

Global change, community assembly and ecosystem function (in Fynbos)

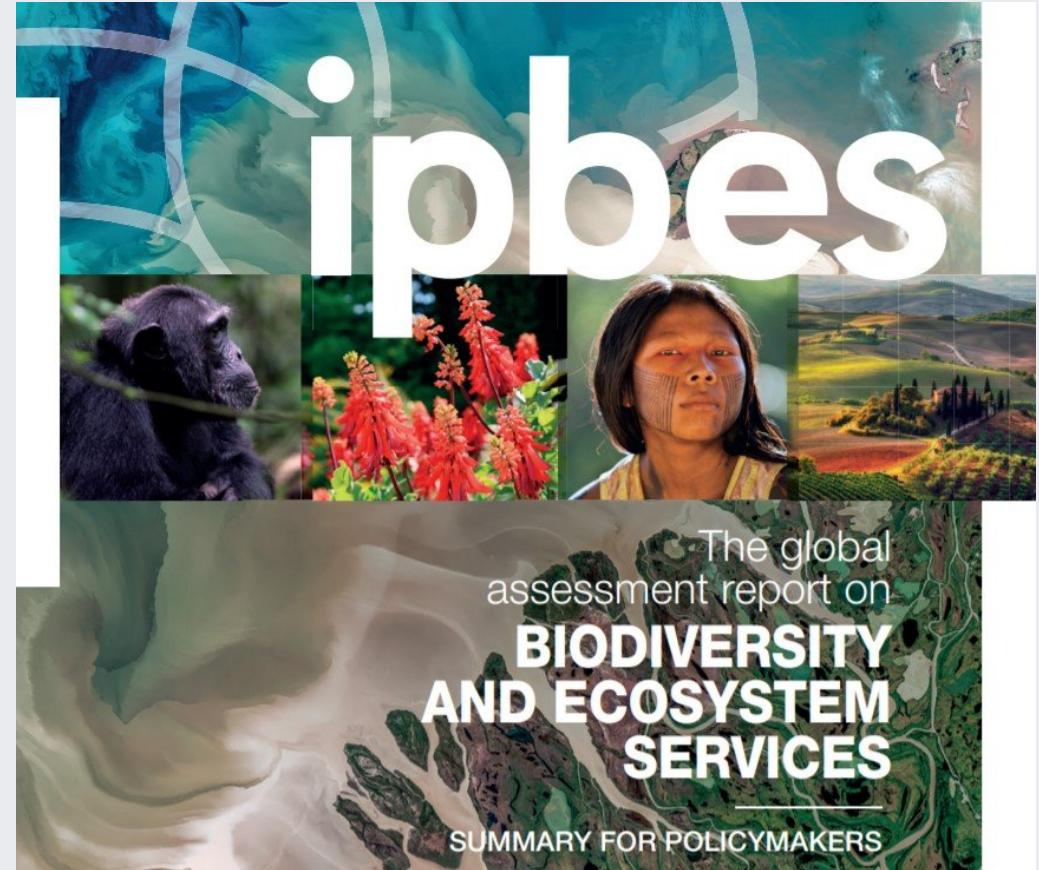
Jasper Slingsby, BIO3018F

2023-05-10

We depend on biodiversity...

There is growing focus on the importance of biodiversity for our survival

Large global initiatives like the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) focus on strengthening the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development

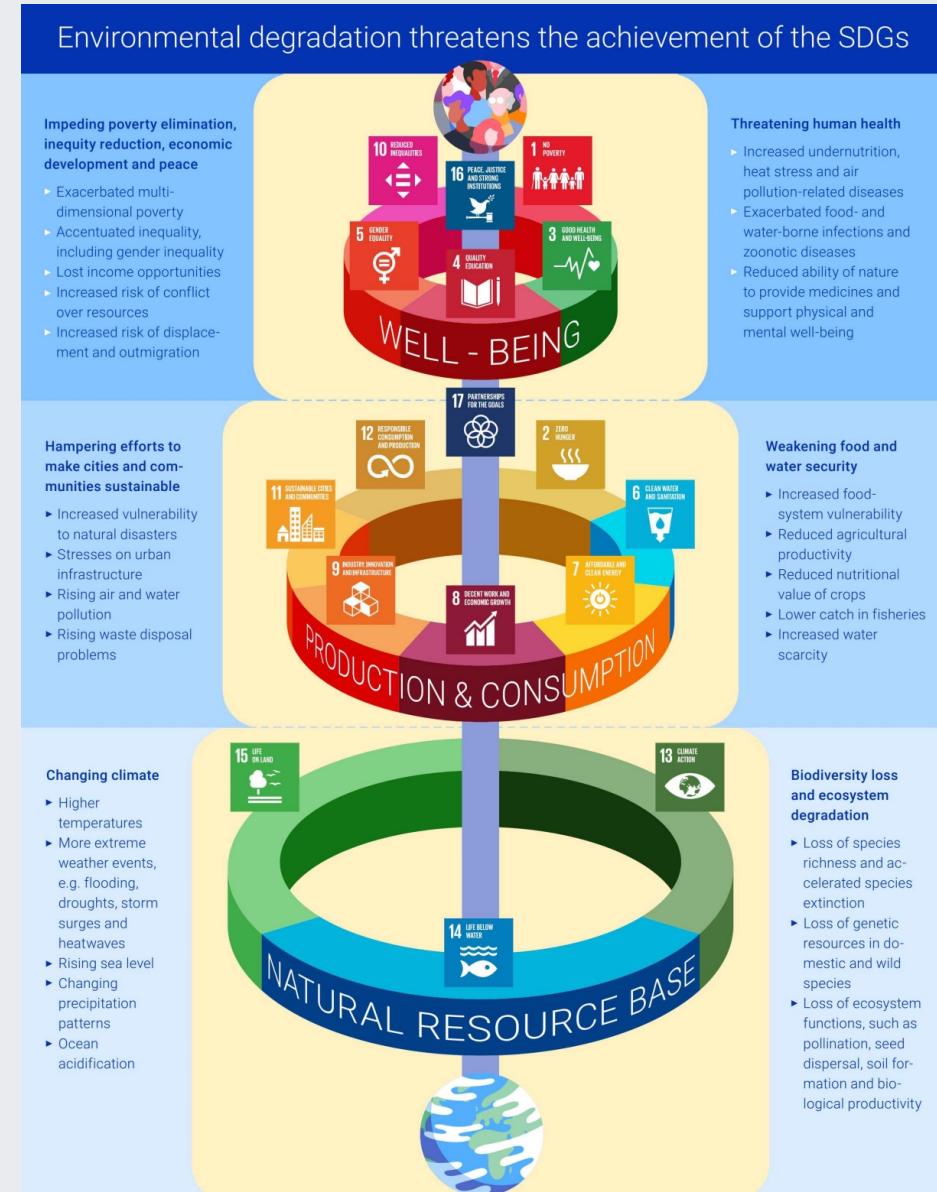


<https://ipbes.net/global-assessment>

We depend on biodiversity...

Attainment of the Sustainable Development Goals (SDGs) depends on the attainment of the goals relating to natural resource management, namely:

- SDG 13 Climate Action
- SDG 14 Life Below Water
- SDG 15 Life On Land



<https://www.unep.org/resources/making-peace-nature>

My research focuses on...

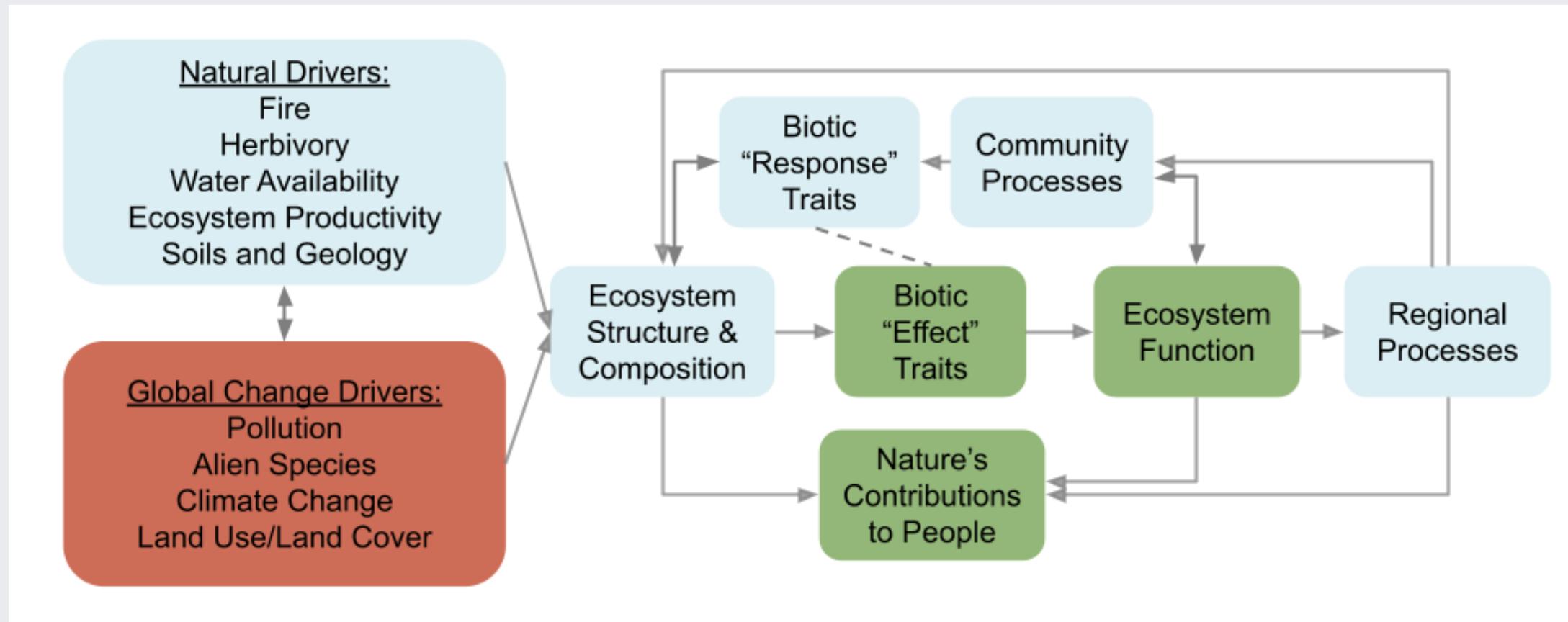
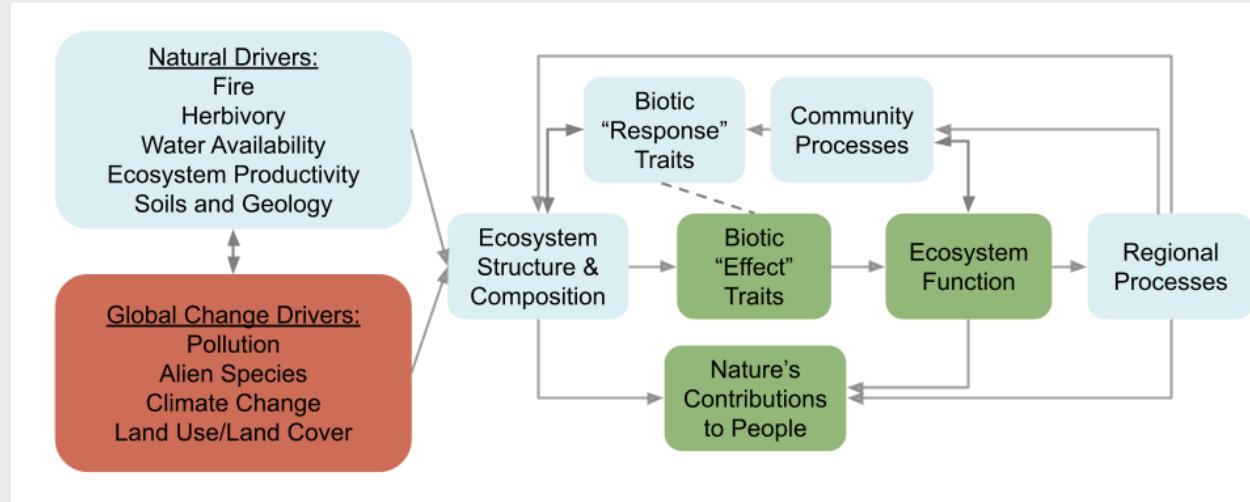


