South African National Biodiversity Institute

GIS METADATA : DETAILED REPORT

FILE NAME: Low_risk_biome_change	
Description (detailed)	Biome delineations based on low risk (best case) scenarios. Modeled biome based on the best case scenario: smallest predicted increases in temperature and changes in rainfall
Copyright Holder	SANParks
Data Origin	Modelled
Capture Source	-
Scale Digitised at	-
Date Captured	2011
Data Copyright	n/a
To be distributed	yes

DATA INFORMATION AND METADATA INFORMATION	
Owner Organisation	SANParks - Park Planning and Development Conservation Services
Contact Person	Stephen Holness & Peter Bradshaw
Position of Contact Person	Park Planning and Development Conservation Services
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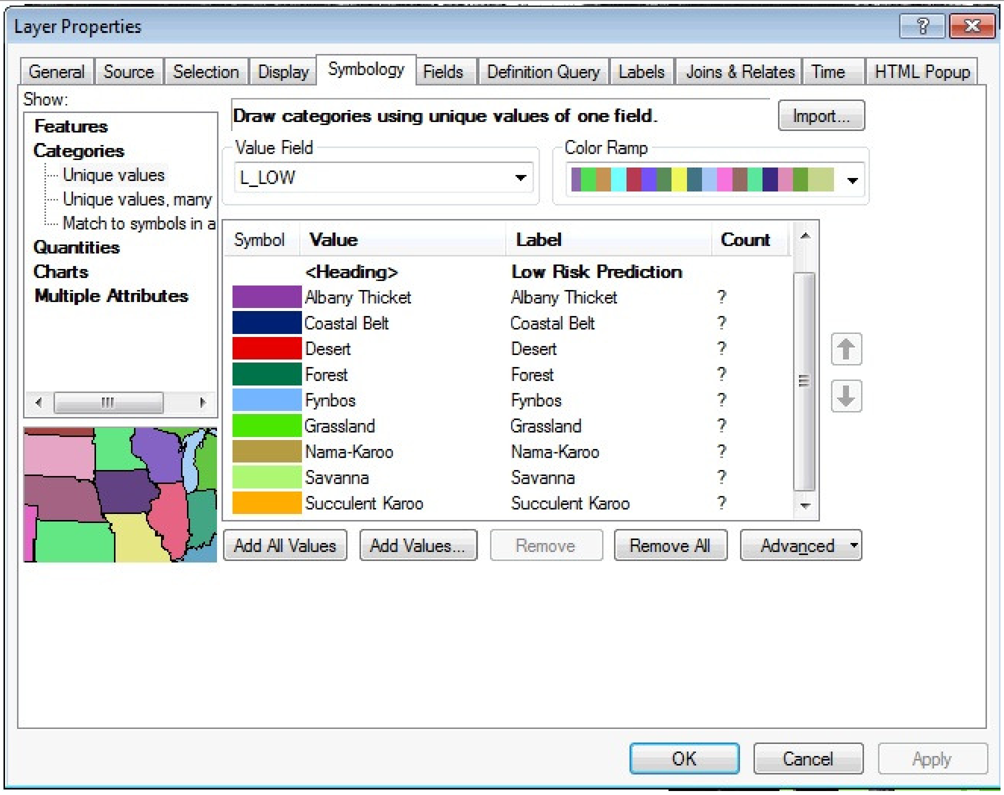
LEGEND PROPERTIES	
Legend Title	Biomes

Feature Type	
Scale Parameters	Should not be used at finer than provincial scale.

PROJECTION	
Projection Name	GCS_WGS_1984
Central Meridian	
Upper Parallel	
Lower Parallel	

DATUM	
Name	D_WGS_1984
Semi Major Axis	0
Semi Minor Axis	0
Inverse Flattening	0

DETAILED NOTES

Purpose:

Re-assessing climate change risk at biome scale

The primary focus of this section is to reassess vulnerability to climate change for the biomes of South Africa according to the latest available science. Each biome has a characteristic ‘climate envelope’ or a range and pattern of temperature and rainfall values within which it occurs. Our understanding of climate control of vegetation types dictates that, as the climate changes, an area that is currently climatically suited to one biome might become climatically suited to another, inducing climate-related stress in components of the biome. If such changes were to occur over a long period of time (many thousands of years), and if natural habitat were predominantly intact, the ecosystems and species that make up the biome would likely be able to undergo adaptation and spatial shifts in response. However, with changes in climate projected to occur over relatively short periods (decades) and the current state of significant natural habitat loss, degradation, and fragmentation, it is more likely that disruptive change (such as population declines and even extinctions) would occur, especially in areas of future climatic unsuitability.

