaternary catchment;
- Examination of 1:50 000 scale topographical maps of the study area;
- Examination of recent and historical aerial photographs and/or satellite imagery to gain an understanding of the land uses on the site and in the surrounding subcatchment;
- Examination of the relief of the site and surrounding areas by referring to the contour lines (at least 20 m intervals) or at least to 'tilted' Google Earth 3D imagery of the study area;

- Desktop mapping of river reaches up- and downstream of the site, including tributaries;
- Mapping the location of Freshwater Ecosystem Priority Areas (FEPA) subcatchments, fish sanctuaries, fish support areas and fish corridors in relation to the ecosystem on site;
- Mapping the location of important wetlands within the subcatchment of the affected aquatic ecosystem. This should at least include critical biodiversity area (CBA) and Ecological Support Area (ESA) wetlands, FEPA wetlands, Ramsar wetlands, FEPA wetland clusters, and any estuaries downstream of the site. Noting that finer scale detail may also be available for specific regions, such as provincial/municipal level bioregional and conservation plans, as well as waterbody information contained in the National Wetland Inventory curated by SANBI and the CSIR;
- Mapping the location of important bird areas (IBAs) in relation to the site; and
- Collation of other potentially relevant biodiversity information available for the surrounding subcatchment or, at the very least, quaternary catchment, for example, Protea Atlas data, Frog Atlas data, CWAC data.

Notes:

- Subcatchment map is the River FEPAs map of NFEPA.
- Quaternary catchment maps are available from the DWS website (<http://www.dws.gov.za/>).
- 1:50 000 scale topographical maps and aerial photographs available from Chief Directorate: National Geo-spatial Information (CD: NGI).
- Satellite imagery is available from, for example, SPOT, Google Earth.
- Contour lines at 10 m intervals are available from CD: NGI.
- 1:50 000 river line and river area maps are available from CD: NGI.
- 1:500 000 rivers maps are available from DEAT.
- The 1:50 000 river line, river area and 1:500 000 rivers maps are all represented on the NFEPA. Rivers map, available from SANBI BGIS.

Important Bird Areas are available on SANBI BGIS.



Step 2: Identification, mapping (delineation) and classification of aquatic systems

1. Identification and mapping

As part of an assessment, the potentially affected inland aquatic ecosystems should be identified and mapped/delineated at an appropriate level of accuracy, based on a number of indicators.

The presence of an inland aquatic ecosystem requires the identification of one or more indicators.

The following are considered indicators of wetland presence (DWAF (now known as DWS), 2008):

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

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

- Topography associated with the watercourse: a general indicator is the edge of the outer channel bank;

- Vegetation: change in growth form and species composition relative to terrestrial areas; and
- Alluvial soils (relatively recent deposits of sand, mud etc. by flowing water) and deposited material (e.g. vegetation and soil deposits).

The delineation of inland aquatic ecosystem includes confirming the presence of a wetland, open waterbody, river channel or riparian area and approximating the outermost boundary (and extent/length) of the aquatic ecosystem and representing this on a map/aerial image. The level of detail required when delineating inland aquatic systems will depend on the objectives of the study. The scale of mapping and the confidence with which it was undertaken should be reported.

The levels of detail include:

- Desktop mapping: use of current and historical aerial imagery is the best approach, with the next best option being good satellite imagery (i.e. SPOT);
- Desktop mapping with field verification; and
- Delineation in the field.

Field delineation must follow the accepted national protocol and must include:

- A map showing the identified boundary and field data collection points (include at least one point outside aquatic area);
- A report explaining how and when the boundary was determined;
- Details of the type and date of imagery used to support the delineation must be included; and
- Ecosystems should preferably be mapped at a scale of at least 1:10 000.

The wet season is the best time of year for determining the presence of inland aquatic ecosystems; this should be motivated to the client (budget, timeframe) and the risks of a dry season site visit also explained. If the project timeframe does not allow for this, this must be stated in the constraints and limitations of the study.

The ecosystem threat status and protection level of the aquatic ecosystem should be included.

2. Classification

Make use of the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis et al., 2014) to describe the types of aquatic ecosystems being assessed. The minimum requirement would be a level 4 description of the aquatic ecosystem type, but the typing should preferably include all of the following:

- **Level 2:** regional setting; using the DWS Level 1 ecoregions (particularly for rivers) and/or NFEPA WetVeg groups;
- **Level 3:** landscape unit, e.g. valley floor, slope, plain or bench;
- **Level 4:** hydrogeomorphic (HGM) unit; landform (shape and localised setting), hydrological characteristics (nature of water movement in and out) and hydrodynamics (direction and strength of flow);
- **Level 5:** hydrological regime; behaviour of water in the wetland or river and, for wetlands, the underlying soil, i.e. duration of saturation/inundation, perenniality of flow for rivers;
- **Level 6:** provides for detail which is useful for understanding the complexity of a system. This may be unfeasible due to budget and/ or timeframe. However, the practitioner should differentiate, where possible, between artificial and natural systems.

