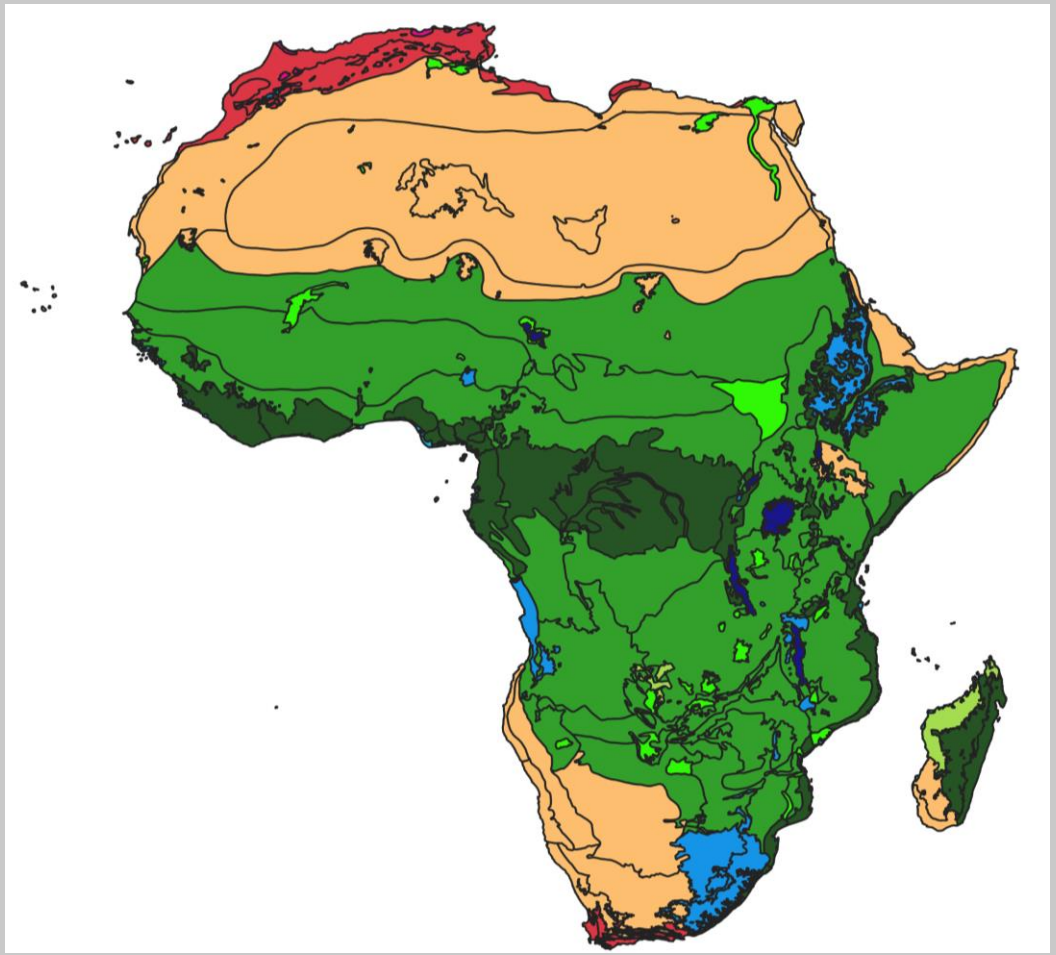
Understanding ecosystem processes in order to deal with climate change



Mthokozisi Moyo

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

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Climate Change
Drought

Madagascar on the brink of climate change-induced famine

By Andrew Harding
Africa correspondent, BBC News

Climate change is hitting Africa's staple crops, increasing parasites - UN report

fin24 Lameez Omarjee

SHARE

Mass starvation, extinctions, disasters: the new IPCC report's grim predictions, and why adaptation efforts are falling behind

Published: February 28, 2022 1.01pm SAST

AFRICA IN FOCUS

Climate migration—deepening our solutions

Simeon K. Ehui and **Kanta Kumari Rigaud** · Thursday, March 17, 2022

Rising sea levels may threaten 70% of Africa's heritage sites by 2050

Published: February 27, 2022 10.32am SAST

Cyclone Idai 'might be southern hemisphere's worst such disaster'

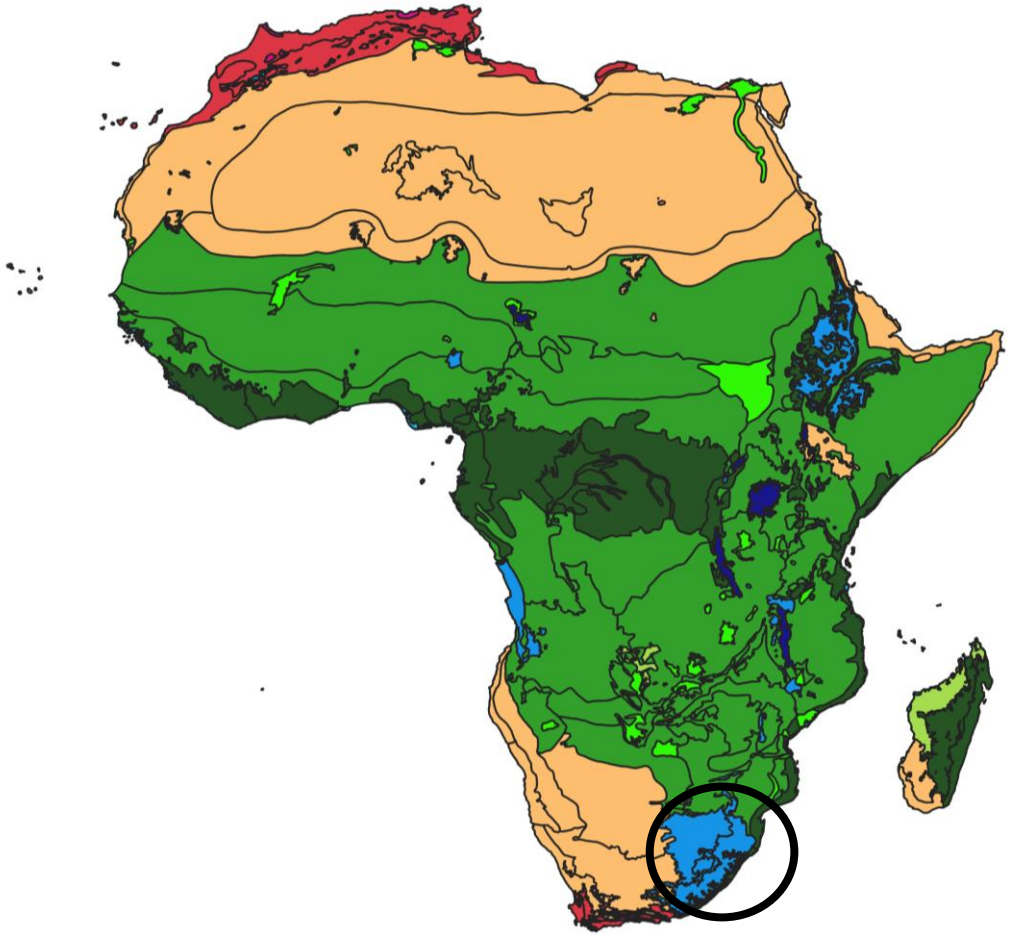
Millions from Mozambique, Malawi and Zimbabwe affected as houses and roads submerged

The Trouble with Trees: Afforestation Plans for Africa

William J. Bond,[1,2,*] Nicola Stevens,[3] Guy F. Midgley,[3] and Caroline E.R. Lehmann[4,5,6]

