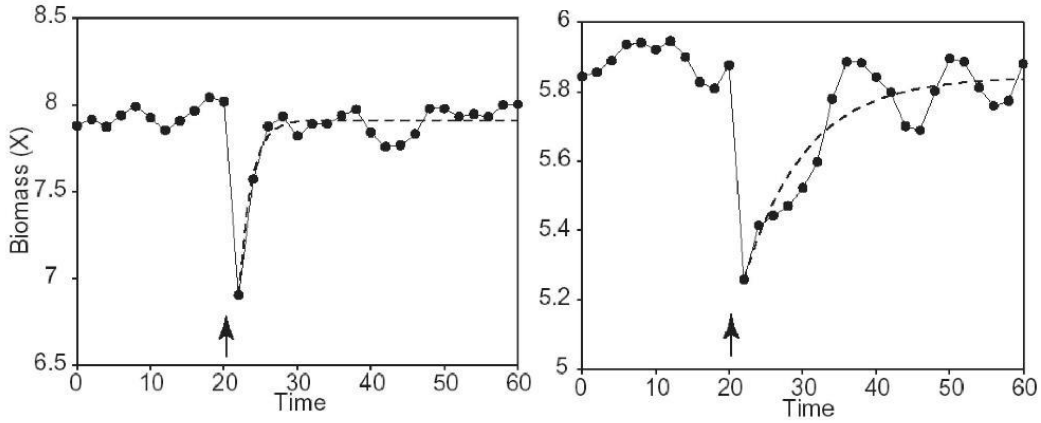
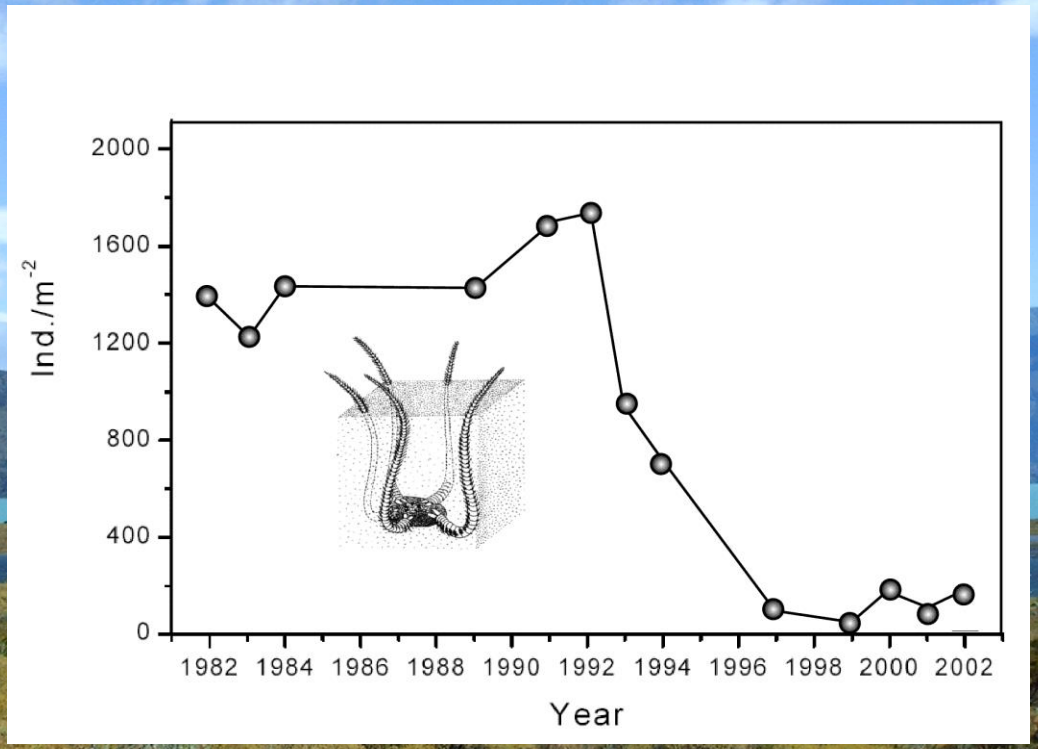
Resilience

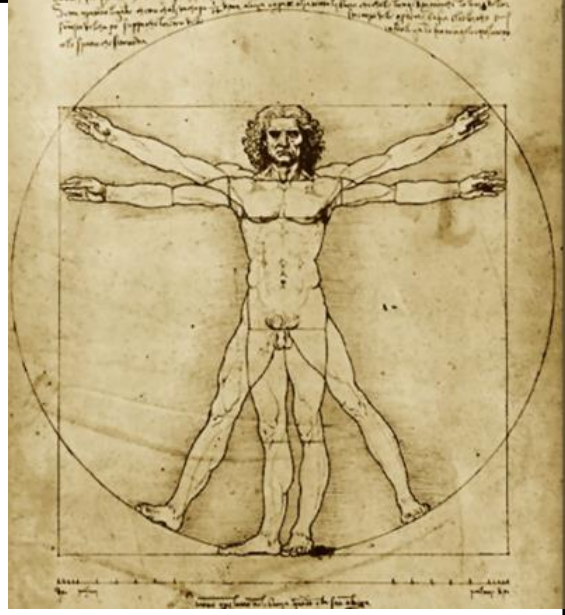
Engineering Resilience

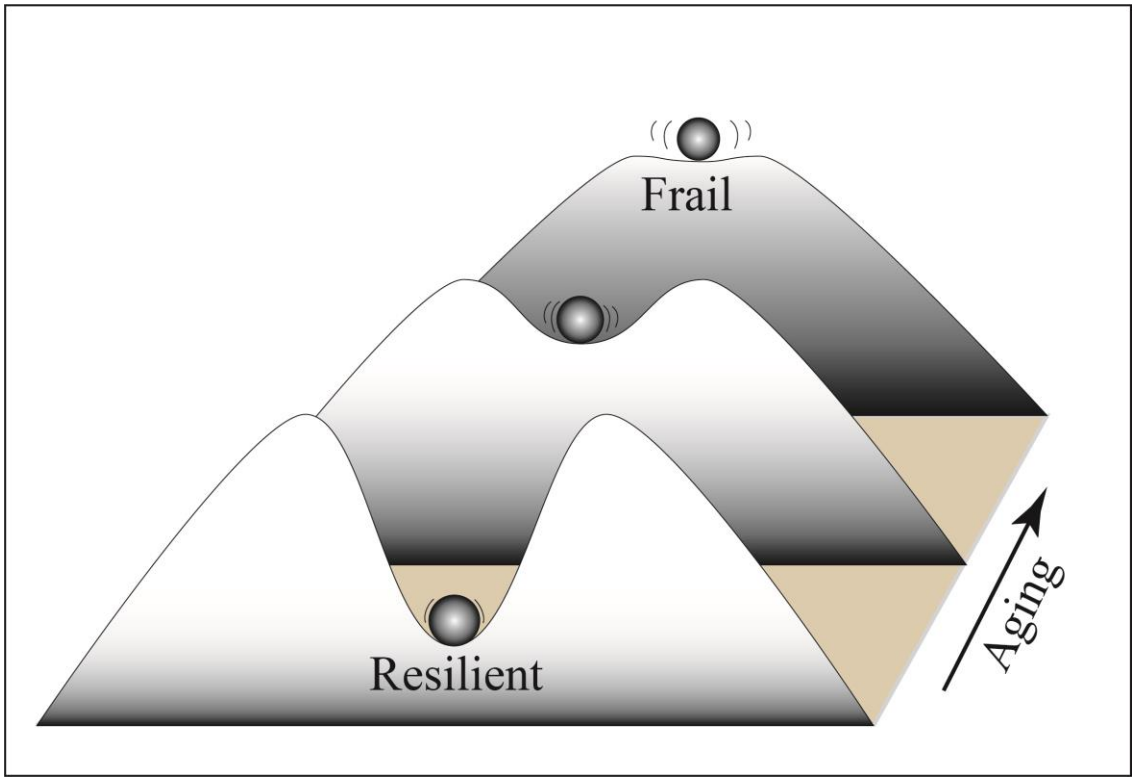



2000
1600
1200
800
400
0
Ind./m-2
1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002
Year

Holling 1973

Ecological Resilience



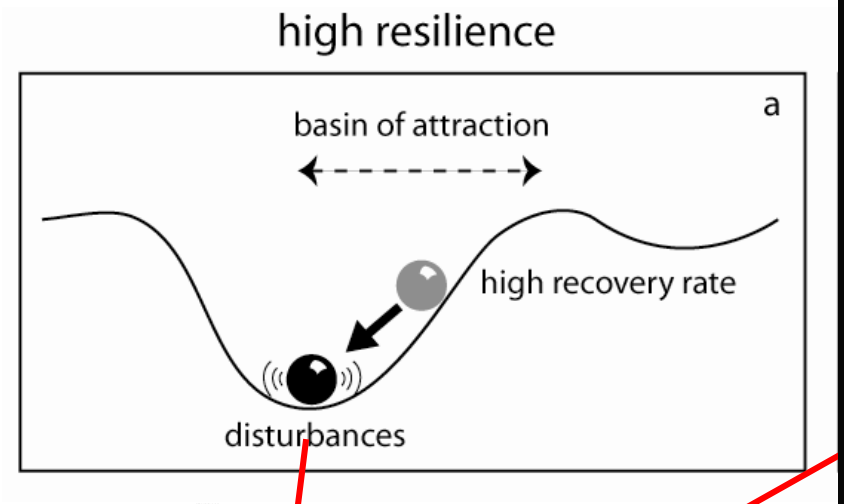


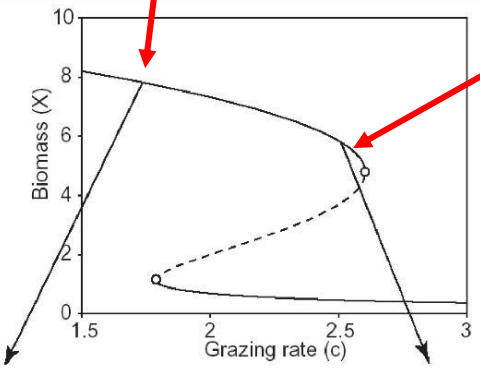
Systemic Resilience of Humans and Animals *Scheffer, et al. in prep.*

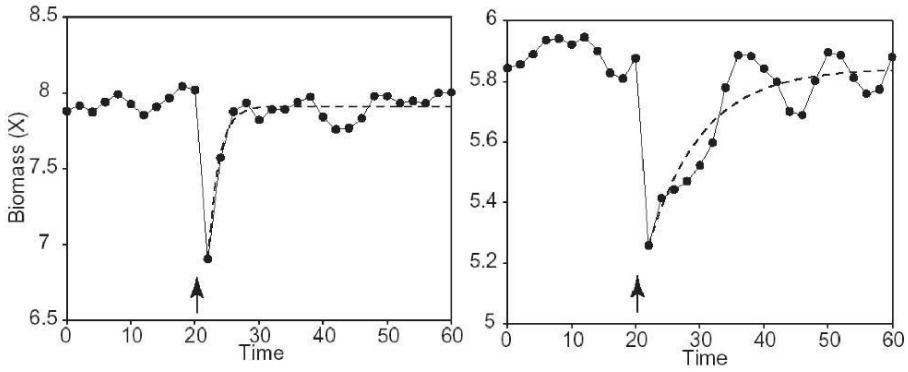
Could We Quantify Systemic Resilience ?

Without destroying the system ?

Critical Slowing Down

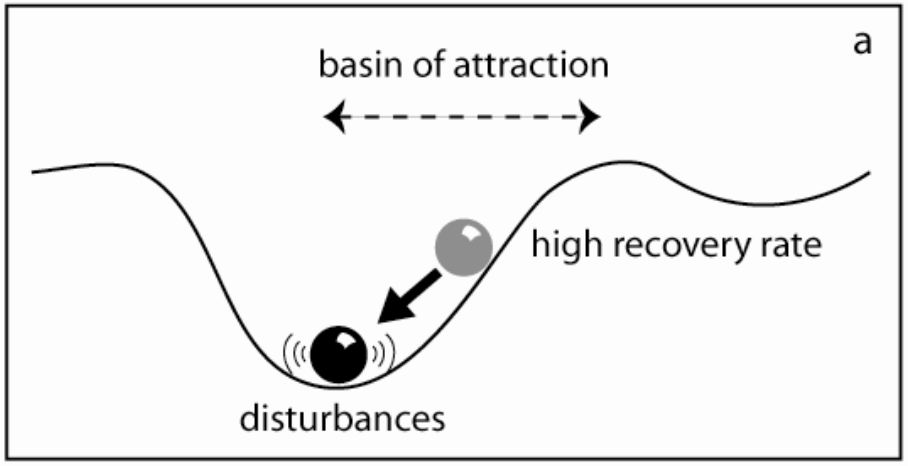




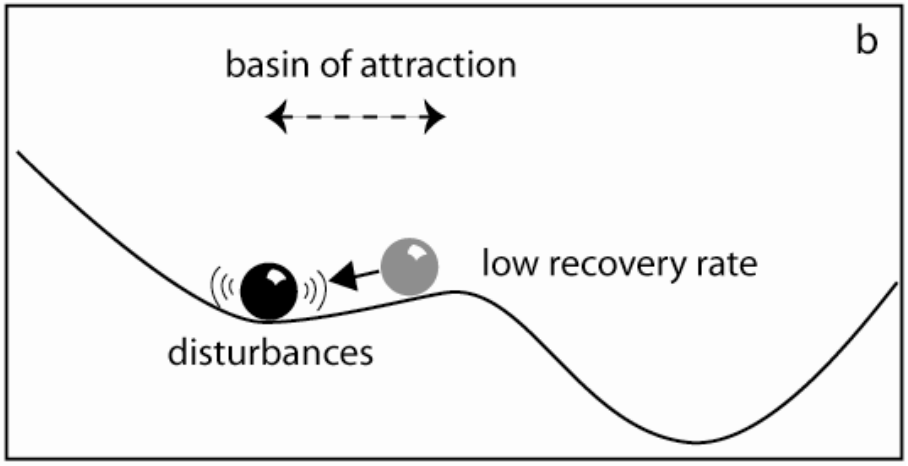


Using Natural Fluctuations

High Resilience



Low Resilience

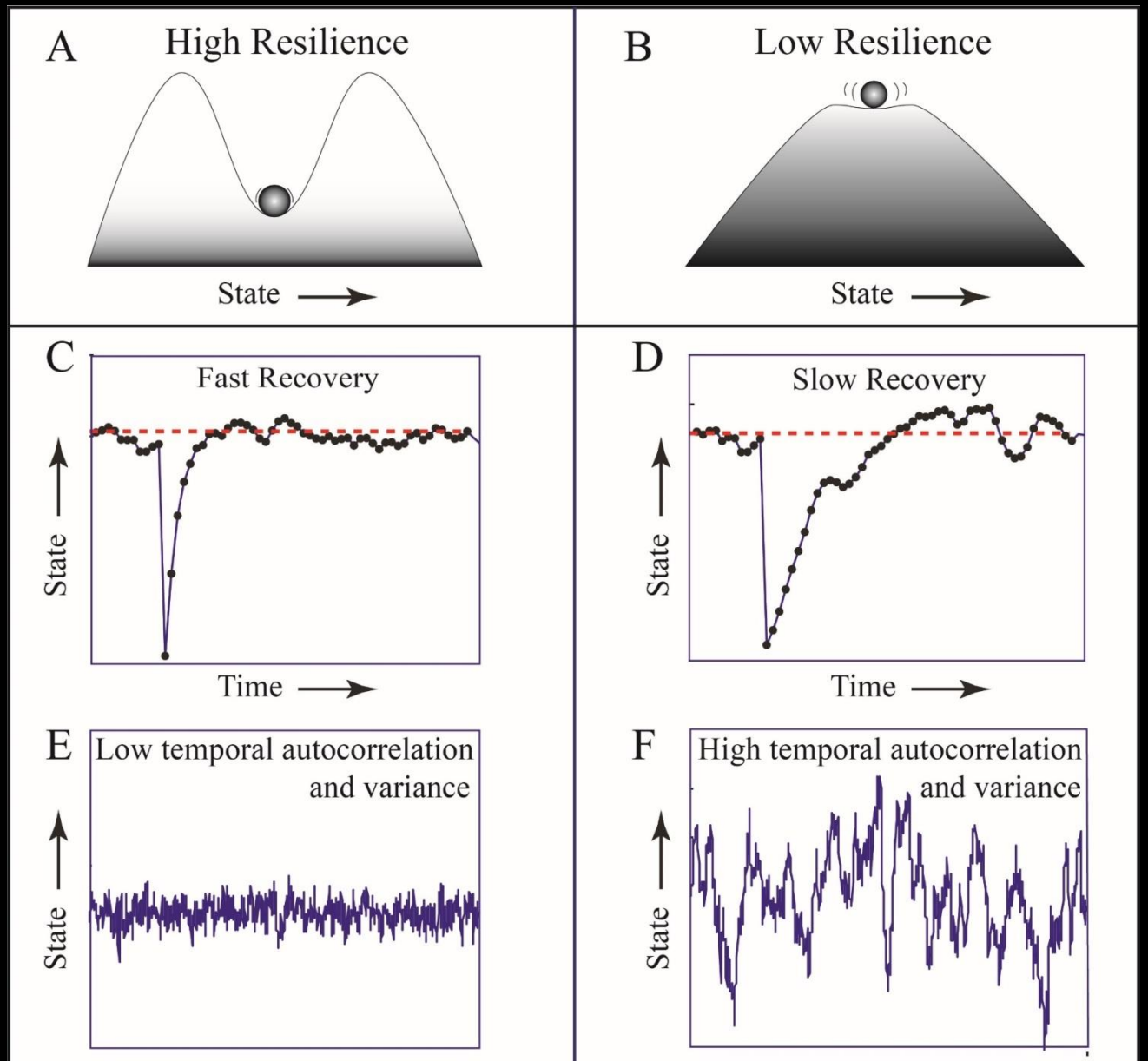


increased variance

