SAF-ADAPT

South Africa / Flanders
Climate Adaptation
Research and Training
Partnership

RESEARCH BRIEF
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Determining local ecosystem-driver dynamics of turning points in arid South African savannas

Integrating remote sensing and field work to explore the ecological reality of Kruger National Park

Queenny Lopez

RESEARCH OVERVIEW

The savanna ecosystem, a mix of grasslands and woodlands, is crucial for its biodiversity and all the functions it performs both locally and globally. In Africa, it covers 50% of the land and due to historical geoclimatic processes, savannas exhibit a remarkable ecological and biological configuration. In South Africa, the savanna biome is the largest, covering 32.5% of the country's surface, thanks to the diverse environmental conditions such as rainfall, temperature, and geology, alongside its rich ecology and biodiversity. Savannas worldwide, including those in KNP, have been significantly affected by social, economic, and environmental processes, leading to alterations in ecosystem functions (e.g., productivity, nutrient cycles). Changes in these functions within savannas can occur suddenly and abruptly, either because the functions can no longer be carried out or because of disturbances that push the ecosystem into a different state of functioning which is not necessarily irreversible. These shifts in ecosystem functioning are known as turning points (TP).

A significant number of TPs have been identified in KNP in the framework of the described project. KNP is one of South Africa's largest and oldest national parks and part of the Maputaland-Pondoland-Albany Biodiversity Hotspot holding a unique flora and fauna, playing a vital role in conserving endangered species and promoting sustainable land use practices. The park's importance spans ecological, social, and economic levels, making the TPs a major threat. Understanding and addressing these TPs is essential for effective management and conservation efforts in KNP, ensuring the protection of vital ecosystems and the benefits they provide both locally and globally.

This study seeks to answer the following questions: What local anthropogenic and natural drivers of TPs are present in the Kruger's savanna? How do different parts of the Kruger's savanna respond to these drivers? How does this link back to their underlying ecosystem characteristics?

PROJECT SUMMARY

This study investigates the local anthropogenic and natural drivers of tipping points (TPs) in the Kruger National Park's savanna, their responses in different regions, and the links to underlying ecosystem characteristics. Using 15 variables, three predictive models with cross-validation were generated, achieving high accuracy, to understand the complex interactions influencing TPs.

KEY FINDINGS

- Mean Annual Precipitation (MAP) and Land Surface Temperature (LST) **are critical climatic factors, and biodiversity significantly impacts TP occurrence**, with TP sites showing greater heterogeneity (Beta diversity) and lower species evenness (Alpha diversity).

- Calcic Luvisol (LVk) and Eutric Leptosols (LPe) soils are **more prone to TPs due to their water retention properties**. TPs are more likely to occur at higher elevations and farther from roads.

- The Lowveld bioregion is vulnerable to woody encroachment, while the Mopane bioregion is susceptible to woody cover loss. Logistic Regression (LR) models effectively predict TP occurrence, **handling both categorical and continuous variables efficiently**, and providing valuable insights for conservation and management strategies.

METHODOLOGY

IDENTIFICATION	PRIORITIZATION	MODELLING	MAPPING
15 internal and external variables	Dimensionality reduction	Predictive models of TPs occurrence	Susceptibility maps for TP occurence
Field campaign + satellite data + official data	Sequential feature selection, PCA	Logistic Regression, Random Forest & Gradient Boosted Regression	Prediction of TPs occurrence in the research area