Figure modified from Chapin et al. 1997, *Science* and Slingsby et al. 2014

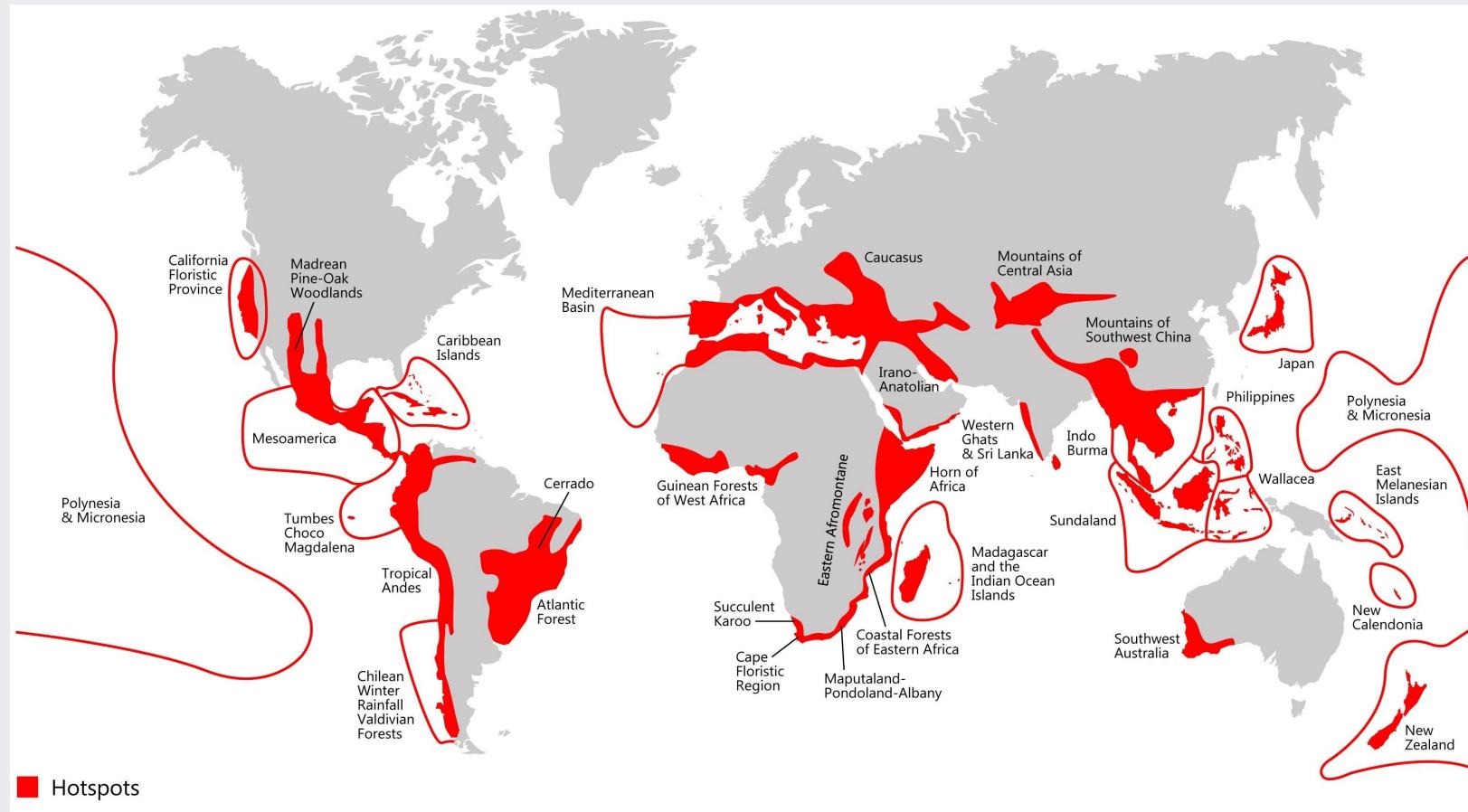
My research focuses on four questions...



1. What determines the composition and diversity of communities and ecosystems at various scales?
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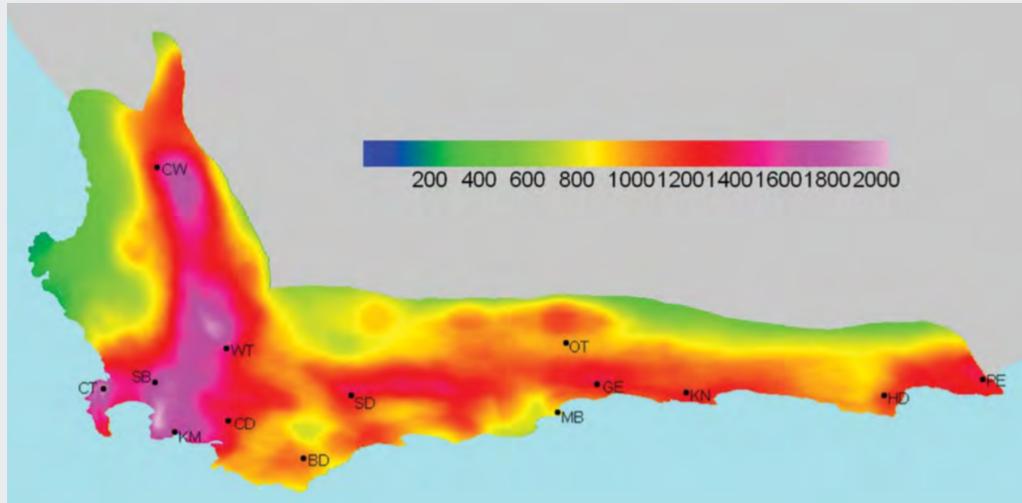
From Chapin et al. 1997, *Science* and Slingsby et al. 2014

I mostly work in the Cape Floristic Region, a Global Biodiversity Hotspot

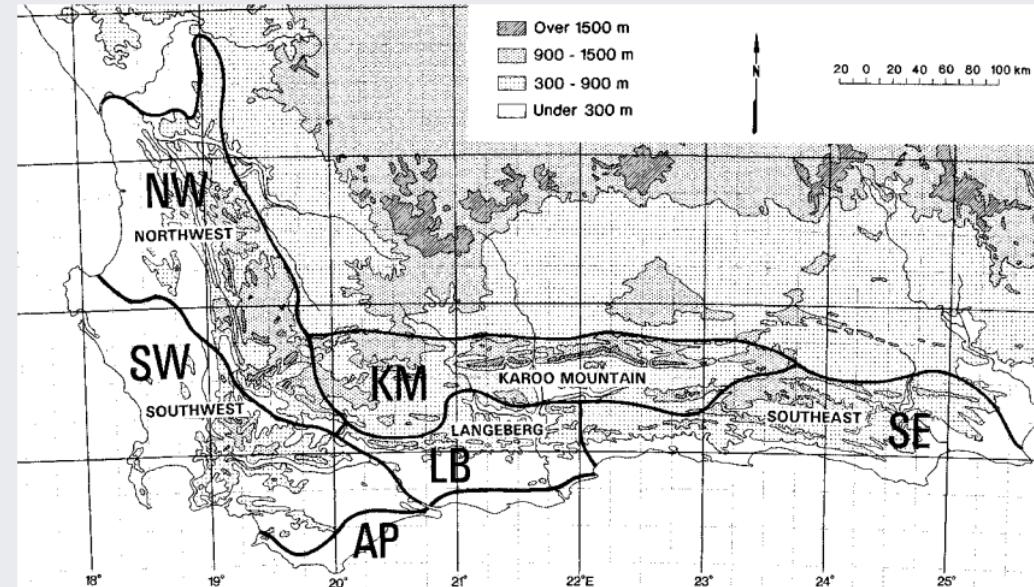


Myers et al. 2001; <https://www.conservation.org/priorities/biodiversity-hotspots>

Fynbos diversity...



- ~9500 vascular plant species in the Cape Flora
- ~2200 native species on the Cape Peninsula alone
- only 1390 native species in the entire Great Britain and Ireland (~3 x CFR area!)



- ~70% endemic to CFR
- Many narrow endemics (e.g. one peak)
- ~40% of all species occur in only 1 phytoregion!

Freiberg and Manning 2013

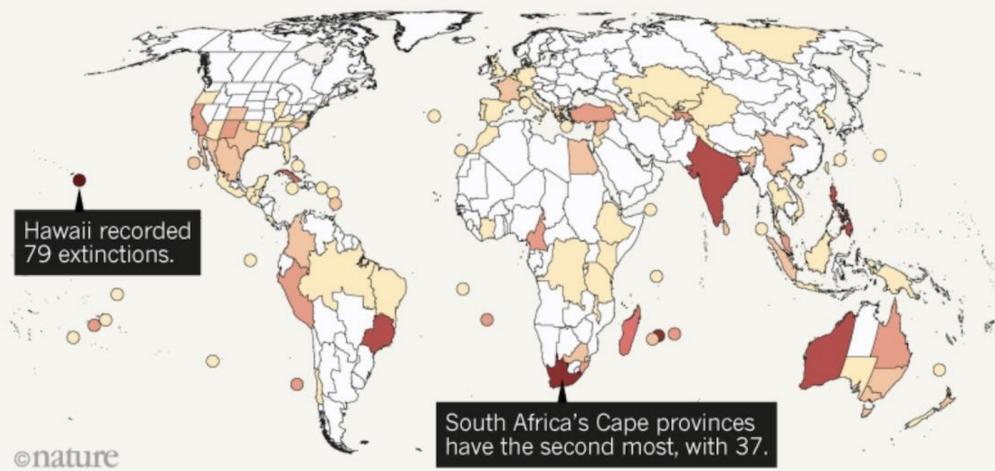
Freiberg and Manning 2013

Sadly, the CFR is also an extinction hotspot...

EXTINCTION PATTERN

The number and locations of seed-bearing plant species that have disappeared since 1900.

□ 0 □ 1-2 □ 3-5 □ 6-10 □ 11-20 □ 21-30 □ 31-40 □ 41-79



- 37 documented plant extinctions
 - 13 in Cape Town
- ~13% of all threatened plant species on the planet
 - 1868 of 14360 on the red list (2019)
- Another 1506 considered Rare or Critically Rare
 - few populations, but no current threats
 - any threat and they shift to EN or CR

1. The composition and diversity of Fynbos ecosystems



1. The composition and diversity of Fynbos ecosystems



- Dominated by a few lineages that have diversified dramatically within the region
 - *Erica* (~650 spp)
 - Fabaceae (~750 spp)
 - Rutaceae (~300 spp)
 - Proteaceae (~320 spp)
 - Poaceae (~ 200 spp)
 - Restionaceae (~300 spp)
 - Cyperaceae (~200 spp)
 - Iridaceae (~650 spp)
 - Orchidaceae (~250 spp)
 - Aizoaceae (~650 spp)
 - Asteraceae (~1000 spp)
 - Scrophulariaceae (~400 spp)

1. The composition and diversity of Fynbos ecosystems



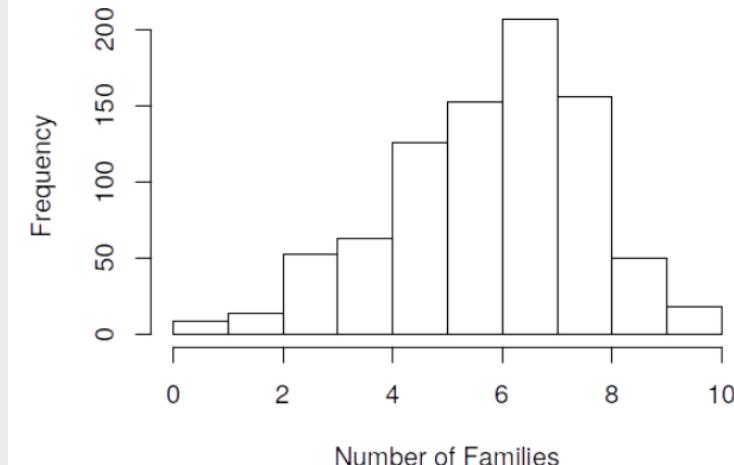
Phylogenetically and functionally similar across huge variation in climate, soils etc.

