STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT IN SOUTH AFRICA

Biodiversity and Ecological Impacts (Terrestrial Ecosystems and Species) - Savanna and Grassland Biomes

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT

Draft v3 Specialist Assessment Report for Stakeholder Review

SAVANNA AND GRASSLAND BIOMES

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ABBREVIATIONS AND ACRONYMS

CBA	Critical Biodiversity Area
CR	Critically Endangered
EN	Endangered
EIA	Environmental Impact Assessment
GIS	Geographic Information System
IAP	Invasive Alien Plants
NEMBA	National Environmental Management: Biodiversity Act, 2004
SANBI	South African National Biodiversity Institute
SEA	Strategic Environmental Assessment
TOPS	Threatened or Protected Species Regulations
VU	Vulnerable

SUMMARY

South African grasslands have a large number of species which occur nowhere else in the world (high endemism) and are threatened due to the high degree of transformation. Grasslands are one of the most threatened biomes in the country as they are the biome in which most crop agriculture and forestry takes place, as well as being the region with a high proportion of South Africa's human settlement and mining (Mucina and Rutherford 2006). The Grasslands have a high diversity of dichotomous plant species as well as a number of threatened animal species, especially reptiles. Past activities have already transformed large areas of some grassland types and therefore the remaining pockets of these grasslands are critical from a conservation perspective (Neke and Du Plessis 2004, Reyers et al. 2001). As a consequence, many of the remaining natural Grasslands are classified as Critical Biodiversity Areas and, if possible, should be avoided by pipeline development. Phase 7 has a disproportionately high level of threatened plant and animal species.

Savannas, though having a high biodiversity, are relatively homogenous over large areas. Compared to Grasslands, Savannas have far lower levels of threatened plant species. Despite this there are some very unique and threatened Savanna habitats requiring special conservation. Many of South Africa's key National and Provincial Parks are found within the Savannas, and the Savannas contain many of South Africa's iconic large mammals, some of which are Endangered or Vulnerable. Re-establishment of large trees will be prevented in a 10 m wide strip above the pipeline (i.e. within the registered servitude). With the exception of areas identified as Critical Biodiversity Areas, routing through the Savannas should have relatively low significance impacts provided suggested mitigation measures are adhered to.

Both Savanna and Grassland are fire dependent ecosystems. It is important that fire regimes are maintained in both these biomes to maintain natural biodiversity.

Summary of key issues by phase

Corridor	Overall Suitability	Comment
Phase 3	Moderate suitability for gas pipeline infrastructure development.	This corridor has a number of pinch points. The Zululand area has a number of large and important conservation areas as well as important biodiversity. The second main pinch point is crossing the Drakensberg, where the high altitude Grasslands contain important biodiversity. Finally, the Gauteng region is extremely complex due to the large urban and agricultural expansion, with remaining natural areas being important conservation refugia.
Phase 4	Moderate suitability	This corridor passes through areas of high biodiversity importance linked to the Maputaland centre of plant endemism, with a large number of Critical and Vulnerable Ecosystems which, combined with important conservation areas such as the iSimangaliso Wetland Park, Umfolozi Hluhluwe complex, Ndumo and Mkhuze reserves, create pinch points for development.
Phase 7	Low suitability for gas line infrastructure development.	This corridor crosses the Maputuland-Pondoland and Albany centre of endemism and large area of endangered or critically endangered habitat. Many of the Grassland and Savanna types are poorly conserved and especially the Grasslands have been extensively transformed or degraded. The area has a disproportionally high degree of plant endemism, as well as threatened species.
Phase 8	Low suitability for gas line infrastructure development	This corridor passes through a number of pinch point areas created by conservation areas, threatened ecosystems and the complexities of crossing the Drakensberg.
Inland corridor and phase 2	Not suitable from a grass perspective	Only tiny patches of grassland are found in this corridor, but where they are found they should be avoided as they are all classed as critical biodiversity areas, with some in conservation areas.

1 INTRODUCTION

Pipeline developments are linear in nature and require total destruction of the aboveground vegetation during the underground installation of pipes. Although this is in a relatively narrow strip of 50 m in width (for the construction right-of-way), summed over the pipeline length this can become thousands of hectares of destroyed biodiversity, if not restored appropriately. The trench represents a substantial disruption of soil and drainage to a depth of approximately 2 m and width of about 1.5 m, some effects of which, despite restoration, persist for centuries. Further, during the construction phase the trench is a temporary barrier to animal movement. Post-installation, and assuming full revegetation with indigenous fauna, the impacts are substantially less, although the vegetation in a narrow corridor (i.e. a 10 m wide operational servitude) may exclude deep-roots and large trees. Because the habitat along the pipeline may differ in species and structure from the original habitat it can conceivably result in a barrier to the movement of insects, small animals, birds, and plant propagules, especially if not fully restored to its initial biodiversity and vegetation structure. Pipeline routing that takes the pipeline parallel to environmental gradients is likely to have greater potential impacts on migration, and also may well cut through a large proportion of any one vegetation type as the vegetation also tends to follow gradients. The soil disturbance during pipeline installation will make the area highly susceptible to invasion by invasive alien plant (IAP) species, and these will need active and long term control to prevent a number of secondary environmental impacts.

Without sound management it is likely that the pipeline corridor can be a source of soil erosion. The pipeline will often, out of necessity, route directly up or down slopes. The unvegetated and loose soil just post construction can easily become trigger points for erosion.

When considering infrastructure projects of this nature it is important to consider the functional attributes of the biomes that may be impacted and how the development may impact on these functional attributes.

The unique feature of Savanna (see Figure 1) that separates them from Grassland is the occurrence of a tree layer in addition to an herbaceous layer. Savanna, although having a high *alpha* diversity (i.e. species diversity at the plot level), the species turnover, *beta* diversity, and landscape (*gamma*) diversity is relatively low (Scholes, 1997). This attribute of Savanna makes them relatively resistant to small-scale disturbances as a small disturbance is unlikely to have catastrophic loss to any particular species. However; there are specific locations with threatened and endangered species where these species would need protection. In addition, a number of the individual tree species within Savannas are protected and require a permit to be cut (see Appendix A).

Grasslands (see Figure 1), as the name implies, are dominated by a grass layer. However, from a biodiversity perspective it is the huge diversity of non-grass species, often referred to as forbs, that give the Grasslands biome their high diversity (O'Connor and Bredenkamp 1997, Mucina and Rutherford 2006). It is also these forbs that are typically the rare and endangered species within the Grassland biome (Appendix C). Identifying and conserving these non-grass species will be of particular importance during the construction phase. In many cases these plants can be dug up and replanted once construction is completed.

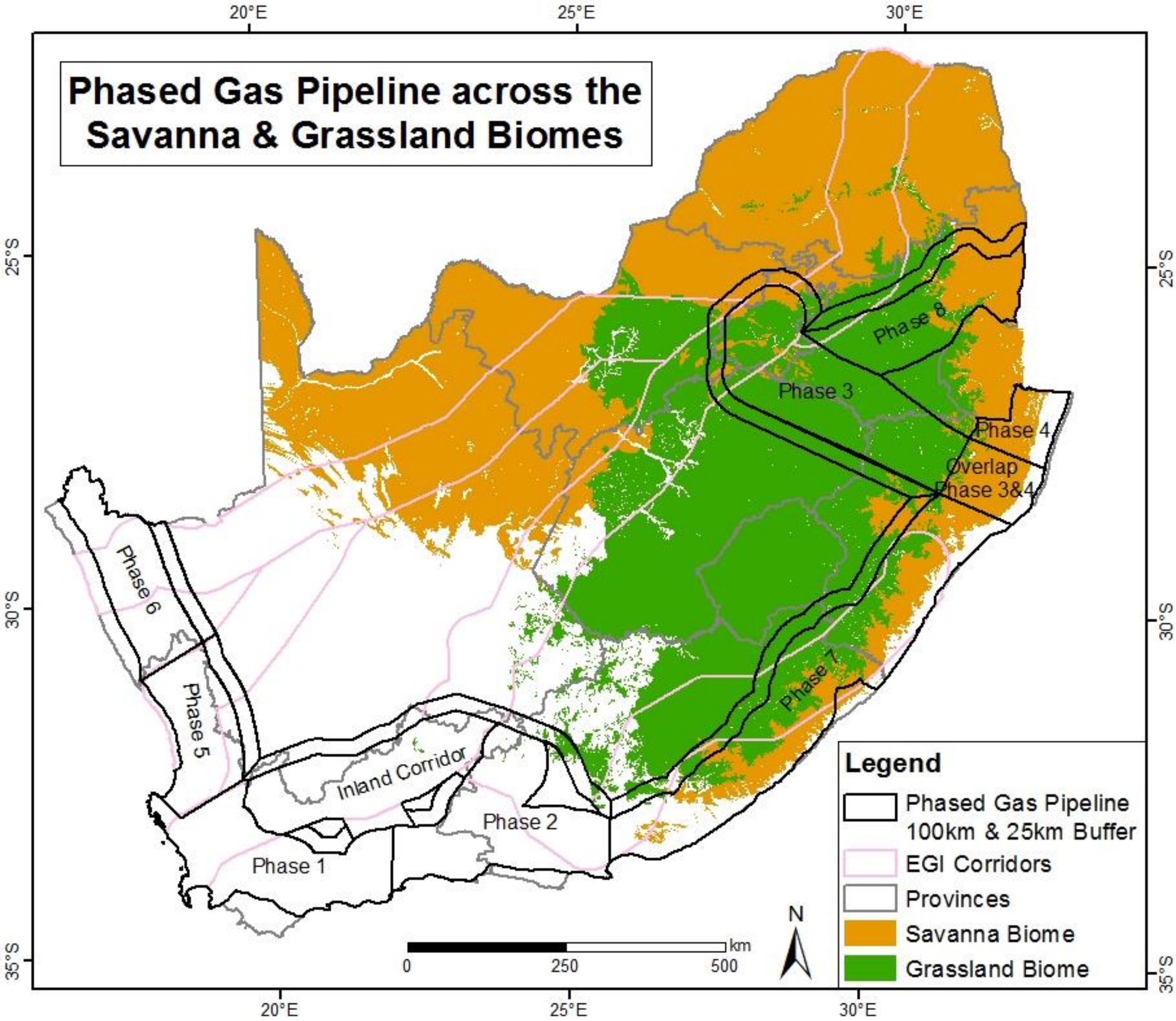


Figure 1: The location of the proposed Gas Pipeline Phases in relation to the national extent of Savanna and Grassland vegetation. Electricity Grid Infrastructure (EGI) corridors Gazetted in early 2018 (https://egis.environment.gov.za/egi) are also presented to indicate the broader energy planning context in South Africa.

Savanna as a biome, is well conserved; however, many of the specific Savanna vegetation types found within the corridors, are very poorly conserved (see Figure 2) (Mucina and Rutherford, 2006). Grasslands are arguably one of the most threatened biomes in the country, with many Grassland types very poorly conserved (Figure 3) (SANBI no date; Mucina and Rutherford, 2006). In addition, Grasslands have some of the most transformed vegetation types, with a large proportion of the national cereal crop agriculture taking place in the Grasslands (Reyers et al 2001, Fairbanks et al 2000). Most of the plantation forestry, a large proportion of mining as well as some of the biggest metropolitan areas are also located within the Grasslands. In Gauteng, there is exceptionally limited natural or even semi-natural Grassland remaining. Similarly, large amounts of the Grassland in the Eastern Cape corridor have also been transformed. This places a high conservation importance on all remaining Grassland.

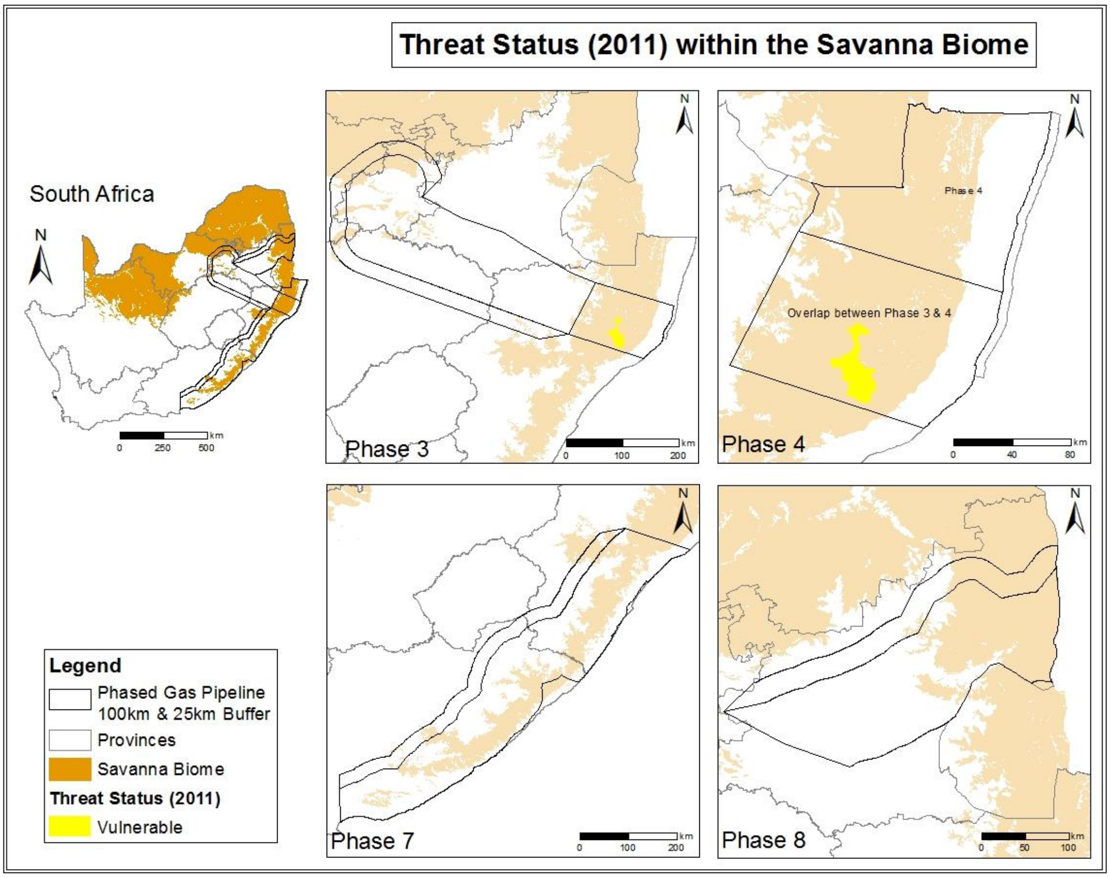


Figure 2: Conservation status of individual Savanna ecosystems (functionally vegetation types from Mucina and Rutherford (2006)) as gazetted (Gazette No 34809 of 2011).

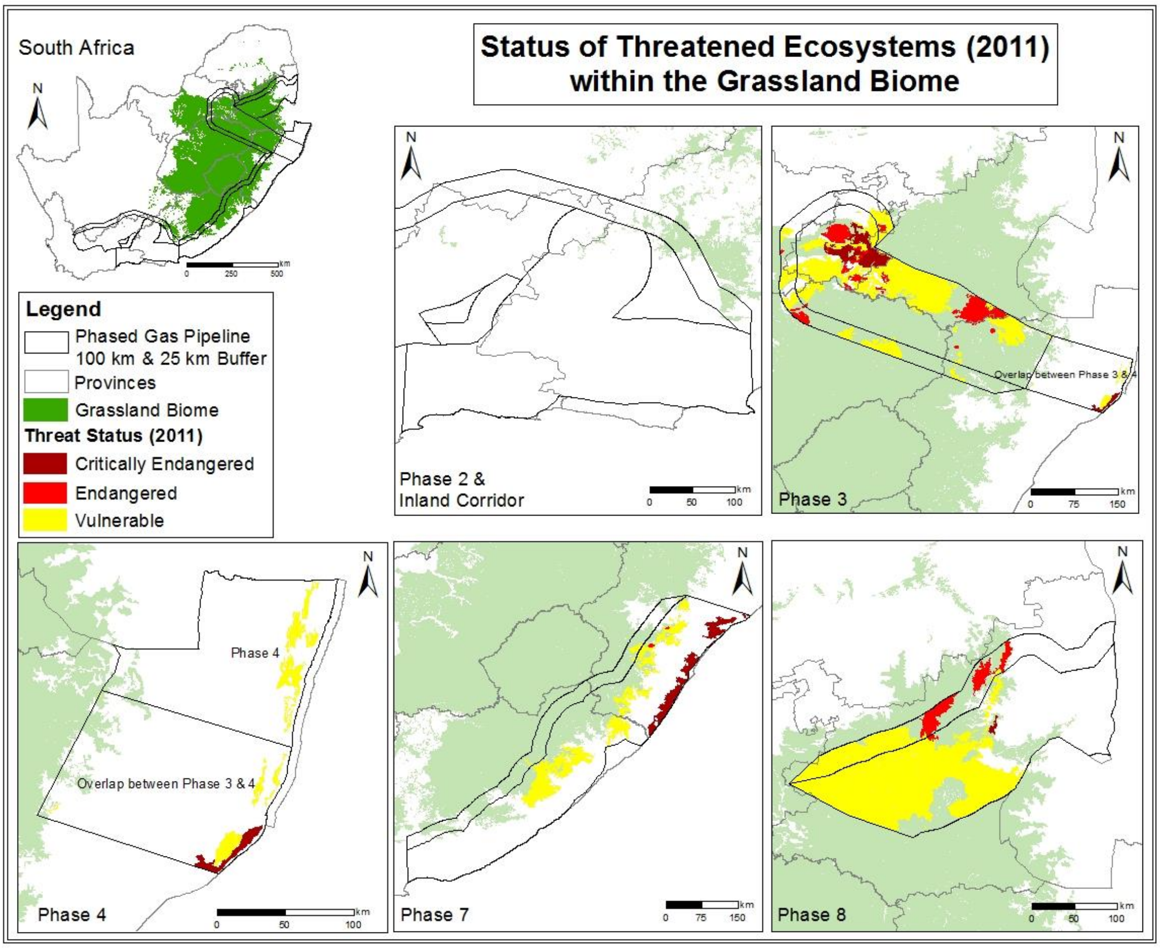


Figure 3: Conservation status of individual Grassland ecoregions (functionally vegetation types from Mucina and Rutherford (2006)) as gazetted (Gazette No 34809 of 2011). Note, some coastal grasslands depicted here fall outside of the grassland biome and are covered in the Indian Ocean Coastal Belt Biome Specialist Assessment.

