Climate-induced change of environmentally defined floristic domains

A conservation based vulnerability framework

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EFETAC

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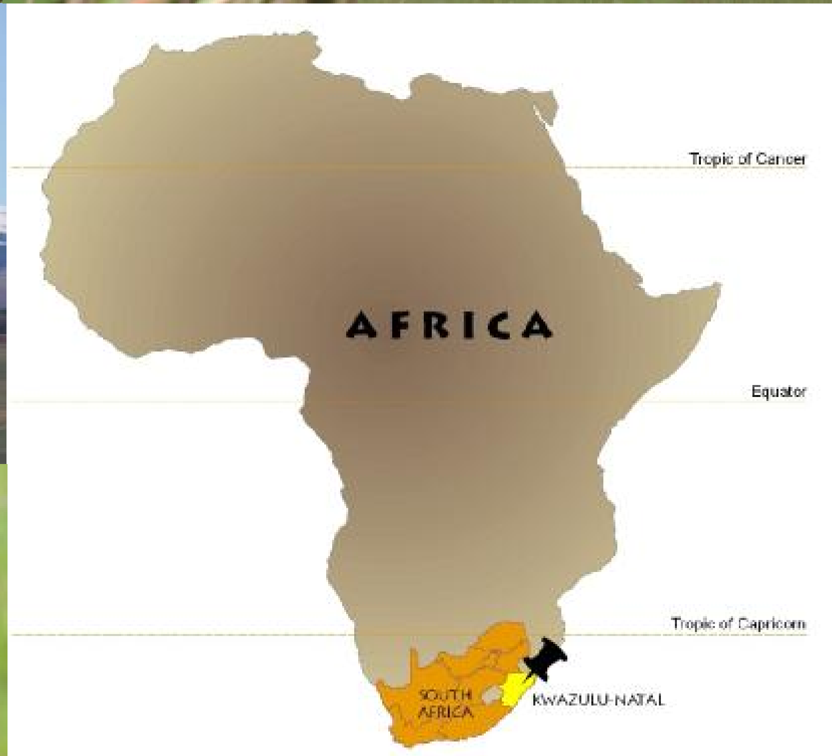
Ezemvelo KZN Wildlife

NRF National Research Foundation

SAEON South African Environmental Observation Network







Tropic of Cancer
AFRICA
Equator
Tropic of Capricorn
SOUTH AFRICA
KWAZULU-NATAL





Climate change impacts on plants

- Climate change is expected to become one of the greatest drivers of biodiversity loss in the next century.
  - altered species distributions
  - ecosystem composition

- But how to model all species occurring in a biodiversity hotspot?

↓

- Model environmental domains correlated to floristic composition
  (identify the metaphorical environmental stage with the species as actors)

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Environmental domains

The steps involved:

- Identify the specific environmental correlates of plant communities.
- Use these to define the environmental domains of these communities, using *k*-means clustering.
- The environmental domains can then be modelled under future climate scenarios to understand how the domains may change and hence how communities are likely to respond.

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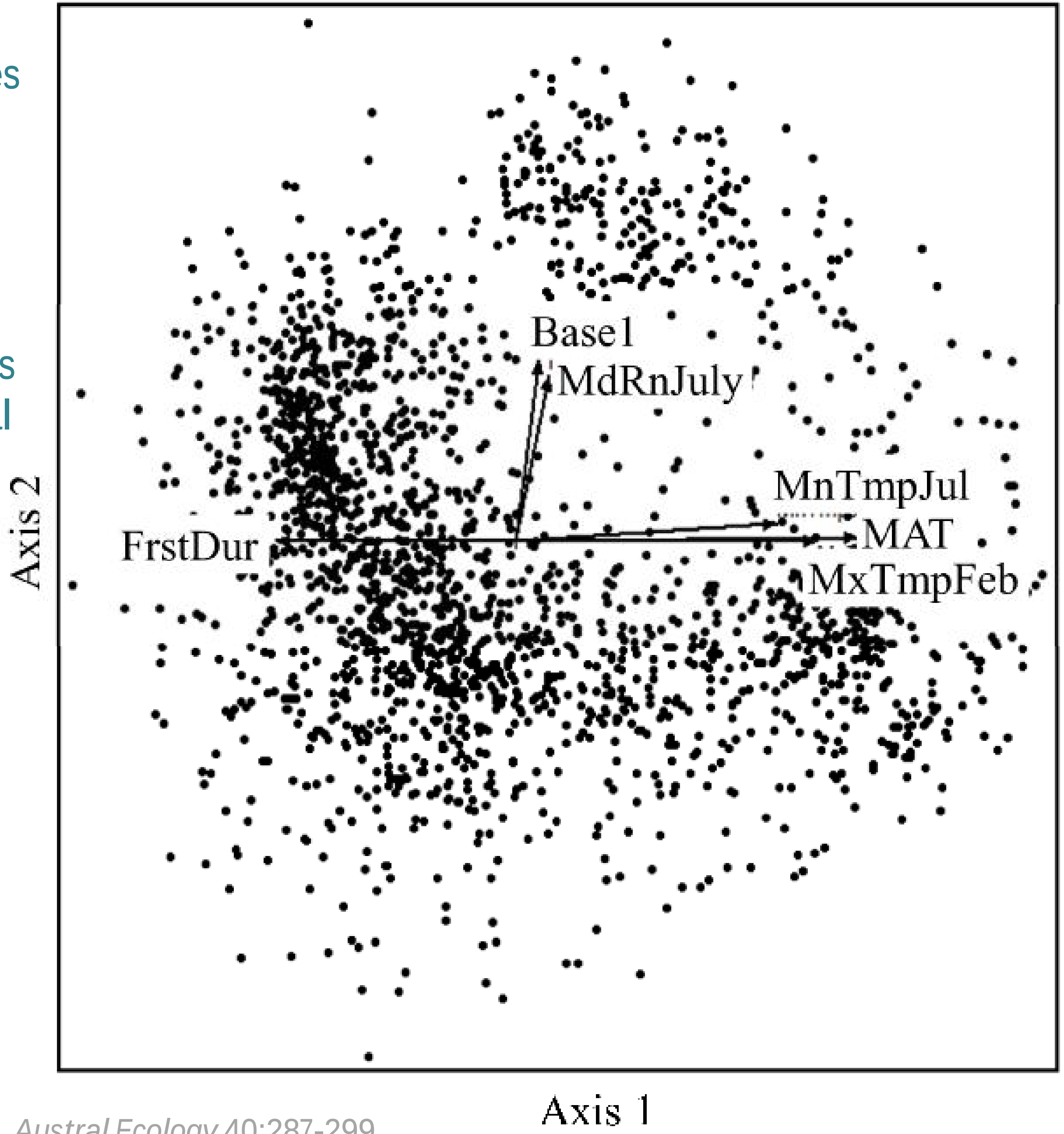
2155 plots
1643 species

