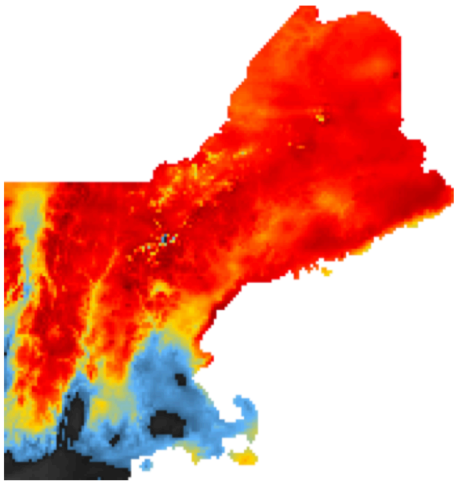
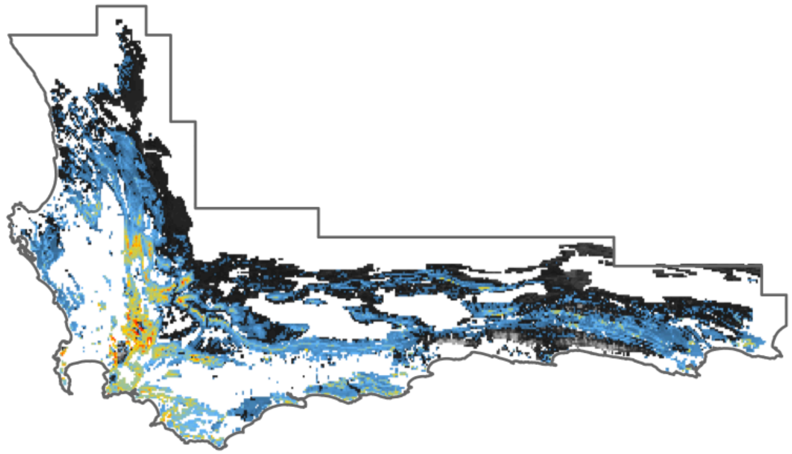
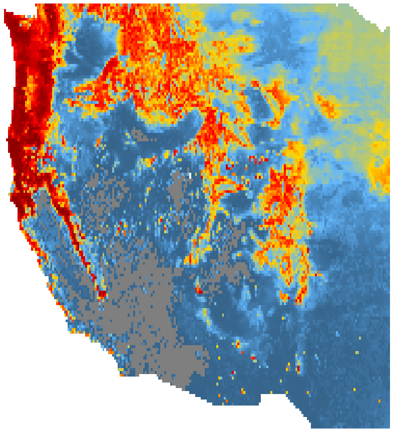
LINKING DEMOGRAPHY TO RANGE DYNAMICS



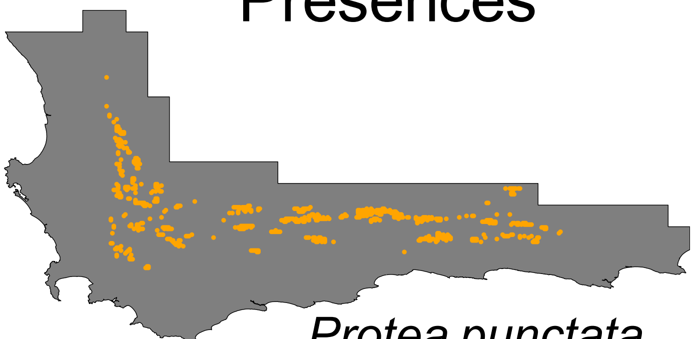
Cory Merow Yale University

Demographic range models

- **Understanding**
  - Vital rates (survival, growth, fecundity)
  - Population statistics (Pop. Growth, Life expectancy…)
- **Better extrapolation**
- **Temporal patterns**
  - Population dynamics
  - Disturbance
  - Dispersal

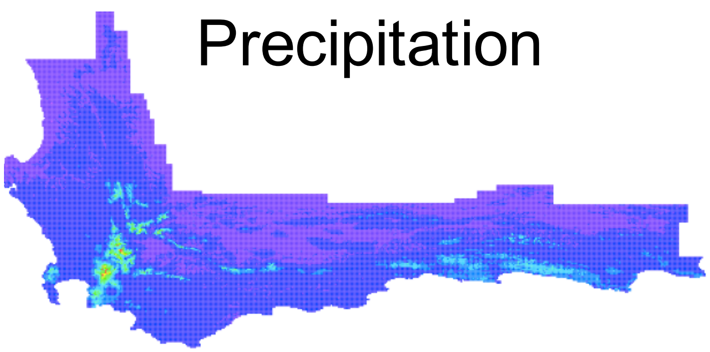
The usual range models…

Presences



Protea punctata

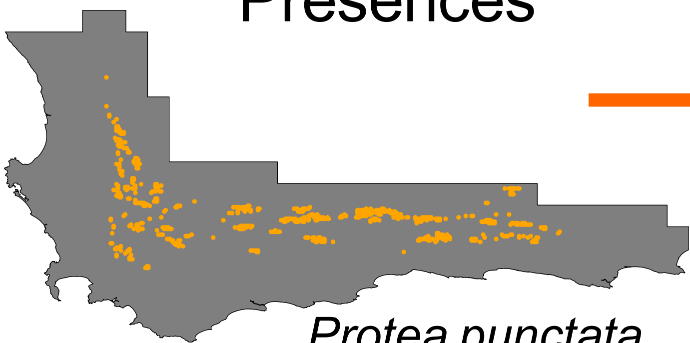
Annual Precipitation



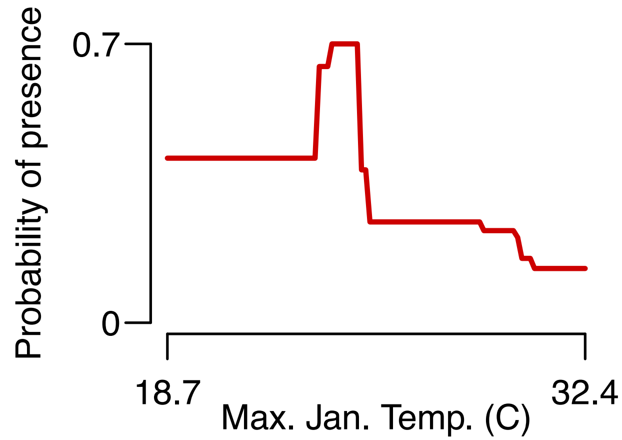
Merow et al., 2013, *Ecography;* Merow et al., 2014, *Ecography*