Savanna and Grassland are the home to a large number of mammals, and these animals move over considerable distances to locate grazing. During the pipeline construction phase it is feasible that the movement of animals might be hindered if not managed appropriately, but this is not likely to be a factor in the post-construction phase assuming adequate rehabilitation is conducted. Small mammals, rodents, reptiles, invertebrates and ground birds may also be hindered during construction. If the post-construction habitat does not have the same functional attributes (e.g. vegetation type and density) as the original habitat, then some of these species may have difficulty crossing or utilizing the new habitat. Many of the large and charismatic threatened mammal species such as both black and white rhinoceroses (*Diceros bicornis & Ceratotherium simum)*, cheetah (*Acinonyx jubatus)* and cape hunting dogs (*Lycaon pictus)* are found in the Savanna and Grassland corridors (see Appendix B). These species are almost exclusively limited to protected areas and private reserves and as such their distribution is easily identified. Despite preventative measures being in place, during construction there is a potential threat of these species falling into the construction trench, although post construction impacts will be minimal. A few large endangered mammals such as leopard (*Panthera pardus)*, mountain reedbuck (*Redunca fulvorufula)* and Oribi (*Ourebia ourebi)* may occur in suitable habitats outside of conservation areas and will need specialists to identify potential locations where these species may be encountered (Child et al. 2016).

The distribution of small mammals, reptiles and insects are far harder to ascertain, although a large number of Critically Endangered, Endangered and Vulnerable species occur within the pipeline corridors (see Appendix B - E and Figure 5). In many cases these species have small ranges and often use burrows for shelter and breeding. As such the construction phase could potentially have high significance impacts. For instance, some of the golden moles e.g. the critically endangered rough-haired golden mole

(*Chrysosphalax villosus*) or the endangered– Juliana's golden mole (*Eamblysomus julianae)* are limited to a few sites. A pipeline trench could conceivably cut through a population and create a habitat that cannot be crossed by this burrowing species. A number of golden moles are found within the potential corridors. The sungazer lizard (*Smaug giganteus)* is an example of an endemic and Vulnerable reptile from the arid Grasslands. Understanding likely occurrences of threatened species will need a qualified specialist with a keen knowledge of the specific habitat requirements of the species. Attempting to map habitat requirements for all endangered species goes beyond the scope of this study, although locations of known occurrences are included and buffered.

Bats and birds, although a critical component of Savanna and Grassland habitats, are not considered in this report as they are fully covered in dedicated specialist reports. Similarly, river and wetland systems and species are also dealt with in their own specialist report, however, although they form an integral part of savanna and grassland ecosystems and this connectivity means that the independent studies must be considered together, not in isolation. Forest patches, including the Critically Endangered Sand Forest, are embedded in the grasslands. All forest patches are assumed excluded from potential routings and as such are given a Very High Sensitivity rating. It is also important to point out that the Indian Ocean Coastal Belt biome is considered in a separate assessment, this despite it having both large areas of open grassland as well as areas that have previously been defined as savanna.

The social importance of natural areas, including 'sense-of-place' is not covered in this report. However, it is important to emphasise that in addition to cropping and forestry, biodiversity-based tourism is an economically important and growing land use activity within the Savanna and Grassland Biomes along the East Coast of KwaZulu-Natal. Biodiversity-based tourism is particularly sensitive to visual and sense-of-place impacts, regardless of whether they endanger the biodiversity populations directly or not.

Both Savanna and Grassland are fire dependent environments. Fire frequency is dependent on mean annual precipitation, with fire return intervals being once every two to three years in moist area, but reducing in dry areas. Maintaining a fire frequency on the restored land is important for maintaining biological integrity of the vegetation type (Mucina and Rutherford 2006, O'Connor and Bredenkamp 1997, Scholes, 1997).

Although both Grassland and Savanna habitats are relatively well adapted to disturbances, a complete clearing of the vegetation during the construction phase will need direct intervention to ensure rapid rehabilitation. Experience has shown that abandoned old fields in Savannas can take 20 or more years before trees re-establish, and even then it is often by early succession tree species. Active intervention will be needed if the habitats are to revert to near-natural vegetation within reasonable timeframes.

Construction phase disturbance is also likely to result in alien invasive plant species colonising the post-installation ground. Active alien plant removal interventions will be required until a natural vegetation cover is fully established. Although this concern is for both Grasslands and Savannas, it is the Grasslands which are most sensitive to this impact, with species such as *Acacia mearnsii* (black wattle) having seeds that can remain in the soil for decades, but which germinate in response to disturbances. Triffid weed, *Chromolaena odorata* is one of multiple common weeds in Savanna and is very common in the Zululand area where it can form impenetrable thickets. Given the vast range of habitats that will be covered by the pipelines, there are a large number for potential invasive species that can be involved. However, inspecting vehicles and clothing to ensure they do not accidently spread alien seeds into the area as well as ensuring identified alien plants are removed before they reach reproductive age can help mitigate impacts.

2 SCOPE OF THE BIODIVERSITY ASSESSMENT FOR THE SAVANNA AND GRASSLAND BIOMES

This study focuses only of areas of Savanna and Grassland biomes, and considers these only from a biodiversity perspective. As noted above, embedded wetlands and river systems form a critical and integral component of Savannas and Grasslands, and in many cases are areas of greatest biodiversity concern. These areas are, however, excluded from this assessment as they are covered within a wetland specific assessment. The same is true for birds and bats. The study considers both the construction phase of the pipeline (i.e. the trenching, laying of the pipeline, closing of the trench and rehabilitation) as well as the operational phase. It is assumed that the pipeline will remain in the ground once the project ceases so there is no true decommissioning phase. It is further assumed that there are no specific decommissioning impacts. If the pipeline is either removed, or replaced by a new pipeline, then the impacts are assumed to be equivalent to the impacts during the construction phase.

The biomes as defined by Mucina and Rutherford (2006) are used as the basis for defining areas of Savanna and Grassland. It is, however, recognised that vegetation types within the Indian Ocean Coastal Belt have many commonalities with both Savanna and Grassland biomes and has been considered as part of these biomes in the past. The embedded sand forest has also been seen as a Savanna type in the past.

This study is a high-level overview based on available secondary data sources. Fortunately, provincial assessments of Critical Biodiversity Areas (CBAs) are available for all the provinces and these provincial assessments of biodiversity importance form the backbone of this assessment. The Geographic Information System (GIS) data used, based on these provincial assessments and other data sources was compiled and provided by the South African National Biodiversity Institute (SANBI).

In addition, existing conservation areas are regarded as very high sensitivity or high sensitivity for conservation. There are a large number of national parks and provincial nature reserves within the corridors including the southern section of Kruger National Park (Phase 8) and the Hluhluwe–Imfolozi Reserve (Phase 3, 4, and 7 intersection).

All forest patches, although not Grassland or Savanna, have been rated as very high sensitivity and included in the Grassland and Savanna assessment where they are imbedded in these biomes.

2.1 Assumptions and Limitations

This assessment provides a strategic overview or important conservation concerns. It is not a detailed impact assessment for a specific location, and such assessments would be required once a proposed routing for a pipeline project is decided. Given the scale of this assessment it cannot identify all specific issues and location specific concerns.

Only biodiversity related constraints are included, and constraints from agriculture, settlement, mining, defence and other land uses are not included. Aesthetic impacts, although often linked to biodiversity, are also not considered.

This assessment only considers terrestrial biodiversity. It is important to emphasise that, within particularly the Grasslands, there are numerous imbedded wetlands that form an integral component of the Grassland ecosystems. The importance of these wetland features is emphasised, although they have been excluded from this section as they are fully covered in a section of their own. The same is true for bird and bat populations. Again they are an important component of the Savanna and Grassland biodiversity, but have been excluded based on the fact that they are being fully covered in their own section.

It was decided that buffering was not appropriate for most features and from a strictly biodiversity perspective. However, buffering for bird and bat impacts would be appropriate, (but is covered in a separate study). Given that exact locations of rare and endangered species is not known, and due to the fact that these species may be mobile (animals) or more examples are likely to occur within the identified habitat (animals and plants), this data has been buffered.

Each province used a separate approach to determine areas of high biodiversity importance. Sensitivity levels between provinces differ, with some provinces potentially using higher sensitivities than others. Provincial biodiversity conservation plans are used subject to all the assumptions that underpin the creation of the plans. Differences in approach between provinces are not assessed, but rather each province's plan is accepted independently. Further, since each province's assessment of core biodiversity areas is determined independently, there may be poor edge matching between provinces.

2.2 Relevant legislation and regulations

National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004)

The National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004) (NEMBA) provides regulations on the management of biodiversity in South Africa, including regulations relating to threatened or protected species. It provides for listing threatened or protected ecosystems, in one of four categories: Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Protected. Activity 12 in Listing Notice 3 (Government Notice R324 of April 2017 as per the 2014 Environmental Impact Assessment (EIA) Regulations, as amended) relates to the clearance of 300 m^2 or more of vegetation, within Critical Biodiversity Areas.

Threatened or Protected Species Regulations of 2013 (ToPS)

The TOPs relates to Section 56 of NEMBA. Species categorised as CR, EN, VU or Protected require permits for activities relating to:

i. Hunt / catch / capture / kill
ii. Gather / collect / pluck
iii. Pick parts of / cut / chop off / uproot / damage / destroy
iv. Import into South Africa / introduce from the sea
v. Export (re-export) from South Africa
vi. Possess / exercise physical control
vii. Grow / breed / propagate
viii. Convey / move/ translocate
ix. Sell / trade in / buy / receive / give / donate/ accept as a gift / acquire /dispose of
x. Any other prescribed activity

(See Appendix A to E for species that might be encountered).

National Environmental Management Act (Act 107 of 1998), as amended

The National Environmental Management Act 107 of 1998 (NEMA), outlines measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

NEMA EIA 2014 Regulations, as amended (Government Gazette 40772) (April 2017)

These regulations provide listed activities that require environmental authorisation prior to development because they are identified as having a potentially detrimental effect on natural ecosystems. Different sorts of activities are listed as environmental triggers that determine different levels of impact assessment and planning required. The regulations detail the procedures and timeframes to be followed for a basic or full scoping and EIA.

The National Forests Act (Act 84 of 1998)

The objective of this Act is to monitor and manage the sustainable use of forests. In terms of Section 12 (1) (d) of this Act and GN No. 1012 (promulgated under the National Forests Act), no person may, except under licence:

- Cut, disturb, damage or destroy a protected tree; or
- 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 from a protected tree.

The Gazette 37941 of 2014. This gazette relates to the National Forest Act of 1998 and lists the tree species that receive protected status under the act. List of protected trees species, many of which are relevant to the corridors in which Savanna and Grassland are present (Appendix A).

KwaZulu-Natal Nature Conservation Management Act (Act 9 of 1997)

This act specifies the institutional structure for nature conservation in KwaZulu-Natal, the establishment of control and monitoring bodies and mechanisms as well as other matters relating to this, including the gazetting of regulation.

The KwaZulu-Natal Environmental, Biodiversity and Protected Areas Management Bill, 2014 (25 February 2015)

The Management Bill, 2014 was passed to provide for the establishment, functions and powers of Ezemvelo KZN Wildlife; the protection and management of the environment and biodiversity; the protection and conservation of indigenous species, ecological communities, habitats and ecosystems; the management of the impact of certain activities on the environment; the sustainable use of indigenous biological resources; the declaration and management of protected areas; and to provide for matters connected therewith.

The Bill includes lists of provincial protected animal and plant species, and it sets rules for activities in protected areas, as well as for the protection of biodiversity.

Mpumalanga Nature Conservation Act, No. 10 of 1998

This Act relates to the establishment and management of conservation areas, and provides legislation relating to protected animals and plants.

Schedules to the Mpumalanga Nature Conservation Act 1998

This Act provides a list of protected species, and rules for conservation areas.

Gauteng Nature Conservation Bill 2014

This bill provides rules for conservation areas; and enables the protection of wild animals and plants including lists of protected species.

Eastern Cape Nature and Environmental Conservation Ordinance (19/1974)

This Ordinance includes rules for conservation areas, and enables the protection of wild animals and plants including lists of protected species.

Note: Much of the Eastern Cape legislation relies on the pre-1994 legislation of the Eastern Cape, Transkei and Ciskei.

3 KEY ATTRIBUTES AND SENSITIVITIES OF THE STUDY AREAS

3.1 Corridors Description

A brief overview of the characteristics and likely impacts per proposed Gas Pipeline Phase, relevant to biodiversity of Savanna and Grasslands is given in Table 1

Table 1: Summary description the likely impacts to Savanna and Grasslands in the proposed Gas Pipeline Phases.

Site	Brief description
Phase 3	This corridor effectively links the Richards Bay area with Gauteng. This corridor cuts from the coast to the centre of the country. With the exception of the coastal strip this corridor falls almost exclusively within Savanna and Grassland regions, with a few embedded forest patches. There are two key pinch points, the one relates to Savanna biodiversity and a string of game reserves centred on the Hluhluwe–Imfolozi Reserve and Nduna reserve in Zululand and the related Maputaland centre of plant endemism. The second is Grassland areas as the corridor cuts through the Drakensberg mountains. In addition the northern half of Gauteng is a complex area due to parallel mountain ranges, and the area being an ecotone between the Highveld Grasslands and Savanna bushland regions.
Phase 4	This corridor is in the Zululand area running from Richards Bay up to the Mozambique border. About half of this corridor is common to Phase 3. The second half being in the Zululand area and running parallel to the sea. With the exception of the coastal strip, most of this corridor is Savanna vegetation, and most is in the Maputaland centre of plant endemism. This region has a number of important private and provincial nature reserves that create pinch points. These include Ndumu, Tembe, Mkuzi and the Isimangaliso wetland park (though this is mostly not Savanna or Grassland).
Phase 7	This is a long corridor running parallel to the sea and stretching from Richards Bay to Port Elizabeth. This corridor runs through and important Pondoland centre of plant endemism. It has a large number of unique and poorly conserved Grassland and Savanna vegetation types with a large number of endemic species, rare and vulnerable species. Pinch points are not created by conservation areas, but rather by un-conserved or poorly conserved areas of high value and irreplaceable biodiversity. The nature of the linear structure of the pipeline combined with the altitudinal alignment of vegetation types mean that it may well cut across almost all areas of a specific vegetation type. This corridor cuts right across three centres of plant endemism.
Phase 8	This phase is a corridor from the Mozambique border to Gauteng (linking to Phase 3). This route is almost exclusively through Savanna and Grassland, with a few embedded forest patches. There are a number of critical squeeze points, the first being through the narrow gap below Kruger National Park and associated conservation areas, and the bulge of Swaziland with the Songimvelo and Barberton Nature reserves. There are also a large number of private reserves in this area. The second pinch point is when crossing the Drakensberg escarpment. Forestry patches as well as important Grasslands are encountered in this area.
Inland corridor and phase 2	The inland corridor and Phase 2 have small patches of grassland (Karoo Escarpment Grassland) within the corridors and the buffer zones. Although small, these patches are identified as having critical biodiversity importance and should be avoided in routing through this corridor. The small, most westerly block is almost entirely within the Karoo National Park. They form solid barriers to using the buffer zone as an alternative routing.

3.2 Feature Sensitivity Mapping

3.2.1 Identification of feature sensitivity criteria

Feature sensitivity mapping is based on available national and provincial data (Table 2). The sensitivity of classes is based largely on sensitivities as used in Provincial biodiversity plans. All National and Provincial conservation areas are considered of national biodiversity importance. For provinces, each province's critical biodiversity plan was seen as the baseline for biodiversity conservation with CBA1 areas given very high status.

Occurrence of CR, EN or VU species within the pipeline corridors is an issue of concern. Unfortunately, by the very nature of these species, for many of them exact locations of all individuals in the population are not known. Therefore, buffers around recorded locations are used as a caution that these species may be found in the area and that precautions should be taken. It is recommended that if the pipeline is likely to cross an area with recorded CR, EN or VU species, that specialist advice is sought from experts in the specific taxa to better understand if the pipeline route is likely to encounter any of the listed species.

Table 2: Data sources and descriptions of sensitivity features.

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors
Protected Areas	National Department of Environmental Affairs South African Protected Areas Database, 2017.	DEA Protected Areas database was compared against the SANBI protected areas database and discrepancies were resolved. Protected areas were added to the DEA data layer based on the SANBI layer in the Western Corridor, otherwise both layers were consistent. ***Note: The Corridor area of the Hluhluwe–Imfolozi complex has a missing section on the National Protected Area Database. This has been corrected in this report, but not in the base GIS maps.***	All corridors assessed in this assessment of Savanna and Grassland Biomes
Critical Biodiversity Areas	Provincial datasets (GP - 2014, EC - 2007, FS - 2016, KZN - 2016, Limpopo - 2013, MP - 2013, NW - 2014, WC - 2017, NC - 2016)	As prepared by SANBI. Eastern Cape was updated with new 2017 data (ECBCP, 2017).	All corridors assessed in this assessment of Savanna and Grassland Biomes
Threatened ecosystems	DEA and the SANBI 2011, Western Cape threatened Ecosystems, Eastern Cape updated threatened ecosystems	Data as downloaded from the SANBI website	All corridors assessed in this assessment of Savanna and Grassland Biomes
Natural Forest Areas	National Forest Inventory (NFI), sourced 2016, Department of Agriculture, Forestry and Fisheries (DAFF) EC CBA Plan	As prepared by SANBI	All corridors assessed in this assessment of Savanna and Grassland Biomes
Critically Endangered, Endangered and Vulnerable species	Mammals – Child et al. 2016 Reptiles – Bates et al. 2014 Frogs – Minter et al. 2004 Plants - Raimondo et al 2009 as updated 2018	As prepared by SANBI. Buffers of 2.5km around the Rodentia, Soricomorpha and Afrosoricida. 5km around everything else. For reptiles, amphibians and butterflies, a 2.5 km buffer, with the exception of *Crocodylus niloticus*, who should get a 25 km buffer. Mammal species have not been shown as they are predominantly linked to conservation areas (E.g. rhinoceros, wild dog) or are close to ubiquitous (leopard).	All corridors assessed in this assessment of Savanna and Grassland Biomes
Protected Area Expansion Areas	Eastern Cape Protected Areas Expansion Strategy, Eastern Cape	As prepared by SANBI	All corridors assessed in this assessment of

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors
	Parks and Tourism Area		Savanna and Grassland Biomes
	Western Cape Protected Areas Expansion Strategy, Cape Nature.	As prepared by SANBI	All corridors assessed in this assessment of Savanna and Grassland Biomes

The ranking of sensitivity classes per feature is given in Table 3.

Table 3: Ratings and buffer areas allocated to feature types.