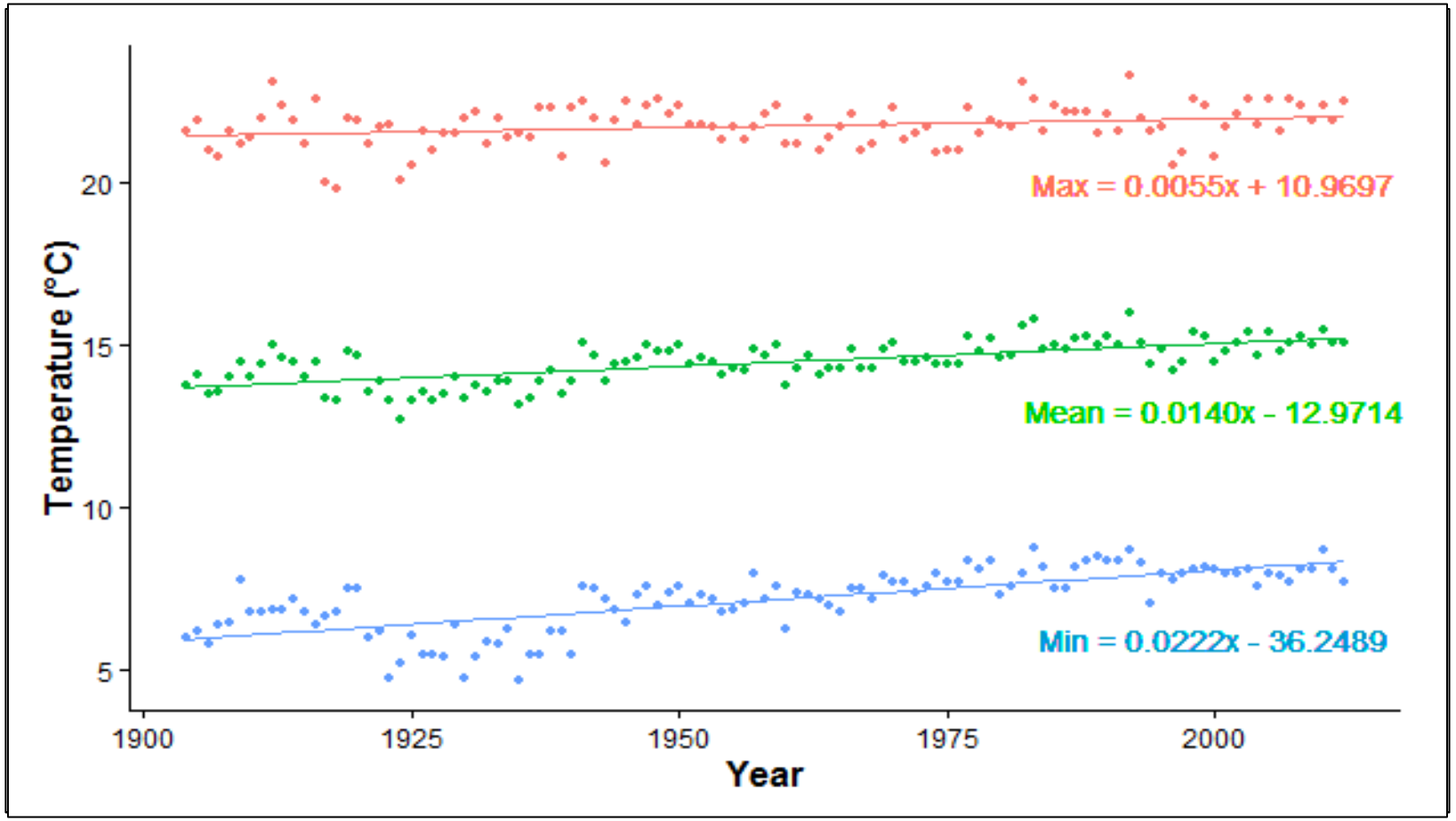
Phenology of high altitude, low latitude grasslands

- Grasslands and the global carbon cycle
- Why these grasslands?
- The aim is to develop a phenology model for the afromontane grasslands.

