Monitoring dimensions of biodiversity in a mega-diverse region of Southern Africa: from traits to communities to ecosystems

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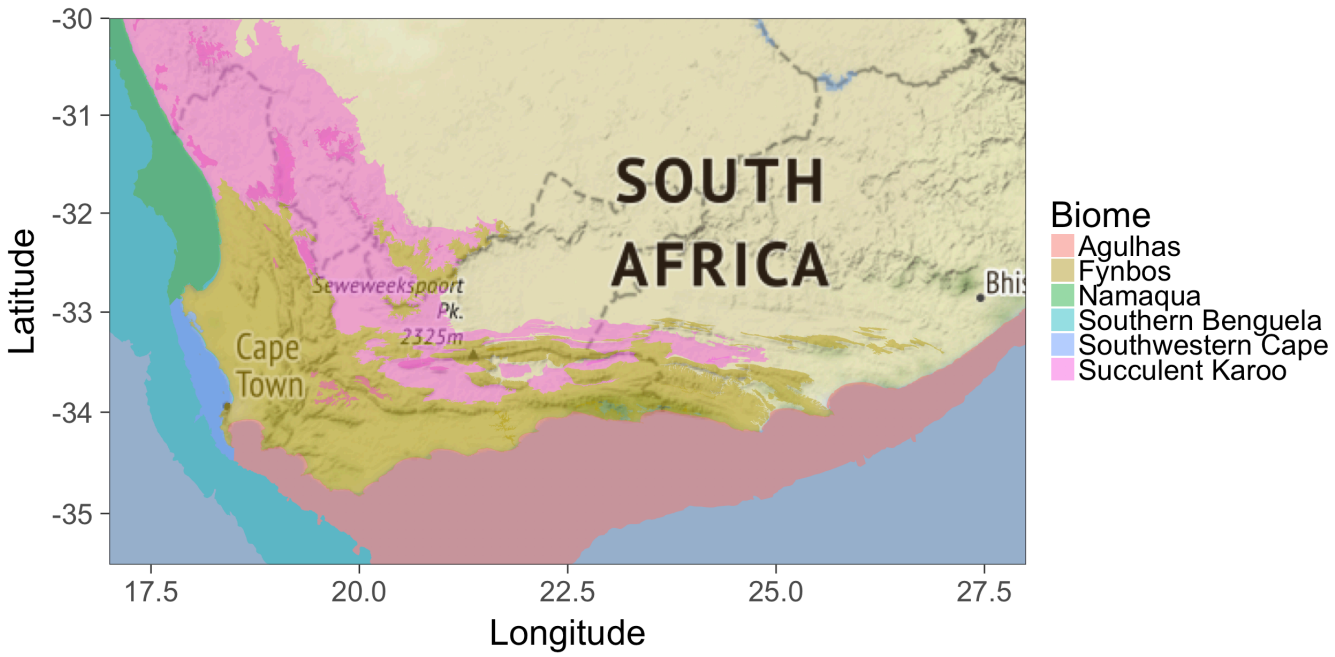
Global biodiversity hotspots

Meyers, et al (2000) *Nature*

Greater Cape Floristic Region of South Africa



≈90,000km^2

Outstanding Biodiversity

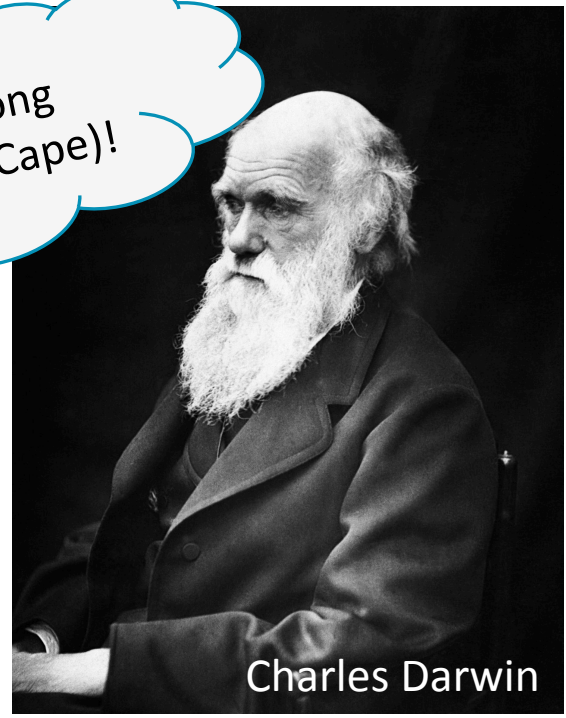
- ~1% Africa's area
- ≈9,000 vascular plants (~20% Africa's)
- 65% endemic

Socio-ecological complexity

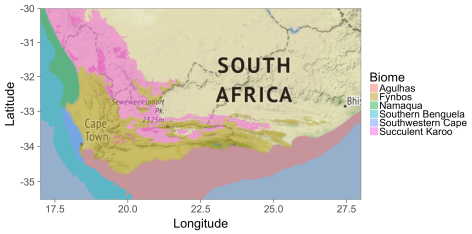
- Climate ↗
- Urban Migration

From Darwin's Notebook (June 1836)

"….but I saw so very little worth seeing, that I have scarcely anything to say…. the monotonous uniformity of the sandstone hills. I never saw a much less interesting country."



GCFR Rich *in situ* biological datasets



Vegetation Survey Plots (46,000 plots with plant community composition and abundance)

PRECIS Plants of Southern Africa (2 million records)

Acocks' vegetation community composition (3,098 plot records)

Global Biodiversity Information Facility (14+ million species occurrence records in region)

Odonata Atlas of Southern Africa (19,000 South African records of 81 South African species)

Atlas of Dung Beetles in Southern Africa Dung beetles (24,421 records, 421 species)

Atlas of African Orchids (1986 records, 238 species)

Southern African Bird Atlas Project (14,605 records, 932 species)

***Protea* Atlas Project** (252,513 records, 350 species)

Jellyfish Database Initiative (JeDI) (8,885 records)

