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

Adam M. Wilson, John A. Silander, Jr. with Jasper Slingsby
Global biodiversity hotspots

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 \(\uparrow\)
- Urban Migration
“....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.”

I was wrong (about the Cape)!

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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)

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

*Just a sample*
Dynamic landscape

Fire frequency increasing due in part to changing climate

<table>
<thead>
<tr>
<th>Decade</th>
<th>Mean Fire Return</th>
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</thead>
<tbody>
<tr>
<td>1970s</td>
<td>31.6 years</td>
</tr>
<tr>
<td>2000s</td>
<td>13.5 years</td>
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</tbody>
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Freshwater Availability

Worst water shortage in 113 Years

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

**UN Sustainable Development Goals**
- Conservation of Biodiversity
- Managing fire risk
- Managing freshwater supplies

**Management decisions**

**Ecosystem Function & Dynamics**
- Biomass & Carbon
- Fire: fuel load & burn severity
- Vegetation community composition
- Biome Boundaries

**Marine, Freshwater, & Terrestrial Biodiversity patterns and processes**
- Environmental drivers of turnover
- Distributions of native and invasive species distributions
- Distribution of functional diversity

**Methodological**
- Structure / biomass estimates
- Spectral signatures for functional composition
- Detection of invasive species
#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)
Monitoring post-fire recovery using Satellite Vegetation Index (MODIS NDVI)
What drives the spatial variation in post-fire recovery?

Wilson, Latimer, & Silander PNAS (2015)
Recovery gradients associated with climate and soil

Faster recovery with
+ Soil Fertility
+ Summer Precipitation
+ Warm Winter Temps

Wilson, Latimer, & Silander PNAS (2015)
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)

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

1966-1996
38% species turnover in plots!

Cape Point National Park

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

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?

Shifting environmental niche of species on Cape Point

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

- ~1m
- ~20m
- 30 & 250m
- ~0.1m
- ~1m

SAEON
South African Environmental Observation Network
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And Freshwater + Marine
Thank you!

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