An indication of the degree of confidence for the classification must be provided in each case.

Step 3: Assessment of inland aquatic ecosystems

1. Reference and Present Ecological State

Reference state: The presumed historical, undisturbed state of an aquatic ecosystem using historical imagery, anecdotal evidence, reports, etc. must be described in the report. The reference state is important and required for a present ecological state (PES) assessment. An understanding of the drivers of change affecting the system will be required, so that the trajectory of change can be described.

Assessment of present ecological state and importance: The PES of all potentially affected naturally-occurring inland aquatic ecosystems relative to the perceived natural reference state must be determined. PES assessment is not applicable to artificial systems, as there is no natural reference state that can be used as the bench-mark.

- For rivers at a desktop level, the condition of 1:500 000 river reaches can be checked against the NFEPA Rivers layer.
- For field verification of rivers use the DWS's PES method (applying Ecological Categories A to F). This must be compared to the National PES scores developed by the DWS in 2014 available from <http://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx>. That data also includes Ecological Importance and Ecological Sensitivity ratings per subquaternary catchment.
- For wetlands at a desktop level, NFEPA assigned condition can be used, however, in many cases NFEPA modelled conditions, so field verification is strongly recommended.

For field verification of wetlands, the practitioner could use:

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

A description of the reference state and Present Ecological State should be included in an aquatic biodiversity assessment using the following characteristics:

- Flow and sediment regimes;
- Water quality;
- Riparian and in stream habitat;
- Morphology (physical structure);
- Riparian Vegetation; and
- Biota.

An indication should be given on the confidence level of these assessments.

2. Ecological importance and sensitivity

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

For rivers, the DWS's EIS for rivers (DWA (now known as DWS), 1999c) should be used. Recently, this has been split into ecological importance (EI) and Ecological Sensitivity (ES), and the information for rating on a national basis can be obtained from <http://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx> per subquaternary catchment.

For wetlands, the accepted protocols are:

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

3. Impact assessment and mitigation

The practitioner must describe the nature and the status (negative or positive) of the potential impacts. The potential impacts on the hydrological regime, geomorphology, biodiversity and ecological functioning of the aquatic ecosystem must be evaluated. The potential impacts of the proposed activity on the aquatic ecosystem on both the proposed and alternative development sites must be described. Impacts are described in terms of their extent, intensity, and duration.

Other aspects that must be included in the evaluation are:

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

The practitioner must provide the rationale behind the evaluation of impacts and for selecting the preferred site.

When carrying out assessments for proposed developments on aquatic CBA, and the aquatic biodiversity features that have a very high sensitivity rating in terms of the national screening tool, the assessment must include reasons why an aquatic ecosystem has been identified as a CBA and provide a professional opinion on whether the proposed development will be consistent in maintaining the CBA in its present state or in a rehabilitated state.

Significance ratings: The significance of an impact is rated according to extent, intensity, and duration. All impacts must be rated with and without mitigation.

Note: With regards to the extent of the impact, FEPA wetlands/river reaches should be assigned a national level, and CBA systems a regional level.

Cumulative impacts: A cumulative impact is described as one which, in itself, may not be significant, but may become significant when added to the existing impacts and/or potential impacts that may occur as a result of other activities taking place in the area.

Cumulative impacts can be described as **additive**, i.e. adding to other similar impacts, or **interactive**, where different impacts combine to result in a new type of impact. As for other impacts, the relationship between the impact and the hydrological regime, geomorphology, biodiversity and ecological functioning of the aquatic ecosystem needs to be established.

Avoidance and mitigation: All identified potential impacts should be accompanied by a recommendation for either avoiding or mitigating the impact on site. Practical mitigation measures should be included which will minimise negative impacts, enhance beneficial impacts and assist in project design. Practitioners may differentiate between essential and optional mitigation measures. Essential measures **must** be implemented and therefore change the significance rating once mitigation is in place. Optional mitigation measures are recommended but do not affect the rating.

A monitoring and review programme should be recommended to determine the efficacy of the recommended mitigation measures.

Offsets: Should there be significant residual impacts after avoidance and on-site mitigation measures have been considered and/or incorporated in project development, mitigation off-site as a biodiversity offset can be considered (this applies only to wetlands). Wetland offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse impacts on wetlands. The currently accepted protocol for the determination of appropriate wetland offsets must be consulted.