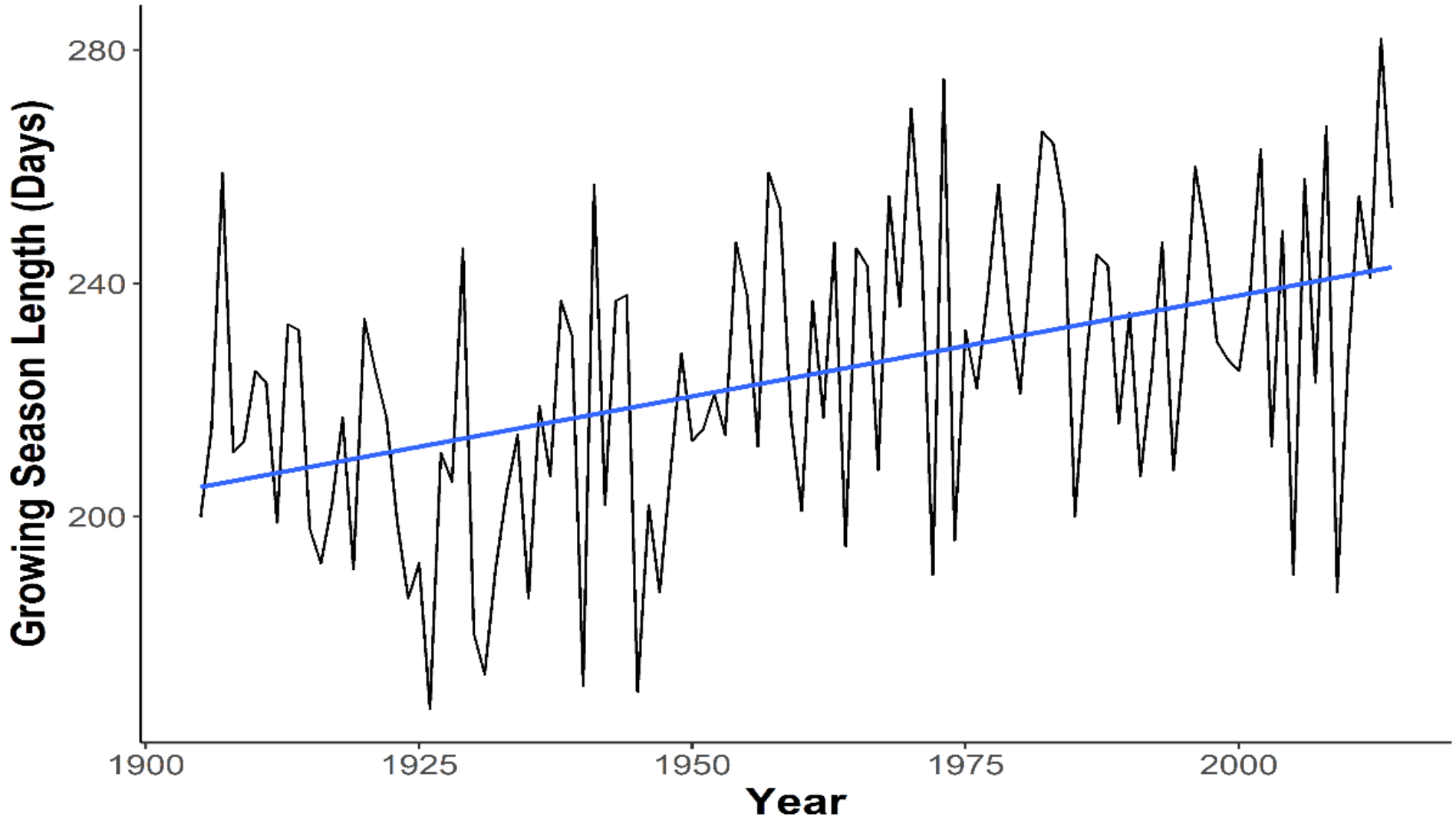


Climate data

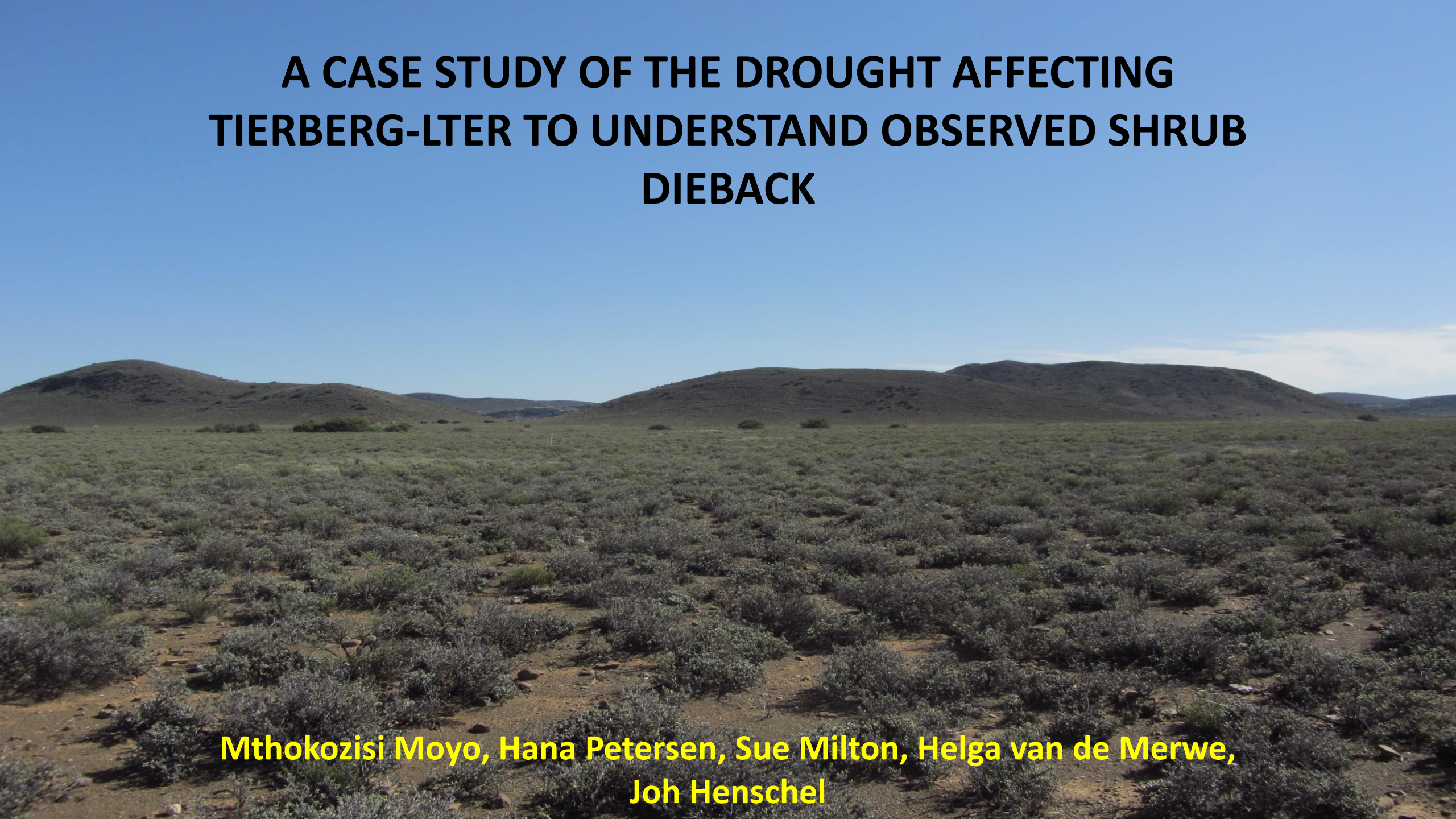
1. Constructed a 110 year dataset not previously available



Growing Season



A CASE STUDY OF THE DROUGHT AFFECTING TIERBERG-LTER TO UNDERSTAND OBSERVED SHRUB DIEBACK



Mthokozisi Moyo, Hana Petersen, Sue Milton, Helga van de Merwe, Joh Henschel

WHY ARE WE DOING THIS STUDY?

- Drought is likely to become a more common occurrence in arid lands, under future climate change projections

- Understanding the degree to which the present drought affects the growth and survival of Karoo vegetation is important for evaluating the potential effects that future climate change scenarios for the Karoo may have on vegetation structure and demographics

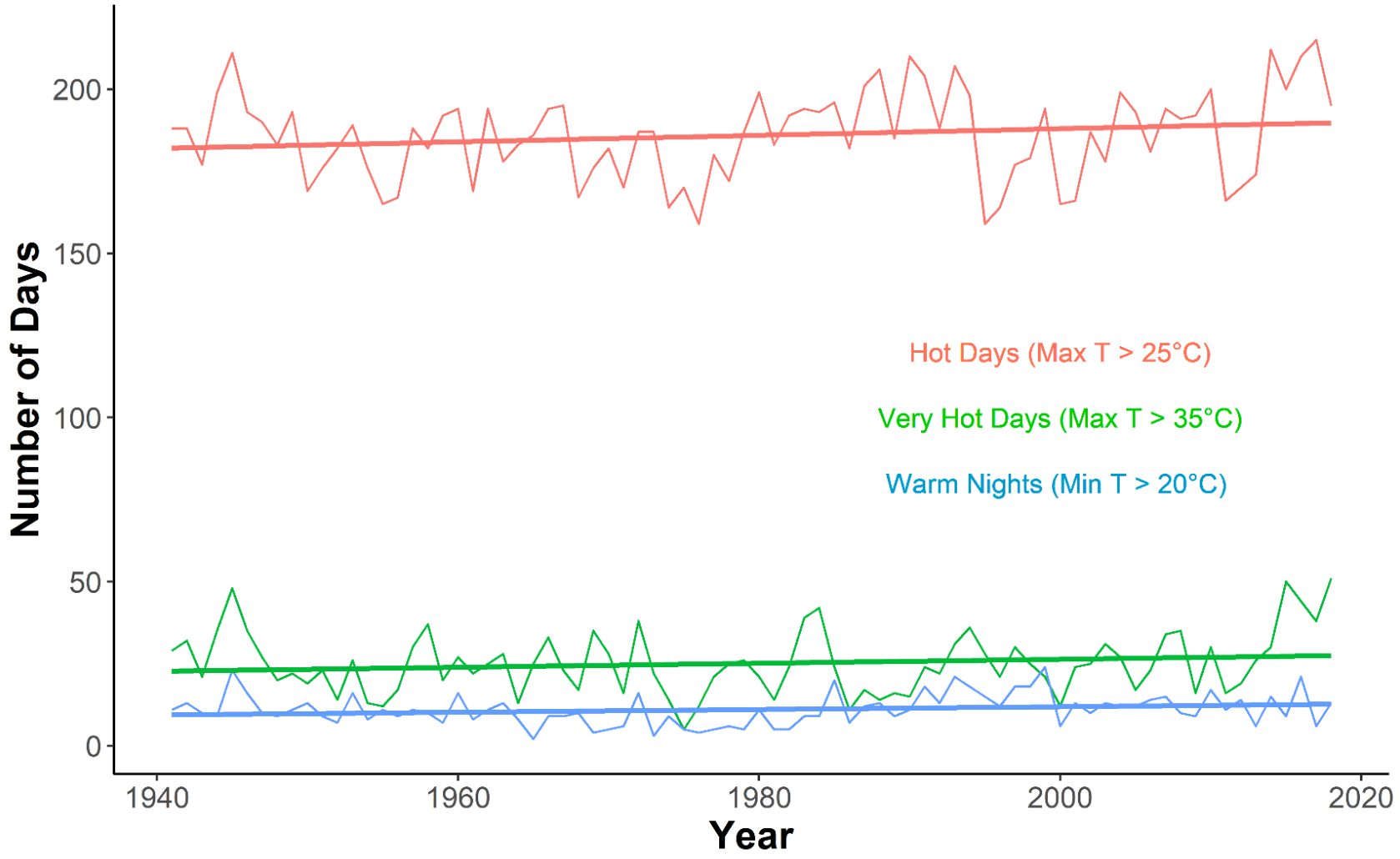
2006 **2017**

(photos: Sue Milton-Dean)