23 communities (Hierarchical cluster analysis)



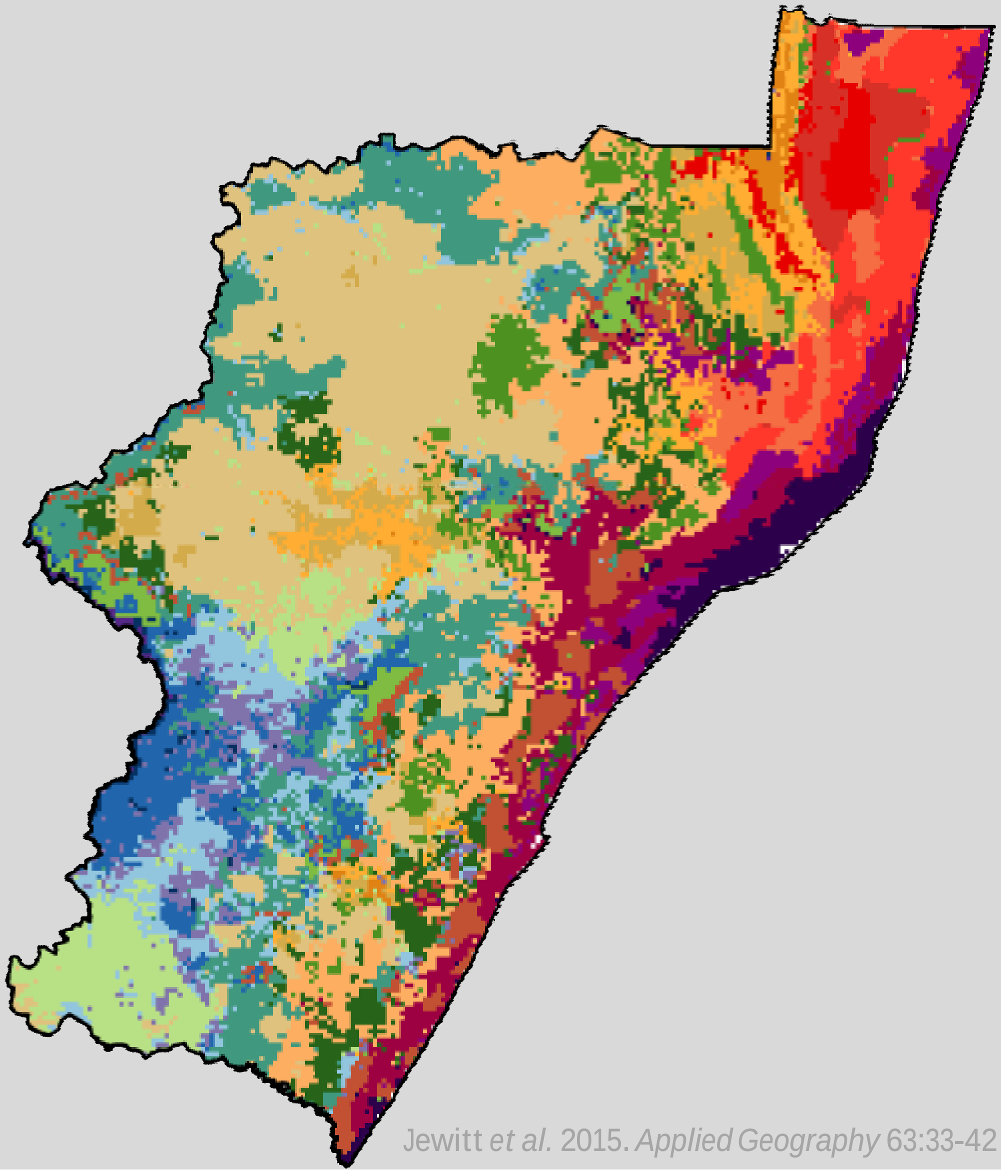
Significant variables:

- Temperature ($R^2 = 0.72$)
- Precipitation
- Soil base status

Jewitt *et al.* 2015. *Austral Ecology* 40:287-299

Environmental Domains

- Iterative *k*-means clustering algorithm.
- The positions in environmental space are mapped back into geographic space.



Legend

Domain number, CEC (cmol.kg^{-1}), MAP (mm), MAT (°C)

1 low <20, dry <800, warm <21
2 high >=50, moist <1500, cold <13
3 low-med <30, average <1000, cool <17
4 low <20, dry <700, warm <20
5 low <20, moist <1400, cool <18
6 very low <10, dry <700, hot <24
7 low <20, dry <800, hot <24
8 med-high <50, moist <1300, cold <14
9 low <20, average <900, warm <20
10 low <20, dry <600, hot <24
11 very low <10, average <900, hot <24
12 low-med <30, average <1100, cool <16
13 low <20, average <1000, hot <23
14 low-med <30, dry <800, cool <17
15 low <20, moist <1200, hot <23
16 low-med <30, average <900, cool <17
17 low <20, average <1000, cool <17
18 very low <10, dry <700, warm <21
19 medium <40, dry <700, hot <23
20 very low <10, average <1000, hot <22
21 low <20, dry <800, cool <18
22 very low <10, average <900, warm <20
23 low <20, average <1000, warm <19

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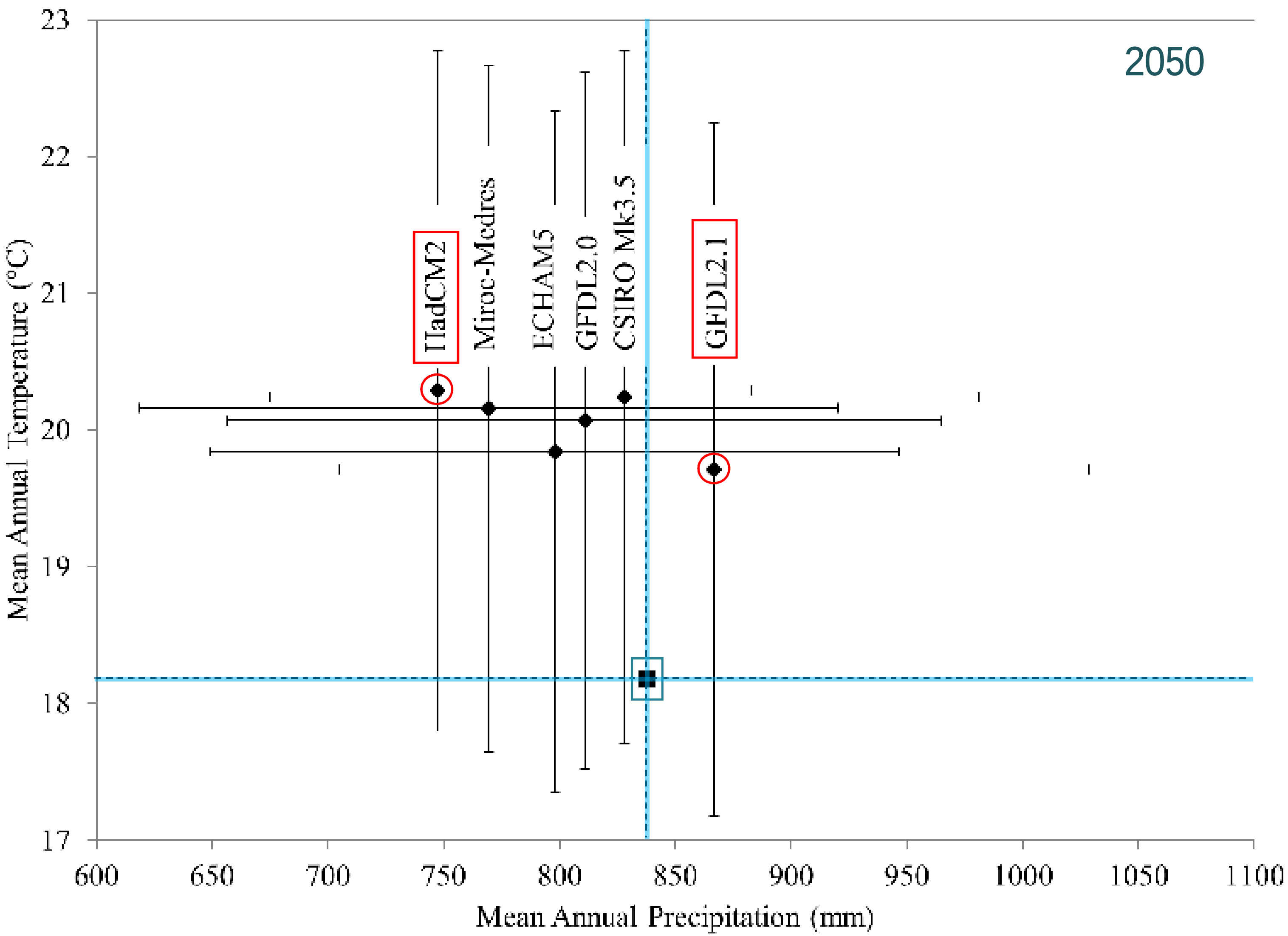
Climate scenarios