Wetlands offsets are not appropriate for:

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



Step 4: Setting of management objectives

1. Recommended Ecological Category and Resource Quality Objectives

The Recommended Ecological Category (REC) needs to be determined for potentially affected inland aquatic ecosystems for Water Use Licence Applications (WULAs), including applications for the registration of a General Authorisation, and for most water resource management studies. This is a useful, though not compulsory, exercise for EIA studies too.

Methods for the determination of the Recommended Ecological Category (REC Categories A to D3) are provided in Kleynhans & Louw (2007) for rivers, and in Rountree & Kotze (2013) for wetlands.

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

RQOs need to be set for an inland aquatic ecosystem when reserve determination studies are carried out. RQOs are also required for aquatic impact assessments carried out in CBA and identified as having a high sensitivity rating by the national environmental screening tool.

2. Buffers

Activities within 32 m of a watercourse trigger the NEMA EIA regulations. This does not, however, equate to a buffer protecting water resources from human disturbance. A detailed and now accepted buffer model was described for rivers, wetland and estuaries by Macfarlane & Bredin (2017), and is listed by the DWS as a minimum requirement when submitting a wetland assessment (see the DWS requirements in terms of GN 267 (40713) of March 2017).

When setting of buffers, the above-mentioned models includes amongst others:

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

3. Water use authorisation

Specialist requirements for both the basic assessment or EIA and the water use authorisation should be combined in one terms of reference to assist with the streamlining of environmental (basic assessment or EIA) and water use authorisation processes and preventing further delays in the water use authorisation process. Reports should however meet the following requirements listed in GN 267 (40713) of March 2017).



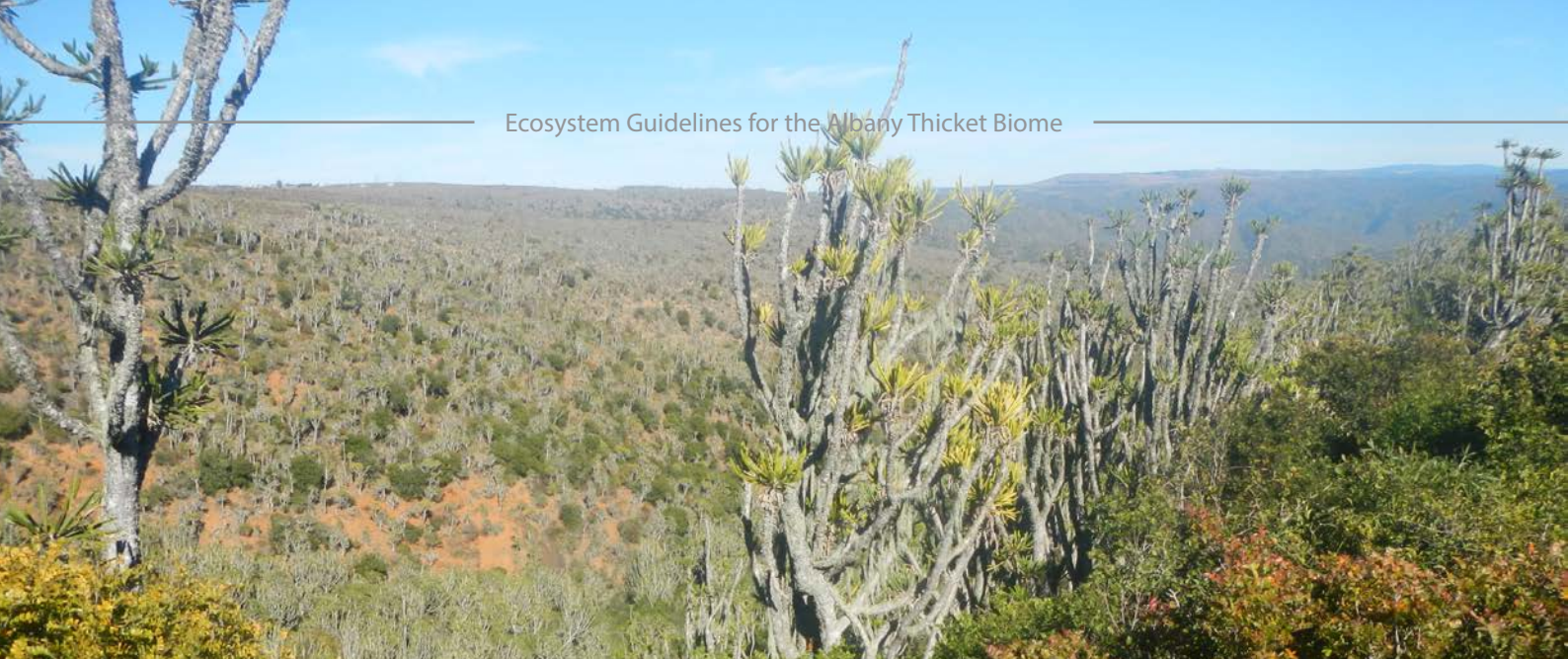
Step 5: Monitoring

A monitoring component should be included in an assessment of inland aquatic ecosystems. Monitoring is required for water use license authorisations. Monitoring can measure the responses, drivers or stressors of an ecosystem.