The first research on how the distribution of South Africa's biomes might be impacted by climate change was done in the mid-1990s and reported in 2000, among the first such work worldwide (Rutherford et al, 2000). Rutherford et al's report was part of the South African Country Study on Climate Change which contributed to South Africa's Initial National Communication to the UNFCCC. This work examined how the distribution of different biomes was likely to be influenced by climate change. The study was conceptually very similar to that used in our current report and the work presented here builds on this concept, using more recent climate data and analysis methods.

Definitions used for habitat description:

Throughout this document, we are using the habitat units as defined and identified for South Africa in Mucina & Rutherford (2006), The Vegetation of South Africa, Lesotho and Swaziland.

Biome - a broad ecological spatial unit representing major life zones of large natural areas, and defined mainly by vegetation structure, climate as well as major large-scale disturbance factors (such as fire). Each biome may consist of a number of bioregions and each of these bioregions will contain many vegetation types.

Bioregion - these are a group of similar vegetation types sharing similar biotic and physical-geographical features, connected by ecological processes operating at a regional scale.

Vegetation types or units - these are a complex of plant communities ecologically and historically (both in spatial and temporal terms) occupying habitat complexes at the landscape scale. A more user friendly definition is that these are the smallest unique units of similar vegetation in terms of composition or structure which have been mapped across the whole country.

Rutherford et al's (2000) analysis was based on climate data which, although relevant at the time of analysis, is now is extremely dated given advancements in climate science over the last decade. Key differences between the outcomes of the previous study and the current study include that Rutherford et al (2000) indicate an almost complete loss of the Succulent Karoo climate envelope as a result of dramatic predicted reductions in winter rainfall while this report suggests that winter rainfall patterns will change slower than originally predicted and, therefore, contractions in the Succulent Karoo biome will be less pronounced in the short to medium term.

Over the last decade, the science of climate change has evolved rapidly. Nevertheless, there is considerable uncertainty about the evolution of climate over 50 or 100 year time-scales, and while confidence in global circulation models is growing there is greater appreciation of the uncertainties involved, especially in 'downscaling' the global models to produce climate projections at the regional and local scales.

Acknowledging this unavoidable uncertainty, we have developed a statistical approach to incorporate a wide range of possible climate scenarios in impacts models that uses median, and 90th and 10th percentile changes in temperature and rainfall from a number of general circulation models, from which future scenarios are developed. These scenarios were compiled by SANBI (Guy Midgley and Danni Guo). Highest temperature increases and largest rainfall decreases were combined to generate a 'high-risk' or 'worst case' scenario, and vice-versa for a 'low-risk' or 'best case' scenario. Likewise the median projected changes in rainfall and temperature were combined to generate an intermediate scenario.
Based on outputs from 15 global circulation models that were spatially interpolated, we developed three climate scenarios for South Africa for approximately 2050 as follows:[1]

- Best case scenario: smallest predicted increases in temperature and changes in rainfall,
- Intermediate scenario: middle of the range (median) predicted increases in temperature increases and changes in rainfall,
- Worst case scenario: greatest predicted increases in temperature and changes in rainfall.

This means that the results presented are not dependent on any particular global circulation model but hold under a very wide range of possible climate futures, enhancing the robustness of conclusions as climate

[1] For more detail on the analysis and methods summarised here see Holness et al. In prep. Where can protected areas contribute most to supporting resilience of biodiversity to climate change at the landscape scale in South Africa?

changes and as climate science revises outputs and projections.
Note that the study was based on medium term data (for 2050) as this represented a compromise between the uncertainty associated with the very long time horizon data (2100) and the very small changes predicted by the shorter duration data (e.g. 2020). This 50 year time horizon also represents a reasonable long term planning horizon as it is within the lifetimes of most people currently living. When this study is updated based on new climate data, if possible (we are dependent on work done by a third party), we will include both the medium term and long term predictions. In the interim, as climate change occurs gradually over time, it is useful to conceptualize the worst case scenarios for 2050 as being likely to represent the intermediate case scenarios in 2100.

