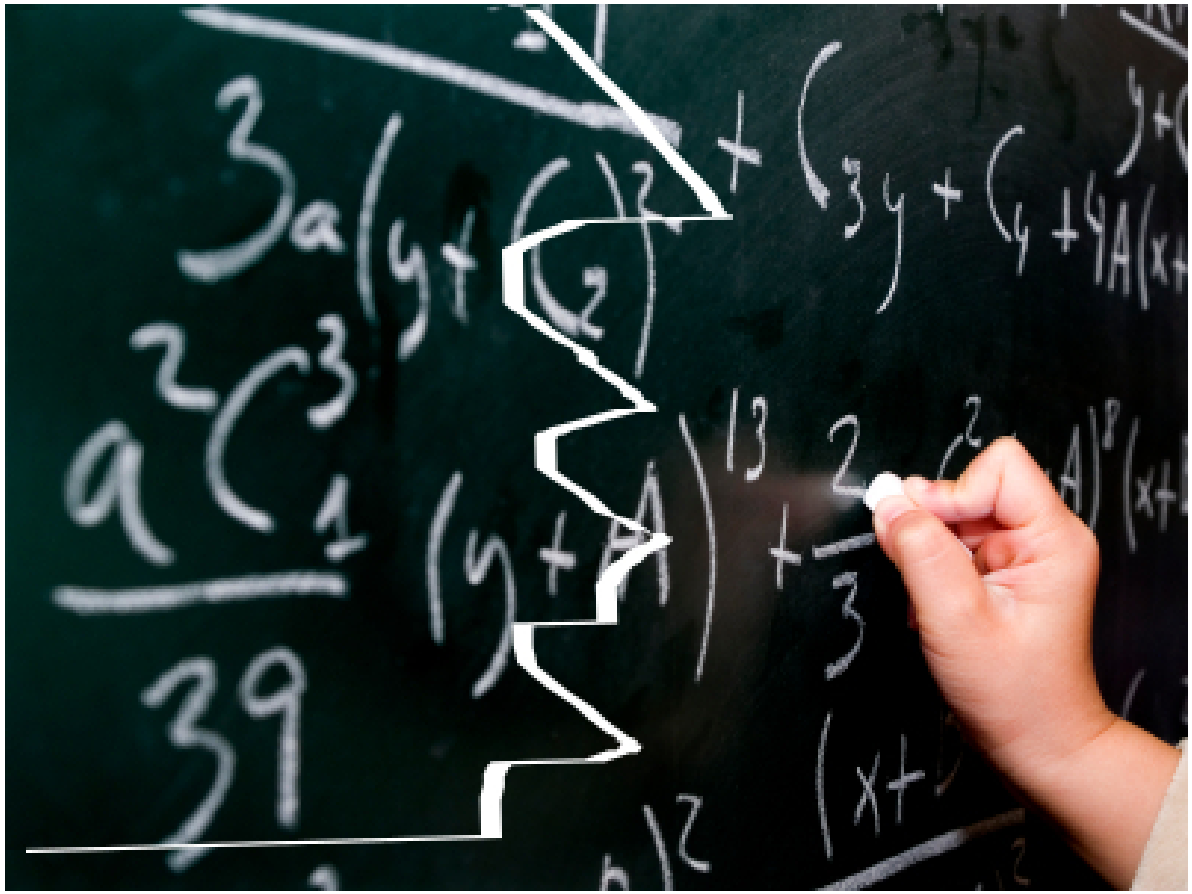
Regime shifts in ecology & evolution

@cboettig

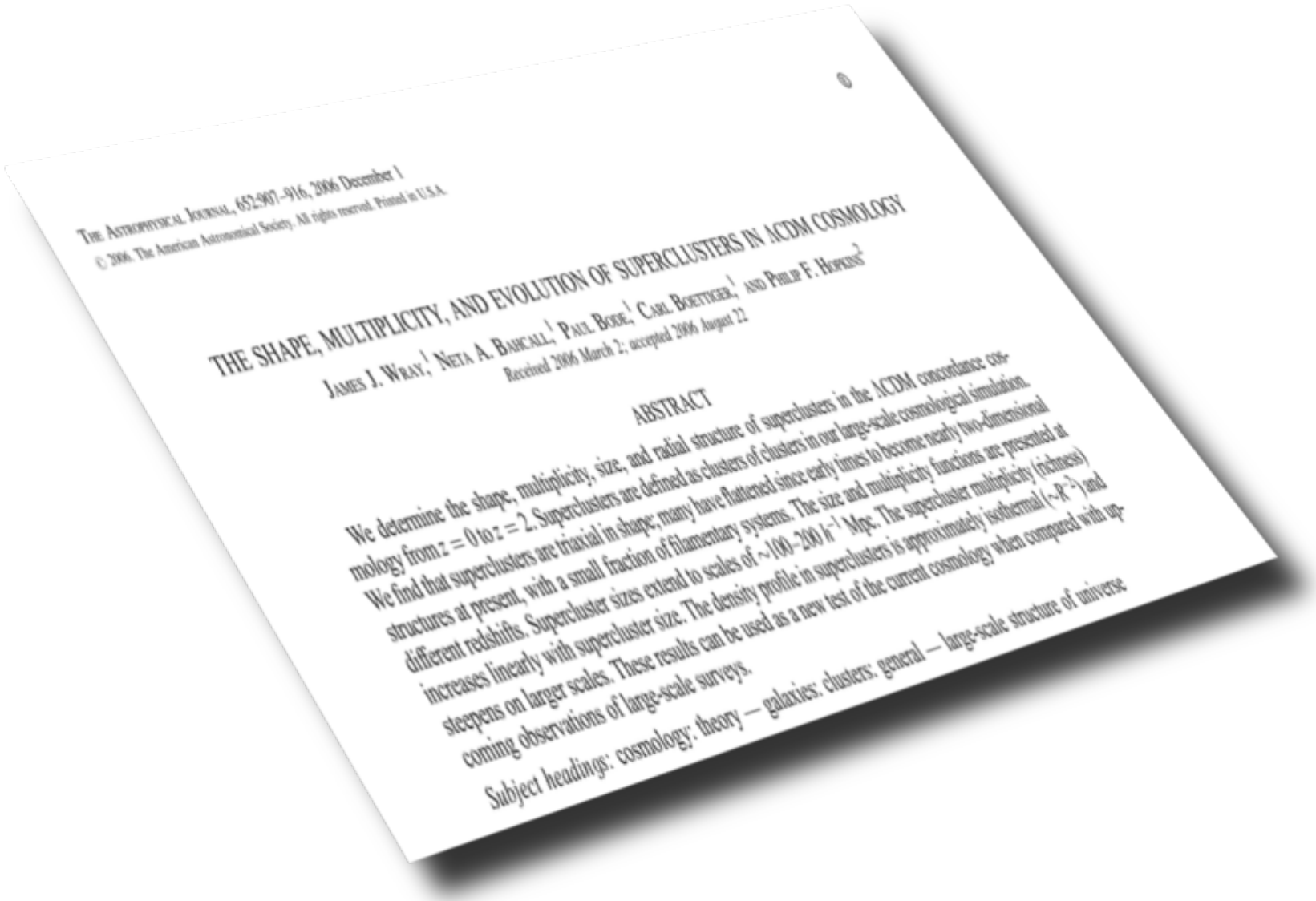
Regime

Shifts



⟨ Ecologist ⟩

started in physics. . .



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THE SHAPE, MULTIPLICITY, AND EVOLUTION OF SUPERCLUSTERS IN ΛCDM COSMOLOGY

James J. Wray[1], Neta A. Bahcall[1], Paul Bode[1], Carl Boettiger[1], and Philip F. Hopkins[2]

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ABSTRACT

We determine the shape, multiplicity, size, and radial structure of superclusters in the ΛCDM concordance cosmology from $z = 0$ to $z = 2$. Superclusters are defined as clusters of clusters in our large-scale cosmological simulation. We find that superclusters are triaxial in shape; many have flattened since early times to become nearly two-dimensional structures at present, with a small fraction of filamentary systems. The size and multiplicity functions are presented at different redshifts. Supercluster sizes extend to scales of ~100–200 h^{-1} Mpc. The supercluster multiplicity (richness) increases linearly with supercluster size. The density profile in superclusters is approximately isothermal ($\sim R^{-2}$) and steepens on larger scales. These results can be used as a new test of the current cosmology when compared with upcoming observations of large-scale surveys.