Corridor	Feature Class	Feature Class Sensitivity	Buffer Distance Sensitivity
All Phases	Protected Areas – national and provincial parks, forest wilderness, special nature reserves and forest nature reserves	Very High	None
	Coastlines	Very High	None
	All indigenous forests	Very High	None
	CBA (CBA1 for EC)	Very High	None
	CBA 2 EC	High	None
	Threatened ecosystems CR	Very High	None
	EN	High	None
	VU	Medium	None
	Land Cover: Natural Area Land Cover: Modified areas	Low	None
	Game Farms	Medium	None
	SANParks Buffer	High	
	Protected Environments	High	None
	National Protected Area Expansion	Medium	None
	Mountain Catchment Areas	High	None
	Biospheres	Medium	None
	Botanical Gardens	Medium	None
	Individual threatened taxa	High	As per the data in the table above
	ESA	Medium	None

3.2.2 Feature maps

This section highlights the different features that have been combined to develop the overall sensitivity map. These maps are of a descriptive nature with the order of the drawing of features being the reverse order of the legend i.e. the first feature in the ledged is drawn on top of lower features if they overlap. The feature maps are to aid in understanding of the sensitivity maps (section 3.3), but in no way attempt to designate sensitivity either in the order of features or the colours used. Although a single map (Figure 10) attempts to consolidate all features, it is easier to understand the issues by considering specific features in isolation, such as results from the provincial biodiversity assessments (Figure 4), and individual plant and animal species (Figure 5 – Figure 9). From the individual species data, it is clear that the phase 7 corridor, in particular, is a hotspot for endangered species, and especially plant species. It is also clear that from a species perspective the Grasslands are more vulnerable than the Savanna areas.

The feature maps only include the Savanna and Grassland biomes. If parts of some features are of a different biome, then in most cases they have been clipped out. It also means that important features such as conservation areas within the phase, but outside of the Grassland and Savanna may not be displayed.

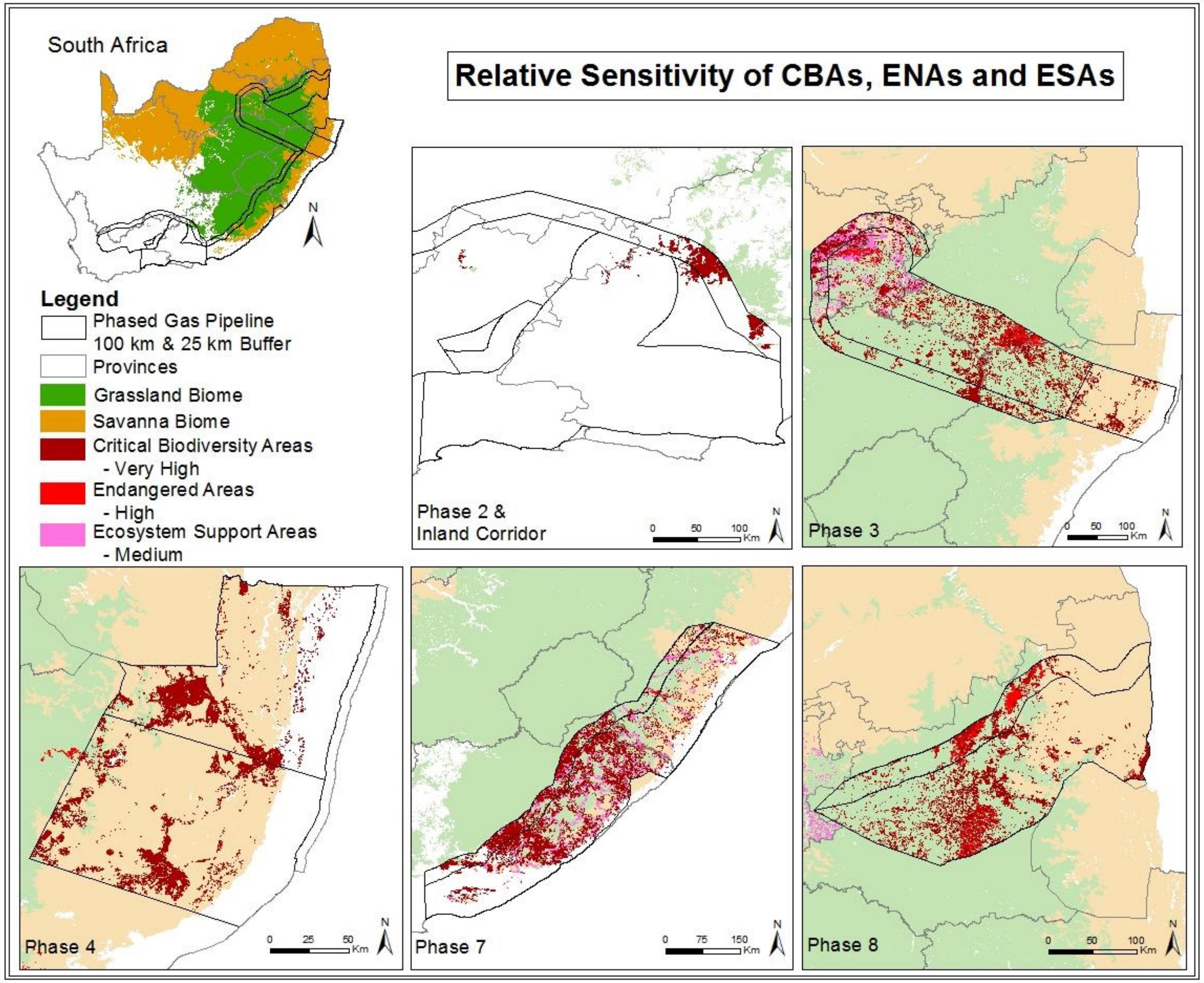


Figure 4: The provincial biodiversity plans were used to identify Critical Biodiversity Areas, Endangered Areas (ENA's) (CBA2 for Eastern Cape) and Ecological Support Areas (ESAs). Note: individual provinces assessments used different criteria for defining their CBAs. National and Provincial parks are excluded from the map, but part of most provinces CBAs.

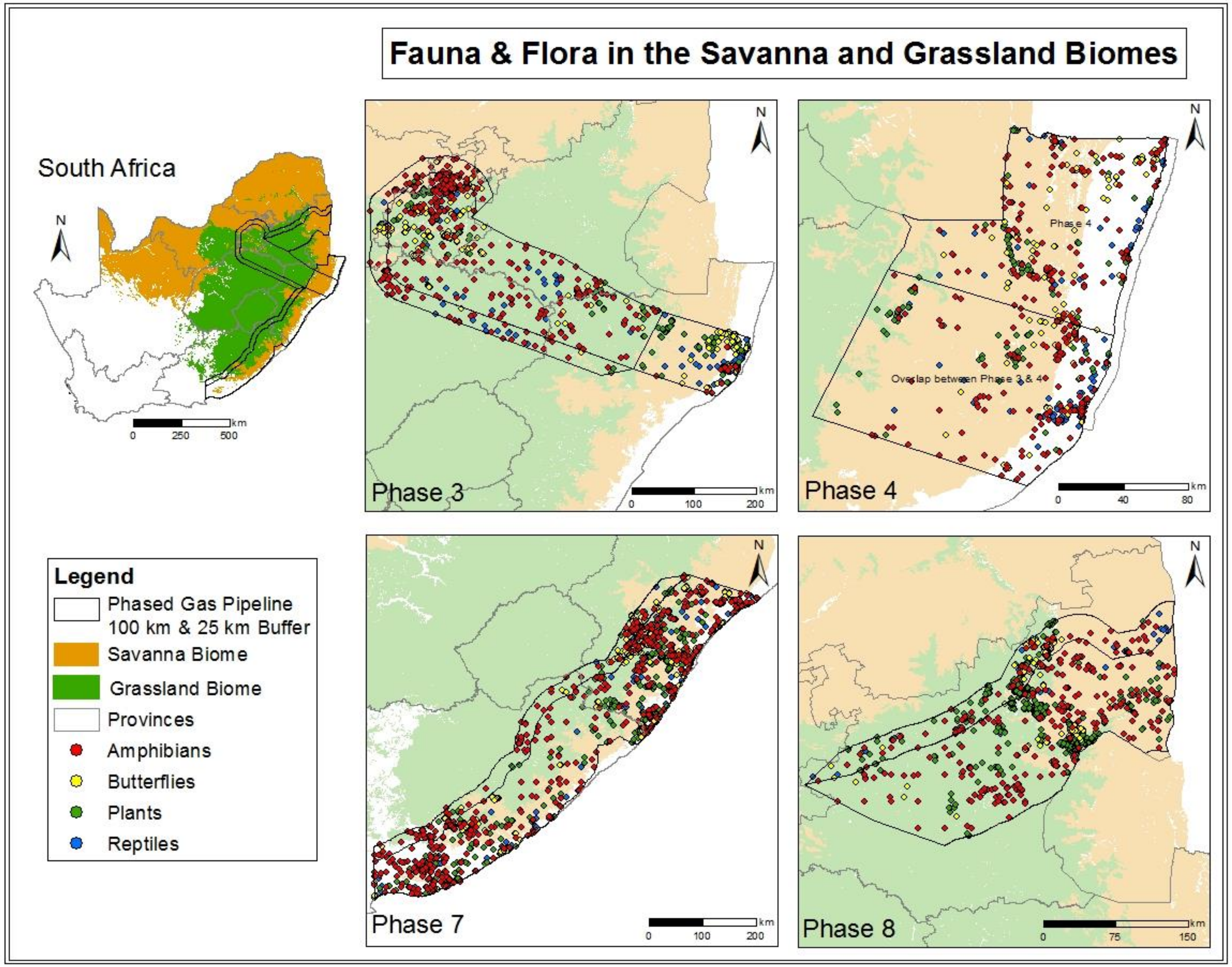


Figure 5: Summary map of all Critically Endangered, Endangered, Vulnerable and Near Threatened fauna and Critically Endangered, Endangered, Vulnerable flora likely to be encountered in the different phases. Large mammals are also excluded. For the inland corridor and Phase 2 see Figure 14.

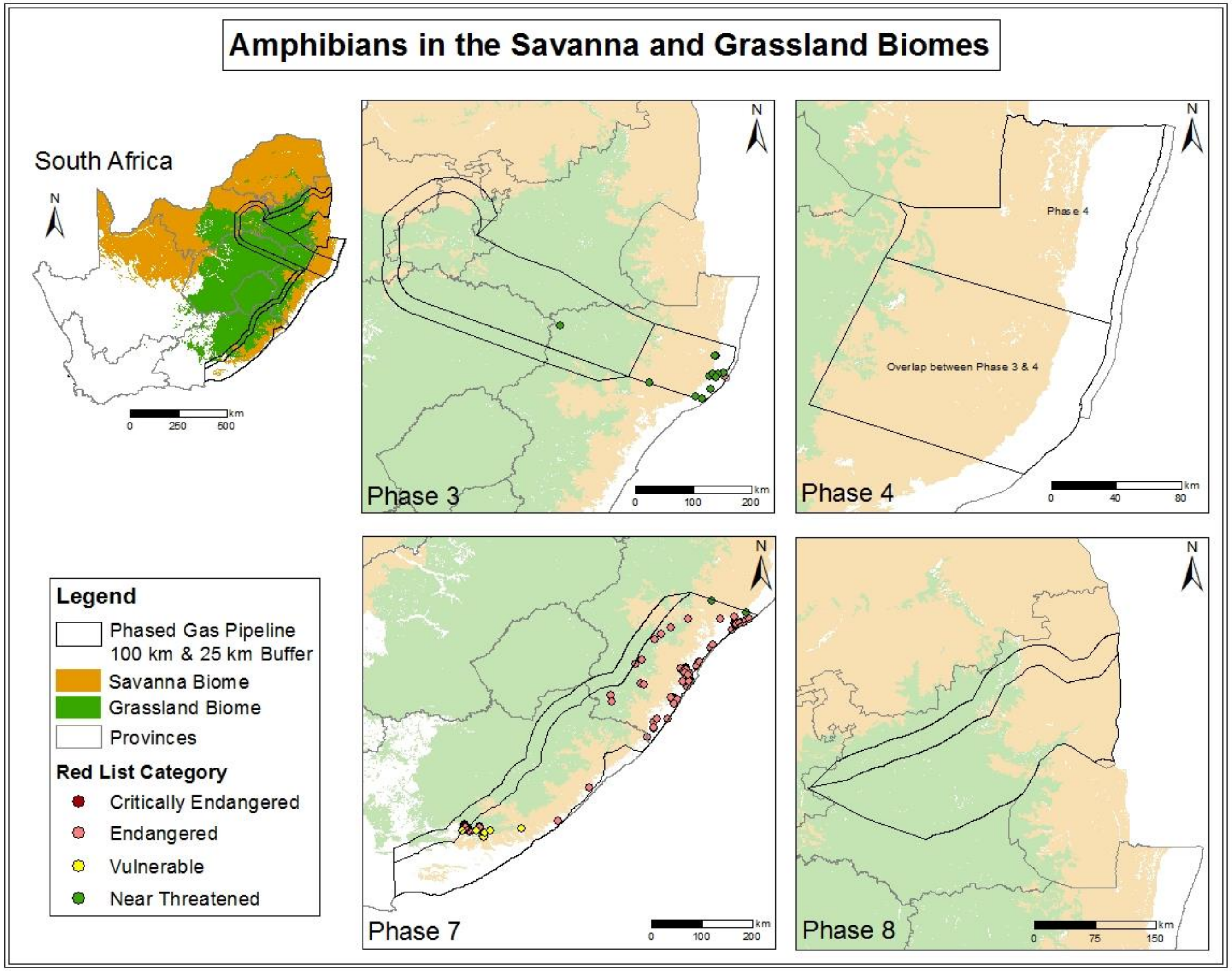


Figure 6: Summary map of all Critically Endangered, Endangered, Vulnerable and Near Threatened Amphibia likely to be encountered in the different phases. For the inland corridor and Phase 2 see Figure 14.

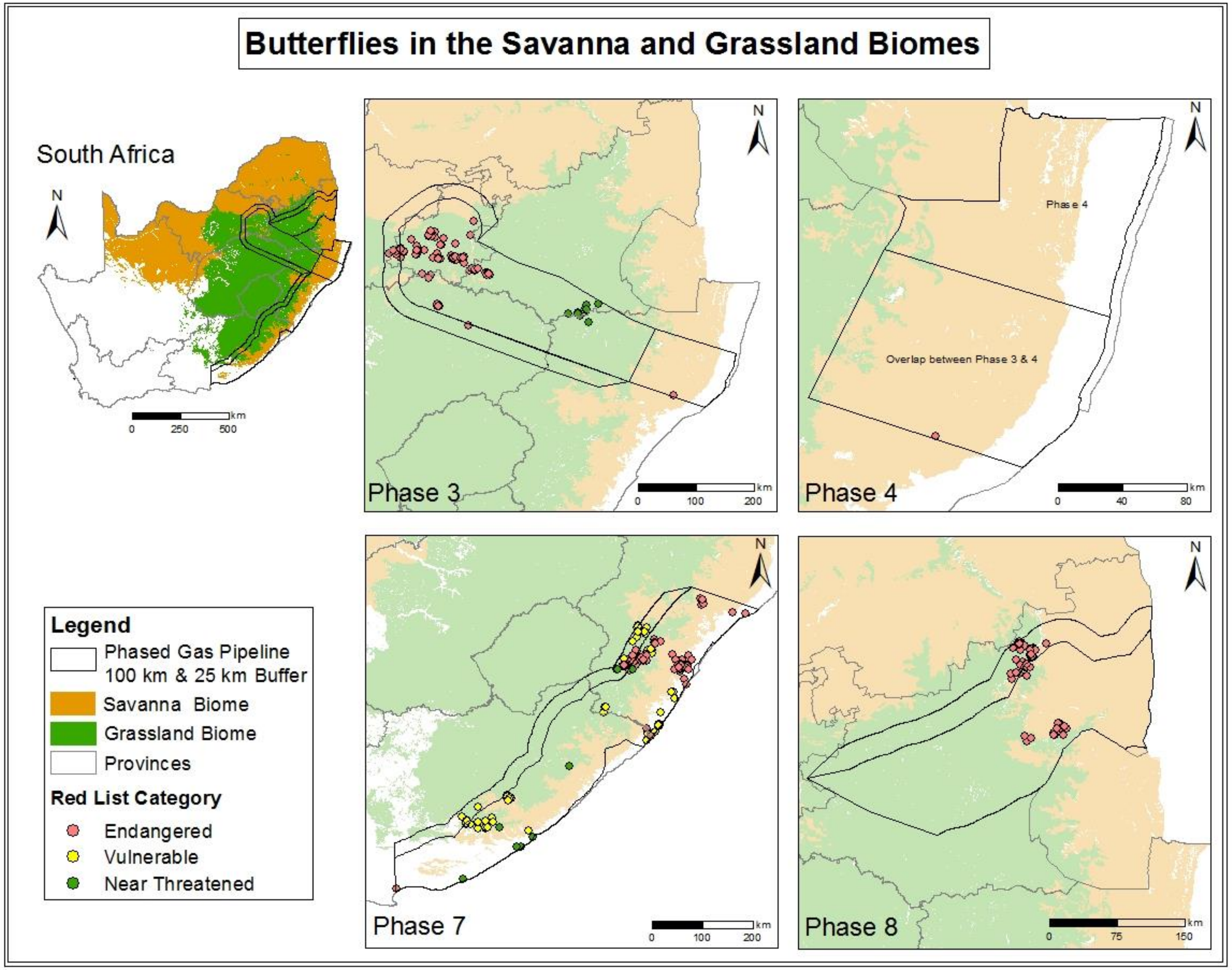


Figure 7: Summary map of all Critically Endangered, Endangered, Vulnerable and Near Threatened butterflies likely to be encountered in the different phases. No butterflies were identified for the inland corridor and Phase 2.