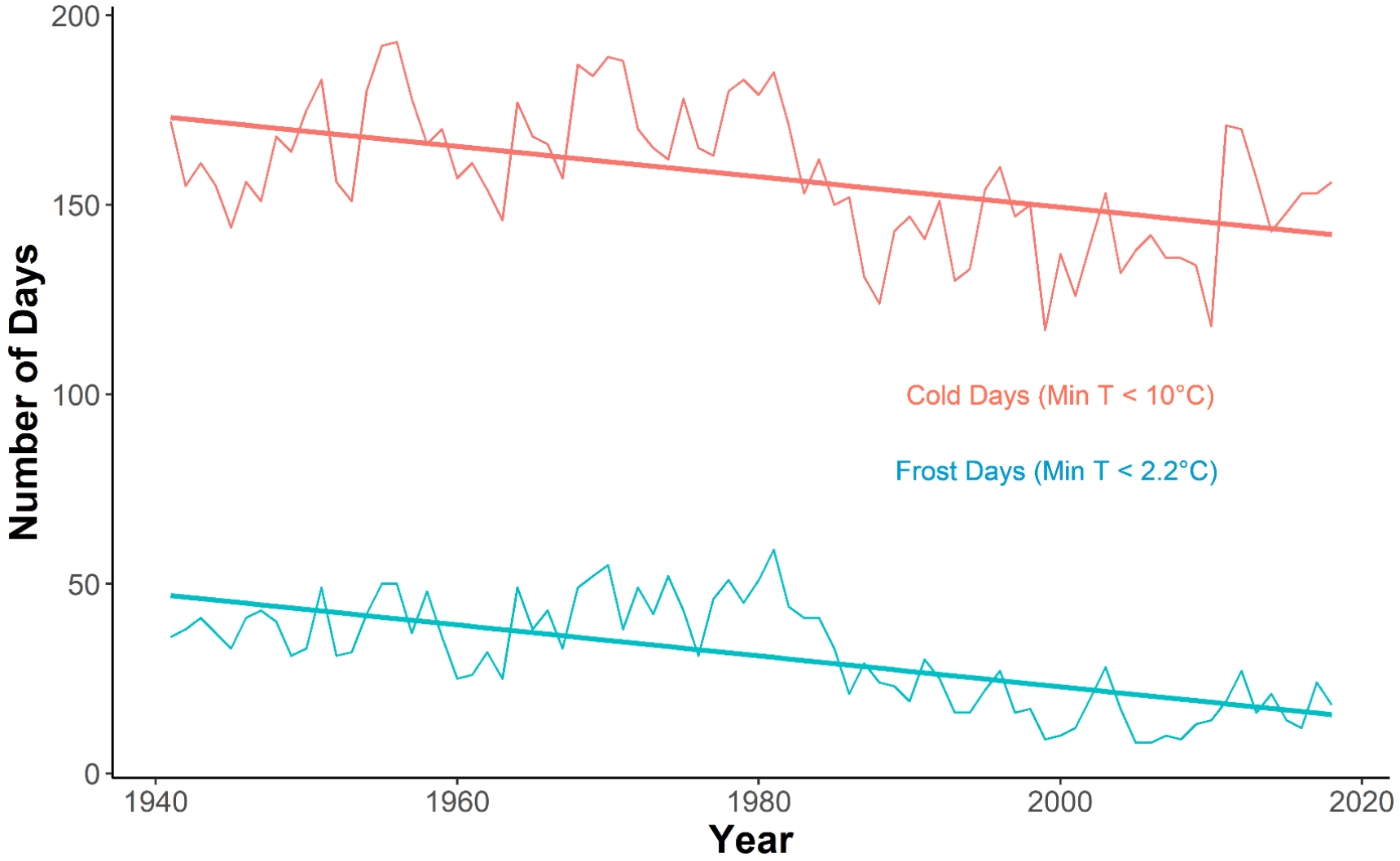
AIM

- **The aim of this study was to conduct a climate analysis of the region and link it to understanding the effect of this drought on the vegetation in the area. We also compared the severity of this drought to previous droughts.**

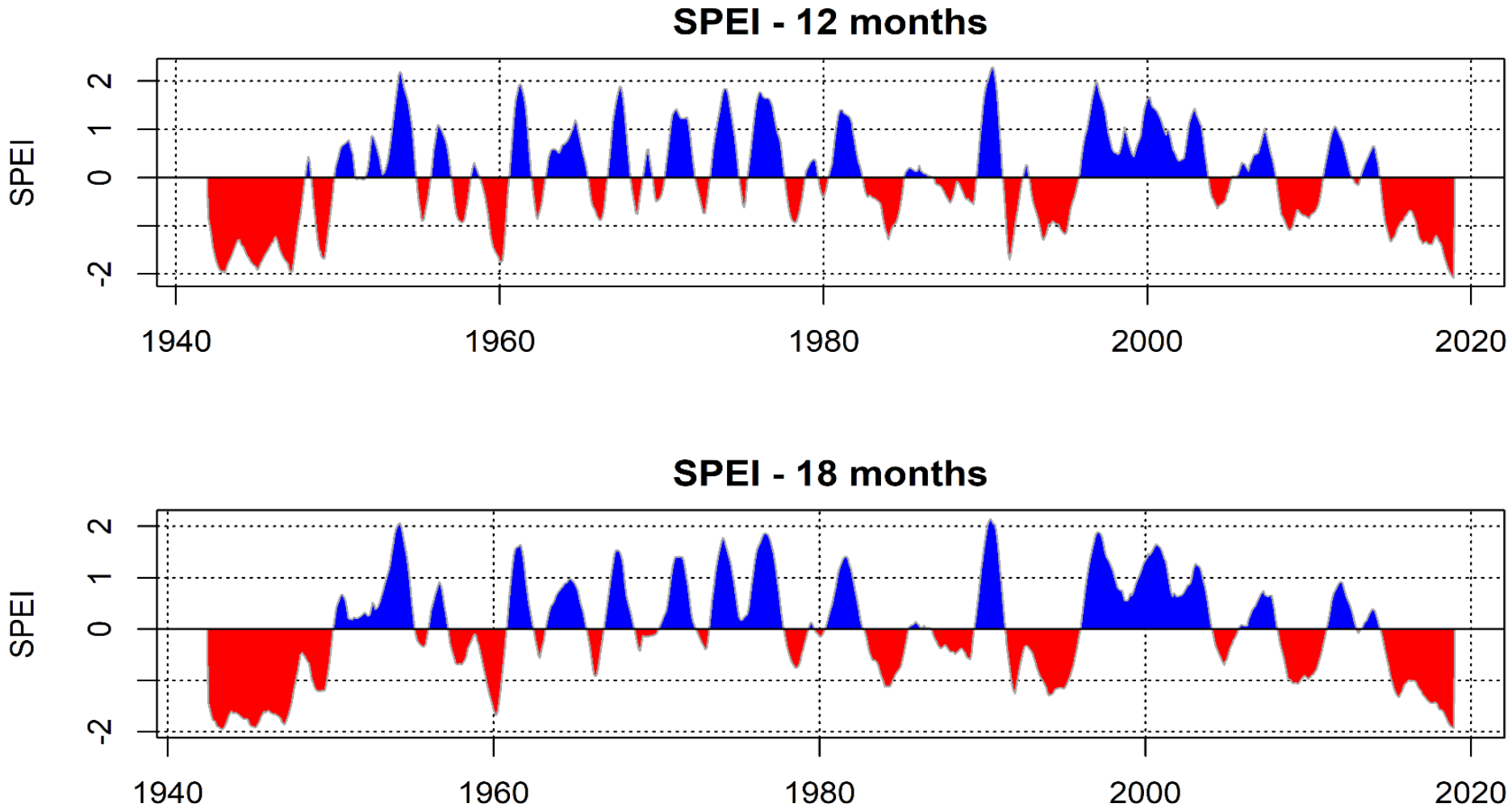
HOT INDICES


Number of Days
200
150
100
50
0
1940
1960
1980
2000
2020
Year
Hot Days (Max T > 25°C)
Very Hot Days (Max T > 35°C)
Warm Nights (Min T > 20°C)