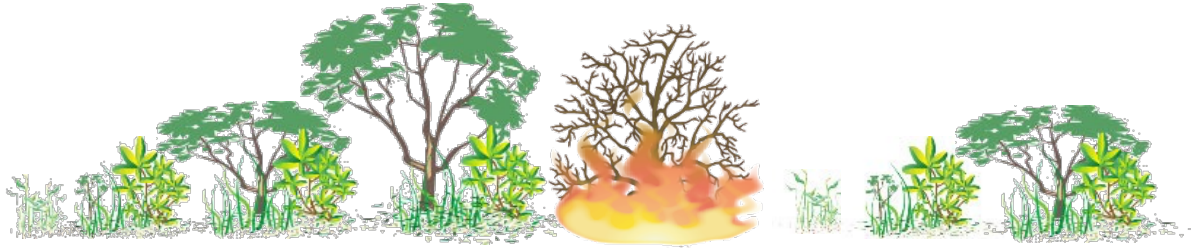
Just a sample

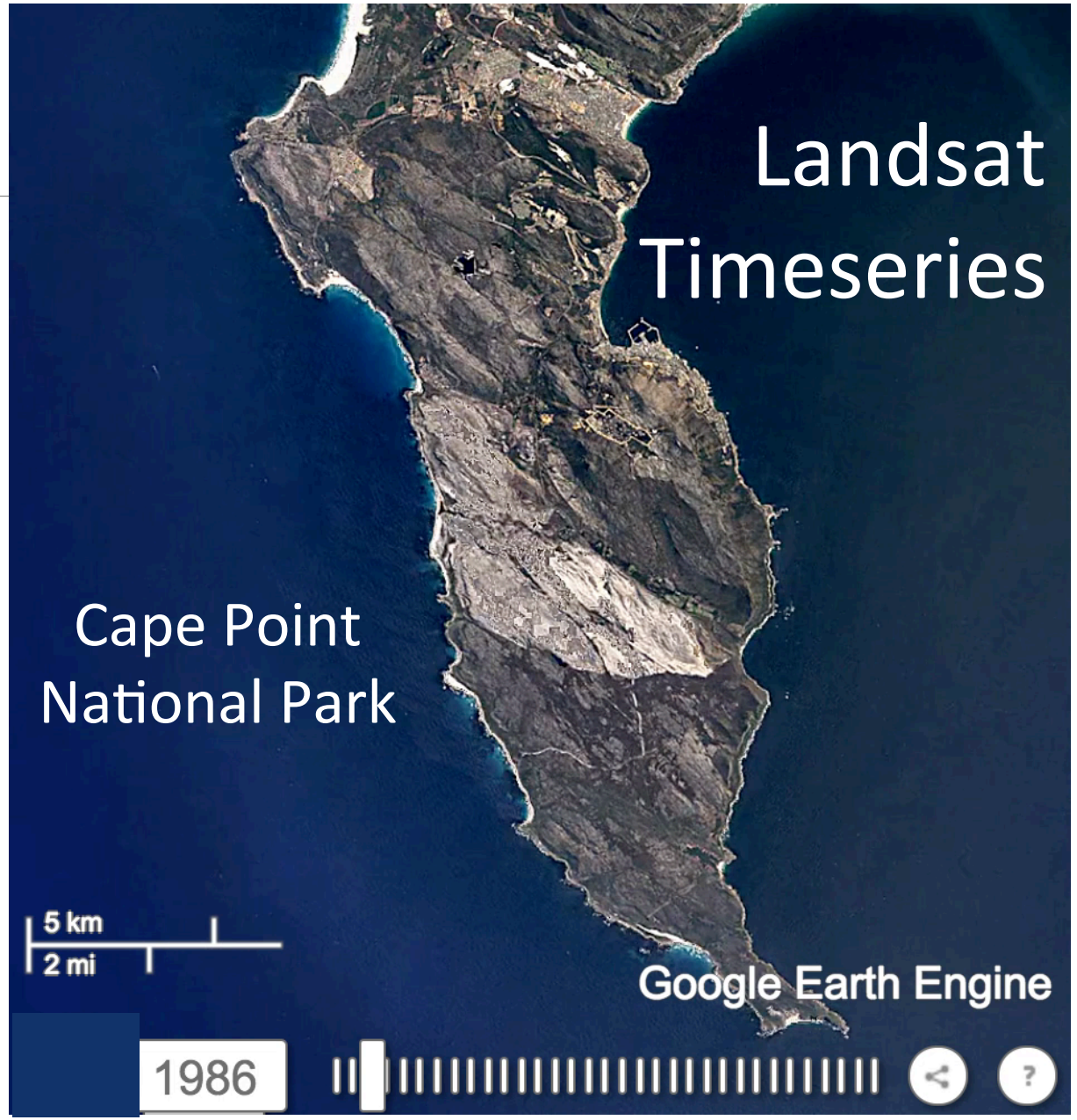
African Node for the Ocean Biogeographic Information System (AfroBIOS) (3,563,562 records total)

Dynamic landscape

Fire frequency increasing
due in part to changing climate

Decade	Mean Fire Return
1970s	31.6 years
2000s	13.5 years

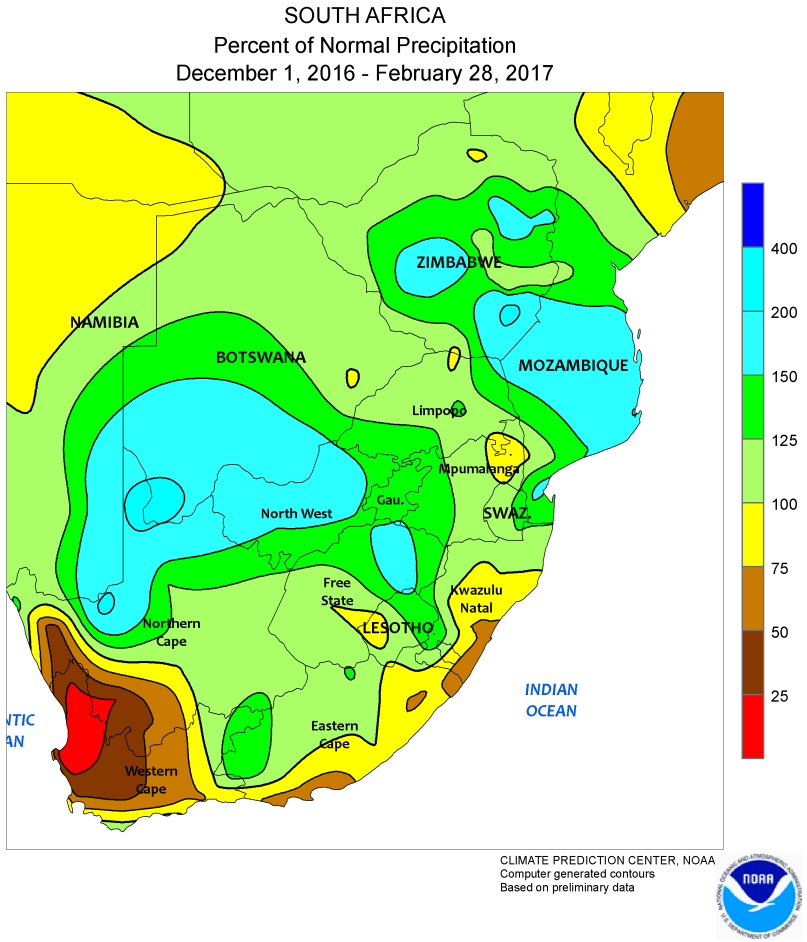




Wilson, et. al, *IJGIS* (2011) Wilson, et. al. *Ecological Modelling* (2010) Forsyth and van Wilgen, *Koedoe* 50(1) 2008

Freshwater Availability

Worst water shortage in 113 Years



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South Africa's Western Cape declares drought disaster

22 May 2017 | Africa

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Le Maitre, et. al (2016)