The usual range models…

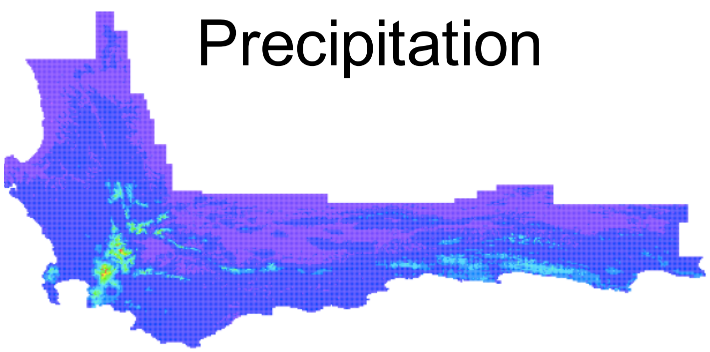
Presences



Protea punctata



Annual
Precipitation



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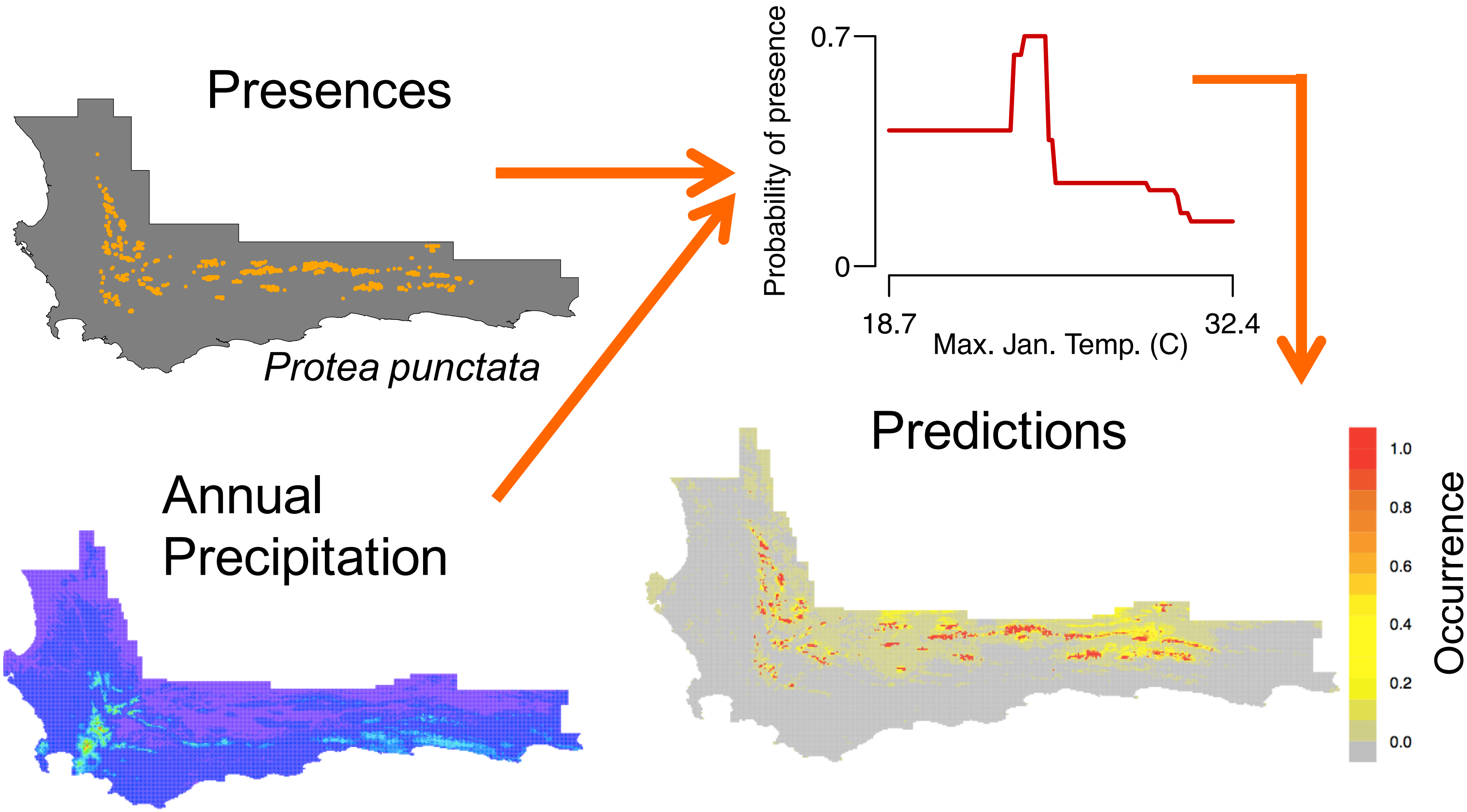
The usual range models…



Merow et al., 2013, *Ecography;* Merow et al., 2014, *Ecography*

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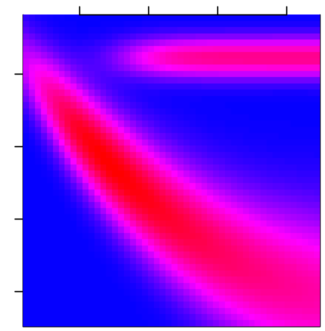
The trouble with mechanims