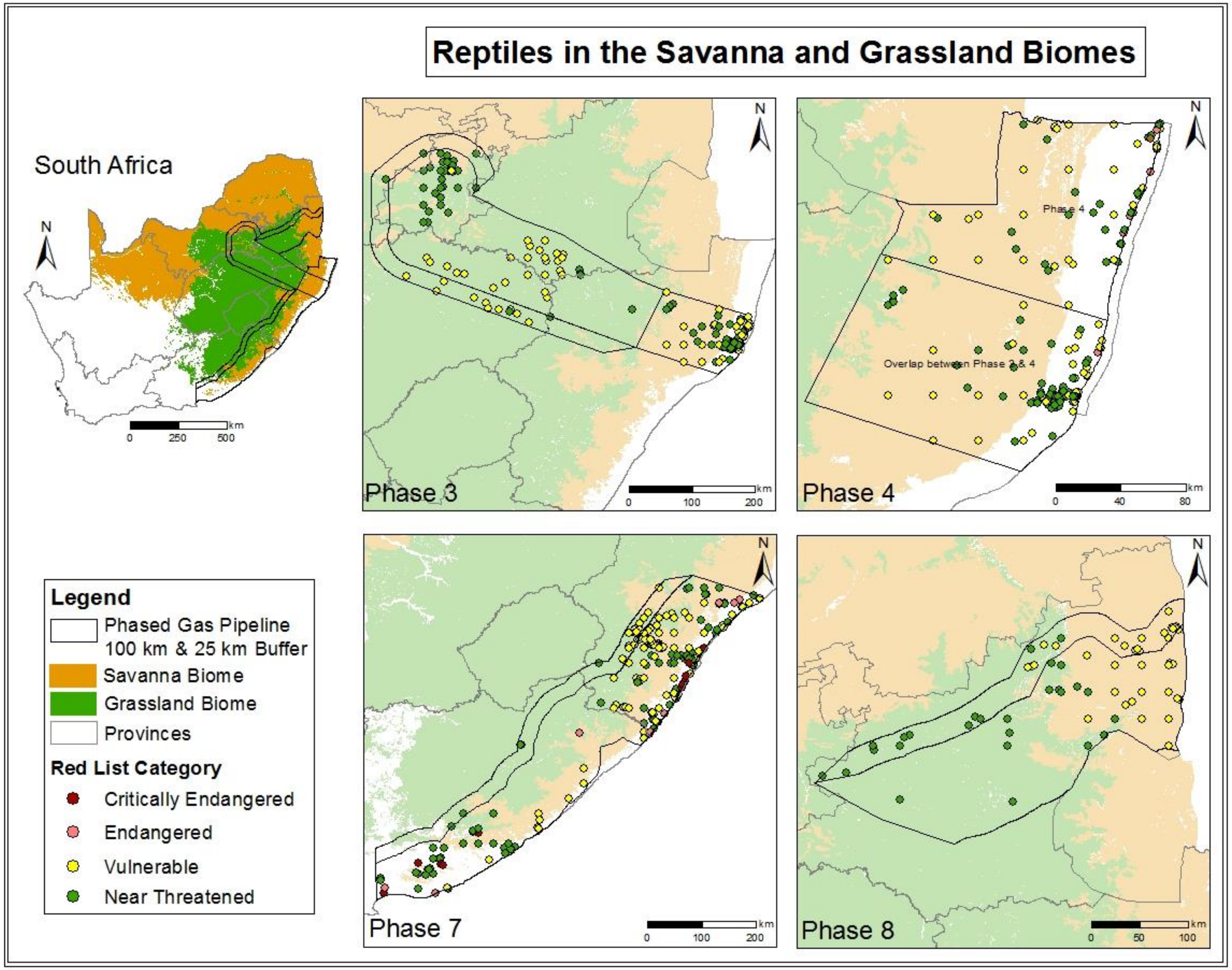


Figure 8: Summary map of all Critically Endangered, Endangered, Vulnerable and Near Threatened reptiles likely to be encountered in the different phases. For the inland corridor and Phase 2 see Figure 14.

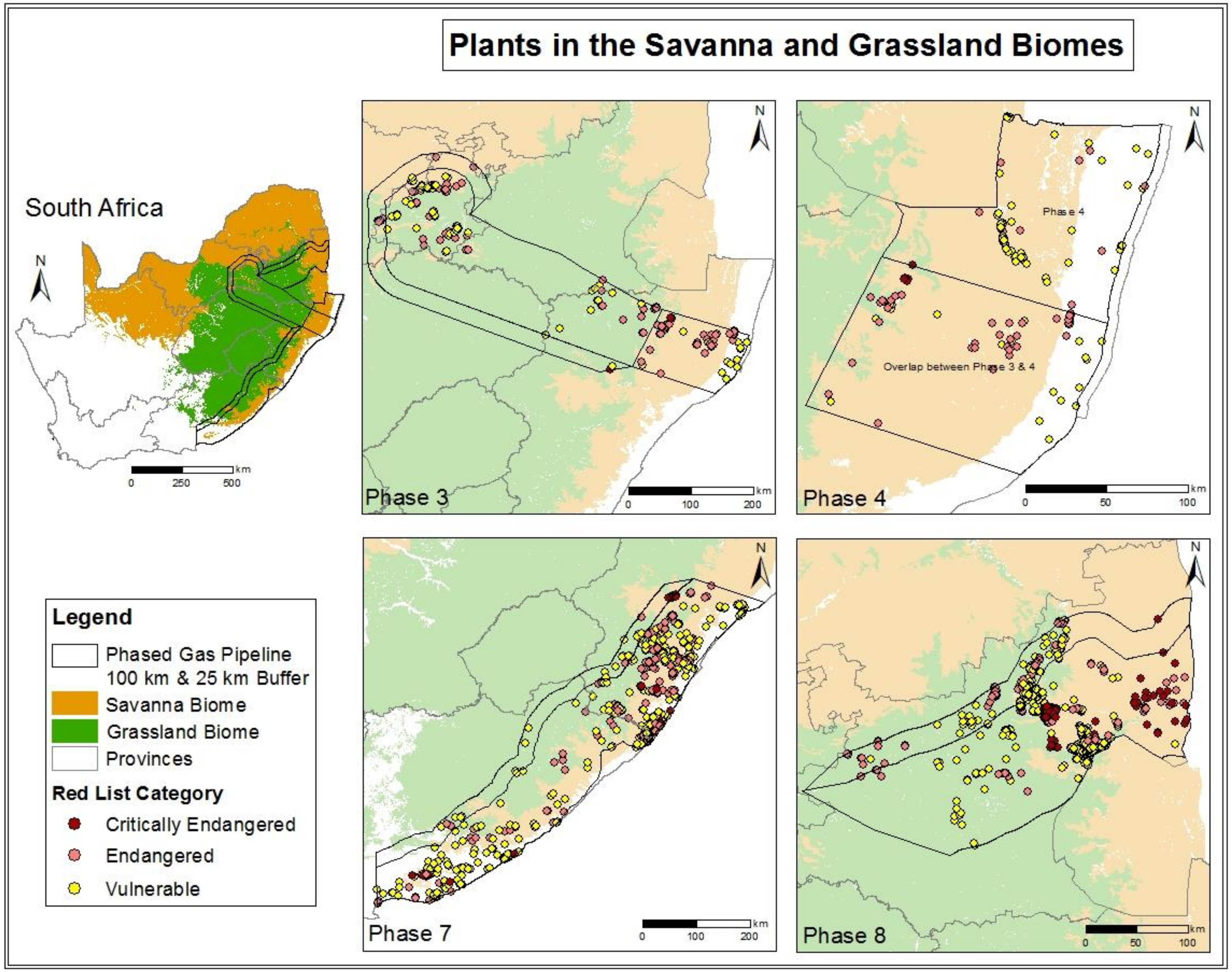


Figure 9: Summary map of all Critically Endangered, Endangered, Vulnerable plants likely to be encountered in the different phases – no plant species mapped onto the inland corridor and Phase 2.

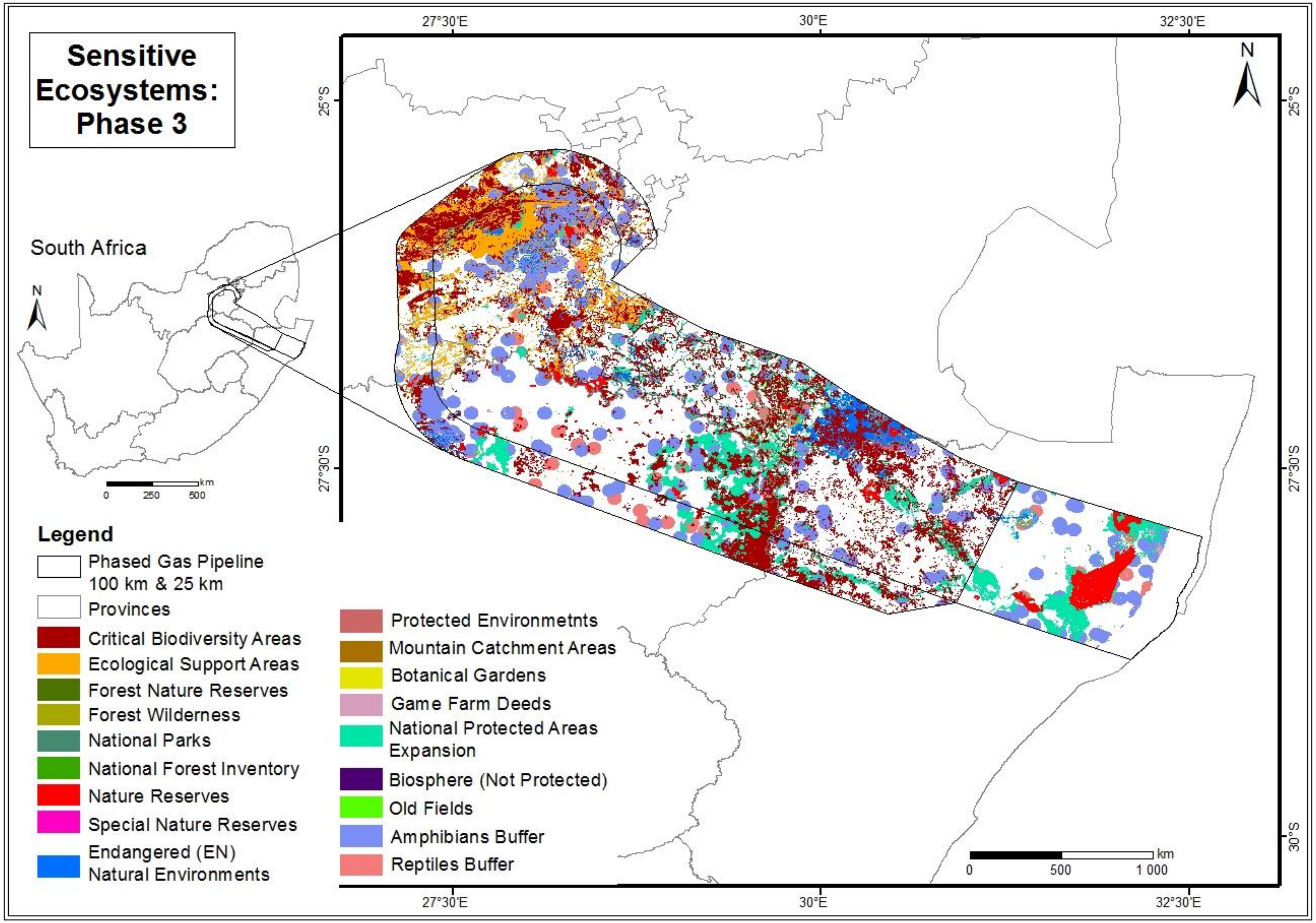
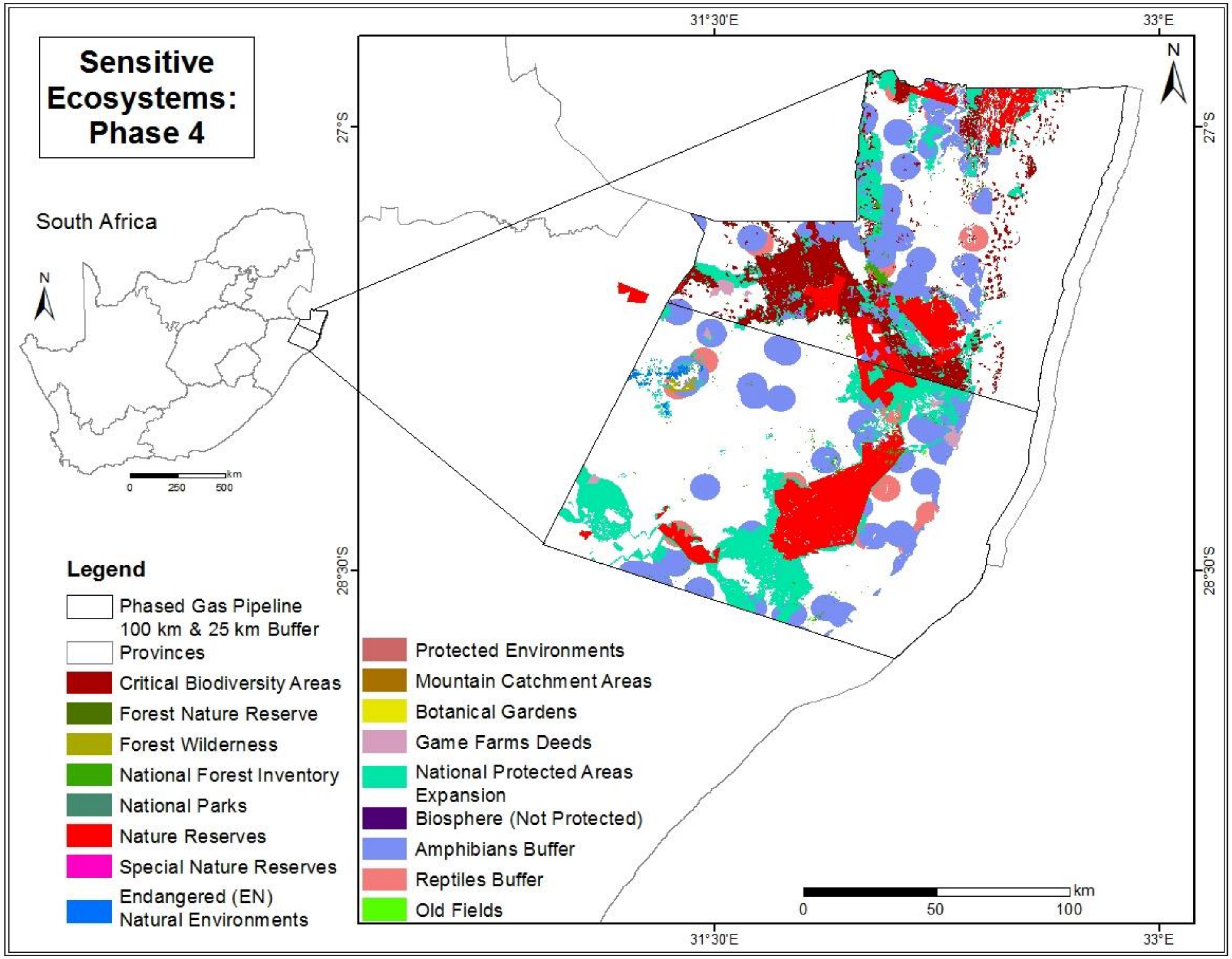


Figure 10: Summary map of features used in the sensitivity assessment for Gas Pipeline Phase 3.



1
2 Figure 11: Summary map of features used in the sensitivity assessment for Gas Pipeline Phase 4.

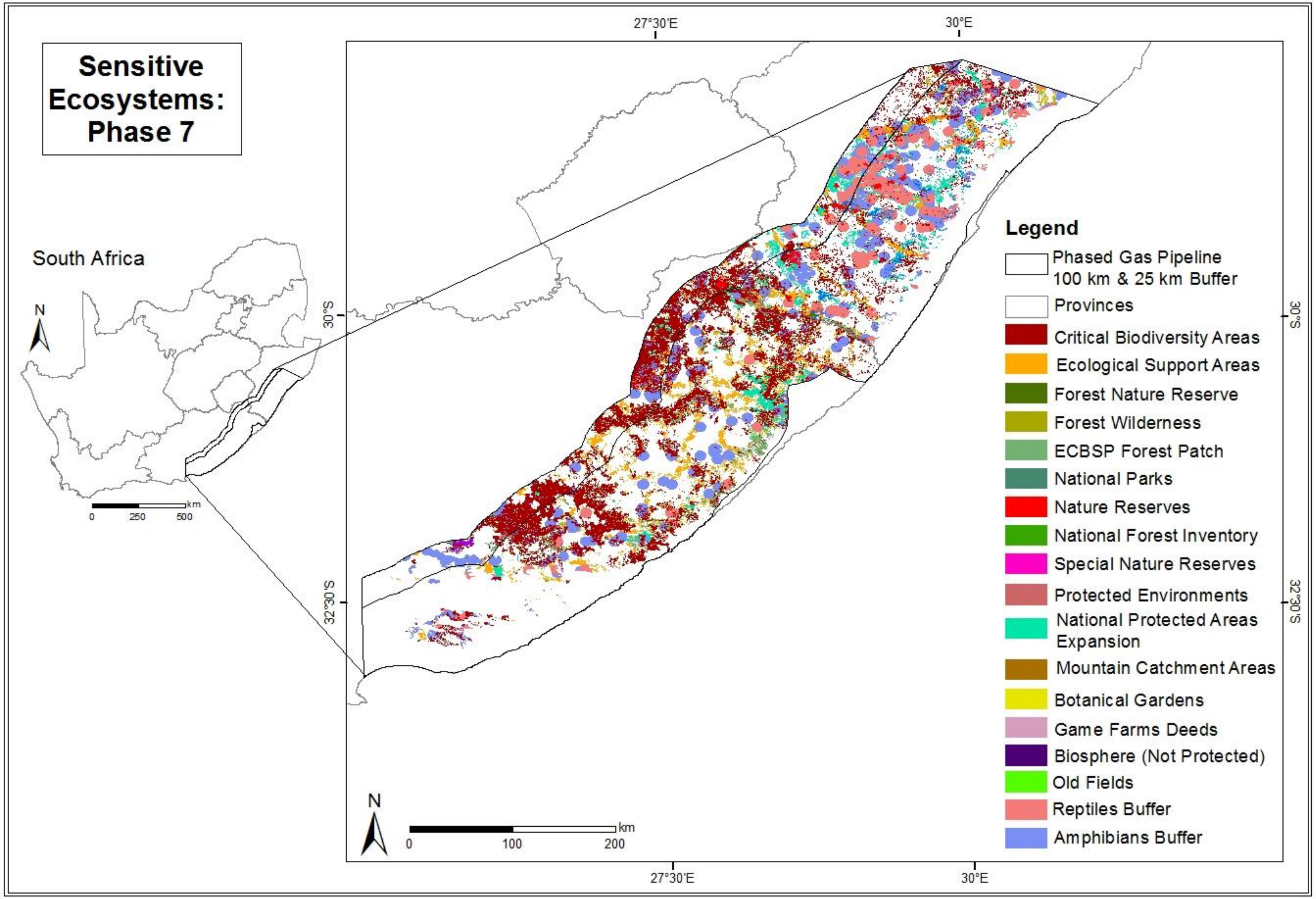


Figure 12: Summary map of features used in the sensitivity assessment for Gas Pipeline Phase 7.