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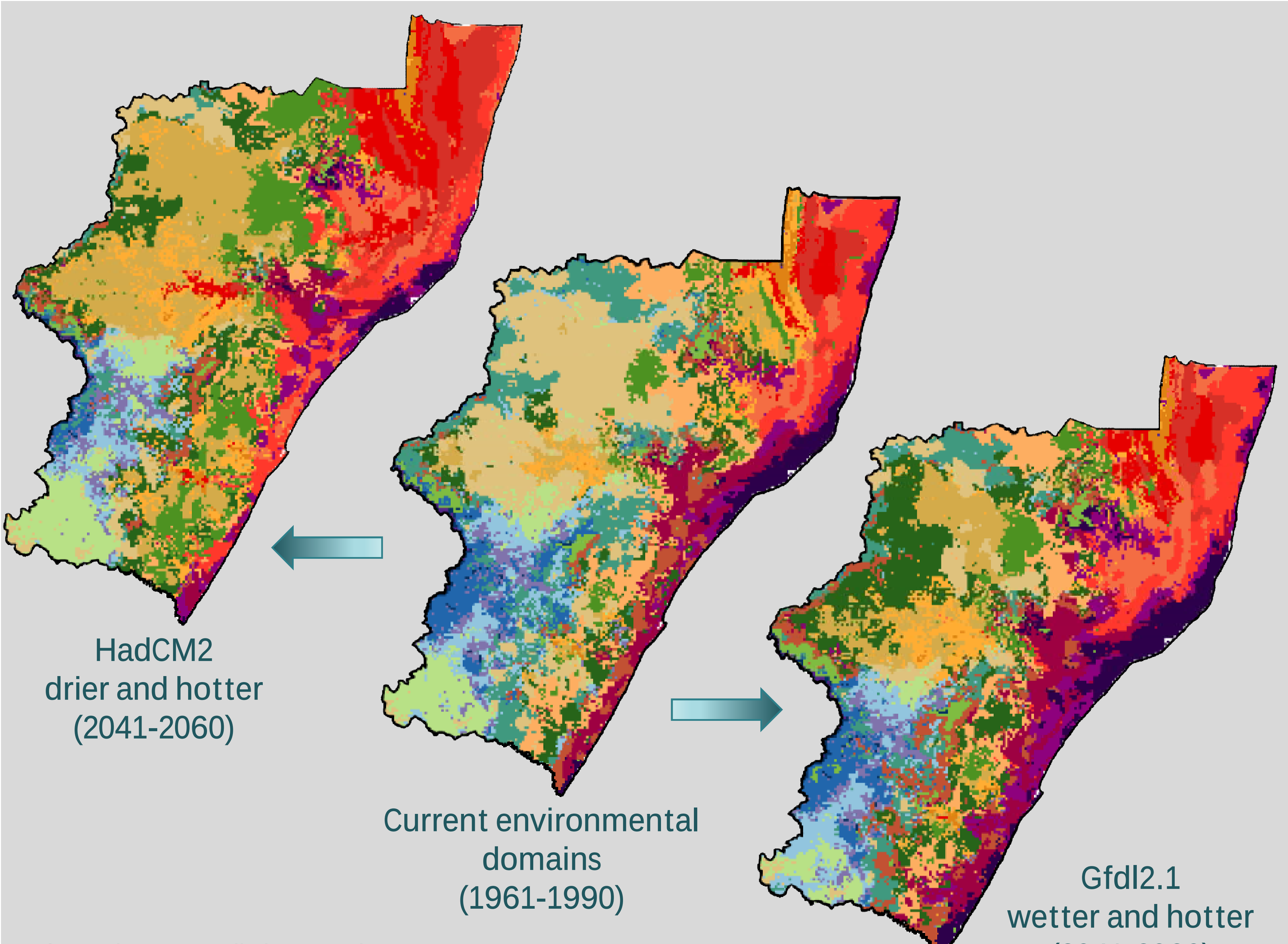

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Magnitude of change

- Since the domain centroids are located in environmental space, Euclidean distances can be used to calculate the magnitude of change associated with a grid cell changing from a current environmental domain type to a different future environmental domain.

- The Euclidean distances between current and future domain centroids were used to generate a dissimilarity matrix which was used to generate a magnitude of change map for each future projection.