COLD INDICES

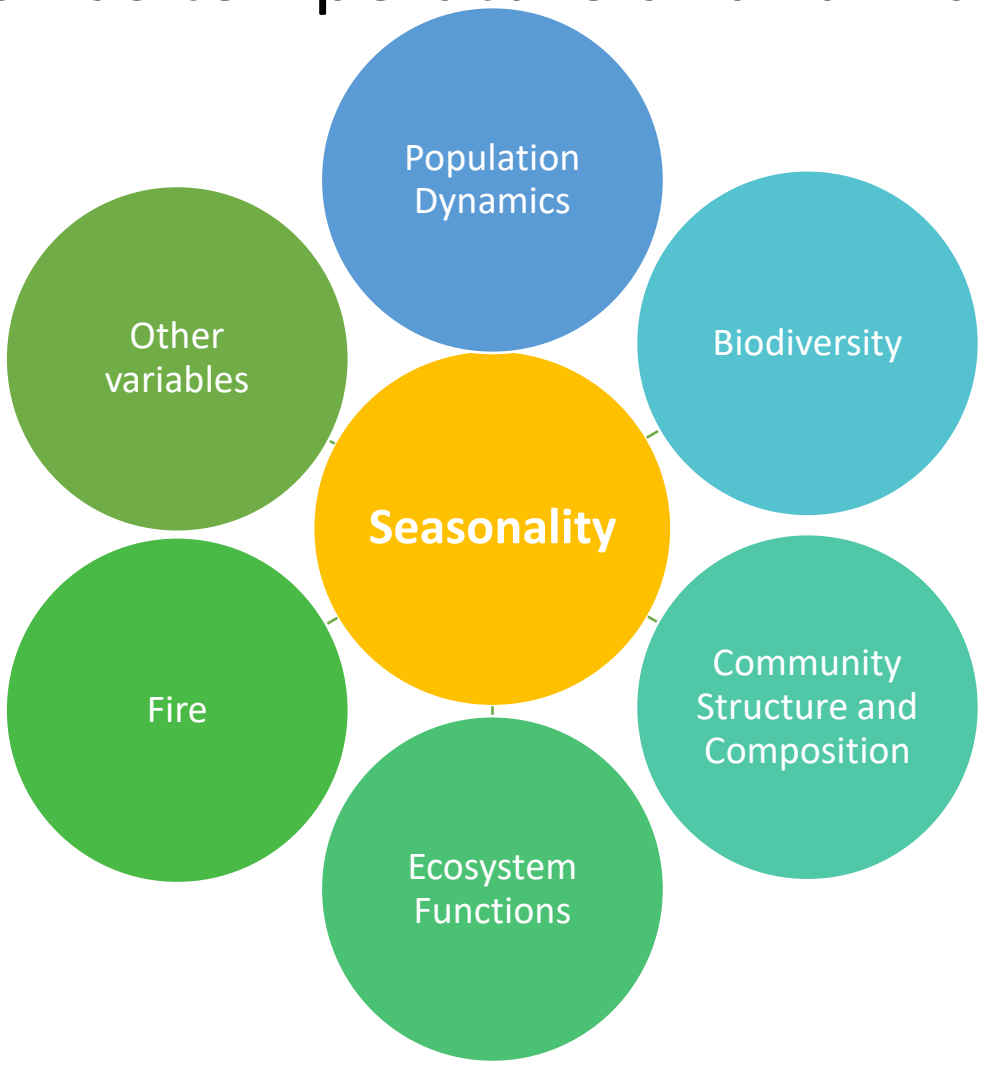


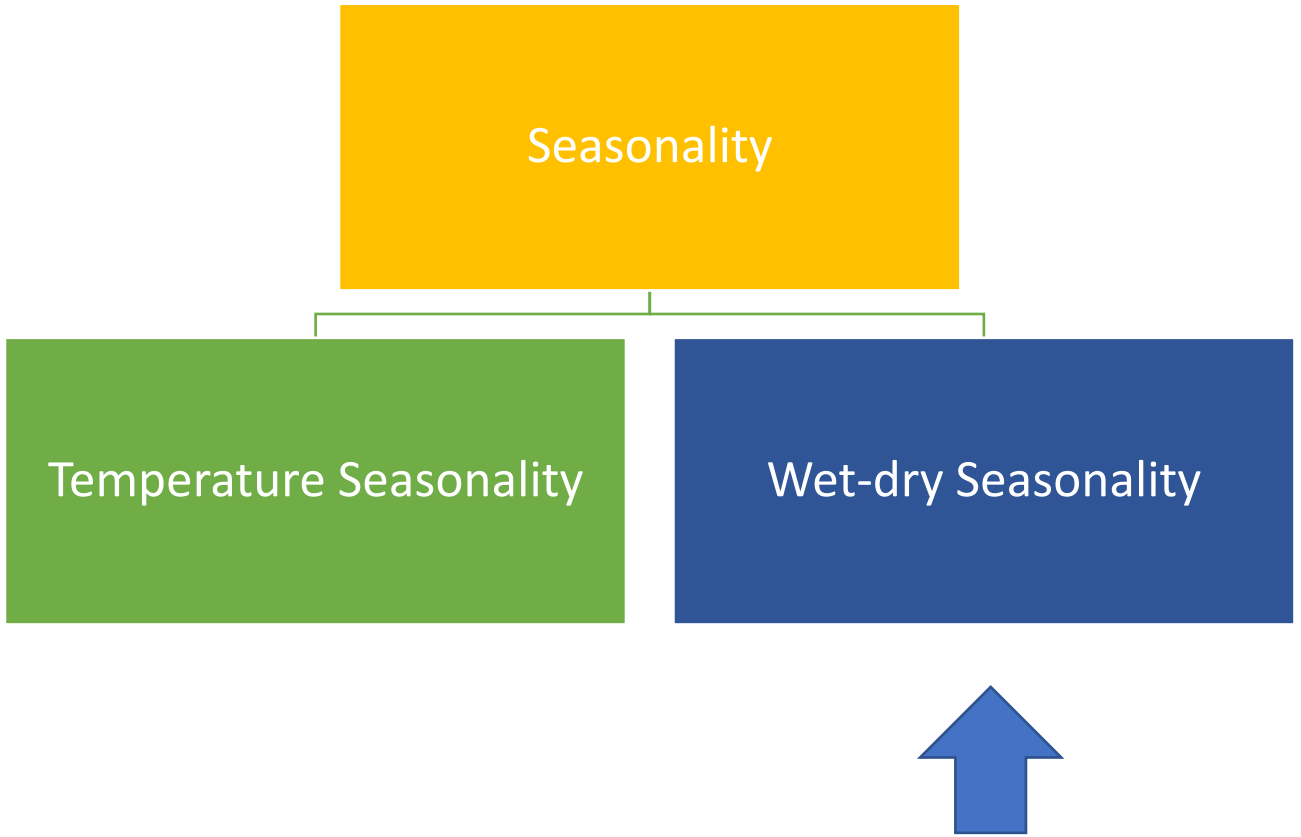
Drought Analysis



Seasonality

Seasonality is the predictable yearly cycle of an environmental variable such as temperature and rainfall and it influences several variables.





Changes in the Earth

Paleocene
(55 – 65 Mya)

- Warming of the earth.
- Drop in the sea level
- Forests spread
- Decline in CO_2 concentration from the Paleocene onwards led to the evolution of C4 photosynthesis

Eocene
(55 – 24 Mya)

- Opening of the Drake Passage led to changes in the ocean circulation and global cooling
- Decline in temperature
- Dying trend begins

Oligocene
(24 - 34 Mya)

- Plants adapted to cool and dry climates begin to diversify (herbaceous plants and grasses)

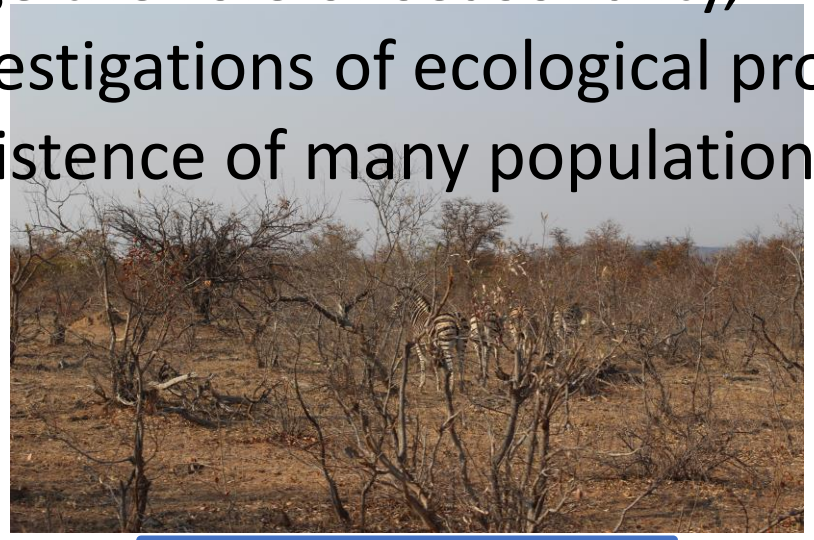
Miocene
(5 – 24 Mya)

- Formation of land bridges – movement of animals between continents
- Changes in the ocean circulation systems in the Southern hemisphere led to a decline in the temperature
- Mid-Miocene warming and cooling
- Expansion of open vegetation systems (grasslands, savannas and deserts). C4 dominated ecosystems spread during the Miocene.
- Increase in the genera of large herbivores

Seasonality as a driver of community change

- Although we acknowledge the role of seasonality, in many cases seasonal factors are ignored in investigations of ecological processes and systems. The persistence and the coexistence of many populations depends on seasonality.