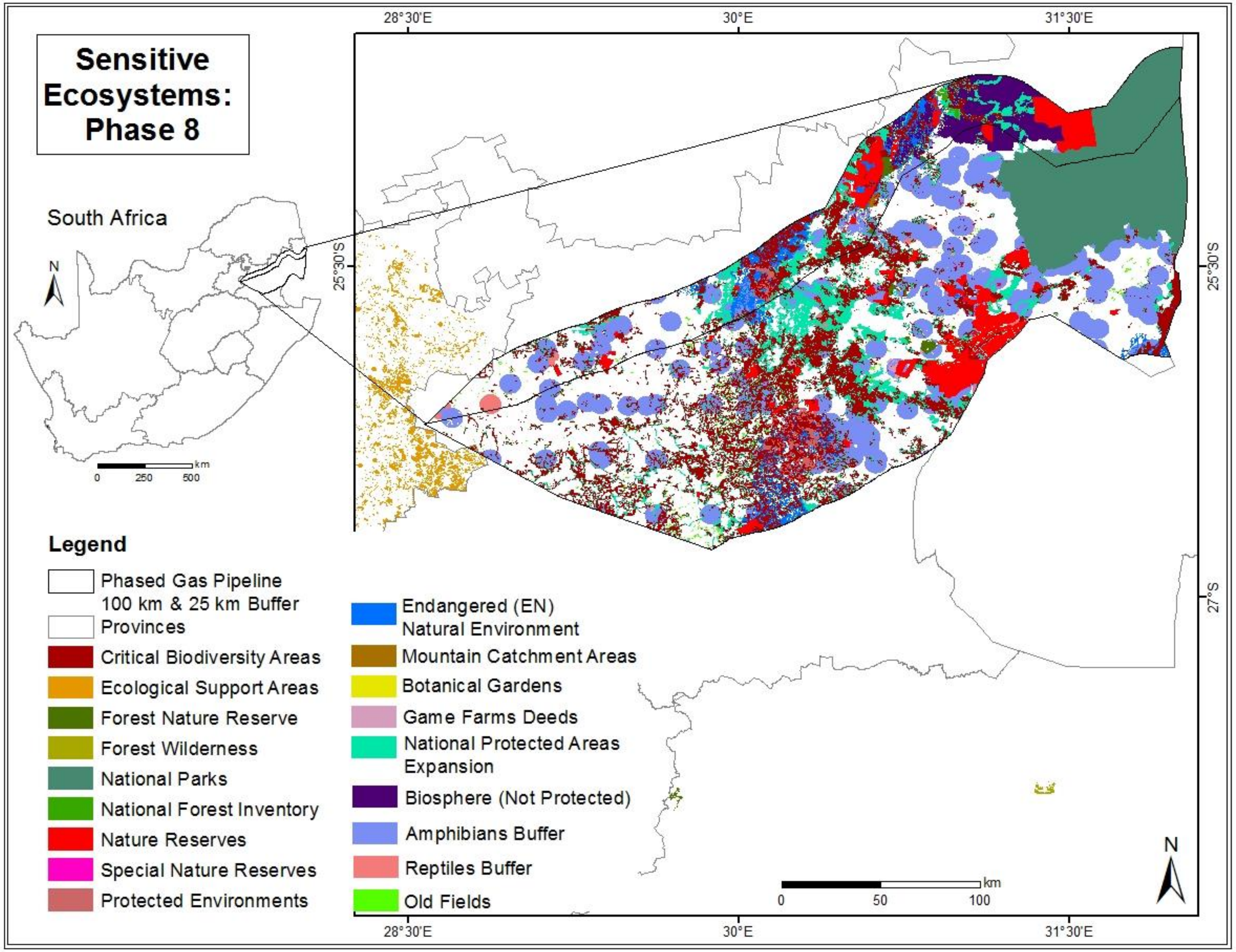


Figure 13: Summary map of features used in the sensitivity assessment for Gas Pipeline Phase 8.

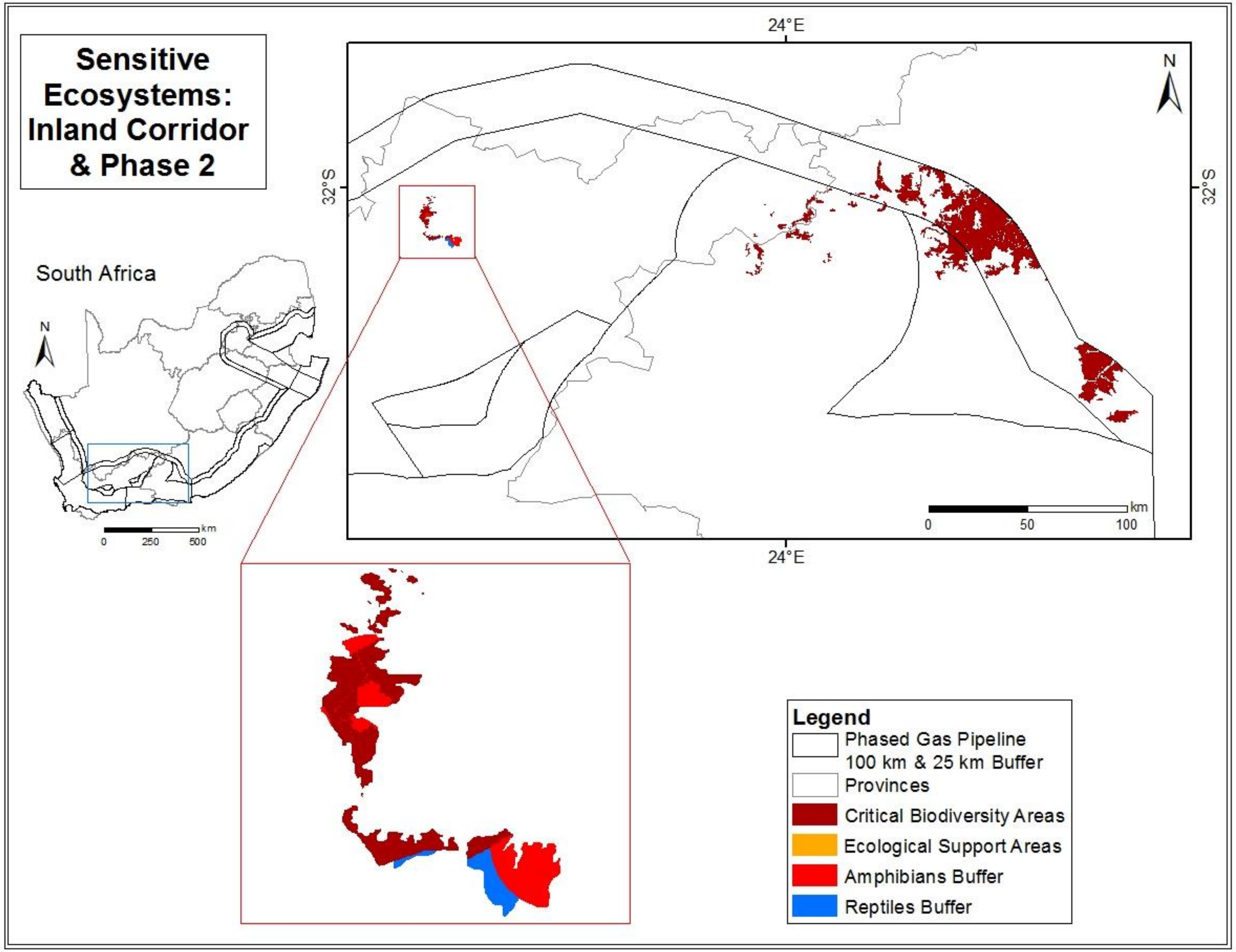


Figure 14: Summary map of features used in the sensitivity assessment for Gas Pipeline inland corridor and Phase 2

3.3 Four-Tier Sensitivity Mapping

The relative sensitivity mapping follows a four tier sensitivity classes approach with:

- Dark Red: Very High Sensitivity
- Red: High Sensitivity,
- Orange: Medium Sensitivity
- Green: Low Sensitivity

Sensitivity maps use a simple approach based on colourations with all criteria of the same sensitivity getting the same colours. The sensitivities are built up from lowest to highest, so on the map the colour seen is the highest sensitivity for a specific area.

3.3.1 Gas Pipeline Phase 3

A sensitivity map for Gas Pipeline Phase 3 is given in Figure 15. Apparent pinch points from a biodiversity perspective relate to the areas around the provincial parks in Zululand, crossing of the Drakensburg and the Gauteng region.

3.3.2 Gas Pipeline Phase 4

A sensitivity map for Gas Pipeline Phase 4 is given in Figure 16, obvious pinch points from a biodiversity perspective relate to the areas around the provincial parks in Zululand as well as areas of high CBA values linked to these parks.

3.3.3 Gas Pipeline Phase 7

A sensitivity map for Gas Pipeline Phase 7 is given in Figure 17. Apparent pinch points relate to the high biodiversity of the Pondoland region, especially within the Eastern Cape. This area has an exceptionally high occurrence of endangered and endemic species.

3.3.4 Gas Pipeline Phase 8

A sensitivity map for Gas Pipeline Phase 8 is given in Figure 18. Apparent pinch points relate to the narrow gap between Kruger National Park and Swaziland, as well as crossing of the Drakensberg Mountains.

3.3.5 Gas Pipeline inland corridor and Phase 2

A sensitivity map for Gas Pipeline inland corridor and phase 2 is given in Figure 19. This area has no savanna and very limited grassland so overall pinch points cannot be identified, however, all grassland areas are considered sensitive and should be avoided. These are, however, a very small and restricted area within the phase 2 corridor.

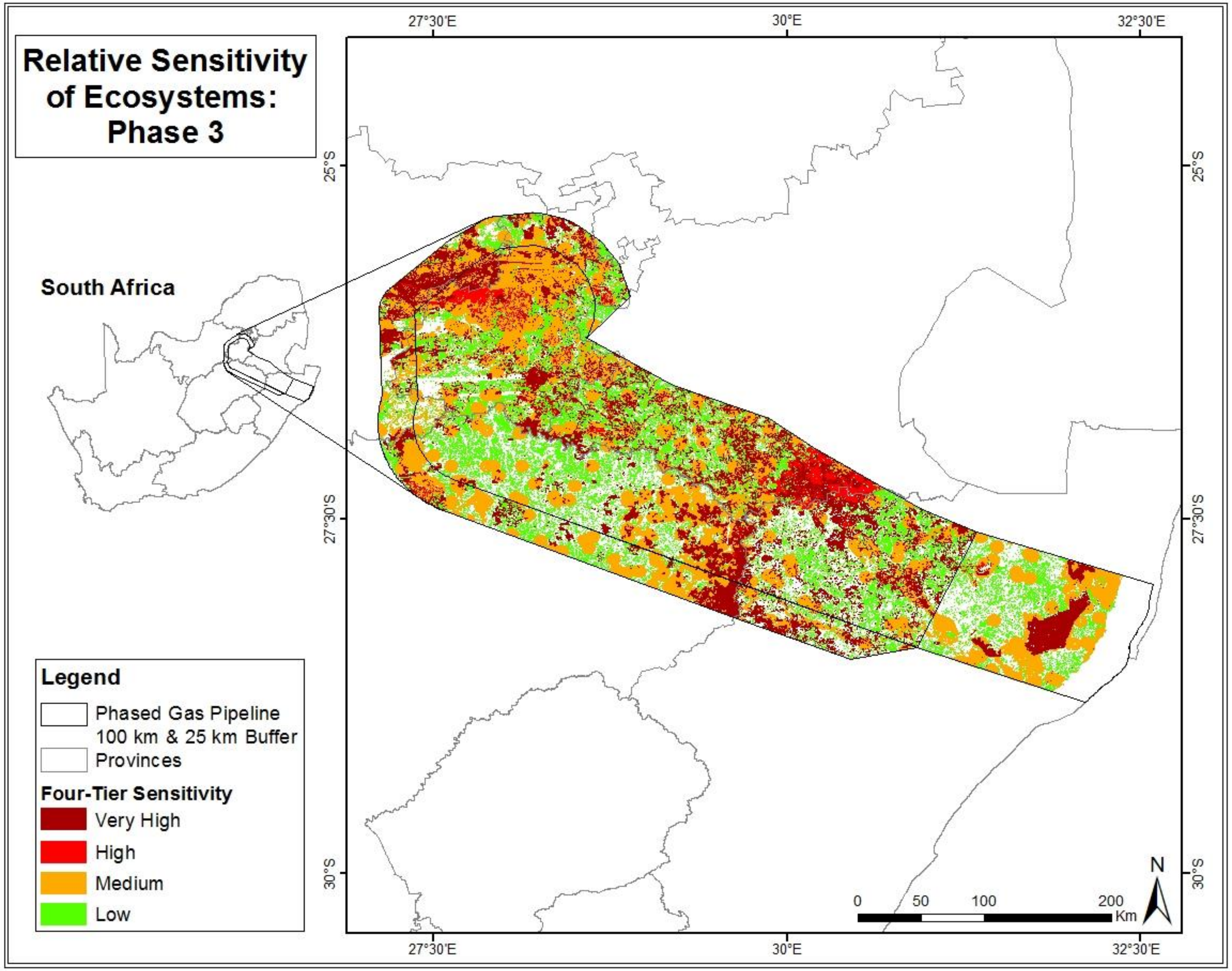


Figure 15: Sensitivity map for Gas Pipeline Phase 3.

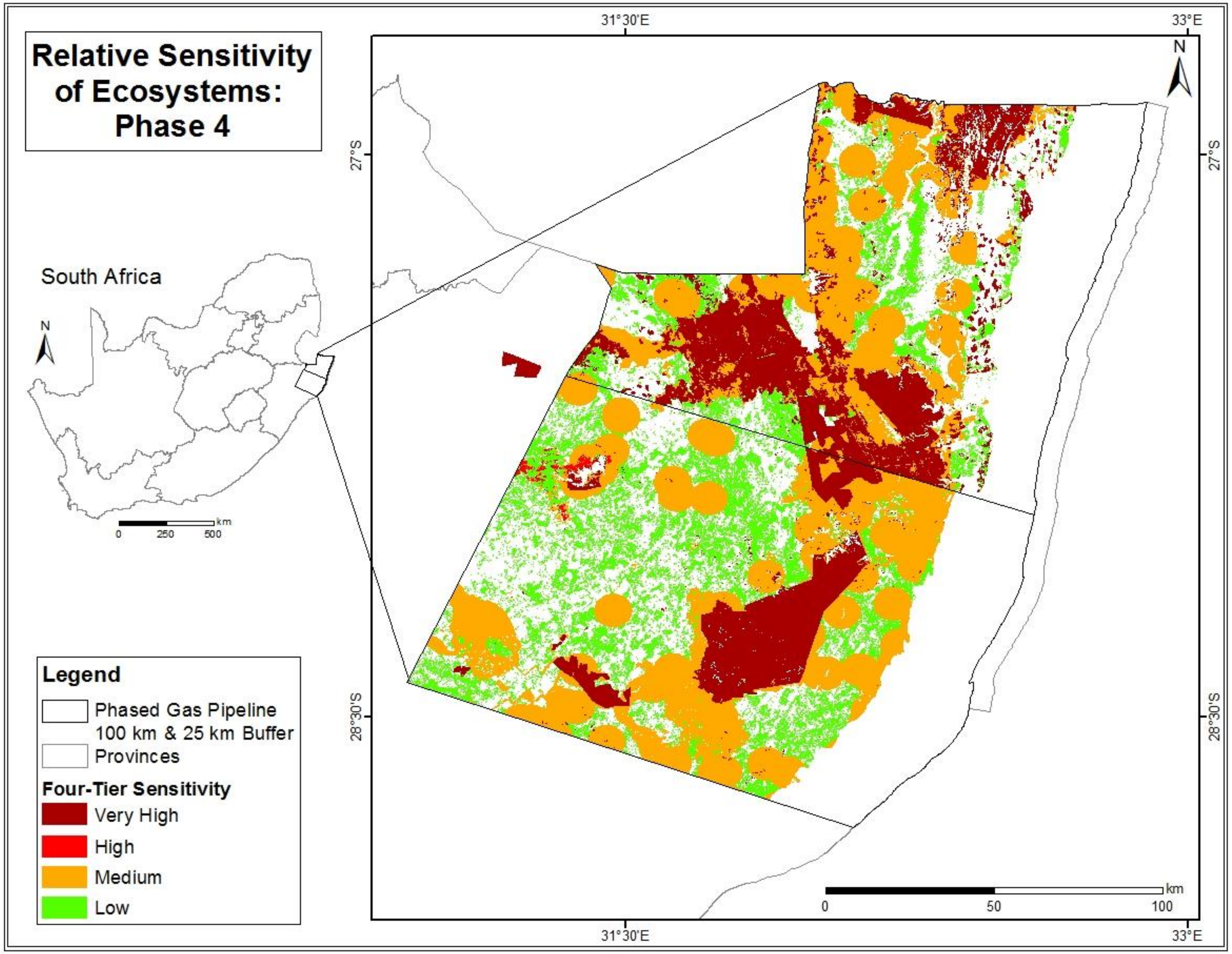


Figure 16: Sensitivity map for Gas Pipeline Phase 4.

