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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

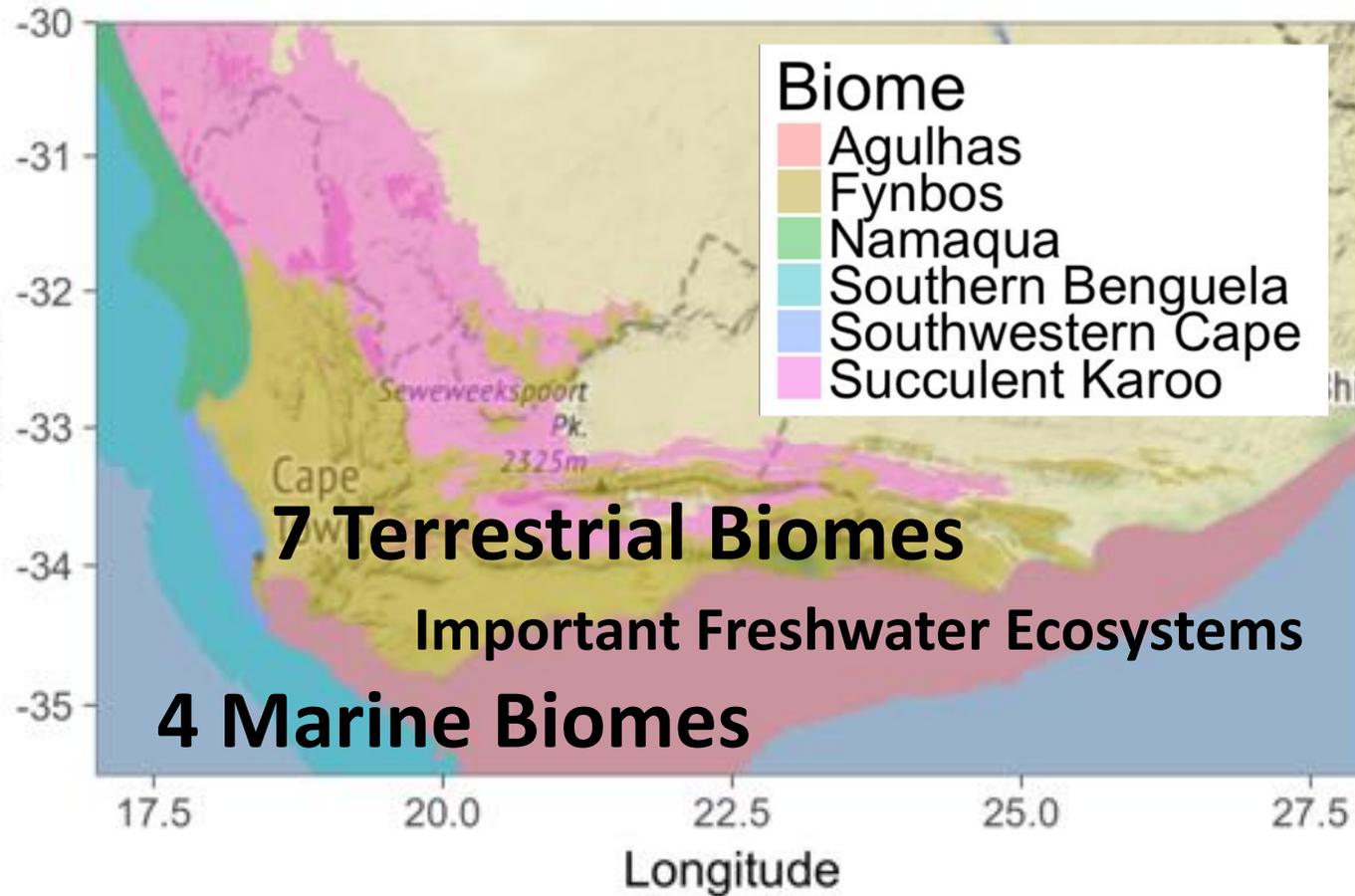
≈90,000km² (PA: 119,000 km²)