1. The composition and diversity of Fynbos ecosystems

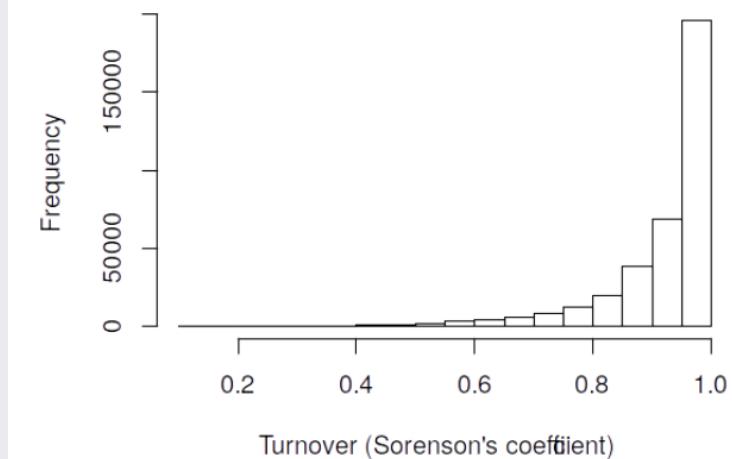


- Most communities are dominated by the same 10 or so lineages
- Sister species look similar, and have similar *effects* in the environment in terms of ecosystem function (carbon, hydrology, fire, etc), but must be *responding* differently to occur in such different environments

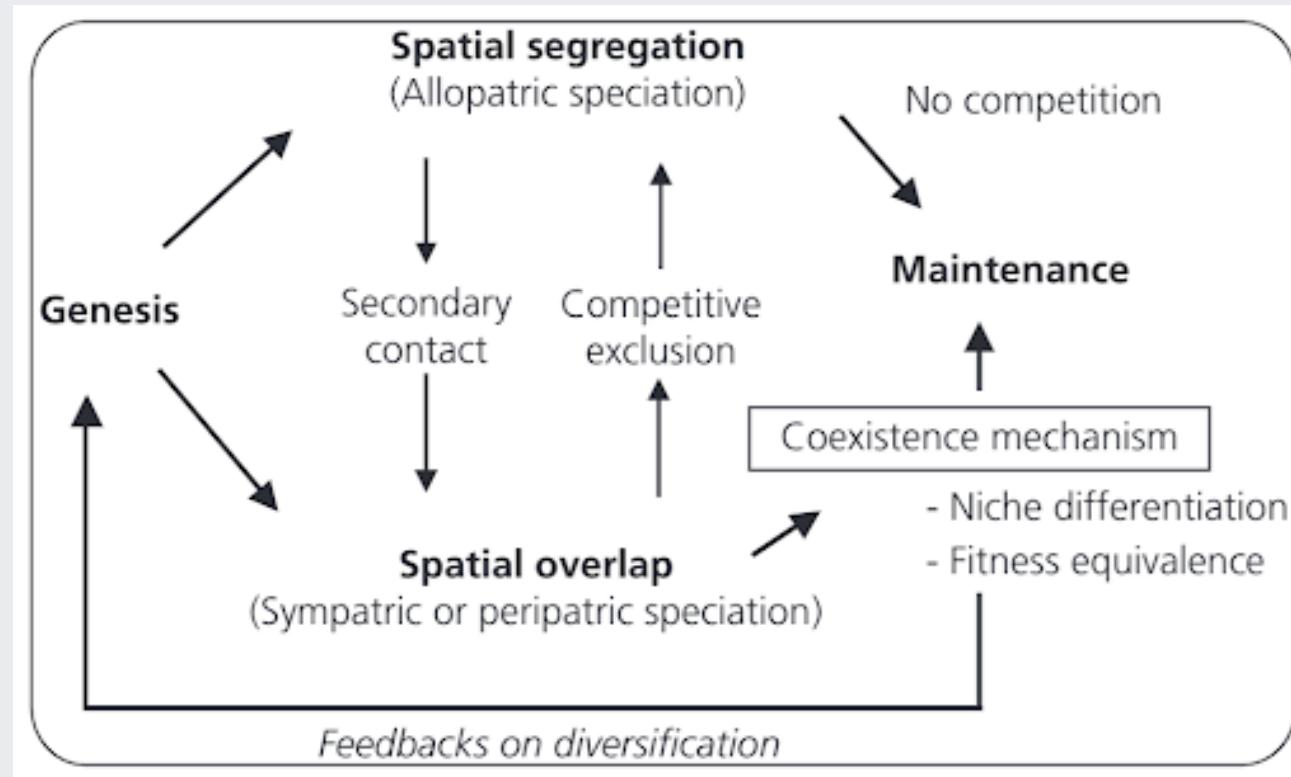
Frequency of the top 10 families across ~850 relevés across the CFR
(Mean = 6.27, Median = 7) (Slingsby unpubl.)



Species turnover across the same plots
(Mean = 0.93, Median = 0.97)



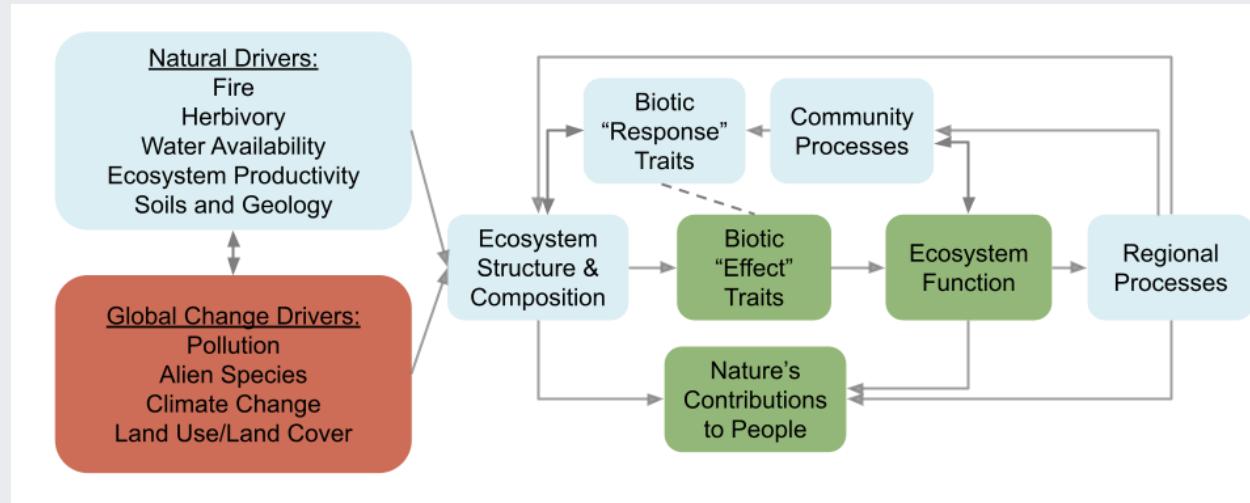
1. The composition and diversity of Fynbos ecosystems



A predominance of speciation in allopathy, with minimal functional divergence?

Slingsby et al. 2014

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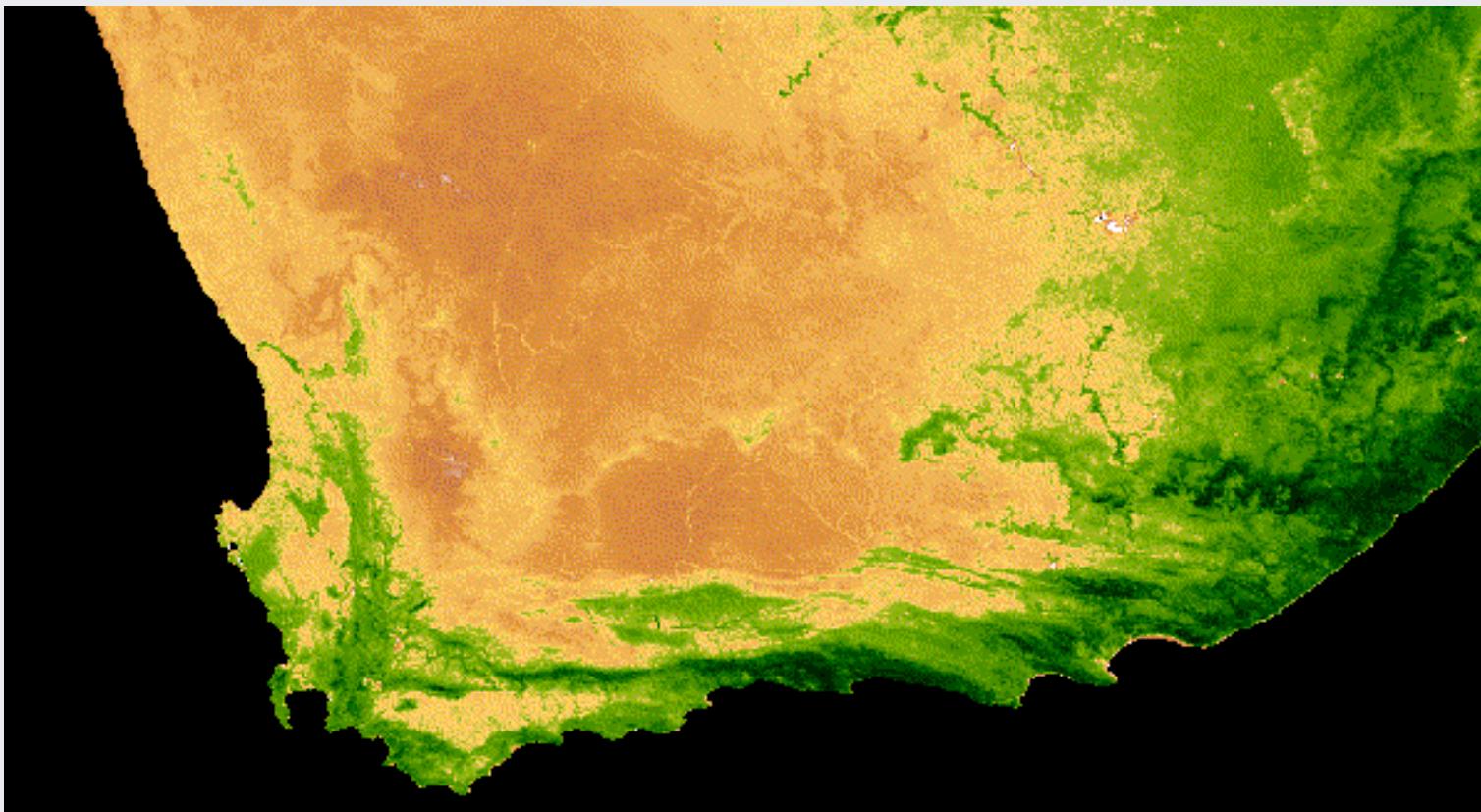
From Chapin et al. 1997, *Science* and Slingsby et al. 2014

2. Biodiversity and the function of Fynbos ecosystems?



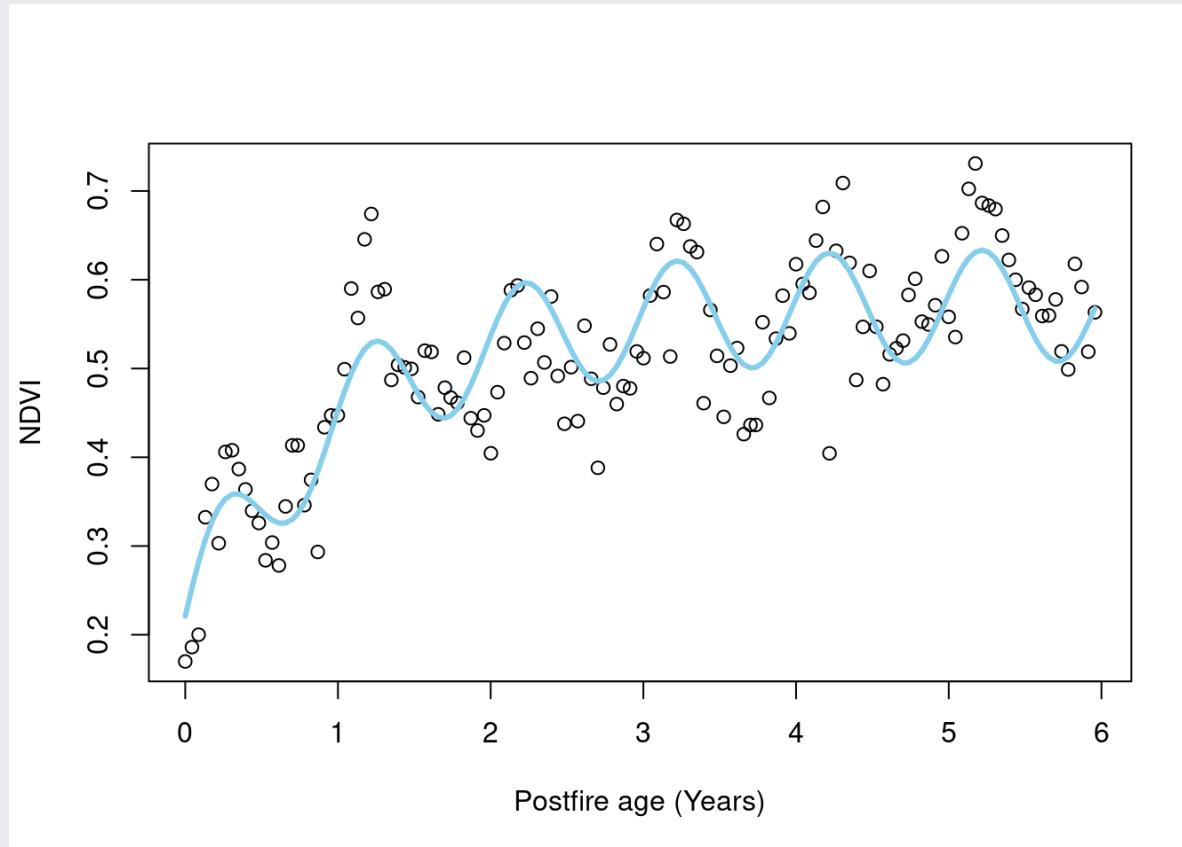
Post-fire recovery

2. Biodiversity and the function of Fynbos ecosystems?



Seasonality

2. Biodiversity and the function of Fynbos ecosystems?



A post-fire timeseries of the Normalized Difference Vegetation Index (NDVI) for one location