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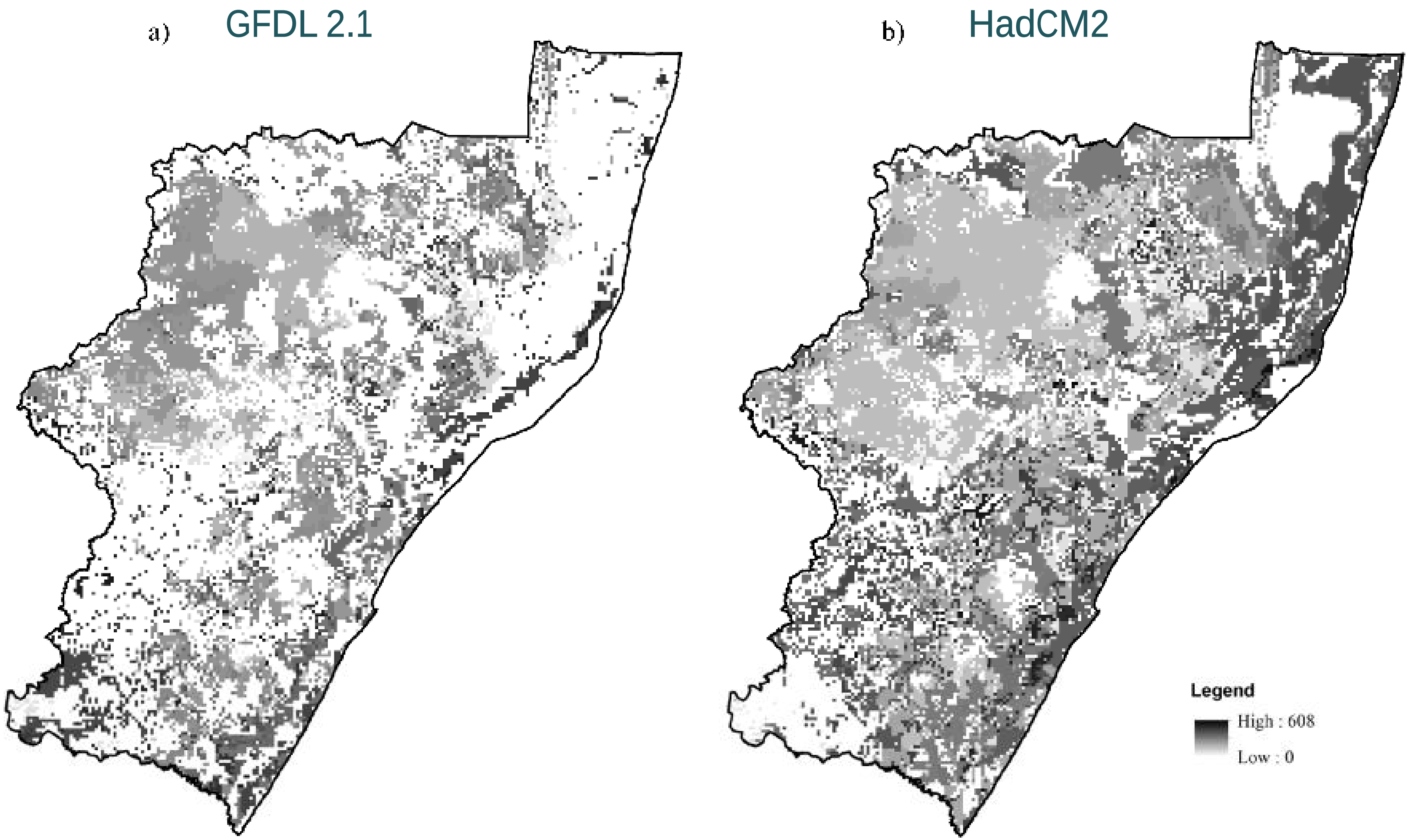
Magnitude of change maps



White areas indicate more stable areas (potential macro-refugia), whereas darker areas indicate a greater magnitude of change (potential novel communities).