- You have to get them **ALL** right to forecast

- Correlative models can look pretty nice, because they're not as constrained

Outline

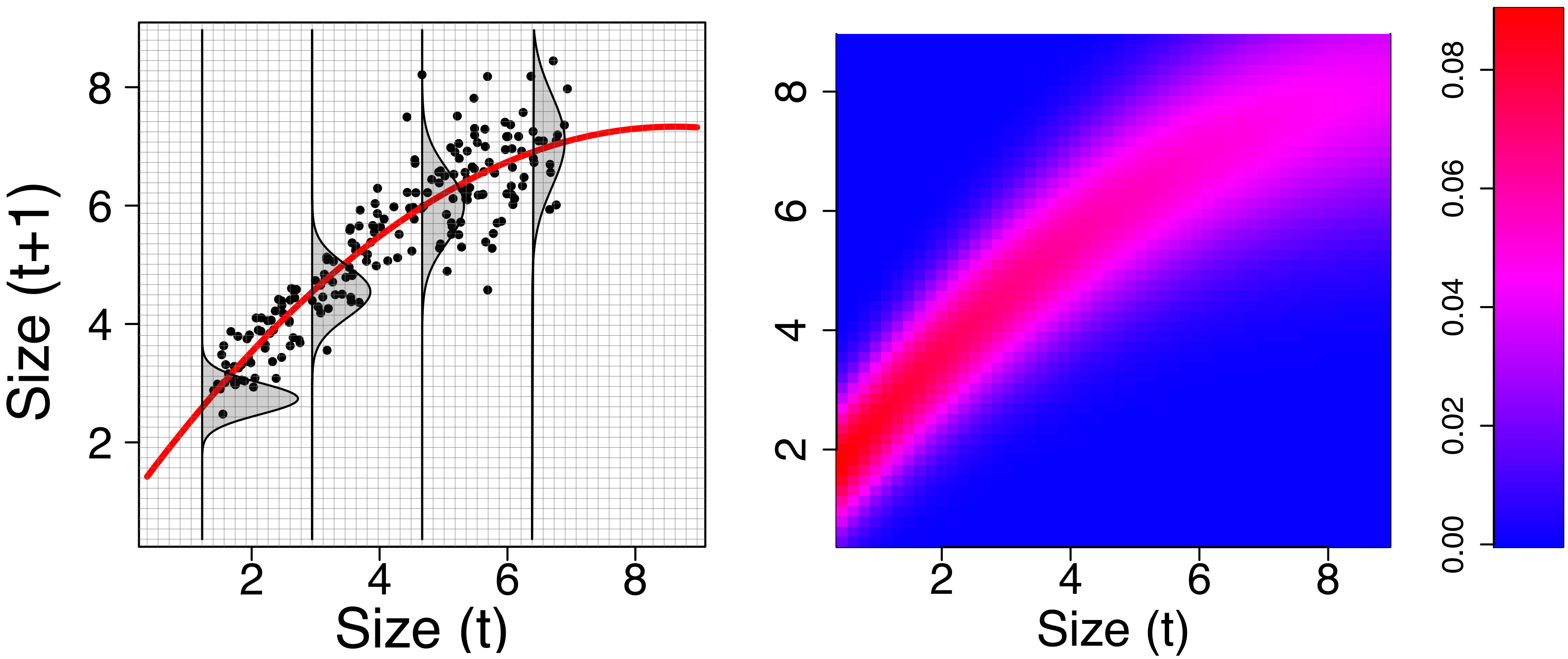
1. Integral Projection Models



2. South African Proteas

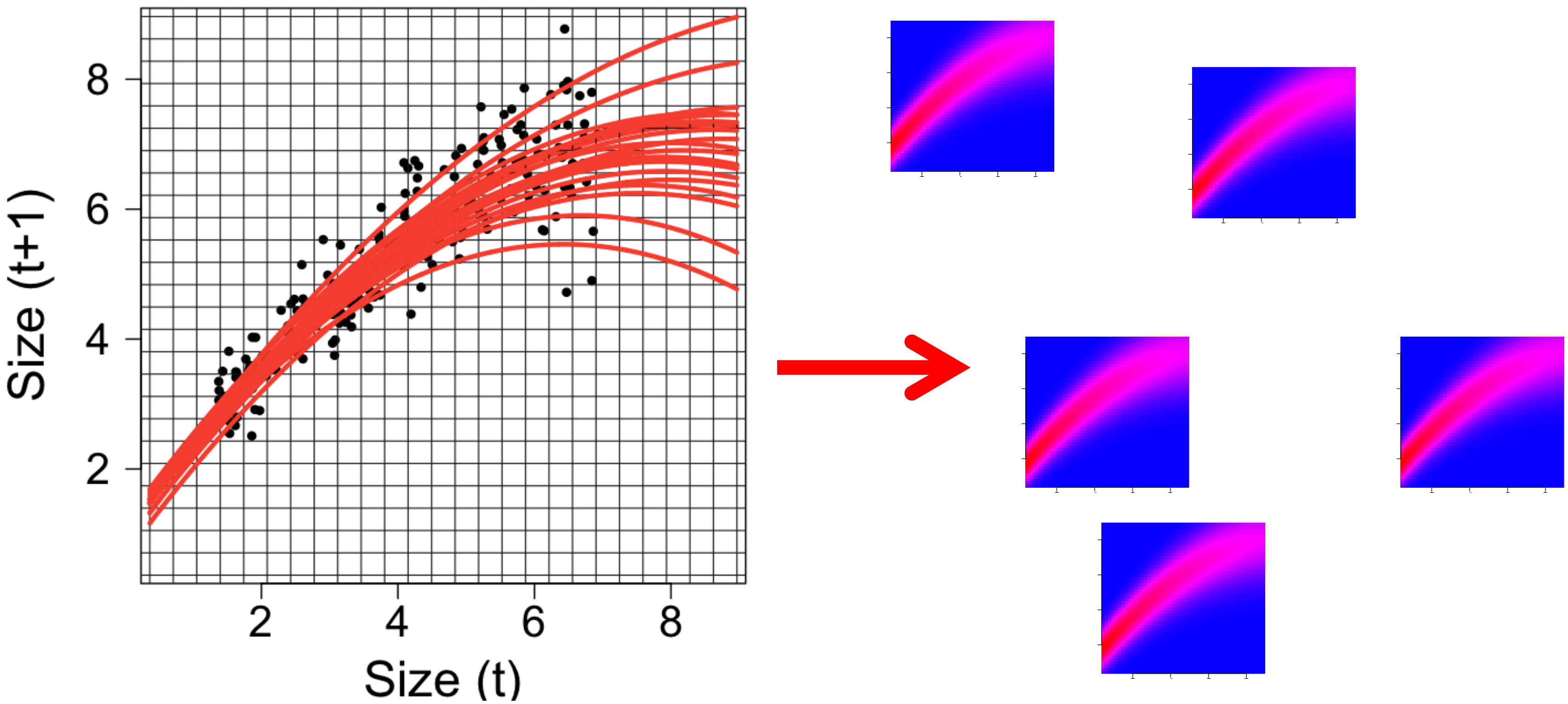
3. Invasive herbs in New England

Vital Rate Regression: Growth



$$\text{mean} = b_0 + b_1 size + b_2 size^2$$

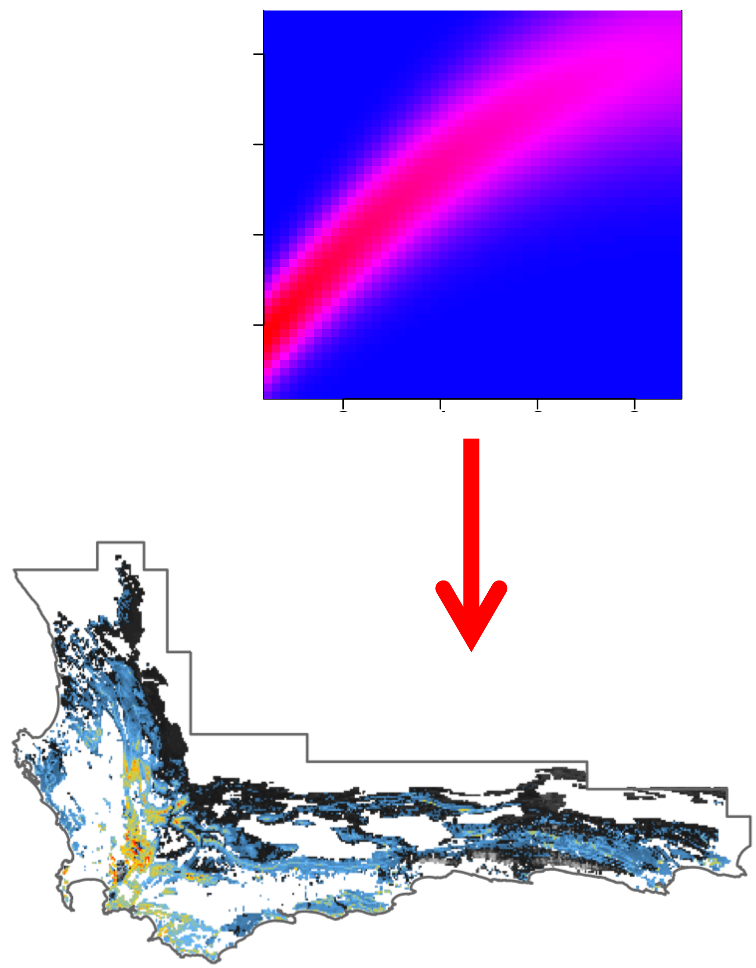
$$\text{variance} = b_3 + b_4 size$$



$$mean = b_0 + b_1 size + b_2 size^2 + b_3 Rain + b_4 Temp$$

Build maps of …

- Population growth rate
- Passage time to given size
- Life expectancy
- Size distributions
- Sensitivities



Merow et al. 2014 *Ecography*

Case Study – *Protea repens*

Photos: Adam Wilson

Objectives

Predict range from demography?

Response to climate change?

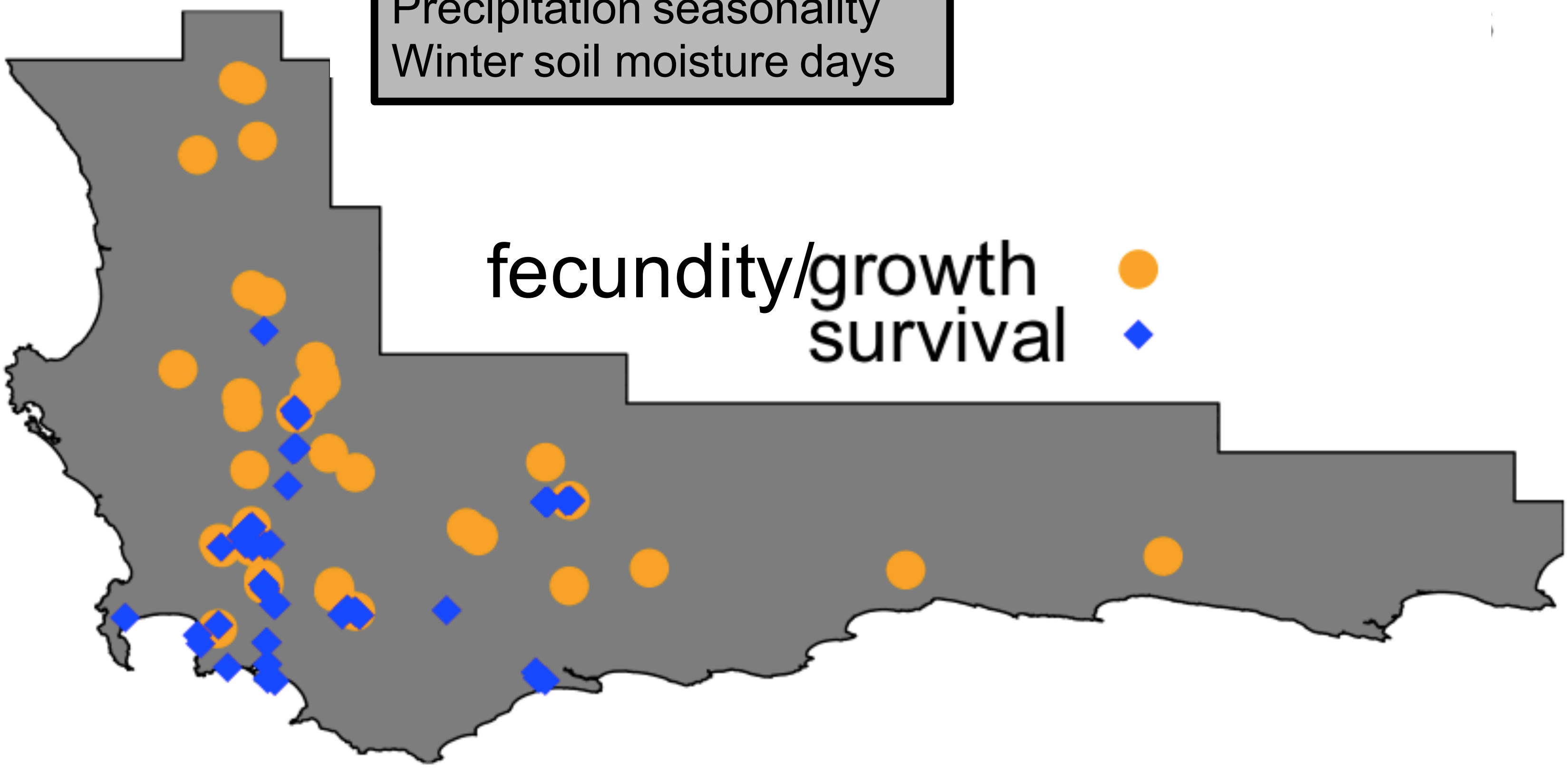
Response to fire change?