2. Biodiversity and the function of Fynbos ecosystems?

Hypothetical curves of various ecosystem functions based on information from a range of sources, see book chapter. The temporal range spans c.15 yr and any seasonal variation is excluded.

Dominance by indigenous seeders vs sprouters (or presence of woody alien species) affects rate of aboveground carbon gain and a range of hydrology-related ecosystem functions in fynbos.

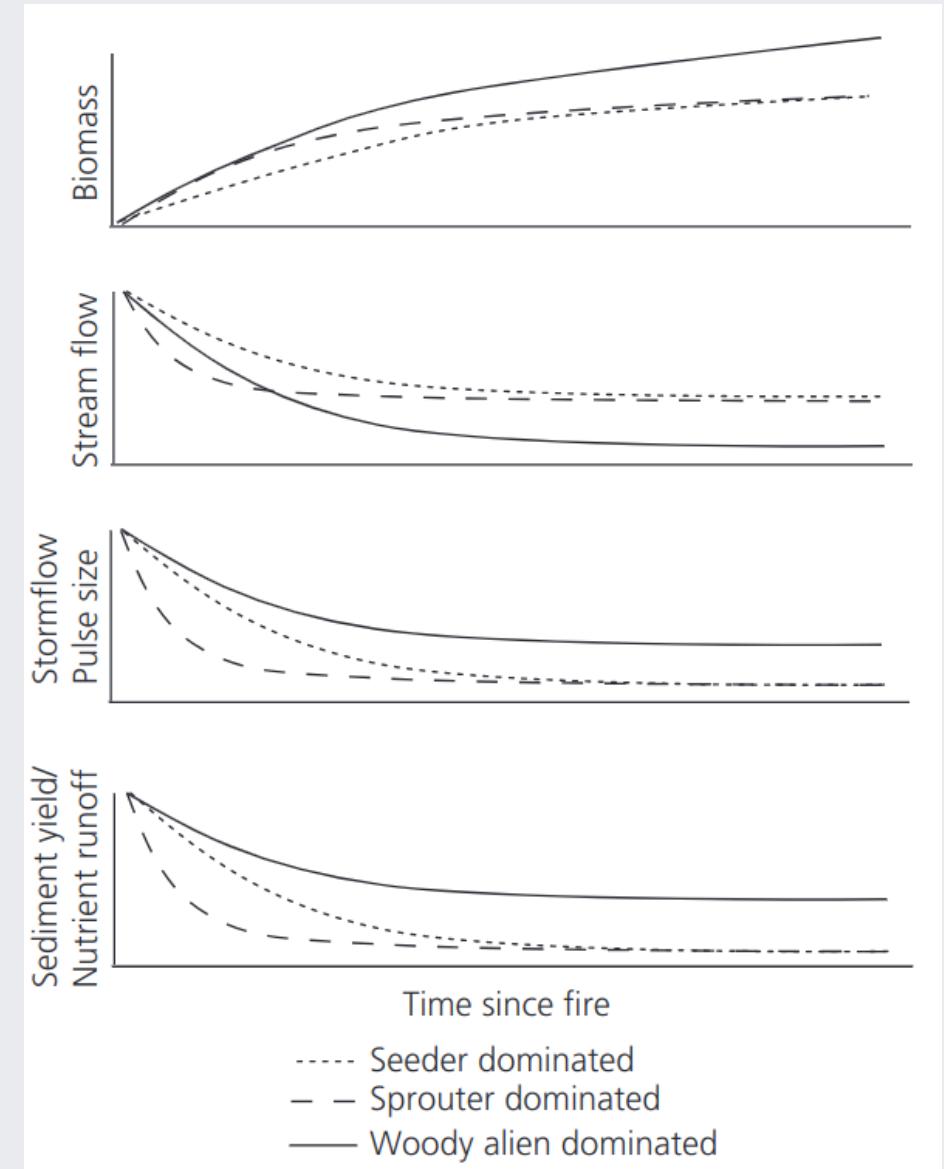
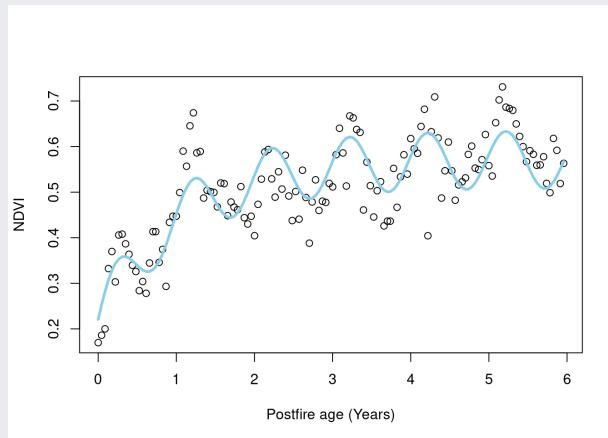


Figure from Slingsby et al. 2014

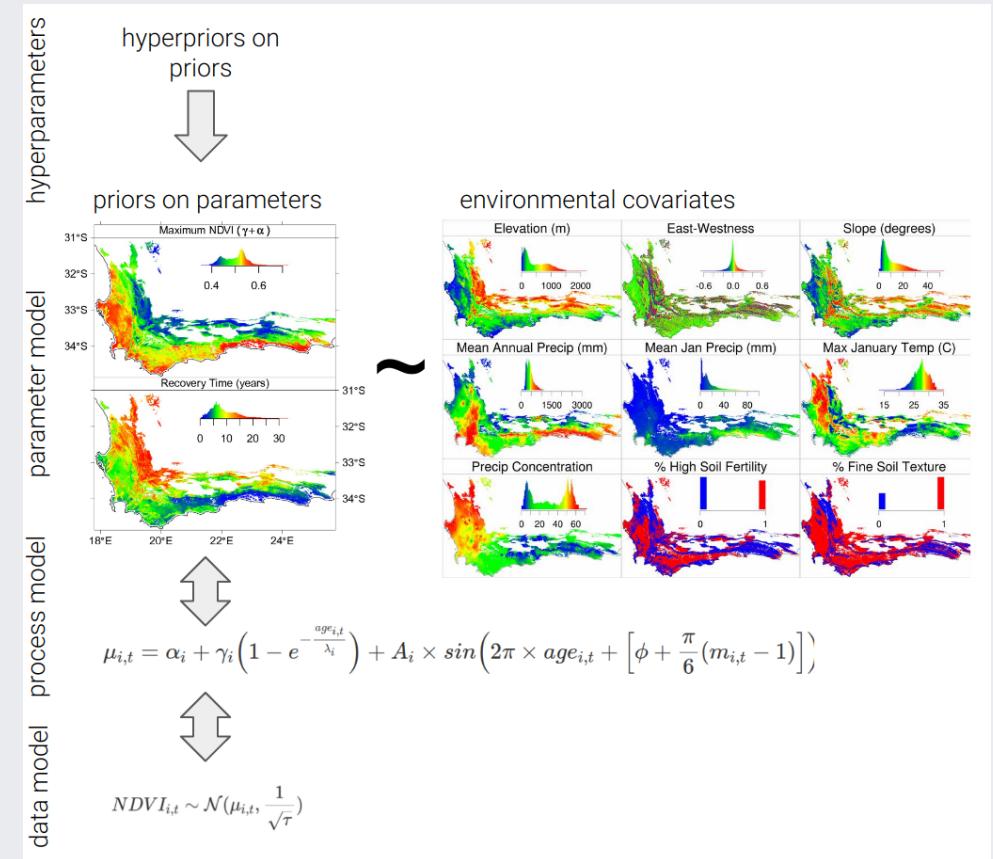
2. Biodiversity and the function of Fynbos ecosystems?

We can look at this empirically by fitting curves to postfire NDVI recovery trajectories.



The curves are defined by a set of parameters ($\alpha, \gamma, \lambda, etc$) that determine the rate of recovery, maximum NDVI, etc.

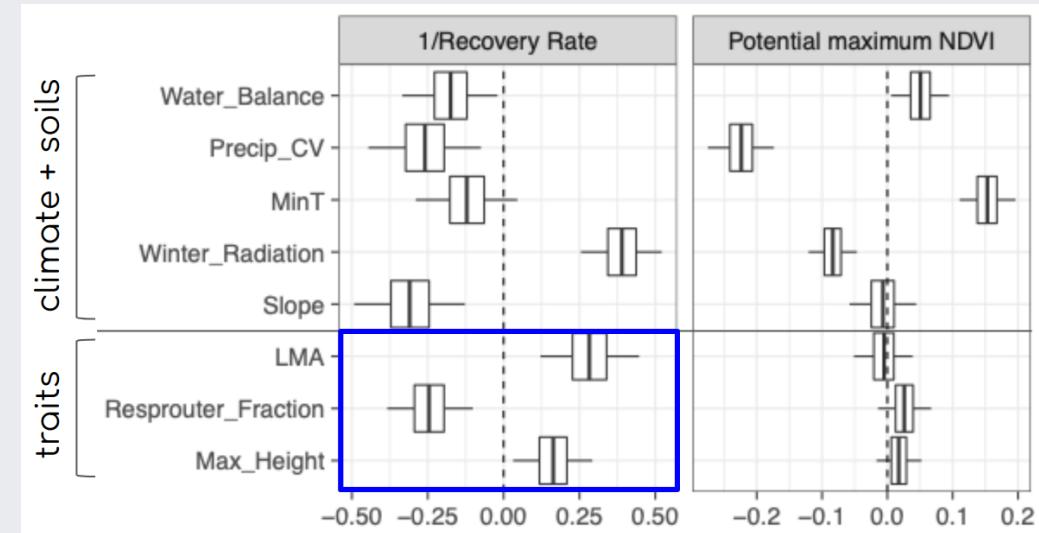
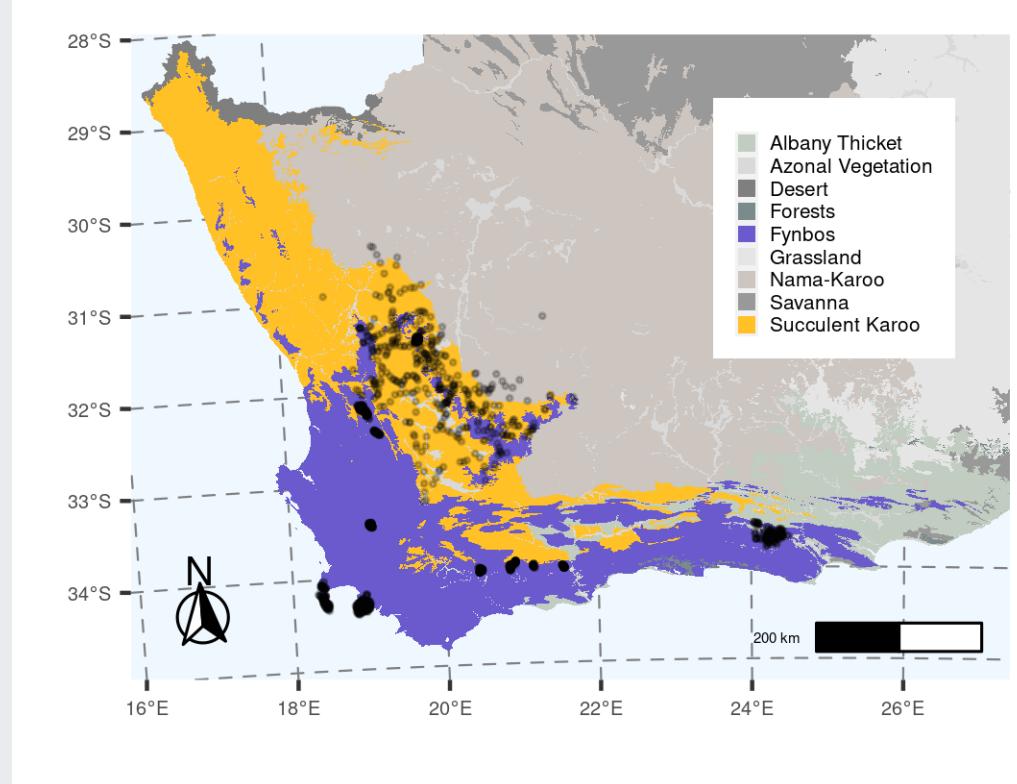
We can also model the parameters as a function of covariates (e.g. soils, climate, topography)