Biodiversity Field Campaign

Platform: NASA's ER-2 aircraft

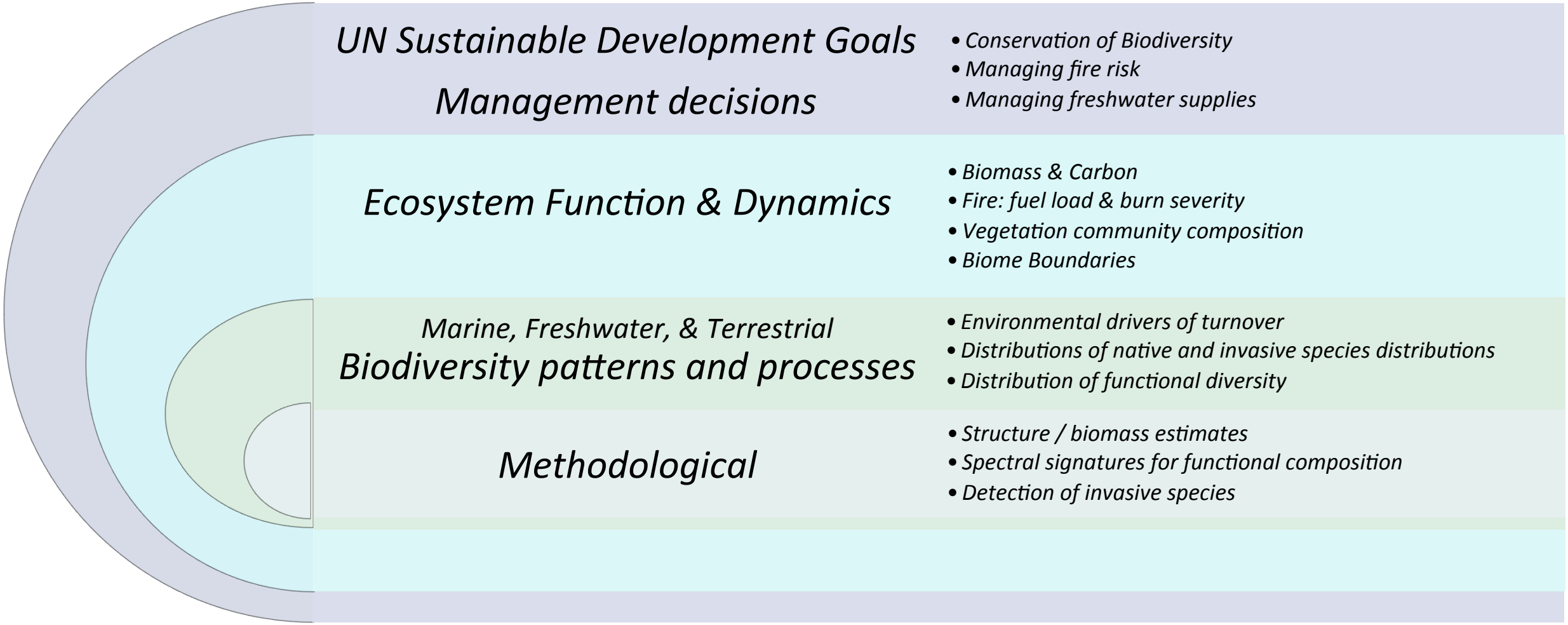
- Altitude: ~21 km (70,000 ft)
- Range: 9,000 km (5,700 mile)
- Simulates orbiting satellites

Sensors:

- Hyperspectral (AVIRIS-NG, 380 to 2510nm)
- Thermal Hyperspectral (HyTES, 7500-12,000nm)
- LiDAR (LVIS)

Existing and new *in situ* data collection

Refine Science Questions



SUSTAINABLE DEVELOPMENT GOALS

#3: Combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world

#4: Ensure conservation of mountain biodiversity & ecosystems to enhance their capacity to provide benefits that are essential for sustainable development

#8: Prevent introduction and reduce impact of invasive species on land and water ecosystems and control or eradicate the priority species

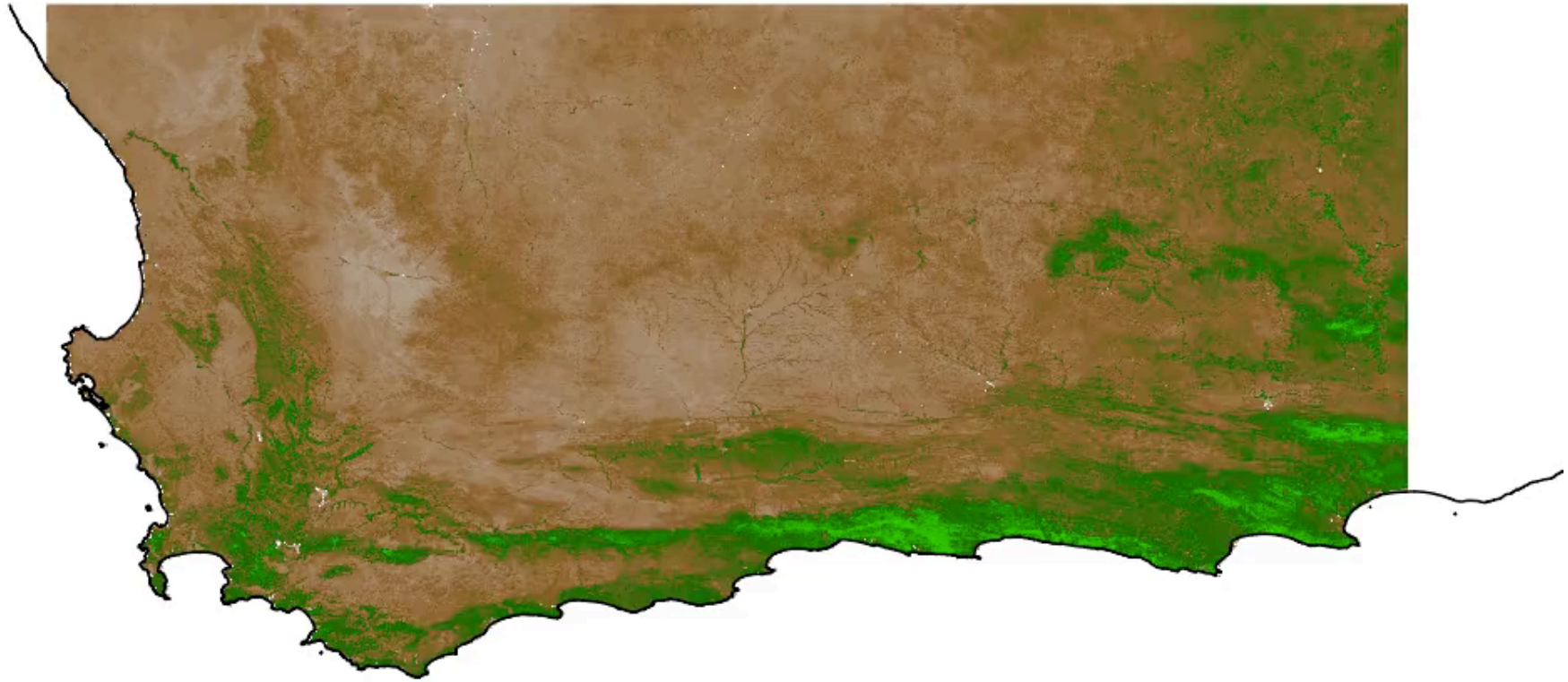
#1: reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

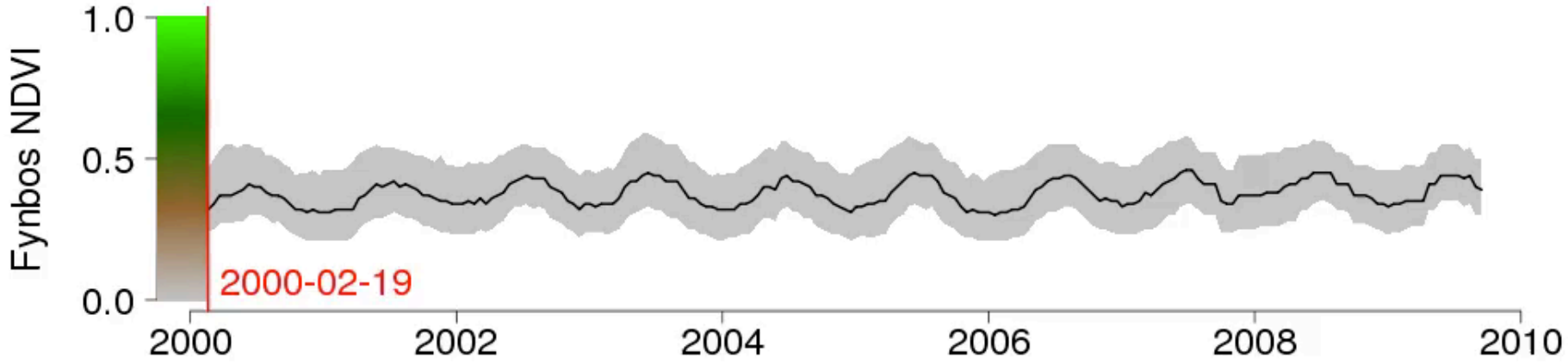
#2: sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans

#5: Conserve >10% of coastal and marine areas, consistent with national and international law and based on the best available scientific information