Outstanding Biodiversity

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

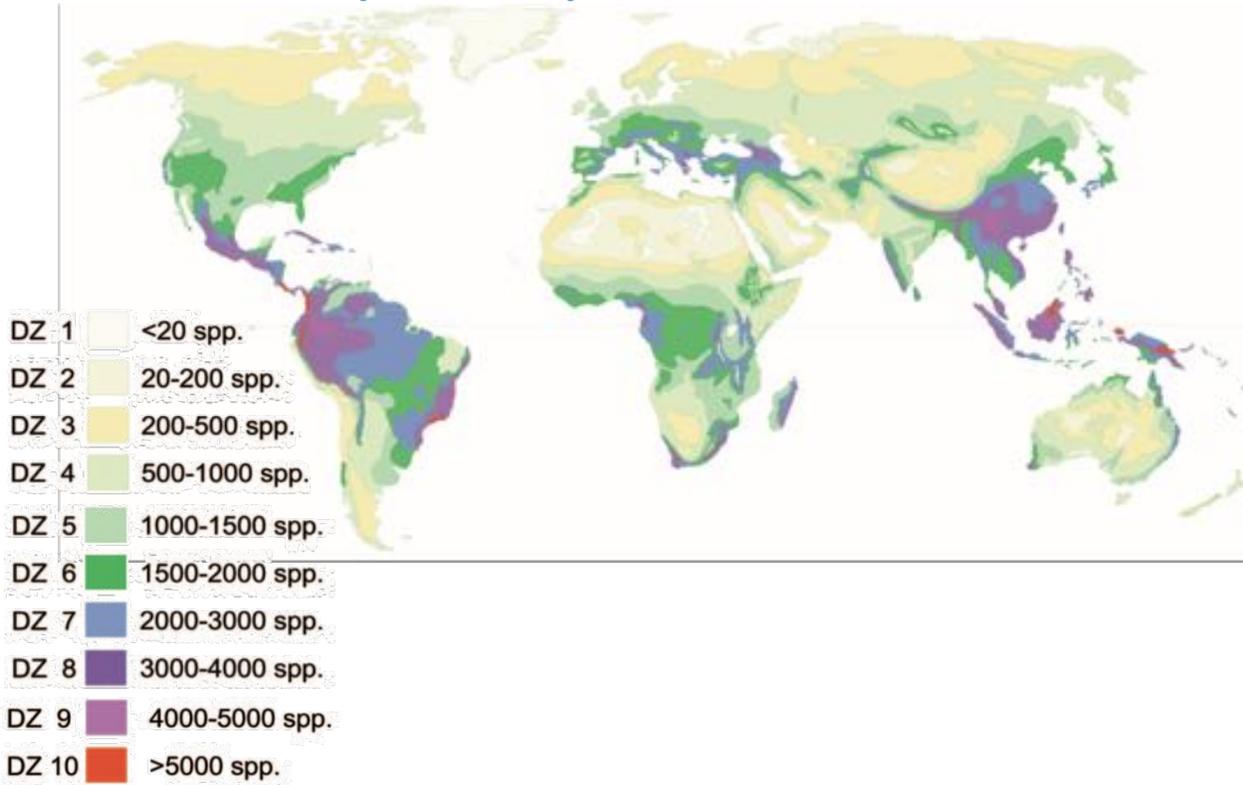
Socio-ecological complexity

- Climate ↗
- Urban Migration



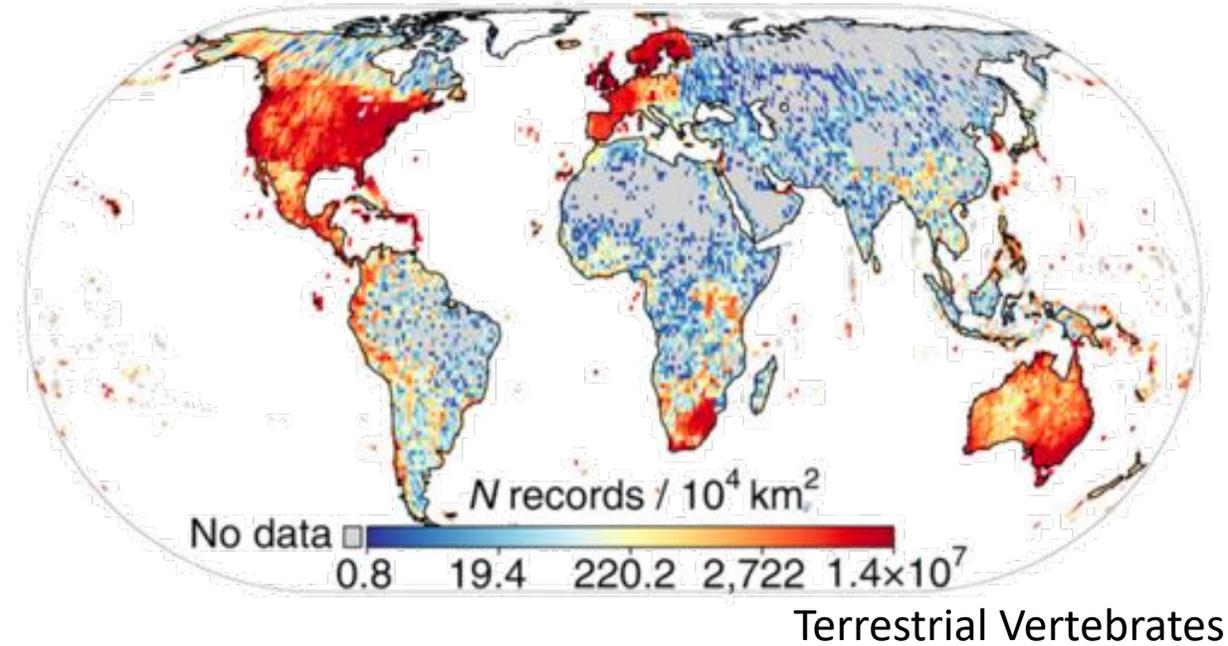
Biodiversity hotspot... with good data!

Vascular Plant Diversity:
Species per 10,000km²



Barthlott, et al., *Nova Acta Leopoldina*, 2005

Digitally accessible biodiversity
data density

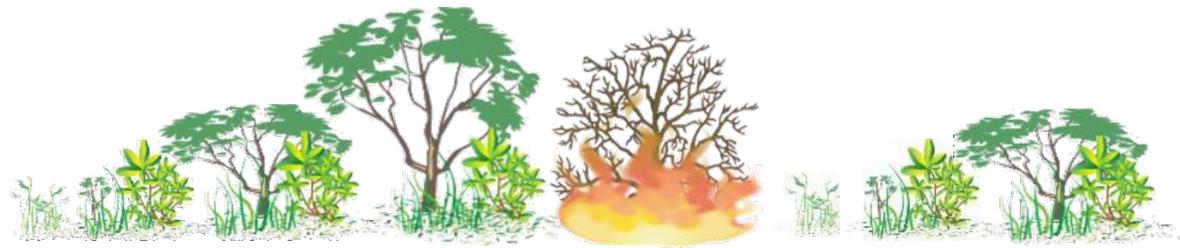


Meyer, et. al. *Nature Communications*, 2015

Fire-prone system undergoing rapid environmental change

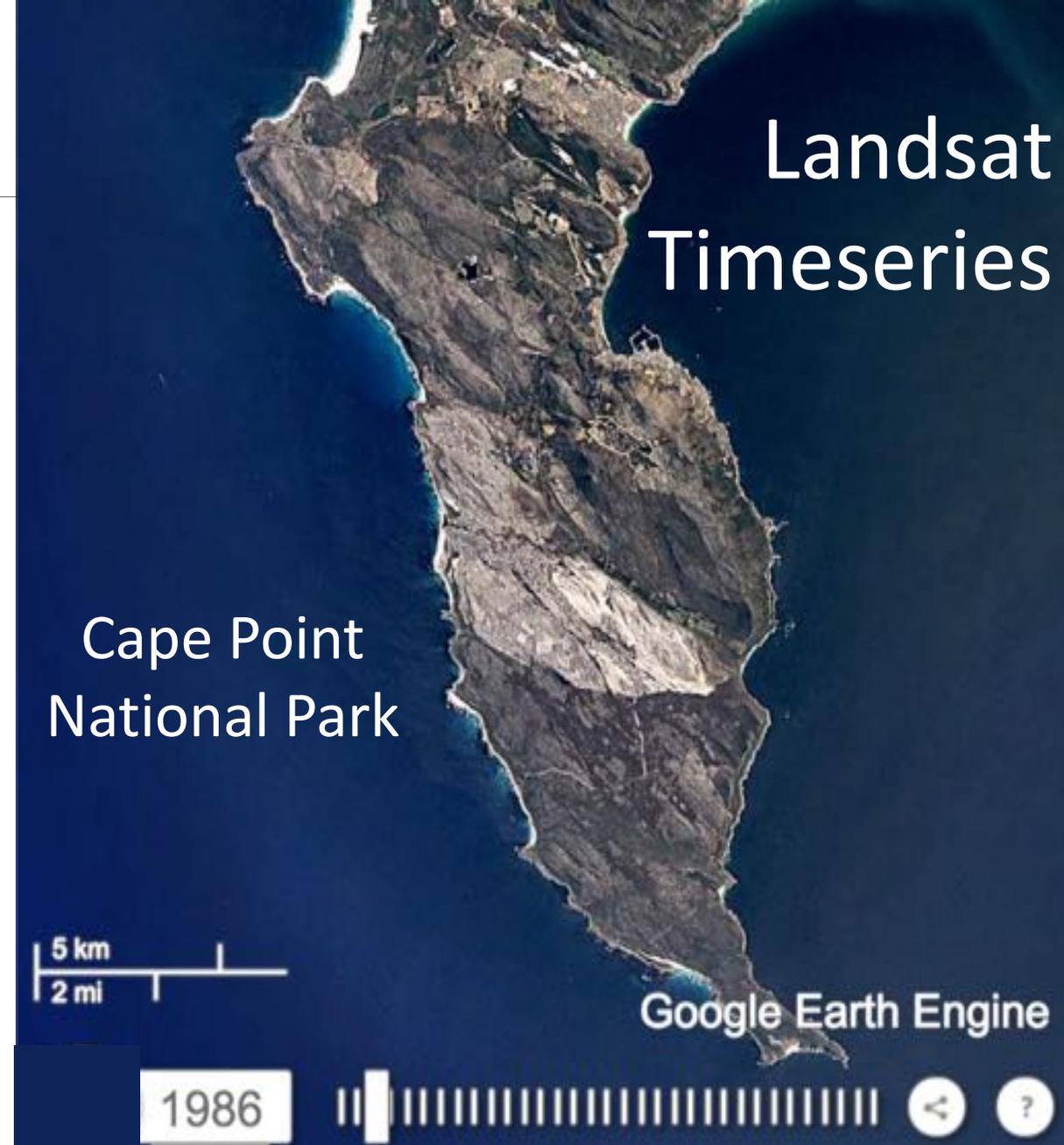
Increasing Fire frequency

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



Time

Wilson, et. al, *IJGIS* (2011) Wilson, et. al. *Ecological Modelling* (2010)
Forsyth and van Wilgen, *Koedoe* 50(1) 2008, Slingsby, et al, *PNAS* (2017)