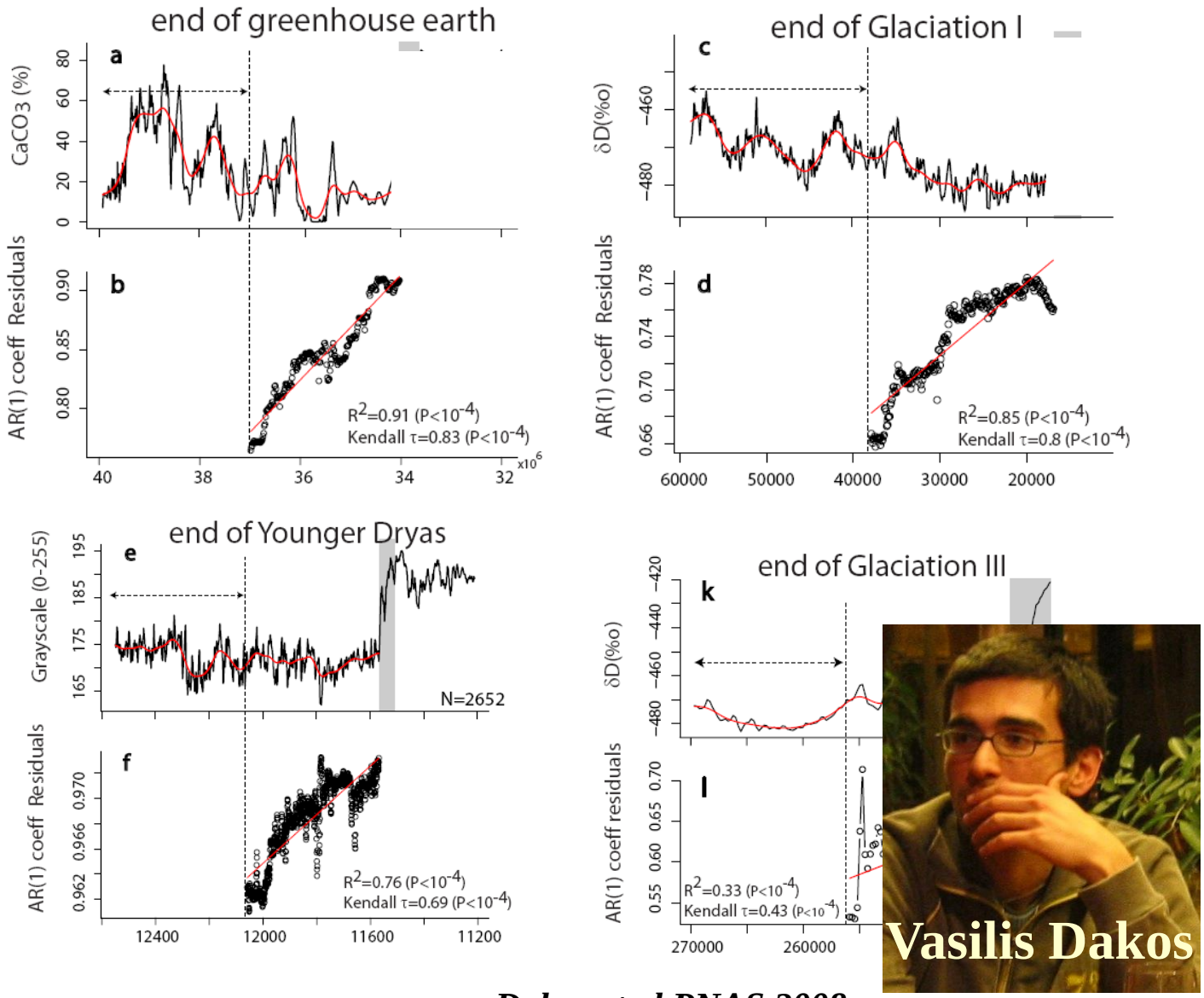
increased autocorrelation

Dynamic Indicators of Resilience

based on patterns of ‘micro-recovery’