The monitoring programme should address (based on Kotze & Macfarlane, 2014):

- Scope and objectives of monitoring:
 - Define what is to be monitored, why and the appropriate level of monitoring,
 - Budget and time dependent.
- Site selection:
 - Carefully select monitoring sites to achieve the objectives of monitoring.
- Indicators:
 - Use key indicators in monitoring.
- Monitoring protocols:
 - Methods and equipment to be used for monitoring.
- Monitoring frequency and responsibilities:
 - How often monitoring is to be repeated,
 - How long monitoring will occur,
 - Who will carry out the monitoring?
- Data storage, analysis and reporting:
 - How monitoring data will be stored and analysed,
 - How monitoring data will be reported on,
 - How monitoring data will be made accessible to appropriate individuals, organisations and government departments. It is recommended that the landowner be provided with a report, in addition to the local or regional conservation authorities.

Should monitoring show that the ecosystem is showing little response to mitigation measures in place or showing signs of a stressed system, additional measures should be put in place and the monitoring programme updated based on new measures, and monitoring of the ecosystem should continue.



5.5. Data sources of spatial information

- South African biomes: VEGMAP 2018 (SANBI BGIS).
- Protected Areas and Conservation Areas: NBA2018_PA_forProtLev_ver20180920 Received from A. Skowno, 18 October 2018.
- Land Cover: Department of Environmental Affairs. DEA National Landcover (TIFF) 2015 [Raster] 2015. Available from the Biodiversity GIS website.
- Critical Biodiversity Areas and Ecological Support Areas.
- Strategic Water Source Areas:
 - SWSA_gw_v3_Nov2017 Council for Scientific and Industrial Research. 2017 SWSA Groundwater [Vector] 2017. Available from the Biodiversity GIS website, downloaded on 19 October 2018.
 - SWSA_sw_v3_Oct2017 Council for Scientific and Industrial Research. 2017 SWSA Surface water [Vector] 2017. Available from the Biodiversity GIS website, downloaded on 19 October 2018.
- Alternative Energy and Gas Corridors
 - Renewable Energy EIA Applications (REEA OR 2018 Q2): Renewable Energy EIA Applications Database, Official Release, 2018 Quarter 2, release date 2018-07-10, DEA EGIS <https://egis.environment.gov.za/>
 - Renewable Energy Development Zones (REDZ DEA Draft 2015). Renewable Energy Development Zones (REDZs), Unpublished Draft, release date 2016-06-11, DEA EGIS.
 - Power Corridors. Renewable Energy Development Zone Strategic Transmission Corridors (release date 2017-04-20), DEA EGIS <https://egis.environment.gov.za/>

TABLE 23.—Spatial data sources (all available on BGIS: <https://bgis.sanbi.org/SpatialDataset>)

Spatial Data	Source
WC Kannaland CBA	CapeNature. 2017 WCBSP Kannaland
WC George CBA	CapeNature. 2017 WCBSP George [Vector]
WC Mossel Bay CBA	CapeNature. 2017 WCBSP Mossel Bay [Vector]
WC Prince Alfred CBA	CapeNature. 2017 WCBSP Prince Albert [vector geospatial dataset]
WC Oudtshoorn CBA	CapeNature. 2017 WCBSP Oudtshoorn [vector geospatial dataset]
WC Hessequa CBA	CapeNature. 2017 WCBSP Hessequa Part 1 [Vector] CapeNature. 2017 WCBSP Hessequa Part 2 [Vector]
WC Laingsburg CBA	CapeNature. 2017 WCBSP Laingsburg [Vector]
EC NMBM CBA	Nelson Mandela Bay Municipality Bioregional Plan 2009
EC Addo CBA	South African National Parks. Addo Biodiversity Sector Plan 2012
EC Garden Route CBA	Garden Route Initiative. Archived Garden Route Critical Biodiversity Areas and Ecological Support Areas 2009
ECBCP Aquatic 2019	DEDEAT Eastern Cape Biodiversity Conservation Plan 2019
ECBCP Terrestrial 2019	DEDEAT Eastern Cape Biodiversity Conservation Plan 2019