OPINION

02/09/2018 05:47 am ET | Updated 2 days ago

1.9k

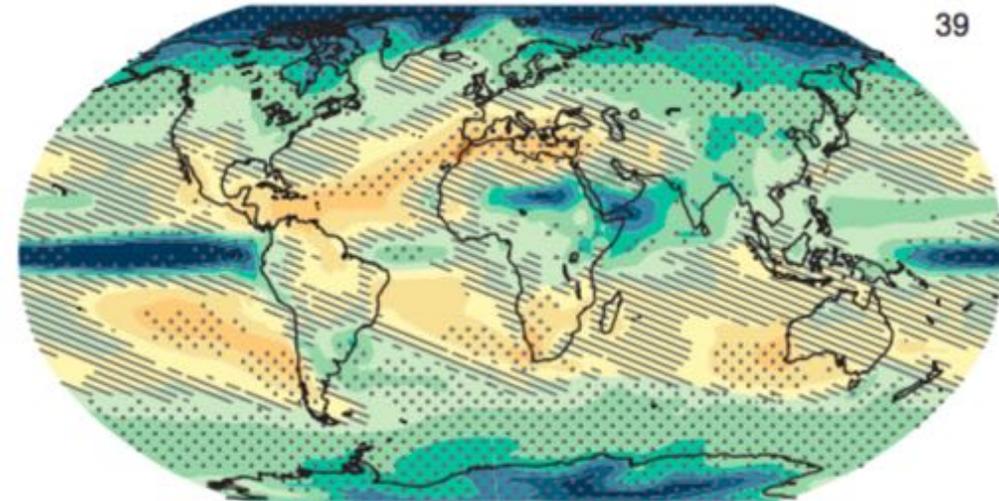


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We Have Seen The Future Of Water, And It Is Cape Town



Peter H. Gleick
Guest Writer



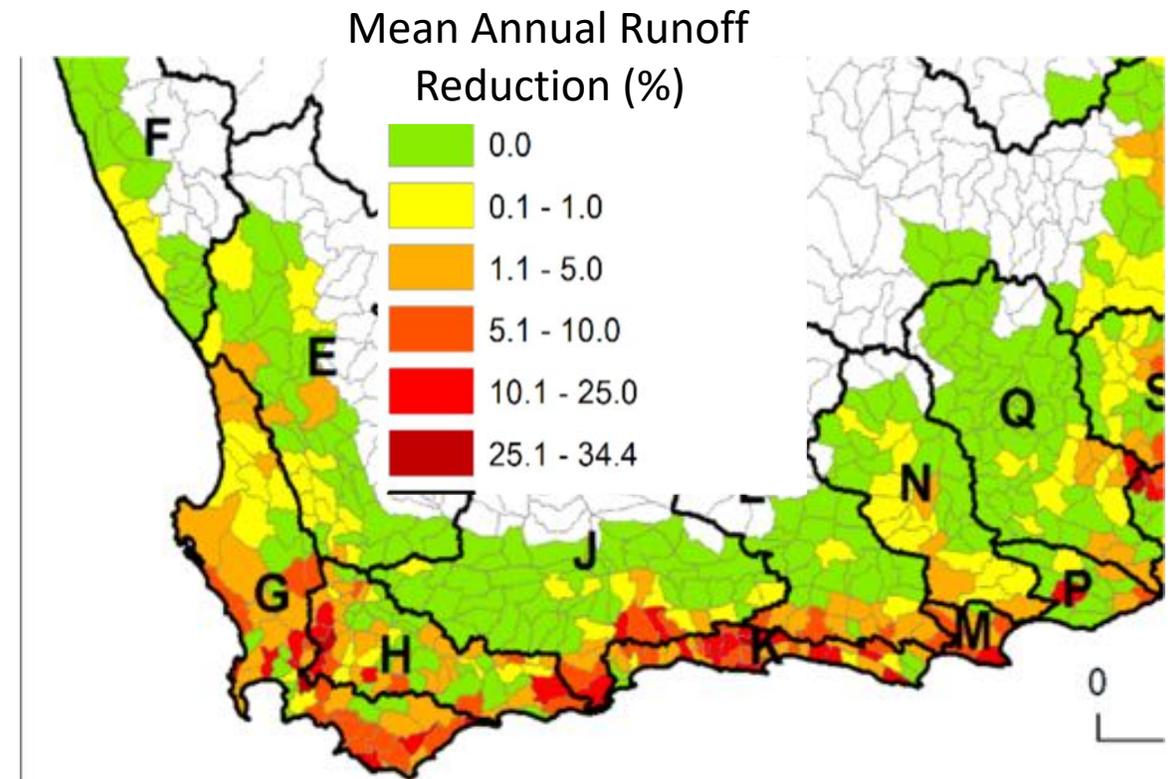
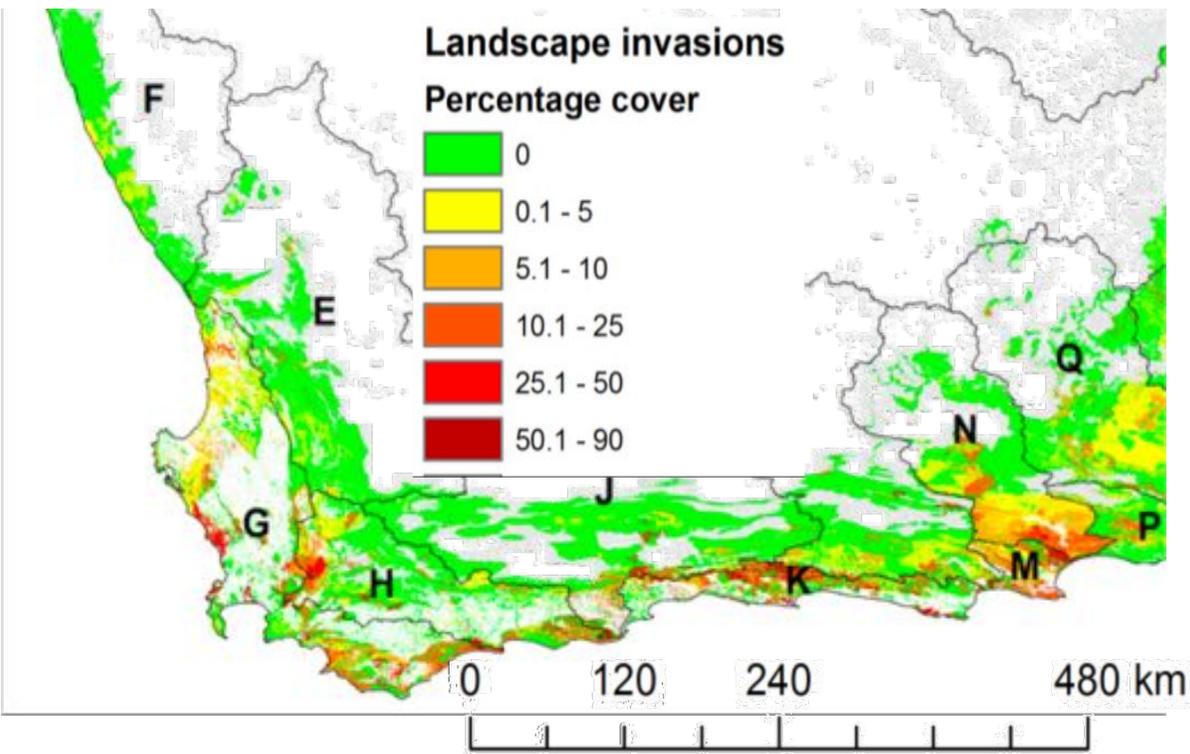
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“Natural” Experiment: Cape Town is now tapping into groundwater supplies to supplement rainfall

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

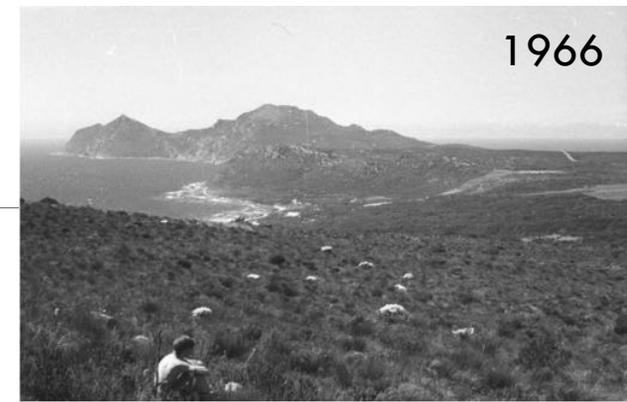
100 5x10m permanent plots
≈10,000 individuals of 323 species



1966-1996
38% species
turnover in plots!