A tale of two time-series

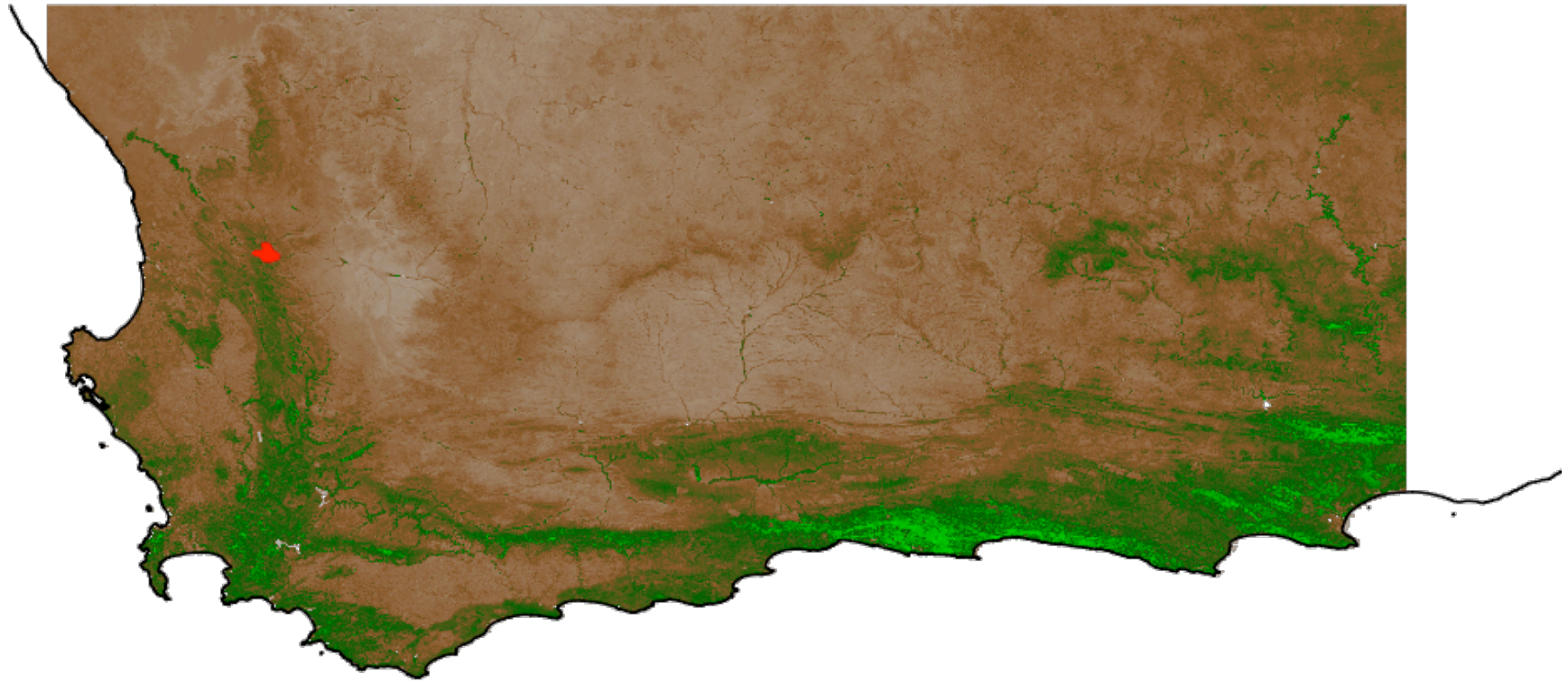
Monitoring post-fire recovery using Satellite Vegetation Index (MODIS NDVI)

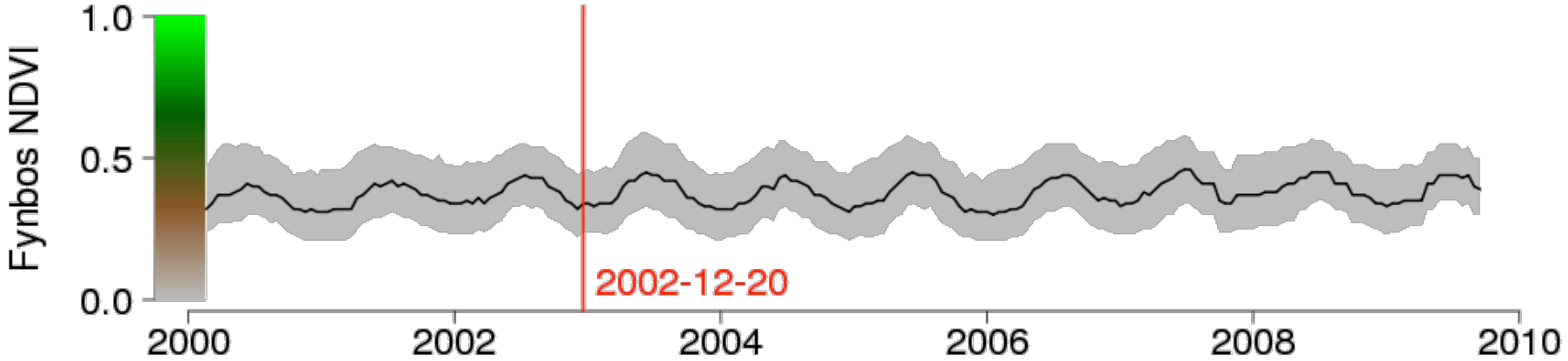




Wilson, Latimer, & Silander PNAS (2015)

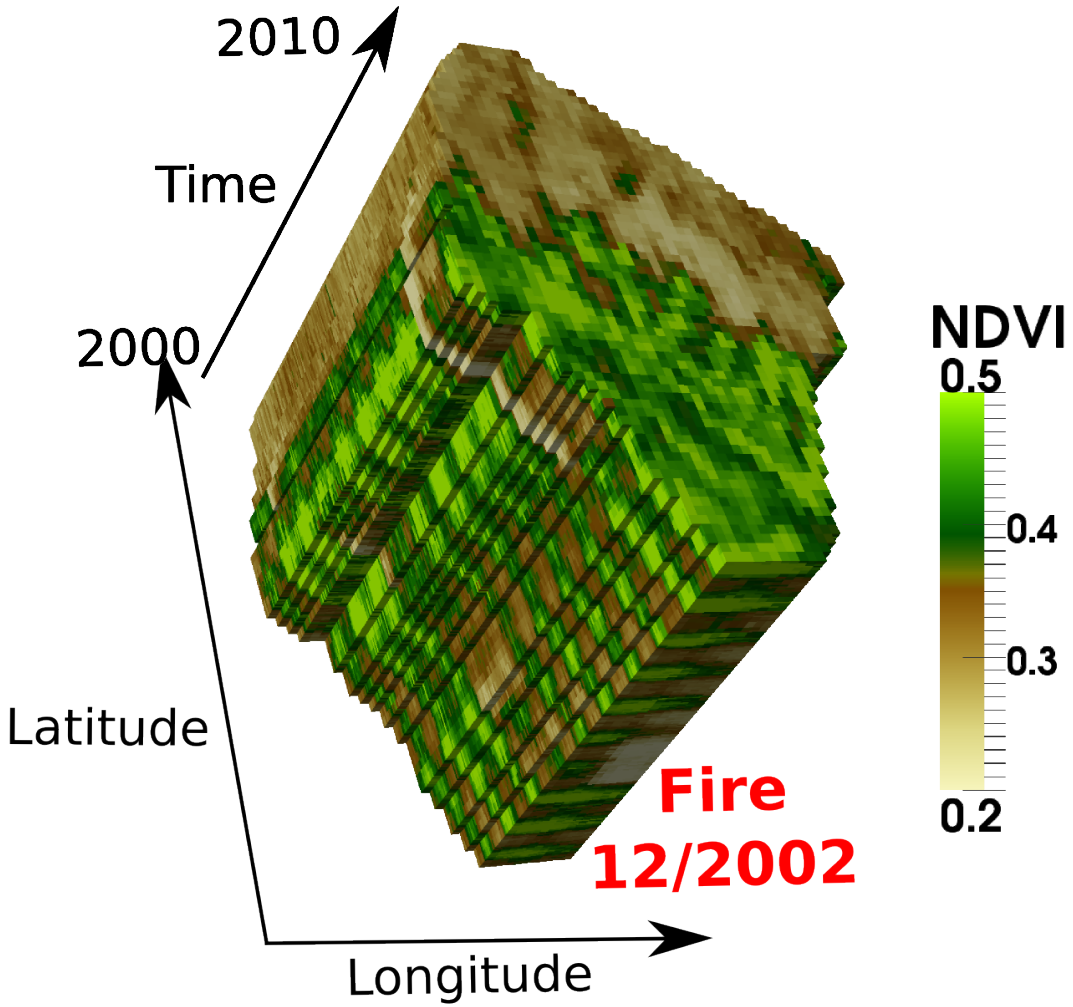
Monitoring post-fire recovery using Satellite Vegetation Index (MODIS NDVI)



