Dimensions of Biodiversity: 
from Traits to Communities to Ecosystems

Adam M. Wilson, Martin van Leeuwen, John A. Silander, Henry Frye, Jasper Slingsby,...
Greater Cape Floristic Region (GCFR) of South Africa

≈90,000km²  
(PA: 119,000 km²)

Outstanding Biodiversity
- ~1% Africa’s area
- ≈9,000 vascular plants
- ~20% Africa’s Plants
- 65% endemic
- ~2.5% world’s plants endemic

Socio-ecological complexity
- Climate ↗
- Urban Migration

7 Terrestrial Biomes
- Agulhas
- Fynbos
- Namaqua
- Southern Benguela
- Southwestern Cape
- Succulent Karoo

4 Marine Biomes

Important Freshwater Ecosystems
Biodiversity hotspot... with good data!

Vascular Plant Diversity: 
# Species per 10,000km²

Digitally accessible biodiversity data density

Terrestrial Vertebrates


Meyer, et. al. *Nature Communications*, 2015
Fire-prone system undergoing rapid environmental change

Increasing Fire frequency

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

“Natural” Experiment: Cape Town is now tapping into groundwater supplies to supplement rainfall

Projected change in average precipitation (%) 2005 to 2100

We Have Seen The Future Of Water, And It Is Cape Town

Peter H. Gleick
Guest Writer
Invasive plants exacerbate drought

Cape Town water supply reduced 2-3 months per year
Could rise to 7-9 months by 2045 if not addressed

Le Maitre et al. 2016 10.4314/wsa.v42i4.17
Repeated vegetation surveys over the past 50 years show rapid species turnover

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

1966-1996
38% species turnover in plots!

<table>
<thead>
<tr>
<th>Year</th>
<th># Species</th>
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<tbody>
<tr>
<td>1966</td>
<td>323</td>
</tr>
<tr>
<td>1996</td>
<td>296</td>
</tr>
<tr>
<td>2010</td>
<td>277</td>
</tr>
</tbody>
</table>

Shifting environmental tolerance of plant communities on Cape Point

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

Selection for species with higher $T_{\text{max}}$ tolerance?

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

Field Campaign Science Themes

Biodiversity Distribution & Abundance
- Direct Observation of Indicator Species
- Inferred through distribution modeling
- Taxonomic Diversity / Functional Diversity

Drivers and Mechanisms of Change
- Shifting Distributions & Abundance
- Disturbance Regime
- Ecological Theory (Trait Driver Theory)

Impacts of Biodiversity Change
- Evapotranspiration: Freshwater Availability
- Feedbacks: climate & wildfire

Terrestrial, Freshwater, & Marine
Field Campaign Design

Satellite
- LANDSAT / MODIS / SENTINEL

NASA Airborne
- AVIRIS-NG & PRISM & HyTES
- LiDAR

Field Component
- Historical Datasets
- Plant community composition
- Plant Traits, leaf, and canopy reflectance
- Wildfire

Modeling component
- Community Simulation
- Ecological modeling

Outreach / Community / Social
- Citizen science participation through “VeldWatch” app
- Social Science – explore relationships with biodiversity

Overview Dynamic Ecosystem Simulation Products Coda
The problem of pattern and scale is THE central problem in ecology

- Simon Levin (1992)
Canopy Reflectance Simulation with ray tracing

Overview
 Dynamic Ecosystem
 Simulation
 Products
 Coda

3D Simulated Canopy

Simulated hyperspectral reflectance for each pixel
Biodiversity observation scaling relationships

Explore Effects of Spectral & Spatial Grain

Image

“Truth”

Classification

Accuracy

Diagonal is good
Importance of (spectral and spatial) grain

Spatial Grain
- 250m
- 1cm

Spectral Grain
- Hyper
- Multi

Biodiversity (EBV, etc.)
Metric
Accuracy

Van Leeuwen
Science Themes

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& Products

Ecosystem Monitoring for Management

Citizen Science / Engagement

Overview Dynamic Ecosystem Simulation Products Coda
Observation and monitoring system to support research and management

Shrub Mortality due to drought

Invasion of Australian Port Jackson Willow (*Acacia saligna*)

Slingsby
Citizen Scientists: VeldWatch App

Overview
Dynamic Ecosystem
Simulation
Products
Coda

Involve citizen scientists in monitoring change.
Connections to new NASA Project: 
Remotely sensed change metrics to inform Essential Biodiversity Variables (EBVs)

Jetz (Yale)  Guralnick (UF)  McShea (SI)  McGeosh (Monash)
Timeline

Network Review
Summer 2018

Public Review
Fall 2018

Final Scoping Proposal
Winter 2018
Thank you!

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