Data

Predictor variables

Mean annual precip.
Min. July temp.
Max. January temp.
Precipitation seasonality
Winter soil moisture days

% High fertility soil
% Fine texture soil
% Acidic soil



Data

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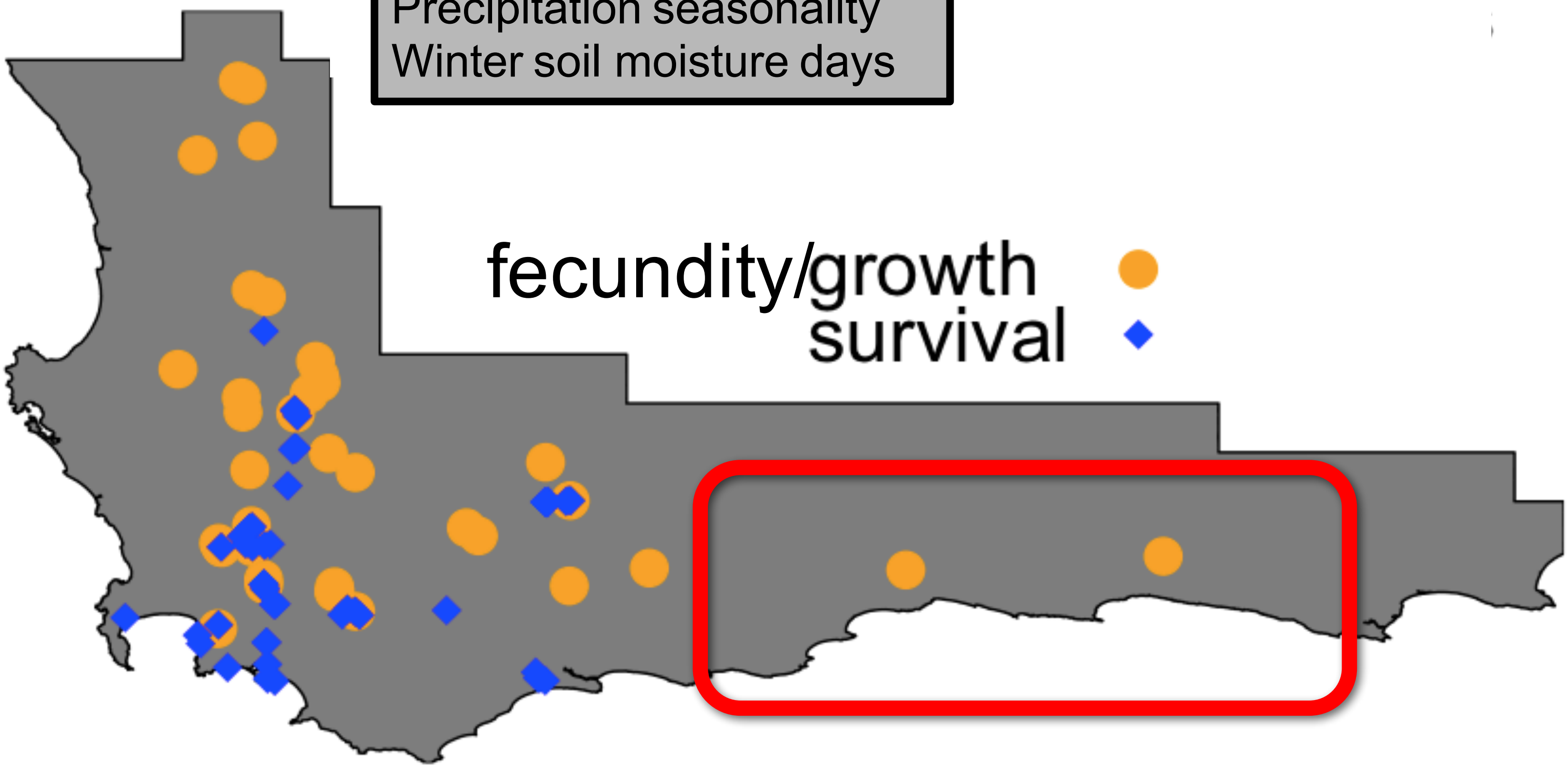


Vital rate models

Growth

Average growth/year ~ Environment

Vital rate models

Growth

Average growth/year ~ Environment

Survival

% Survival ~ Size + Environment

Vital rate models

Growth

Average growth/year	~	Environment

Survival

% Survival	~	Size + Environment

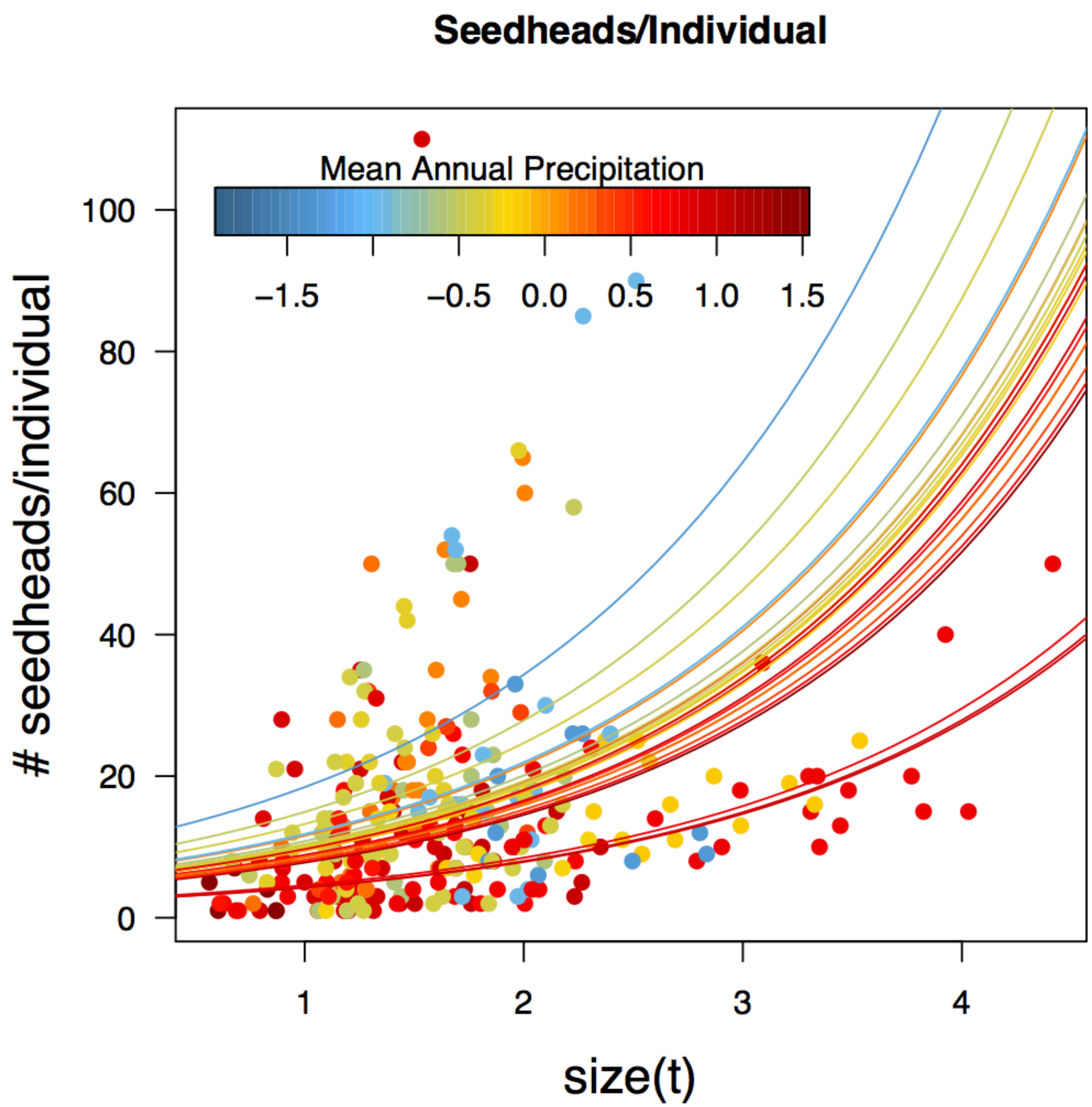
Fecundity

Flowering Probability	~	Size + Environment
# Flowers/Individual	~	Size + Environment
Seeds/Flower	=	74
Germination	=	1.1%