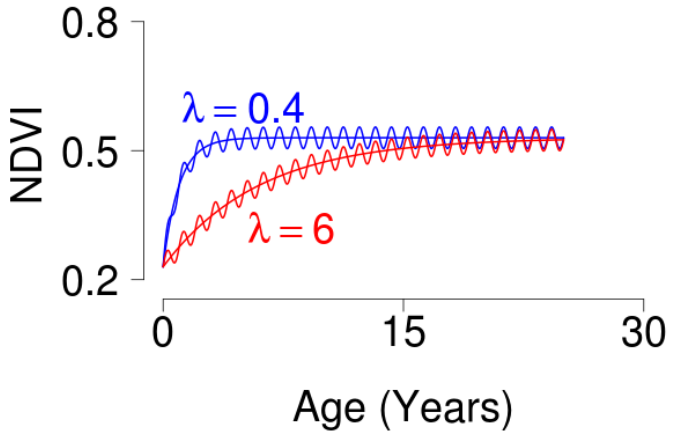


Wilson, Latimer, & Silander PNAS (2015)

What drives the spatial variation in post-fire recovery?

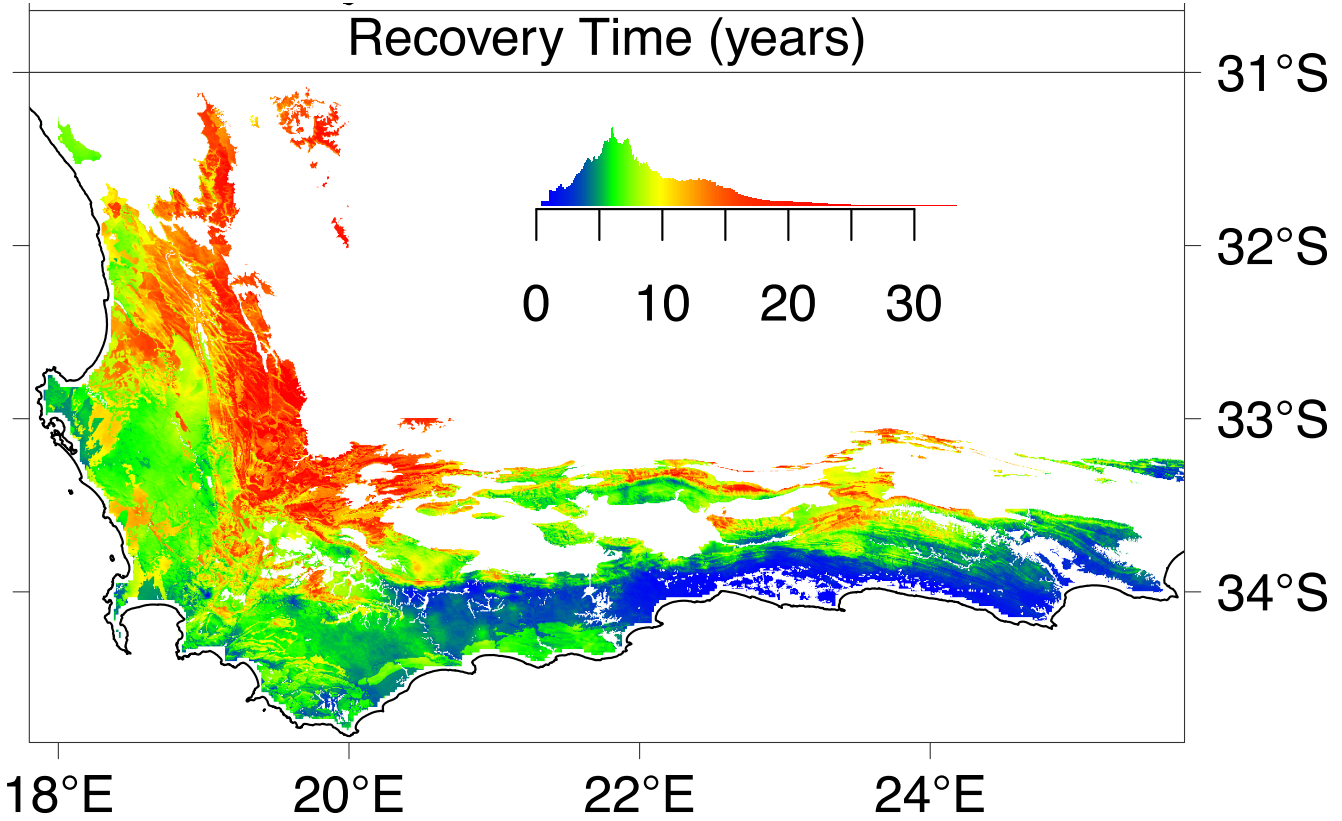


Recovery gradients associated with climate and soil



Faster recovery with

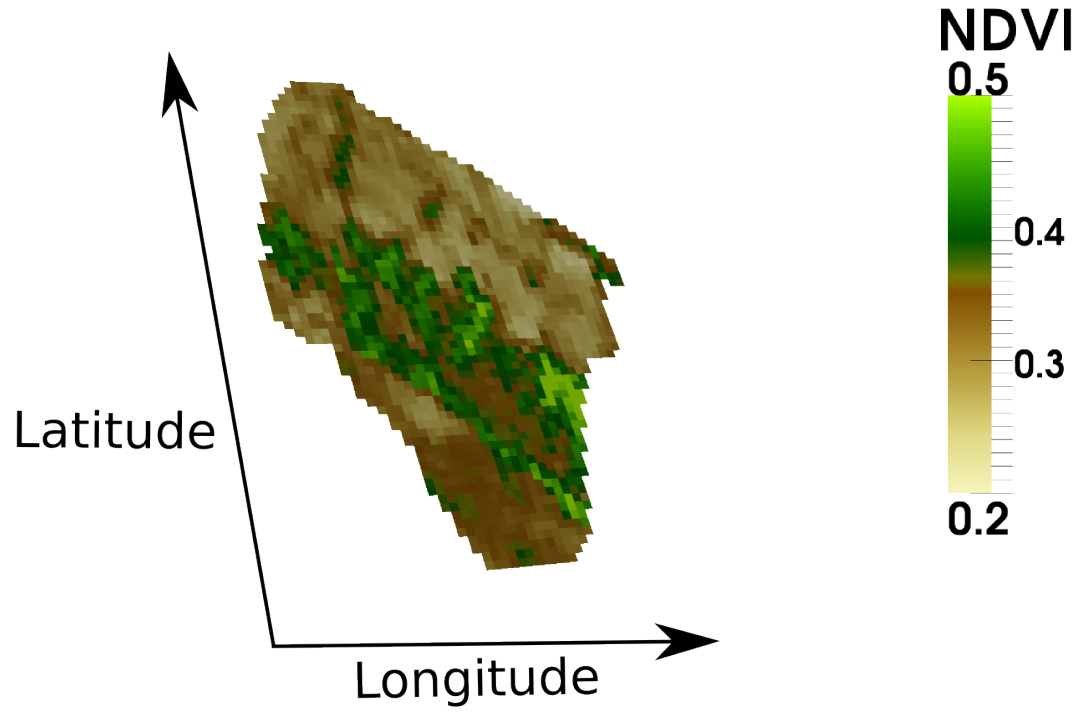
+ Soil Fertility
+ Summer Precipitation
+ Warm Winter Temps



Monitoring Ecosystems with Vegetation Indices

High spatio-temporal resolution,
but low ecological resolution.