Subject headings: cosmology: theory — galaxies: clusters: general — large-scale structure of universe

Digging for dinosaurs

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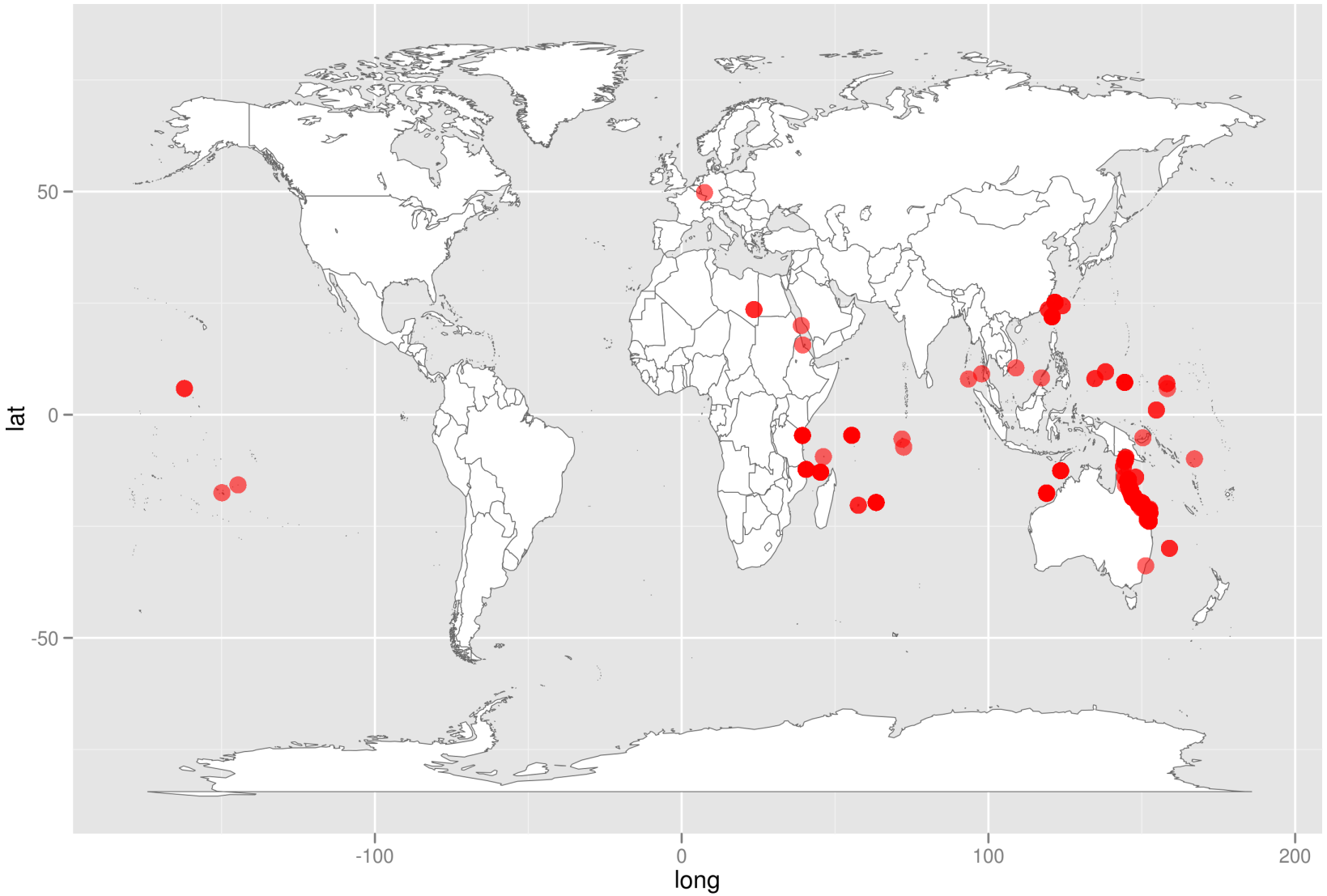
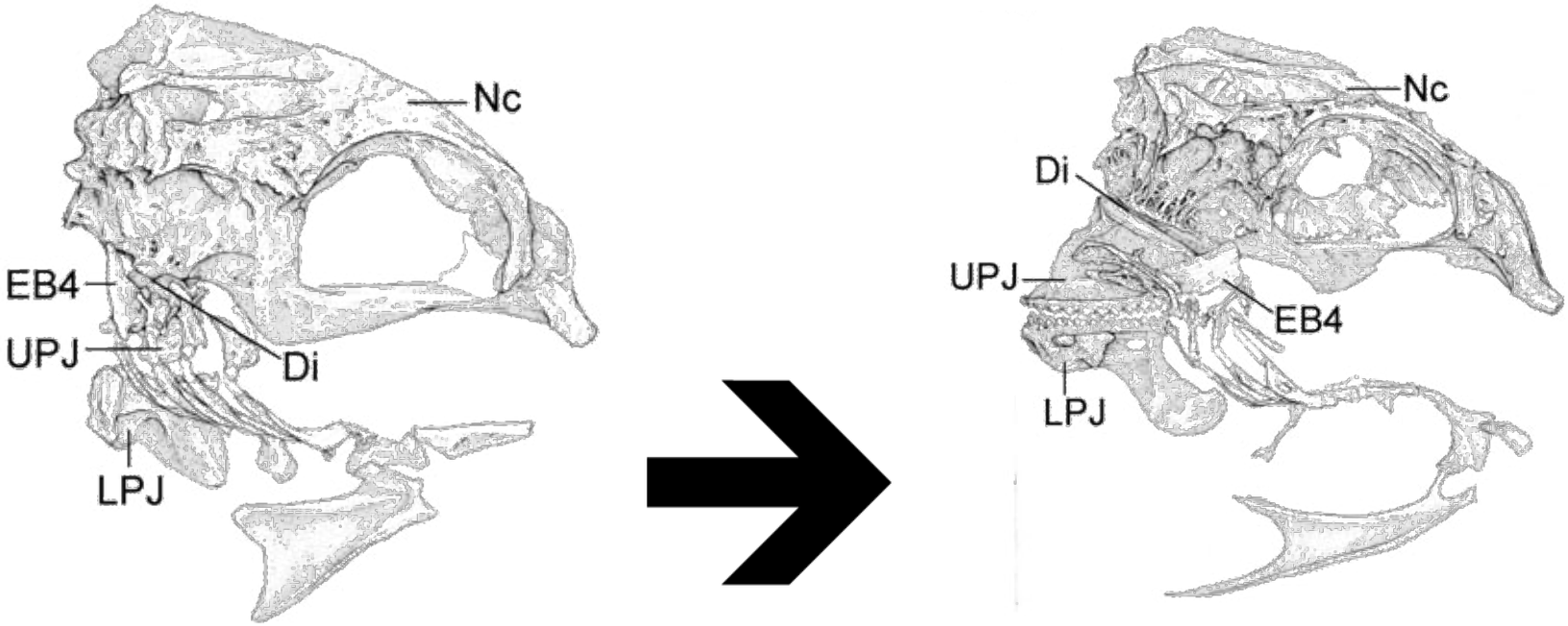
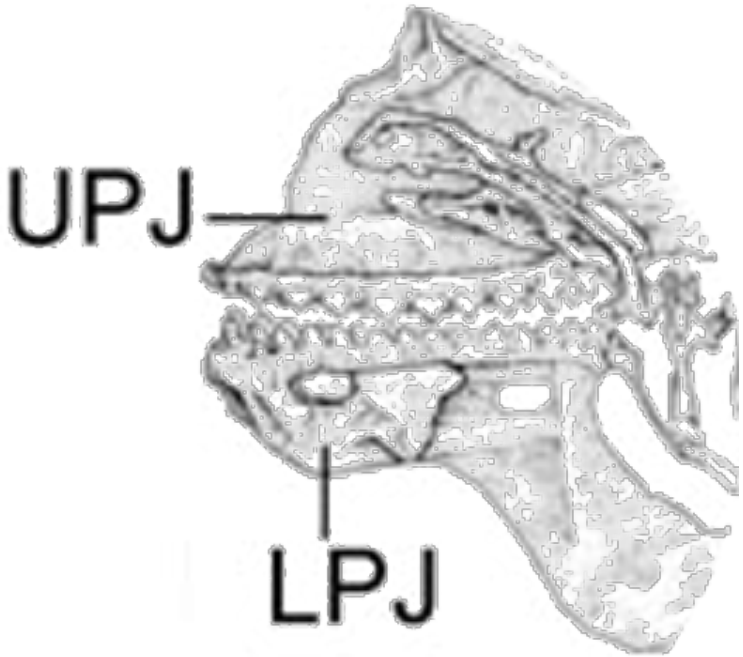
Peter Wainwright

Peter's dives




Nc
EB4
UPJ
Di
LPJ
Nc
Di
UPJ
EB4
LPJ


UPJ
LPJ

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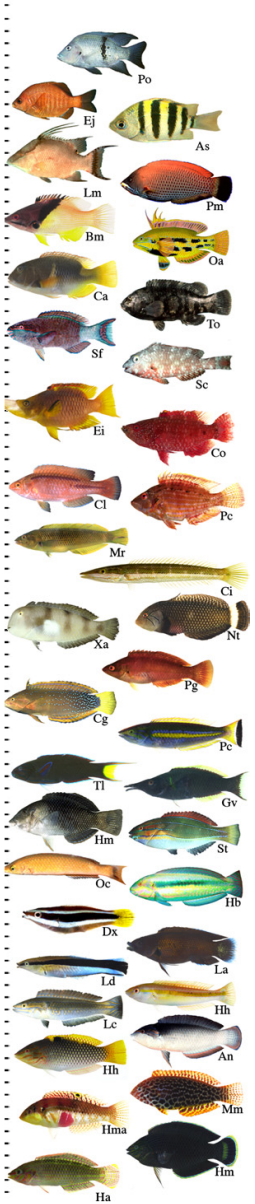
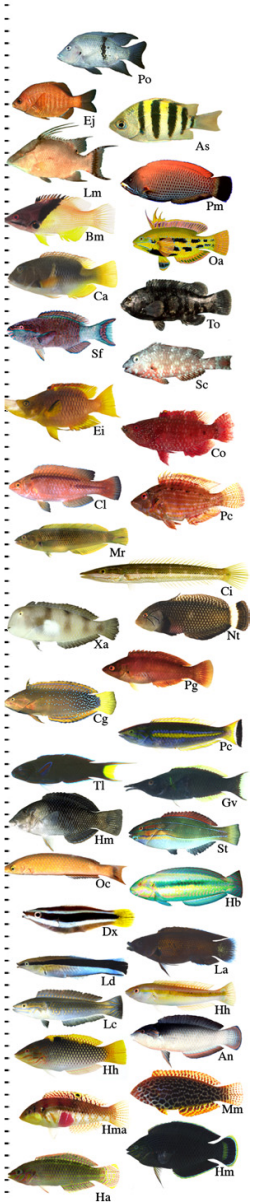
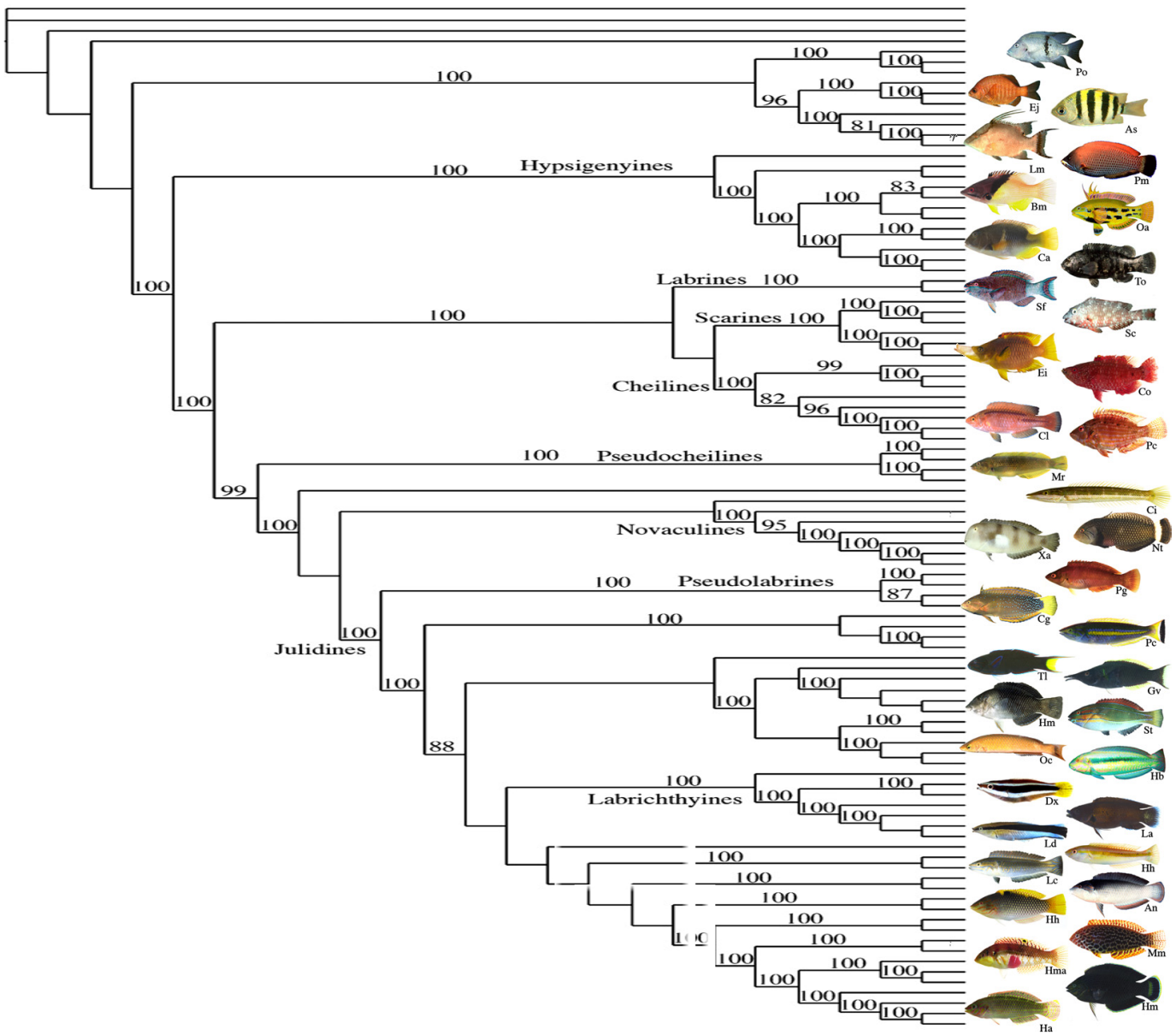
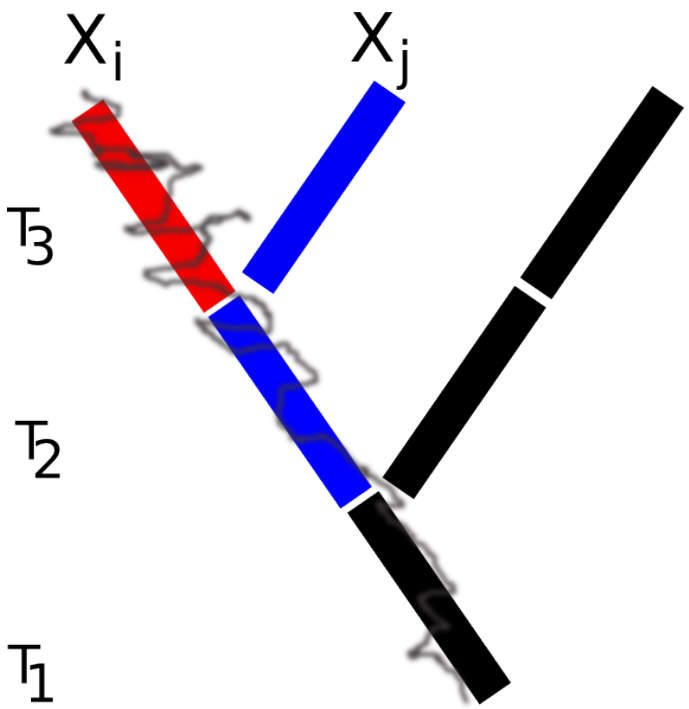
A release of constraint?


Po
Ej
As
Lm
Pm
Bm
Oa
Ca
To
Sf
Sc
Ei
Co
Cl
Pc
Mr
Ci
Xa
Nt
Pg
Cg
Pc
Tl
Gv
Hm
St
Oc
Hb
Dx
La
Ld
Hh
Lc
An
Hh
Mm
Hma
Hm
Ha


Po
Ej
As
Lm
Pm
Bm
Oa
Ca
To
Sf
Sc
Ei
Co
Cl
Pc
Mr
Ci
Xa
Nt
Pg
Cg
Pc
Tl
Gv
Hm
St
Oc
Hb
Dx
La
Ld
Hh
Lc
An
Hh
Mm
Hma
Hm
Ha

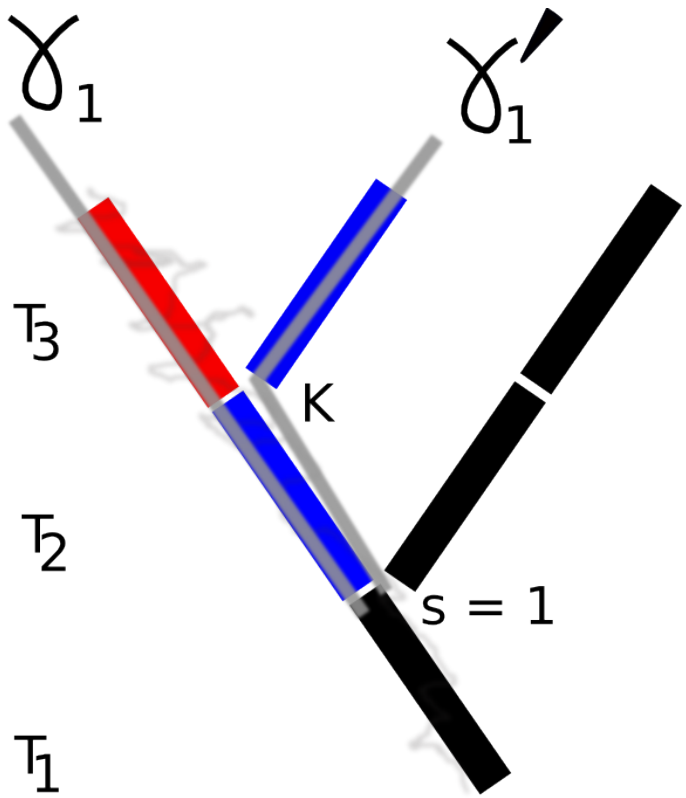

Hypsigenyines
Labrines
Scarines
Cheilines
Pseudocheilines
Novaculines
Pseudolabrines
Julidines
Labrichthyines
Po
Ej
As
Lm
Pm
Bm
Oa
Ca
To
Sf
Sc
Ei
Co
Cl
Pc
Mr
Ci
Nt
Xa
Pg
Cg
Pc
Tl
Gv
Hm
St
Oc
Hb
Dx
La
Ld
Hh
Lc
Hh
An
Mm
Hma
Hm
Ha

How do we get an evolutionary time series from present-day species?



$$X_{T_1} = \underbrace{X_0}_{\text{where you start}} e^{-\alpha_1 T_1} + \underbrace{\theta_1 \left(1 - e^{-\alpha_1 T_1}\right)}_{\text{Where you are going}} + \underbrace{\int_0^{T_1} \sigma_1 e^{\alpha_1 (s - T_1)} \mathrm{d}W_s}_{\text{Random shocks along the way}}$$

$$\gamma_i = -\sum_{j=i+1}^{n} \alpha_j t_j$$

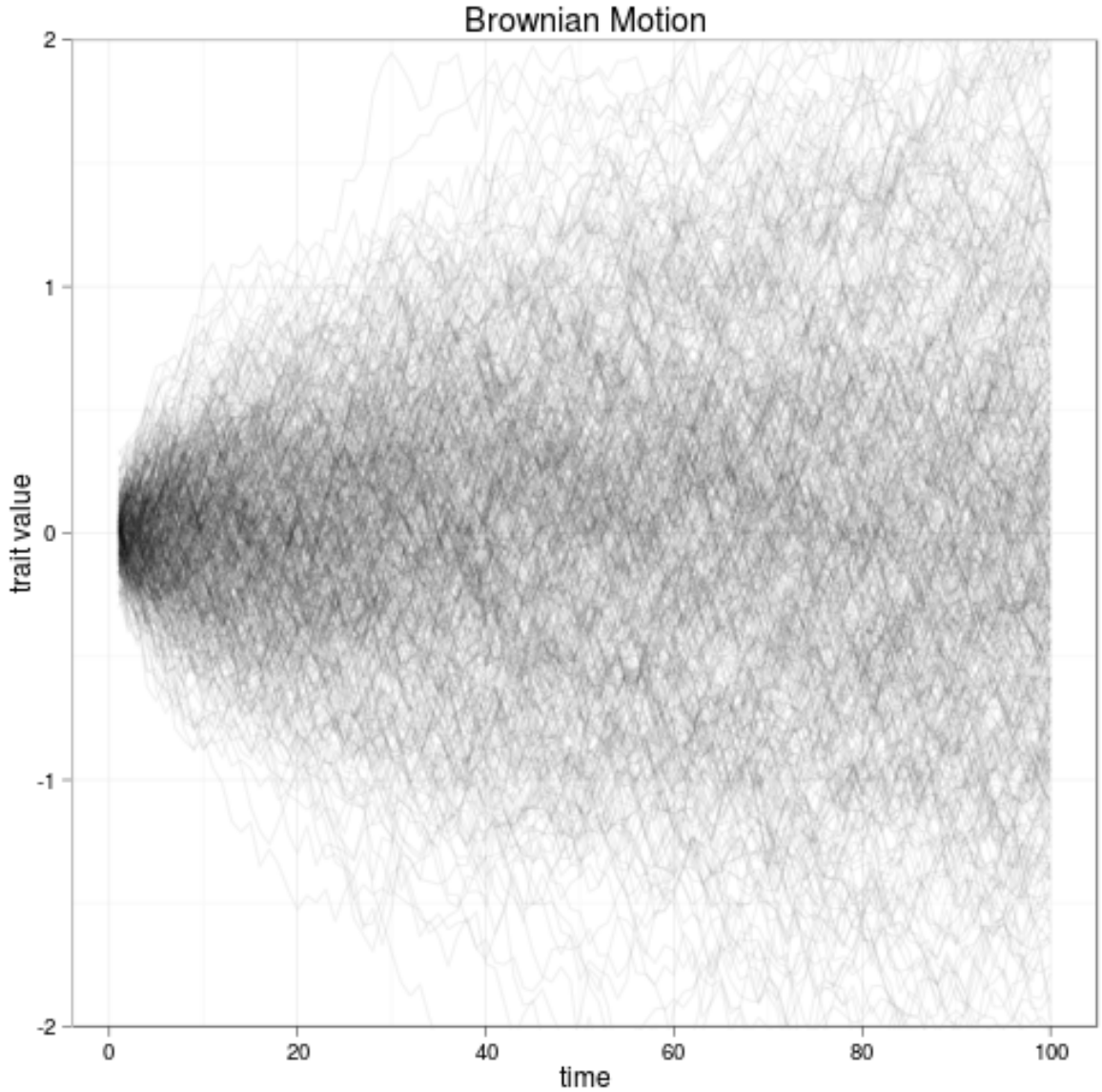


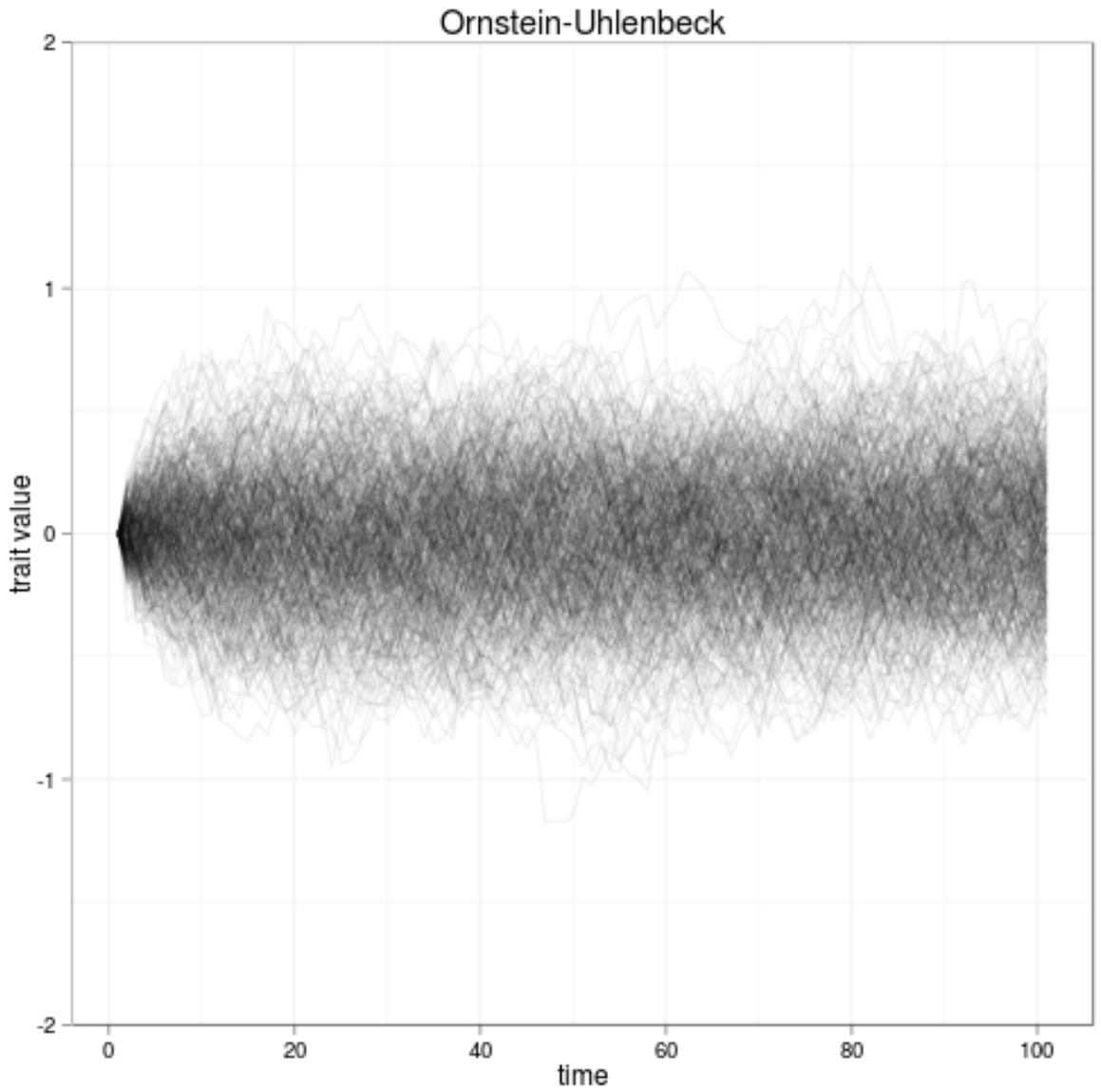
Solves as:

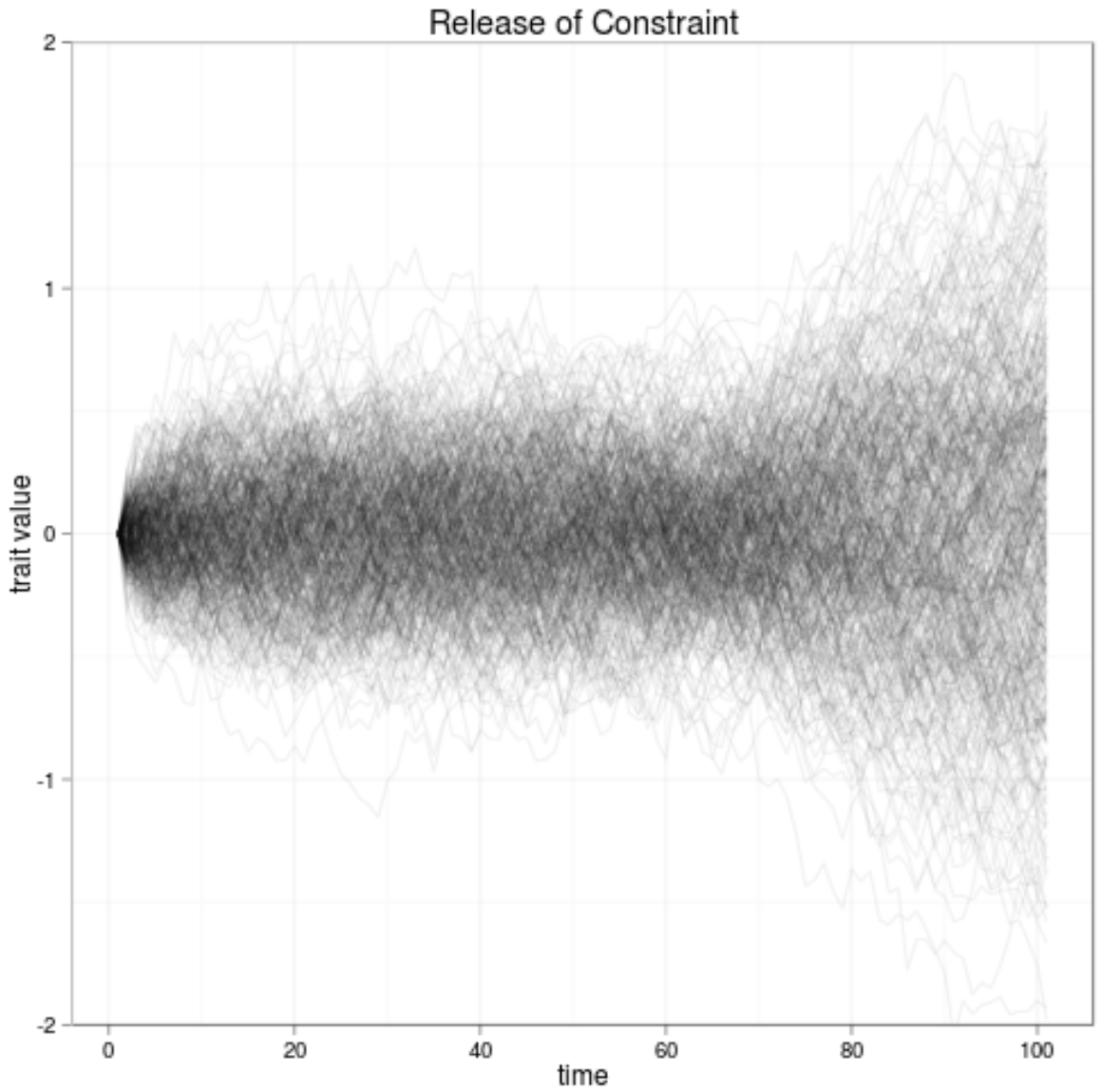
$$\mathrm{E}(X_i) = \sum_{i=0}^{n} e^{\gamma_i} \left[\theta_i \left(1 - e^{\alpha_i t_i}\right)\right]$$

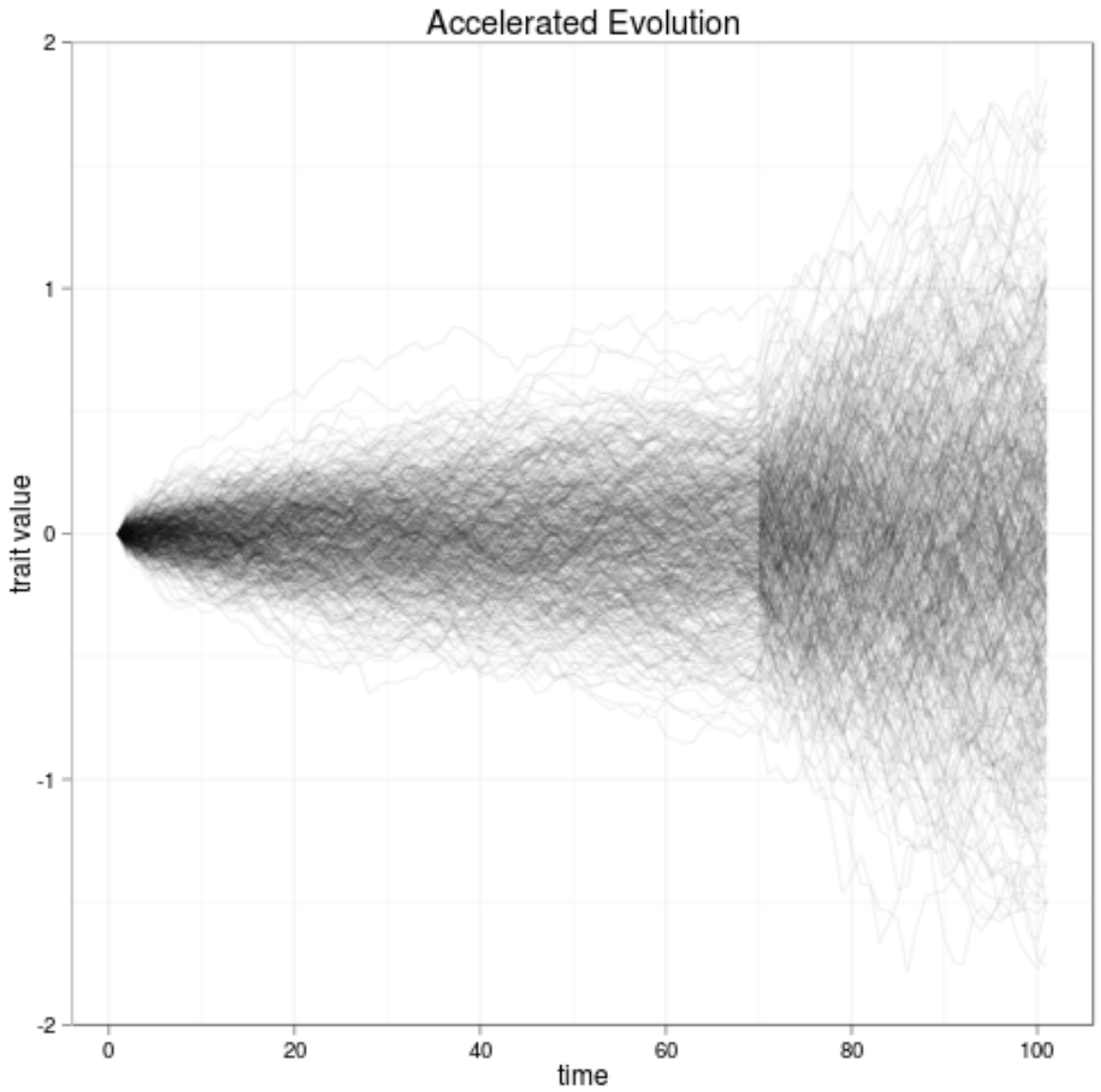
$$\mathrm{Cov}(X_i, X_j) = \sum_{s=0}^{k} \left[e^{\gamma_s + \gamma_s'} \frac{\sigma_s^2}{2\alpha_s} \left(1 - e^{-2\alpha_s t_s}\right)\right]$$

Candidate models

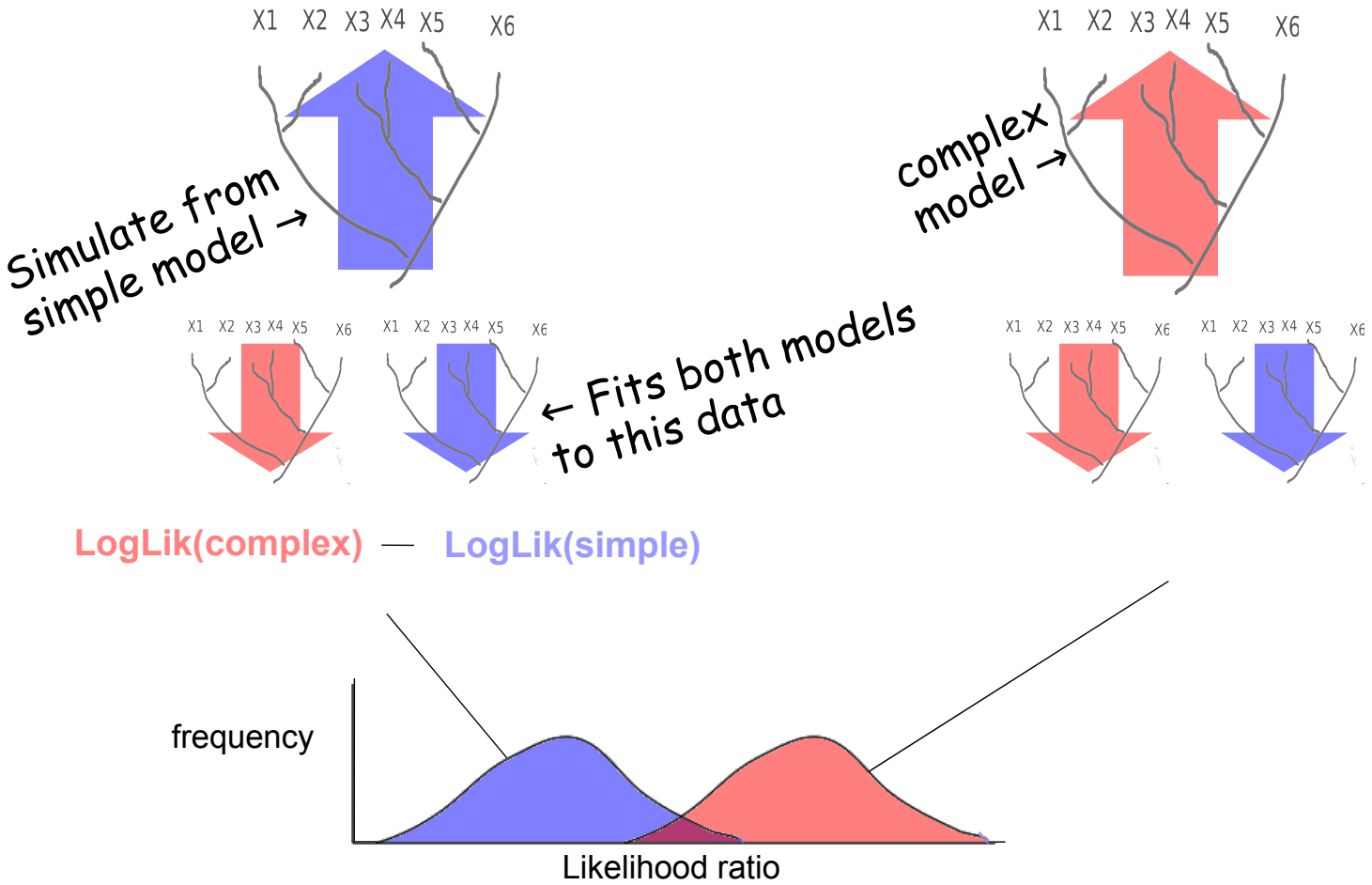

Brownian Motion
trait value
time
2
1
0
-1
-2
0
20
40
60
80
100


Ornstein-Uhlenbeck
trait value
time
2
1
0
-1
-2
0
20
40
60
80
100

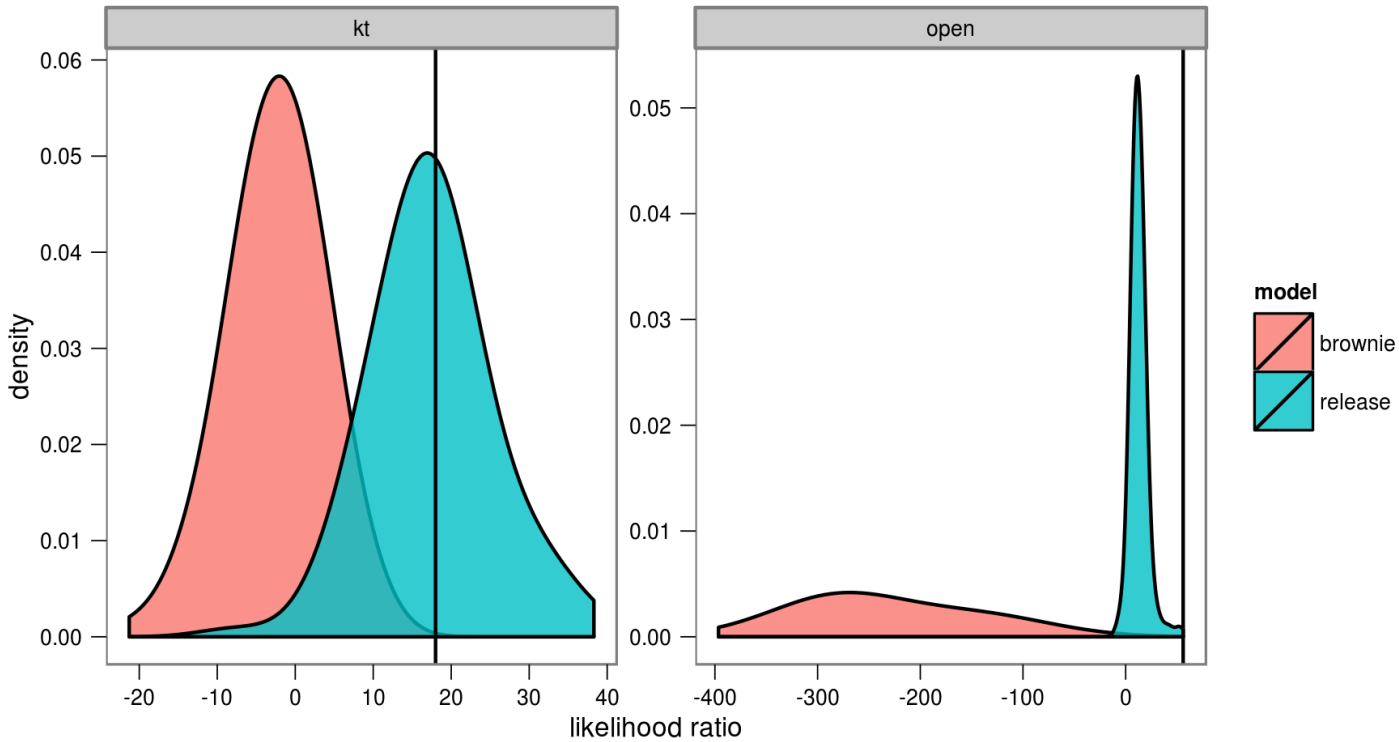

Release of Constraint
trait value
time
2
1
0
-1
-2
0
20
40
60
80
100


Accelerated Evolution
trait value
time
2
1
0
-1
-2
0
20
40
60
80
100

Phylogenetic Monte Carlo



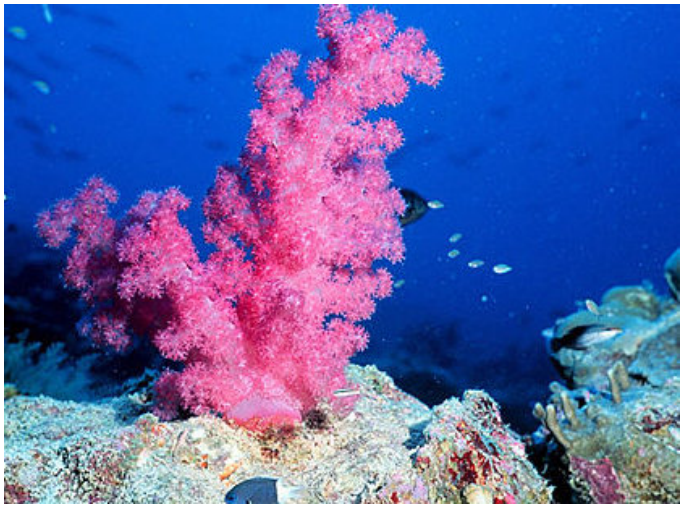
Boettiger et al. 2012, *Evolution*, `pmc` R package

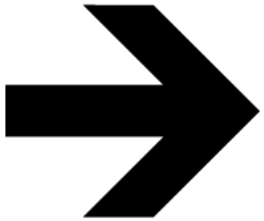

kt
open
density
likelihood ratio
0.06
0.05
0.04
0.03
0.02
0.01
0.00
-20
-10
0
10
20
30
40
-400
-300
-200
-100
0
model
brownie
release

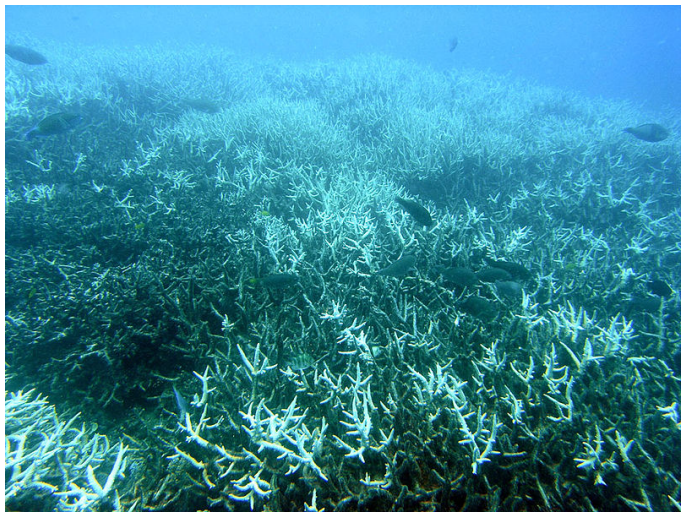
Part II

Fish landings in tons
900 000
800 000
700 000
600 000
500 000
400 000
300 000
200 000
100 000
0
1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000
1992
Source: Millennium Ecosystem Assessment