Seasonality



Fire

Deciduous trees

Grassiness

Identifying traits associated with seasonality:

Credit: Joh Henschel

Credit: Nobukhosi Ndlovu

- **The purpose of this review is to identify traits that are important for organisms to survive in a wet-dry seasonal environment.**

- **Develop theory around life history strategies that are associated with wet-dry seasonality.**

Seasonality

High water requirements ⟷ **Low water requirements**

Avoidance

- Migration
- Change in habitat use
- Change in movement patterns
- Habitat Selection
- Annual
- Change in activity
- Seasonal Dormancy
- Avoid water loss

- Deciduousness
- Avoid water loss

Flexibility

- Diet flexibility/ Seasonal variation in diet
- Change in activity
- Habitat selection
- Risky Behaviour
- Reduce water losses

- Reduce water losses
- Deciduousness
- Timing of flowering

Tolerance

- Fat storage
- Form larger family groups
- Risky behaviour
- Increase dietary water intake
- Store water in the body
- Reduce physiological activity

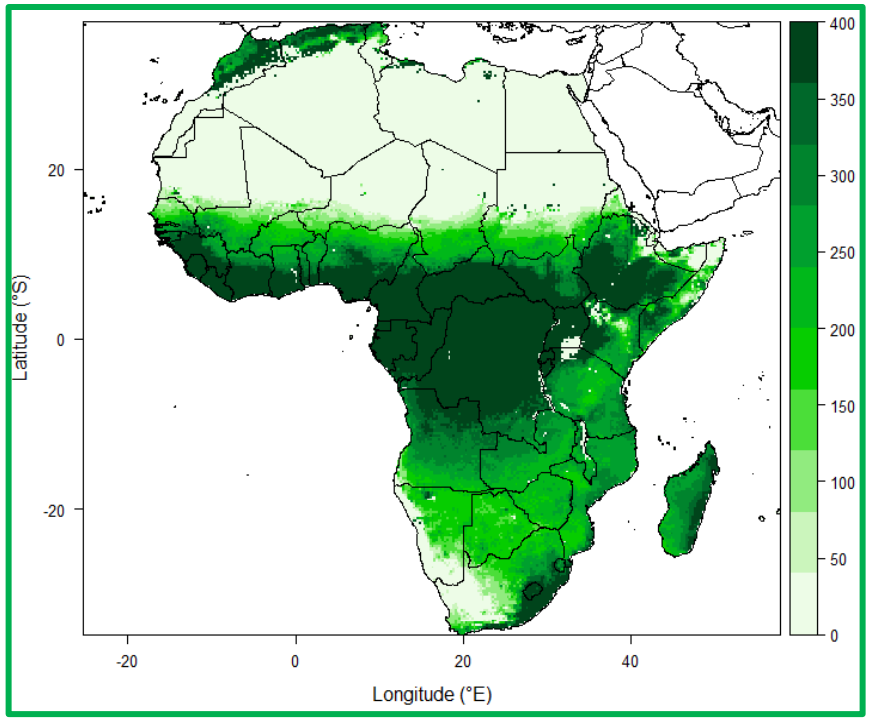
- Serotiny
- Below ground storage organs
- Two flowering seasons
- Deep roots
- Evergreen
- Sclerophyllous leaves
- Reduce physiological activity
- Succulence
- Stomatal limitation

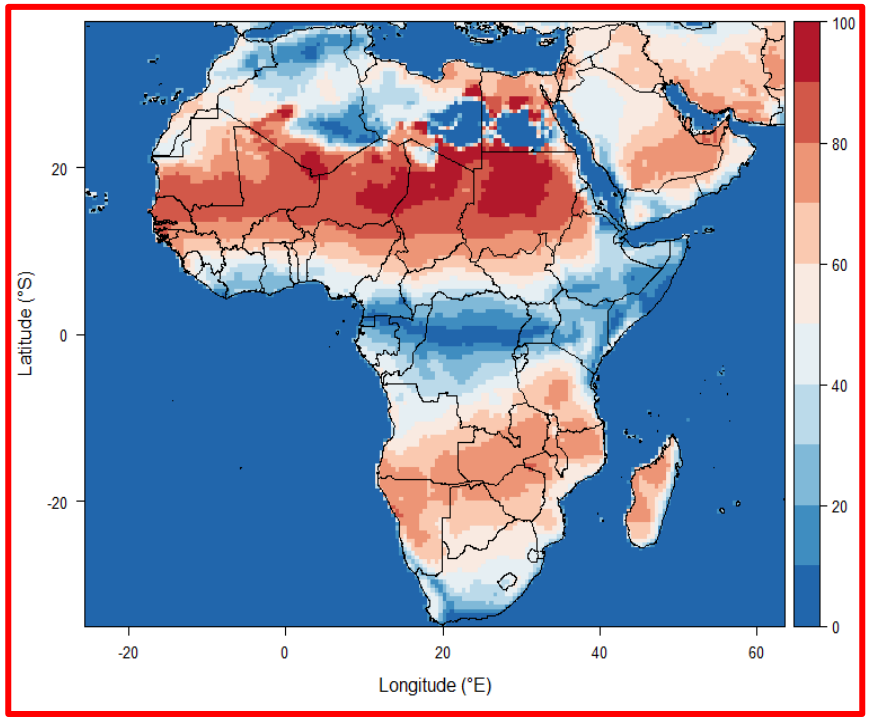
Measuring wet-dry seasonality

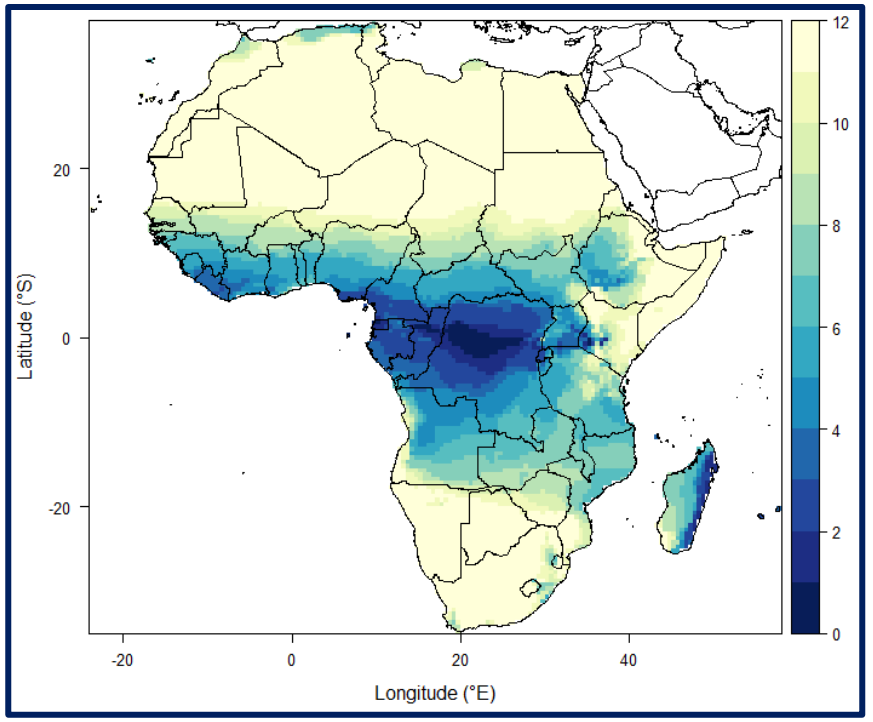
Number of Growth Days

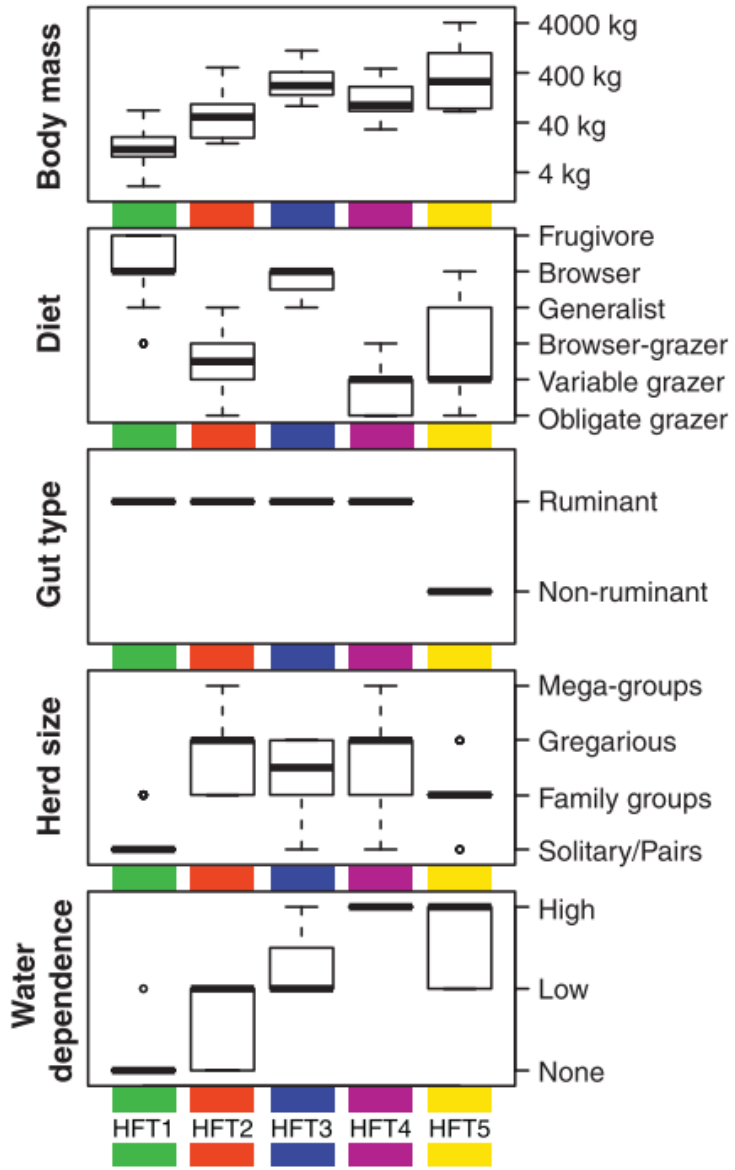
Rainfall Concentration

Length of the Dry Season









HERBIVORE FUNCTIONAL TYPE CLASSIFICATIONS

Small nonsocial browsers (SNSBr)