model from Wilson et al. 2015

2. Biodiversity and the function of Fynbos ecosystems?

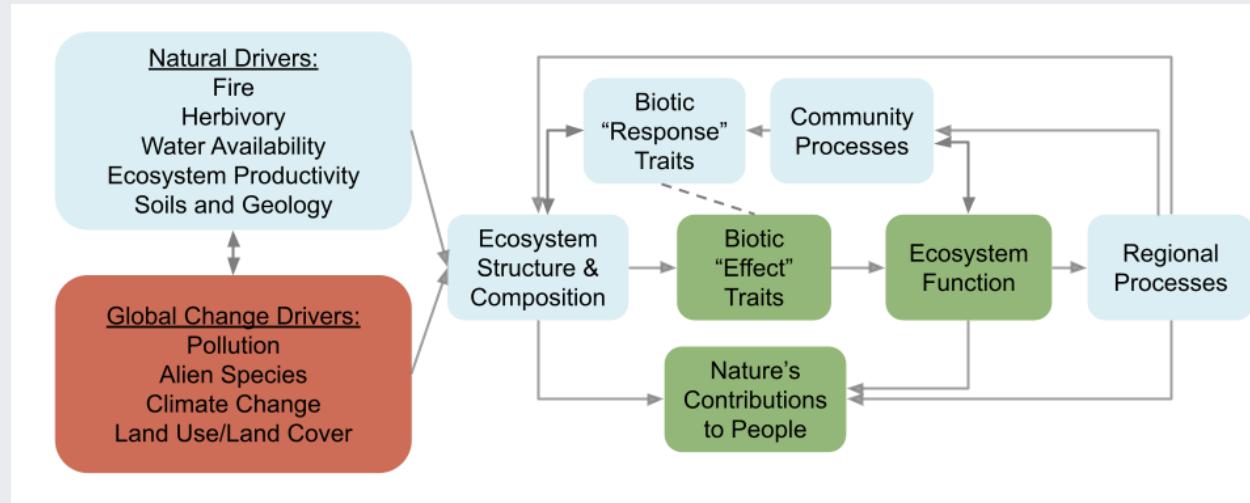
If we look at sites where we have vegetation survey data and information on species traits...



Traits are better predictors of some recovery parameters than soils, climate and topography!

Moncrieff/Slingsby/Wilson in prep

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From Chapin et al. 1997, *Science* and Slingsby et al. 2014

3. Global change and Fynbos?

PNAS

Intensifying postfire weather and biological invasion drive species loss in a Mediterranean-type biodiversity hotspot

Jasper A. Slingsby^{a,b,1}, Cory Merow^{c,d}, Matthew Aiello-Lammens^{d,e}, Nicky Allsopp^a, Stuart Hall^f, Hayley Kilroy Mollmann^g, Ross Turner^g, Adam M. Wilson^h, and John A. Silander Jr.^d

^aFynbos Node, South African Environmental Observation Network, Claremont 7735, South Africa; ^bCentre for Statistics in Ecology, Environment and Conservation, Department of Biological Sciences, University of Cape Town, Rondebosch 7701, South Africa; ^cEcology and Evolutionary Biology, Yale University, New Haven, CT 06511; ^dEcology and Evolutionary Biology, University of Connecticut, Storrs, CT 06269-3043; ^eEnvironmental Studies and Science,

A 44-year repeat vegetation survey at Cape Point



Slingsby et al. 2017

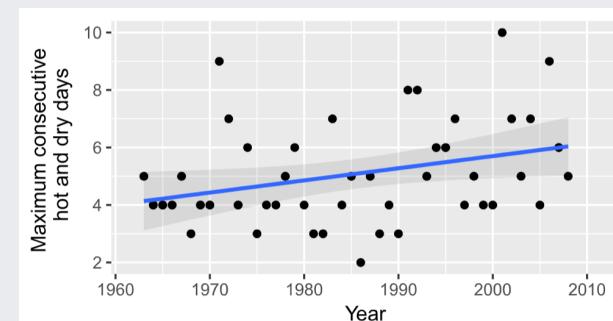
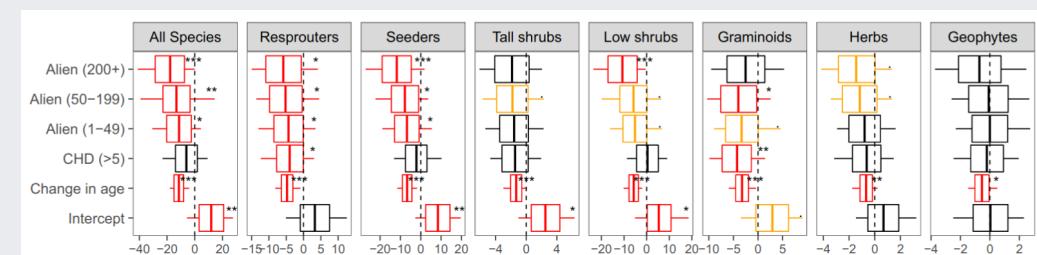


Fig. 1. The maximum CHD at the Cape Point Global Atmospheric Watch Station for the Austral summer for the years 1963–2009. These were days where the temperature exceeded the 0.9 quantile of the record (21°C) and rainfall was $<1\text{ mm}$.

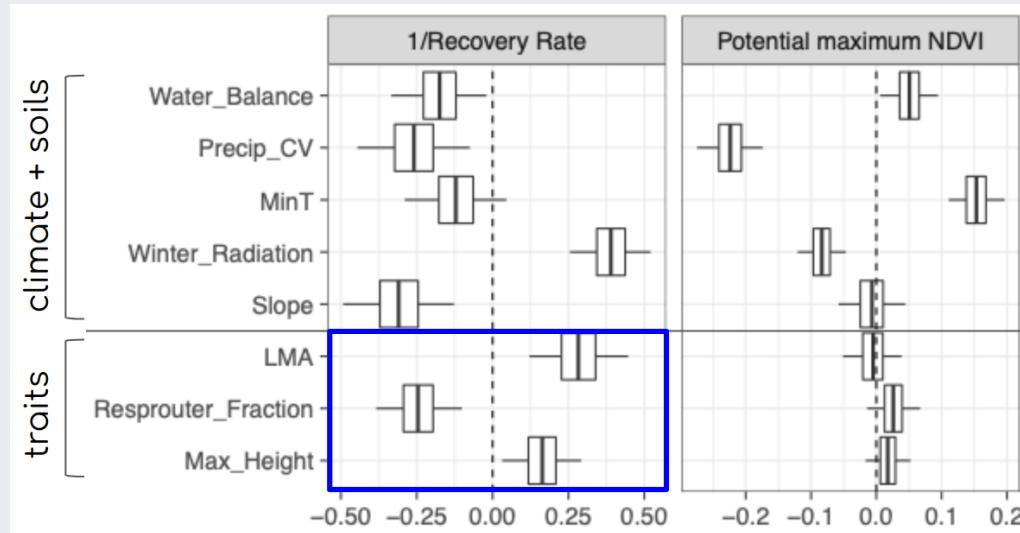
Annual max consecutive hot and dry days (CHD) increased



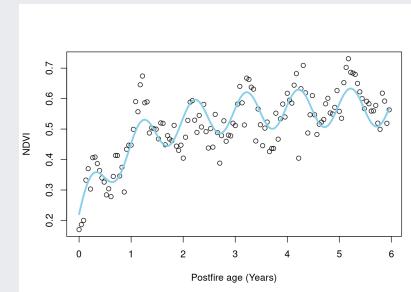
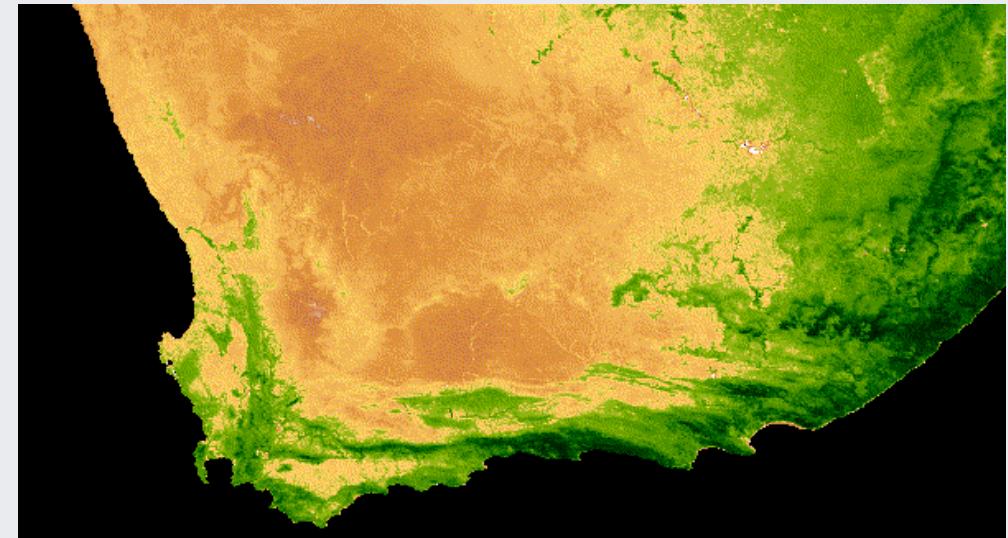
Plots that experienced higher CHD in the first year after fire lost species

Resprouters and graminoids (low stature, high LMA) were the worst affected

3. Global change and Fynbos?



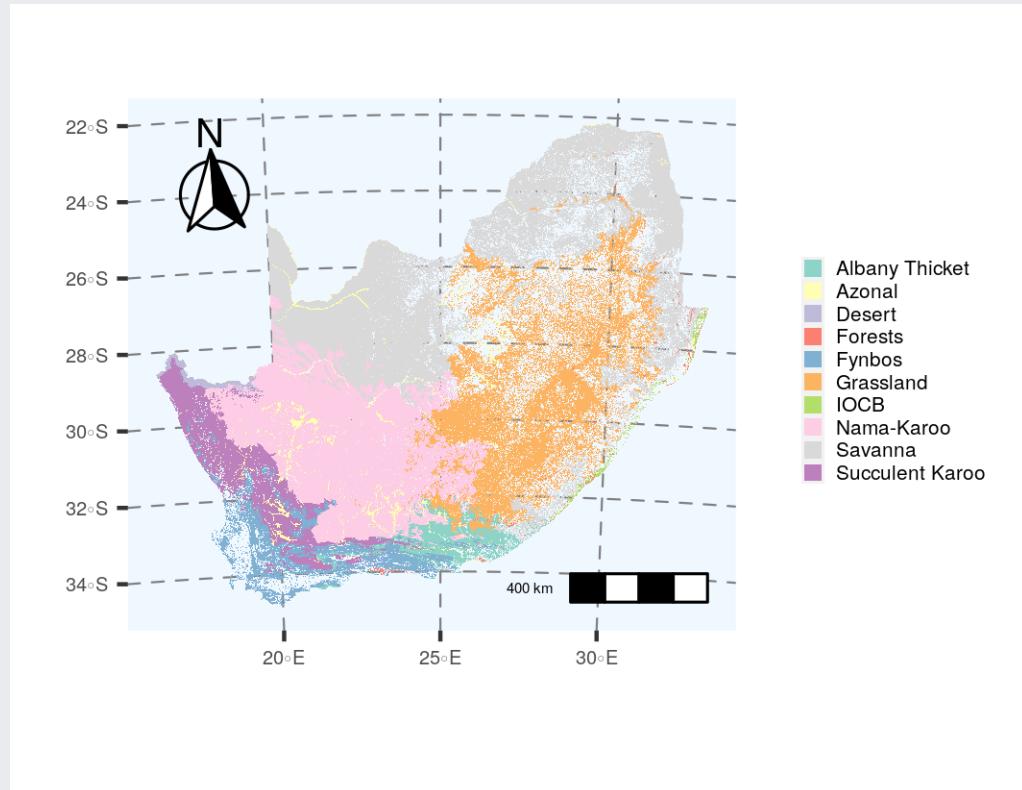
Predicts slower post-fire recovery?