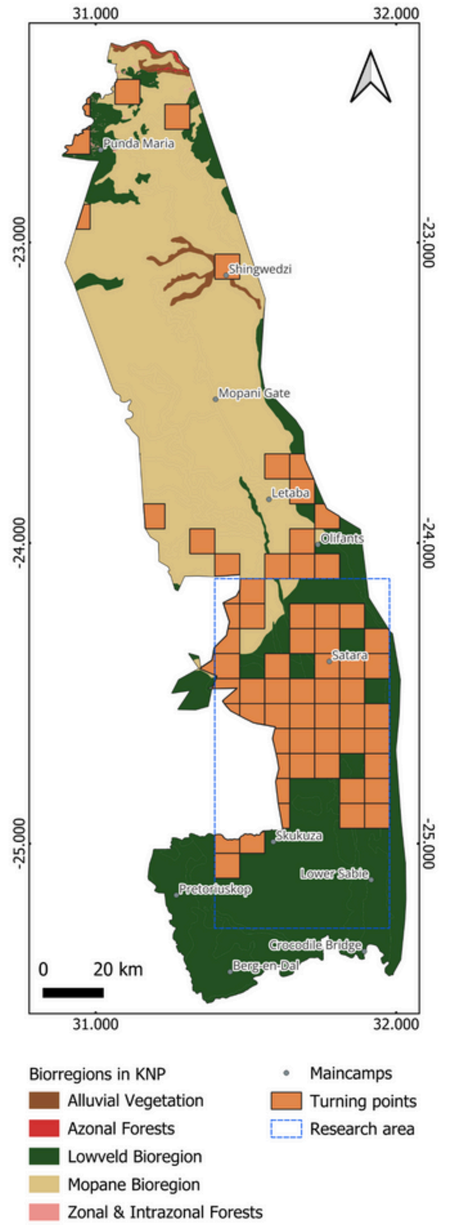


Figure 1. Bioregions and turning points in Kruger National Park

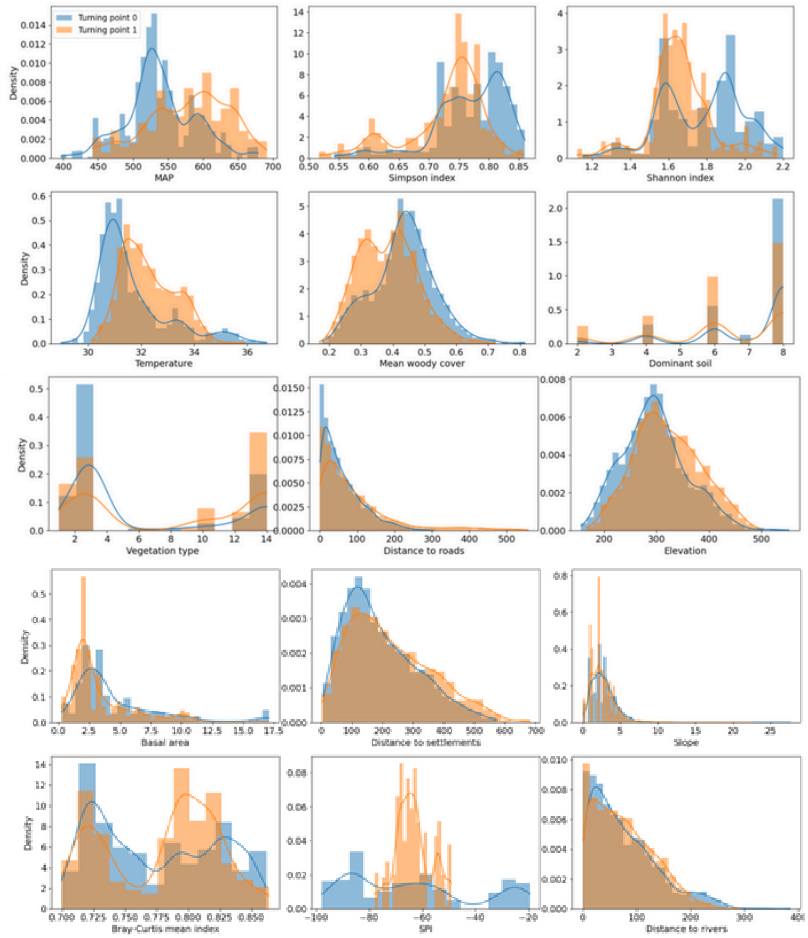
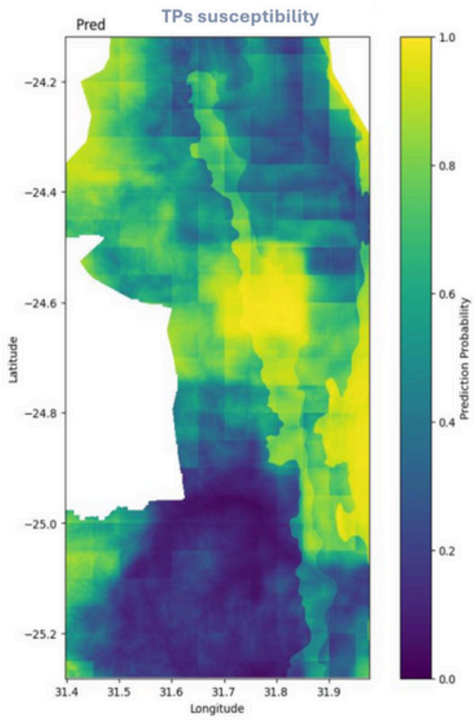


