science & technology

Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation | SAEON South African Environmental Observation Network

Dynamic Vegetation Models as a tool for understanding global change impacts on South African biomes

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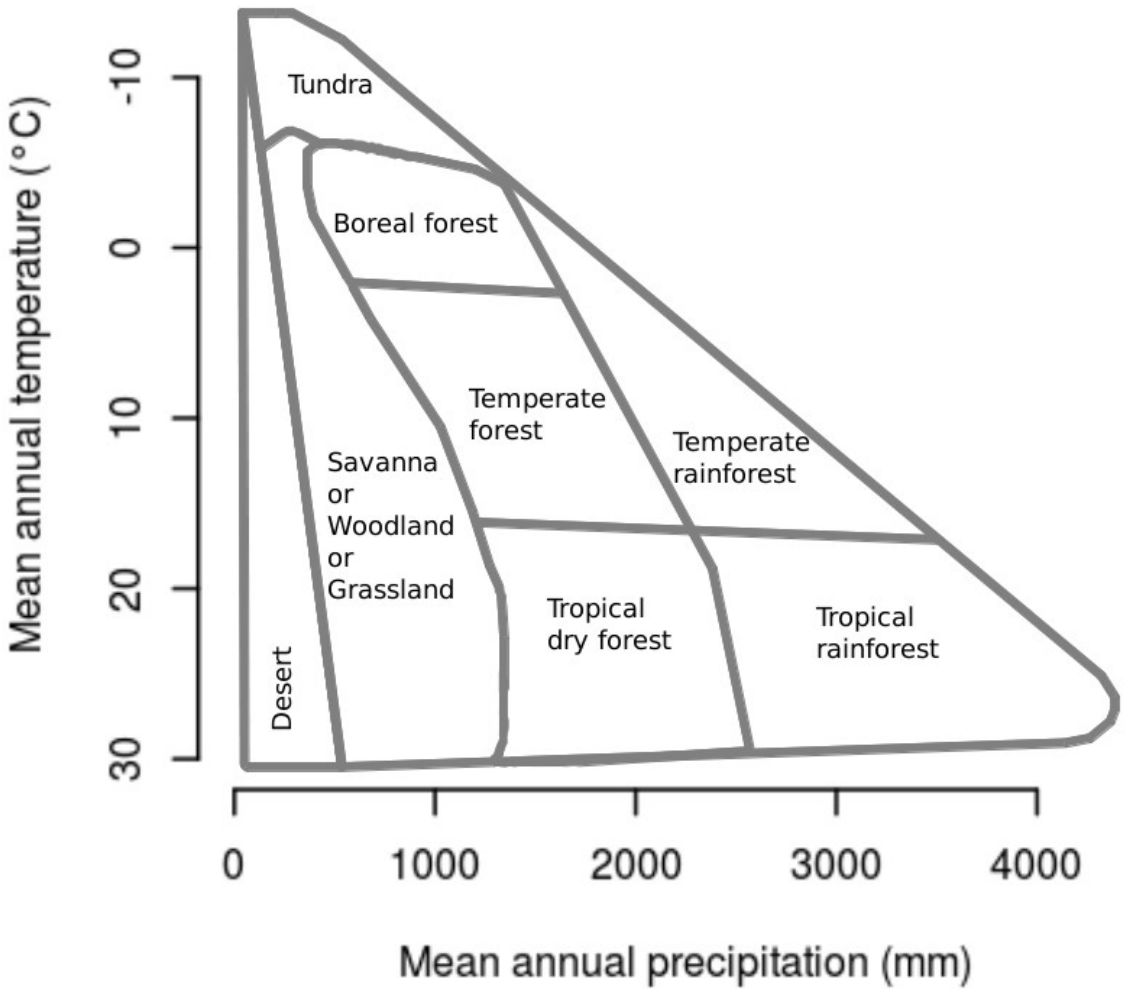
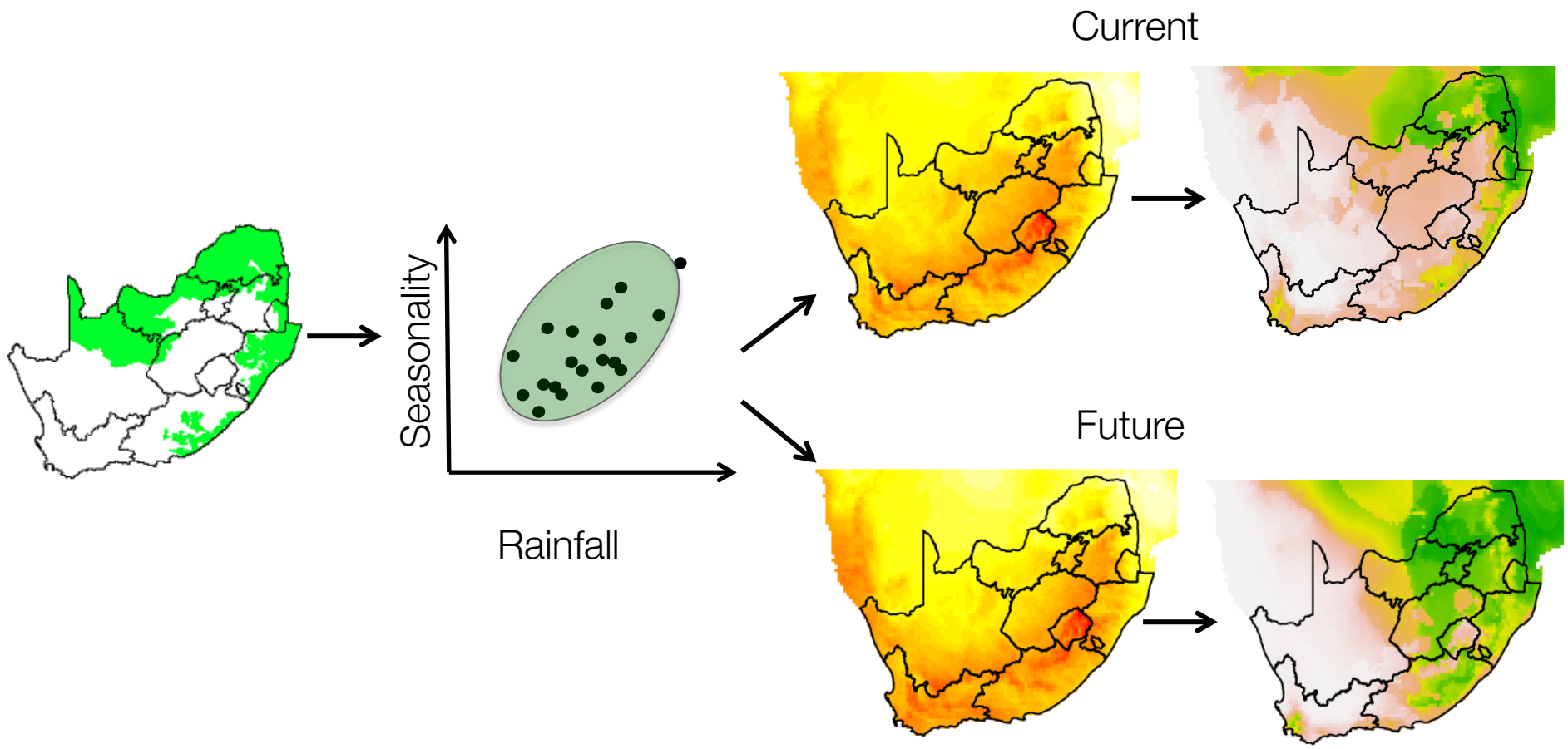
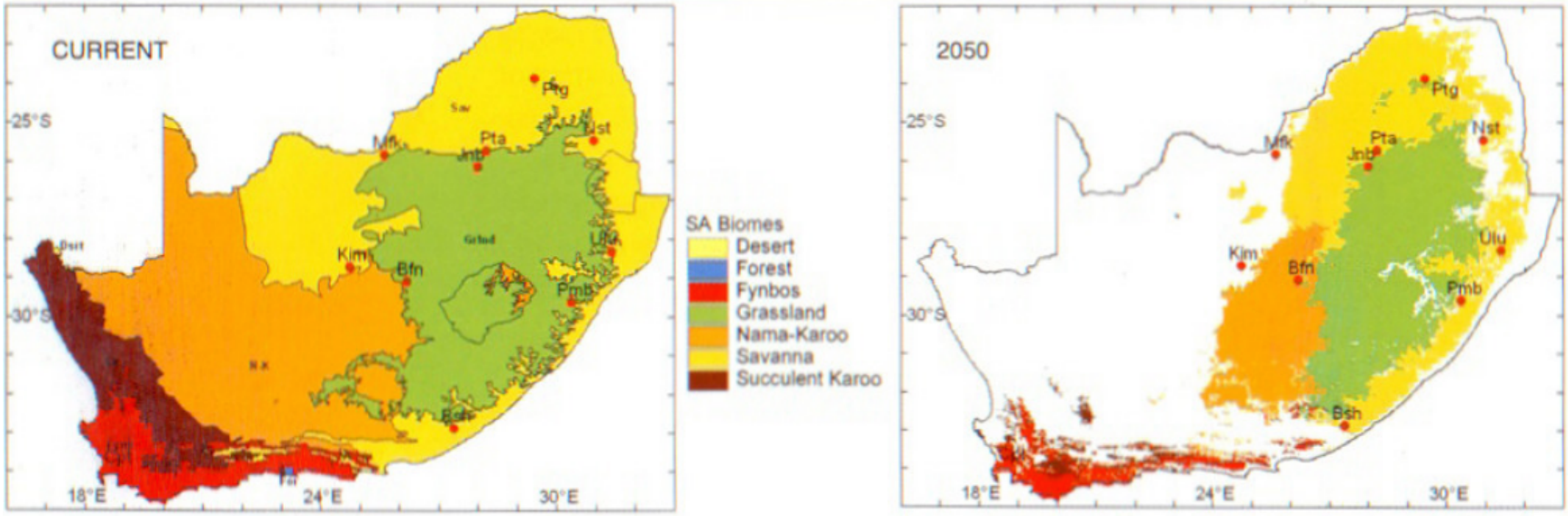
Predicting biome distributions



Whittaker 1975

Species distribution models

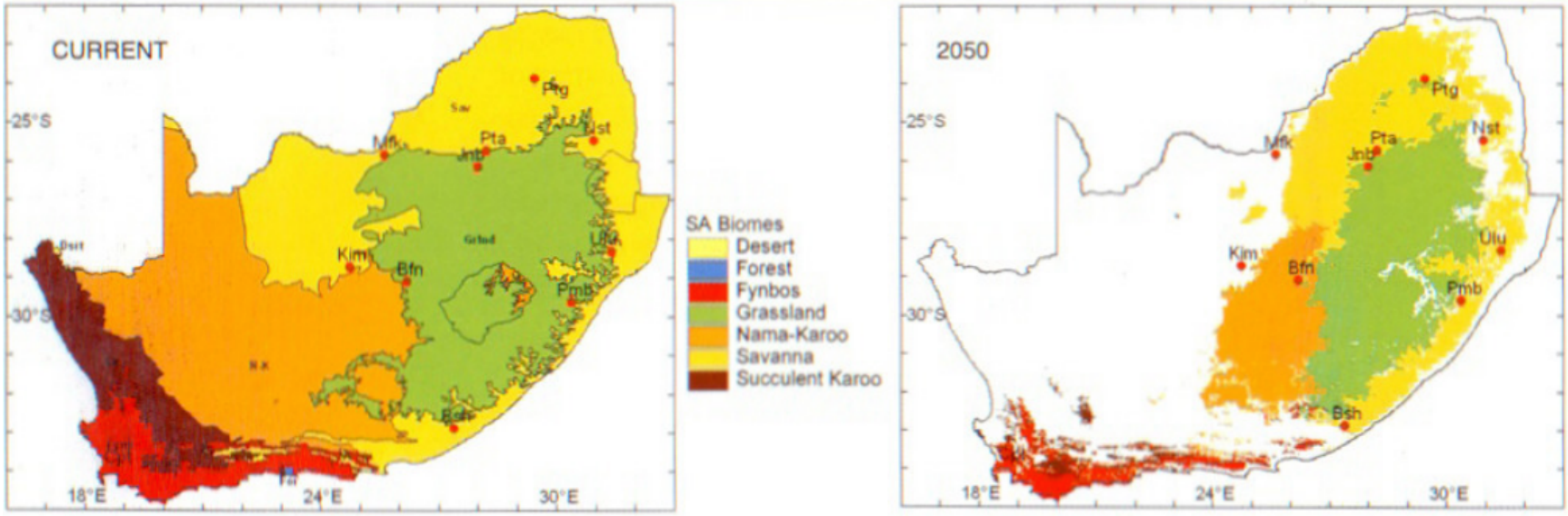




Midgley et al 2008. The Heat is On.

390 ppm

500-700 ppm



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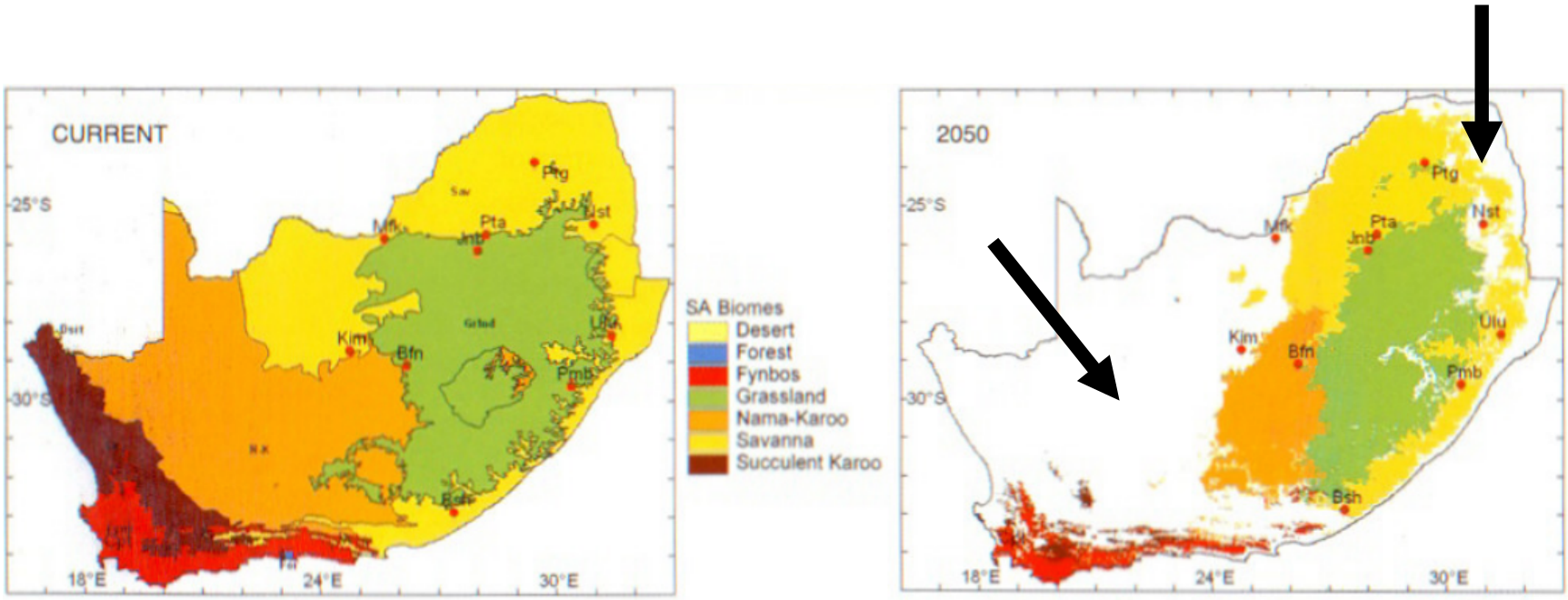

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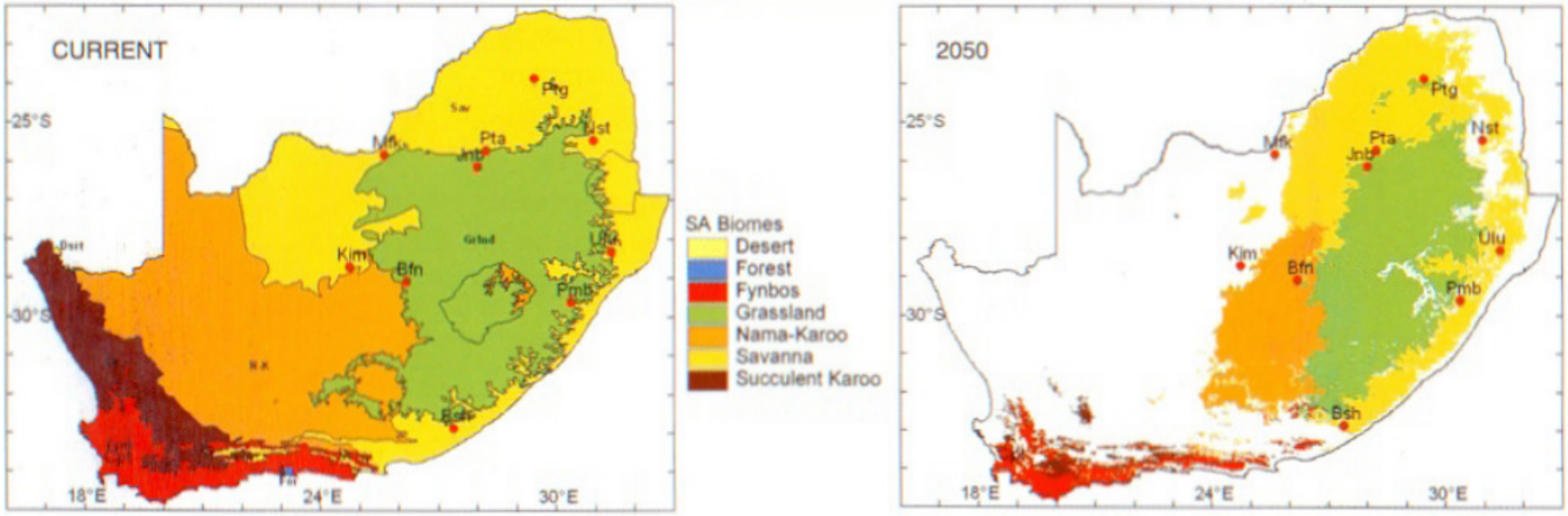
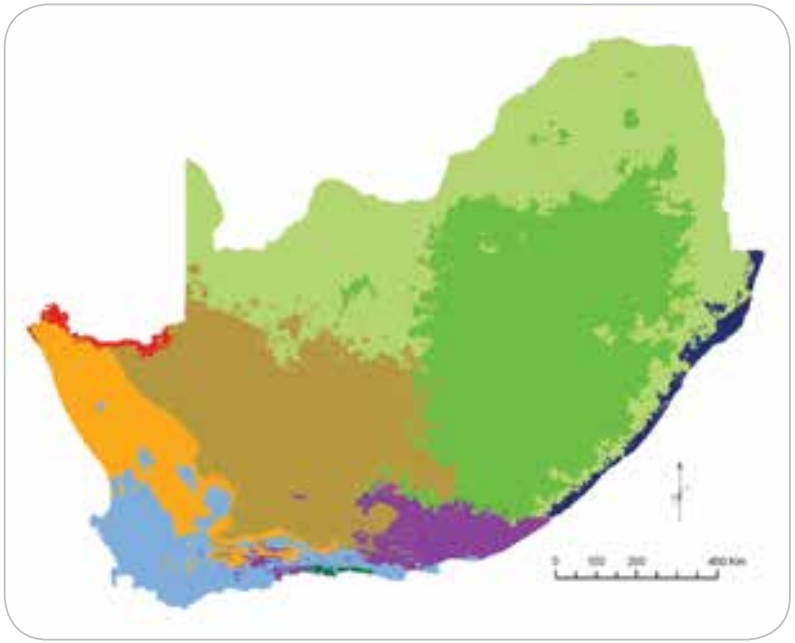
Instantaneous equilibrium

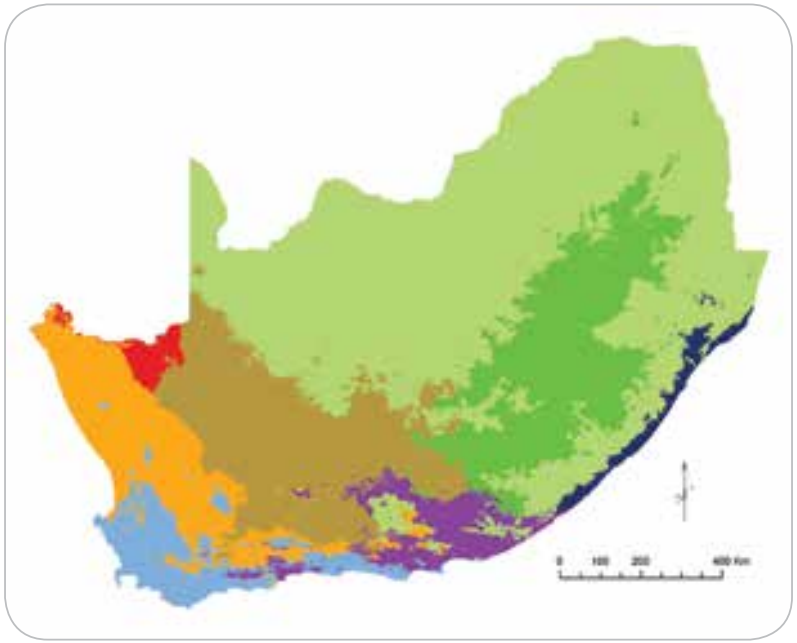


Midgley et al 2008. The Heat is On.

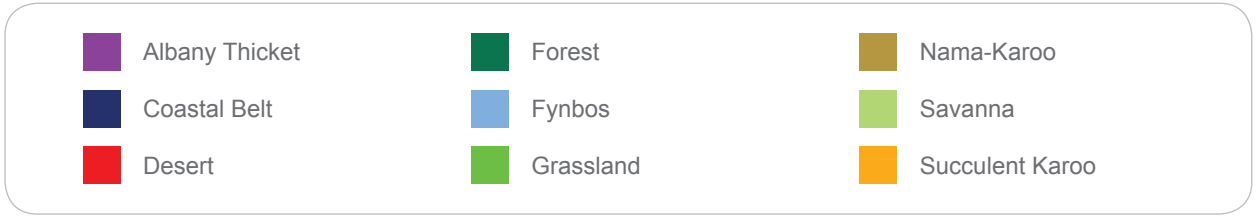
Long term adaptation scenarios



Predicted current biome climate envelope



Predicted biome climate envelope: CSIRO



Adding plant functioning

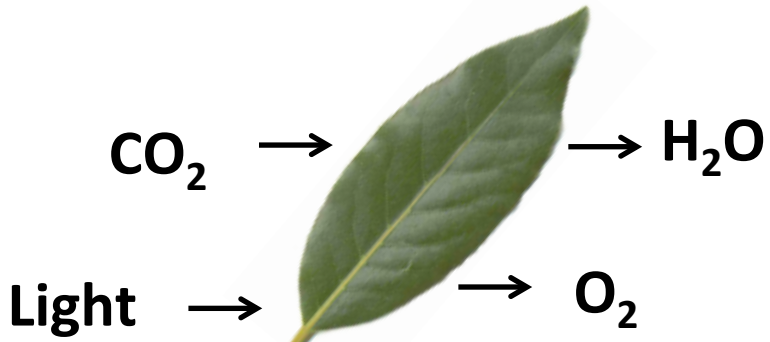
To overcome these problems we need to model plants more mechanistically

We need to model the rate at which change occurs

To do this we start at the leaf level:

Photosynthesis = f (Internal CO2, Temp, Light, Nutrients)

Farquar et al 1980



Adding plant functioning

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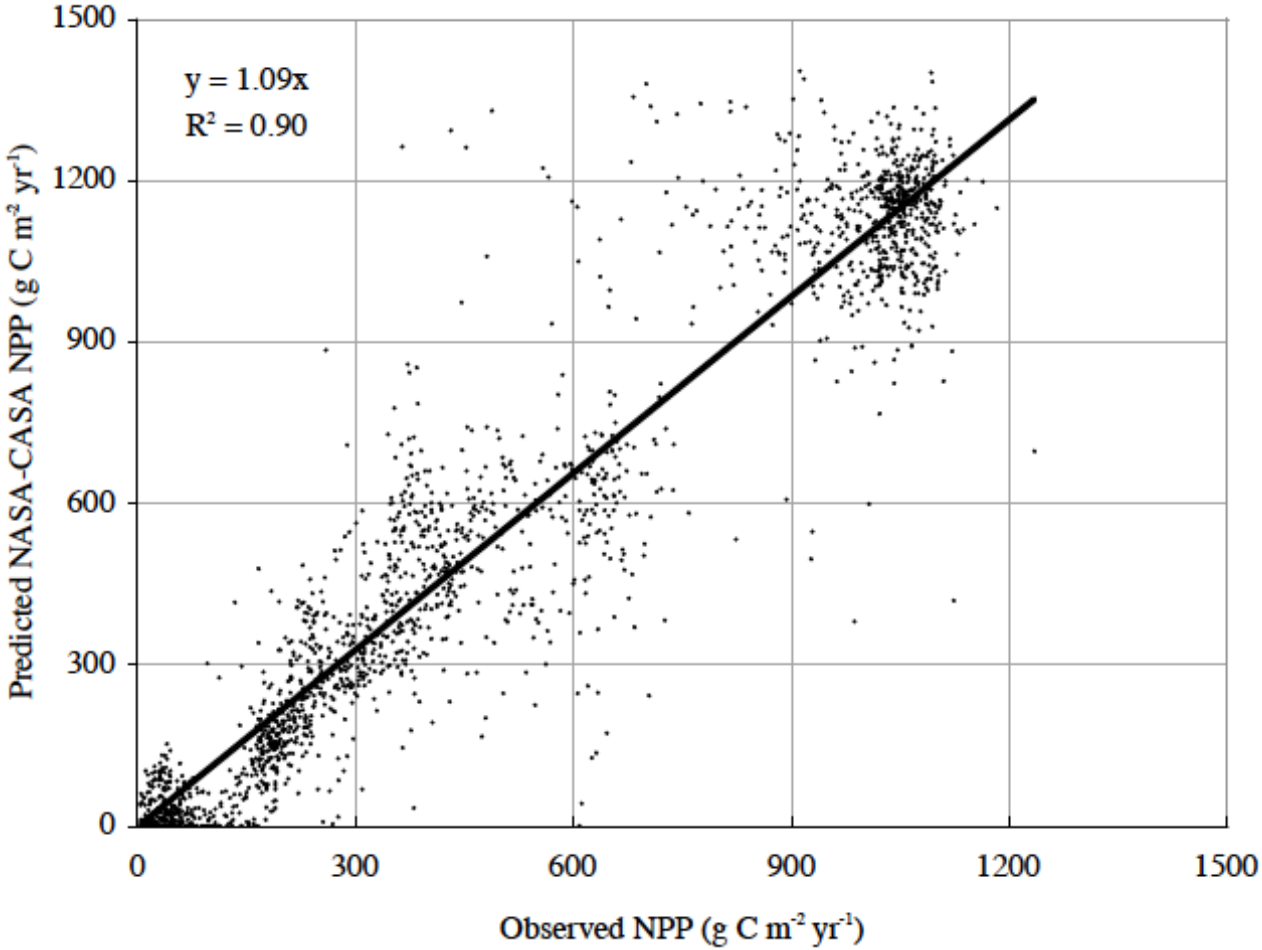
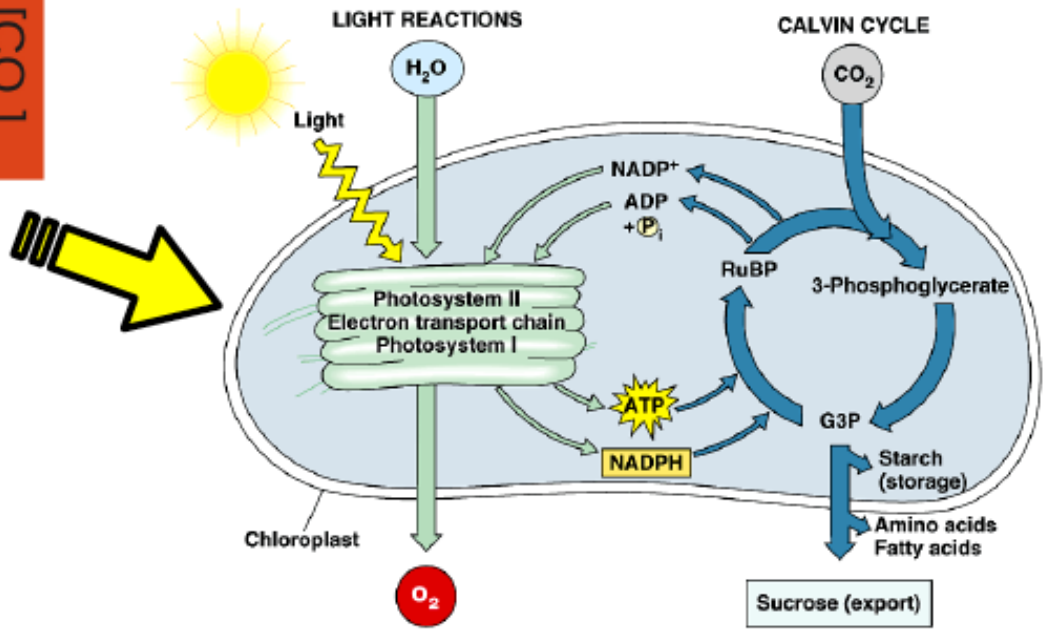


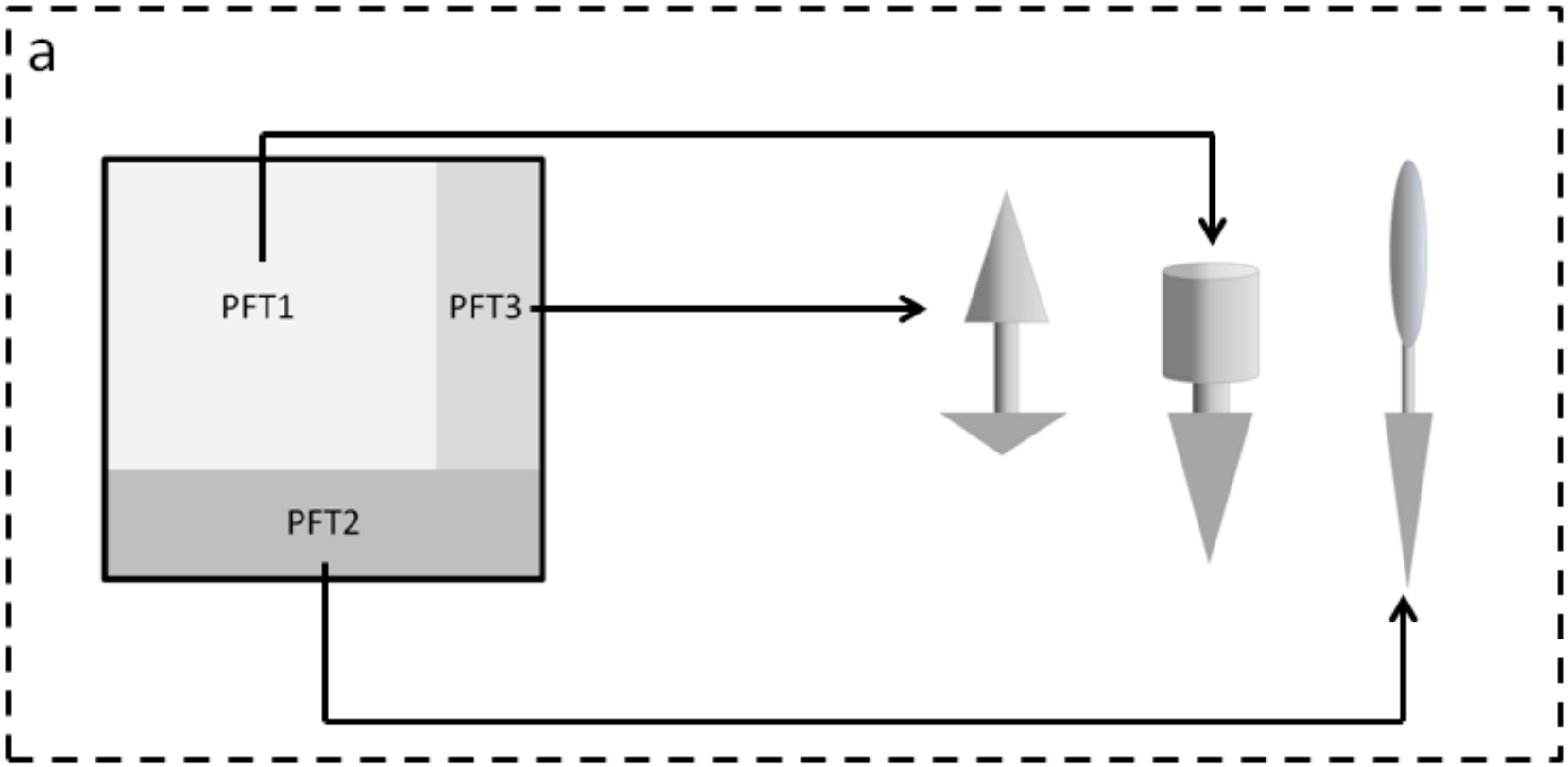
Potter et al 2003

Dynamic Vegetation Models

Soil hydraulic properties
Solar radiation
Precipitation
Temperature
$[CO_2]$



Plant functional types



Global Change Biology

Global Change Biology (2009) 15, 2224–2246, doi: 10.1111/j.1365-2486.2008.01838.x

Impacts of climate change on the vegetation of Africa: an adaptive dynamic vegetation modelling approach

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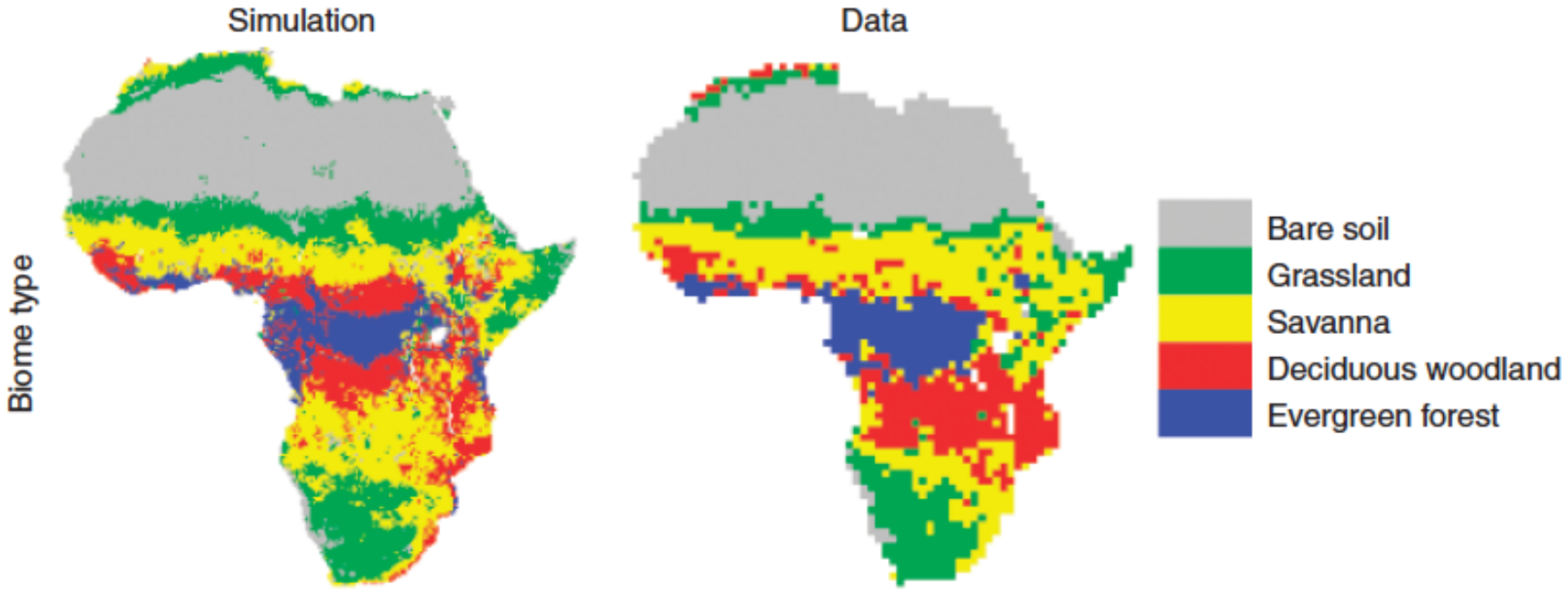
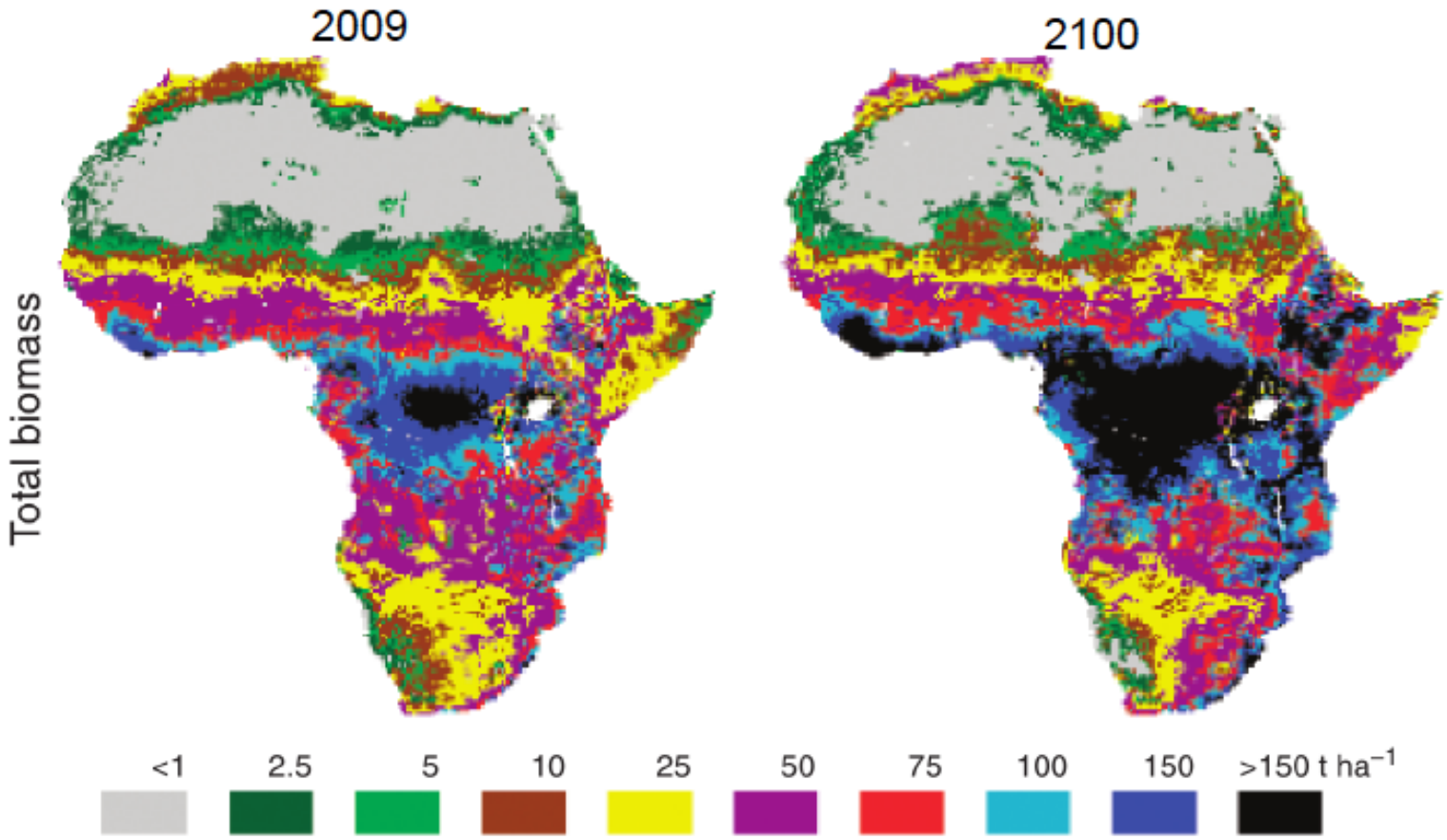




Scheiter and Higgins 2009

Can we trust this?

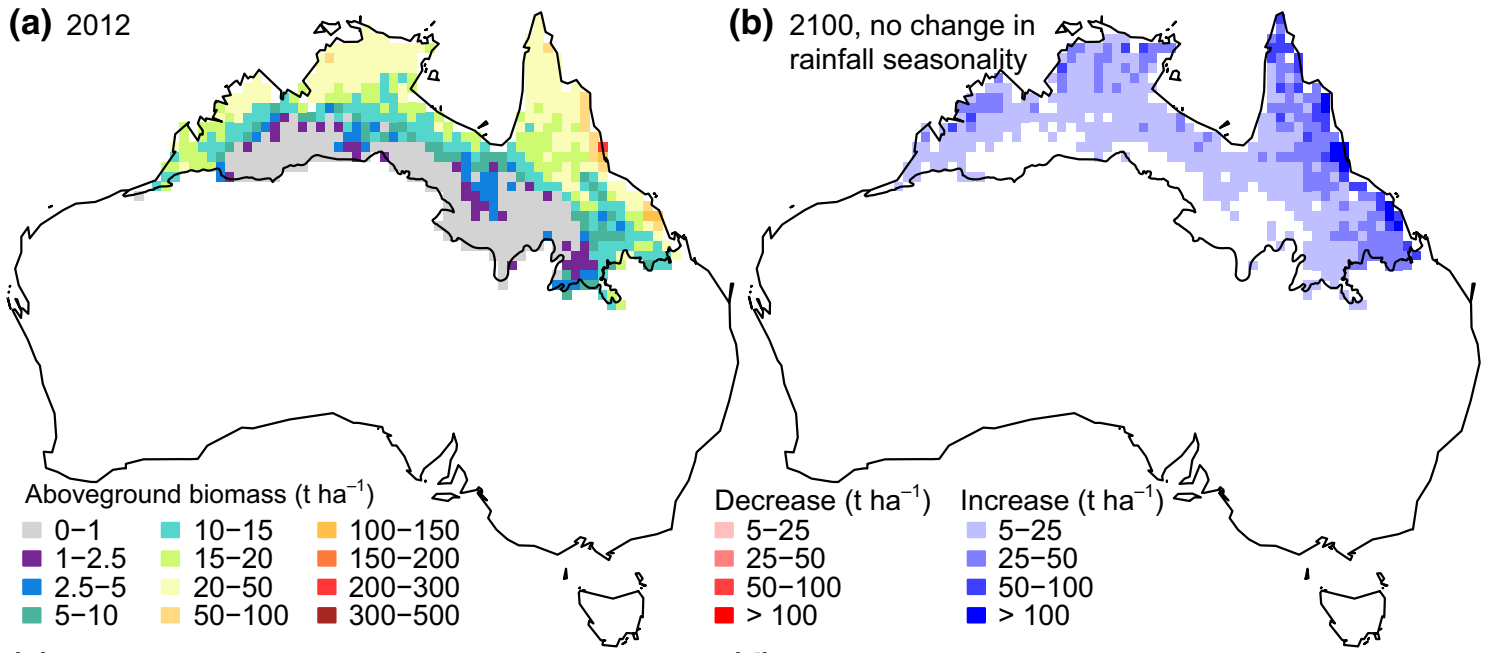
I can give you a prediction of many, many aspects of vegetation

I can also get it to match simple maps of observed vegetation

But I am getting the right answer for the wrong reasons?

Australia example: New continent, new parameters, should we believe the projections?

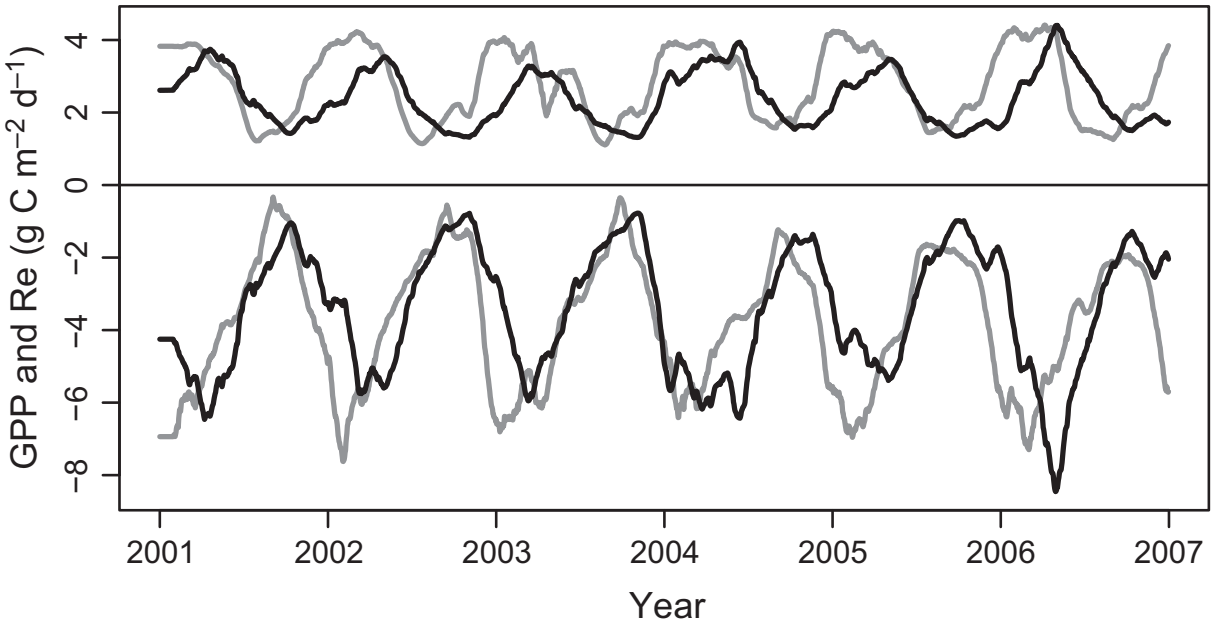
Prediction



Scheiter et al 2014

Validation

Howard Springs



Scheiter et al 2014

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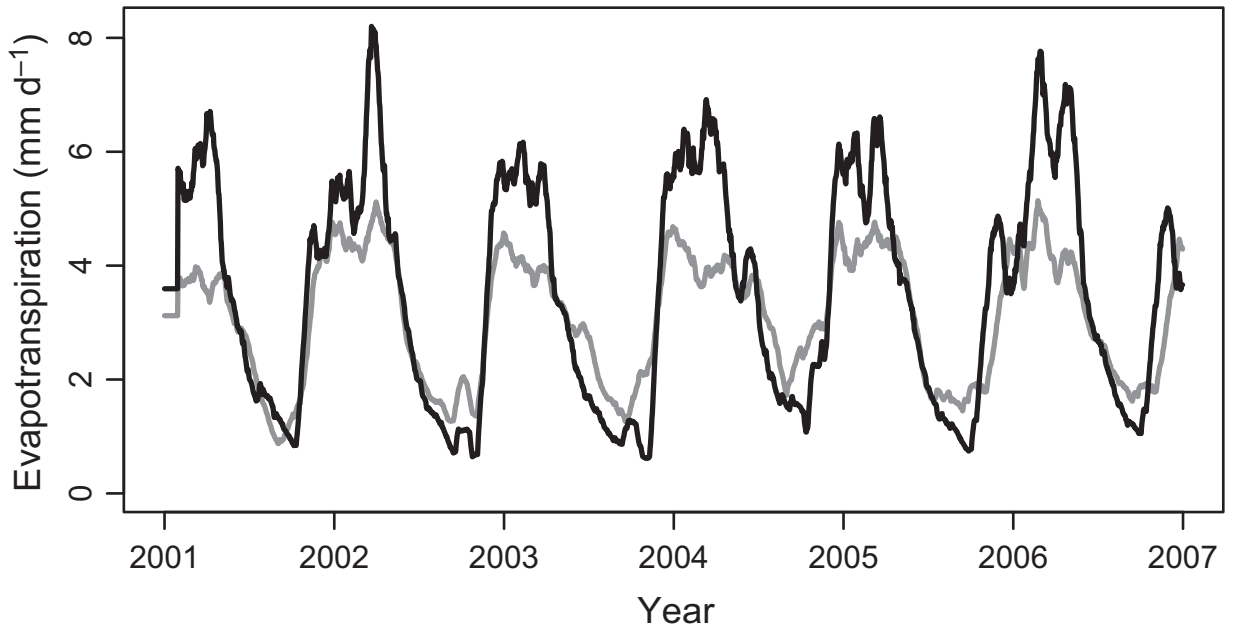

Scheiter et al 2014

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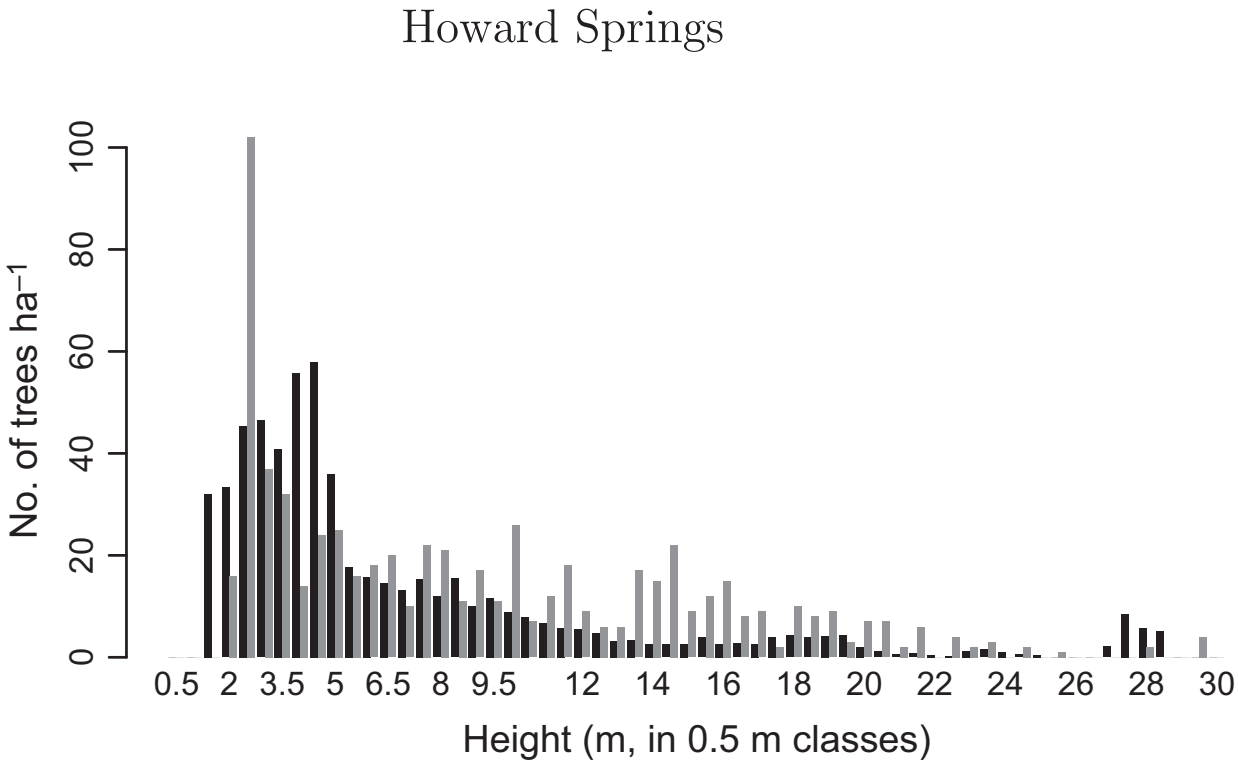
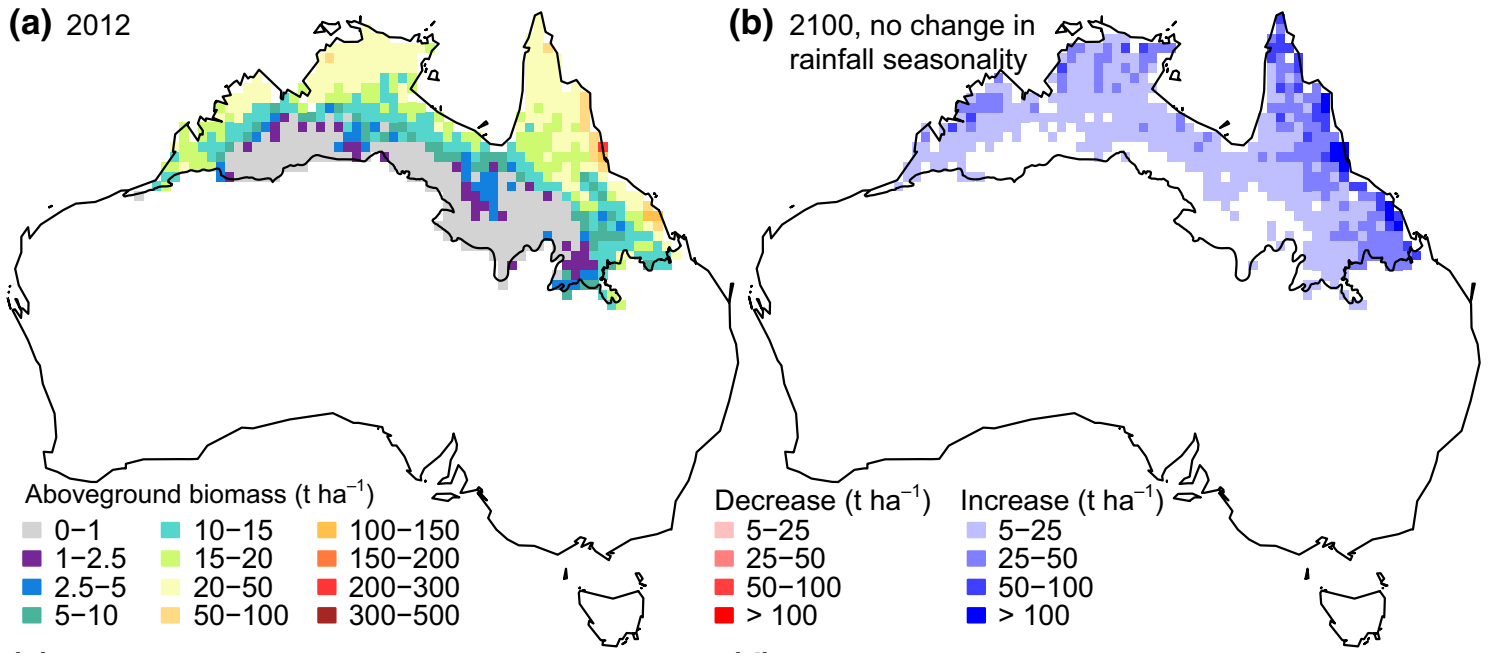


Scheiter et al 2014

Prediction



Scheiter et al 2014

Models are rapidly improving

New process included
- -fire
- -herbivores
- -human land use

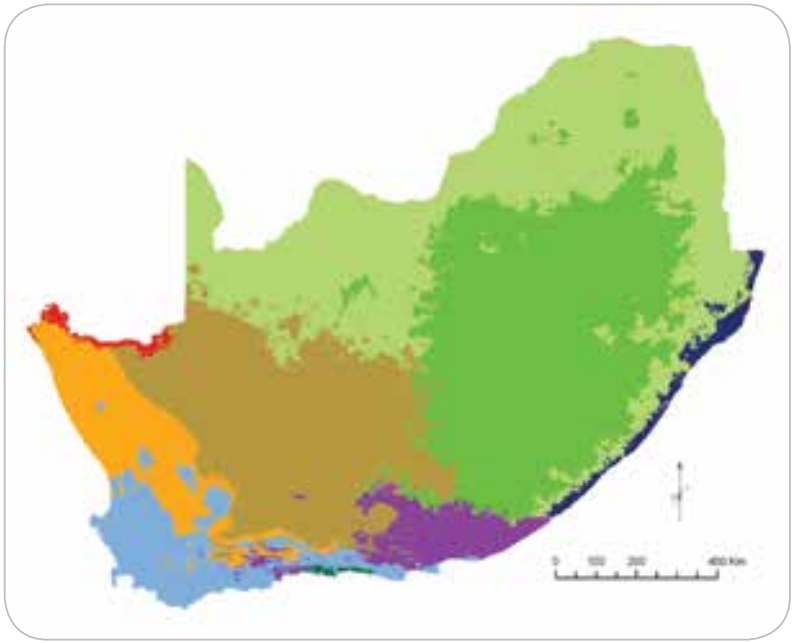
Great for global studies, great for studying carbon cycling, doing cool experiments, but....

desert
grassland

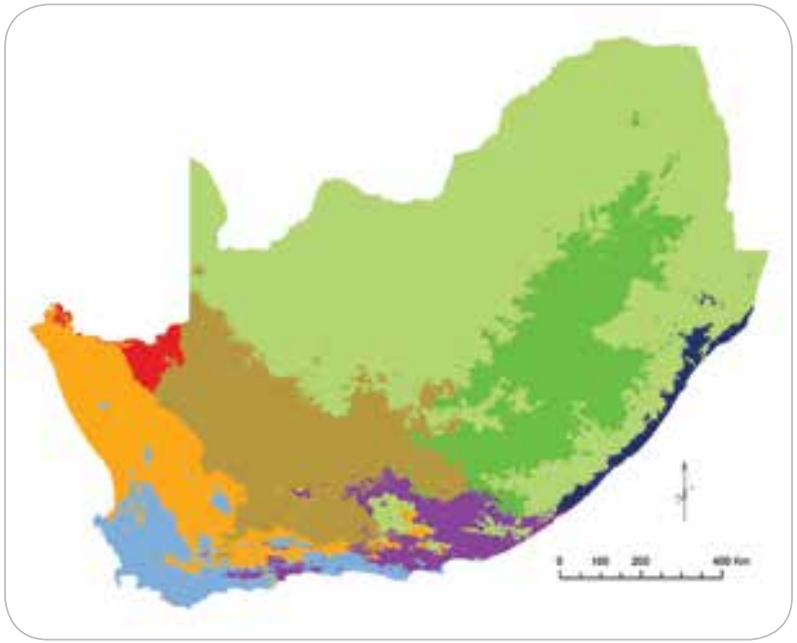
savanna
deciduous forest

mixed forest
evergreen forest

South Africa

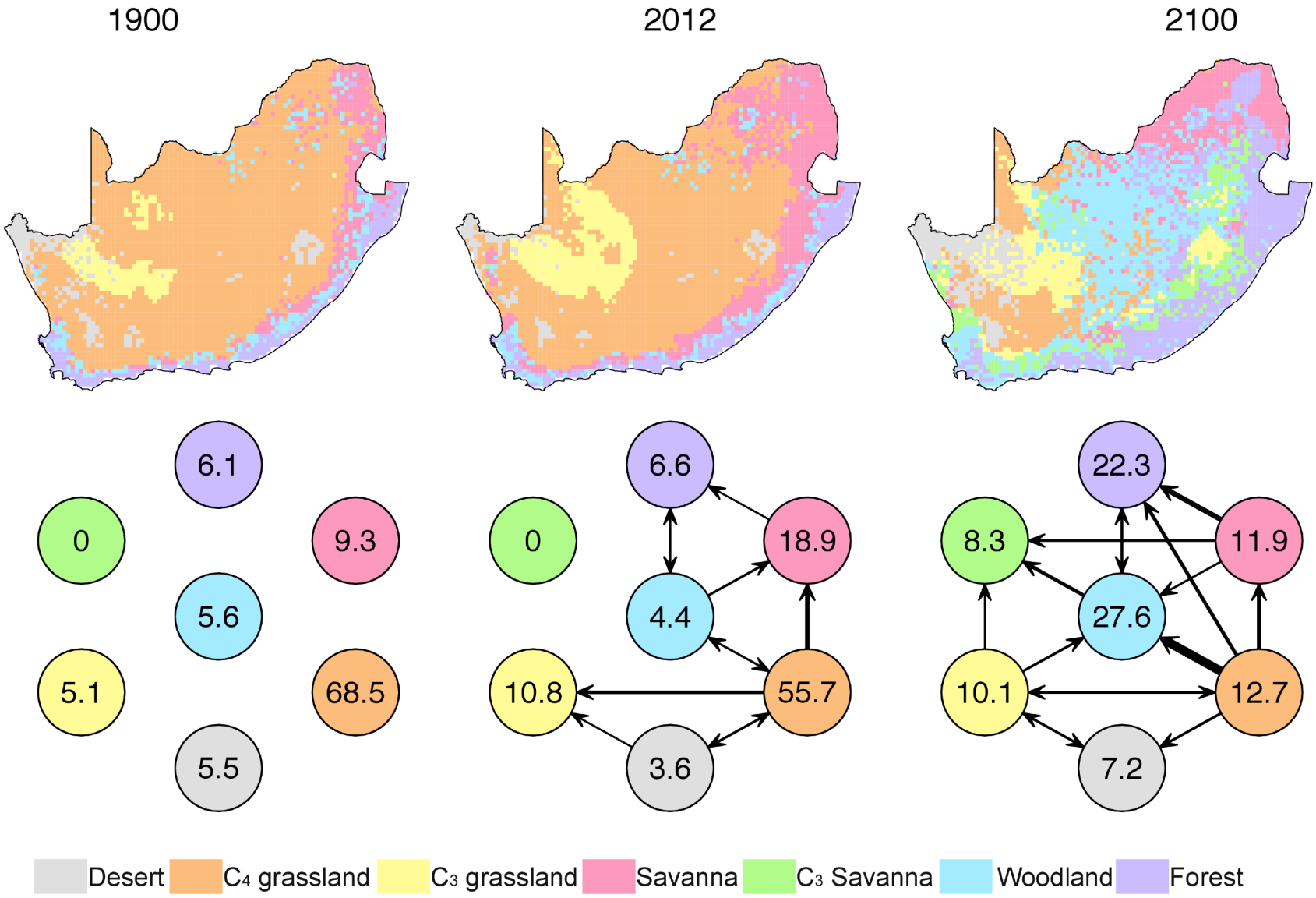


Predicted current biome climate envelope



Predicted biome climate envelope: CSIRO

Albany Thicket
Coastal Belt
Desert
Forest
Fynbos
Grassland
Nama-Karoo
Savanna
Succulent Karoo


1900
2012
2100
6.1
0
9.3
5.6
5.1
68.5
5.5
6.6
0
18.9
4.4
10.8
55.7
3.6
22.3
8.3
11.9
27.6
10.1
12.7
7.2
Desert
C4 grassland
C3 grassland
Savanna
C3 Savanna
Woodland
Forest

Adding Fynbos

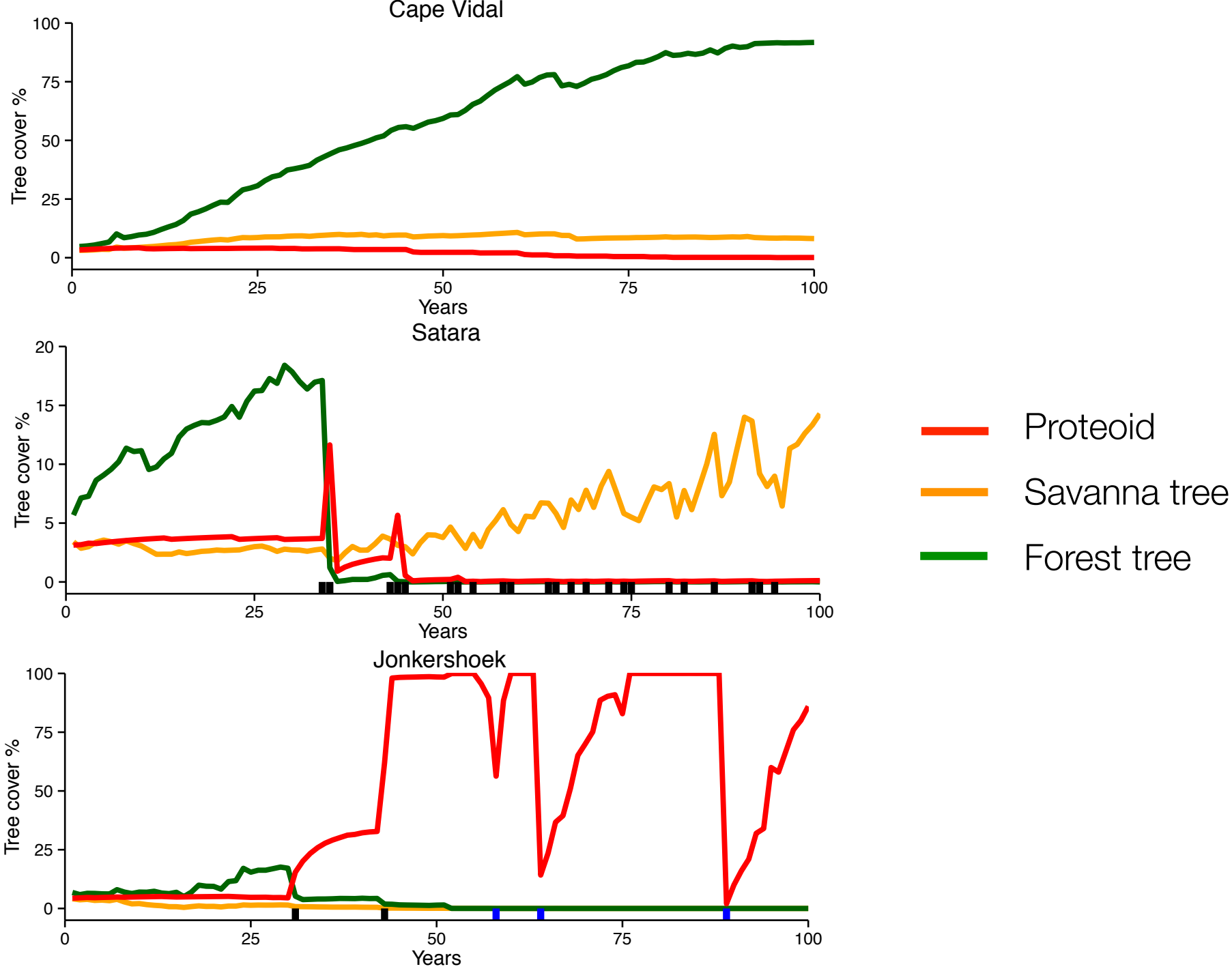
Add fynbos fires

New Plant types:
Restios, Proteoids

New trade offs: Thick leaves live long, photosynthesize slow

New nutrient dynamics: Growth of new tissue cost more on infertile soil

New hydrological games: Proteoids have roots in deepest soil layers


Cape Vidal
Tree cover %
Years
Satara
Tree cover %
Years
Jonkershoek
Tree cover %
Years
Proteoid
Savanna tree
Forest tree

Next steps

Validate, Validate, Validate

Project spatially and under climate change

Add succulents?

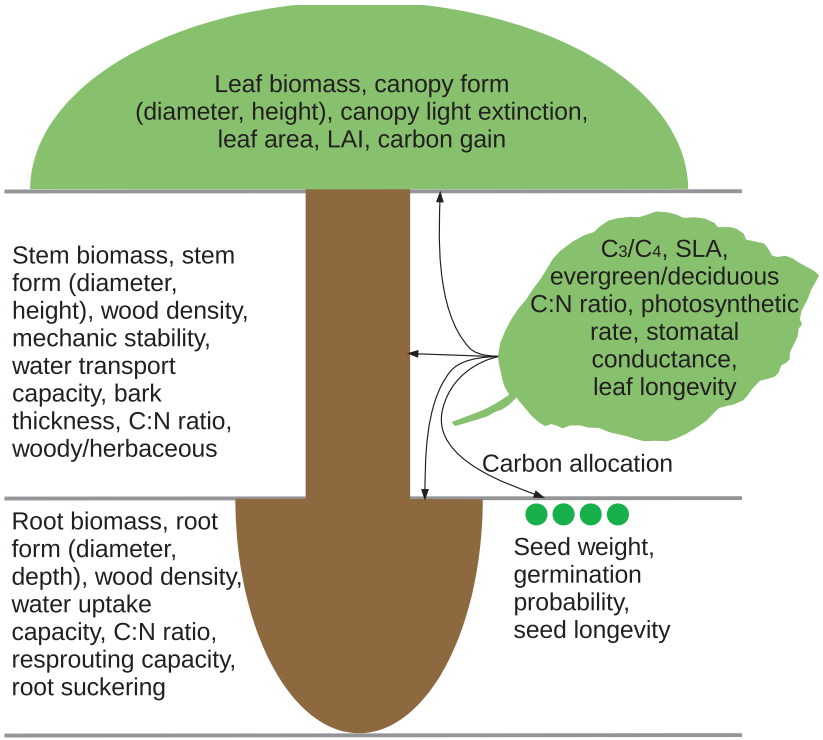
Moving away from PFTs

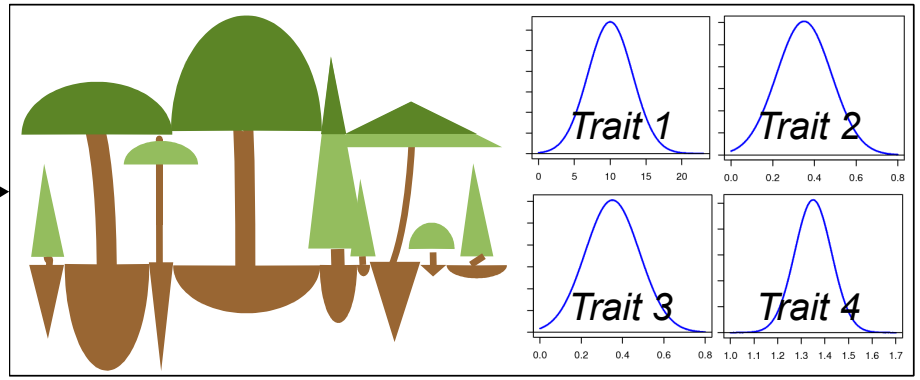
We already know that PFTs have many drawbacks

In a diverse system like fynbos, we can hardly expect one PFT to capture all diversity

We can however use traits to describe plant diversity, and if we want to, classify our simulated community of traits afterwards into a biome we are familiar with….

Trait based models





Scheiter et al 2013

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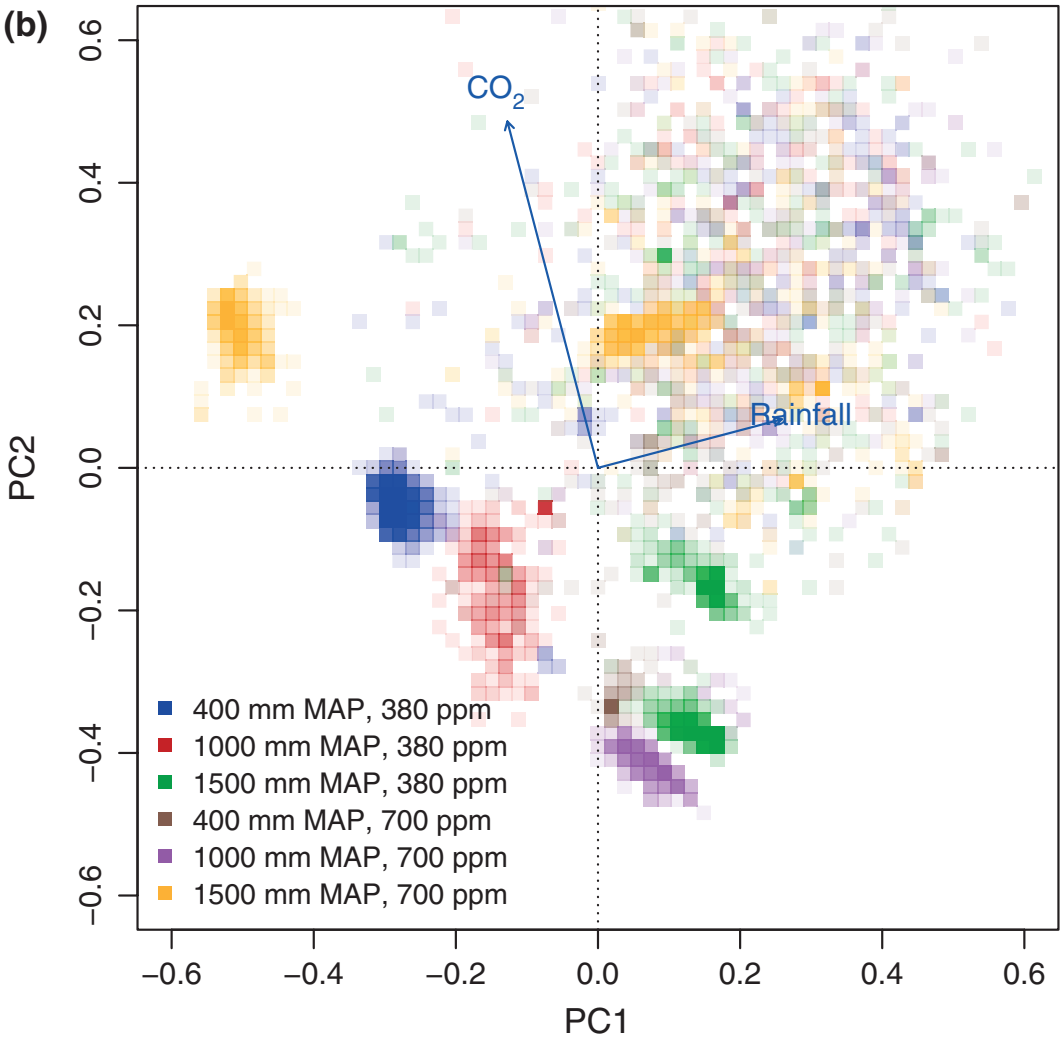
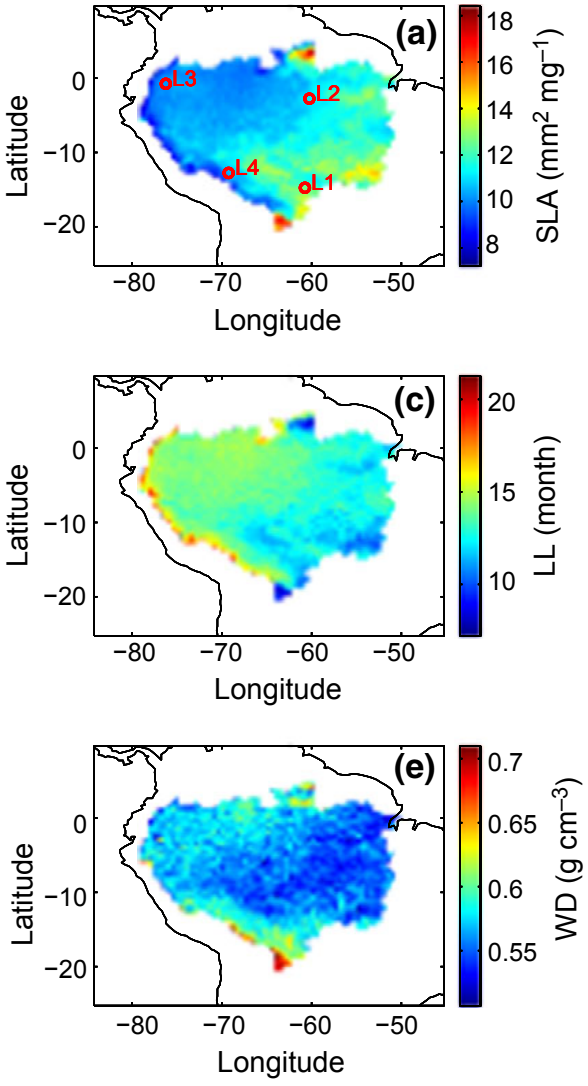


Scheiter et al 2013

Existing regional models



Sakschewski et al 2015

Recap

Correlative models are useful, but have big drawbacks

DGVMs can overcome some of these problems, but are very complex and need to be interrogated

Out-of-the-box global models aren't appropriate, they need modifications

Ultimately we need to give up on PFTs and use traits to model plant diversity, but this requires lots of detail and data

Thanks:

William Bond - UCT, SAEON

Guy Midgley - Stellenbosch

Liam Langan – Goethe University Frankfurt

Biodiversity and Climate Research Center, Frankfurt, Germany

SAEON fynbos node