Moncrieff/Slingsby/Wilson in prep

3. Global change and Fynbos?

Loss and fragmentation of habitat...



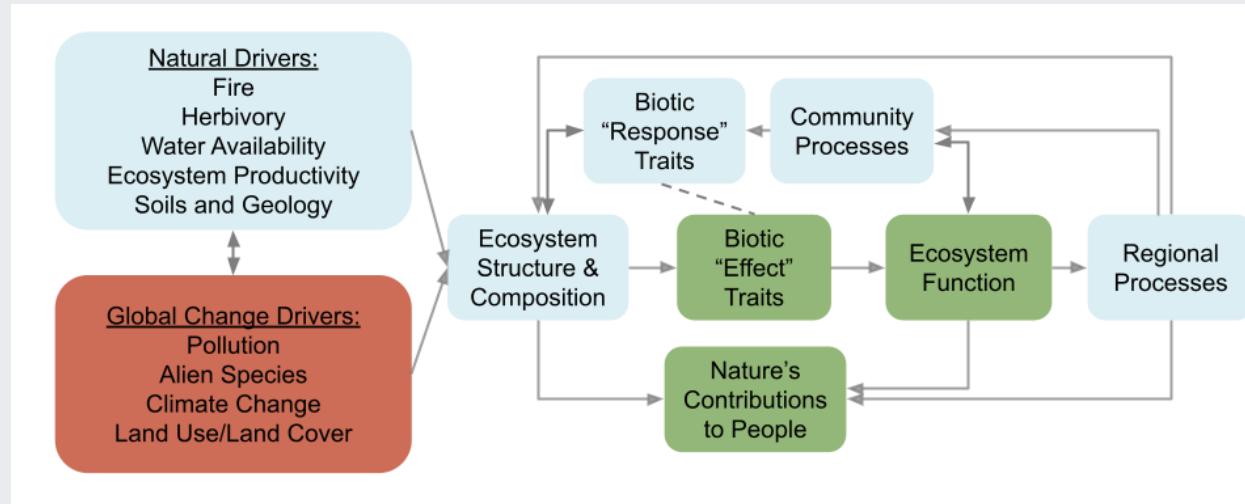
Skowno et al. 2021

Invasive alien plants...



Many knock-on effects for productivity, water, fire, etc

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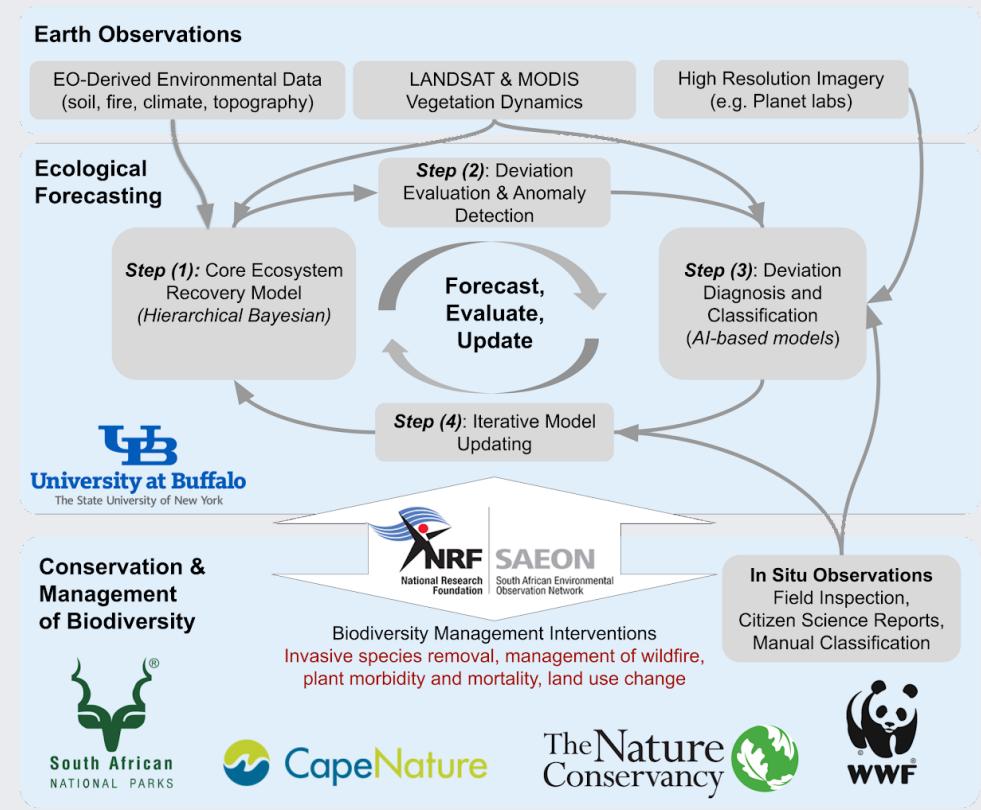
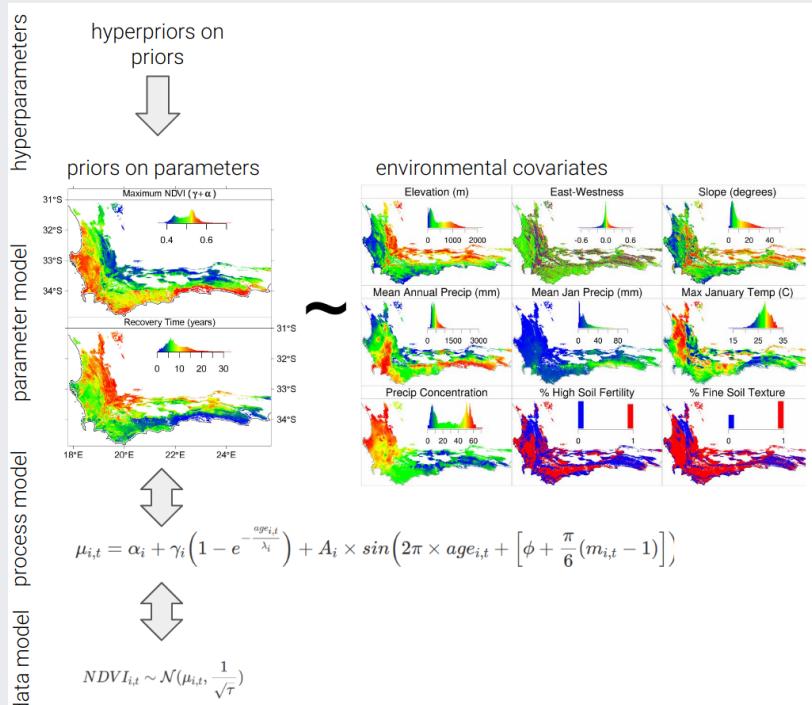


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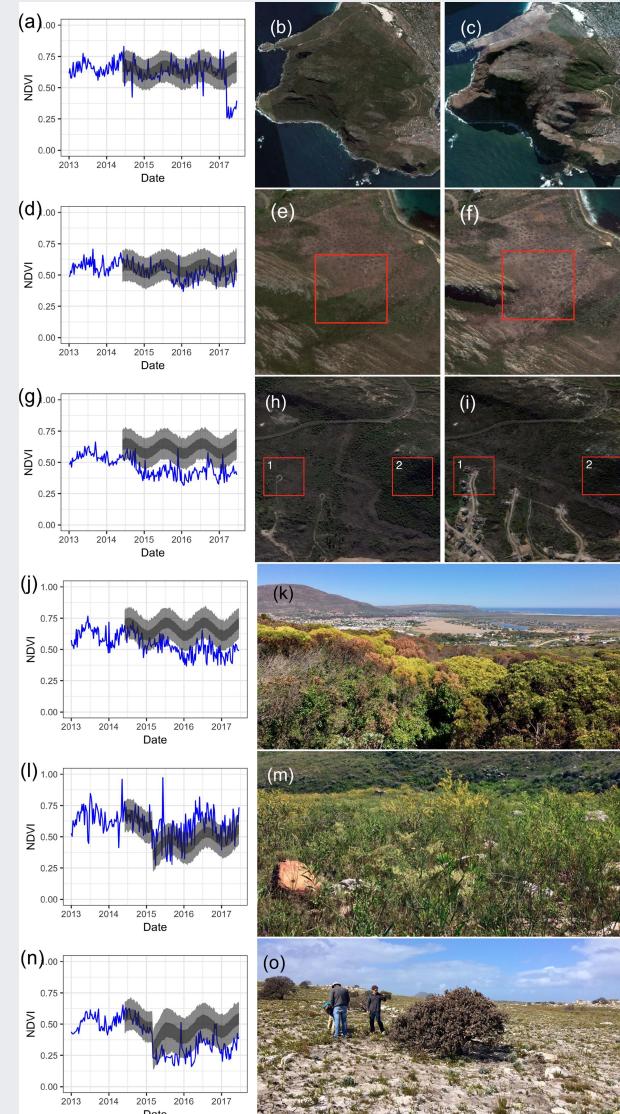
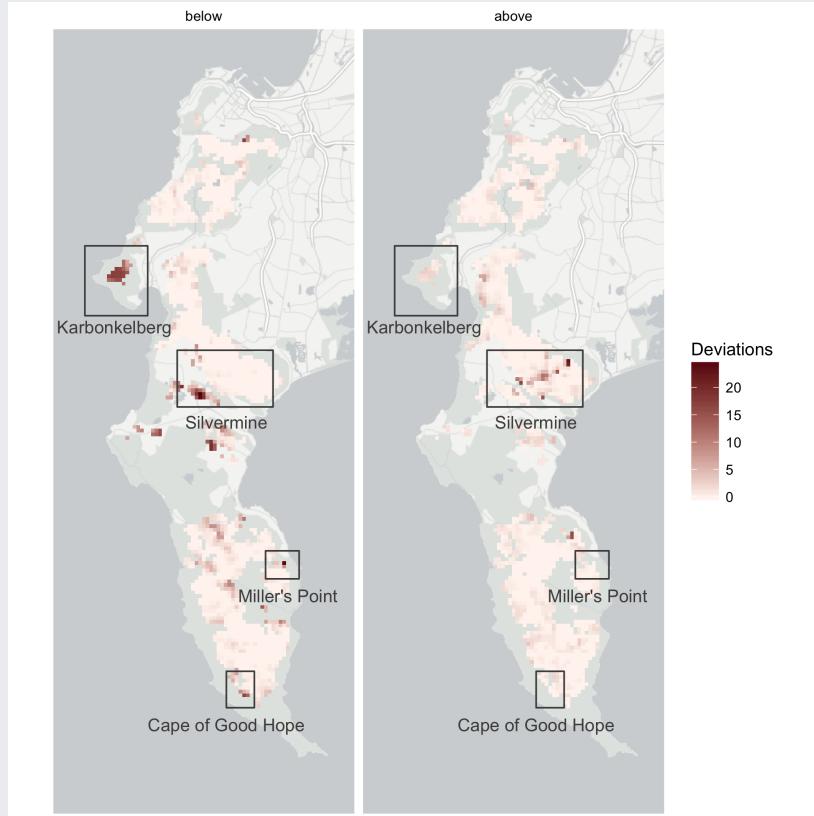
4. Mitigating or adapting to change...

The postfire recovery model allows us to predict what the natural NDVI trajectory for fynbos should be under any given environmental conditions...



<https://www.emma.eco/>

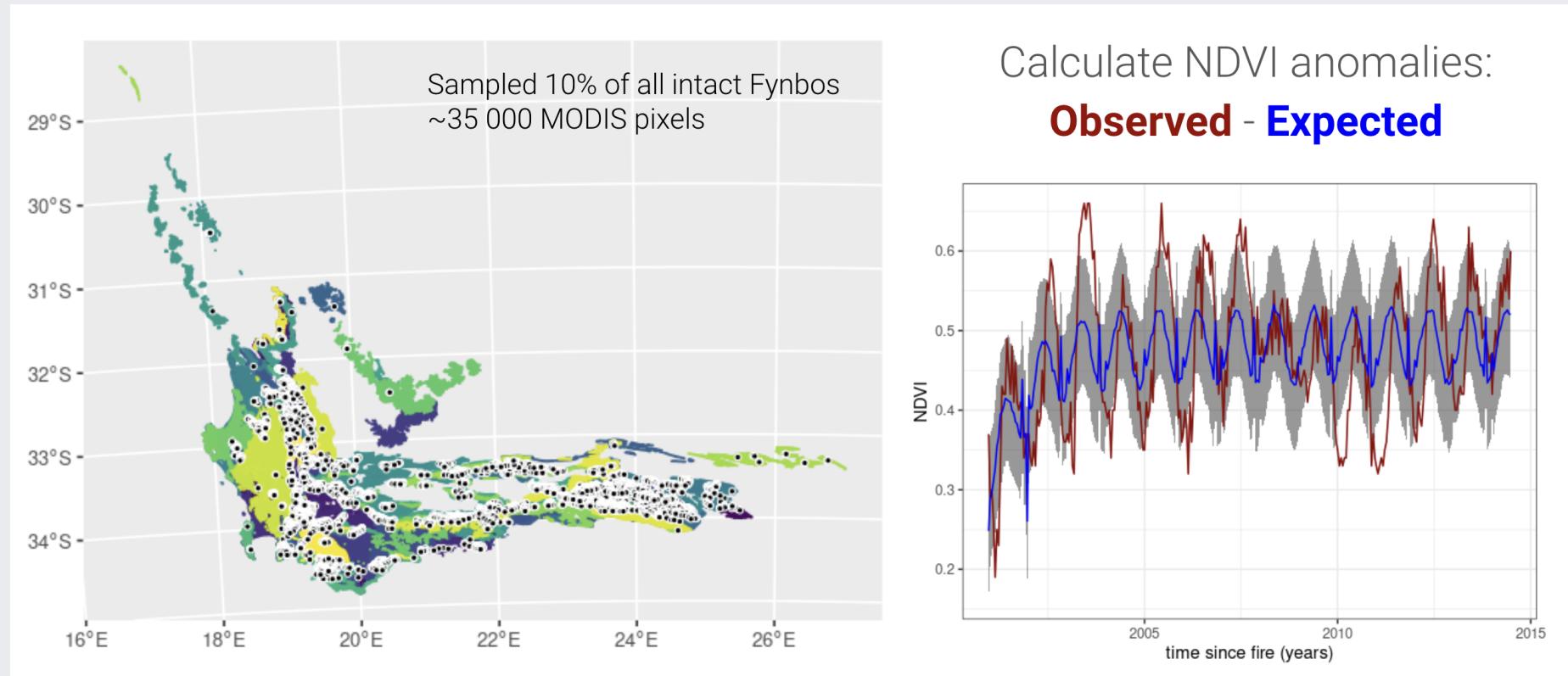
4. Mitigating or adapting to change...



<https://www.emma.eco/>; Slingsby et al. 2021

4. Mitigating or adapting to change... (Also 3. Global change and Fynbos?)

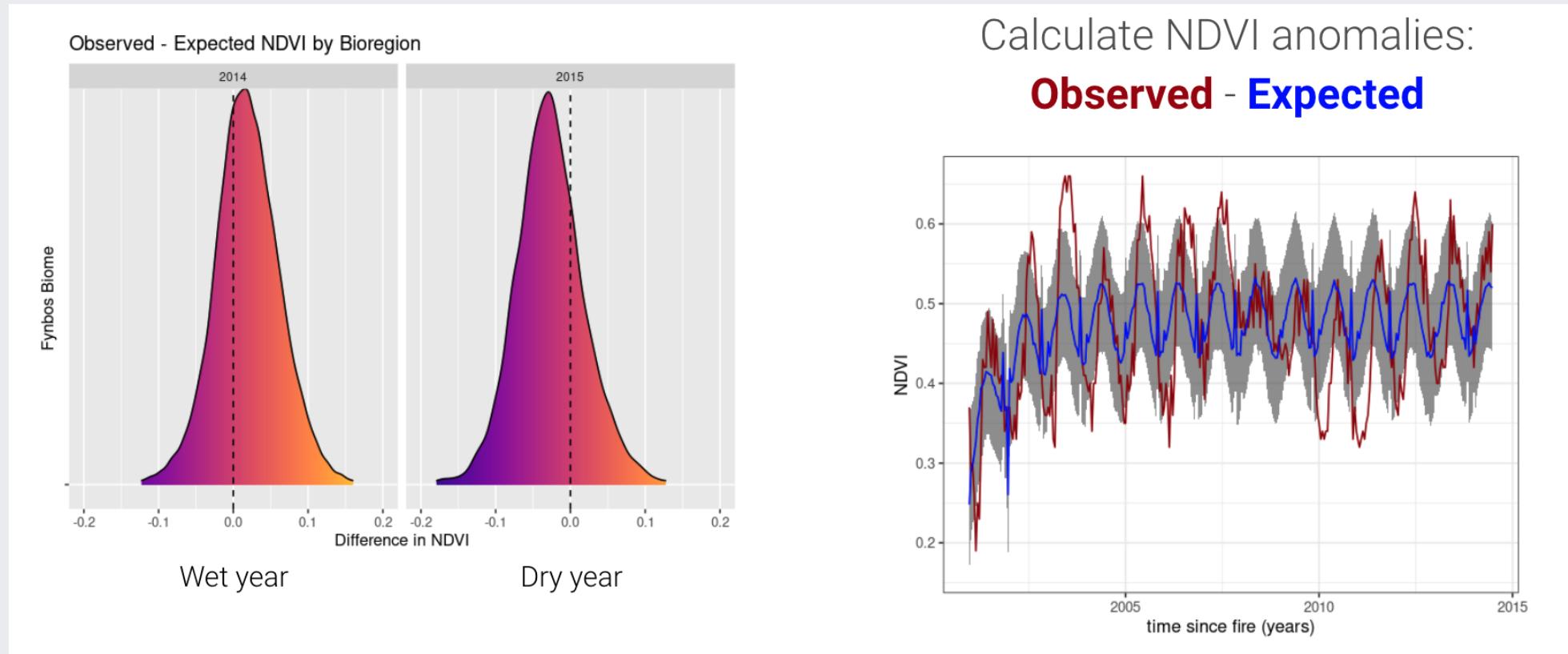
Impact of the "Day-Zero" drought on Fynbos vegetation greenness (NDVI)



Slingsby et al in prep

4. Mitigating or adapting to change... (Also 3. Global change and Fynbos?)

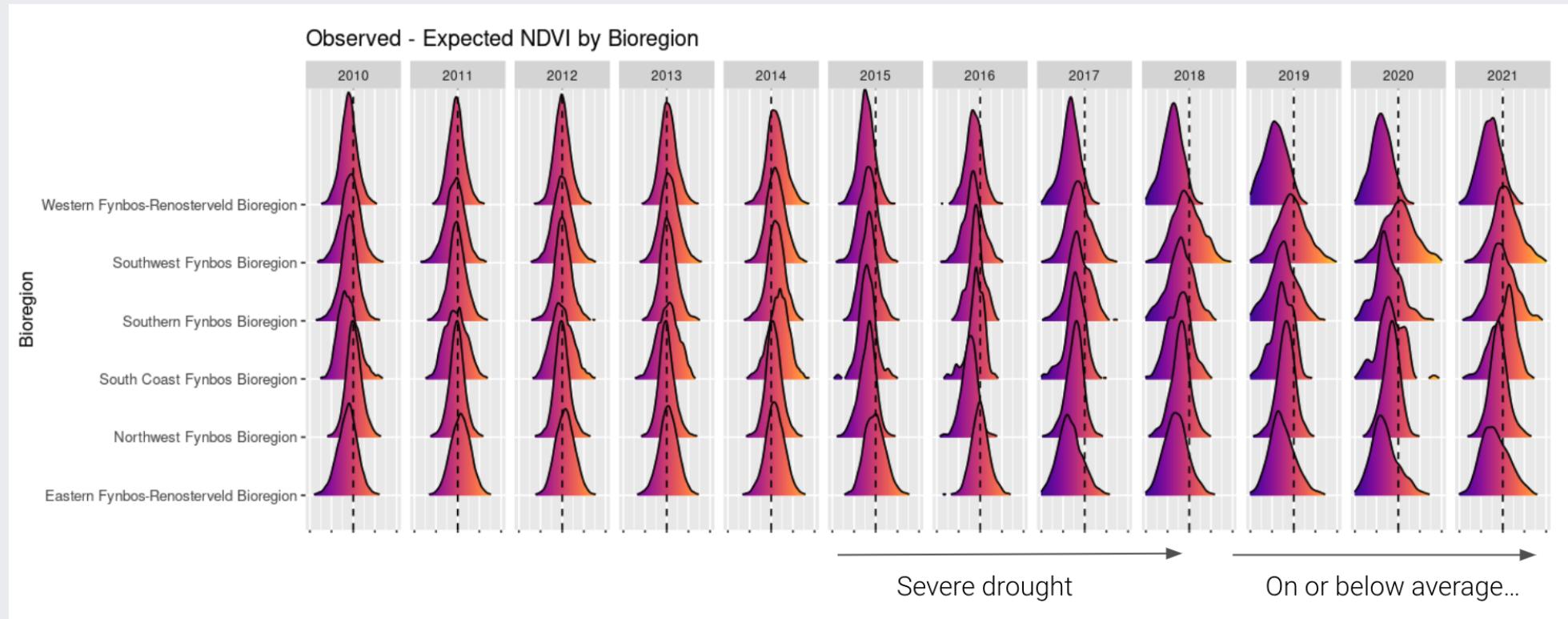
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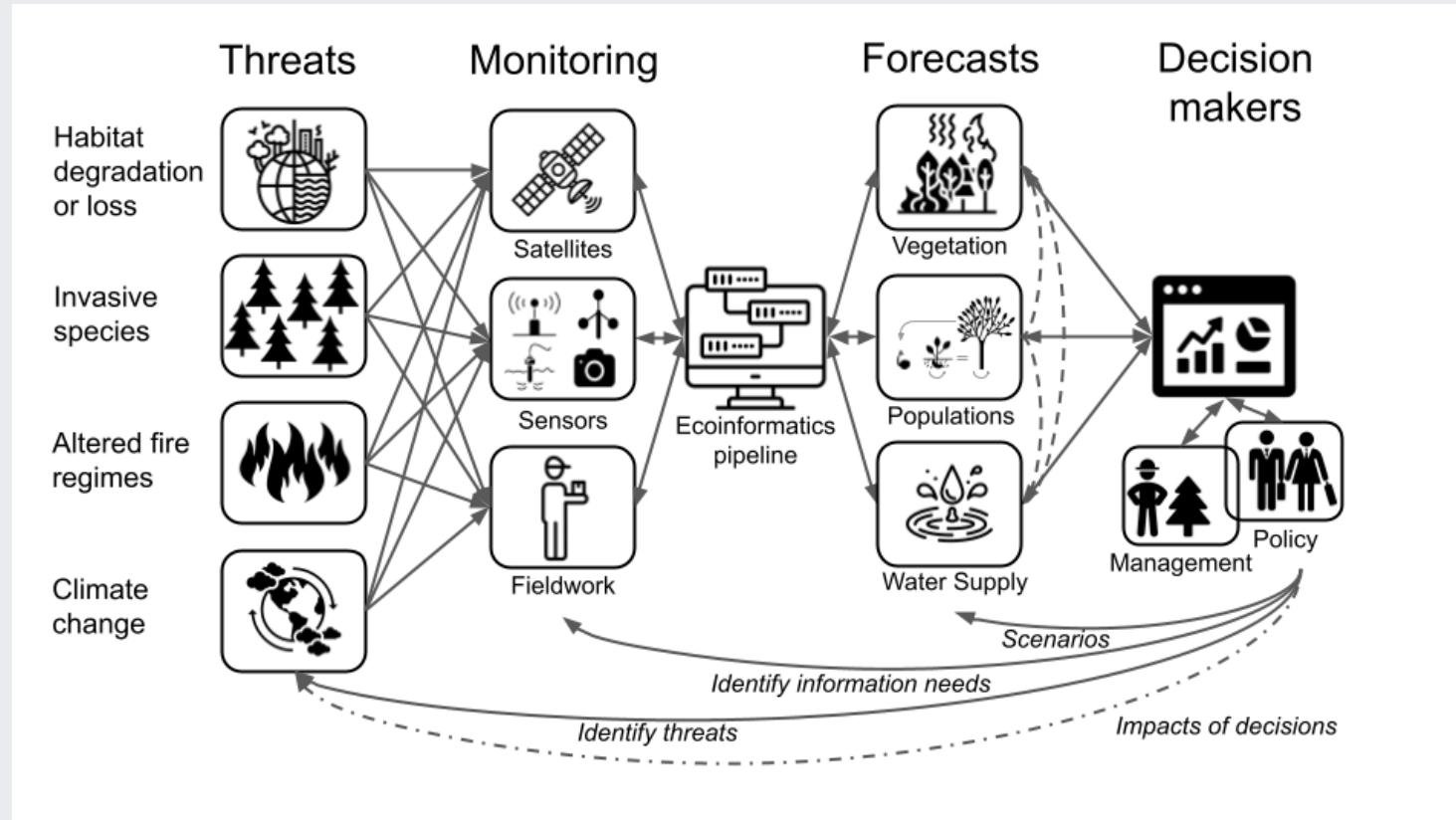
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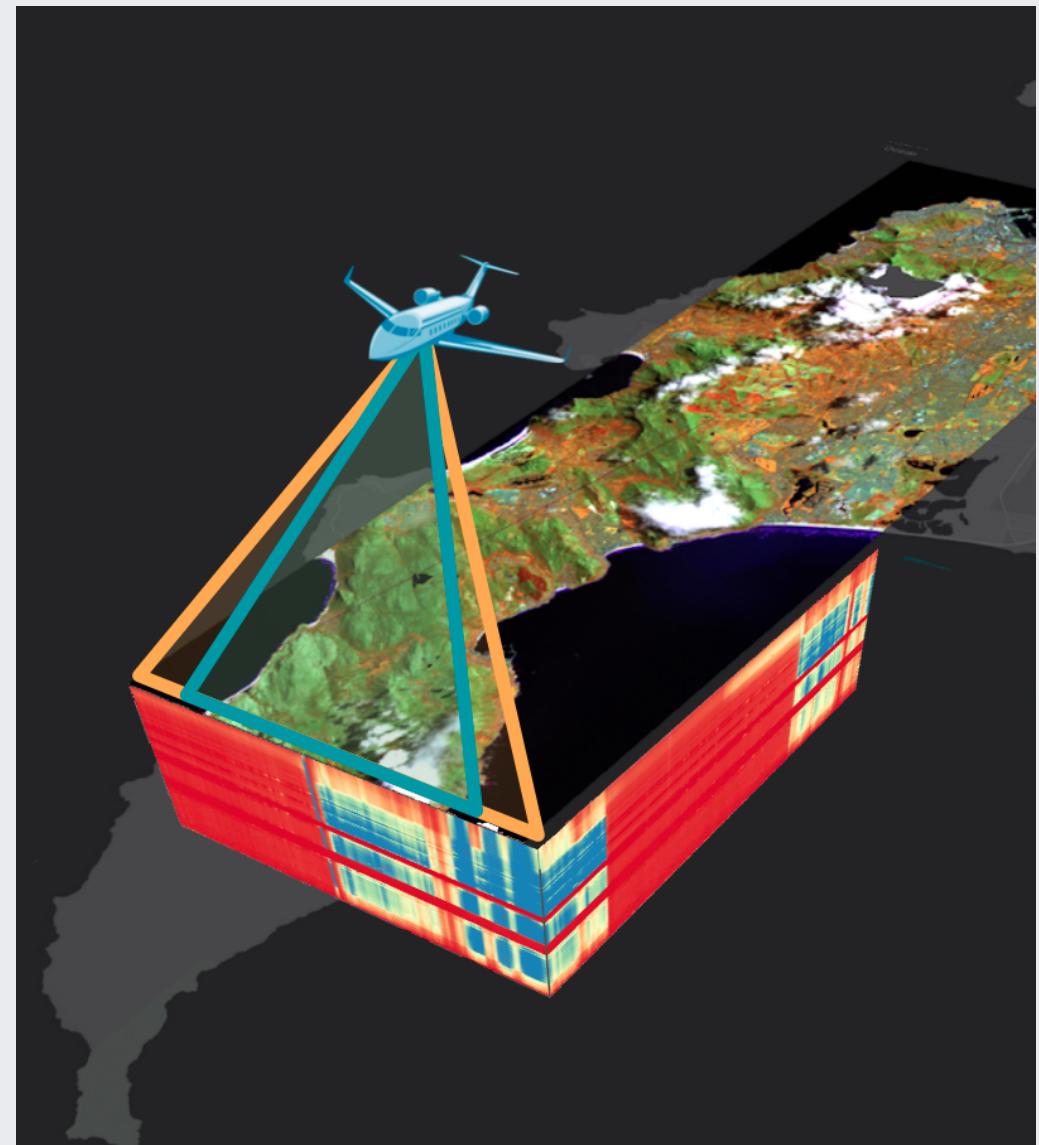
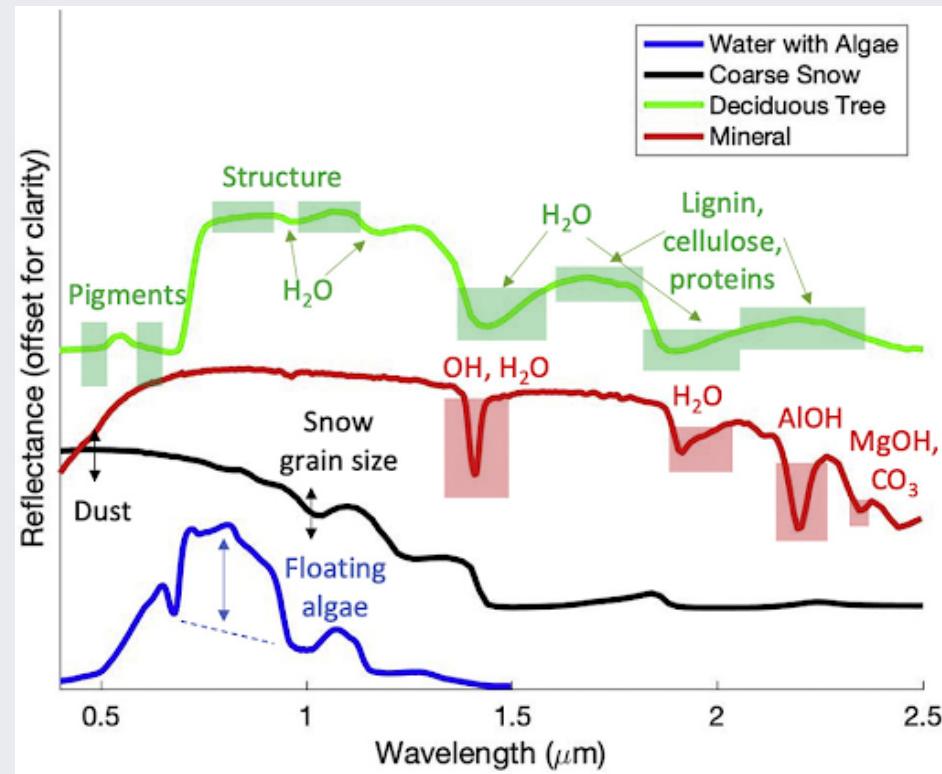
4. Mitigating or adapting to change... Where too from here?

Integrating multiple forecasts for a focal region...

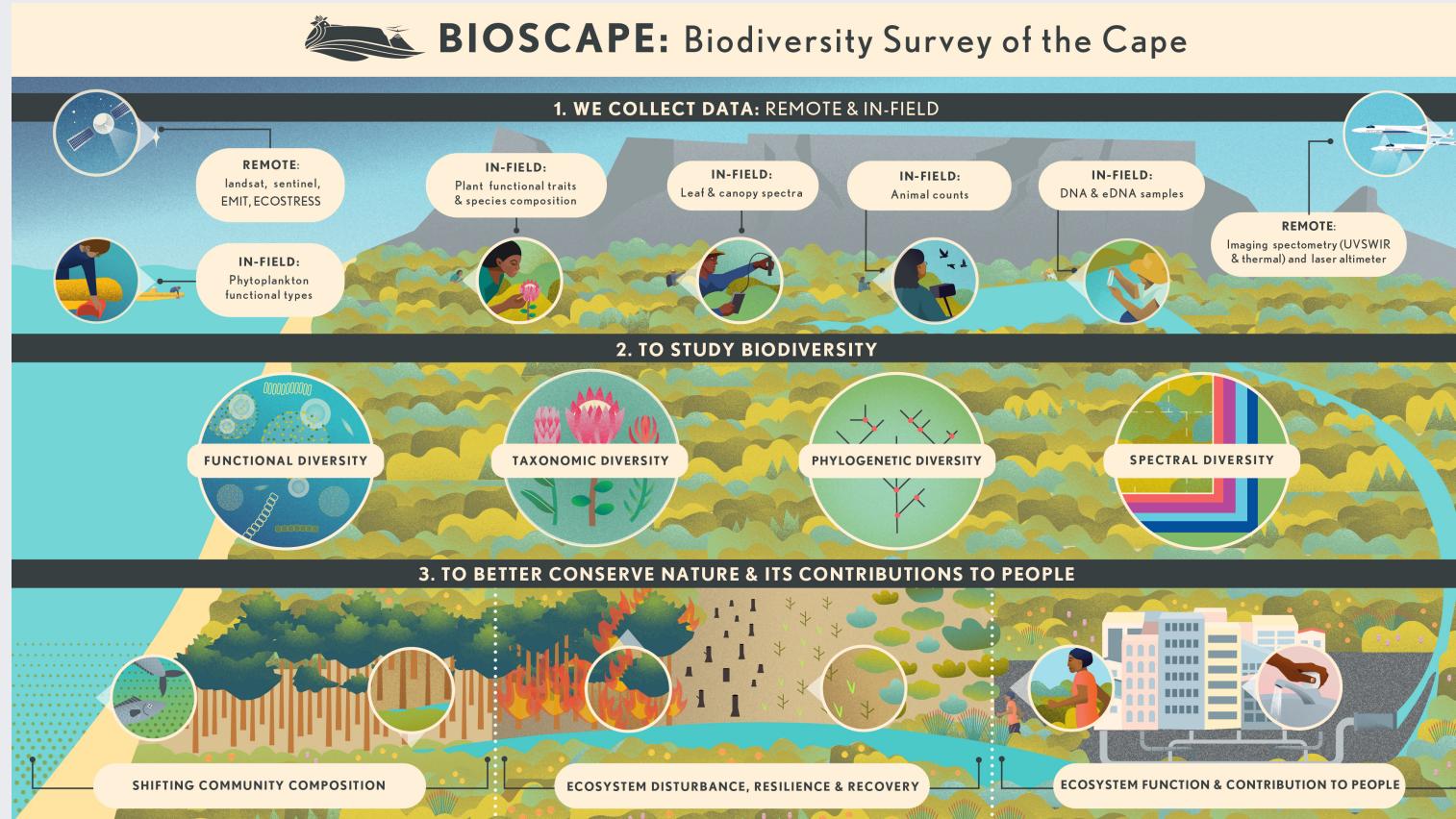


New tools?

Imaging spectroscopy ("hyperspectral" remote sensing) opens new avenues for biodiversity science



New tools? - Biodiversity Survey of the Cape



www.bioscape.io

References

I need to add these...

Thanks!

More at my lab website plantecolo.gy

Slides created via the R packages:

xaringan
gadenbuie/xaringanthemer

The chakra comes from remark.js, **knitr**, and R Markdown.