- 35 sp. incl. dik-diks, duikers and *Raphicerus* sp.
- Paragon: Common duiker *Sylvicapra grimmia*
- Distinctive: Blue duiker *Philantomba monticola*

Medium-sized social mixed diets (MSMix)

- 18 sp. incl. gazelles and oryx
- Paragon: Grant's gazelle *Nanger granti*
- Distinctive: Gemsbok *Oryx gazella*

Large browsers (LBr)

- 8 sp. incl. giraffe, okapi and most *Tragelaphus* sp.
- Paragon: Greater kudu *Tragelaphus strepsiceros*
- Distinctive: Giraffe *Giraffa camelopardalis*

Water-dependent grazers (WDGr)

- 17 sp. incl. *Hippotragus* sp. and *Kobus* sp.
- Paragon: Hartebeest *Alcelaphus buselaphus*
- Distinctive: Wildebeest *Connochaetes taurinus*

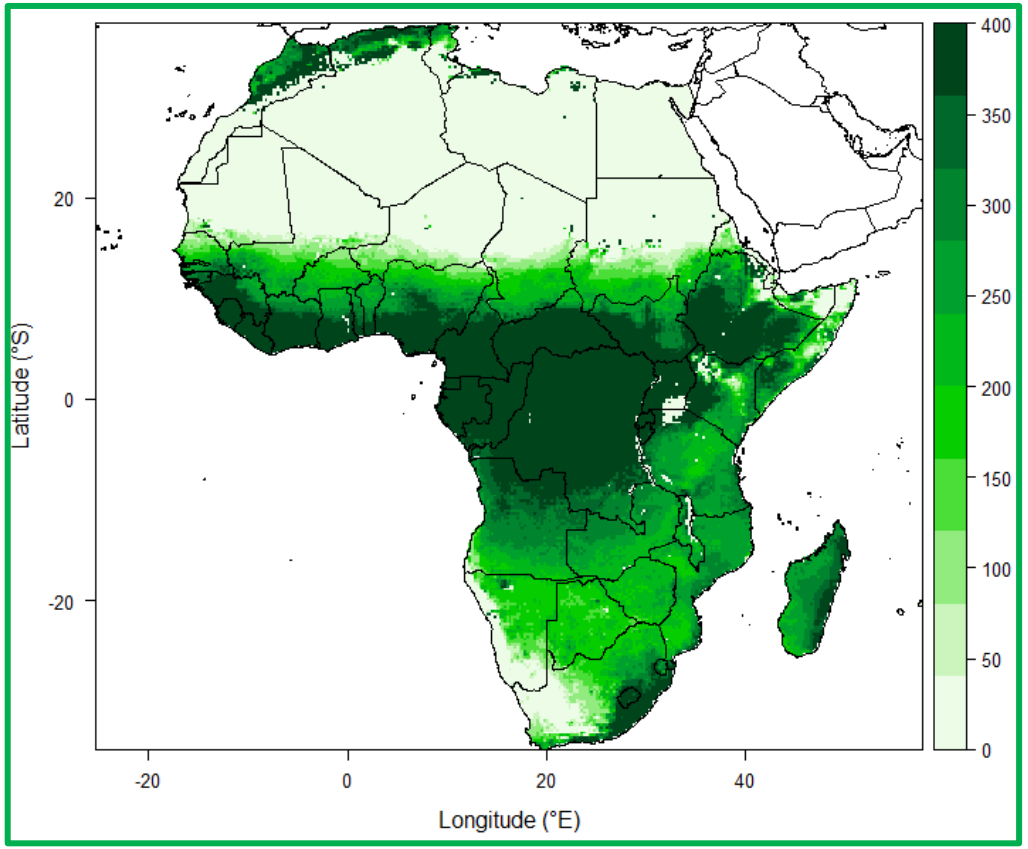
Nonruminants (NRum)

- 14 sp. incl. equids, hippos, rhinos and suids
- Paragon: Plains zebra *Equus quagga*
- Distinctive: African elephant *Loxodonta africana*