Detail on the climate scenarios:
The present values are based on the agro-hydrology data for rain and temperature. Temperature and precipitation data for seasons DJF (Dec,Jan,Feb), MAM (Mar,Apr,May), JJA (Jun,July,Aug) and SON (Sept,Oct,Nov) were used as the base climate variables. The current climate data are a 1' grid (approximately 1.8km x 1.8km).
The climate scenario data used were based on the difference between future and current values for each of the 15 GCMs (i.e. future predicted value - control values produced by the model for present conditions), with present being 1960-1999, and future being 2040-2059. The future climate data are approximately a 50km x 50km grid.
The scenarios are calculated as [present agro-hydrology data values for rain and temp] + [anomaly].
The anomaly chosen varied for each scenario:
- Best case scenario: temperatures at the lowest end of those predicted by the 15 downscaled GCMs (10th percentile for temperature values) and rainfall values at the highest end of the range predicted (90th percentile of rainfall values).
- Intermediate scenario: median temperature and rainfall changes from the 15 models.
- Worst case scenario: temperatures at the highest end of those predicted by the 15 downscaled GCMs (90th percentile for temperature values) and rainfall values at the lowest end of the range predicted (10th percentile of rainfall values).

Note1. This does not imply that these particular combinations are predicted to occur in combination by a specific model or are more or less likely. They are specifically chosen to represent the full range of potential values, in order to ensure that actual futures are likely to be within the range of these scenarios.
Note2. All GCM outputs are used in each of the scenarios.

Biome envelope modelling

The approach taken here is to model the climate envelopes responsible for biome suitability. In this way, we were able to identify biomes, and specific areas within biomes, that are likely to be more stable under climate change.
A maximum entropy model (using the industry standard software MaxEnt) was used to develop a biome distribution model which predicts the distribution of biomes based on a set of climate variables. The ability of the model to predict future distributions of biomes was tested by using it to 'predict' the current distribution of biomes. The model was very accurate at 'predicting' the current distribution of biomes, producing a map that matched the actual distribution of biomes very closely. This biome distribution model was then used to show how the distribution of climate envelopes associated with different biomes is likely to change under each of the three climate scenarios. The results are shown over the following pages. The maps show which biome's climate envelope the future climate in an area is likely to resemble most closely; this is often different from the current biome in that area.

Details on biome envelop modelling:
Current (control) climate data as described above were entered into MaxEnt. Temperature and precipitation data for seasons DJF (Dec, Jan, Feb), MAM (Mar, Apr, May), JJA (Jun, July, Aug) and SON (Sept, Oct, Nov) were used as the base climate variables. The climate data are a 1' grid.
The National Vegetation level map (Mucina et al. 2006) was dissolved on the biome field, to produce an accurate biome boundaries map. Centroids of the climate data grid pixels were used as sample sites to generate training points for MaxEnt. These training points were fed into MaxEnt to produce models for each of the biomes under current conditions.
We produced a ‘Current Modelled’ Biome map by taking the outputs from the above MaxEnt models. We then assigned a modelled biome based on the MaxEnt score (for each biome) with the final modelled biome being assigned according to the highest MaxEnt predicted value.
To test the ‘Current Modelled’ Biome map we compared it to an ‘Actual Current’ generalized biome map created by assigning the area dominant biome in each grid square.
We compared the modelled biome map with the actual biome map. Just over 86% of the areas were correctly predicted. Areas that were misidentified were mostly on the boundaries of biomes, or had a mixture of biomes present in the square (e.g. the square may have been 55% Fynbos - 45% Succulent Karoo, and the MaxEnt model may have a slightly stronger Succulent Karoo signal).
We then used the models created for the biomes and applied these to the future climate modelled data.

Methodology:
Available documentation:

Driver A., Sink, K.J., Nel, J.N., Holness, S., Van Niekerk, L., Daniels, F., Madjiet, P.A., Jonas, Z. and Maze, K. 2012. National Biodiversity Assessment 2011: An assessment of South Africa’s biodiversity and ecosystems. Synthesis Report. South African National Biodiversity Institute and Department of Environmental Affairs, Pretoria.

ATTRIBUTE FIELDS

Field Name	Description	Alias
L_low	Modeled biome based on the best case scenario: smallest predicted increases in temperature and changes in rainfall	