What's really going on?

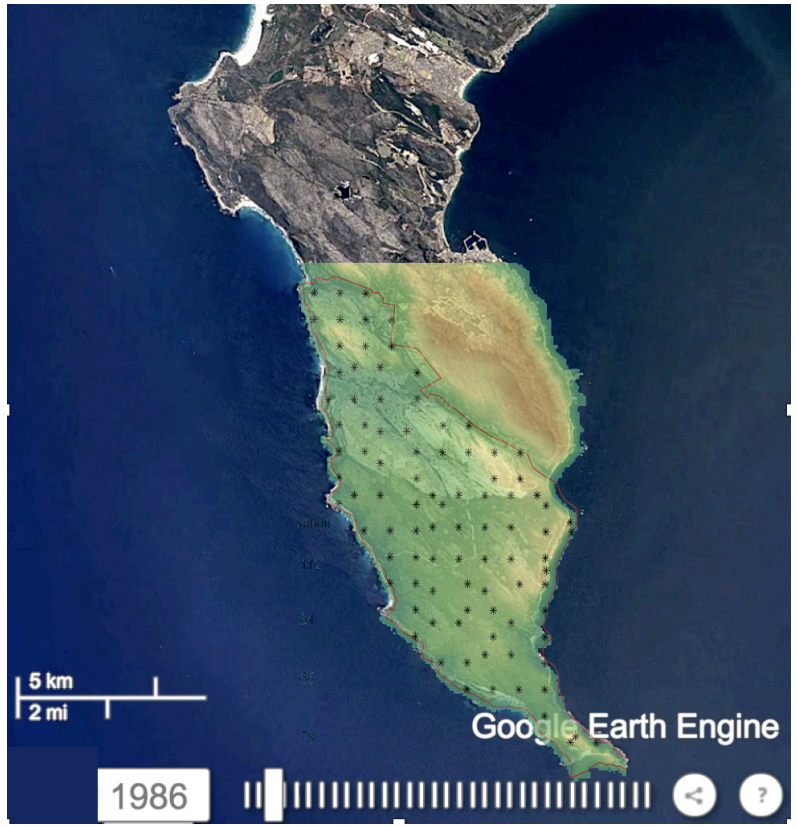


Measuring biomass in the Kogelberg Mountains

Wilson, Latimer, & Silander PNAS (2015)

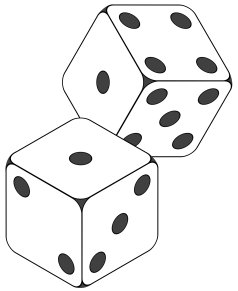
51 year Repeated Vegetation Survey on the Cape of Good Hope – 1966, 1996, 2010, 2017

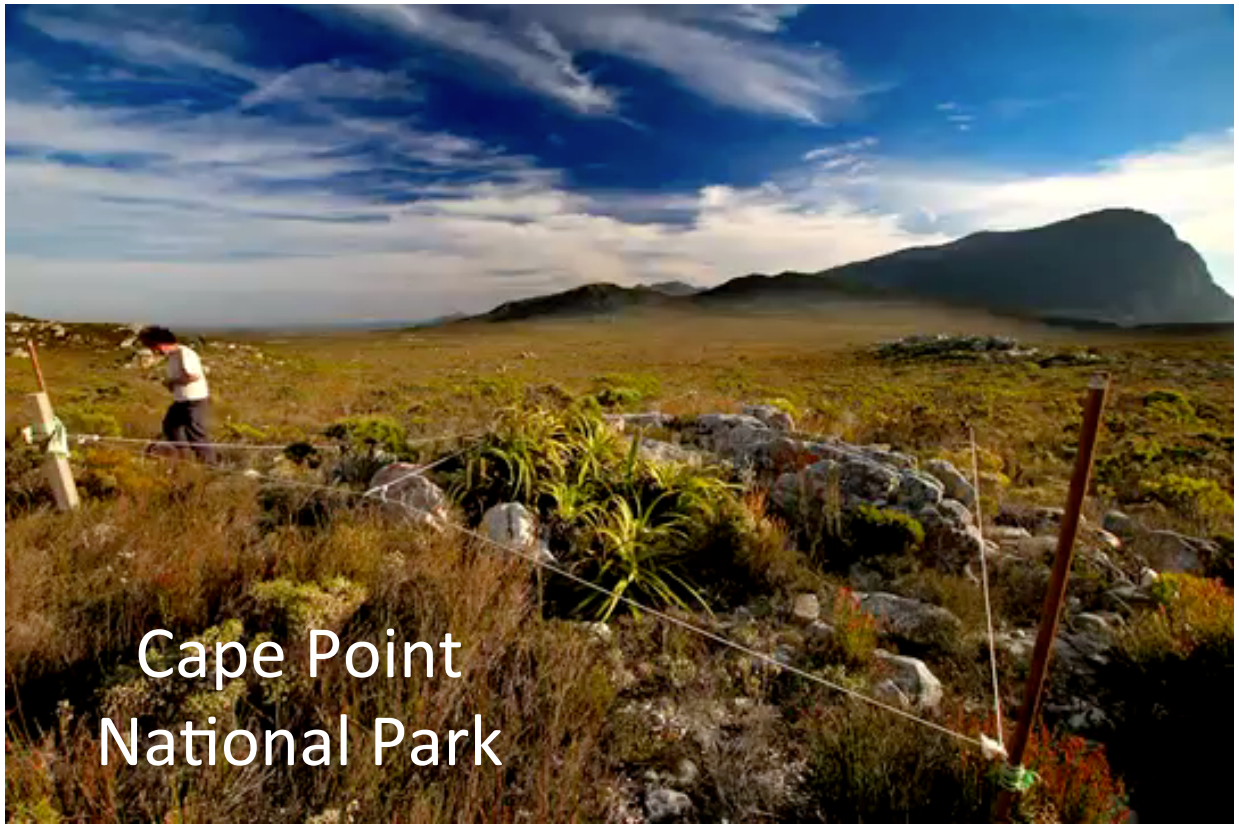
100 5x10m permanent plots
≈10,000 individuals with 323 species



1966-1996

38% species turnover in plots!