Figure 2. Occurrence of TP against evaluated variables

KEY FINDINGS

A total of 7 of the 15 variables analyzed were prioritized, with which 3 predictive models were generated with cross-validation, giving an accuracy greater than 0.86 for all cases.

- The most important climatic variables were **MAP** and **LST,** while **Biodiversity** is a very significant factor in the occurrence of TPs.
- TP sites show greater heterogeneity expressed as Beta diversity, than the rest of the landscape with a lower number of species and evenness (Alpha diversity). Possible loss of large trees in TP sites.
- Calcic Luvisol (LVk) and Eutric Leptosols (LPe) soil types are more susceptible to TPs due to their characteristics regarding water retention.
- TPs occur at higher elevations and distances from roads.
- The Lowveld bioregion is more susceptible to woody encroachment while the Mopane bioregion is more susceptible to loss of woody cover.
- Logistic Regression (LR) model handles both categorical and continuous variables efficiently. Its advantages include speed, reproducibility, and suitability for large datasets, generating probabilistic outputs for nuanced TP susceptibility evaluation. The geographical accuracy of LR predictions was notable, with maps depicting the distribution of TPs and their relationship with factors like rivers, soil, and vegetation types.



- TPs result from complex, synergistic interactions of multiple ecological and biophysical processes rather than isolated events.

Combining information from various sources and tools, such as fieldwork, remote sensing techniques, and official national data, allows for a robust and holistic analysis that integrates climatic, ecological, and anthropogenic variables. Future research should consider factors like herbivore activity, CO2 increase, fire, and hydrological systems and features, as these elements play a crucial role in shaping Kruger National Park's (KNP) savanna and were not included in this study. The results suggest that tipping points (TPs) in KNP are not unidirectional but depend on multiple internal and external factors. Statistical tests revealed that some variables synergistically influence TP occurrence, highlighting the complexity of the ecosystem. Logistic regression has been identified as a useful predictive model for TP occurrence, capable of managing both categorical and continuous variables effectively. Understanding these interactions is essential for developing targeted conservation and management strategies to prevent irreversible ecosystem changes. Such comprehensive strategies are vital to maintaining the ecological balance and ensuring the long-term sustainability of KNP's diverse habitats and species.

RECOMMENDATIONS

1. **Water conservation and drought management are crucial in the Lowveld bioregion** to mitigate climate change effects. Improving water infrastructure, such as reservoirs, can ensure water availability during extreme droughts.
2. Effective techniques like **controlled burning and herbivore management have shown positive results** in Kruger National Park (KNP). Strategies to protect large trees from elephant damage should be maintained.
3. While roads and settlements were not significant for tipping point (TP) occurrence, they **may contribute to other impacts**, such as the spread of invasive species, and should be controlled.
4. KNP's ongoing management plan, valid until 2028, can **optimise conservation resource allocation by focusing on high-risk areas for ecological transitions**. Remote sensing techniques for continuous monitoring of critical variables, such as temperature, precipitation, and vegetation cover, should be integrated as proactive management tools.

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Corresponding author: Queenny Lopez (queennylop@gmail.com) or **READ THE FULL THESIS HERE**

SPECIAL THANKS TO: