On adaptation climate change and mathematical models in ecology

Pablo A. Marquet

Goles´ Fest (ISCV, Valparaíso Noviembre 25, 2011)

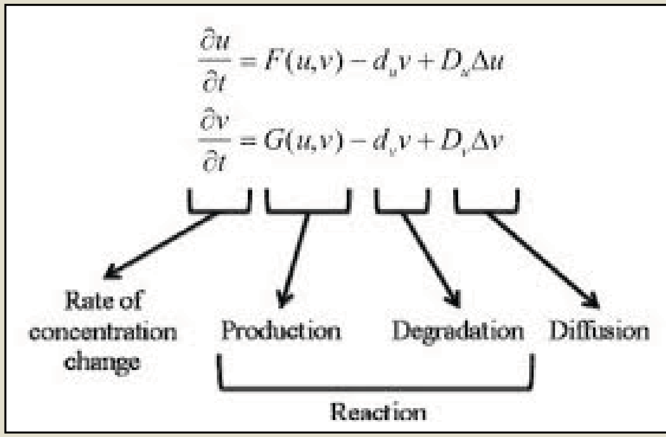
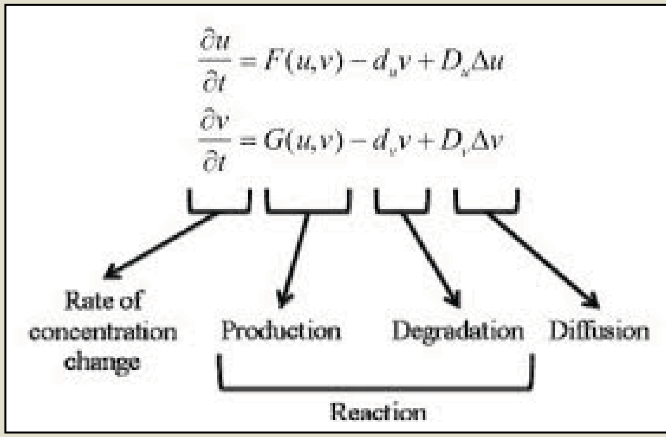

$\frac{\partial u}{\partial t} = F(u,v) - d_u v + D_u \Delta u$
$\frac{\partial v}{\partial t} = G(u,v) - d_v v + D_v \Delta v$
Rate of concentration change
Production
Degradation
Diffusion
Reaction


photo (c) Alex Wild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Rate of concentration change
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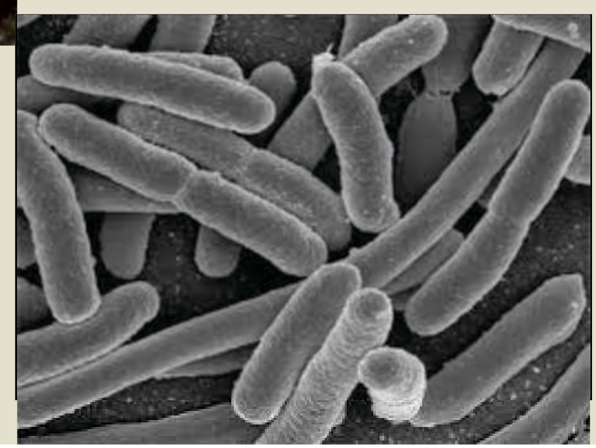
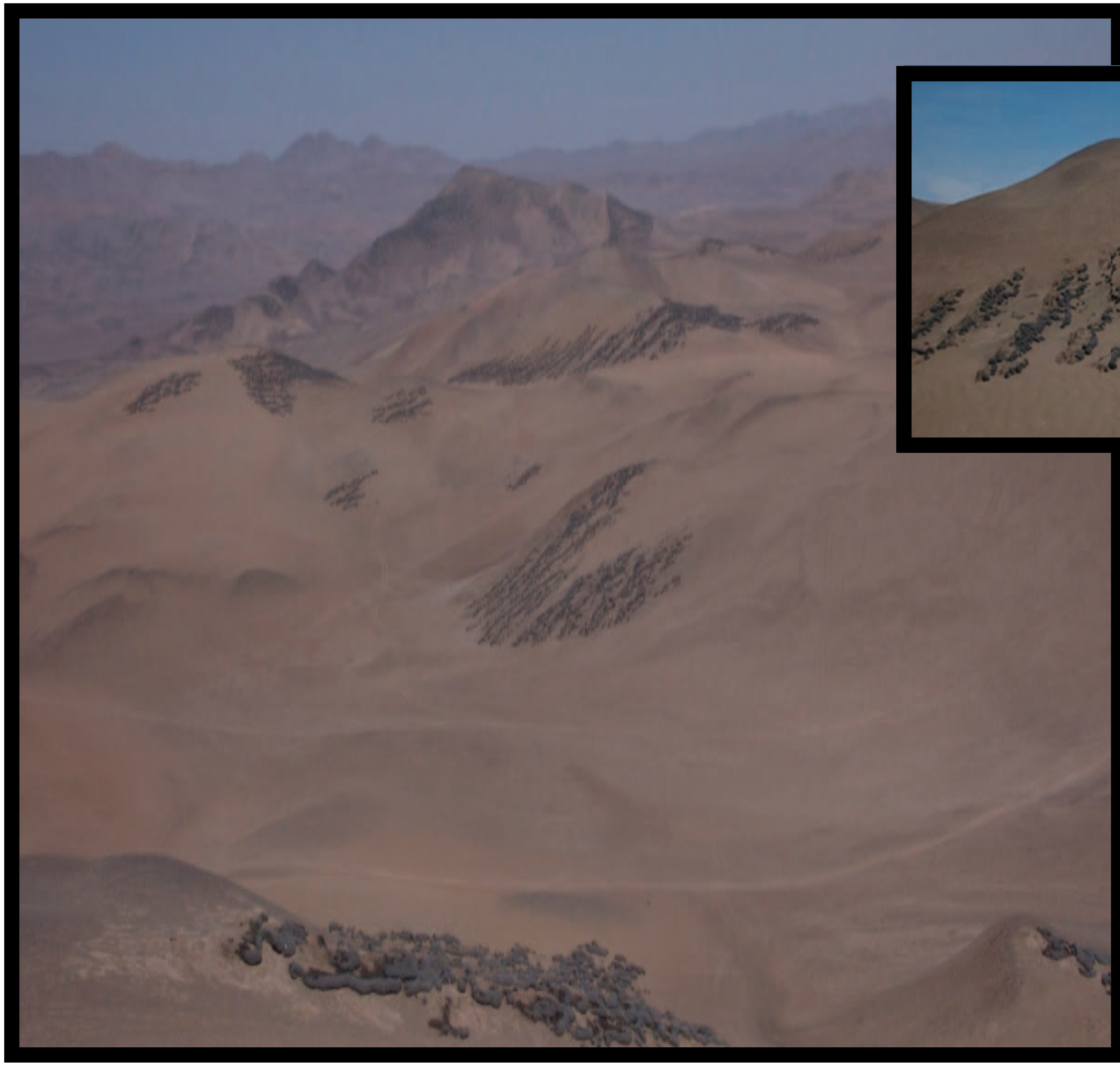
Diffusion
Reaction



Tillandsia landbeckii



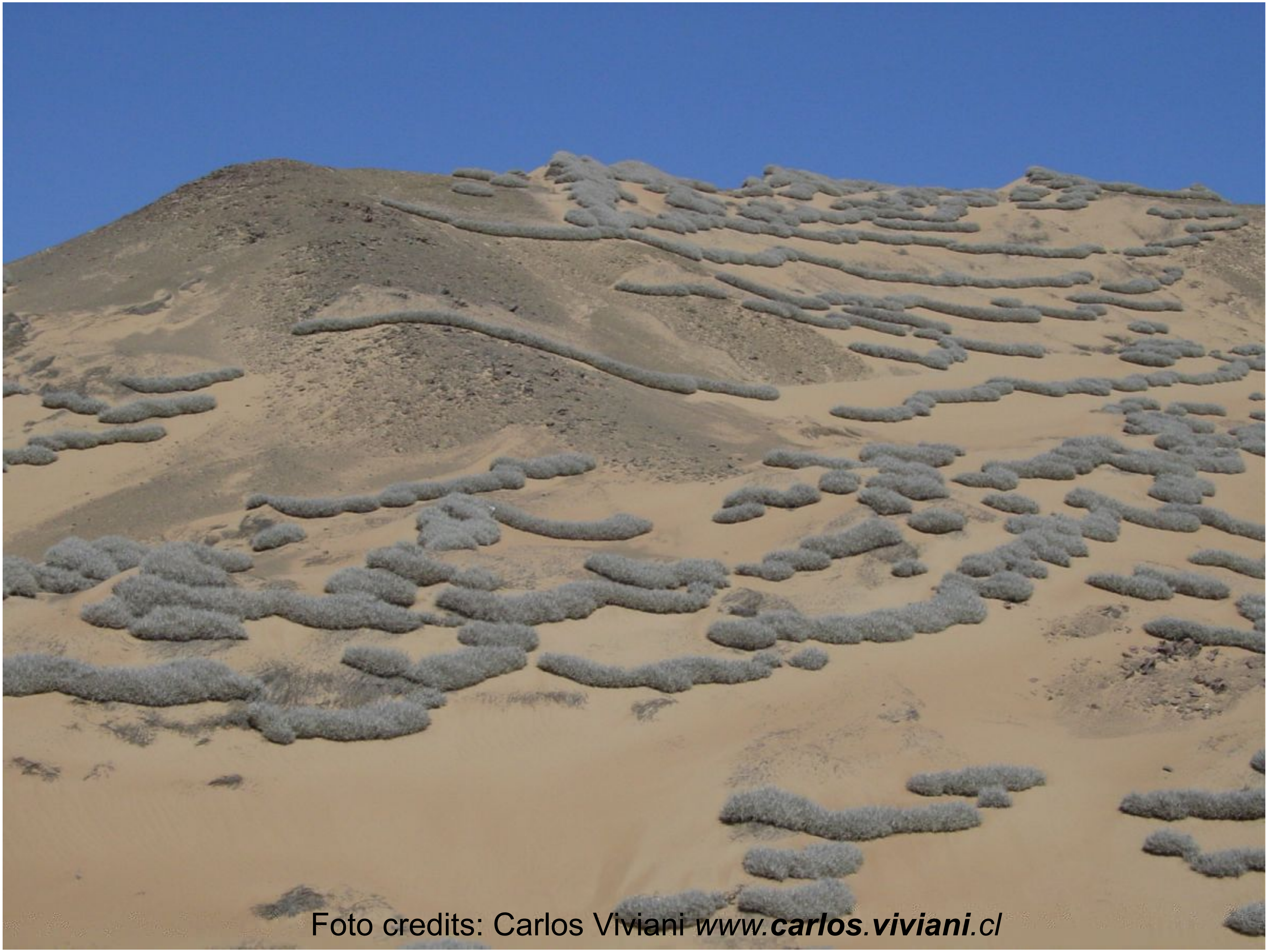
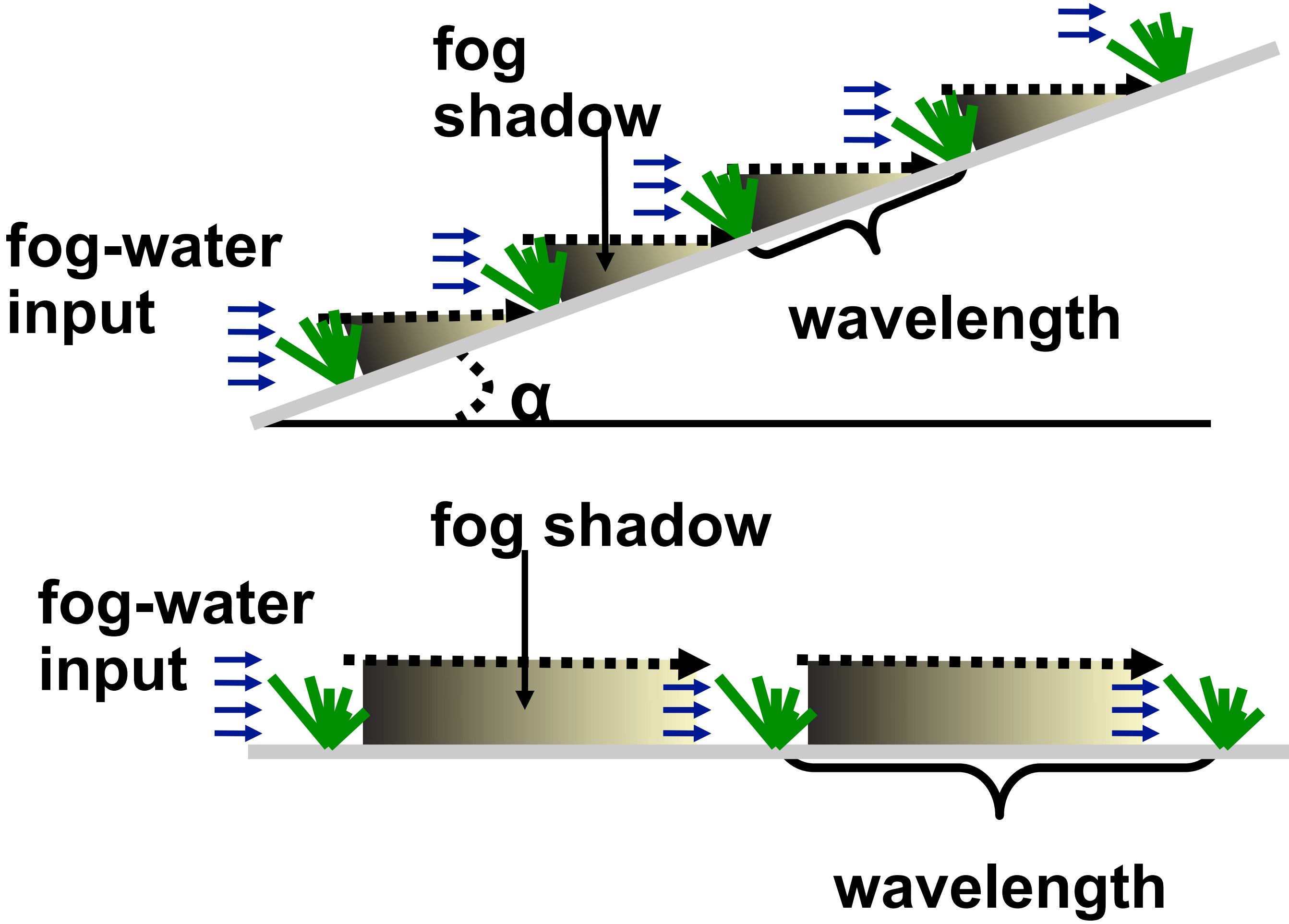


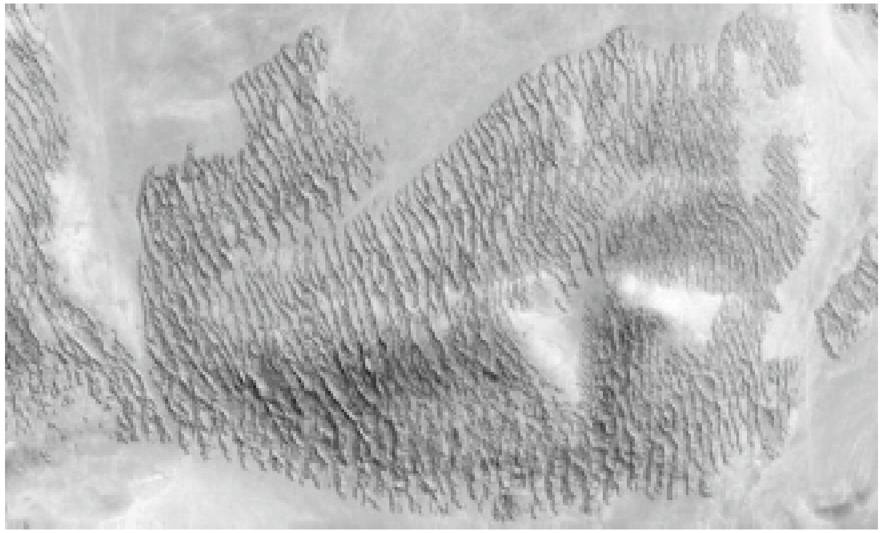
Foto credits: Carlos Viviani *www.**carlos.viviani**.cl*


Foto credits: Carlos Viviani www.carlos.viviani.cl


Foto credits: Carlos Viviani www.carlos.viviani.cl

Foto credits: Carlos Viviani *www.**carlos**.**viviani**.cl*

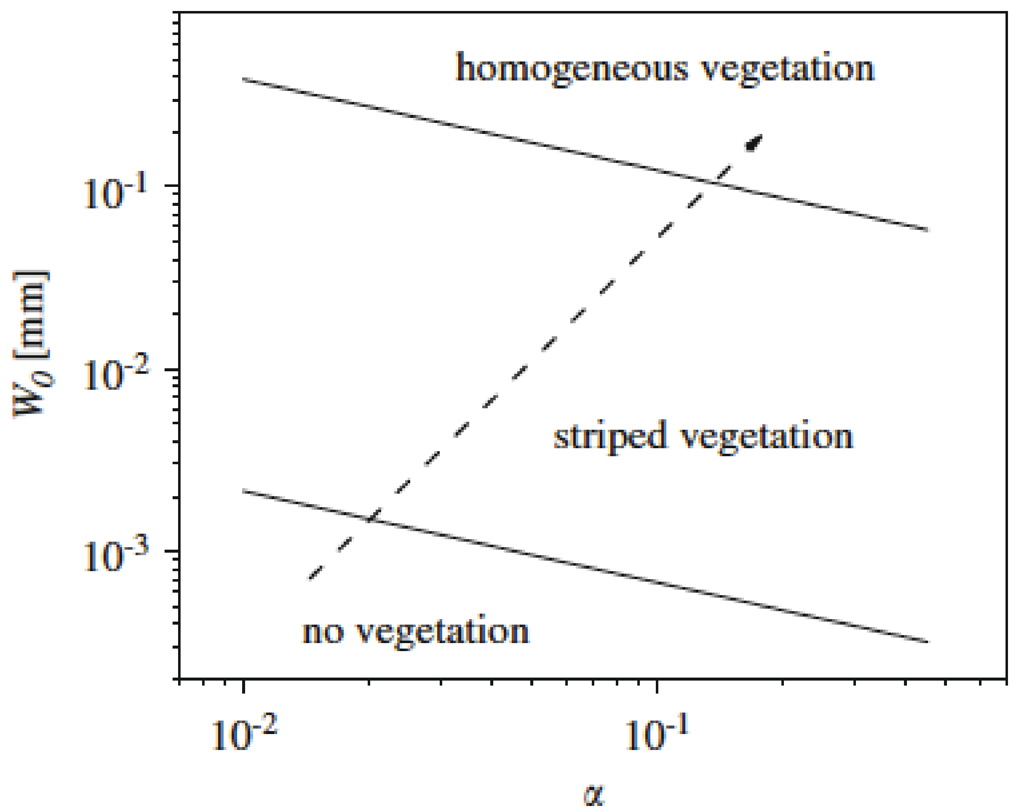

fog
shadow
fog-water
input
wavelength
α
fog shadow
fog-water
input
wavelength



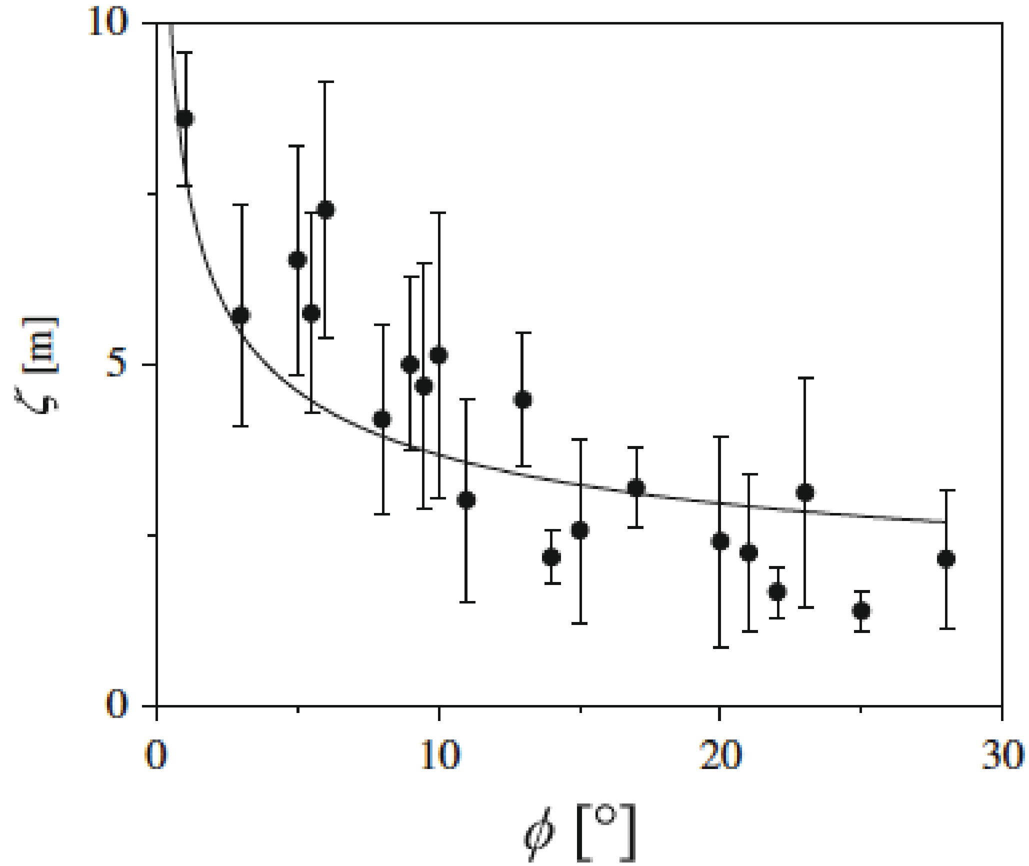
$$\frac{\partial W(x,t)}{\partial t} = W_0 - RW(x,t) - \alpha c W(x,t) B(x,t)^2 + V \frac{\partial W(x,t)}{\partial x},$$

$$\frac{\partial B(x,t)}{\partial t} = e\alpha c W(x,t) B(x,t)^2 - MB(x,t) + D \frac{\partial^2 B(x,t)}{\partial x^2}$$

B	Plant biomass
W	Fog-water
t	Time
x	Space
W_0	Fog-water supply
R	Water evaporation
α	Topography effect on capture of water
c	Water uptake
e	Conversion of water uptake
M	Loss of plant density due to mortality
V	Diffusion coefficient for water-fog
D	Plant dispersal or lateral growth



homogeneous vegetation
striped vegetation
no vegetation
10^{-1}
10^{-2}
10^{-3}
W_0 [mm]
10^{-2}
10^{-1}
α


10
5
0
ζ [m]
0
10
20
30
φ [°]

On the emergence of diversity lessons from E. coli

1. Empirical motivation

2. Model

Previous Blog home

Bacteria make computers look like pocket calculators

Biologists have created a living computer from E. coli bacteria that can solve complex mathematical problems

Scanning electron micrograph of E. coli bacteria. A rapidly growing colony can be programmed to act as a hugely powerful parallel computer. Photograph: Getty

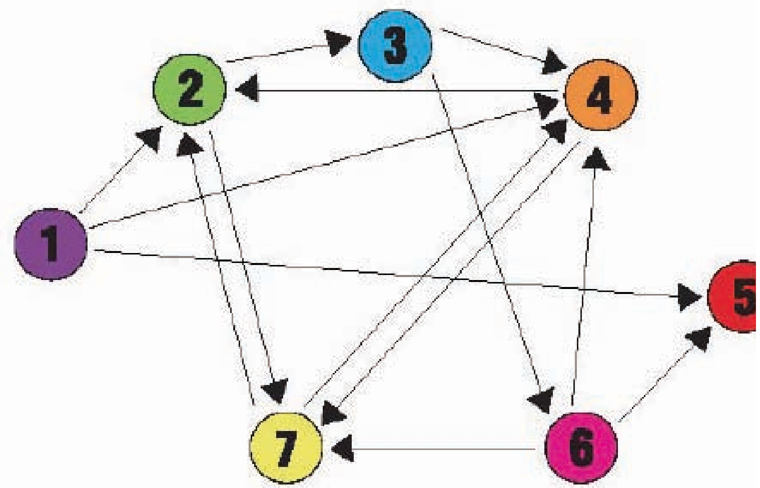


Figure 1

A directed graph containing a unique Hamiltonian path. The seven nodes are connected with fourteen directed edges. The Hamiltonian Path Problem is to start a node 1, end at node 5, and visit each node exactly once wh following the available edges. Adleman programmed a DN computer to find the unique Hamiltonian path in this grapl (1→4→7→2→3→6→5).

Empirical Motivation E. coli under prolonged starvation (Zambrano, Finkel, Kolter)

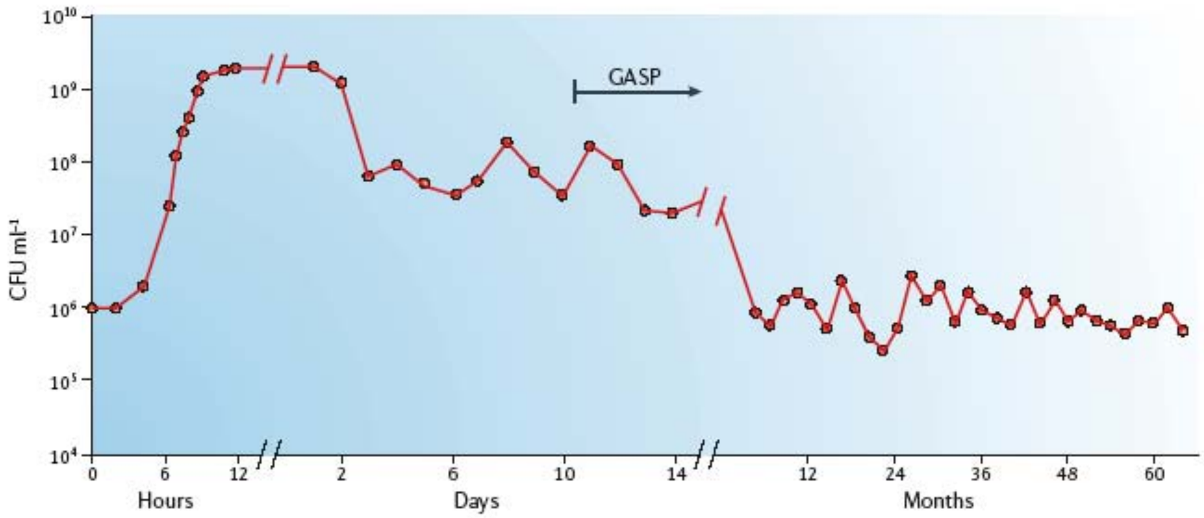
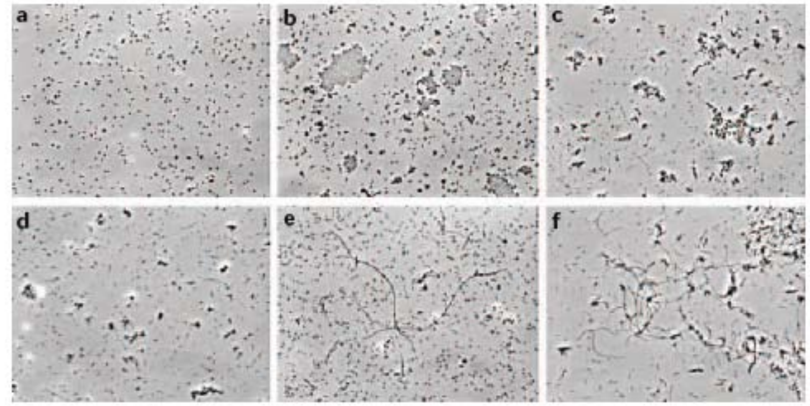


Figure 1 | **The five phases of the bacterial life cycle.** Once bacteria are inoculated into fresh medium, such as Luria–Bertani (LB) medium, there is an initial lag period followed by exponential-phase growth. After remaining at high density for 2 or 3 days, cells enter death phase. After ~99% of the cells die, the survivors can be maintained under long-term stationary-phase culture conditions for months or years. The arrow indicates the time after which cells expressing the growth advantage in stationary phase (GASP) phenotype are observed (usually day 10 in LB batch cultures).

The mutation cycle



Coexisting CFU morphologies at 150 days

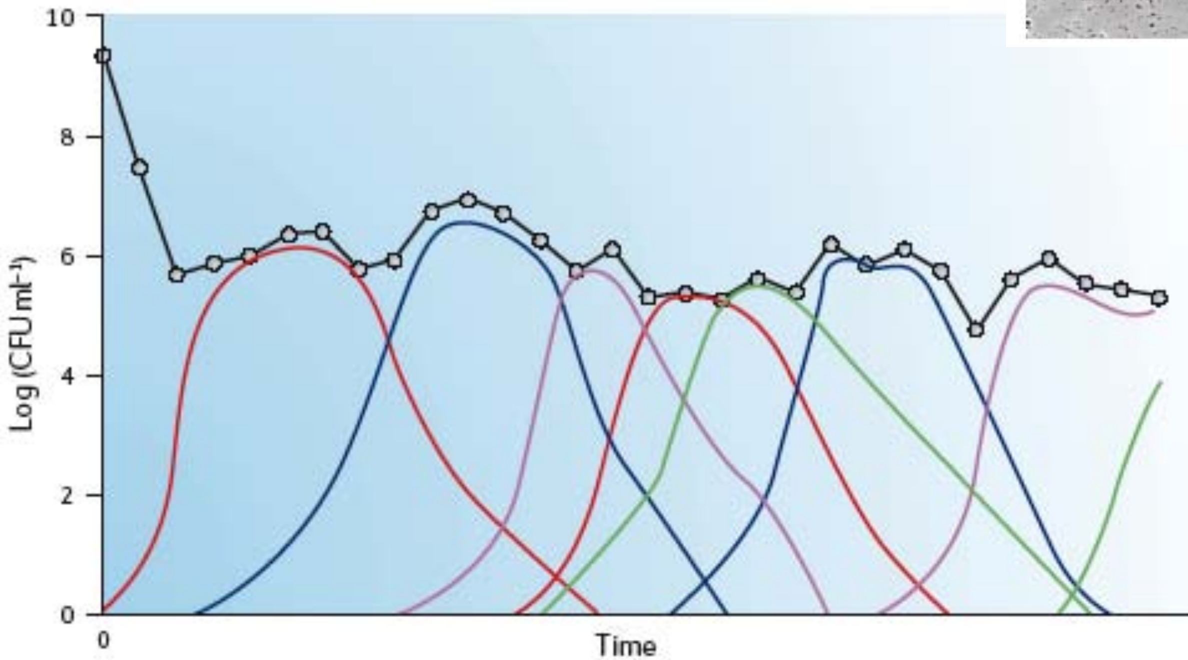
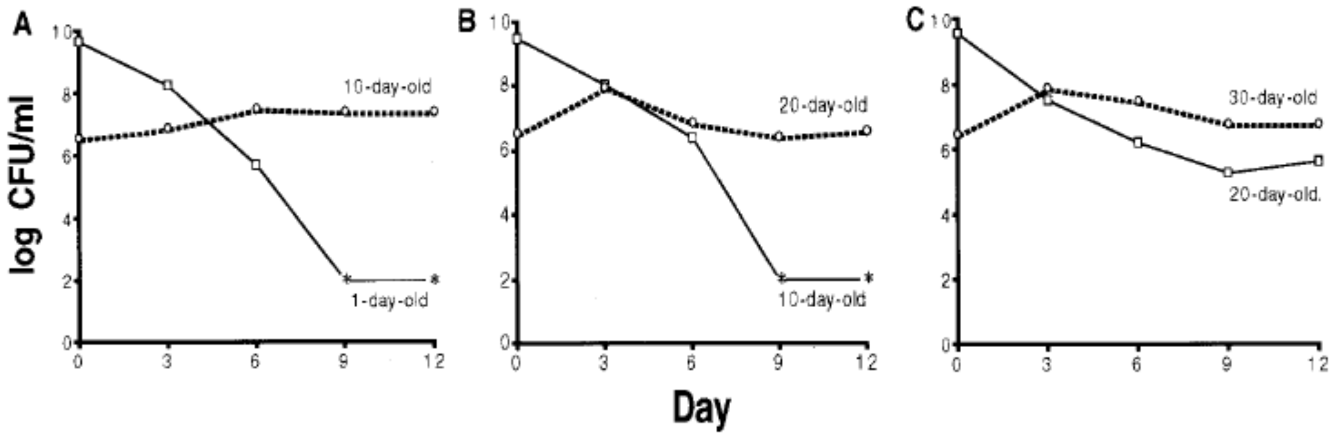


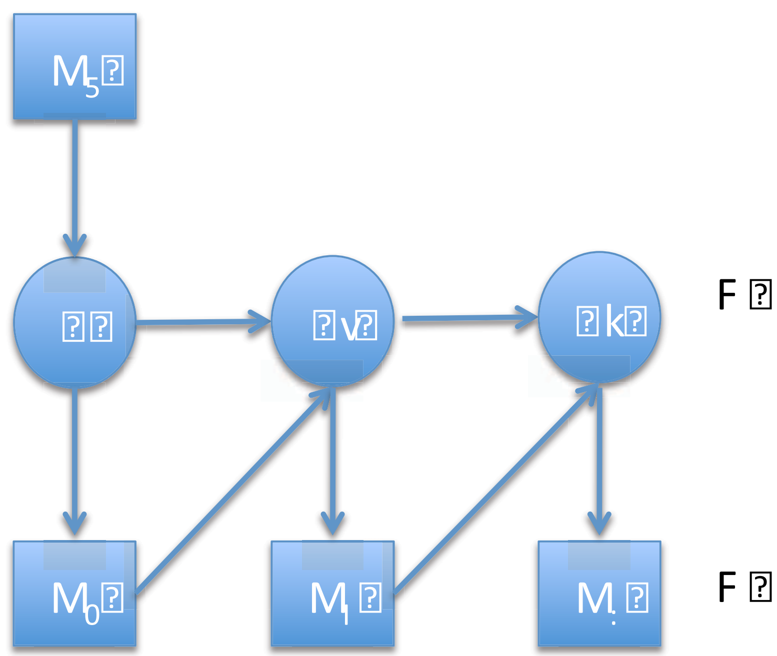
Figure 3 | **Population dynamics of long-term stationary-phase cultures.** After death phase, as cells continue to incubate under long-term stationary-phase conditions, the apparent number of colony-forming units (CFU) per ml remains relatively stable. However, these cultures are not static. There is a dynamic equilibrium between newly created growth advantage in stationary phase (GASP) mutants and less competitive cells. The birth rates and death rates within the population are balanced. Each coloured line represents a different GASP mutant that appears during long-term incubation. The black line represents the total population density.

Increased mutation rate due to:

Increased replication errors
Reduction in repair activity
Incorporation of chromosomal DNA from dead siblings
Response to resource stress and competition.

Progressively older mutants outcompete younger ones




M5
v
k
F
M0
M1
M
F

The model

$$\frac{d}{dt}\phi = r\phi(1-\phi) \tag{1}$$

$$r(\omega) = f\omega - m. \tag{2}$$

$$\frac{d}{dt}\omega = S - C \tag{3}$$

$$S \equiv \lambda(1-\omega) \tag{4}$$

$$C \equiv \epsilon\phi\omega f \tag{5}$$

Phi= Biomass

f = fecundity

m= mortality

w = Available resources

e= Conversion efficiency
of resources into biomass

$$\frac{d}{dt}\phi = (f\omega - m)\phi(1-\phi)$$

$$\frac{d}{dt}\omega = \lambda(1-\omega) - \epsilon\phi\omega f.$$

Equilibium solutions

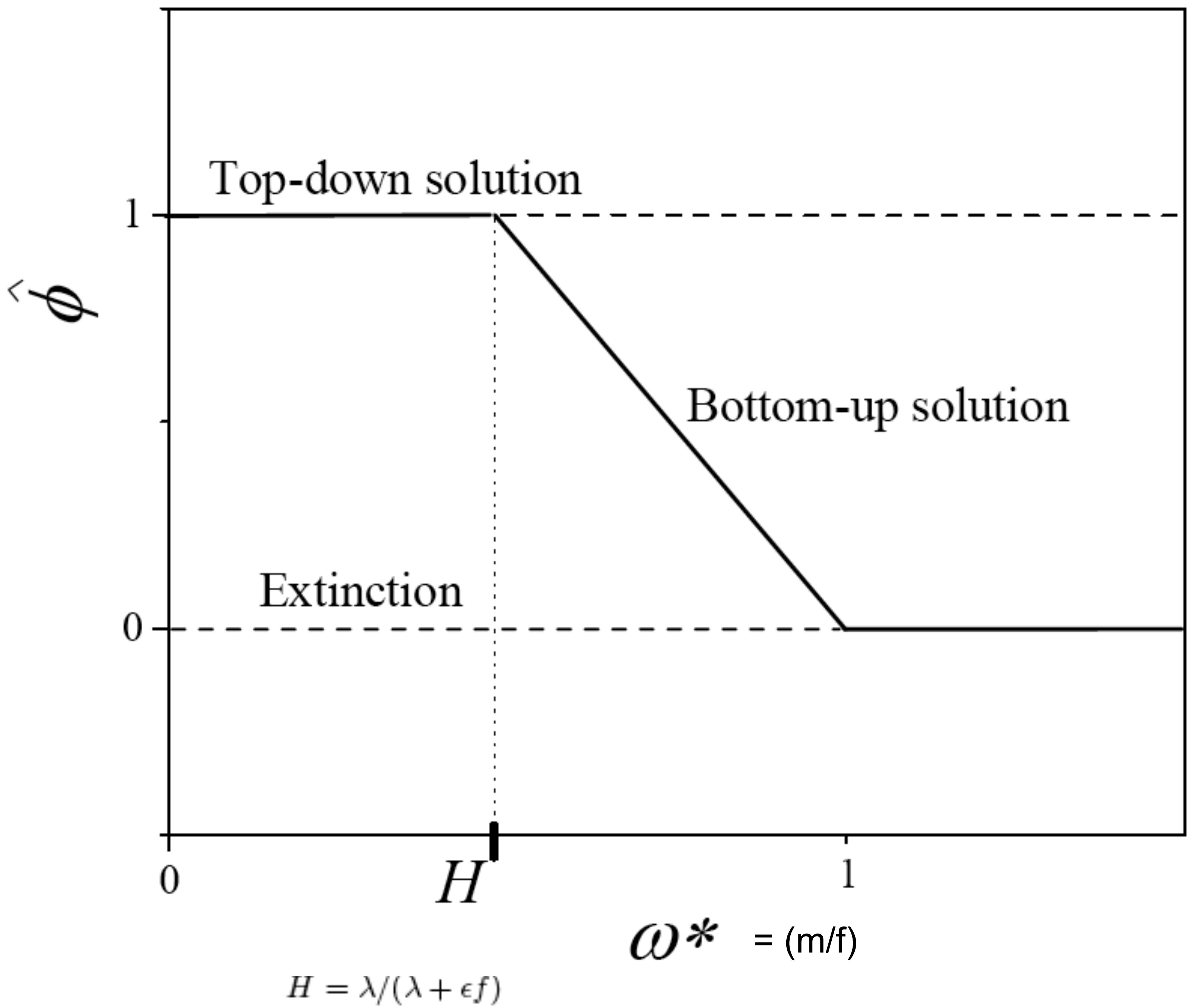
Extinction $\hat{\phi} = 0 \equiv \hat{\phi}^0.$ $\hat{\omega} = 1.$

Bottom-up regulation $\hat{\phi}^{1/2} = \lambda(R-1)/(f\epsilon)$ $\hat{\omega} = \omega*$

$R = 1/\omega^*$ and $\omega^* = m/f$

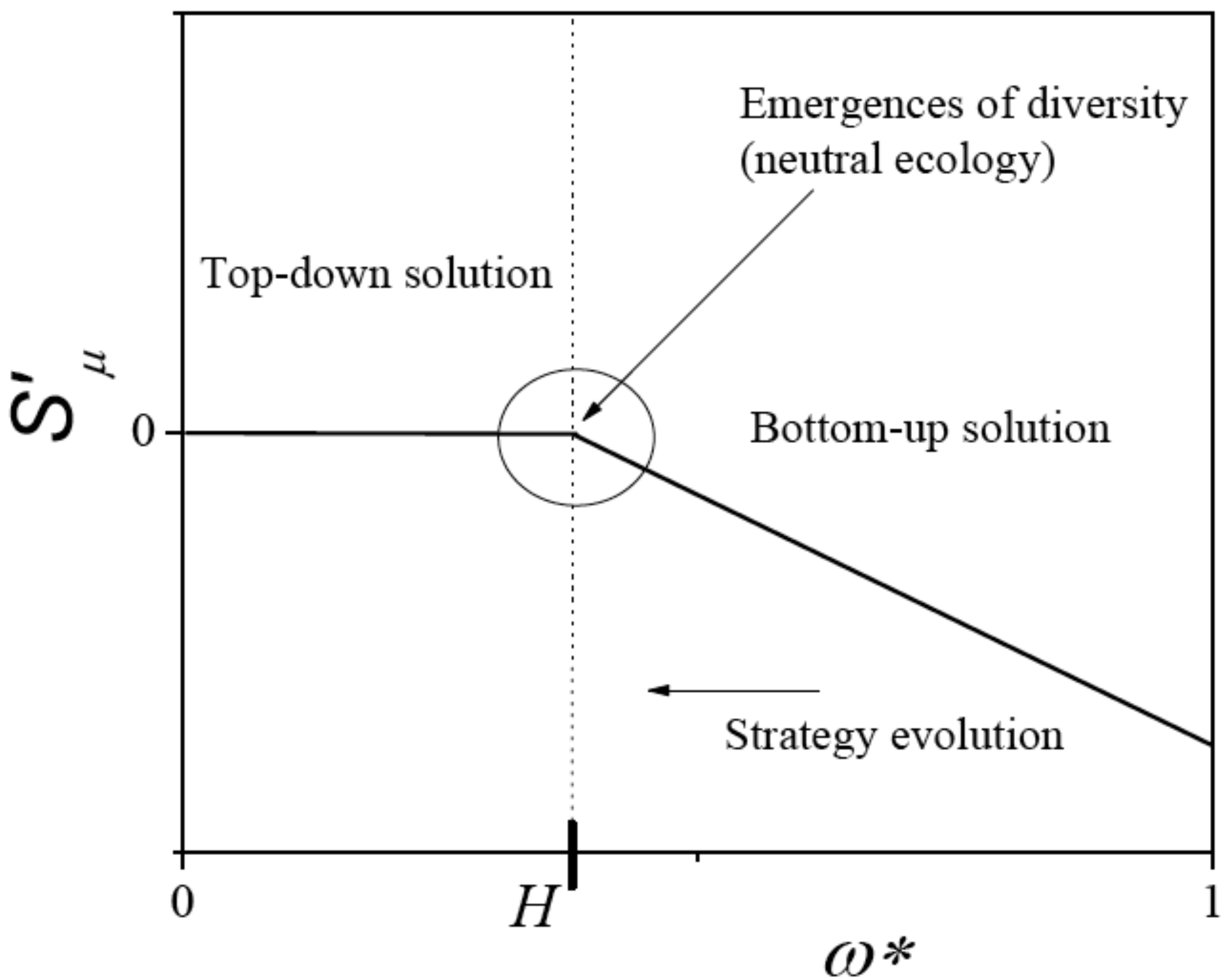
Top-down regulation $\hat{\phi} = 1$ $\hat{\omega} = H$

$H = \lambda/(\lambda + \epsilon f)$


Top-down solution
Bottom-up solution
Extinction
1
0
$\hat{\phi}$
0
H
1
ω^* = (m/f)
$H = \lambda/(\lambda + \epsilon f)$

$$S \equiv S_{\omega_r^*}(\omega_\mu^*) \equiv \frac{1}{\phi_\mu} \left. \frac{d}{d\tau} \right|_{\phi_r = \hat{\phi}_r ; \phi_\mu \to 0} \phi_\mu = (\omega_r^* - \omega_\mu^*)(1 - \hat{\phi}_r).$$

Adaptive Dynamics



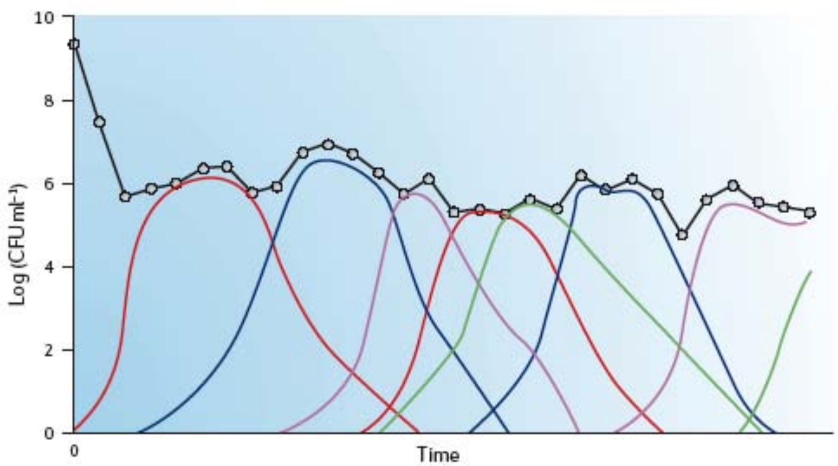
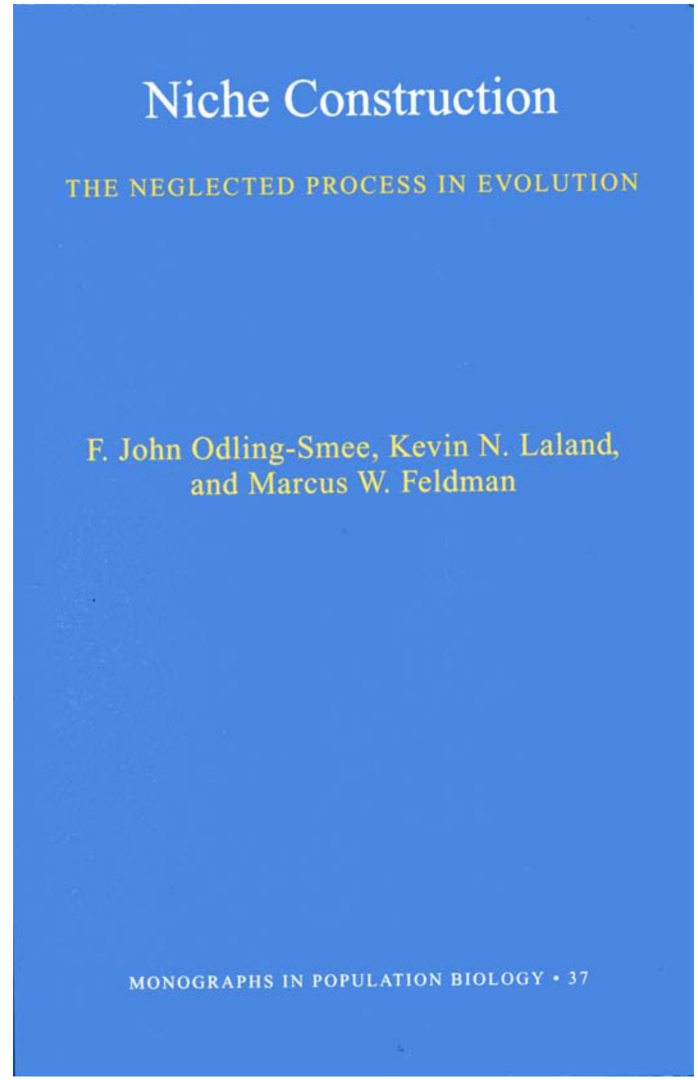
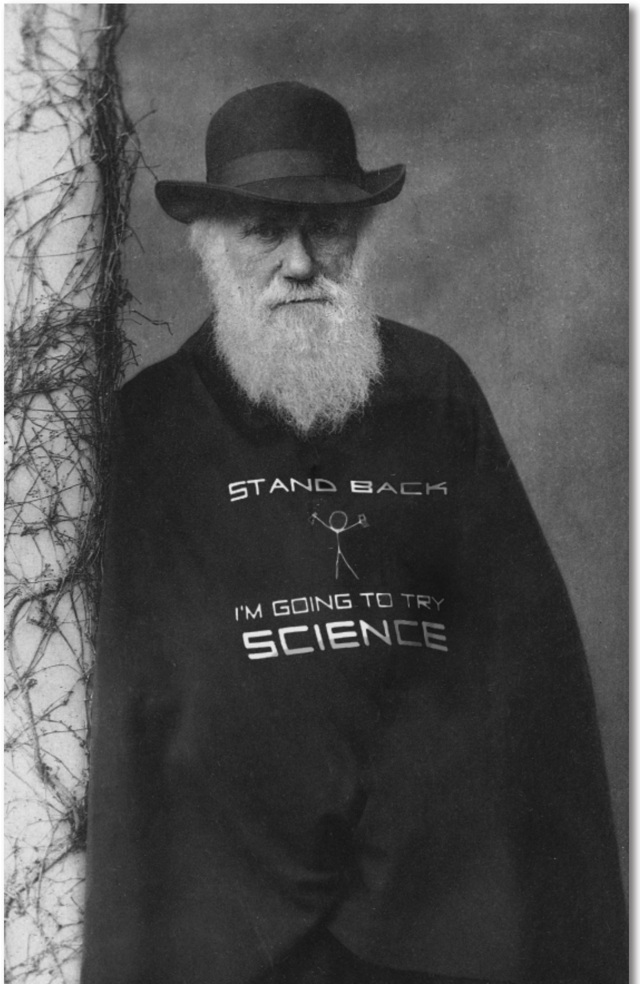
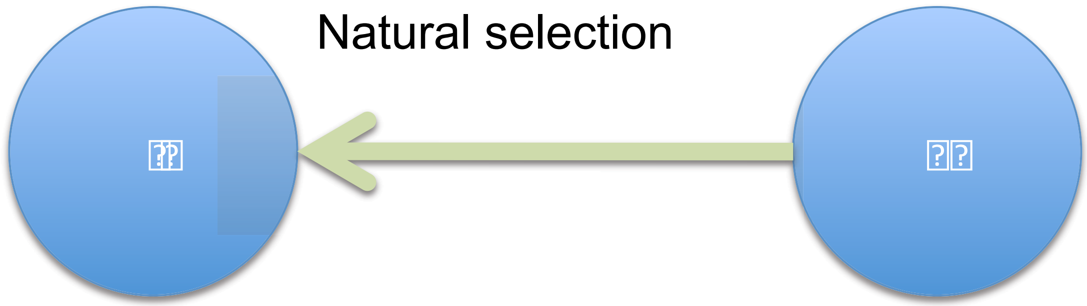
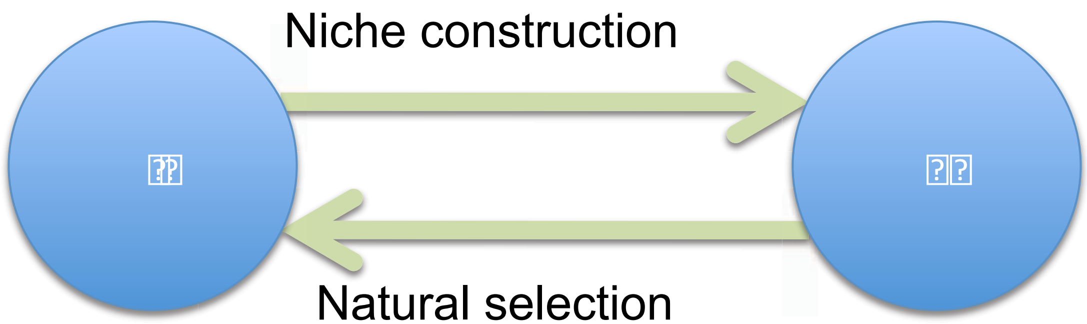


Figure 3 | **Population dynamics of long-term stationary-phase cultures.** After death phase, as cells continue to incubate under long-term stationary-phase conditions, the apparent number of colony-forming units (CFU) per ml remains relatively stable. However, these cultures are not static. There is a dynamic equilibrium between newly created growth advantage in stationary phase (GASP) mutants and less competitive cells. The birth rates and death rates within the population are balanced. Each coloured line represents a different GASP mutant that appears during long-term incubation. The black line represents the total population density.

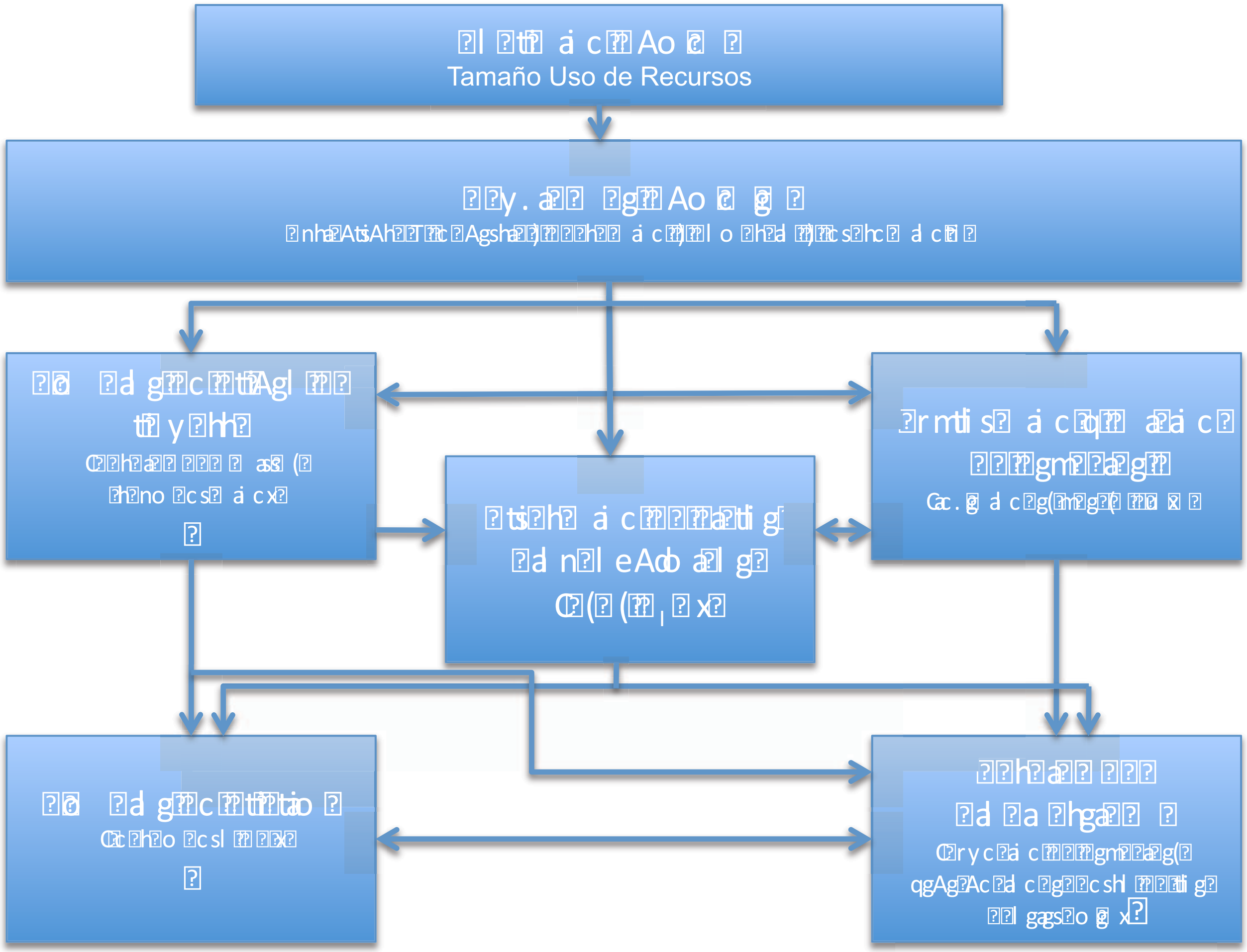


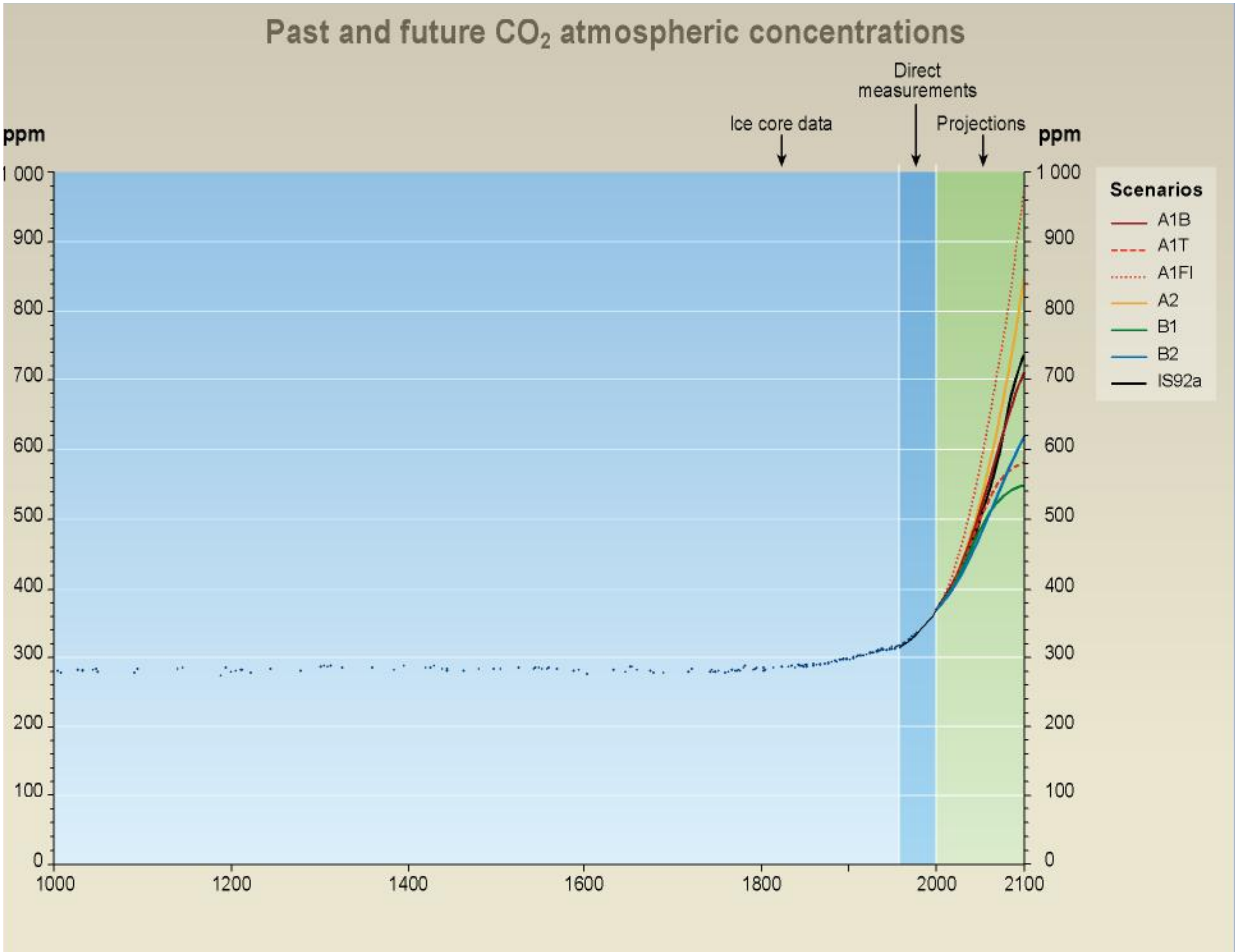

STAND BACK
I'M GOING TO TRY
SCIENCE

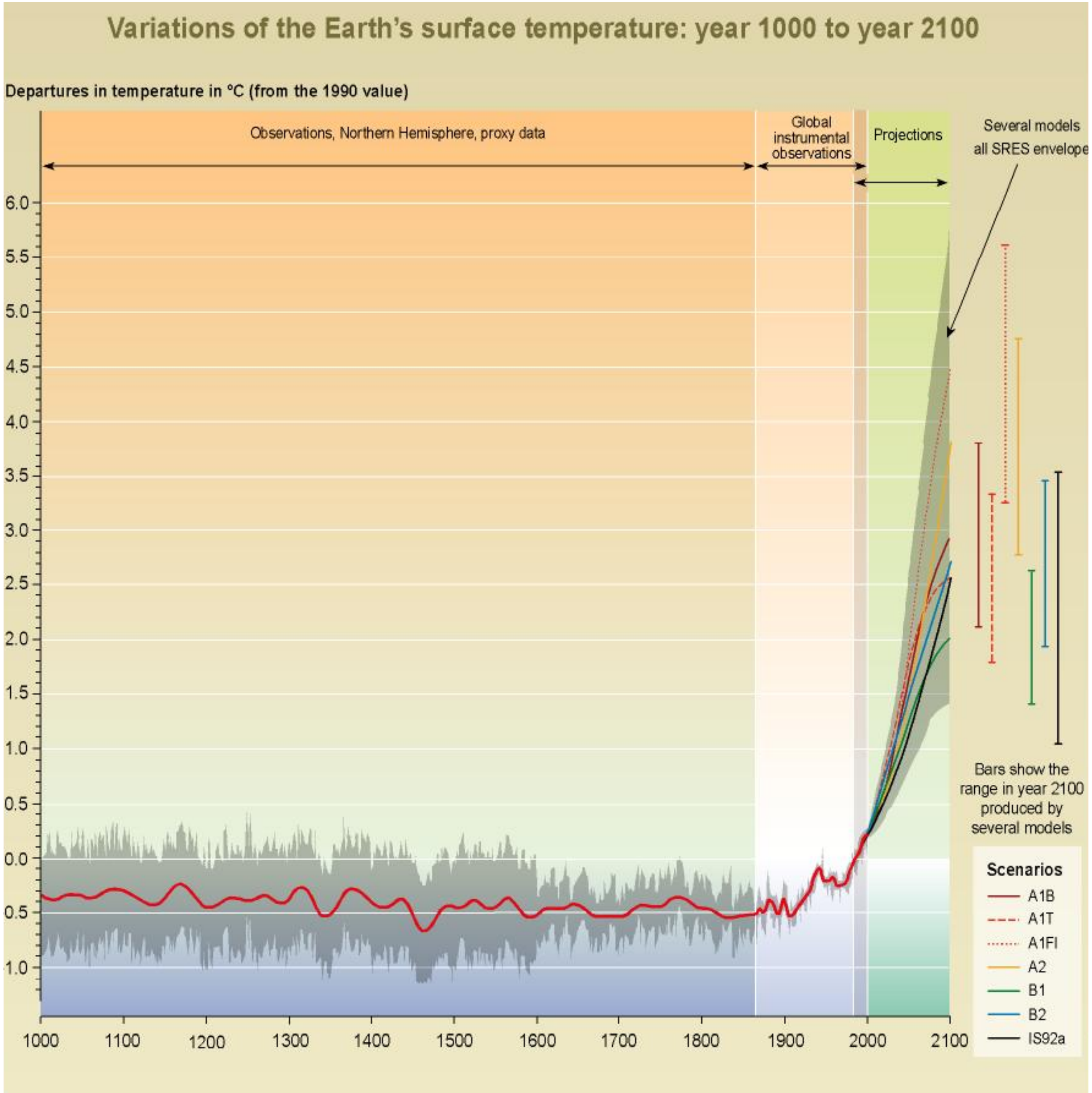

Natural selection


Niche construction
Natural selection


STOP CLIMATE CHANGE
BEFORE IT CHANGES YOU.


Tamaño Uso de Recursos


Past and future CO2 atmospheric concentrations
Direct measurements
Ice core data
Projections
ppm
ppm
1 000
900
800
700
600
500
400
300
200
100
0
1000
1200
1400
1600
1800
2000
2100
Scenarios
A1B
A1T
A1FI
A2
B1
B2
IS92a



Variations of the Earth's surface temperature: year 1000 to year 2100
Departures in temperature in °C (from the 1990 value)
Observations, Northern Hemisphere, proxy data
Global instrumental observations
Projections
Several models all SRES envelope
Bars show the range in year 2100 produced by several models
Scenarios
A1B
A1T
A1FI
A2
B1
B2
IS92a
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.5
1.0
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100

Populations in dynamic landscapes

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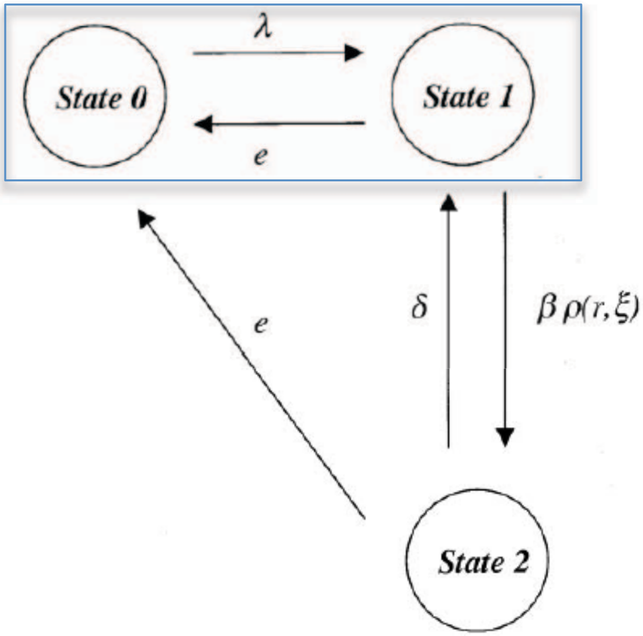
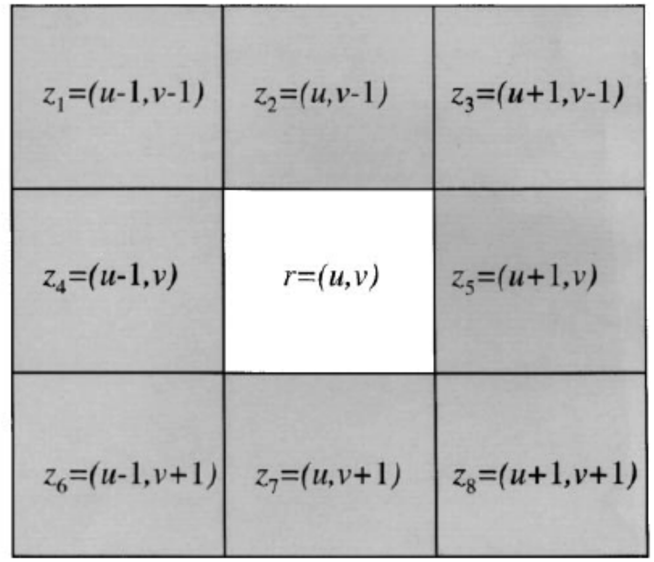
Extinction Thresholds and Metapopulation Persistence in Dynamic Landscapes

Juan E. Keymer,[1,*] Pablo A. Marquet,[2,†] Jorge X. Velasco-Hernández,[3,‡] and Simon A. Levin[1,§]


State 0
State 1
State 2
λ
e
e
δ
β ρ(r,ξ)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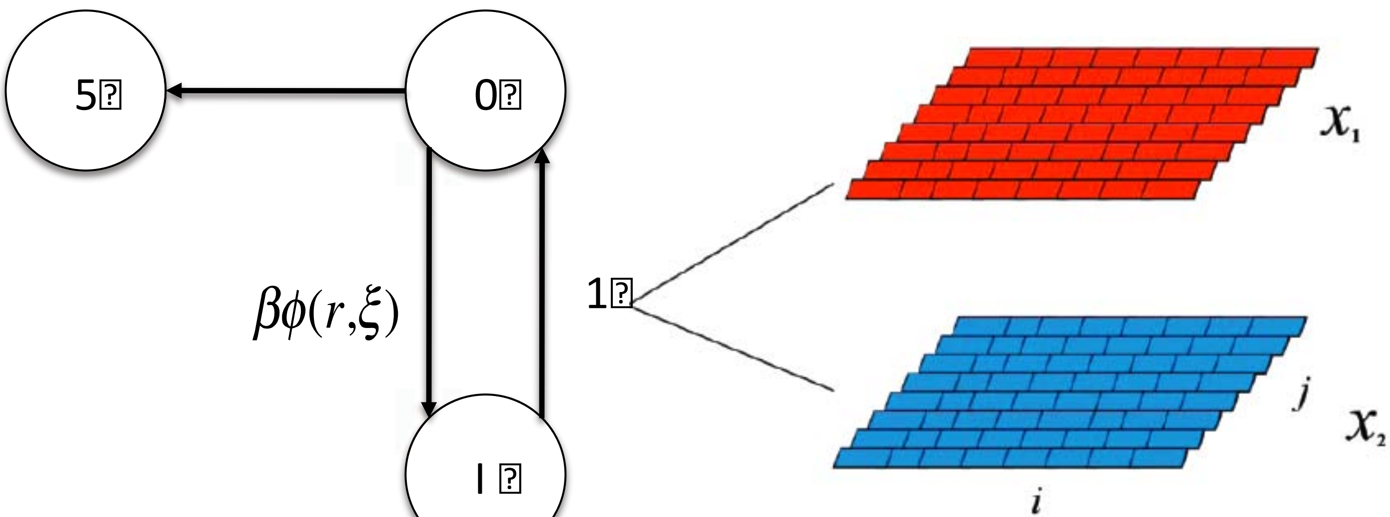
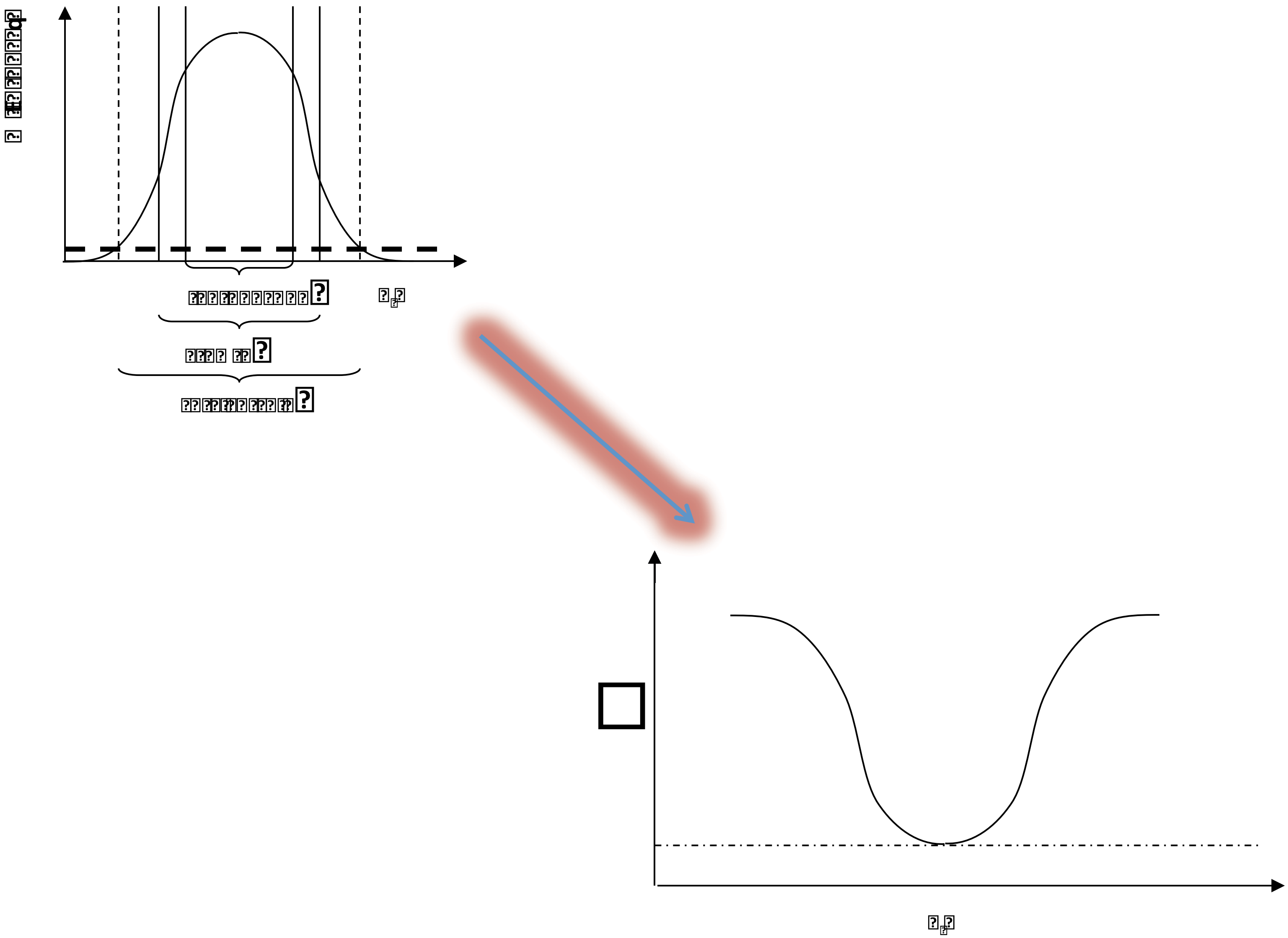
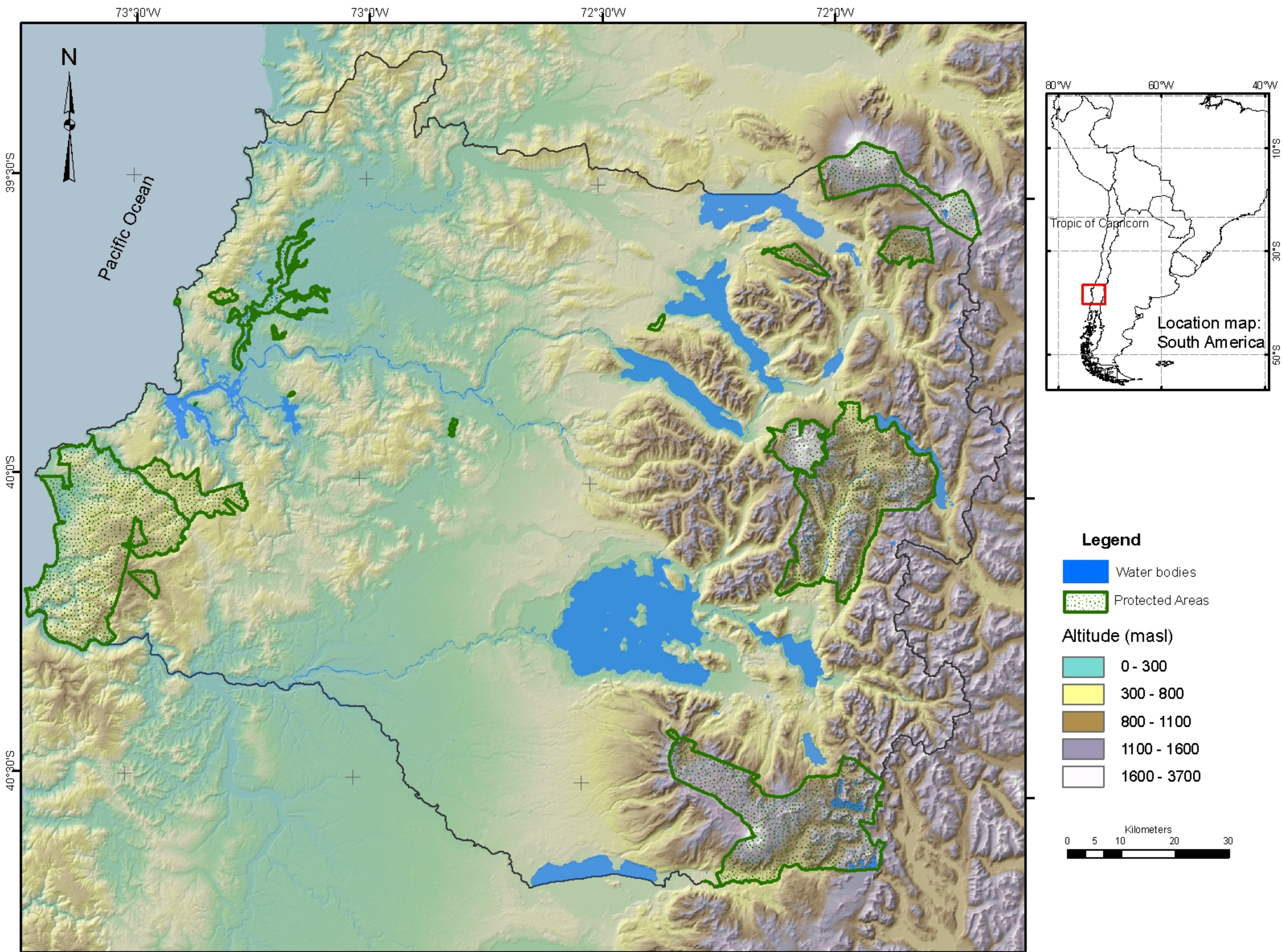
z_2=(u,v-1)
z_3=(u+1,v-1)
z_4=(u-1,v)
r=(u,v)
z_5=(u+1,v)
z_6=(u-1,v+1)
z_7=(u,v+1)
z_8=(u+1,v+1)

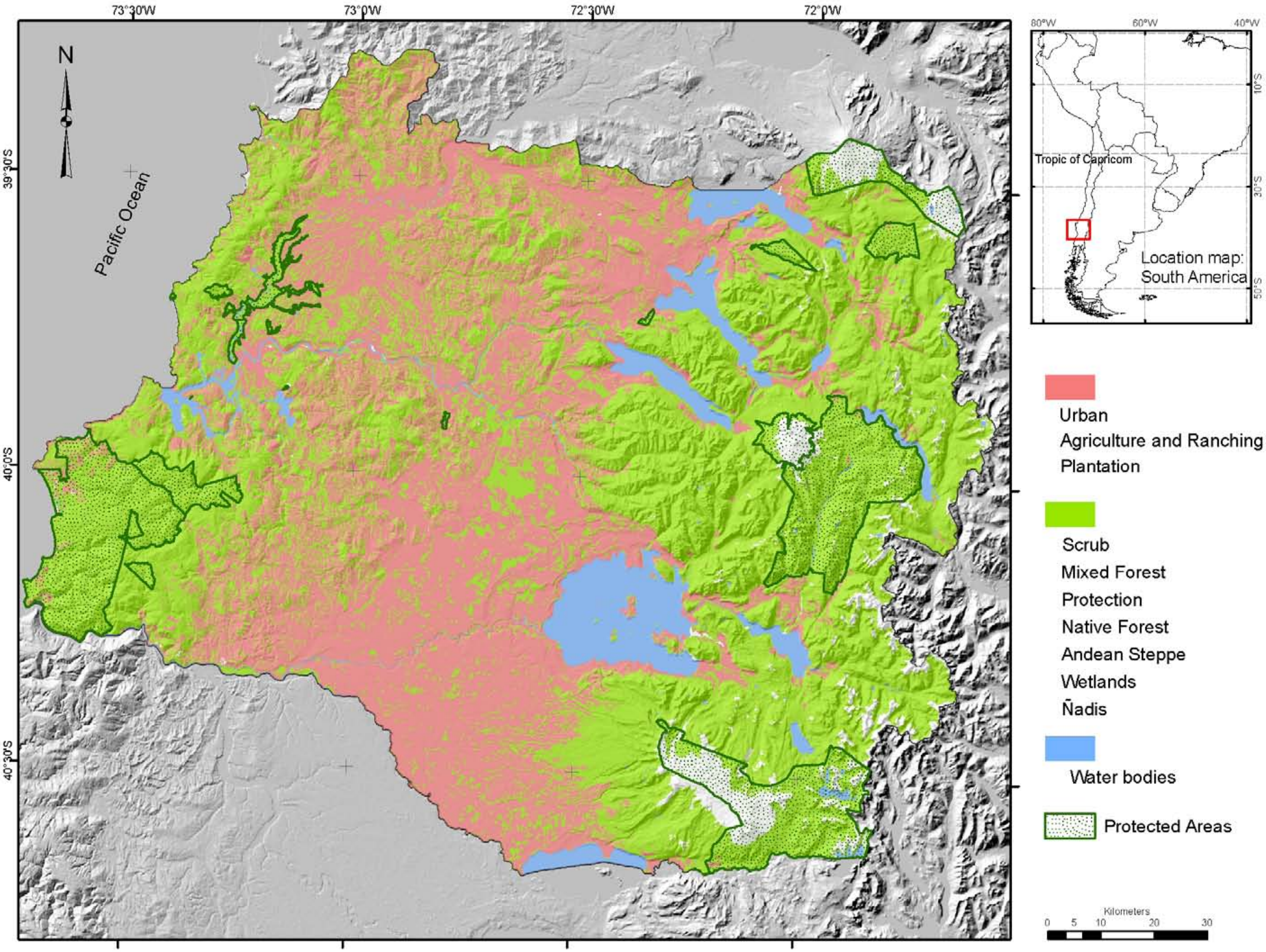
?qc? a??c a? ??o l ???ti?

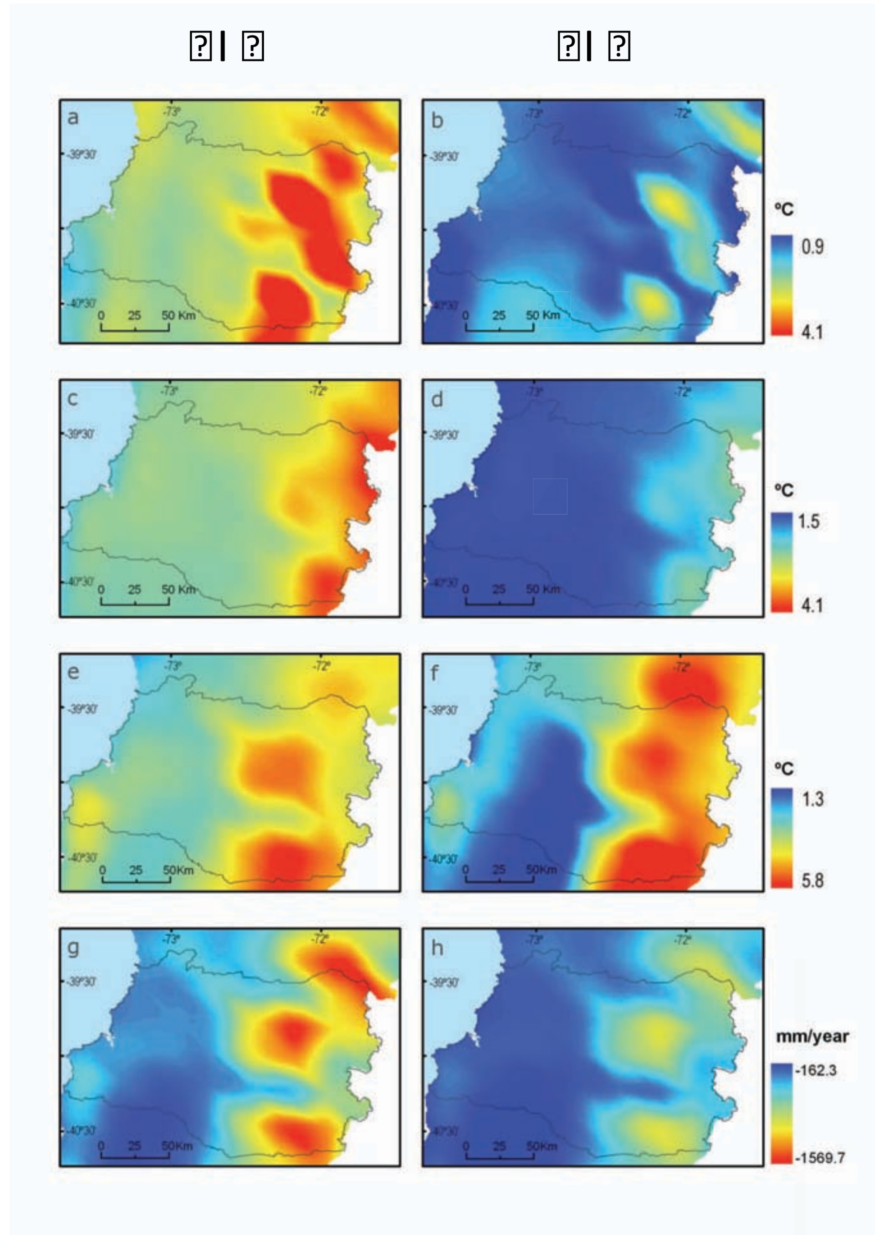


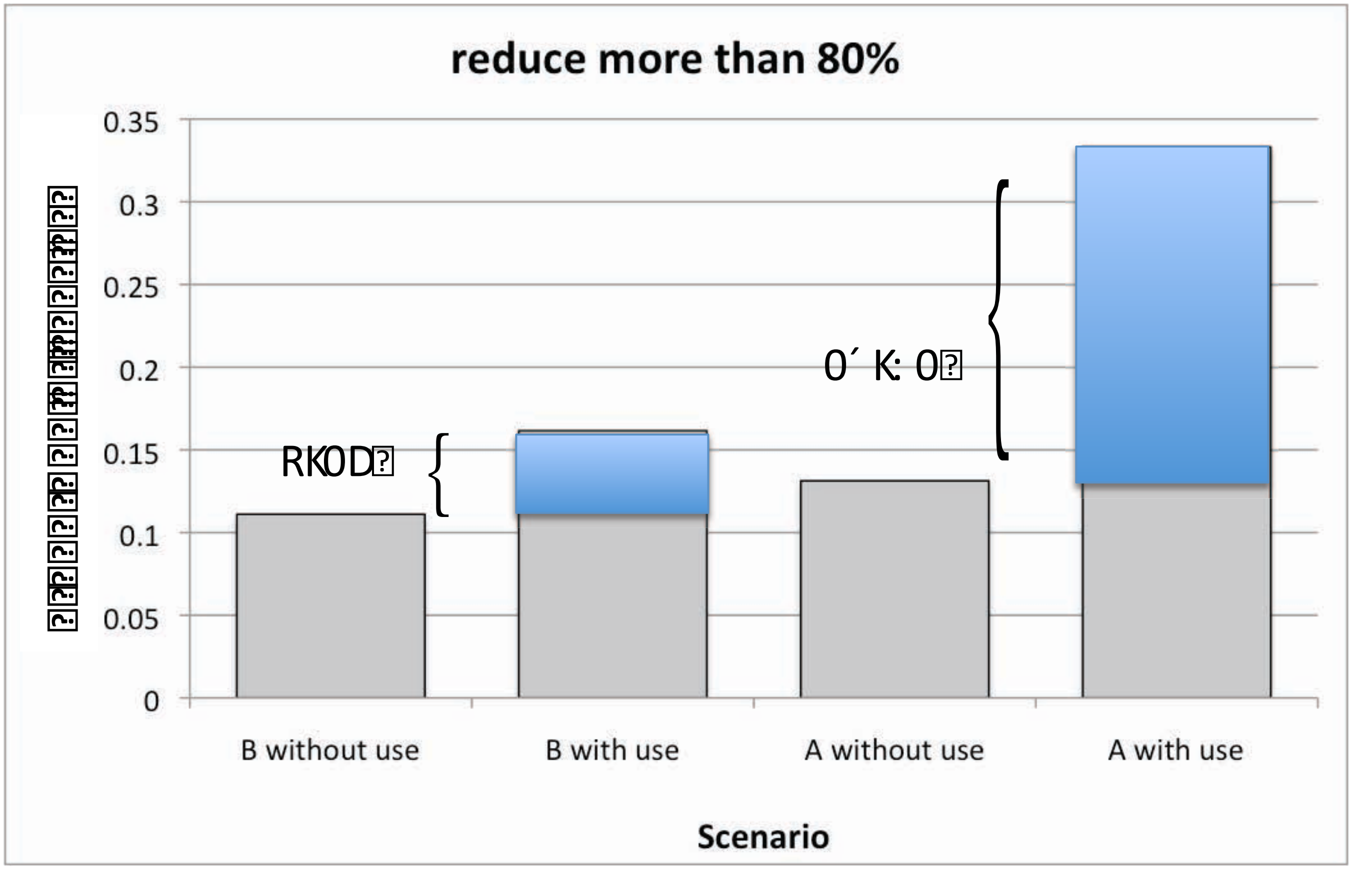


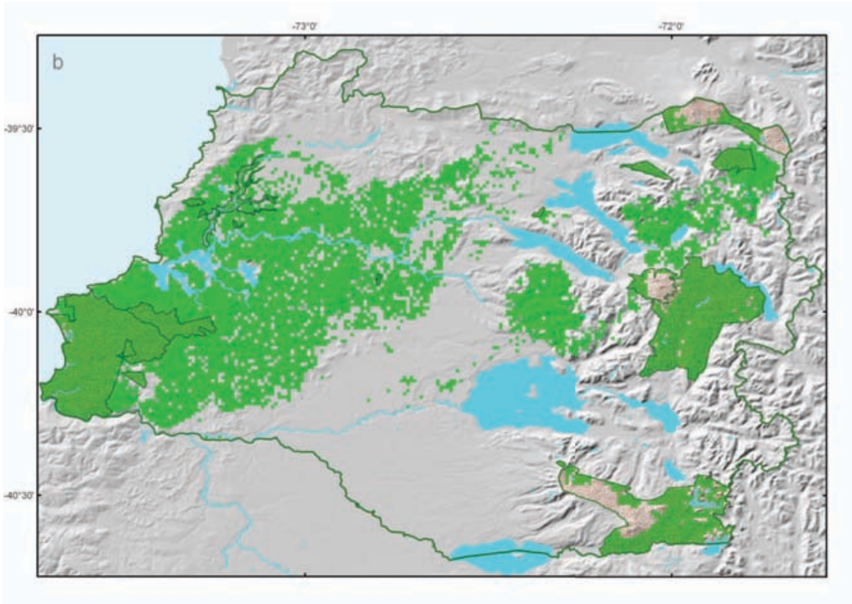


73°30'W
73°0'W
72°30'W
72°0'W
39°30'S
40°0'S
40°30'S
N
Pacific Ocean
80°W
60°W
40°W
10°S
30°S
50°S
Tropic of Capricorn
Location map:
South America
Legend
Water bodies
Protected Areas
Altitude (masl)
0 - 300
300 - 800
800 - 1100
1100 - 1600
1600 - 3700
Kilometers
0 5 10 20 30


73°30'W
73°0'W
72°30'W
72°0'W
39°30'S
40°0'S
40°30'S
N
Pacific Ocean
80°W
60°W
40°W
10°S
30°S
50°S
Tropic of Capricorn
Location map: South America
Urban
Agriculture and Ranching
Plantation
Scrub
Mixed Forest
Protection
Native Forest
Andean Steppe
Wetlands
Ñadis
Water bodies
Protected Areas
Kilometers
0 5 10 20 30

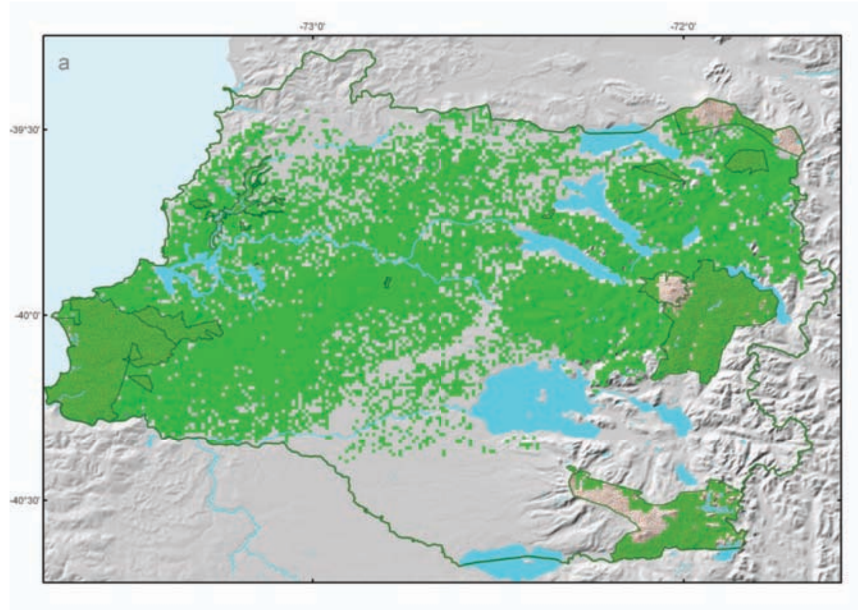

a
b
c
d
e
f
g
h
-73°
-72°
-39°30'
-40°30'
0 25 50 Km
°C
0.9
4.1
°C
1.5
4.1
°C
1.3
5.8
mm/year
-162.3
-1569.7


reduce more than 80%
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
B without use
B with use
A without use
A with use
Scenario


b
-73°0'
-72°0'
-39°30'
-40°0'
-40°30'

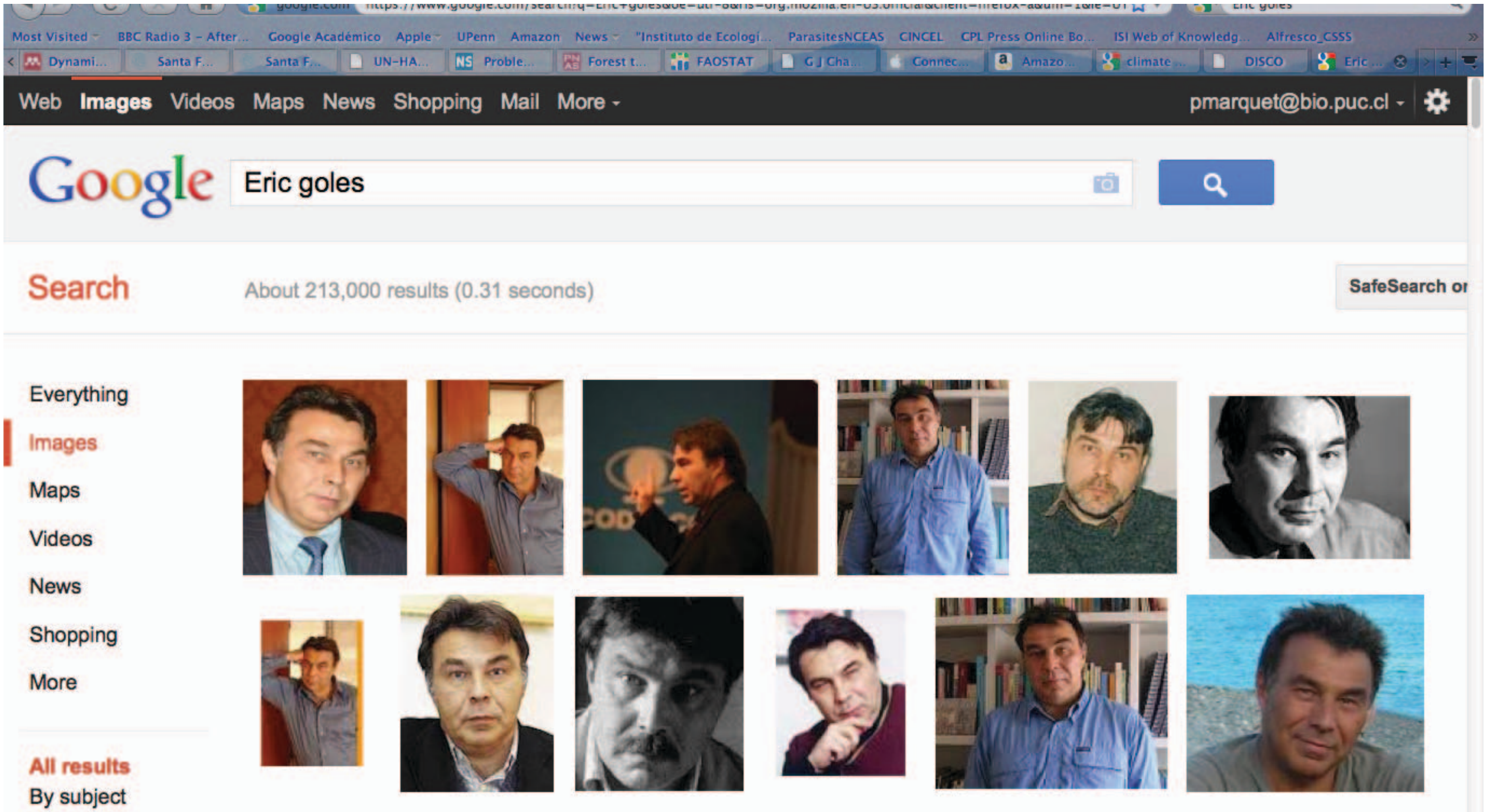
[illegible]

[illegible]


a
-73°0'
-72°0'
-39°30'
-40°0'
-40°30'

[illegible]

[illegible]


Most Visited
BBC Radio 3 - After...
Google Académico
Apple
UPenn
Amazon
News
"Instituto de Ecologí...
ParasitesNCEAS
CINCEL
CPL Press Online Bo...
ISI Web of Knowledg...
Alfresco_CSSS
Dynami...
Santa F...
Santa F...
UN-HA...
Proble...
Forest t...
FAOSTAT
G J Cha...
Connec...
Amazo...
climate...
DISCO
Eric...
Web
Images
Videos
Maps
News
Shopping
Mail
More
pmarquet@bio.puc.cl
Google
Eric goles
Search
About 213,000 results (0.31 seconds)
SafeSearch or
Everything
Images
Maps
Videos
News
Shopping
More
All results
By subject