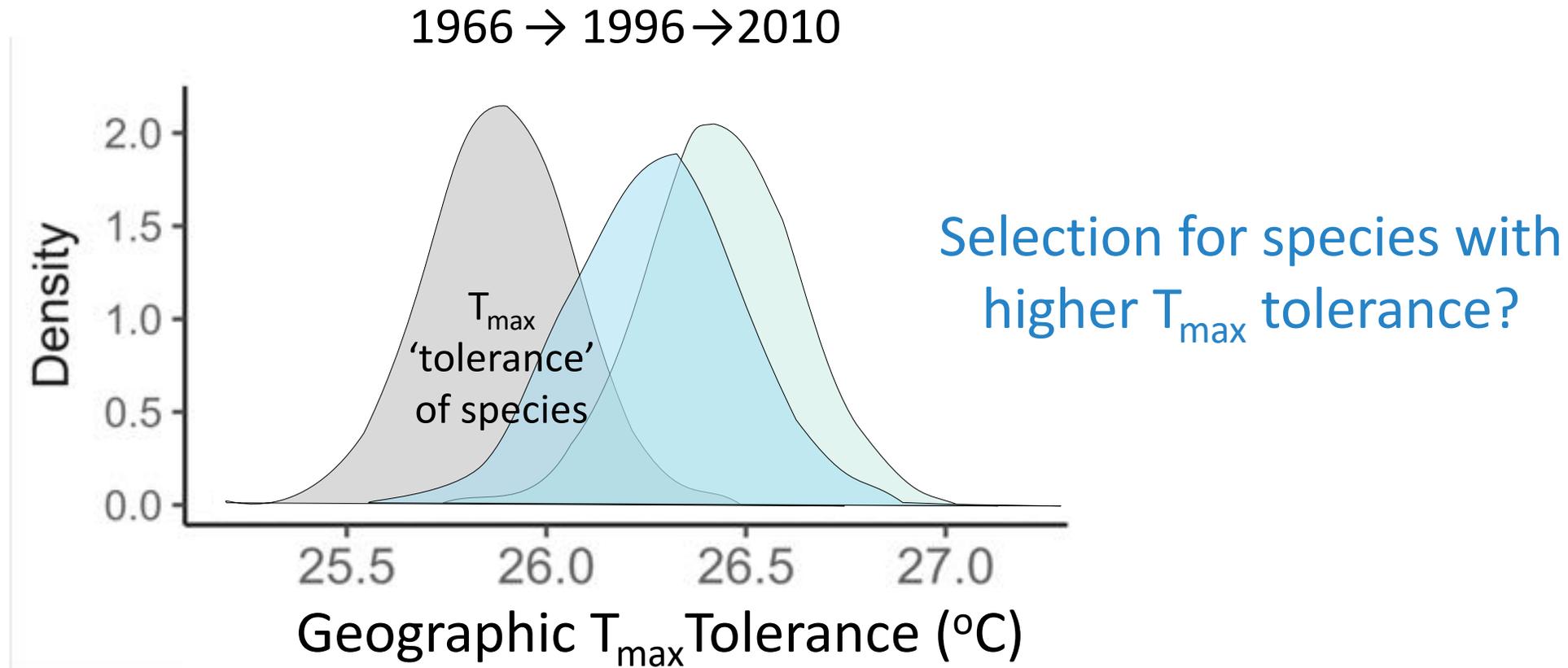


Year	# Species
1966	323
1996	296
2010	277



Slingsby, et al, *PNAS* (2017)

Shifting environmental tolerance of plant communities on Cape Point



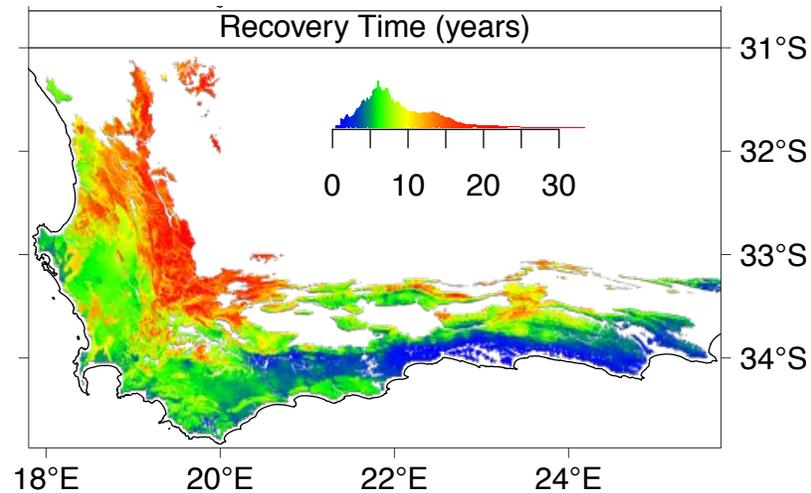
High ecological resolution, but small domain... **What's really going on?**

Slingsby, et al, *PNAS* (2017)

Inferring process from pattern



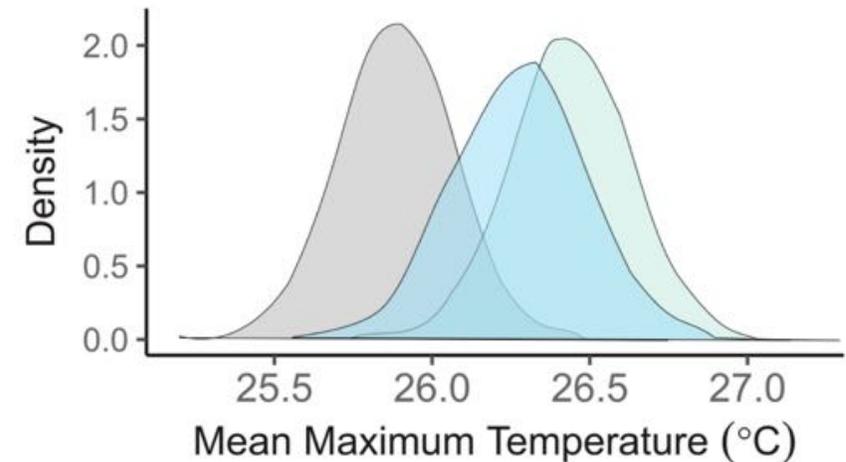
Top Down



Observed gradients in ecosystem recovery associated with climate

Wilson, et al, *PNAS* (2015)

Bottom Up



Observed shifts in community functional and phylogenetic composition associated with climate

Slingsby, et al, *PNAS* (2017)