Coral Bleaching

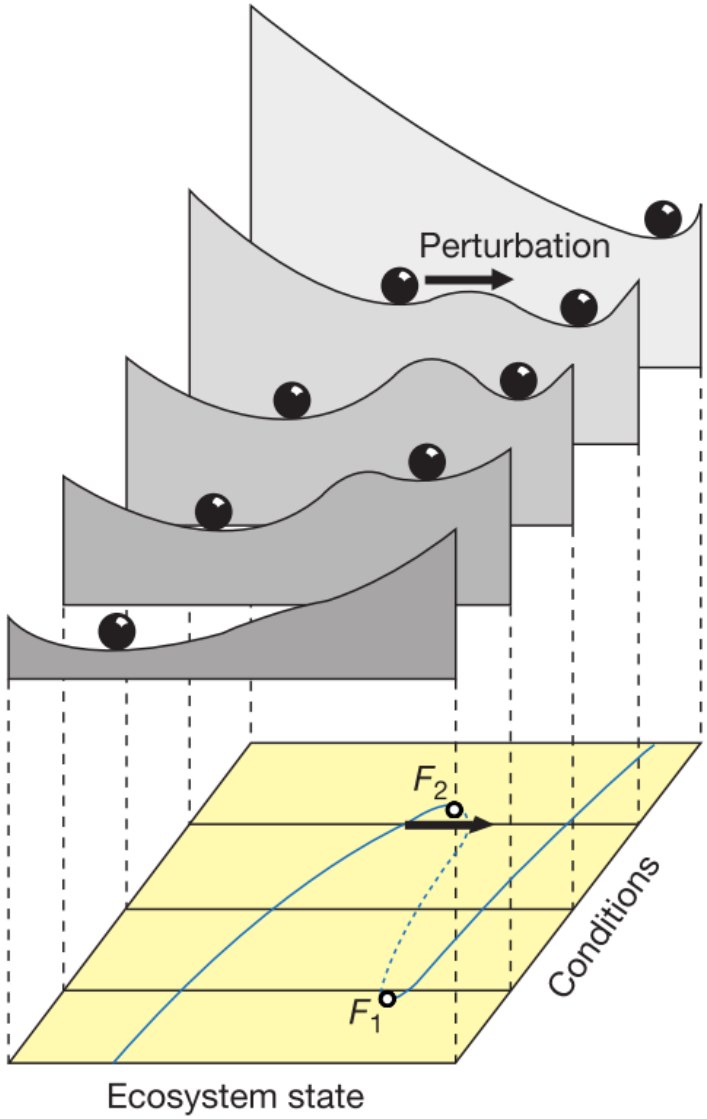






Eutrophication

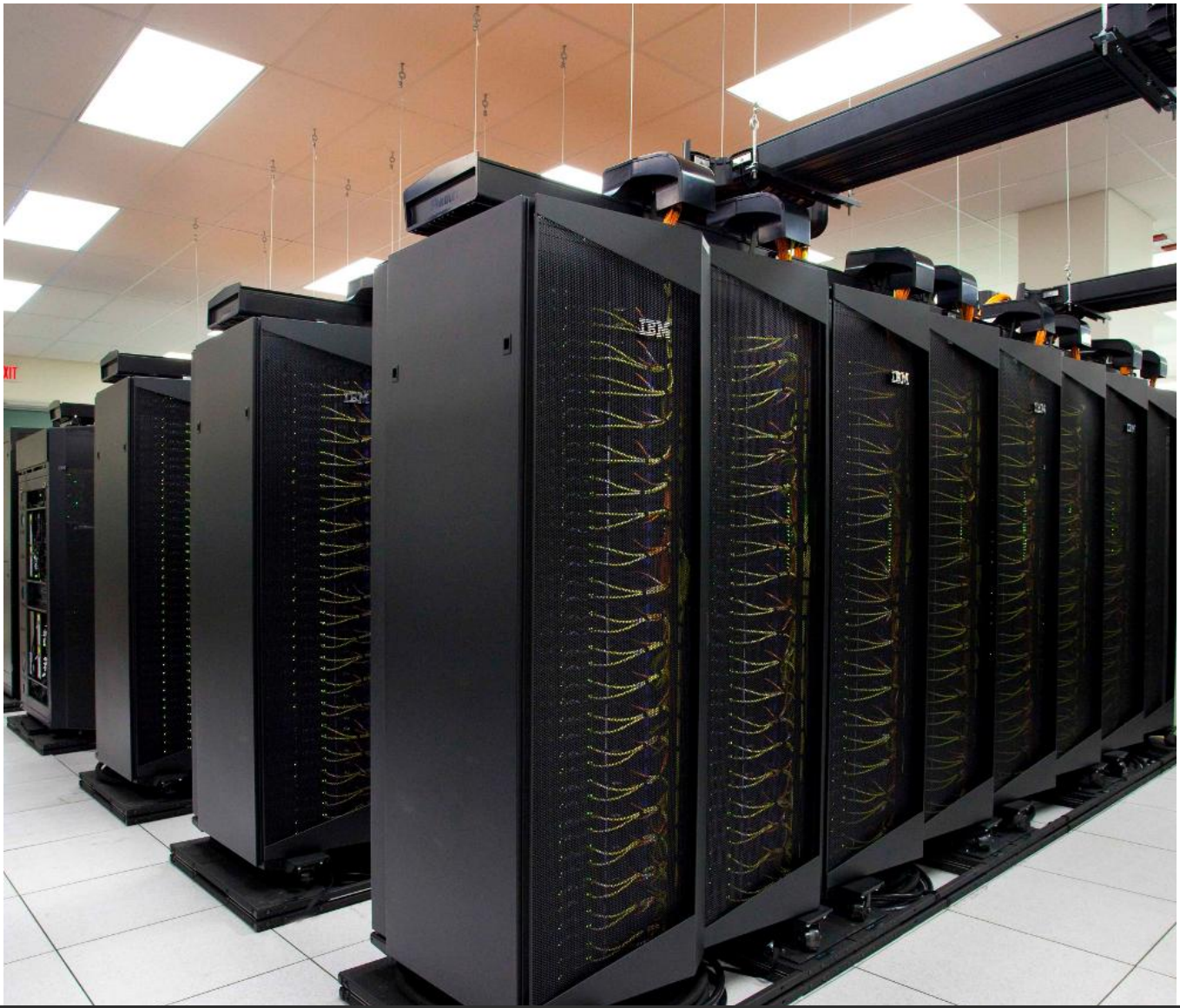
WARNING!!
CLIMATE
TIPPING
POINT AHEAD

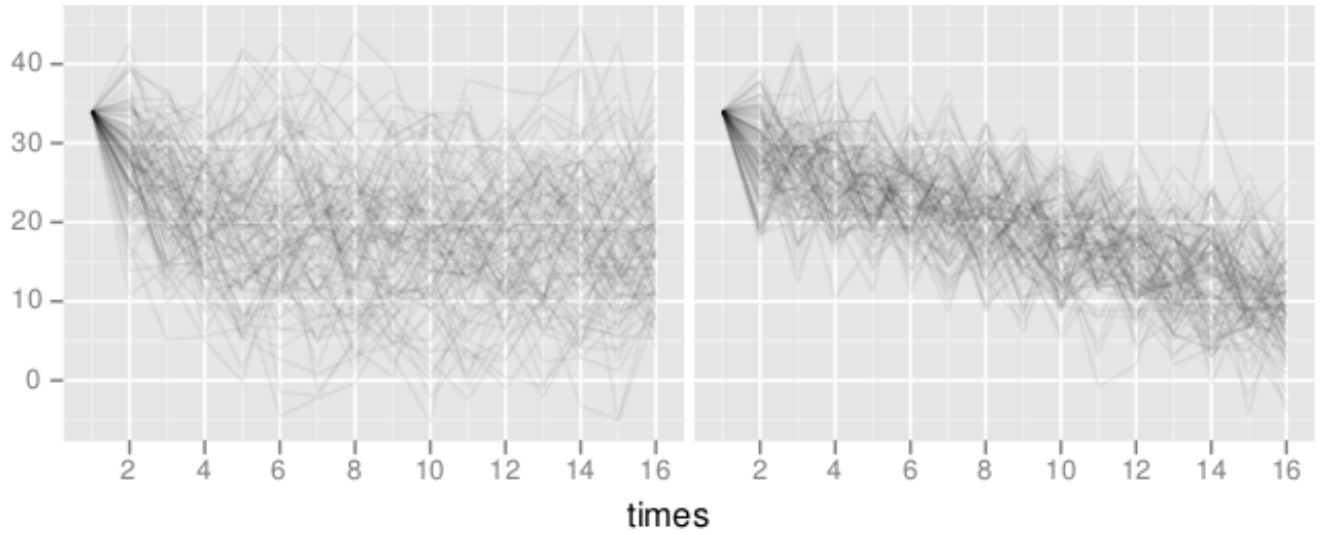

Perturbation
F_2
F_1
Conditions
Ecosystem state

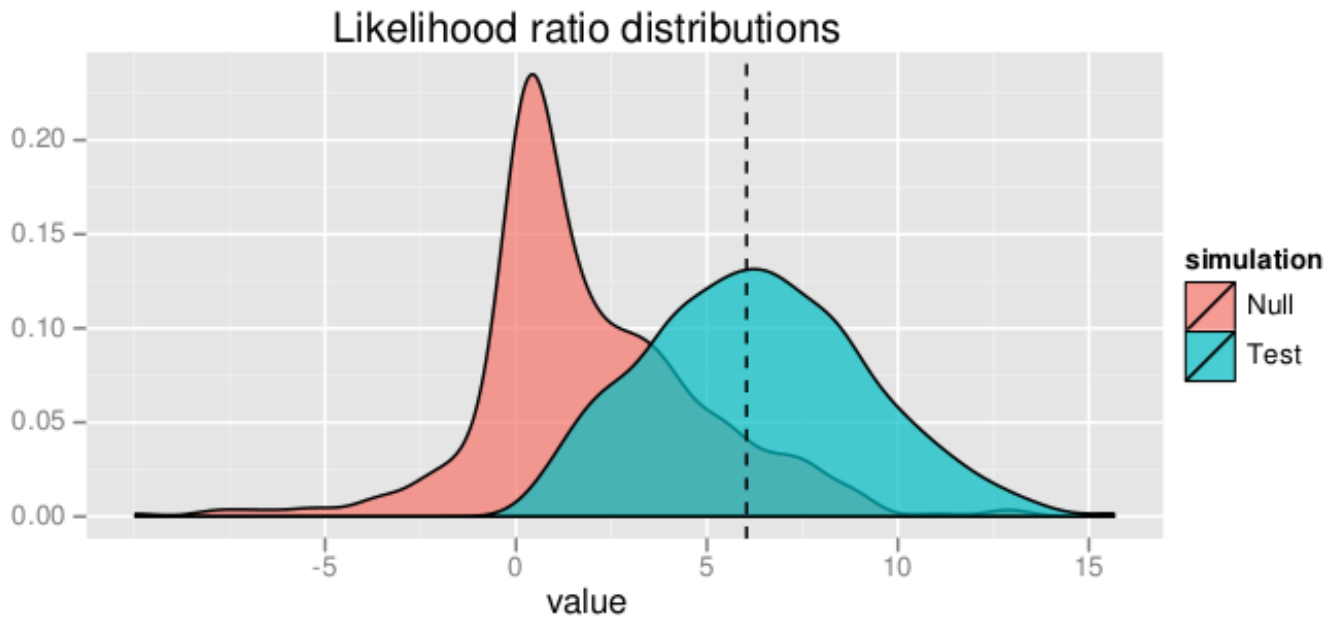
$$\frac{\mathrm{d}}{\mathrm{d}t}E(x_i) = 2\sqrt{r(t)}(\sqrt{r(t)} + \theta - x_i) \quad (1)$$

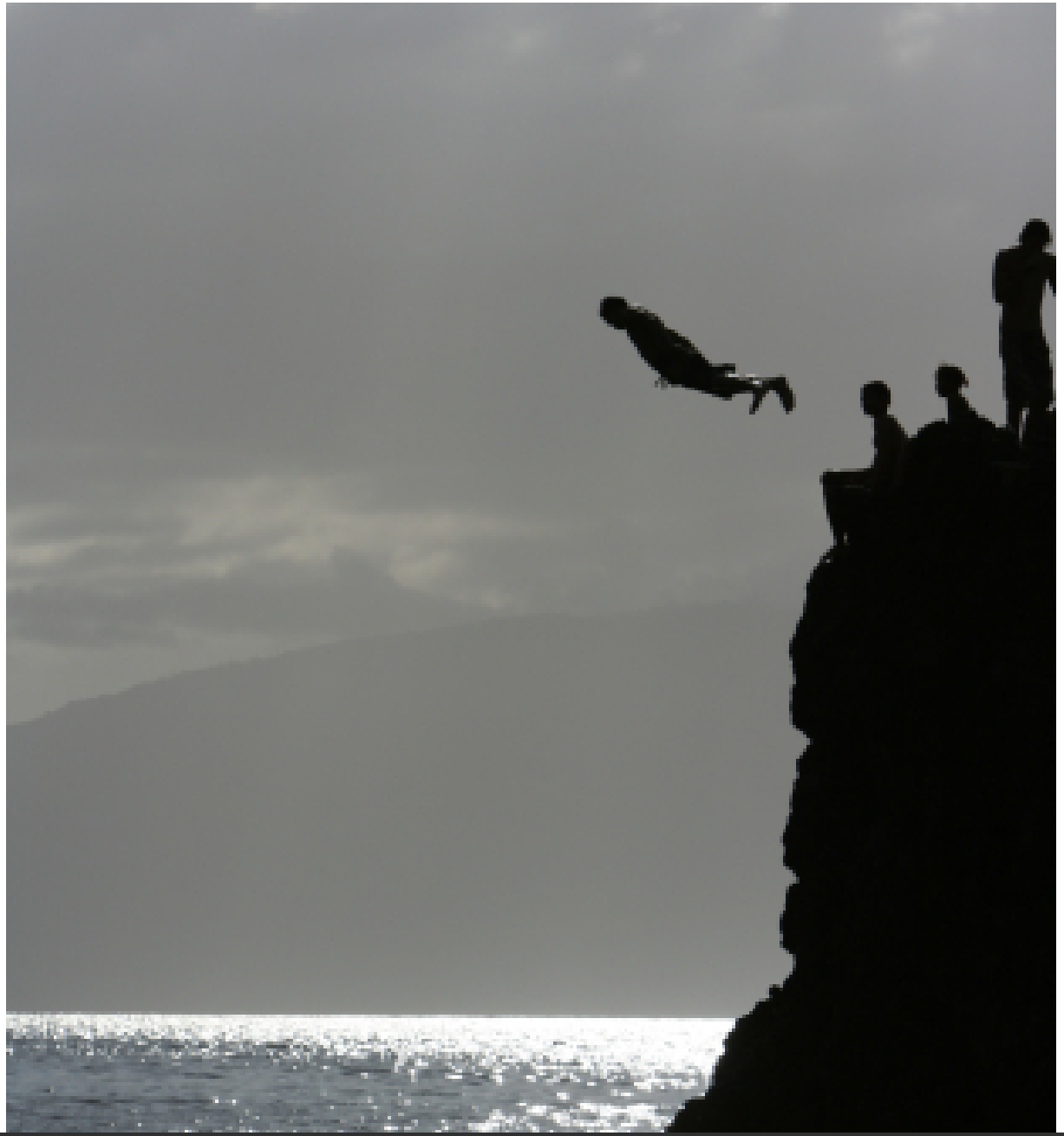
$$\frac{\mathrm{d}}{\mathrm{d}t}V(x_i) = -2\sqrt{r(t)}V(x_i) + \sigma^2(\sqrt{r(t)} + \theta) \quad (2)$$

Carver




40
30
20
10
0
2
4
6
8
10
12
14
16
times


Likelihood ratio distributions
0.20
0.15
0.10
0.05
0.00
-5
0
5
10
15
value
simulation
Null
Test



VEGAS

Unifying challenges in regime shifts