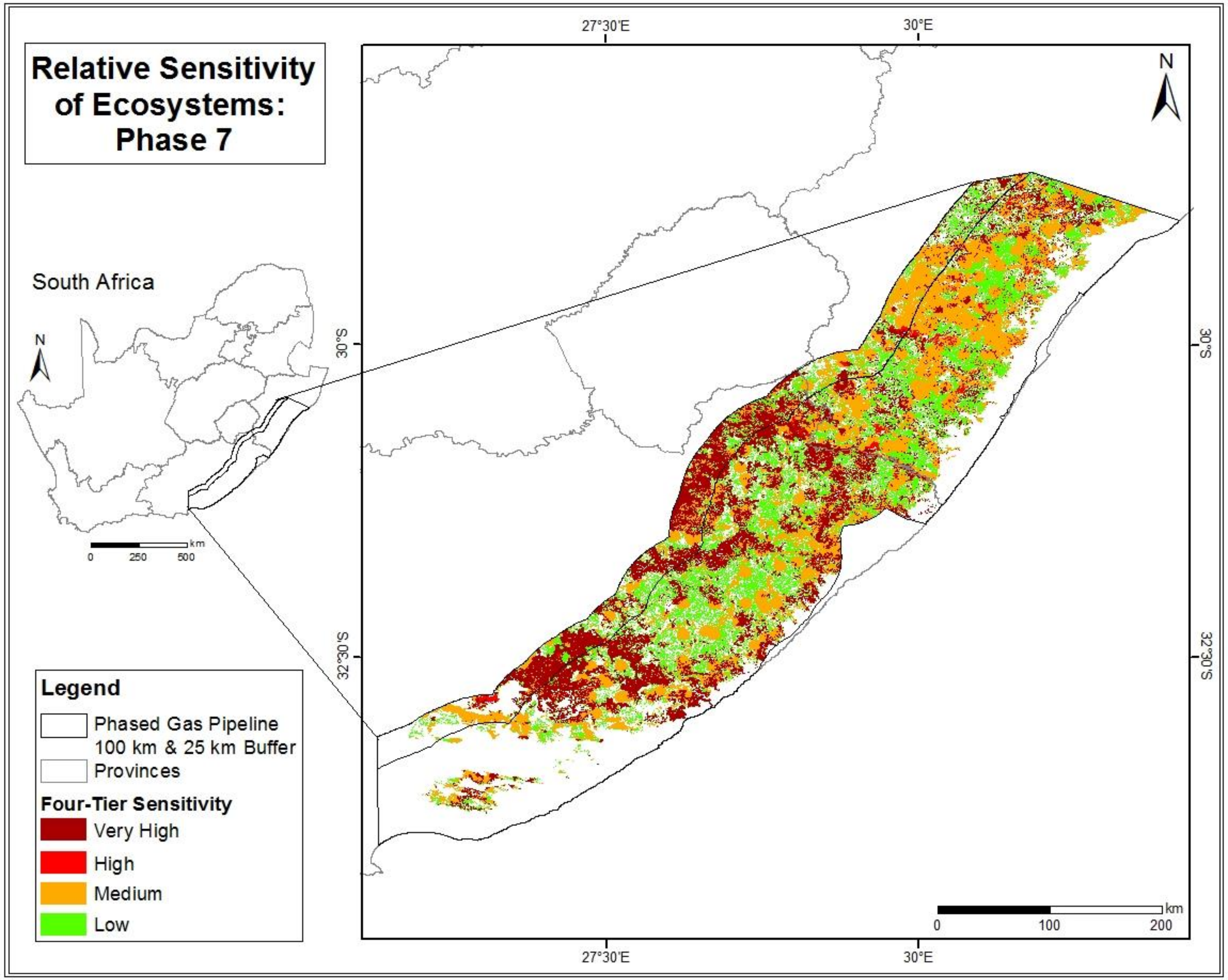


Figure 17: Sensitivity map for Gas Pipeline Phase 7.

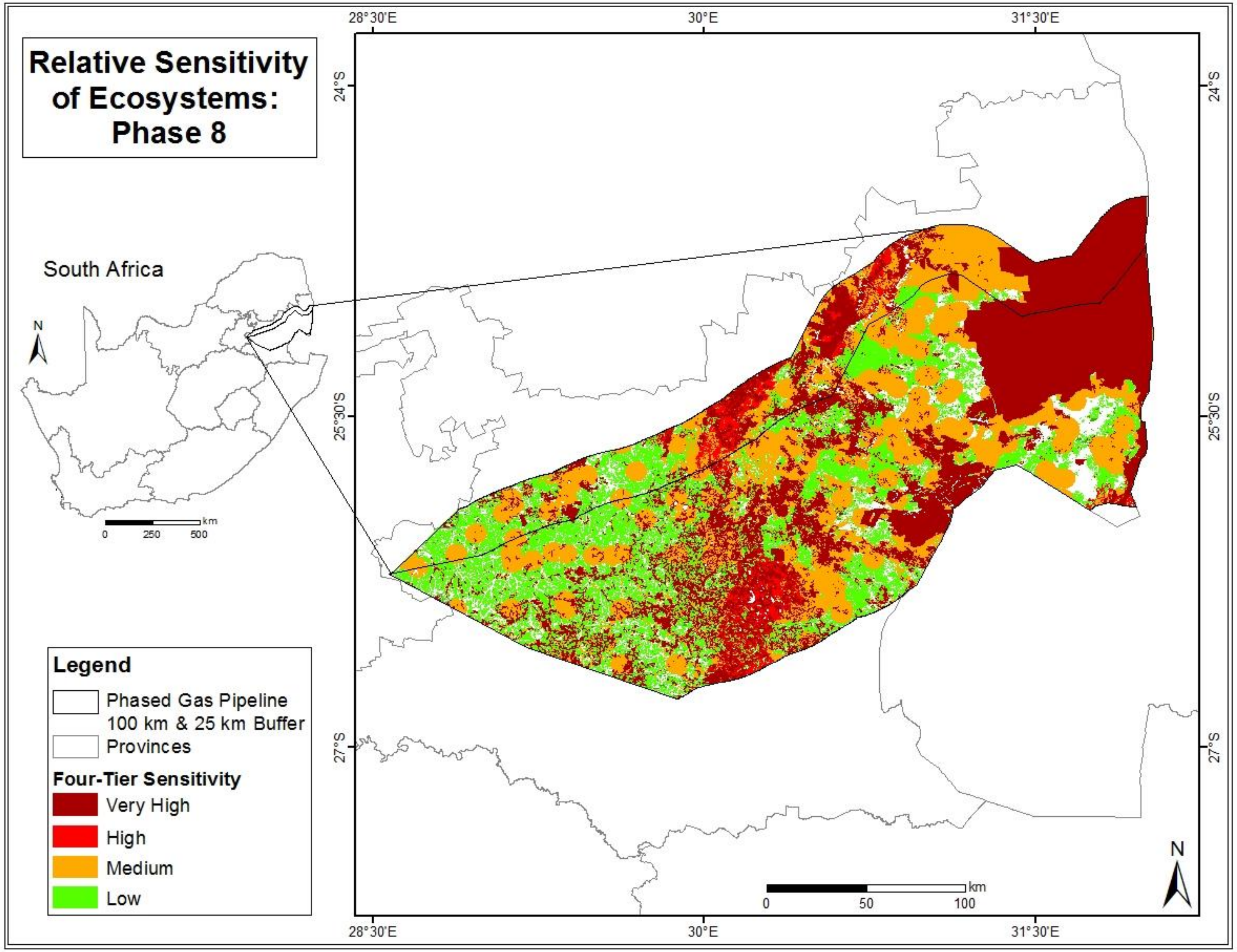


Figure 18: Sensitivity map for Gas Pipeline Phase 8.

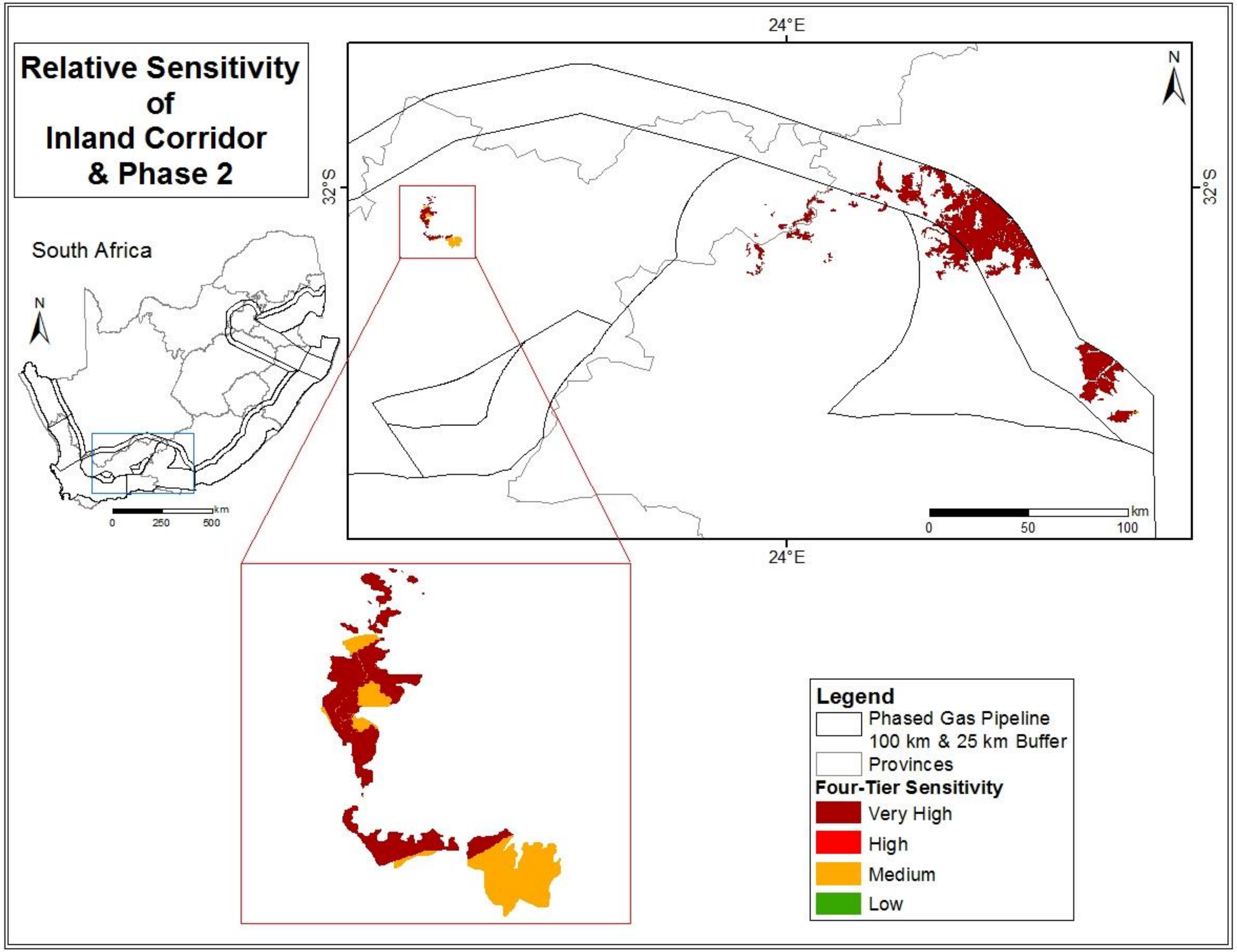


Figure 19: Sensitivity Map of grasslands in the inland corridor and Phase 2

4 KEY POTENTIAL IMPACTS AND THEIR MITIGATION

4.1 Impact 1. Physical disruption of the land surface as a result of vegetation clearance and development infrastructure

An area of 50 m in width suffers almost total degradation of vegetation during the construction phase for the right-of-way (see Figure 20). The most severe degradation is the actual trench line which is a few meters across and may vary in depth, but is typically about 2 m to the top of the pipeline. The remaining area suffers varying degrees of degradation dependent on the use, but includes surface soil storage, subsoil storage and transportation. The transportation zones may suffer high levels of compaction. These activities will destroy all or most of the biodiversity in the pathway. Although the construction line is relatively narrow (30-50 m), it can occur over hundreds of kilometres, potentially having high impacts on narrow vegetation types that follow the same path (Figure 21 - Figure 22). During construction there will be noise and vibrations from the trenching, drilling and blasting. These will all impact on faunal species, driving the more mobile species from the area, but potentially having devastating impacts on less mobile species, or those species that seek refuge underground. Both during and after construction the trench-line as well as the temporary soil storage can alter hydrological patterns, drainage and runoff movements, leading to short term or long term erosion and altered hydrological patterns. For instance, disruption to impermeable rock layers in the trench-line may create new subsurface drainage patterns, or the newly filled trench-line may easily erode and channel water in new ways. This could potentially lead to drying of wetlands or creating new wetland areas. This may be particularly relevant where trenches cut across unstable sodic soils. Where trenches cut across vertic soils, consideration will need to be made for the inherent movement of these soils as they swell and contract with soil moisture levels.

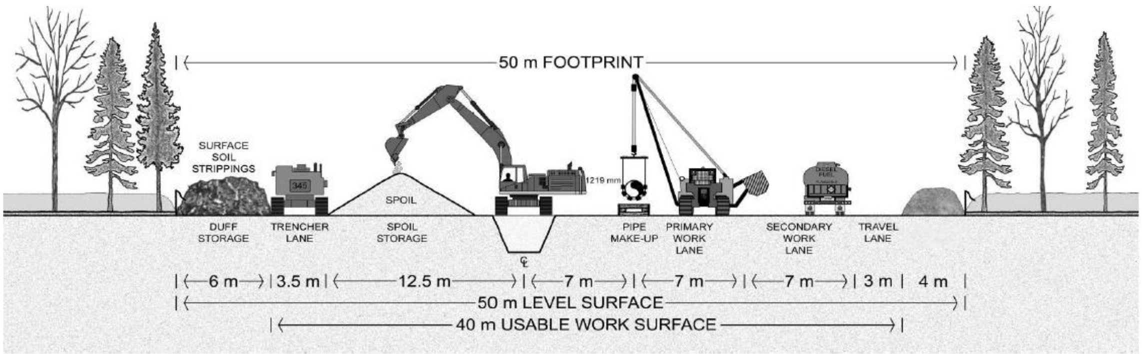


Figure 20: Illustration of a typical construction path as provided by Ephraim (2017) as background to the project.

This Figure 21 illustrates how many of the Grassland vegetation types follow environmental gradients running parallel to the coast for Gas Pipeline Phase 7 (the same is true for the Savanna types (Figure 22)). A pipeline running parallel to the coast could, by chance, follow the same vegetation type (e.g. the Vulnerable Ngonguni) for most of its route, effectively cutting through every large patch and having a disproportionately high impact on that vegetation type. Although less threatened, the same impact is likely for the Bisho Thornveld.

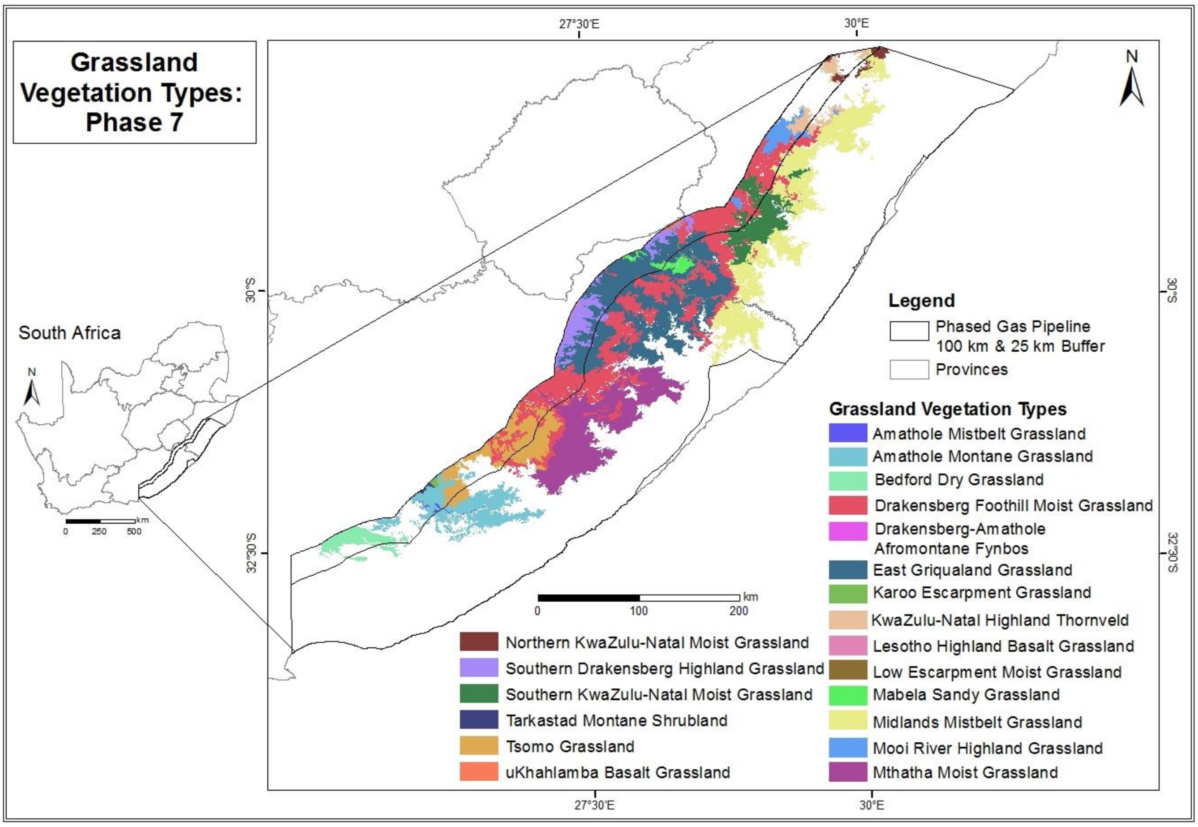


Figure 21: Narrow grassland vegetation types present in Gas Pipeline Phase 7.

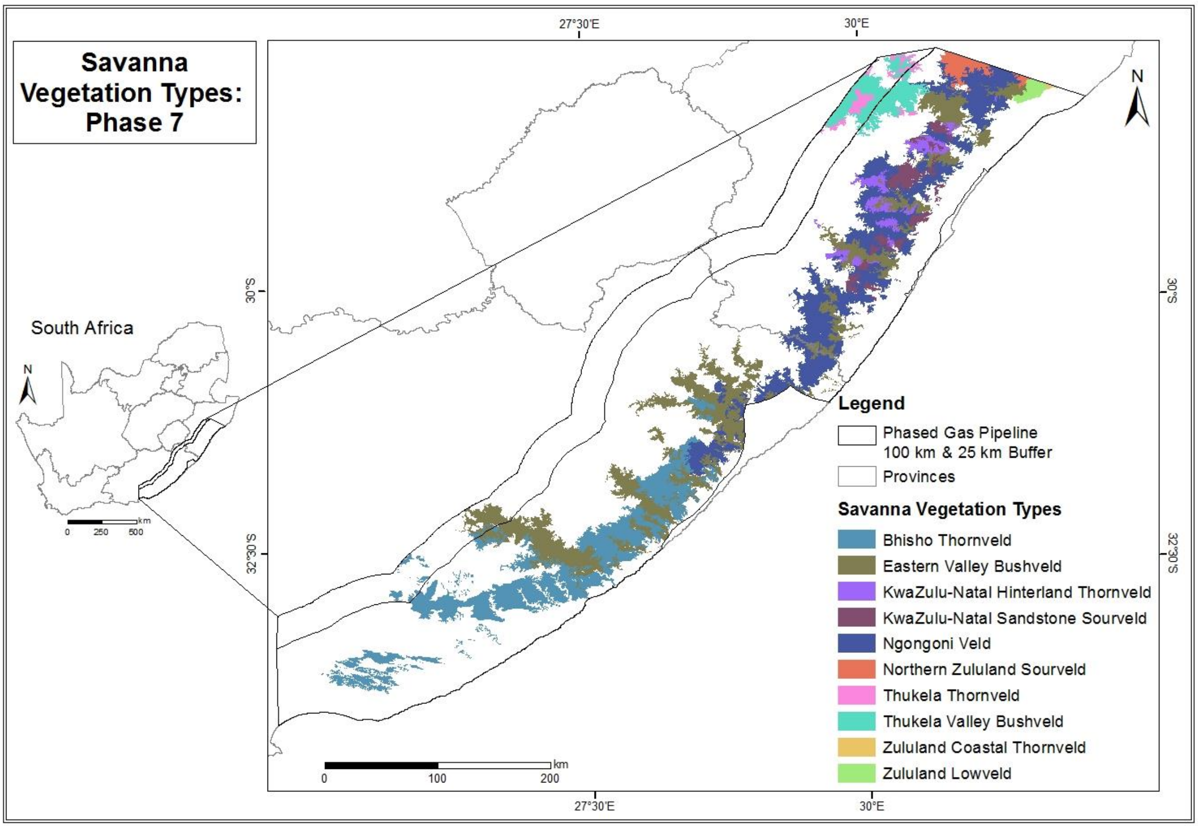


Figure 22: Narrow savanna vegetation types present in Gas Pipeline Phase 7.