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

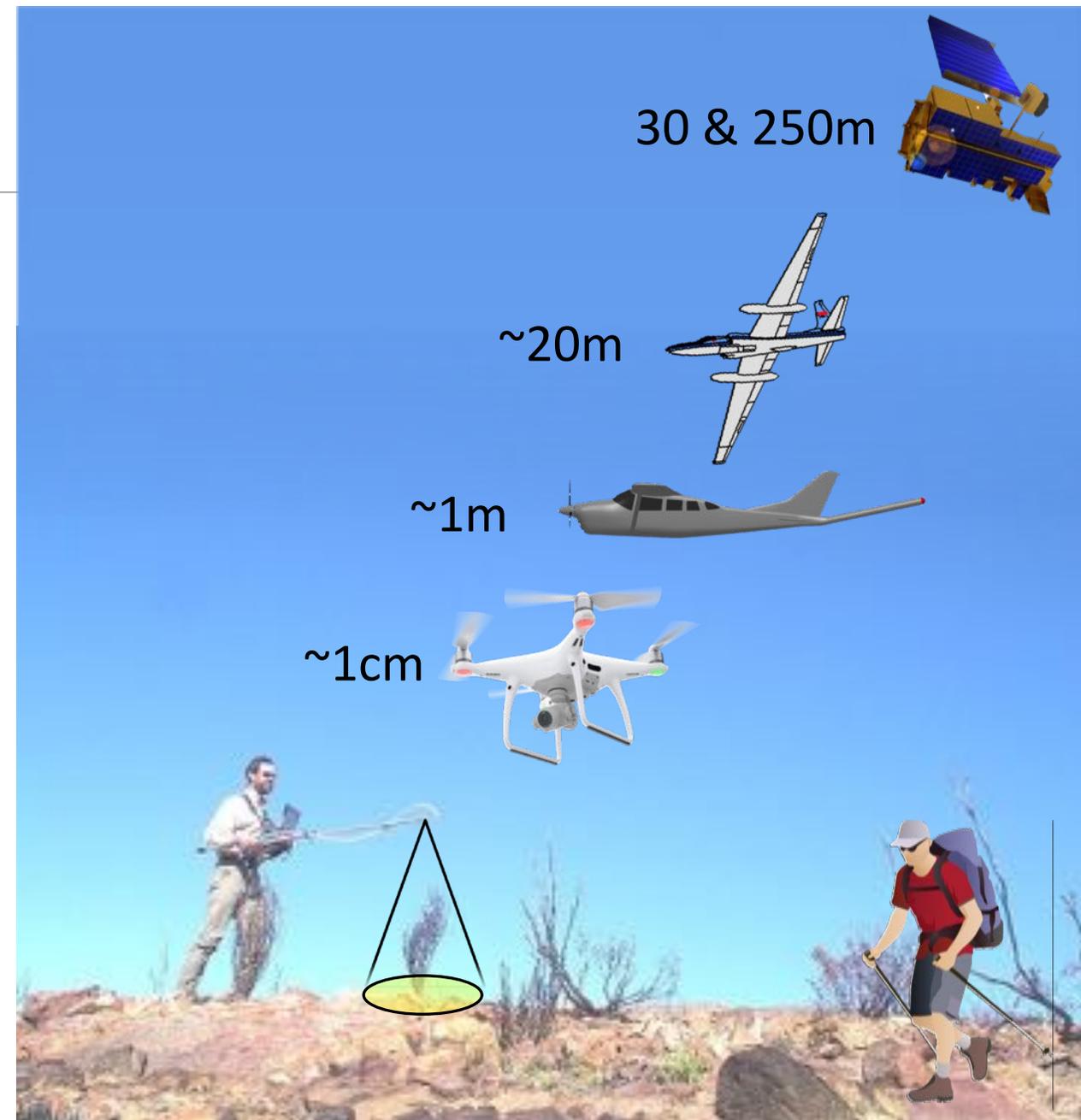
- Historical Datasets
- Plant community composition
- Plant Traits, leaf, and canopy reflectance
- Wildfire