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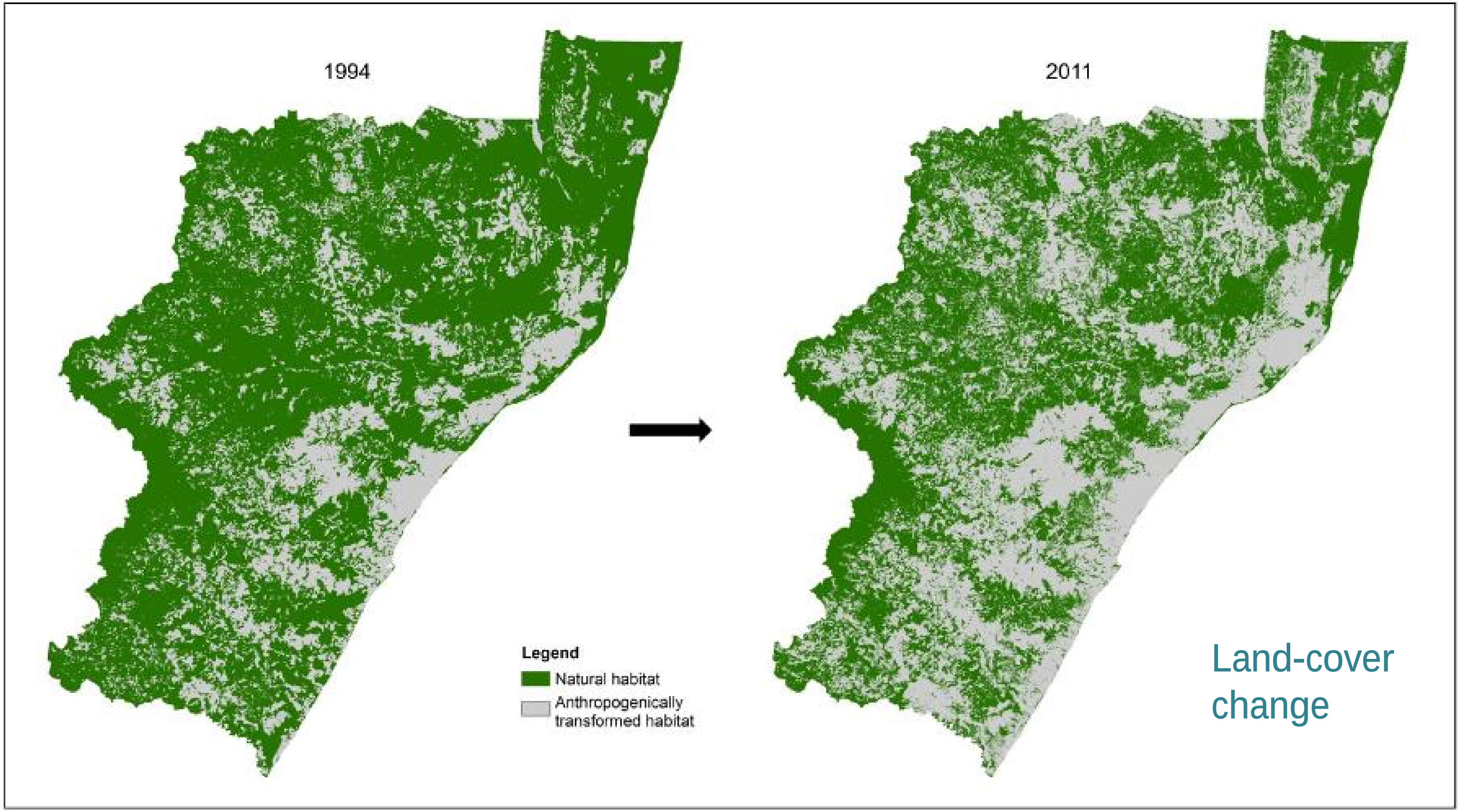
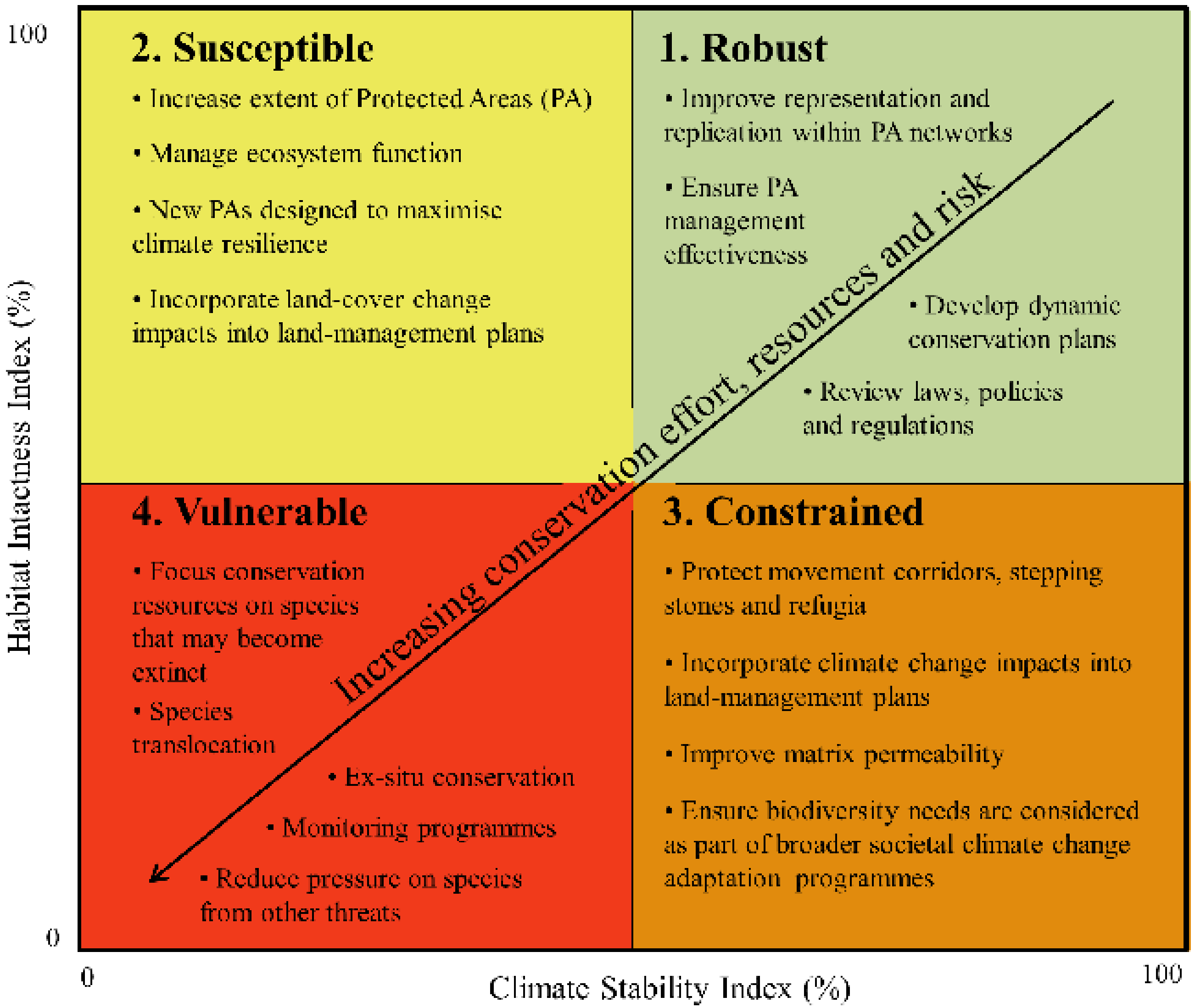