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References

- African Centre for Biodiversity (ACB). Sprag. L. (ed.) 2017. *Against the odds: Smallholder farmers and agricultural biodiversity in South Africa*. Fieldwork Report. Available at: www.acbio.org.za.
- Beier, P. & Brost, B. 2010. The use of land facets to plan for climate change: conserving the arenas, not the actors. *Conservation Biology* 24: 701–710.
- Biggs, R., Schluter, M., Biggs, D., Bohensky, E.L., BurnSilver, S., Cundill, G., Dakos, V., Daw, T.M., Evans, L.S., Kotschy, K., Leitch, M.A., Meek, C., Quinlan, A., Raudsepp-Hearne, C., Robards, M.D., Schoon, M.L., Schultz, L. & West, P.C. 2012. Toward Principles for Enhancing the Resilience of Ecosystem Services. *Annual Review of Environmental Resources* 37: 421–448.
- Blaum, N., Seymour, C., Rossmanith, E., Schwager, M. & Jeltsch, F. 2008. Changes in arthropod diversity along a land-use driven gradient of shrub cover in savanna rangelands: identification of suitable indicators. *Journal of Biodiversity and Conservation* 18(5): 1187–1199. Available at: <https://link.springer.com/article/10.1007/s10531-008-9498-x>.
- Bowers, M.A. & Harris, L.C. 1994. A large-scale metapopulation model of interspecific competition and environmental change. *Ecological Modelling* 72:251–273.
- Child, M., Davies-Mostert, H. & Raimondo, D. 2017. Mammal Red List 2016. Available at: <https://www.ewt.org.za/reddata/reddata.html>.
- Cocks, M., Dold, T. & Wiersum, F. 2003. The Cost of Culture: the role of natural resources in maintaining Xhosa customs in the Eastern Cape. *Veld & Flora* 89: 146–149.
- Cocks, M.L., Dold, T. & Vetter, S. 2012. 'God is my forest' - Xhosa cultural values provide untapped opportunities for conservation. *South African Journal of Science* 108: 5–6.
- Cowling, R.M. 1984. A syntaxanomic and synecological study in the Humansdorp region of the Fynbos Biome. *Bothalia* 15: 175–227.
- Cowling, R.M., Proches, S., Vlok, J.H.J. & Van Staden, J. 2005. On the origin of southern African subtropical thicket vegetation. *South African Journal of Botany* 71: 1–23.
- DEA 2015. Climate Change Adaptation Plans for South African Biomes (Eds. Kharika, J.R.M., Mkhize, N.C.S., Munyai, T., Khavhagali, V.P., Davis, C., Dziba, D., Scholes, R., Van Garderen, E., Von Maltitz, G., Le Maitre, D., Archibald, S., Lotter, D., Van Deventer, H., Midgely, G. & Hoffman, T.). Department of Environmental Affairs, Pretoria.
- Department of Environmental Affairs (DEA), Department of Mineral Resources, Chamber of Mines, South African Mining and Biodiversity Forum, and South African National Biodiversity Institute. 2013. *Mining and Biodiversity Guideline: Mainstreaming biodiversity into the mining sector*. Pretoria. 100 pp.
- Department of Water and Sanitation (DWS). 2014. *A desktop assessment of the present ecological state, ecological importance and ecological sensitivity per subquaternary reaches for secondary catchments in South Africa*. Department of Water and Sanitation. Compiled by RQIS-RDM. Available at: <http://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx>.
- DWAF (DWS). 1999a. Appendix W4: IER (Floodplain wetlands): Present Ecological Status (PES) Method. In DWAF Resource Directed Measures for Protection of Water Resources, Volume 4: Wetland Ecosystems; Version 1.0. Department of Water Affairs and Forestry, pp. W4/1–W4/6.
- DWAF (DWS). 1999b. Appendix W5: IER (Floodplains): Determining the Ecological Importance and Sensitivity (EIS) and the Ecological Management Class (EMC). In DWAF Resource Directed Measures for Protection of Water Resources, Volume 4: Wetland Ecosystems; Version 1.0. Department of Water Affairs and Forestry, pp. W5/1–W5/7.
- DWAF (DEFF). 2007a. *Policy principles and guidelines for control of development affecting natural forests*. Department of Environment, Forestry and Fisheries.
- DWAF (DWS). 2007b. *Manual for the assessment of a Wetland Index of Habitat Integrity for South African floodplain and channelled valley bottom wetland types*. RQS Report N/0000/00/WEI/0407. Resource Quality Services, Department of Water Affairs and Forestry.
- DWAF (DWS). 2008. *Updated manual for the identification and delineation of wetlands and riparian areas*. Prepared by M. Rountree, A. L. Batchelor, J. MacKenzie and D. Hoare. Department of Water Affairs and Forestry, Pretoria, South Africa.
- Edwards, R., Macfarlane, D., Robinson, K., Israel, A., De Groen, M. & Dunsmore, S. 2018. *Wetland Management Guidelines: building capacity and supporting effective management of wetlands within South African municipalities*. International Council for Local Environmental Initiatives, Local Governments for