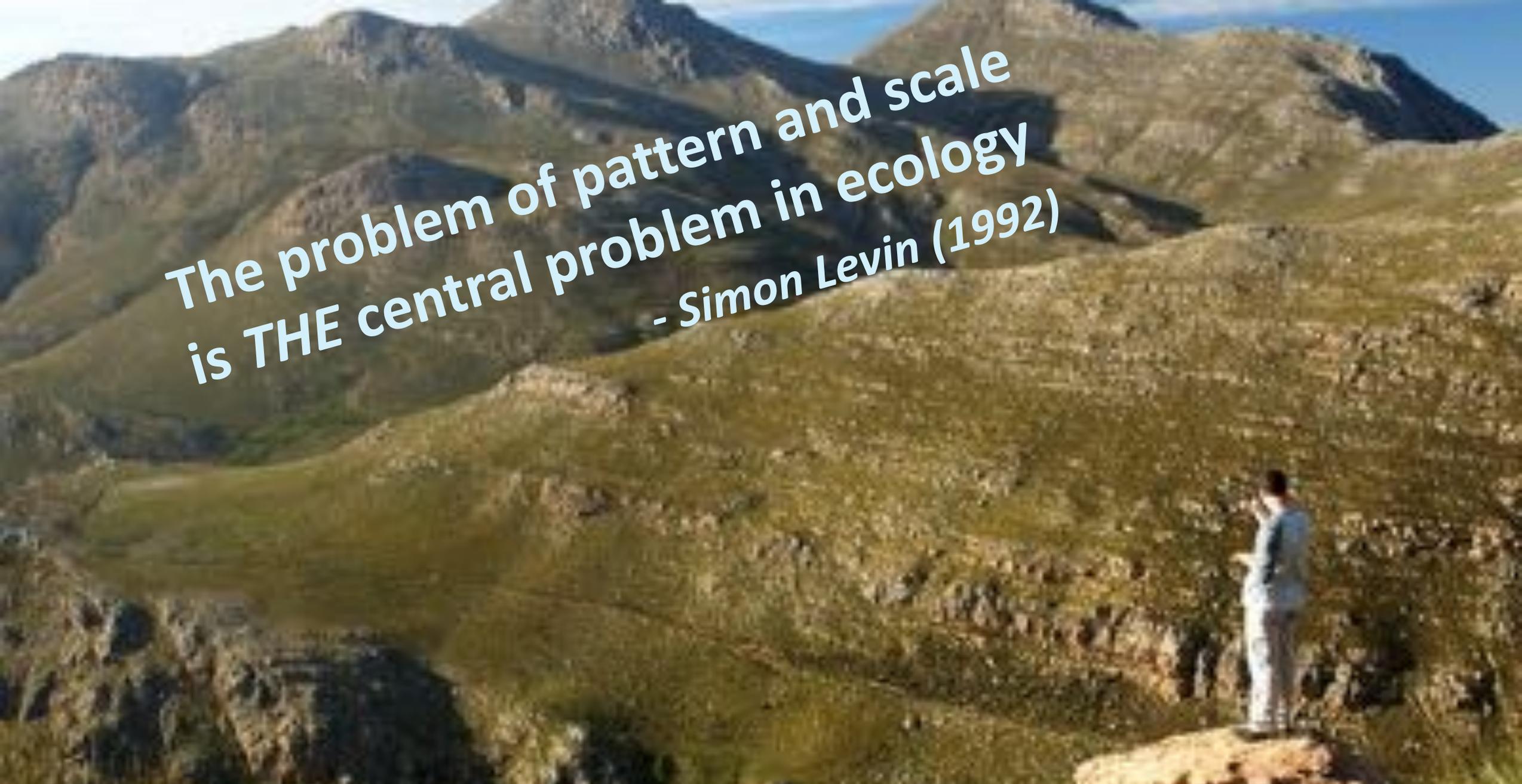
Modeling component

- Community Simulation
- Ecological modeling

Outreach / Community / Social

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



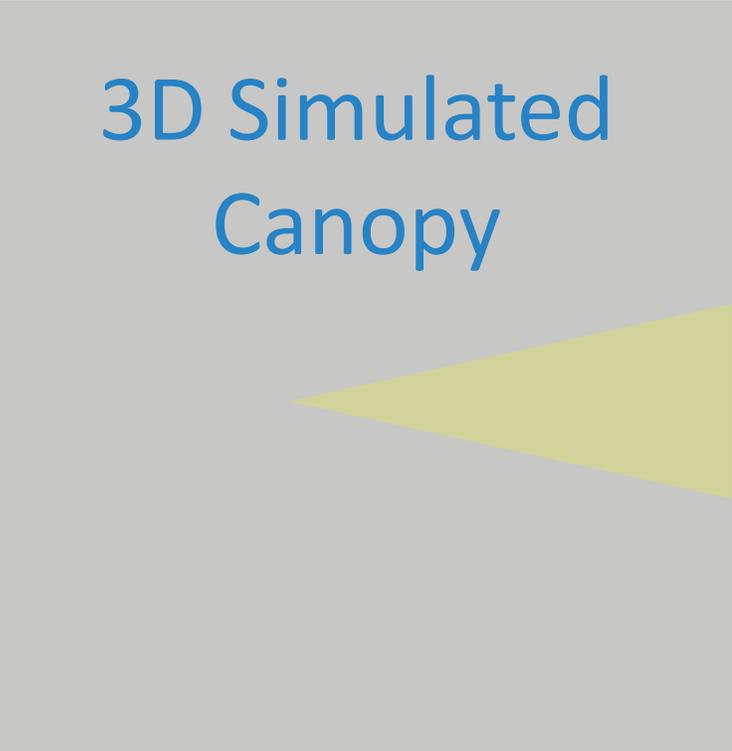
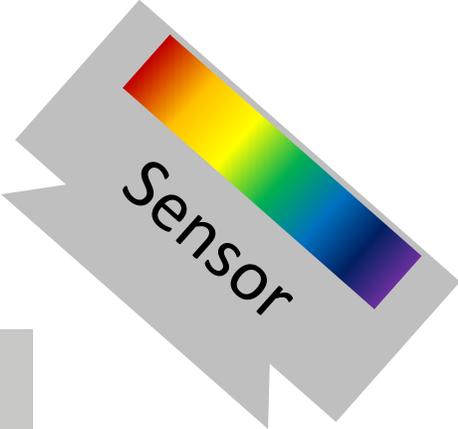
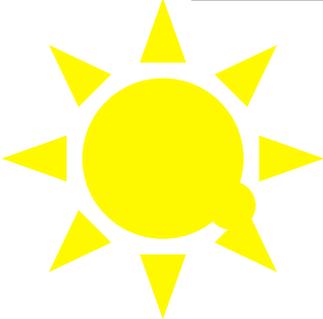


The problem of pattern and scale
is **THE** central problem in ecology
- Simon Levin (1992)

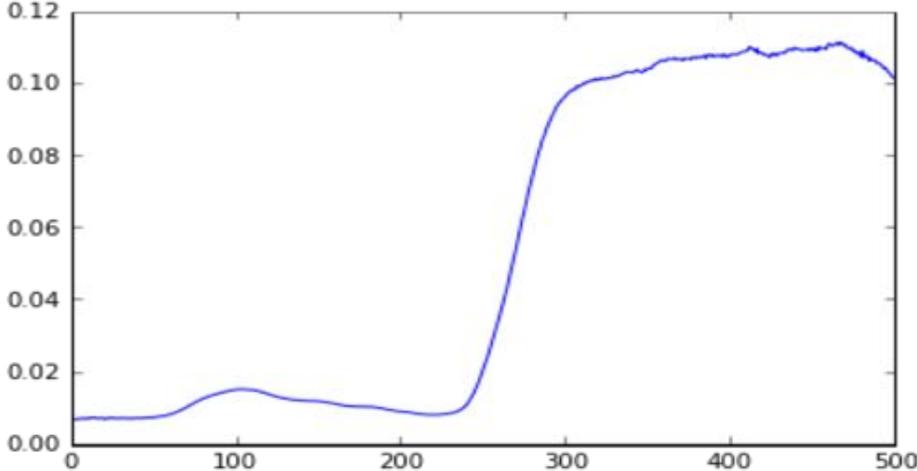
Canopy Reflectance Simulation with ray tracing



Van Leeuwen



Simulated hyperspectral reflectance for each pixel

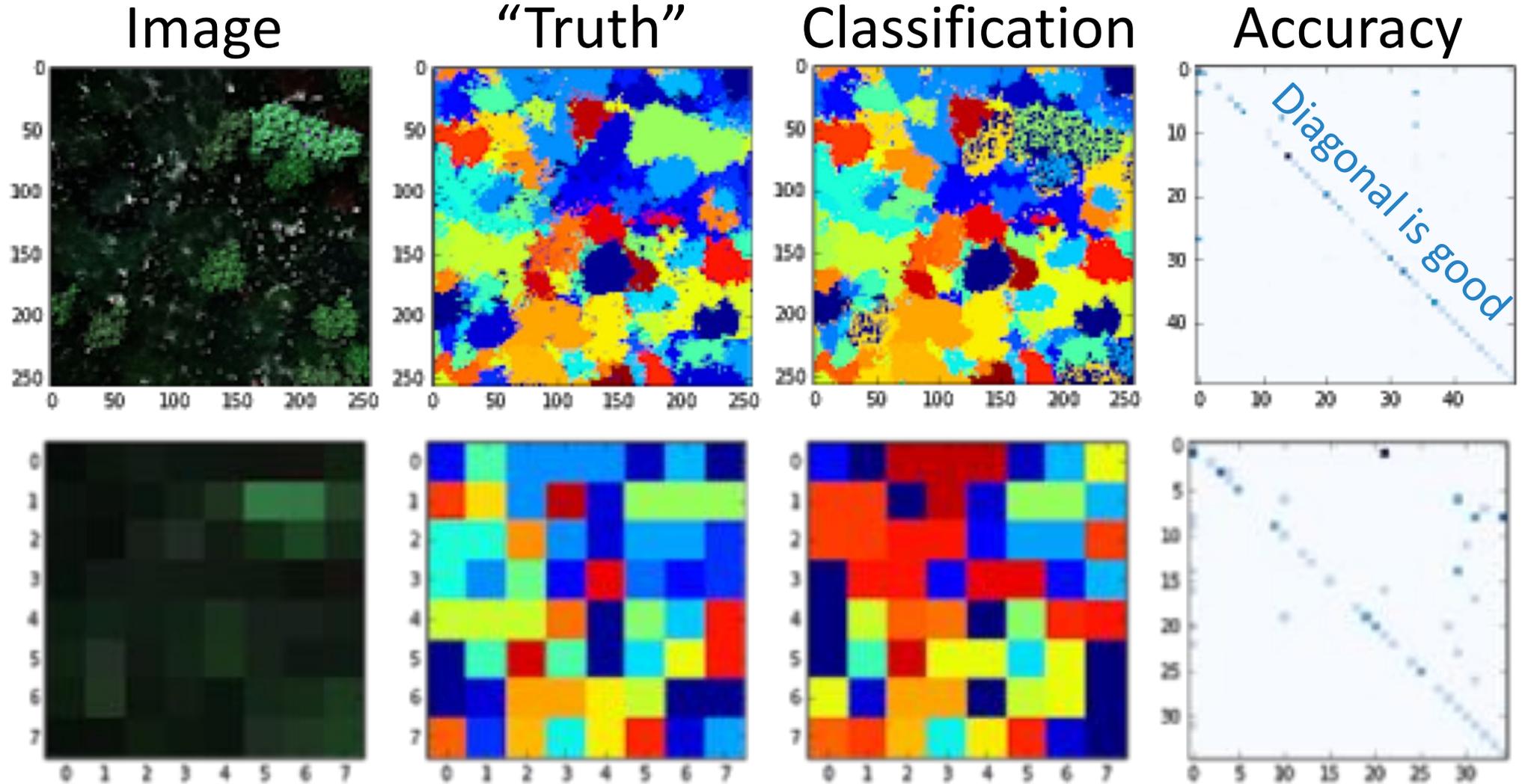


Biodiversity observation scaling relationships



Van Leeuwen

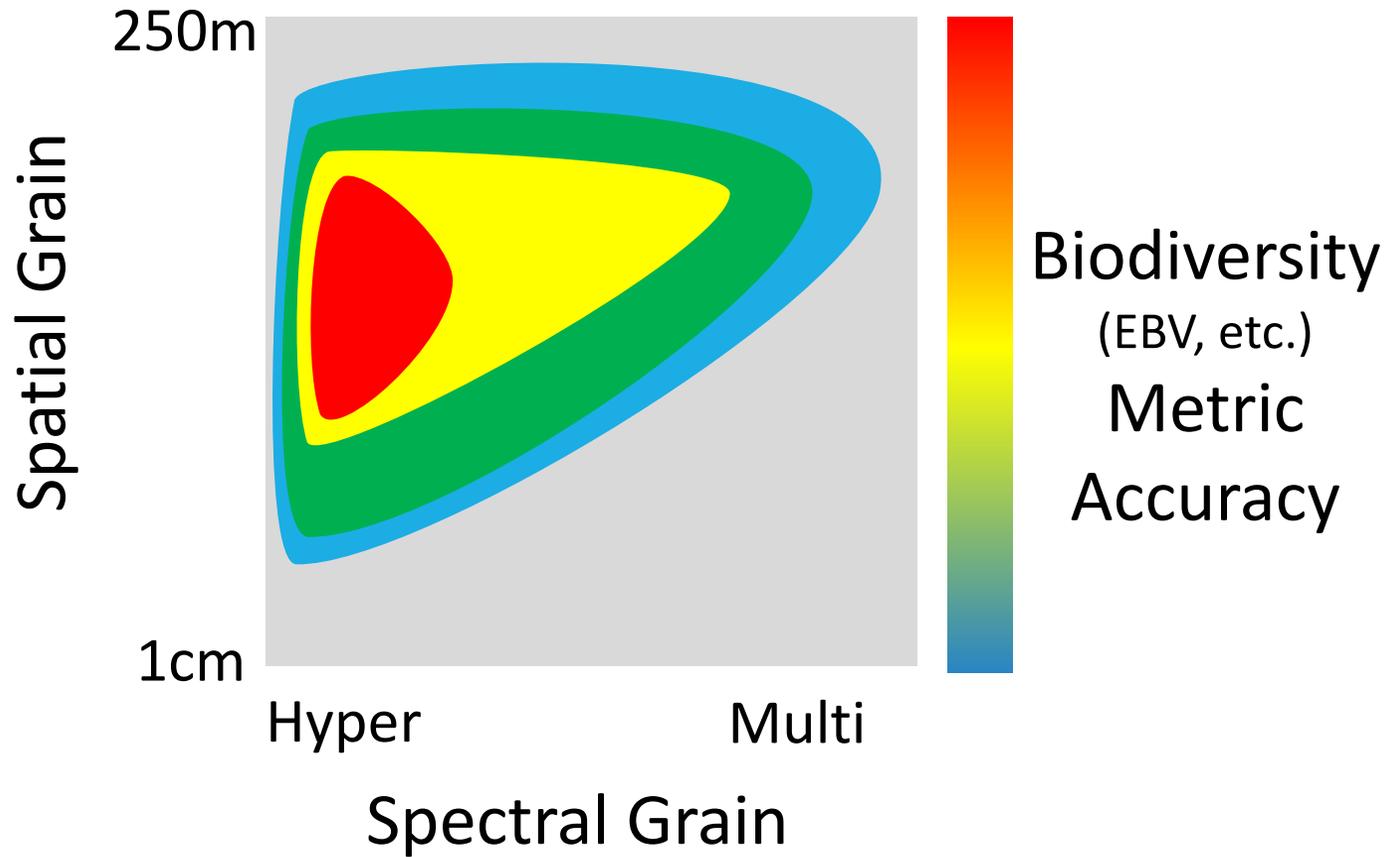
Explore Effects of Spectral & Spatial Grain





Importance of (spectral and spatial) grain

Van Leeuwen



Science Themes

& Products



Biodiversity Distribution & Abundance

- Direct Observation of Indicator Species **EBV**
- Inferred through distribution modeling **EBV**
- Taxonomic Diversity / Functional Diversity **EBV**



Drivers and Mechanisms of Change

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- Ecological Theory (Trait Driver Theory)



Impacts of Biodiversity Change

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- Feedbacks: climate & wildfire

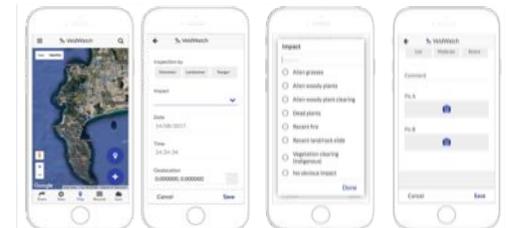
GEO BON EBVs



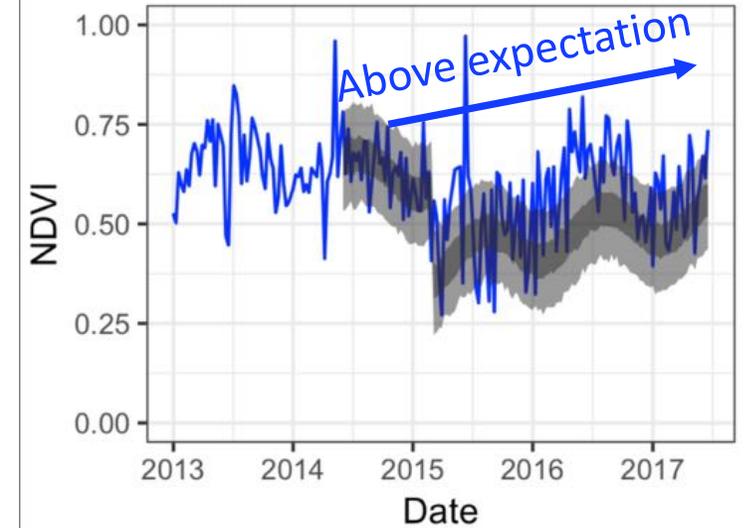
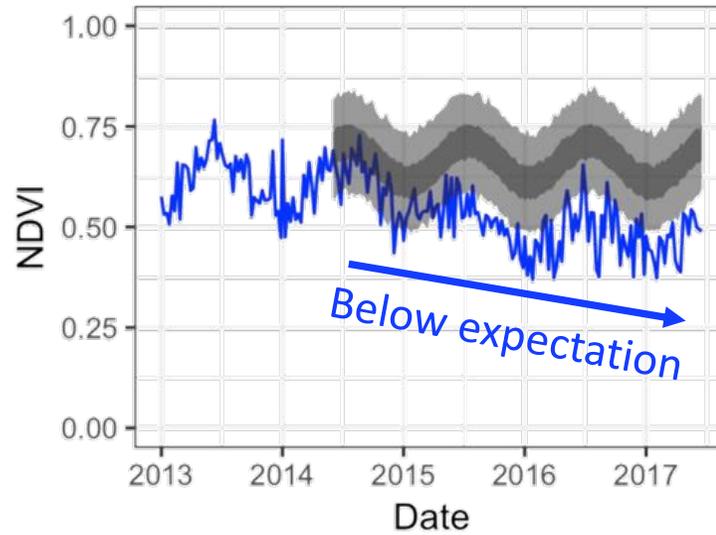
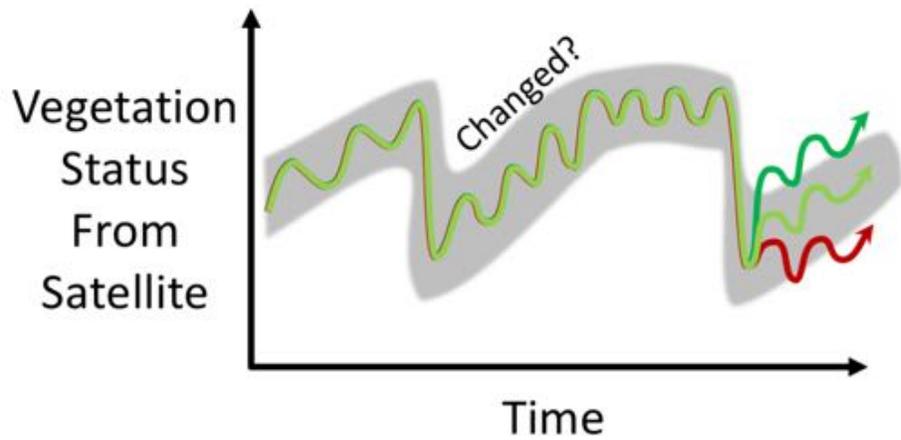
Ecosystem Monitoring for Management