Privett, Cowling, and Taylor *Bothalia* (2001)

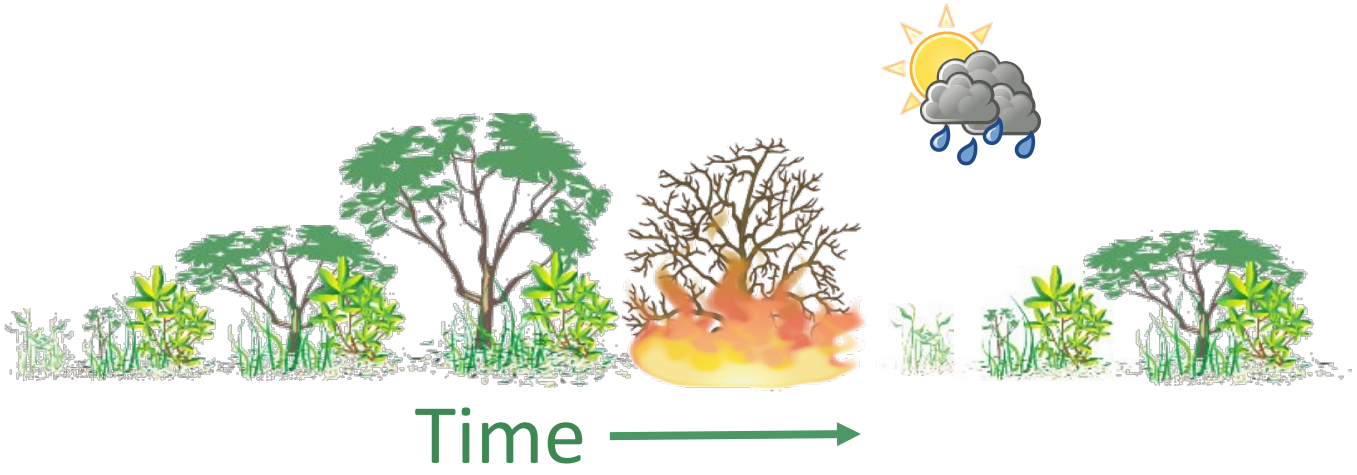
Slingsby, et al, *PNAS* (2017)

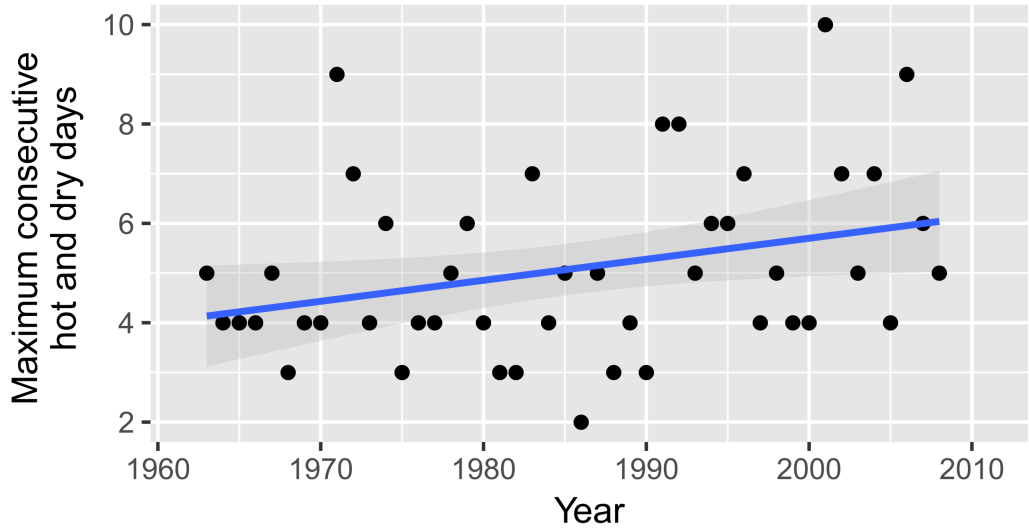
Decreasing Species Richness over time
(after accounting for time-since-fire)

 # Species
- 323 in 1966
- 296 in 1996
- 277 in 2010

Why? Partly invasive plants and partly climate

But effects vary by species traits / functional type

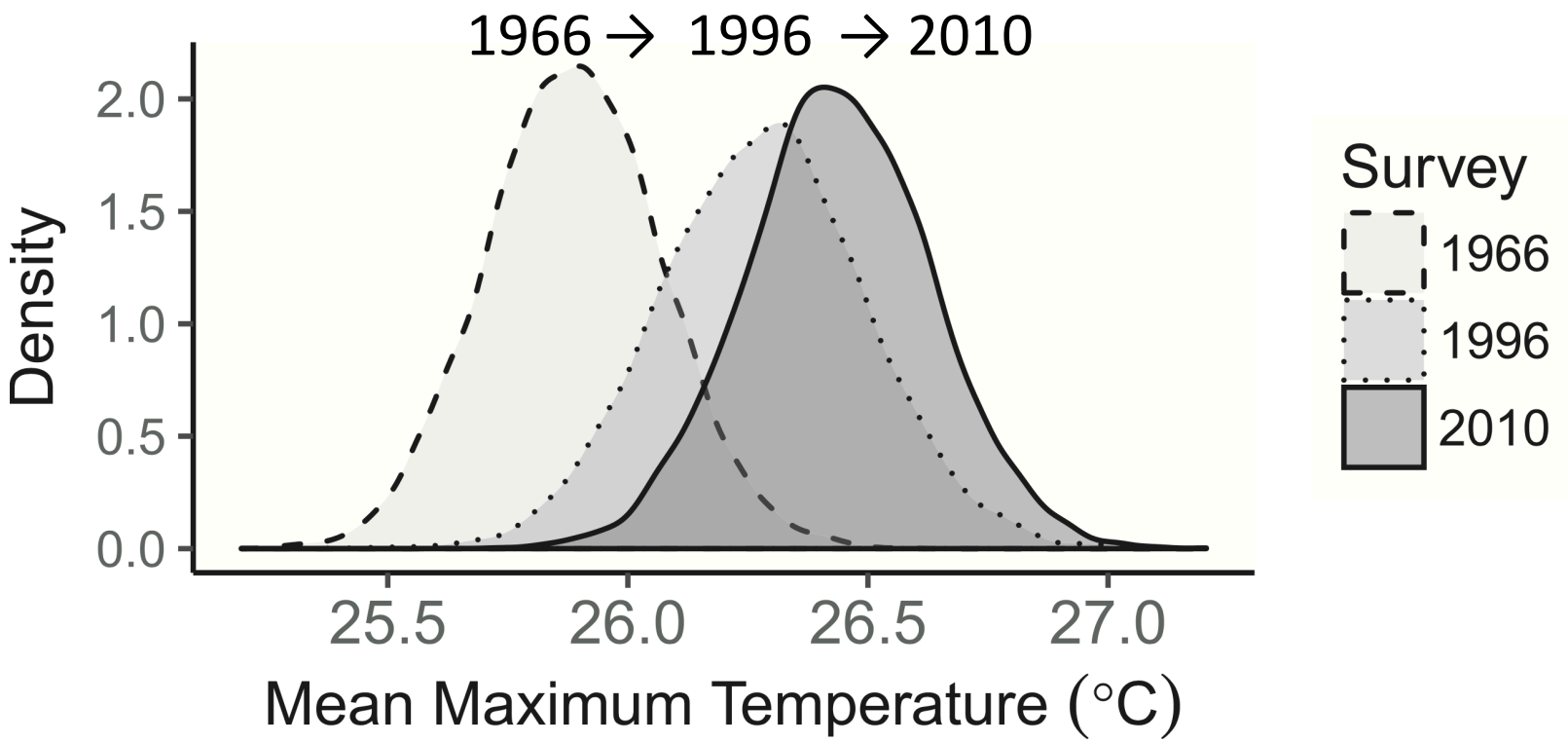




Slingsby, et al, *PNAS* (2017)

Shifting environmental niche of species on Cape Point

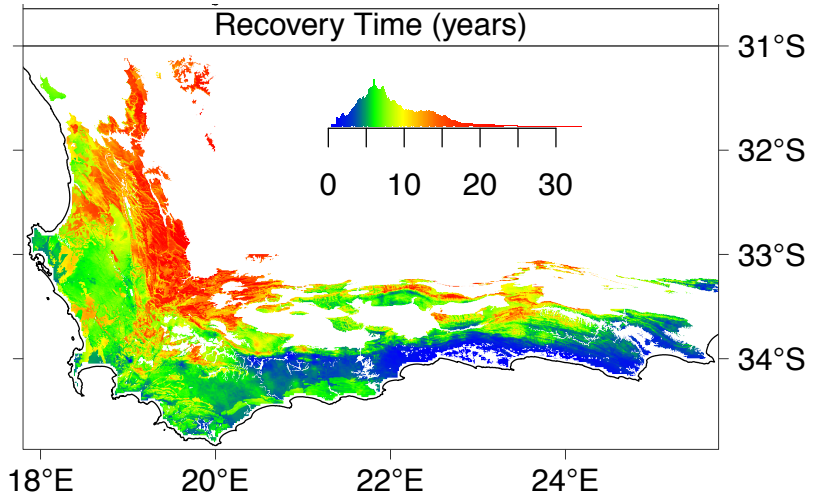
Mean maximum temperature observed across full geographic range of species unique to each survey



High ecological resolution, but small domain... What's really going on?