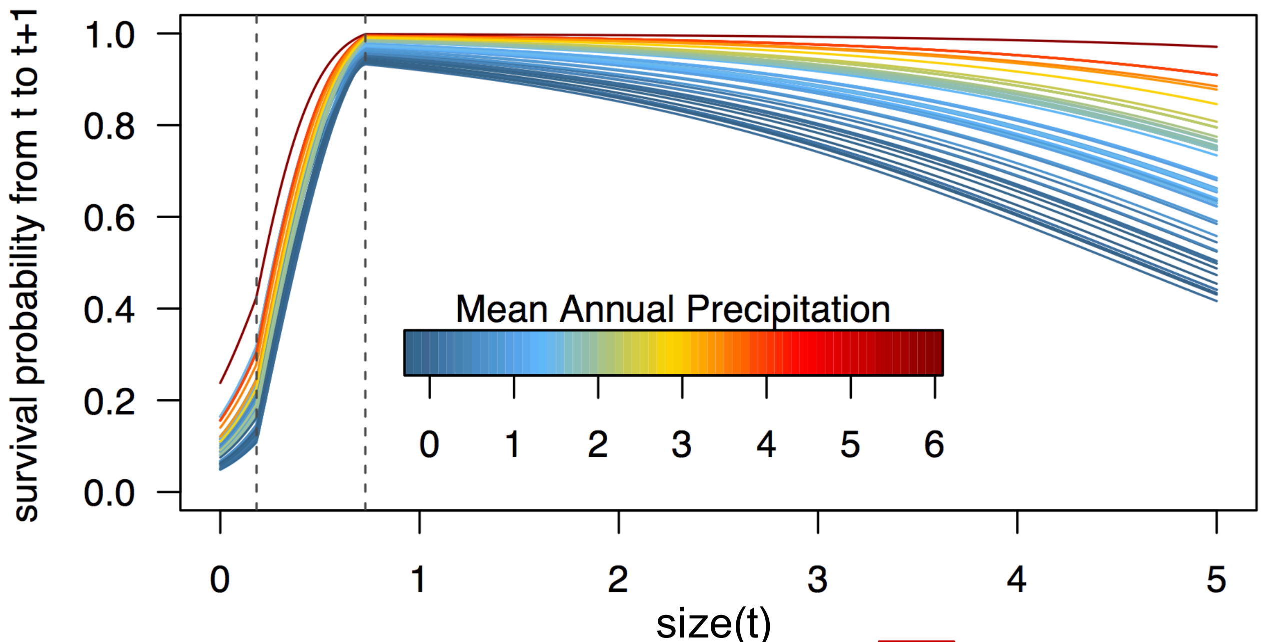
Offspring size

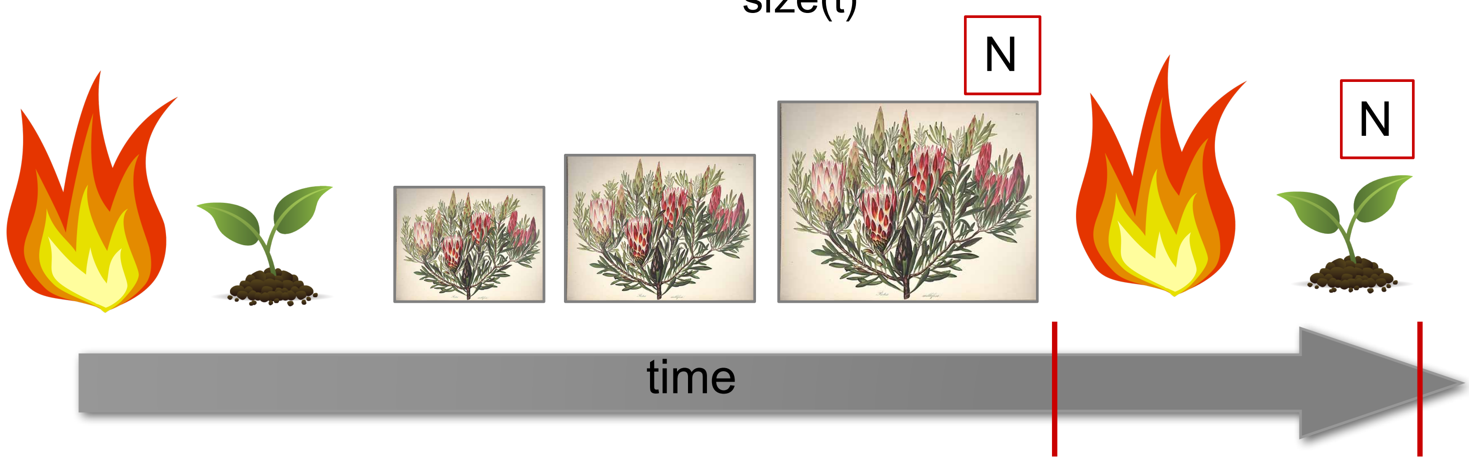
Size	~	Environment

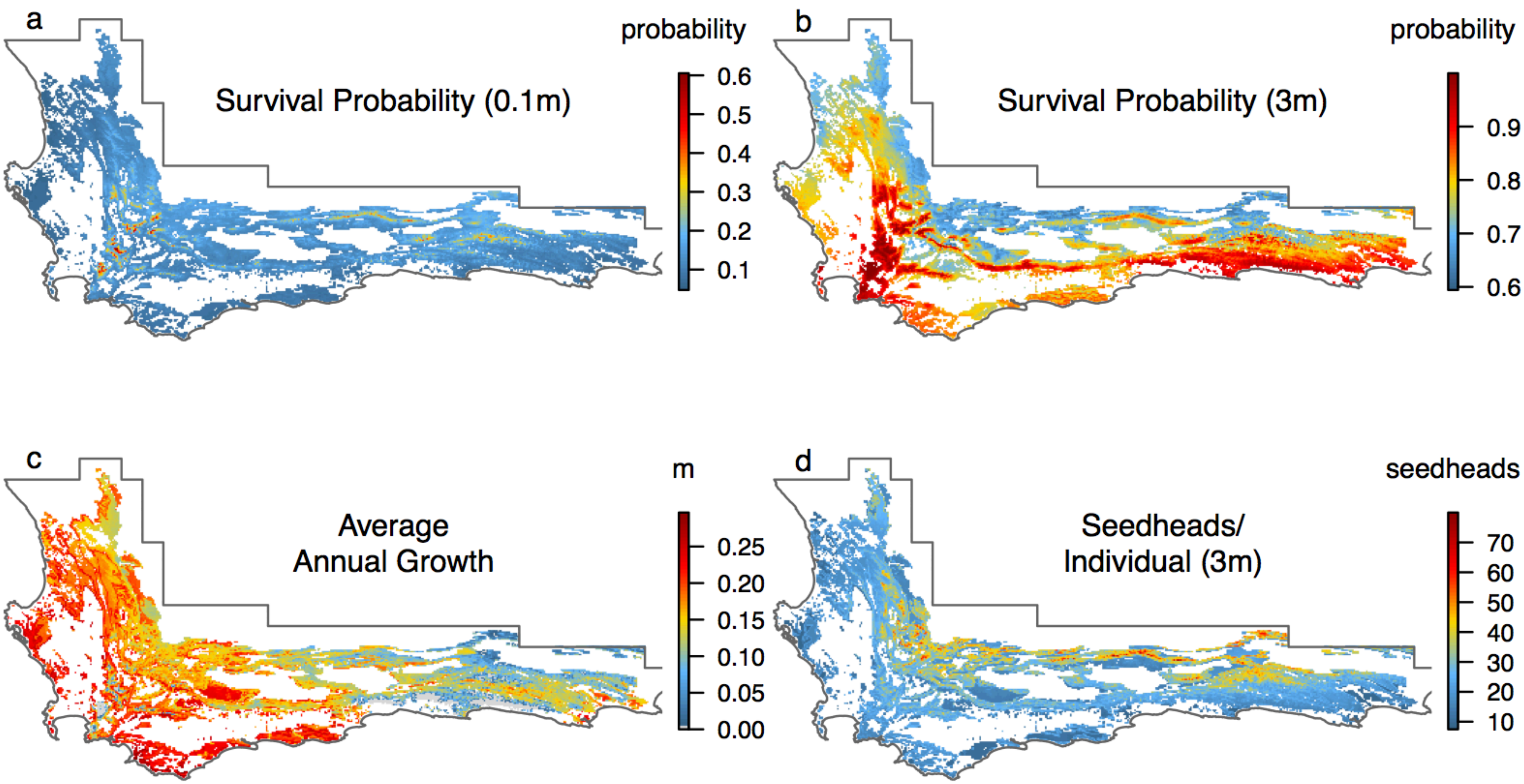
Vital Rate Models



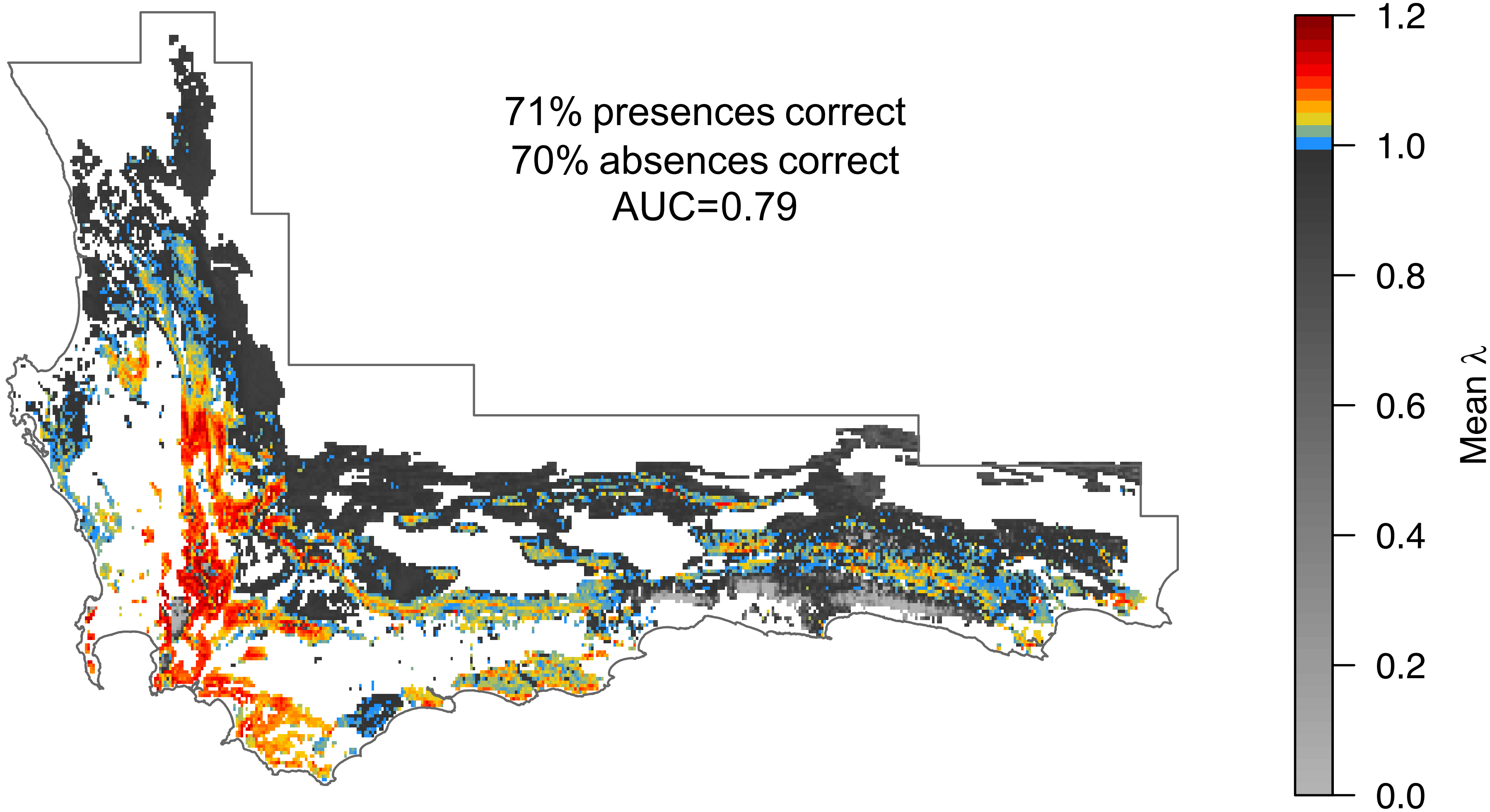
Vital Rate Models



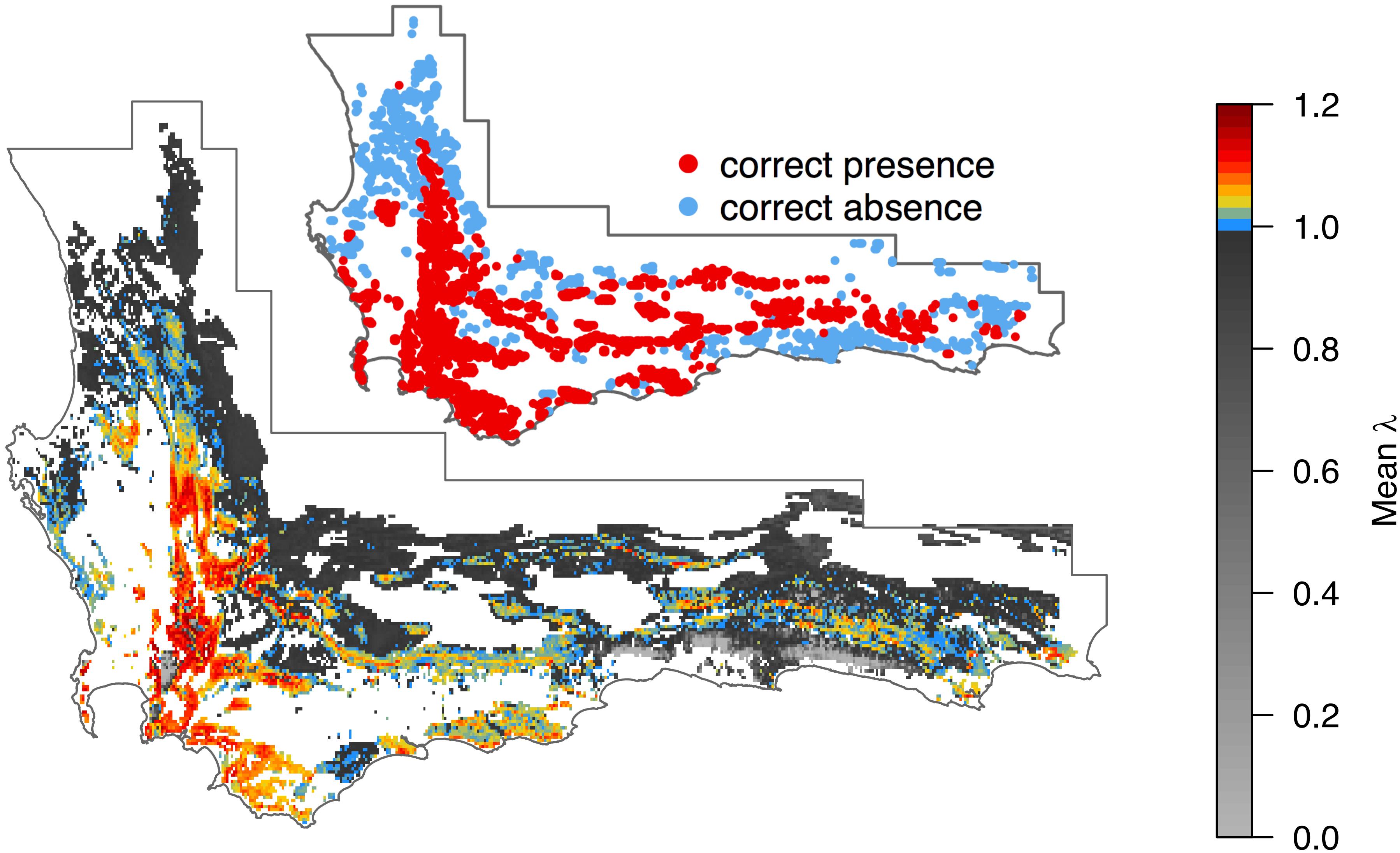



a
probability
Survival Probability (0.1m)
0.6
0.5
0.4
0.3
0.2
0.1
b
probability
Survival Probability (3m)
0.9
0.8
0.7
0.6
c
m
Average
Annual Growth
0.25
0.20
0.15
0.10
0.05
0.00
d
seedheads
Seedheads/
Individual (3m)
70
60
50
40
30
20
10

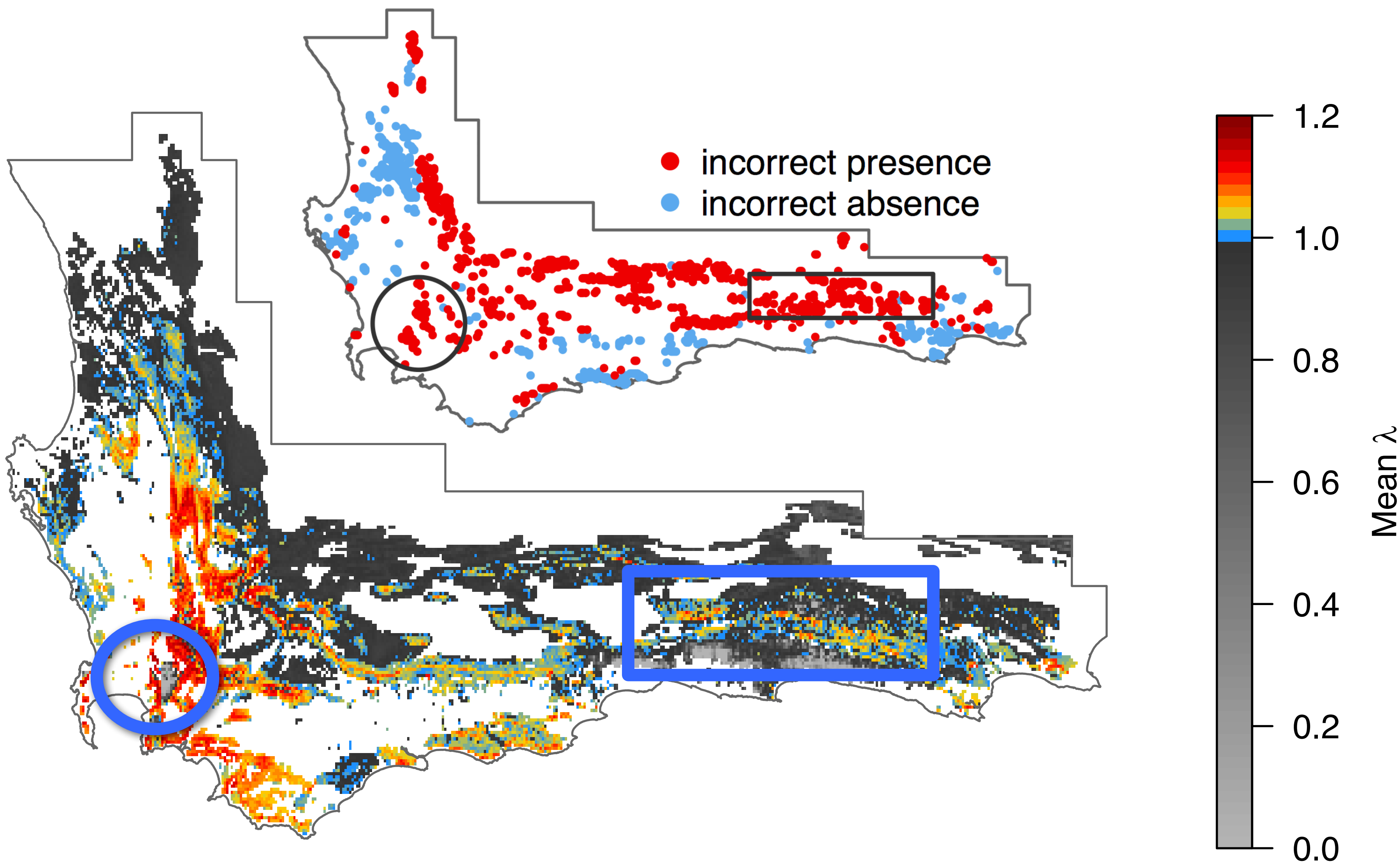
Predictions



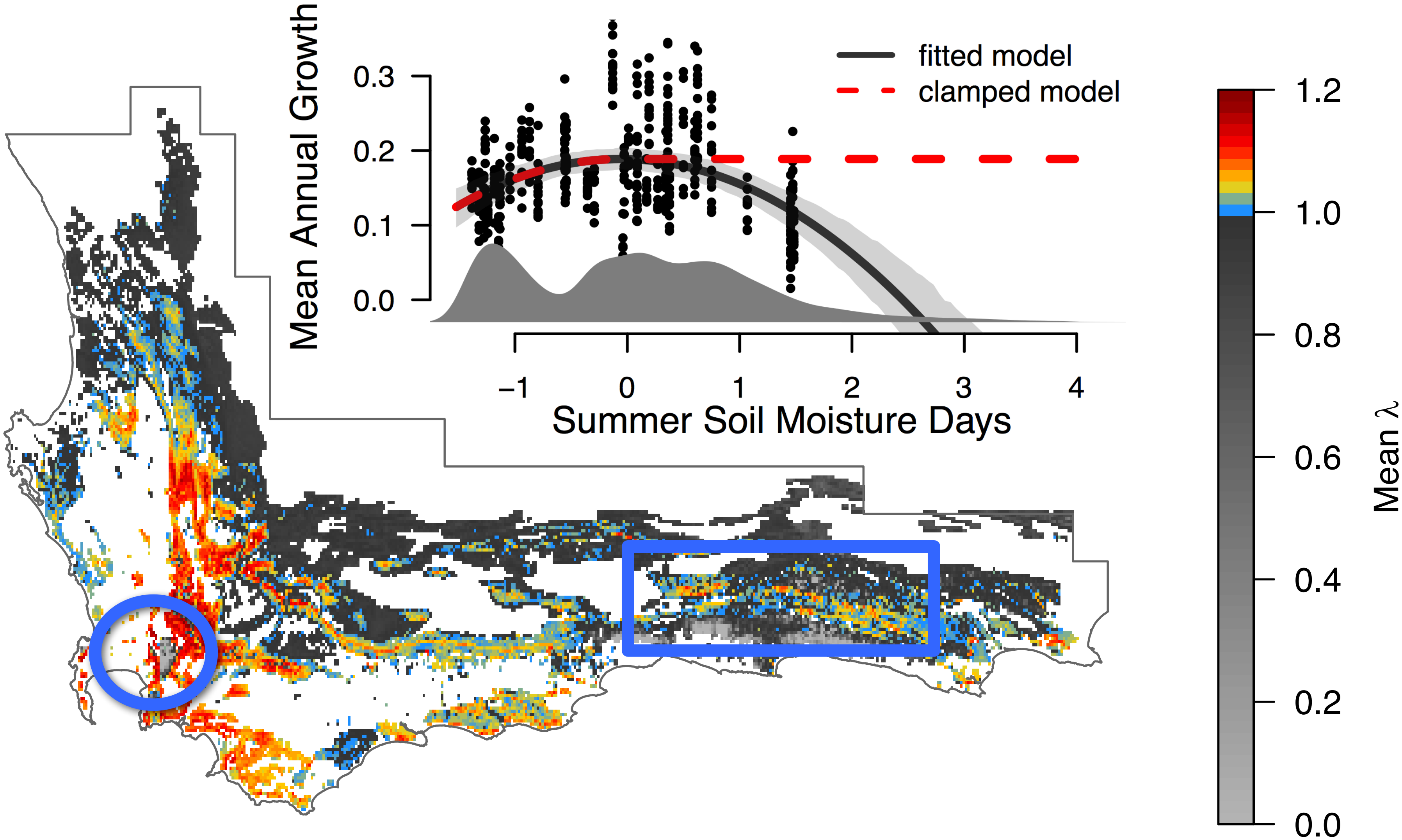
Predictions



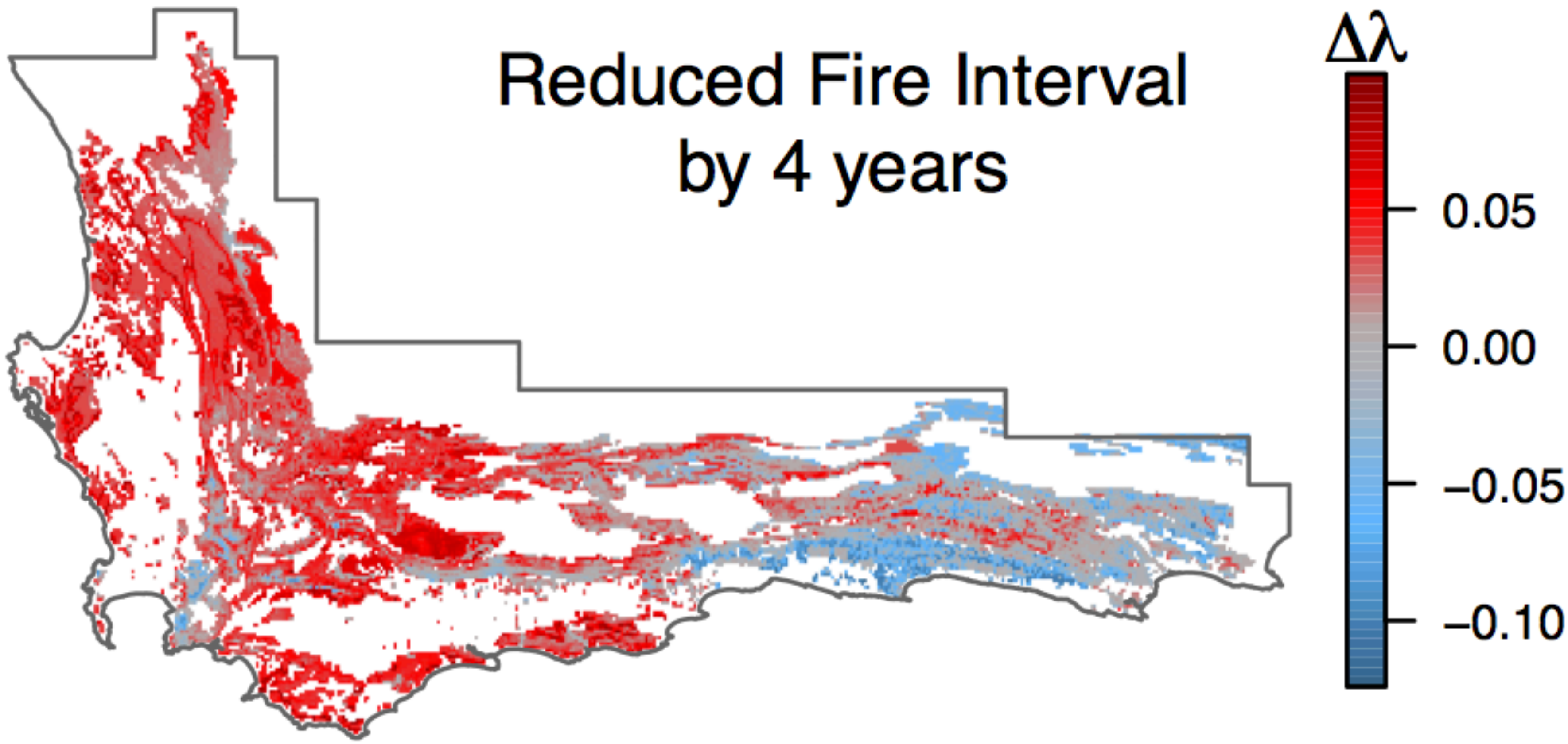
Predictions



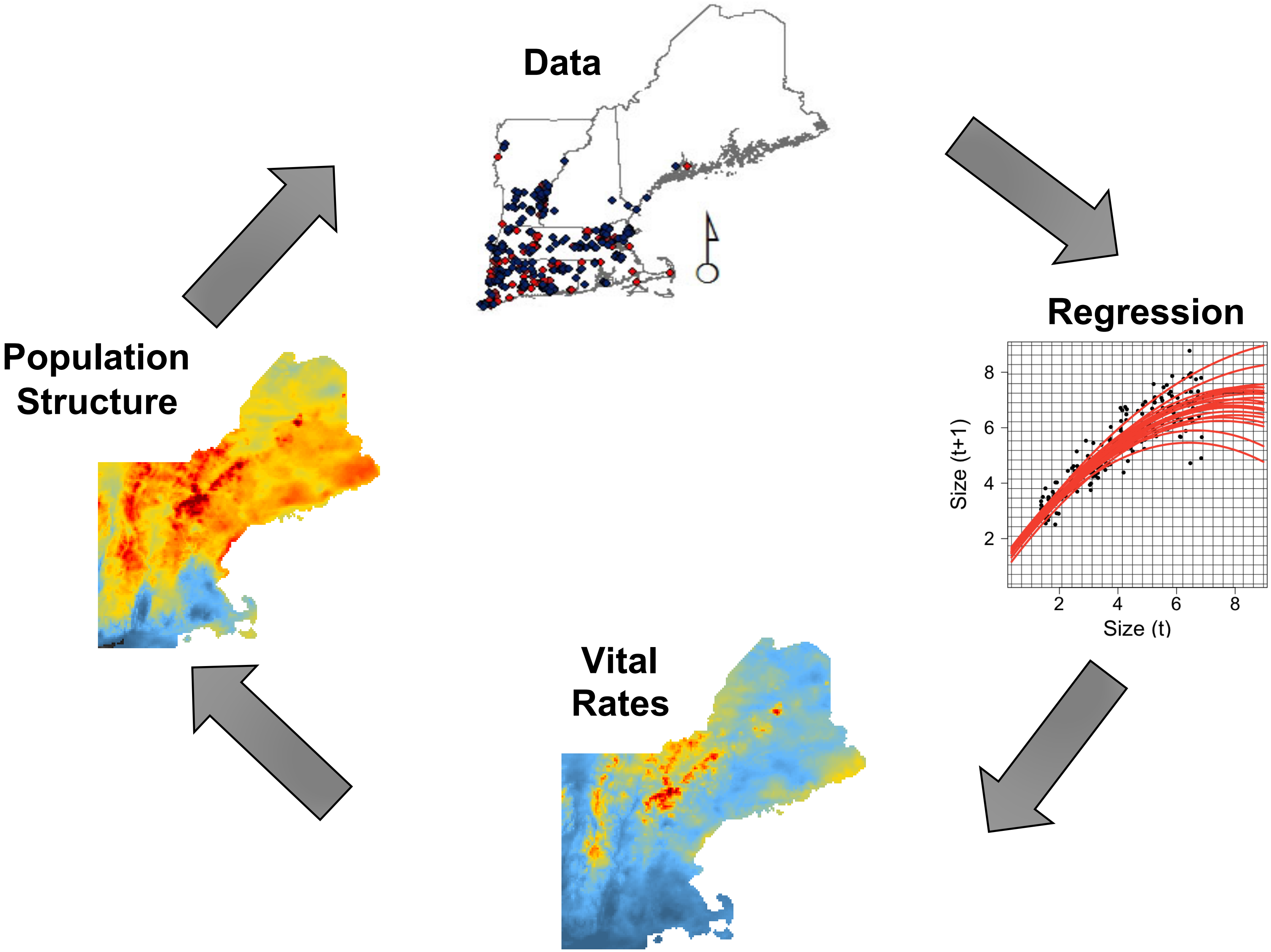
Predictions



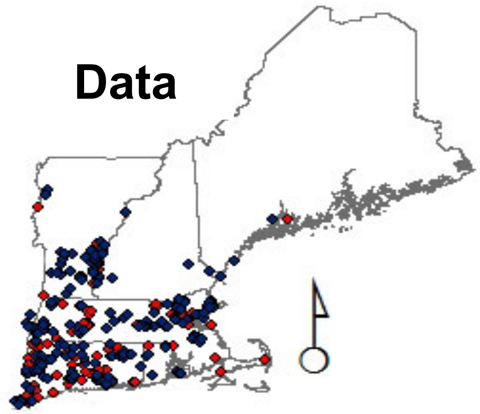
Forecasts



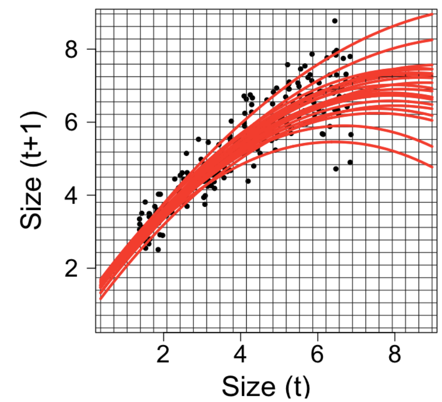
Merow et al. 2014 *Ecography*


Data
Regression
Size (t+1)
Size (t)
2
4
6
8
Vital
Rates
Population
Structure

Data

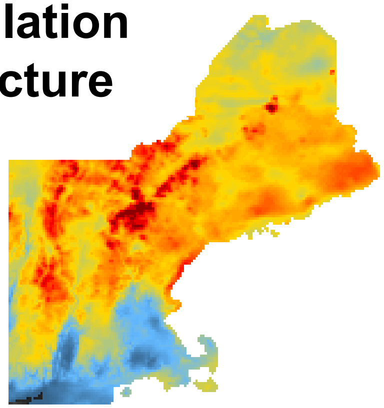


Regression

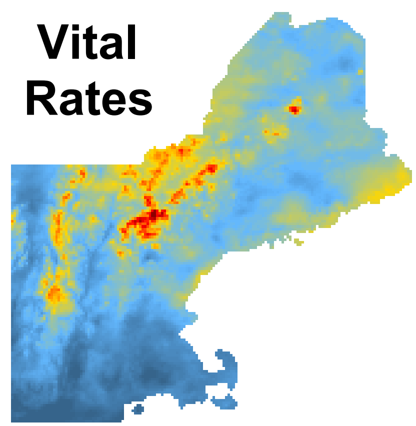


Questions?

Population Structure



Vital Rates



British Ecological Society
Plant Environmental Physiology Group

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