- Sustainability. Available at: <https://cbc.iclei.org/project/lab-wetlands-sa/#1523618274000-b381d4a8-7b43>.
- Freedman, A.H., Buermann, W., Mitchard, E.T.A., DeFries, R.S. & Smith, T.B. 2010. Human impacts flatten rainforest-savanna gradient and reduce adaptive diversity in a rainforest bird. *PLoS ONE* 5(9):e13088. doi: 10.1371/journal.pone.0013088.
- Guo, D., Desmet, P.G. & Powrie, L.W. 2017. Impact of the future changing climate on the southern Africa biomes, and the importance of geology. *Journal of Geoscience and Environment Protection* 5: 1–9. Available at: <http://www.scirp.org/journal/PaperInformation.aspx?PaperID=77469>
- Hamann, M. & Tuinder, V. 2012. *Introducing the Eastern Cape: A quick guide to its history, diversity and future challenges*. Compiled for Programme on Governance of Ecosystem Services under Scenarios of Change in Southern and Eastern Africa led by Stockholm Resilience Centre (SRC). Stockholm University.
- Hoffman, M.T. & Cowling, R.M. 1990. Desertification in the lower Sundays River Valley, South Africa. *Journal of Arid Environments* 19: 105–118.
- Hoffman, M.T., Todd, S., Ntshona, Z. & Turner, S. 1999. *Land Degradation in South Africa*. National Botanical Institute, Cape Town.
- Intergovernmental Panel on Climate Change (IPCC). 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
- IPCC 2018. Summary for Policymakers. In V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor & T. Waterfield, *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. World Meteorological Organization, Geneva, Switzerland, 32 pp.
- Jewitt, D., Goodman, P.S. & Erasmus, B.F.N. 2017. Planning for the Maintenance of Floristic Diversity in the Face of Land Cover and Climate Change. *Environmental Management* 59: 792–806.
- Kerley, G.I.H. & Landman, M. 2006. The impacts of elephants on biodiversity in the Eastern Cape Subtropical Thickets. *South African Journal of Science* 102: 395–402.
- Kerley, G.I.H., Knight, M.H. & De Kock, M. 1995. Desertification of subtropical thicket in the Eastern Cape, South Africa: Are there alternatives? *Environmental Monitoring and Assessments* 37: 211–230.
- Kleynhans, C.J. & Louw, M.D. 2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. *WRC Report No. TT 329/08*.
- Kotze, D., Marneweck, G., Batchelor, A., Lindley, D. and Collins, N. 2009. WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. Breen, C., Dini, J. Ellery, W., Mitchell, S and Uys, M. (Eds). *WRC Report No. TT 339/09*. Water Research Commission.
- Kotze, D.C. & Macfarlane, D.M. 2014. *A framework to monitor and evaluate the ecological effectiveness of the Working for Wetlands Programme*. Pretoria Working for Wetlands.
- Landman, M., Schoeman, D., Hall-Martin, A. & Kerley, G. 2014. Long-term monitoring reveals differing impacts of elephants on elements of a canopy shrub community. *Ecological Applications* 24: 2002–2012. 10.1890/14-0080.1.
- Lechmere-Oertel, R.G., Kerley, G.I.H., Mills, A.J. & Cowling R.M. 2008. Little dynamics across browsing-induced fence line contrasts in succulent thicket, South Africa. *South African Journal of Botany* 74: 651–659.
- Lloyd, J.W., Van den Berg, E.C. & Palmer, A.R. 2002. Patterns of transformation and degradation in the thicket biome, South Africa. *Terrestrial Ecology Research Unit. Report Number 39*. University of Port Elizabeth.
- Lubke, R.A., Everard, D.A. & Jackson, S. 1986. The biomes of the Eastern Cape with emphasis on their conservation. *Bothalia* 16: 251–261.
- Macfarlane, D.M. & Bredin, I.P. 2017. Buffer Zone Guidelines for Rivers, Wetlands and Estuaries Part 1: Technical Manual. *WRC Report No. TT 715/1/17*, Water Research Commission.
- Macfarlane, D., Holness, S.D., Von Hase, A., Brownlie, S., Dini, J.A. & Kilian, V. 2016. Wetland Offsets: a best practice guideline for South Africa. *WRC Report No. TT 660/16*. Water Research Commission.
- Macfarlane, D., Kotze, D., Ellery, W., Koopman, V., Goodman, P.S., Goge, M. & Walters, D. 2009. *WET-Health: A technique for rapidly assessing wetland health*. *WRC Report No TT 340/09*. Water Research Commission
- Matteucci, S.D. 1987. The vegetation of Falcón state, Venezuela. *Vegetation* 70: 67–91.
- McGeoch, M.A. 2002. The verification and application of bioindicators: a case study of dung beetles in a savanna ecosystem. *Journal of Applied Ecology* 39(4): 661–672. Available at: <http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2664.2002.00743.x/full>.
- Mills, A.J. & Cowling, R.M. 2006. Rate of carbon sequestration at two thicket restoration sites in the Eastern Cape, South Africa. *Restoration Ecology* 14: 38–49.
- Mills, A.J., Cowling, R.M., Fey, M.V., Kerley, G.I.H., Lechmere-Oertel, R.G., Sigwela, A., Skowno, A. & Rundel, P.W. 2005. Effects of goat pastoralism on ecosystem carbon storage in semi-arid thicket, Eastern Cape, South Africa. *Austral Ecology* 30: 807–813.

- Mills, A.J., Spear, D., Ndhlovu, T., Knight, M. H., Peinke, D., Hofmeyr, S. & Cowling, R.M. 2014. Biomass of herbivores in South African subtropical thicket. *African Journal of Ecology* 52: 577–580.
- Mills, A.J., Turpie, J.K., Cowling, R.M., Marais, C., Kerley, G.I.H., Lechmere-Oertel, R.G., Sigwela, A.M. & Powell, M. 2007. Assessing costs, benefits, and feasibility of restoring natural capital in subtropical thicket in South Africa. Chapter 21. In J. Aronson, S.J. Milton & J.N. Blignaut, *Restoring Natural Capital – Science, Business and Practice*. Island Press, Washington.
- Milne, T.A. 2008. *The effects of thicket transformation on the diet and body condition of Angora Goats*. Unpublished M.Sc. dissertation. Nelson Mandela Metropolitan University, Port Elizabeth.
- Mittermeier, R.A., Robles, G.P. & Hovman, M. 2004. *Hotspots revisited: earth's biologically richest and most endangered terrestrial ecoregions*. CEMEX, Mexico City.
- Morelli, T.L., Daly, C., Dobrowski, S.Z., Dulen, D.M., Ebersole, J.L., Jackson, S.T., Lundquist, J.D., Millar, C.I. Maher, S.P., Monahan, W.B., Nydick, K.R., Redmond, K.T., Sawyer, S.C., Stock, S. & Beissinger, S.R. 2016. Managing Climate Change Refugia for Climate Adaptation. *PLOS ONE*. DOI: 10.1371/journal.pone.0159909.
- Nel, J., Maree, G., Roux, D., Moolman, J., Kleynhans, N., Silberbauer, M. & Driver, A. 2004. *South African National Spatial Biodiversity Assessment 2004: Technical Report*. Volume 2: River Component. CSIR Report Number ENV-S-I-2004-063. Stellenbosch: Council for Scientific and Industrial Research.
- Ollis, D.J., Day J.A., Malan, H.L., Ewart-Smith J.L. & Job, N.M. 2014. *Development of decision-support tools for assessment of wetland Present Ecological Status (PES) Volume 2*. Development of a decision-support framework for wetland assessment in South Africa and a decision-support protocol for the rapid assessment of wetland ecological condition. *WRC Report No. TT 609/14*. Water Research Commission.
- Ollis, D.J., Snaddon, C.D., Job, N.M. & Mbona, N. 2013. *Classification system for wetlands and other aquatic ecosystems in South Africa. User manual: inland systems*. SANBI Biodiversity Series 22. South African National Biodiversity Institute (SANBI).
- Pierce, S. & Skowno, A. 2009. In A.J. Mills, J. Blignaut, R.M. Cowling, A. Knipe, C. Marais, S. Marais, M. Powell, A.M. Sigwela, & A. Skowno, *Investing in Sustainability: Restoring degraded ticket, creating jobs, capturing carbon and earning green credit*. DG Murray Trust administered via the Climate Action Partnership, Working for Woodlands Programme, Department of Water Affairs, and Wilderness Foundation. http://www.rncalliance.org/WebRoot/rncalliance/Shops/rncalliance/4B45/777F/46E7/8C2D/D572/C0A8/D218/F935/Final_CAP_Thicket_Restoration.pdf
- Reyers, B., O'Farrell, P., Cowling, R.M., Egoh, B.N., Le Maitre, D.C. & Vlok, J.H.J. 2009. Ecosystem services, land-cover change, and stakeholders: finding a sustainable foothold for a semiarid biodiversity hotspot. *Ecology and Society* 14(1): 38. Available at: <http://www.ecologyandsociety.org/vol14/iss1/art38/>.
- Rountree, M.W. & Kotze, D.C. 2013. Specialist Appendix A3: EIS Assessment. In M.W. Rountree, H.L. Malan & B.C. Weston, *Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Version 2.0)*; *WRC Report No. 1788/1/13*. Water Research Commission, Pretoria, pp. 42–46.
- Sigwela, A.M. 1999. *Goats and Kudu in subtropical thicket: dietary competition and seed dispersal efficiency*. Unpublished M.Sc. dissertation. University of Port Elizabeth. Port Elizabeth, South Africa.
- Sims-Castley, R. 2002. *A preliminary review of gross financial incomes generated by industries dependent on thicket vegetation*. Terrestrial Ecology Research Unit, University of Port Elizabeth, Report No. 37.
- Skead, C.J. 2007. *Historical Incidence of the Larger Land Mammals in the Broader Eastern Cape*. 2nd Ed. Centre for African Conservation Ecology, Nelson Mandela Metropolitan University, Port Elizabeth. 570 pp.
- Skowno, A.L. 2018. *Terrestrial habitat modification change map (1990–2014) for South Africa*. National Biodiversity Assessment 2018 – Technical Reports. Version 5.1.
- Skowno, A.L., Raimondo, D.C., Poole, C.J. & Fizotti, B. (Eds.) 2019. *National Biodiversity Assessment 2018 Technical Report Volume 1: Terrestrial Realm*. South African National Biodiversity Institute, Pretoria.
- South African National Biodiversity Institute (SANBI) (2006–2018). *The Vegetation Map of South Africa, Lesotho and Swaziland (VEGMAP)*. Mucina, L., Rutherford, M.C. and Powrie, L.W. (Eds). Available at: <http://bgis.sanbi.org/Projects/Detail/208>, Version 2018.
- Staver, A.C. & Bond, W.J. 2014. Is there a 'browse trap'? Dynamics of herbivore impacts on trees and grasses in an African savanna. *Journal of Ecology* 102: 595–602.
- Stuart-Hill, G.C. 1992. Effects of elephants and goats on the Kaffrarian succulent thicket of the Eastern Cape. *Journal of Applied Ecology* 29: 699–710.
- Theron, J.M. 1978. Proewe met Round-up op hakea. *Bosforus*: 19–21. Faculty of Forestry, University of Stellenbosch.
- Thompson, M., Vlok, J., Rouget, M., Hoffman, M., Balmford, A. & Cowling, R. 2009. Mapping grazing-induced degradation in a semi-arid environment: a rapid and cost effective approach for assessment and monitoring. *Environmental management* 43(4): 585–596.
- Van Deventer, H., Van Niekerk, L., Adams, J., Dinala, M., Gangat, R., Lamberth, S., Lötter, M.C., Mbona, N., MacKay, F., Nel, J., Ramjukadh, C.L., Skowno, A. & Weerts, S. 2020. *National Wetland Map 5: An improved spatial extent and representation of inland aquatic and estuarine ecosystems in South Africa*. Water SA. 46. 10.17159/wsa/2020.v46.i1.7887.
- Van Rooyen, S.E. 2016. *Composition and structure of woody vegetation in thickened and controlled bushveld savanna in the Molopo*. Unpublished M.Sc. dissertation, North-West University, Potchefstroom.
- Van Wilgen, B.W., Forsyth, G.C., Le Maitre, D.C., Wannenburgh, A., Kotze, J.D.F., Van den Berg, E. & Henderson,