The ability of species to track changing environmental domains will be hampered by habitat loss and land-cover change, which are recognised as major drivers of biodiversity loss.

Jewitt et al. 2015. *South African Journal of Science* 111(9/10)

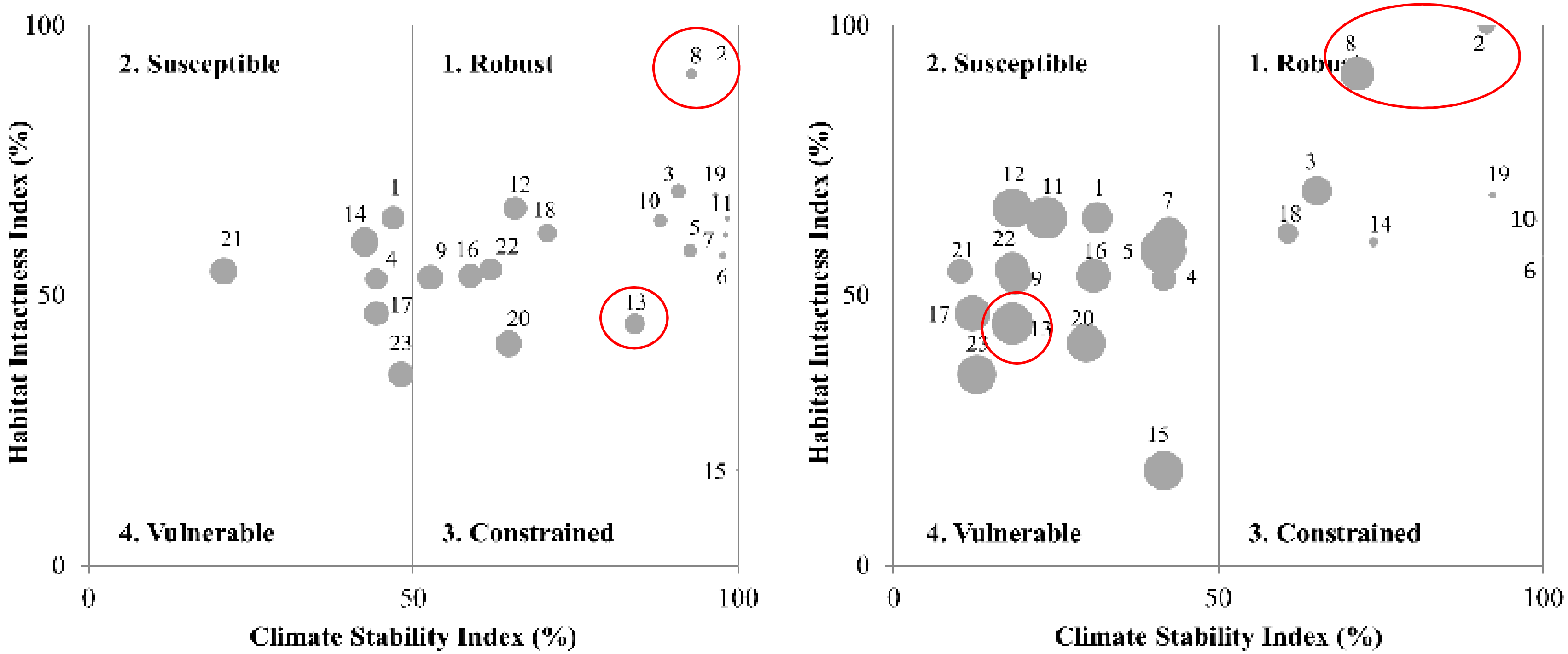
The vulnerability framework



By considering the degree of habitat loss as well as climate stability the vulnerability of environmental domains can be determined.