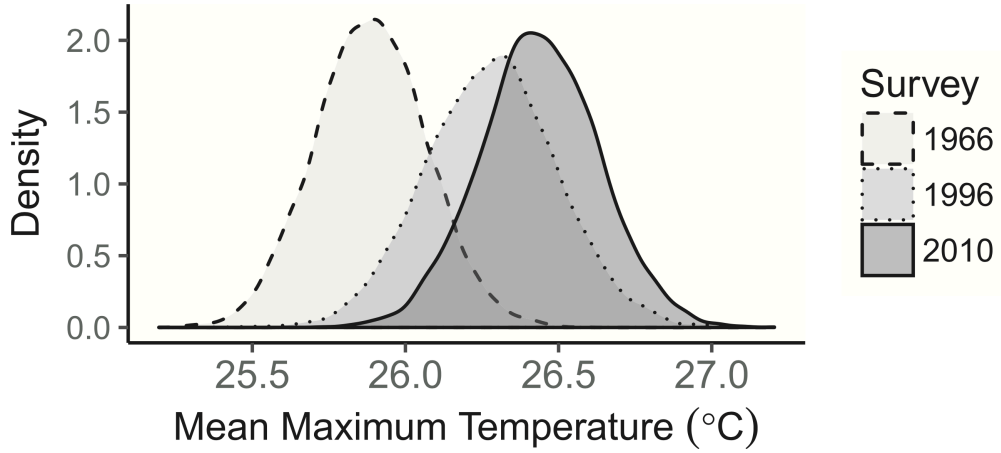
Inferring process from pattern

Top Down



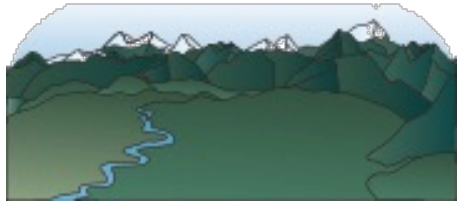
Observed gradients in ecosystem recovery associated with climate

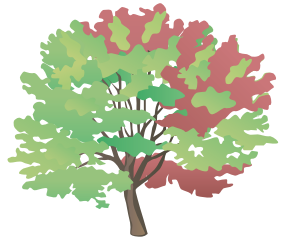
Bottom Up

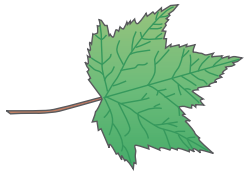


Observed shifts in community functional and phylogenetic composition associated with climate

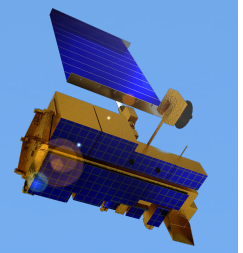
Multi-scale Sampling



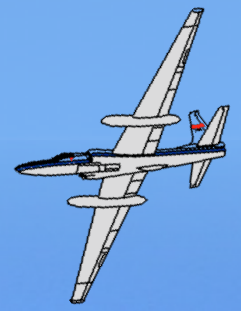




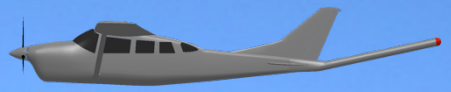
30 & 250m



~20m



~1m

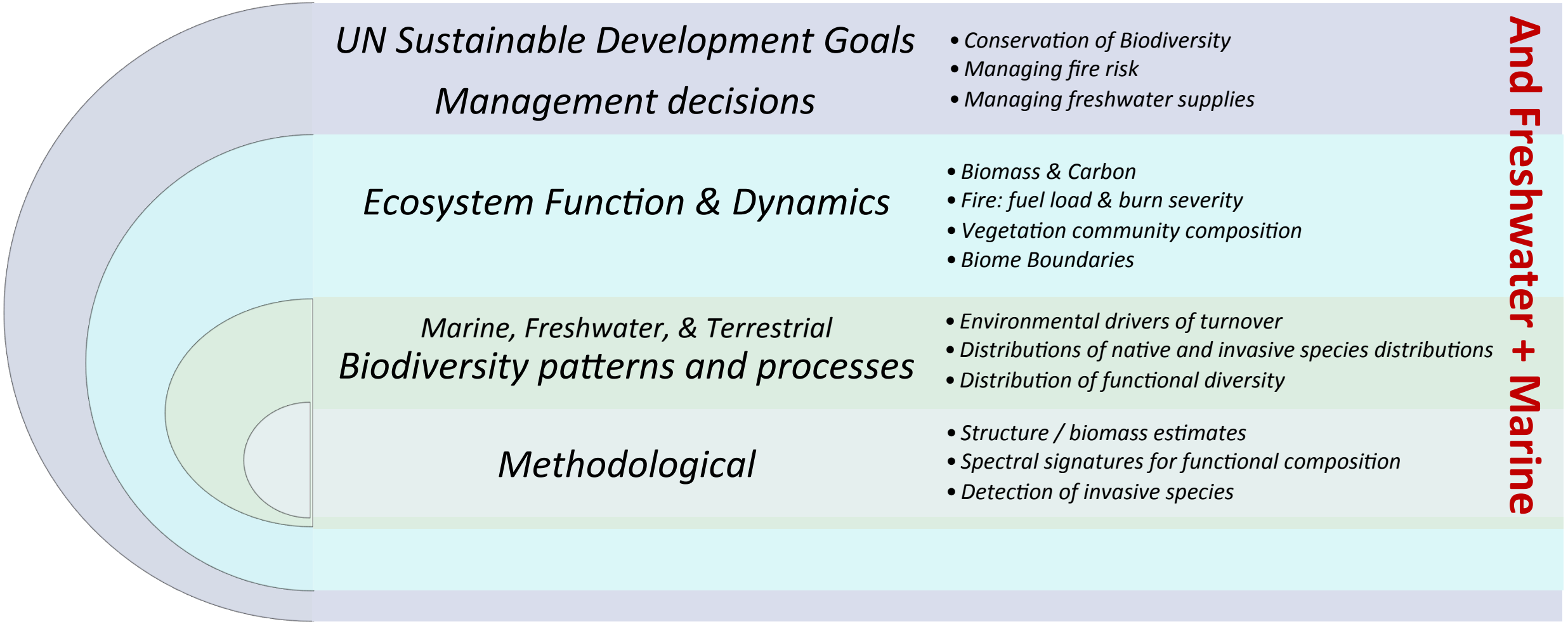


SAEON

South African Environmental Observation Network

~0.1m

Refine Science Questions



NRF National Research Foundation | SAEON South African Environmental Observation Network

SANBI Biodiversity for Life
South African National Biodiversity Institute

UCONN

University of Cape Town • iYunivesithi yaseKapa • Universiteit van Kaapstad

NASA

Thank you!

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