- L. 2012. An assessment of the effectiveness of a large, national scale invasive plant control strategy in South Africa. *Biological Conservation* 148: 28–38.
- Vlok, J.H.J. & Euston-Brown, D.I.W. 2002. *The patterns within, and the ecological processes that sustain, the subtropical thicket vegetation in the planning domain for the Subtropical Thicket Ecosystem Planning (STEP) Project*. Terrestrial Ecology Research Unit, Report No. 40: 1–145.
- Vlok, J.H.J., Euston-Brown, D.I.W., Cowling, R.M., 2003. Acocks' Valley Bushveld 50 years on: new perspectives on the delimitation, characterisation and origin of subtropical thicket vegetation. *South African Journal of Botany* 69: 27–51.
- Water Research Commission (WRC). 2017. *Identification, delineation and importance of the strategic water source areas of South Africa, Lesotho and Swaziland for surface water and groundwater* (Project no. K5/2431). Accessible from <https://bgis.sanbi.org/Projects/Detail/207>.
- Webb, I.J. 1978. A general classification of Australian rainforest. *Australian Plants* 9: 349–363.
- White, F. 1983. *Vegetation of Africa - a descriptive memoir to accompany the Unesco/AETFAT/UNSO vegetation map of Africa*; Natural Resources Research Report; U.N. Educational, Scientific and Cultural Organization; 7 Place de Fontenoy, 75700 Paris, France; 356 pages. Available on: <https://www.creaf.uab.es/mirammon/mmr/examples/miombo/docs/database/white/index.htm>. Accessed on 19 January 2021.
- Williams, V.L., Victor, J.E. & Crouch, N.R. 2013. Red Listed medicinal plants of South Africa: Status, trends, and assessment challenges. *South African Journal of Botany* 86: 23–35.





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