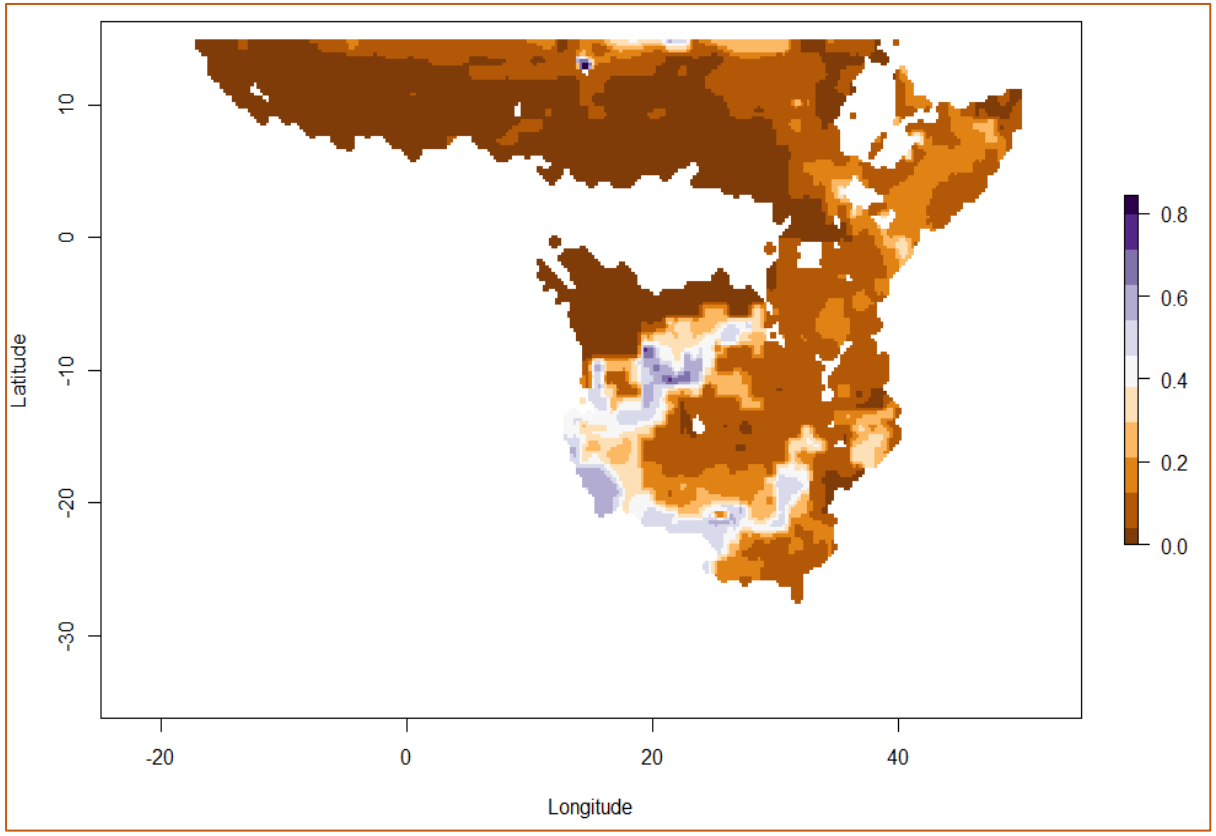
Hempson et al. 2015

Spatial associations between rainfall seasonality and herbivore diet

Growth Days



Mixed Feeder Proportion

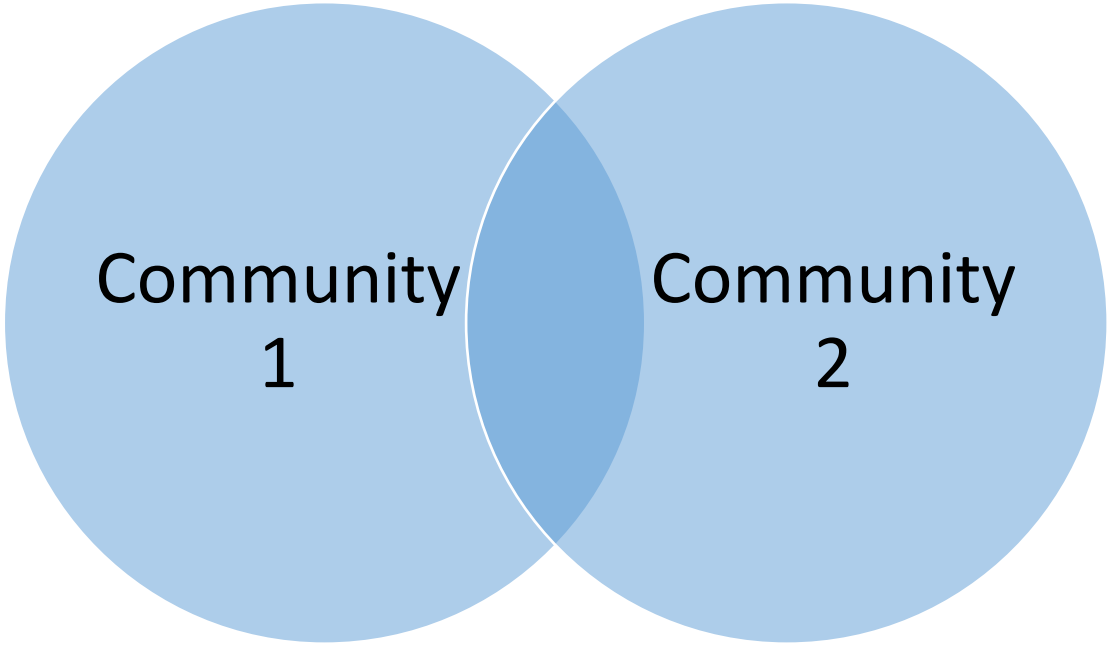


Beta Diversity

Beta diversity is “the extent of change in community composition, or degree of community differentiation, in relation to a complex-gradient of environment, or a pattern of environments” (Whittaker 1960)

Nestedness

Turnover



Whittaker, R. H. (1960) Vegetation of the Siskiyou Mountains, Oregon and California. Ecological Monographs, 30, 280-338.

Aim: To identify species which are characteristic of seasonal environments

- Which sites are in seasonal environments and what species are associated with those sites.
- Test whether there are unique species associated with seasonal environments.

HOME PEOPLE PUBLICATIONS DATA MANUALS

SEOSAW

A Socio-Ecological Observatory for Southern African Woodlands

Bitbucket

https://seosaw.github.io/

9863
Woodland plots

12
Countries

538942
Tree
measurements

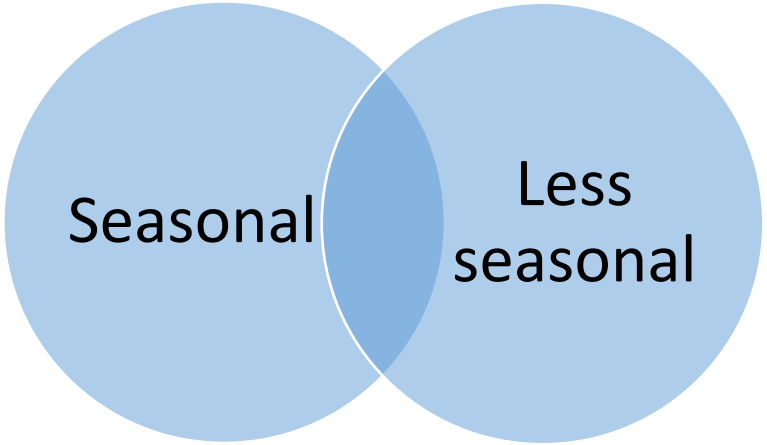
84
Researchers

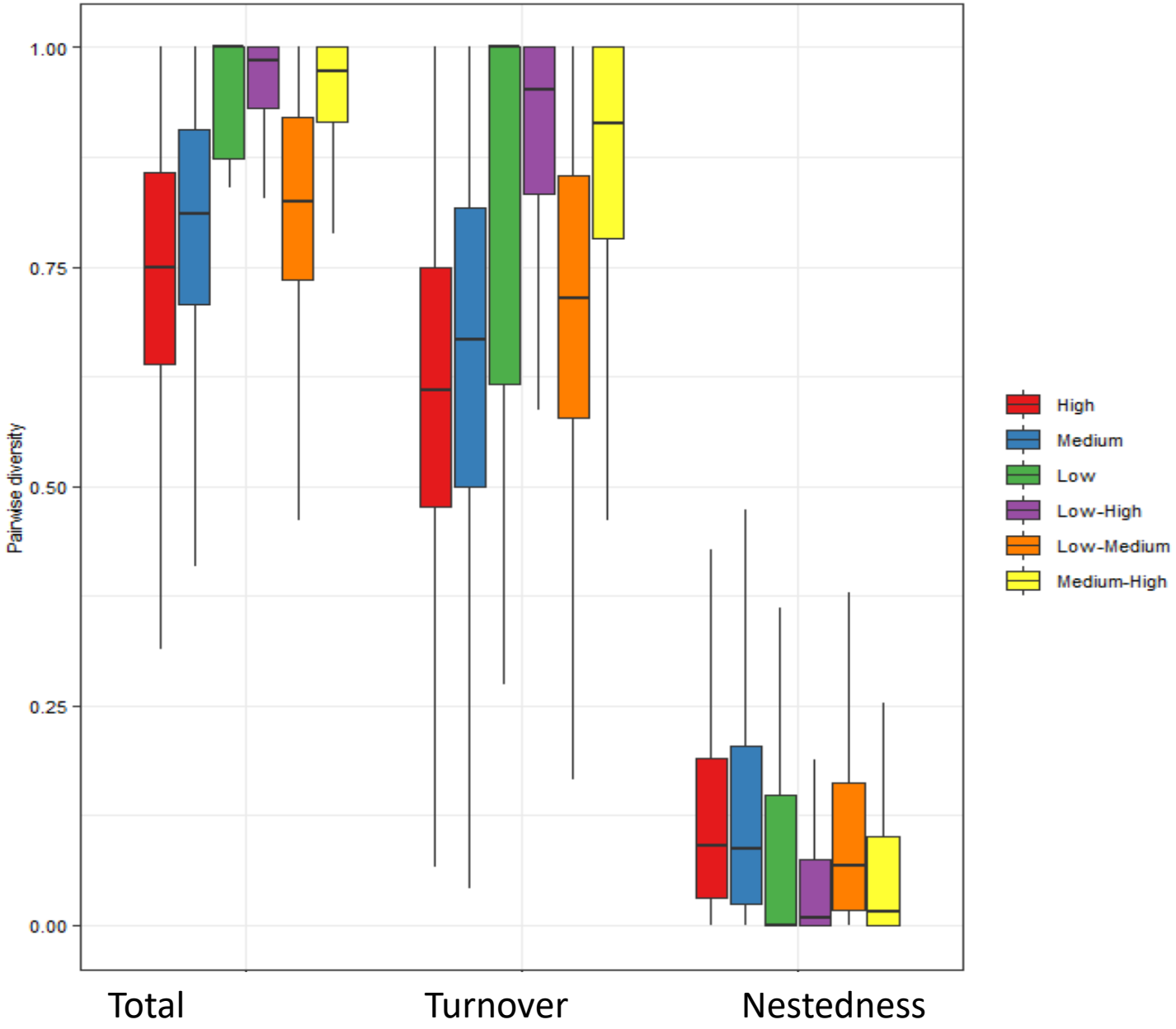
What is SEOSAW?

SEOSAW comprises a network of scientists and also a network of woodland survey plots in southern Africa. The long-term goal of SEOSAW is to understand the response of southern African woodlands to global change. Members of SEOSAW conduct diverse research which is unified by a shared interest in the ecology woodlands and savannas.

Pairwise Diversity

- Total Diversity = Turnover + Nestedness
- There is high biodiversity in areas with low seasonality. There is low diversity in areas with high seasonality.
- Influenced by turnover and not nestedness.





Summary

- Seasonality is important in African ecosystems as it controls the distribution and ecology of plant and animal species.
- Temperature has increased in the past 100 years and the rainfall has decreased during the same period. The droughts are also getting longer
- The high beta-diversity across gradients of seasonality in Southern Africa is influenced by turnover and not nestedness – i.e. there are species that are specifically adapted to this environment.
- Understanding ecosystem processes is the first step in being able to deal with climate change. That way we are able to better adapt to and mitigate climate change.

Comments and Questions Welcome

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Twitter: @Mtho_Moyo