- Weak signals

Unifying challenges in regime shifts

- Weak signals
- Uncertainty quantification

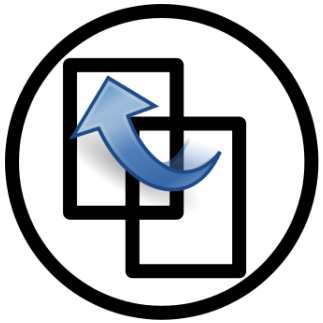
Unifying challenges in regime shifts

- Weak signals
- Uncertainty quantification
- Computationally intensive

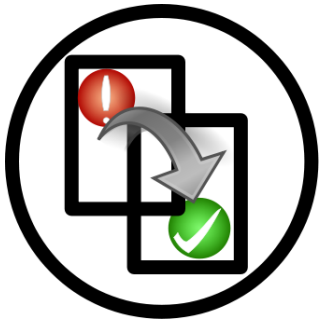
Unifying challenges in regime shifts

- Weak signals
- Uncertainty quantification
- Computationally intensive
- Statistical power is **data limited**

Why Open Source?



Reproduce research



Find & fix bugs

Extend into new software

Code

Literature

Discussions

Lab Notebook

The Open Lab Notebook

Acknowledgements

NIMBioS
National Institute for Mathematical and Biological Synthesis

NERSC

DOE CSGF

Berkeley Lab