Citizen Science / Engagement



Observation and monitoring system to support research and management

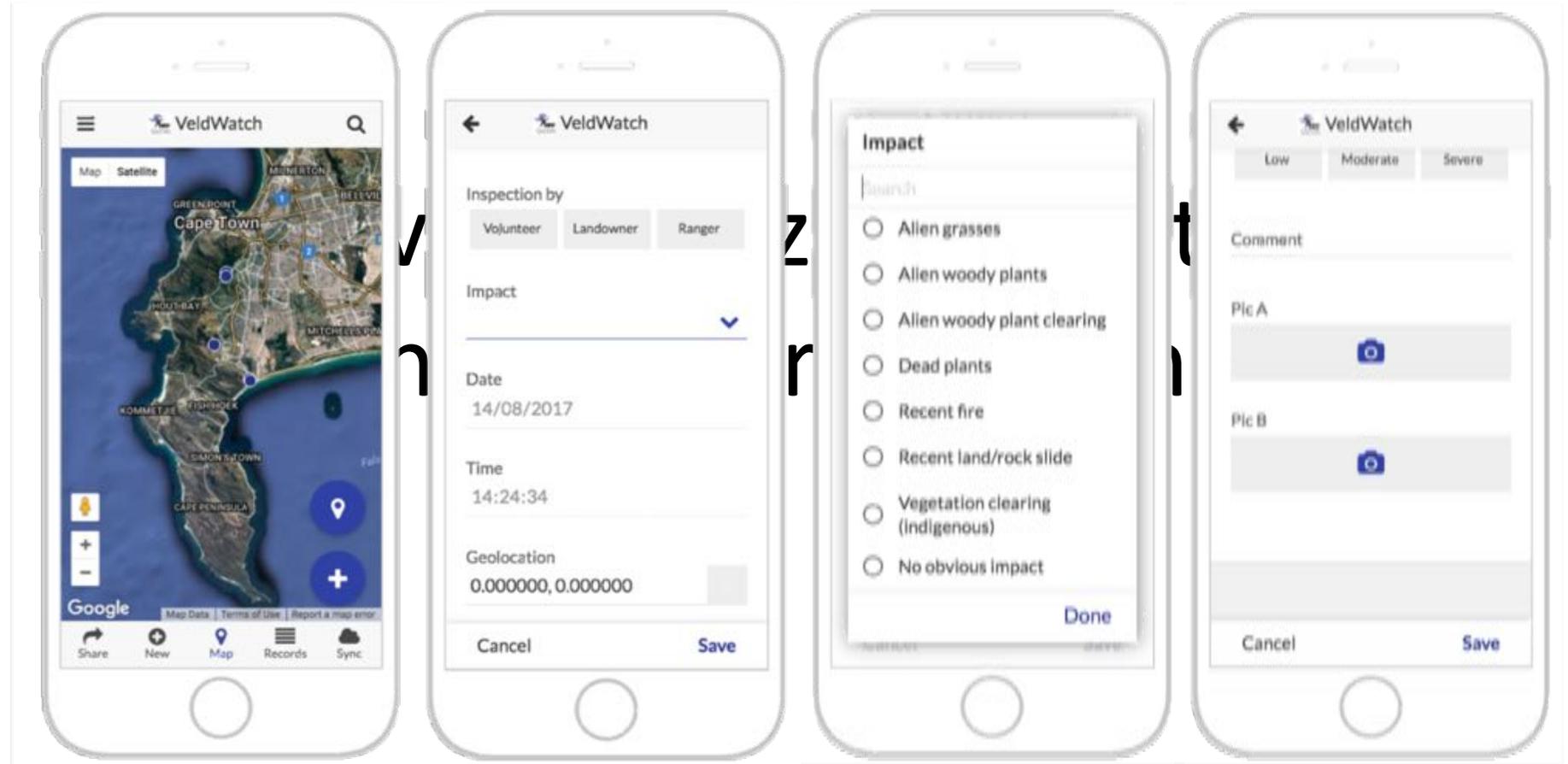


Shrub Mortality due to drought



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

Citizen Scientists: VeldWatch App

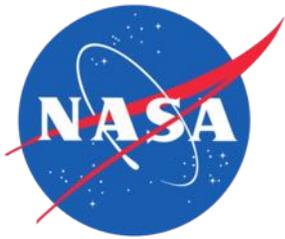
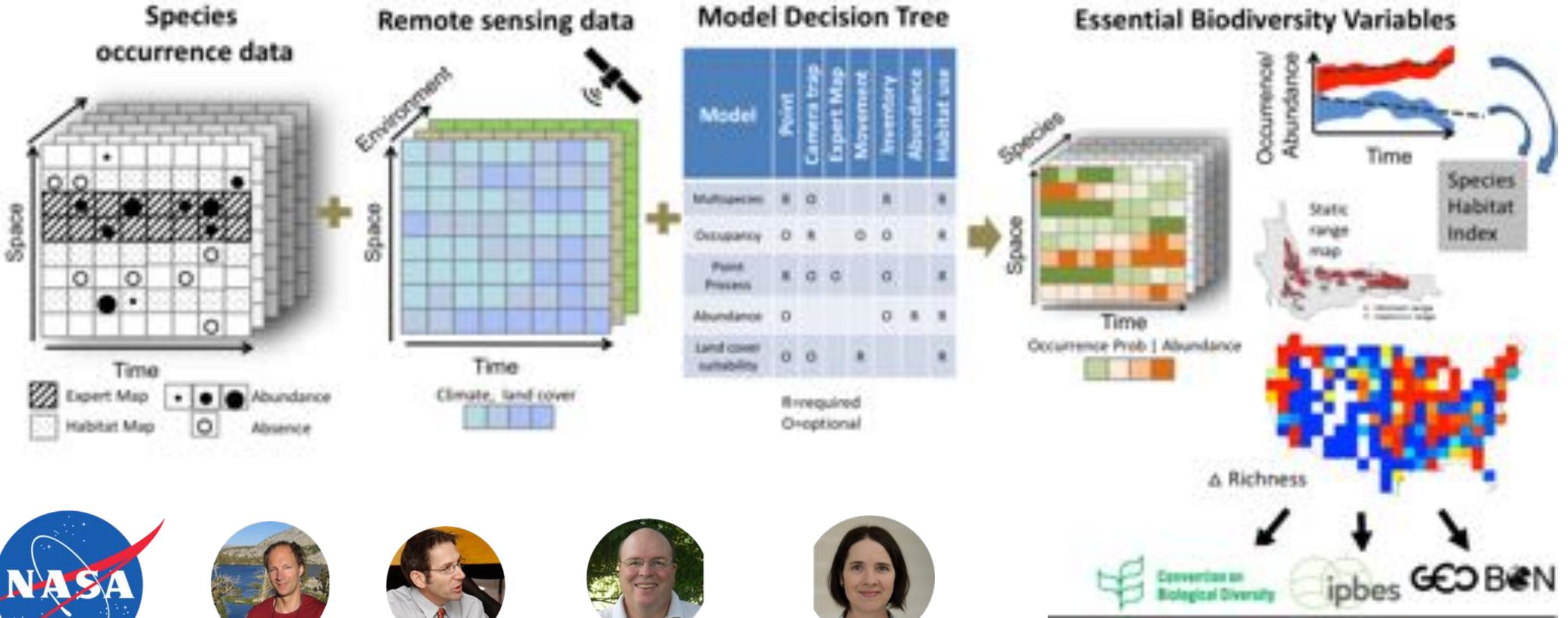


Location

Impact

Photo / Note

Connections to new NASA Project: Remotely sensed change metrics to inform Essential Biodiversity Variables (EBVs)



Jetz (Yale)



Guralnick (UF)



McShea (SI)



McGeosh (Monash)

Timeline





Thank you!

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adamwilson.us/CFR_Biodiversity



University at Buffalo
The State University of New York
Department of Geography



SAEON

South African Environmental
Observation Network