The applied vulnerability framework

a) GFDL 2.1 b) HadCM2



The Climate Stability Index reflects the percentage of the domains that remain stable in the future. The Habitat Intactness Index identifies the current levels of natural habitat remaining. The size of the circles indicates the relative mean magnitude of change expected in each domain.

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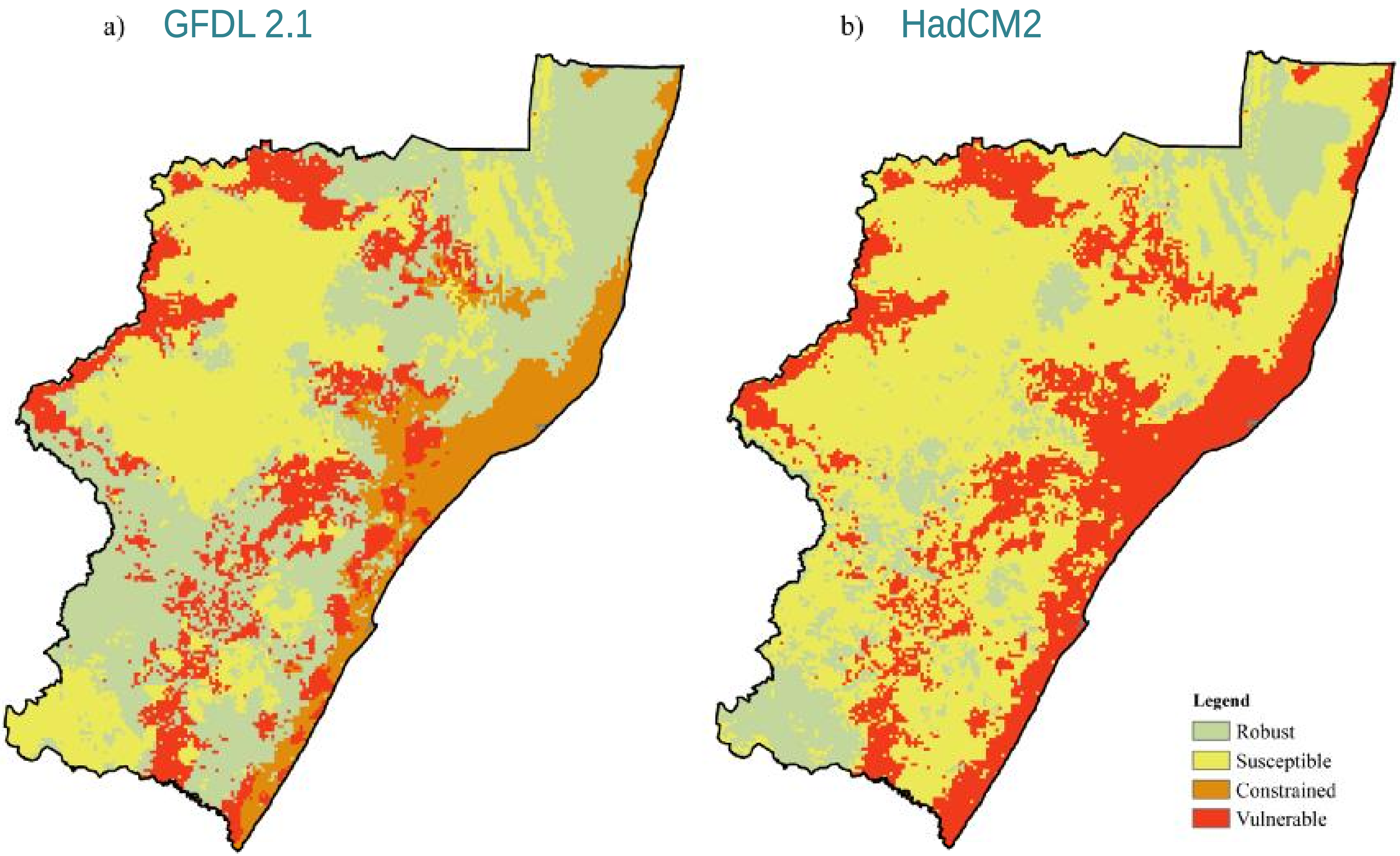
The environmental domains ranked according to the vulnerability framework for:



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Summary

- Our study gives an indication of the **nature and extent of climate impacts** in KZN using environmental domains.
- The study **explicitly links floristic pattern and climate variability** and provides useful insights to facilitate conservation planning for a changing climate.
- The spatial distribution of the environmental domains shows where species with **good dispersal ability** would be able to disperse to in the **increasing domains**, assuming no barriers to species movements.
- Species restricted to **diminishing domains may become stranded** and would require a targeted conservation effort.

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Summary

- The models predicted conditions suiting **savanna species would increase at the expense of current grassland areas**.
- The identification of broad-scale stable areas may **guide the location of future protected areas** which would limit climate change impacts on biodiversity.
- The **vulnerability framework** informs appropriate **conservation actions**.

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Thank you!

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