4.1.1 Mitigation

- As far as possible avoid High and Very High Sensitivity areas, and where avoidance is impossible work with fauna and flora specialists to mitigate impacts. This may include relocations, additional controls during construction, selecting best seasonal timings, and shortening the duration of the impact.
- Specialist faunal and floral assessments in areas of Medium to Very High sensitivity to finalise micro-siting of route.
- Avoidance of roosts, nests and burrows of sensitive species where possible. If not possible then conduct the trenching operations outside of the breading season and/or have specialists relocate the individuals that are being threatened.
- Avoid crossing of key migration or movement corridors, or limiting construction in these areas to less sensitive seasons (e.g. winter for many species). Reduce the construction phase to the shortest possible time.
- If possible, avoid construction activities in the breeding season of conservation important taxa.
- Minimising the width of the construction zone, and minimising the duration of construction.
- Ensure that rare and endangered species are not buried under the temporary soil dumps.
- Replacing soil in the sequence it was extracted, and replacing the topsoil on the top, avoiding rare and endangered species where possible. This should be done, within a month of excavation. This not only limits changes in the soil, but ensures that the exposed area of the trench, a potential trap for animals, is minimised.
- Transplanting / replanting rare and endangered species, and re-establishing natural vegetation on the zone after completion, except deep rooted trees.
- Allowing the revegetated areas to advance to as near natural a state as possible, this includes allowing tall trees to re-establish (possibly with a limited buffer around the pipeline), managing invasive alien vegetation, and maintaining natural fire regimes.
- If at all possible rootstock of existing vegetation should be retained in all but the trench area. Most Savanna trees have an incredible ability to sprout from felled trees and hence can re-colonise the area far faster than new seedlings.
- Include drainage structures to prevent erosion, and where required (especially on slopes) ensure suitable engineering structures are in place to direct or redirect surface runoff and sub-surface flows.
- Ensure that were the pipeline cuts through sodic soils that adequate interventions are taken to prevent erosion and piping.
- Care must be taken on vertic soils to ensure that soil movement does not cause damage to the pipeline with resultant secondary environmental damage.

4.2 Impact 2. Prevention of animal movement during the construction phase and loss of forage habitat

During construction, both the trench and the pipeline (before going into the trench) effectively create an impenetrable barrier to animal movement. Depending on the construction, this could conceivably be over distances of many kilometres at any point in time. There are two consequences, animals cannot migrate over their normal areas and secondly small animals (e.g. mammals, reptiles) might fall into the trench and be trapped. In addition, animals lose access to the habitat for forage or other purposes, either directly or through the trench preventing access.

4.2.1 Mitigation

- Where possible avoid High and Very High Sensitive areas. Where avoidance is impossible work with fauna specialists to mitigate impacts. This may include relocations, additional controls during construction, selecting best seasonal timings, shortening the duration of the impact, and working on short sections at a time to limit the spatial extent of the impact.
- Specialist faunal assessments to finalise micro-siting of route.

- Keep the development footprint to a minimum.
- Control dust settlement on the surrounding vegetation.
- Control sedimentation runoff into rivers and water bodies.
- Reducing the time of construction at any one point to a minimum.
- Doing daily patrols for trapped animals.
- If there is a risk of preventing seasonal migrations, then time the construction to a season where this is less critical.

4.3 Impact 3. Death or harm to animals or loss of breeding habitat

During construction, both the trench and the pipeline (before going into the trench) effectively create potential harm to animals. This could be either through direct contact, or through the animal falling into the trench and being either trapped or harmed. In addition, the large workforce during construction creates a very real possibility of illicit poaching, setting of snares, killing of perceived harmful animals (snakes, chameleons etc.), providing poaching intelligence, collecting plants for traditional medicine, and accidently creating fires.

4.3.1 Mitigation

- Construction activities to either avoid the breeding or migration periods of conservation important taxa that may be encountered along the route, or take measures to minimise impacts where this avoidance is not possible.
- Construction activities to happen in short phased stretches and continuous rehabilitation to occur as sections are complete.
- In addition to areas with open trenches being demarcated and fenced, all open trenches are to be equipped with ladders or ramps every 50m to enable trapped animals to escape.
- Fencing to be placed in higher animal activity areas to prevent animals falling into trenches.
- A walk through of the route to be conducted prior to clearing of vegetation and breaking of ground to ensure no animals or nests/ burrows/ roosts are harmed, or to minimise the risk to these or relocate them when this is possible.
- Rescue and release of less mobile species such as snakes, frogs, reptiles, invertebrates and certain burrowing mammals to occur prior to construction.
- Undertaking daily patrols for trapped animals.
- If there is a risk of preventing seasonal migrations, then timing the construction to a season where this is less critical.
- Ensure that rare and endangered species are not buried under the temporary soil dumps.
- Vehicles to move slowly along access roads to prevent collision with animals.
- Training of staff regarding biodiversity responsibilities, monitoring staff behaviour and sanctioning of transgressions should be undertaken.

4.4 Impact 4. Limiting animal (and plant) movement in the post-construction phase

The pipeline creates a long cleared strip within the natural vegetation. This may remain an altered habitat or revert to a near natural habitat over time depending on management. While revegetation is taking place this altered habitat can be a barrier to many, especially small, animal species. For instance, a structure change of the habitat from woody plants to a low Grassland might inhibit movement of animals dependent on moving from tree to tree. In extreme situations this could also inhibit plants adaptation responses to climate change. Plants and their associated pollinators need to migrate with a changing climate. For plants this is done mostly through seed/propagule dispersal, which for some species is over very limited distances. Although unlikely, it is feasible that altered vegetation could create a barrier that prevents this migration.

4.4.1 Mitigation

- Return the area to as near natural a state as possible, with natural processes such as fire being retained.

4.5 Impact 5. Soil disturbance leading to Invasive alien plants

Disturbed ground is often re-colonised by invasive species rather than the natural vegetation. This then changes the composition of the vegetation as well as acting as a conduit for alien species to invade into the surrounding habitat. Bush encroachment of indigenous species may also be enhanced by disturbance. For instance, many abandoned old fields become thickets of *Dichrostachys cinerea* (sekelbos), a species uncommon in good quality mature vegetation.

4.5.1 Mitigation

- Clear alien invasion over the lifespan of the project or until they show no signs of invading the area.
- Actively re-vegetate to the natural vegetation cover.
- Keep future disturbances to a minimum.

4.6 Impact 6. Soil erosion

Accelerated soil erosion is possible on the post construction, re-vegetated land. This is especially likely where the pipeline runs perpendicular to the contour lines, i.e. straight up or down a hill slope. A combination of slope, rainfall intensity and soil type leads to enhanced erosion, so it is difficult to specify at what gradient this will start to occur. Any gradient of more than 10 degrees should be treated with caution.

4.6.1 Mitigation

- Where possible avoid running the pipeline or access and maintenance roads up or down steep slopes. Where avoidance is not possible then ensure that water management and erosion control structures are in place.
- Establish dense cover vegetation as soon as possible after completion of the construction phase.
- Install appropriate soil conservation measures.
- Ensure appropriate water drainage.

4.7 Impact 7. Rupture of pipe

Rupture, puncturing of the pipe or other causes of gas leakage could result in gas pollution in the atmosphere, and in a worst case scenario, explosion. Gas leakage, especially if of short duration is unlikely to have major effects on flora, but could potentially be devastating for immobile fauna. An explosion (most likely linked to an existing fire event) could result in vegetation fire or the total destroying of vegetation and animals in the proximity of the explosion. Such events are, however, considered as extremely unlikely. Further, any repairs to the pipeline are likely to have a similar scale of impact to pipeline installation and should be treated in a similar manner from a mitigation perspective.

4.7.1 Mitigation

- Sensors for loss of pressure as well as automatic cut off valves are located at regular intervals. This greatly reduces the risks associated with leakage, and limits the extent of the leakage.
- If repair is required on the pipeline, the same environmental considerations as used in the construction apply.
- Prevention of potential causes of problems such as preventing deep-rooted plant species directly above the pipeline.

- Due consideration of possible impacts to the pipe infrastructure when routing the pipeline through vertisols (clays that extract and expand) or through peat (which can carry deep underground and very hot fire).

5 RISK ASSESSMENT

5.1 Consequence levels

Five consequence levels are proposed i.e. slight, moderate, substantive, severe, and extreme.

As a broad guideline, the following is proposed as definitions for the consequence categories:

- Extreme – Over 10% of a threatened habitat or Critically Endangered, Endangered or Vulnerable species are destroyed.
- Severe – Any area of a very highly sensitive environment or any individuals of Critically Endangered or Endangered species are destroyed without appropriate mitigation.
- Substantive - Any area of a highly sensitive environment is destroyed, or and Vulnerable species are destroyed without appropriate mitigation.
- Moderate - Any area of a moderate sensitive environment is destroyed without appropriate mitigation.
- Slight - Areas of habitats or species not mentioned above are destroyed.

5.2 Risk assessment results

The risk assessment considers impacts with and without mitigation actions (i.e. actions to mitigate negative impacts or enhance benefits) (Table 4). The management actions are described in Section 6.

5.3 Limits of Acceptable Change

What constitutes limits to acceptable change is highly subjective and as much driven by societal values as by ecological theory. Legislative requirements relate to species classified as Critically Endangered, Endangered, Vulnerable and Protected. Note that some provinces have their own lists of protected species, as does the Department of Agriculture, Forestry and Fisheries (as noted above). The individual provincial Critical Biodiversity Assessments should form the key basis for acceptable change. In this regard CBA1 and CBA2 areas should be avoided if at all possible. If these cannot be avoided, then full Biodiversity Impact Assessments should be undertaken and mitigation management guidelines followed.

Clearly there are a number of legislative requirements that relate to destruction of habitats and individual species (see legislative section).

Clearly the development should not lead to the destruction of individuals of any critically endangered species, and should have as its goal not to destroy any individuals of any endangered or vulnerable species.

Provincial CBA plans set out guidelines on what activities should be allowed/disallowed from CBAs. CBA1 areas according to their guidelines should not have any destructive activities.

Although destruction of individual plant and animal species is of concern, a far higher concern is that the development effects important ecological processes. Changes in hydrological flows, fire regime etc. could have wide and long term detrimental impacts that extend far beyond the actual footprint of the development.

Table 4: Risk assessment for the impacts of gas pipeline development (all Phases) to the biodiversity and ecology of the Grassland and Savanna biomes.

Impact	Location	Without mitigation			With mitigation		
		Consequence	Likelihood	Risk	Consequence	Likelihood	Risk
Physical disruption of the land surface as a result of vegetation clearance and development infrastructure	Very high sensitivity area	Severe	Very likely	High negative	Substantial	Very likely	Moderate negative
	High sensitivity area	Substantial	Very likely	Moderate negative	Moderate	Very likely	Low negative
	Medium sensitivity area	Moderate	Very likely	Low negative	Slight	Very likely	Very low negative
	Low sensitivity area	Slight	Very likely	Very low negative	Slight	Very likely	Very low negative
Prevention of animal movement during the construction phase and loss of foraging habitat	Very high sensitivity area	Severe	Likely	High negative	Substantial	Likely	Moderate negative
	High sensitivity area	Substantial	Likely	Moderate negative	Substantial	Likely	Moderate negative
	Medium sensitivity area	Moderate	Likely	Low negative	Moderate	Likely	Low negative
	Low sensitivity area	Slight	Likely	Very low negative	Slight	Likely	Very low negative
Death or harm to animals or loss of breeding habitat	Very high sensitivity area	Severe	Likely	High negative	Substantial	Not likely	Moderate negative
	High sensitivity area	Substantial	Likely	Moderate negative	Substantial	Non likely	Moderate negative
	Medium sensitivity area	Moderate	Likely	Low negative	Moderate	Not likely	Low negative
	Low sensitivity area	Slight	Likely	Very low negative	Slight	Not likely	Very low negative
Limiting animal (and plant) movement in the post construction phase.	Very high sensitivity area	Severe	Very unlikely	Low negative	Substantial	Extremely unlikely	Very low negative
	High sensitivity area	Substantial	Very unlikely	Low negative	Substantial	Extremely unlikely	Very low negative
	Medium sensitivity area	Moderate	Very unlikely	Low negative	Moderate	Extremely unlikely	Very low negative
	Low sensitivity area	Slight	Very unlikely	Very low negative	Slight	Extremely unlikely	Very low negative
Soil disturbance leading to Invasive alien plants	Very high sensitivity area	Severe	Very likely	High negative	Moderate	Likely	Low negative
	High sensitivity area	Substantial	Very likely	Moderate negative	Moderate	Likely	Low negative
	Medium sensitivity area	Moderate	Very likely	Low negative	Slight	Likely	Very low negative
	Low sensitivity area	Moderate	Very likely	Low negative	Slight	Likely	Very low negative
Soil erosion	Very high sensitivity area	Substantial	Very likely	Moderate negative	Substantial	Not likely	Moderate negative
	High sensitivity area	Moderate	Very likely	Low negative	Moderate	Not likely	Low negative
	Medium sensitivity area	Moderate	Very likely	Low negative	Moderate	Not likely	Low negative
	Low sensitivity area	Slight	Very likely	Very low negative	Slight	Not likely	Very low negative

Impact	Location	Without mitigation			With mitigation		
Leakage, rupture and explosion	Very high sensitivity area	Severe	Very unlikely	Low negative	Severe	Very unlikely	Low negative
	High sensitivity area	Severe	Very unlikely	Low negative	Severe	Very unlikely	Low negative
	Medium sensitivity area	Slight	Very unlikely	Very low negative	Slight	Very unlikely	Very low negative
	Low sensitivity area	Slight	Very unlikely	Very low negative	Slight	Very unlikely	Very low negative

6 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

This section provides "best practice" (or "good practice") guidelines and management actions (including relevant standards) that cover the following development stages, and include practical, target-directed recommendations for monitoring of specified aspects raised in previous sections: During planning, construction, operations, rehabilitation.

Recommendations are based on Richardson et al. (2017).

6.1 Planning phase

- Consider where high biodiversity areas can be avoided
- Consider where threatened species can be avoided
- Consider seasonal timing
- Consider the workflow so that any area is only disrupted for a short period of time
- Align and design the route such that hillslope hydrology and soil erosion impacts are minimised

6.2 Construction phase

- Scan the proposed corridor for rare and threatened species. Obtain the appropriate permits. If they cannot be avoided, then either re-locate them or remove them for replanting (where possible)
- Carefully retain topsoil
- If possible, cut trees in the construction zone in a way that will allow them to re-sprout, provided that they do not impact on the pipeline during the operational phase in relation to deep roots within the pipeline servitude. Minimise the construction period at any site
- Conduct daily patrols to rescue any animals trapped in the trench
- Replace soils in the reverse order
- Replace topsoil
- Undertake rehabilitation activities.
- Train the construction workers and inspectors with regards to their responsibilities regarding biodiversity and ecological impacts, and monitor, reward or penalise their actions.

6.3 Operations phase

- Ensure revegetation is occurring to plan
- Control alien invasive plants (this will be a yearly or more frequent activity that needs to be maintained until there is no further infestation)
- Ensure sound soil and water management to prevent erosion
- Repair erosion when identified
- If unintended subsurface drainage (e.g. desiccation of wetlands or creation of new wetlands), piping or erosion around the former trench is identified, take remedial action such as excavation drains or installing plugs

6.4 Rehabilitation and post closure

- It is assumed that closure leaves the pipeline in the ground and as such few or any impacts are anticipated. If the pipeline were to be removed, then the impacts would be equivalent to the initial installation phase.

6.5 Monitoring requirements

- Monitoring should be conducted twice yearly in late spring and autumn for the first 2 years, then yearly in summer until natural vegetation cover is fully re-established, no erosion is being observed and there has been a 2 year period of no new alien invasion
- Monitor vegetation re-establishment to ensure that there is a succession to the natural vegetation cover.
- Monitor the structure of the rehabilitated vegetation.
- Monitor for erosion and changes in wetland areas.
- Monitor the species composition.
- Monitor for alien infestation
- Monitoring of poaching/livestock theft/illegal plant collection along the line of the pipeline, especially where it passes through private or public protected areas, especially during construction, but also during operation.

7 GAPS IN KNOWLEDGE

Location of specific sites with rare and threatened species is based on relatively crude assessments that are not of sufficient detail for detailed route planning and would require onsite inspections. In many cases the location of rare and threatened species is recorded at the level of a ¼ degree square (1:50 000 map sheet). In many cases the species is likely to occur only within specific habitat types within this broad location and specialist input will be required. Development of habitat specific location maps could increase the usability of this data in the future.

Core to this assessment is the use of the provincial biodiversity plans. This assessment is therefore subject to all the gaps in knowledge that underpinned the provincial plans.

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APPENDIX A: Trees protected through the National Forestry Act (Act 84 of 1998) and the phases in which they are likely to be encountered. Some of the species are limited to riverine or forest habitats and not strictly Savanna or Grassland species (Government Gazette 37941, 29 August 2014). Species marked n/a are unlikely to be found growing naturally in the grassland or savanna pipeline areas. No protected trees are anticipated in the small patches of grassland in the inland corridor and Phase 2.

BOTANICAL NAMES	ENGLISH COMMON NAMES	OTHER COMMON NAMES	NATIONAL TREE NUMBER	GAS PIPELINE PHASES WHERE SPECIES MAY OCCUR
Acacia erioloba	Camel thorn	Kameeldoring	168	n/a
Acacia haematoxylon	Grey camel thorn	Vaalkameeldoring, Mokholo	169	n/a
Adansonia digitata	Baobab	Kremetart, Seboi, Mowana	467	n/a
Afzelia quanzensis	Pod mahogany	Peulmahonie, Inkehli	207	3, 4, 7, 8
Balanites subsp. maughamii	Torchwood	Groendoring, Ugobandlovu	251	3, 4, 8
Barringtonia racemosa	Powder-puff tree	Poeierkwasboom, Iboqo	524	3, 4
Boscia albitrunca	Shepherd's tree	Witgat, Umvithi	122	3, 4, 7, 8
Brachystegia spiciformis	Msasa	Msasa	198.1	n/a
Breonadia salicina	Matumi	Mingerhout, Umfomfo	684	3, 4, 8
Bruguiera gymnorrhize	Black mangrove	Swartwortelboom, IsiHlobane	527	n/a
Cassipourea swaziensis	Swazi onionwood	Swazi uiehout	531.1	3, 4
Catha edulis	Bushman's tea	Boesmanstee, Umhlwazi	404	3, 4, 7 ,8
Ceriops tagal	Indian mangrove	Indiese wortelboom, Isinkahe	525	n/a
Cleistanthus schlechteri	False tamboti	Bastertamboti, Umzithi	320	3, 4, 8
Colubrine nicholsonii	Pondo weeping thorn	Pondo-treurdoring	453.8	7
Combretum imberbe	Leadwood	Hardekiil, Impondondlovu	539	8
Curtisia dentata	Assegai	Assegaai, Umagunda	570	3, 7, 8
Elaeodendron transvaalensis	Bushveld saffron	Bosveld-saffraan, Ingwavuma	416	3, 4, 8

BOTANICAL NAMES	ENGLISH COMMON NAMES	OTHER COMMON NAMES	NATIONAL TREE NUMBER	GAS PIPELINE PHASES WHERE SPECIES MAY OCCUR
Erythrophysa transvaalensis	Bushveld red balloon	Bosveld-rooiklapperbos	436.2	8
Euclea pseudebenus	Ebony guarri	Ebbeboom-ghwarrie	598	n/a
Ficus trichopoda	Swamp fig	Moerasvy, Umvubu	54	4
Leucadendron argenteum	Silver tree,	Silwerboom	77	n/a
Lumnitzera racemosa	Tonga mangrove	Tonga-wortelboom, isiKhahaesibomvu	552	n/a
Lydenburgia abbottii	Pondo bushman's tea	Pondo-boesmanstee	407	7
Lydenburgia cassinoides	Sekhukhuni bushman's tea	Sekhukhuni-boesmanstee	406	n/a
Mimusops caffra	Coastal red milkwood	Kusrooimelkhout, Umkhakhayi	583	3, 4, 7
Newtonia hildebrandtii	Lebombo wattle	Lebombo-wattel, Umfomothi	191	3, 4, 7, 8
Ocotea bullata	Stinkwood	Stinkhout, Umnukane	118	3, 4, 7, 8
Ozoroa namaquensis	Gariep resin tree	Gariep-harpuisboom	373.2	n/a
Philenoptera violacea	Apple-leaf	Appelblaar, isiHomohomo	238	3, 4, 8
Pittosporum viridiflorum	Cheesewood	Kasuur, Umfusamvu	139	3, 4, 7, 8
Podocarpus elongatus	Breede river yellowwood	Breeriviergeelhout	15	n/a
Podocarpus falcatus (Afrocarpus falcatus)	Outeniqua yellowwood	Outeniquageelhout, Umsonti	16	3, 4, 7, 8
Podocarpus henkelii	Henkel's yellowwood	Henkel se geelhout, Umsonti	17	3, 7
Podocarpus latifolius	Real yellowwood	Regte-geelhout, Umkhoba	18	3., 4, 7, 8
Prota comptonii	Saddleback sugarbush	Barberton-suikerbos	88	8
Protea curvata	Serpentine sugarbush	Serpentynsuikerbos	88.1	n/a
Prunus africana	Red stinkwood	Rooistinkhout, Umdumezuz	147	3, 4, 7, 8
Pterocarpus	Wild teak	Kiaat, Umvangazi	236	8

BOTANICAL NAMES	ENGLISH COMMON NAMES	OTHER COMMON NAMES	NATIONAL TREE NUMBER	GAS PIPELINE PHASES WHERE SPECIES MAY OCCUR
angolensis				
Rhizophora mucronata	Red mangrove	Rooiwortelboom	526	n/a
Sclerocarya birrea subsp. caffra	Marula	Maroela, Umganu	360	3, 4, 8
Securidaca longepedunculata	Violet tree	Krinkhout, Mmaba	303	8
Sideroxylon inerme subsp. inerme	White milkwood	Witmelkhout, Umakhwelafingqane	579	3, 4, 7, 8
Tephrosia pondoensis	Pondo poison pea	Pondo-gifertjie	226.1	n/a
Warburgia salutaris	Pepper-bark tree	Peperbasboom, isiBaha	488	3, 4, 8
Widdringtonia cedarbergensis	Clanwilliam cedar	Clanwilliamseder	19	n/a
Widdringtonia schwarzii	Willowmore cedar	Baviaanskloofseder	21	n/a

APPENDIX B: Savanna and Grassland Endangered and Vulnerable mammals that are likely to be encountered in the different phases (species that may occur in the tiny patch of grassland in the inland corridor and Phase 2 were not included).

ORDER	FAMILY	BOTANICAL NAME	ENGLISH COMMON NAMES	GAS PIPELINE PHASES WHERE THE SPECIES IS LIKELY TO OCCUR
Endangered				
Afrosoricida	Chrysochloridae	*Amblysomus marleyi*	Marley's Golden Mole	Grassland Phase 4
Afrosoricida	Chrysochloridae	*Chrysospalax trevelyani*	Giant Golden Mole	Forest Patches Phase 7
Afrosoricida	Chrysochloridae	*Neamblysomus julianae*	Juliana's Golden Mole	Phase 8 Savanna/Grassland
Artiodactyla	Bovidae	*Hippotragus equinus*	Roan Antelope	Grassland / Savanna Phase 3
Artiodactyla	Bovidae	*Nesotragus moschatus zuluensis*	Suni	Savanna Phase 4
Artiodactyla	Bovidae	*Ourebia ourebi ourebi*	Oribi	Grassland Phase 3, 7, 8
Artiodactyla	Bovidae	*Redunca fulvorufula fulvorufula*	Mountain Reedbuck	Grassland Phase 3, 4, 7, 8
Carnivora	Canidae	*Lycaon pictus*	African Wild Dog	Savanna Phase 3, 4, 8
Hyracoidea	Procaviidae	*Dendrohyrax arboreus*	Tree Hyrax	Savanna Phase 7
Perissodactyla	Rhinocerotidae	*Diceros bicornis minor*	Southern-central Black Rhinoceros	Savanna Phase 3, 4, 7, 8
Vulnerable				
Afrosoricida	Chrysochloridae	*Chrysospalax villosus*	Rough-haired Golden Mole	Grassland Phase 3, 7, 8
Artiodactyla	Bovidae	*Damaliscus lunatus lunatus*	Tsessebe	Savanna Phase 4, 7, 8
Artiodactyla	Bovidae	*Hippotragus niger niger*	Sable Antelope	Savanna Phase 8
Artiodactyla	Bovidae	*Philantomba monticola*	Blue Duiker	Savanna Phase 3, 4, 7
Carnivora	Felidae	*Acinonyx jubatus*	Cheetah	Savanna 3, 7, 8
Carnivora	Felidae	*Felis nigripes*	Black-footed Cat	Grassland Savanna Phase 3, 8
Carnivora	Felidae	*Panthera pardus*	Leopard	Grassland Savanna 3, 4, 7, 8
Perissodactyla	Equidae	*Equus zebra hartmannae*	Hartmann's Mountain Zebra	Grassland Phase 7
Pholidota	Manidae	*Smutsia temminckii*	Temminck's Ground Pangolin	Savanna 3, 4, 8
Primates	Cercopithecidae	*Cercopithecus albogularis labiatus*	Samango Monkey	Savanna 3, 4, 7, 8
Rodentia	Nesomyidae	*Mystromys albicaudatus*	White-tailed Rat	Grassland Phase 3, 7

APPENDIX C: Grassland Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) plant species likely to be found in the Grassland and forest habitats in each phase. The hot links link to the SANBI red list of South African plants where details including likely location of each species are likely to be found. (Species that may occur in the tiny patch of grassland in the inland corridor and Phase 2 were not included).

GRASSLAND SPECIES BOTANICAL NAME AND STATUS	GAS PIPELINE PHASE WHERE THE SPECIES IS LIKELY TO BE FOUND
Acalypha entumenica Prain EN	3, 4
Alepidea cordifolia B.-E.van Wyk EN	3, 4, 8
Aloe chortolirioides A.Berger var. chortolirioides VU	8
Aloe condyae Van Jaarsv. & P.Nel VU	8
Aloe craibii Gideon F.Sm. CR	8
Aloe integra Reynolds VU	8
Aloe kniphofioides Baker VU	8
Aloe neilcrouchii R.R.Klopper & Gideon F.Sm. EN	7, 3
Aloe saundersiae (Reynolds) Reynolds CR	4, 3, 7
Argyrolobium longifolium (Meisn.) Walp. VU	3, 4, 7
Asclepias bicuspis N.E.Br. CR	7
Asclepias bicuspis N.E.Br. CR	7
Asclepias disparilis N.E.Br. EN	7
Asclepias dissona N.E.Br. CR PE	8
Asclepias gordon-grayae Nicholas EN	3, 4
Asclepias schlechteri (K.Schum.) N.E.Br. EN	7
Asclepias schlechteri (K.Schum.) N.E.Br. EN	7
Aspalathus abbottii C.H.Stirt. & Muasya VU	7
Aspalathus gerrardii Bolus VU	3, 4, 7
Aspidoglossum demissum Kupicha VU	3
Aspidoglossum demissum Kupicha VU	3
Brachystelma gerrardii Harv. EN	3, 4, 7
Brachystelma ngomense R.A.Dyer EN	3, 4
Brachystelma sandersonii (Oliv.) N.E.Br. VU	3, 4, 7
Brachystelma tenellum R.A.Dyer VU	7
Brachystelma vahrmeijeri R.A.Dyer EN	4
Brunia trigyna (Schltr.) Class.-Bockh. & E.G.H.Oliv. CR	7
Cephalaria foliosa Compton VU	3
Cineraria dryogeton Cron VU	7
Cyathocoma bachmannii (Kük.) C.Archer VU	4, 7
Dierama ambiguum Hilliard EN	7
Dierama dubium N.E.Br. VU	3, 4
Dierama luteoalbidum I.Verd. VU	7
Dierama pallidum Hilliard VU	7
Dierama pumilum N.E.Br. VU	7, 3
Dioscorea brownii Schinz EN	7
Disa amoena H.P.Linder VU	8
Disa clavicornis H.P.Linder EN	8
Disa clavicornis H.P.Linder EN	8
Disa vigilans McMurtry, T.J.Edwards & Bytebier EN	8
Encephalartos ghellinckii Lem. VU	7
Encephalartos heenanii R.A.Dyer CR	8
Encephalartos middelburgensis Vorster, Robbertse & S.van der Westh. CR	8

GRASSLAND SPECIES BOTANICAL NAME AND STATUS	GAS PIPELINE PHASE WHERE THE SPECIES IS LIKELY TO BE FOUND
Encephalartos msinganus Vorster CR	3
Eriosema latifolium (Benth. ex Harv.) C.H.Stirt. VU	7
Eriosema populifolium Benth. ex Harv. subsp. populifolium EN	7
Eriosema umtamvunense C.H.Stirt. EN	7
Eriosema umtamvunense C.H.Stirt. EN	7
Eriosemopsis subanisophylla Robyns VU	7
Euphorbia flanaganii N.E.Br. VU	7
Geranium natalense Hilliard & B.L.Burtt VU	7
Geranium sparsiflorum R.Knuth VU	7
Gerbera aurantiaca Sch.Bip. EN	3, 4, 7, 8
Gymnosporia woodii Szyszyl. EN	3, 4
Haworthiopsis limifolia (Marloth) G.D.Rowley VU	4, 8
Helichrysum citricephalum Hilliard & B.L.Burtt CR	7
Helichrysum ingomense Hilliard EN	4
Helichrysum montis-cati Hilliard VU	7
Helichrysum pannosum DC. EN	7
Helichrysum summo-montanum I.Verd. EN	8
Huttonaea woodii Schltr. VU	7
Kniphofia latifolia Codd EN	7
Kniphofia leucocephala Baijnath CR	3, 4
Ledebouria remifolia S.Venter VU	8
Macowania conferta (Benth.) E.Phillips VU	7
Macowania conferta (Benth.) E.Phillips VU	7
Moraea hiemalis Goldblatt VU	7
Nerine gibsonii Douglas VU	7
Nerine gracilis R.A.Dyer VU	8
Oxygonum dregeanum Meisn. subsp. *streyi* Germish. EN	3, 4, 7
Pachycarpus acidostelma M.Glen & Nicholas CR	7
Pachycarpus concolor E.Mey. subsp. *arenicola* Goyder VU	3, 4
Pachycarpus suaveolens (Schltr.) Nicholas & Goyder VU	8
Phylica simii Pillans VU	7
Plectranthus malvinus Van Jaarsv. & T.J.Edwards VU	7
Polygala praticola Chodat VU	3, 7
Psoralea abbottii C.H.Stirt. VU	7
Restio zuluensis H.P.Linder VU	3, 4
Riocreuxia flanaganii Schltr. var. alexandrina H.E.Huber CR	7
Riocreuxia woodii N.E.Br. CR PE	7
Schizoglossum ingomense N.E.Br. EN	3, 4
Schizoglossum peglerae N.E.Br. EN	7
Schizoglossum rubiginosum Hilliard VU	7
Searsia rudatisii (Engl.) Moffett EN	7
Selago zuluensis Hilliard EN	3, 4
Senecio dregeanus DC. VU	3, 4, 7
Senecio exuberans R.A.Dyer EN	7
Senecio ngoyanus Hilliard VU	3, 4
Senecio triodontiphyllus C.Jeffrey VU	8
Senecio villifructus Hilliard EN	4
Sisyranthus fanniniae N.E.Br. VU	7
Struthiola anomala Hilliard VU	7
Syncolostemon incanus (Codd) D.F.Otieno EN	8
Syncolostemon latidens (N.E.Br.) Codd VU	3, 4

GRASSLAND SPECIES BOTANICAL NAME AND STATUS	GAS PIPELINE PHASE WHERE THE SPECIES IS LIKELY TO BE FOUND
Tephrosia bachmannii Harms VU	7
Tephrosia inandensis H.M.L.Forbes EN	3, 4, 7
Tephrosia pondoensis (Codd) Schrire EN	7
Thesium polygaloides A.W.Hill VU	3, 4, 7
Turraea pulchella (Harms) T.D.Penn. VU	7
Turraea streyi F.White & Styles CR PE	7
Watsonia bachmannii L.Bolus VU	7
Watsonia pondoensis Goldblatt EN	7

APPENDIX D: Savanna Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) plant species likely to be found in the Savanna and forest habitats in each phase. The hot links link to the SANBI red list of South African plants where details including likely location of each species are likely to be found. (There is no savanna in the inland corridor and Phase 2).

SAVANNA SPECIES BOTANICAL NAME AND STATUS	GAS PIPELINE PHASE WHERE SPECIES IS LIKELY TO BE FOUND
Ledebouria ovatifolia (Baker) Jessop subsp. *scabrida* N.R.Crouch & T.J.Edwards VU	3
Plectranthus porcatus Van Jaarsv. & P.J.D.Winter VU	3
Encephalartos lebomboensis I.Verd. EN	4
Raphionacme elsana Venter & R.L.Verh. EN	4
Warneckea parvifolia R.D.Stone & Ntetha CR	4
Aloe pruinosa Reynolds VU	7
Tephrosia pondoensis (Codd) Schrire EN	7
Euphorbia gerstneriana Bruyns VU	3, 4, 7
Dioscorea sylvatica Eckl. VU	3, 4, 7, 8
Ceropegia cimiciodora Oberm. VU	4, 3

APPENDIX E: Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and Near Threatened reptiles likely to be found in each proposed Gas Pipeline Phase.

REPTILES SCIENTIFIC NAME	IUCN STATUS	GAS PIPELINE PHASE WHERE SPECIES IS LIKELY TO BE FOUND
Acontias poecilus	Endangered	7
Bitis albanica	Critically Endangered	7
Bitis gabonica	Near Threatened	4
Bradypodion caeruleogula	Endangered	7
Bradypodion dracomontanum	Near Threatened	3
Bradypodion kentanicum	Vulnerable	7
Bradypodion melanocephalum	Vulnerable	7
Bradypodion nemorale	Near Threatened	7
Bradypodion ngomeense	Near Threatened	4
Bradypodion pumilum	Vulnerable	8
Bradypodion taeniabronchum	Endangered	7
Bradypodion thamnobates	Vulnerable	7
Caretta caretta	Vulnerable	4, 7
Chamaesaura aenea	Near Threatened	3, 7, 8
Chamaesaura macrolepis	Near Threatened	3, 4, 7, 8
Chelonia mydas	Near Threatened	7
Cordylus niger	Near Threatened	8
Crocodylus niloticus	Vulnerable	3, 4, 7, 8
Cryptoblepharus boutonii	Endangered	4
Dendroaspis angusticeps	Vulnerable	4, 7, 8
Dermochelys coriacea	Endangered	4, 7
Eretmochelys imbricata	Near Threatened	4
Homoroselaps dorsalis	Near Threatened	3, 4, 7, 8
Leptotyphlops sylvicolus	Data Deficient	7, 4
Leptotyphlops telloi	Near Threatened	4
Lycophidion pygmaeum	Near Threatened	4, 7
Macrelaps microlepidotus	Near Threatened	4, 7, 8
Nucras taeniolata	Near Threatened	7
Pelusios rhodesianus	Vulnerable	4, 7
Pseudocordylus spinosus	Near Threatened	7
Scelotes bourquini	Vulnerable	7
Scelotes gronovii	Near Threatened	8
Scelotes inornatus	Critically Endangered	7
Smaug giganteus	Vulnerable	3
Tetradactylus breyeri	Vulnerable	3, 7, 8