Such signals announced 8 abrupt climate shifts



Dakos et al PNAS 2008

Evidence from a living system in the lab

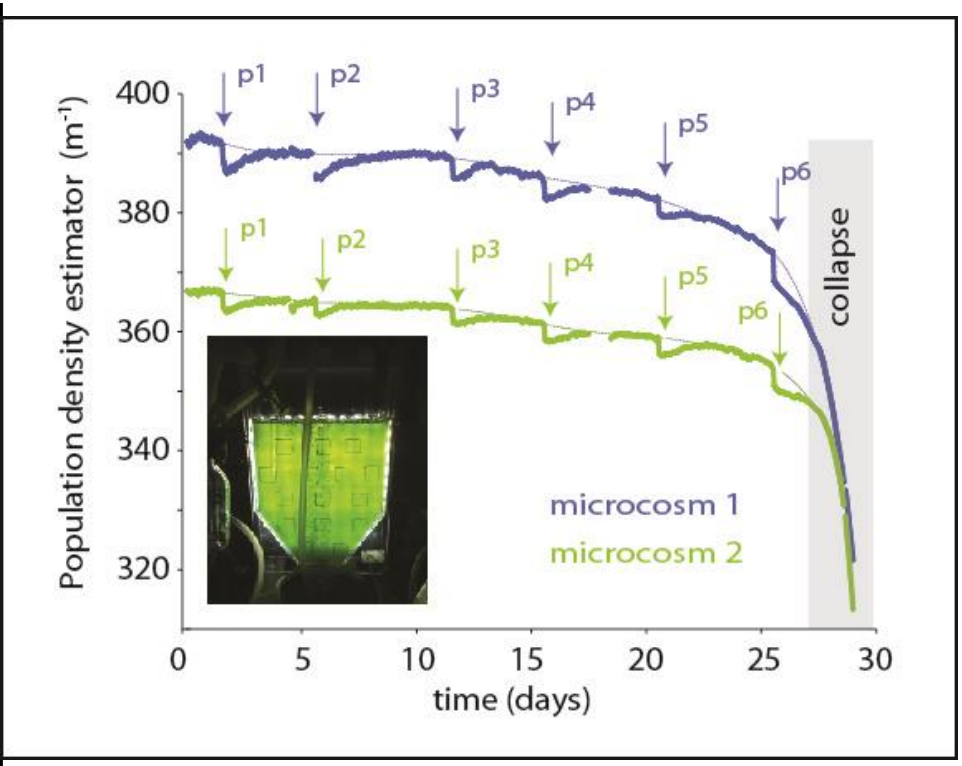
LETTER

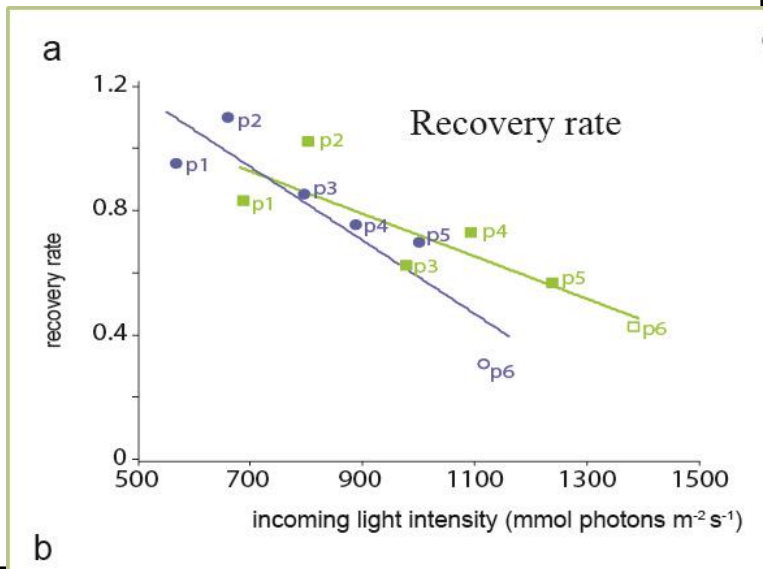
Nature, 2012

doi:10.1038/nature10723

Recovery rates reflect distance to a tipping point in a living system

Annelies J. Veraart[1], Elisabeth J. Faassen[1], Vasilis Dakos[1], Egbert H. van Nes[1], Miquel Lürling[1,2] & Marten Scheffer[1]





Forests and Societies

nature climate change

LETTERS

PUBLISHED ONLINE: 5 SEPTEMBER 2016 | DOI: 10.1038/NCLIMATE3108

Remotely sensed resilience of tropical forests

Jan Verbesselt[1*], Nikolaus Umlauf[2], Marina Hirota[3,4,5], Milena Holmgren[6], Egbert H. Van Nes[3], Martin Herold[1], Achim Zeileis[2] and Marten Scheffer[3*]

PNAS

European Neolithic societies showed early warning signals of population collapse

Sean S. Downey[a,1], W. Randall Haas Jr.[a], and Stephen J. Shennan[b]

[a]Anthropology Department, University of Maryland, 4302 Chapel Lane, College Park, MD 20742; and [b]Institute of Archaeology, University College London, London WC1H 0PY, United Kingdom

Edited by Timothy A. Kohler, Washington State University, Pullman, WA, and accepted by Editorial Board Member James O'Connell June 30, 2016 (received for review March 16, 2016)

Ecosystems on the verge of major reorganization—regime shift— archaeological data (14–16) are narrowing the gap between theory

and the human mood

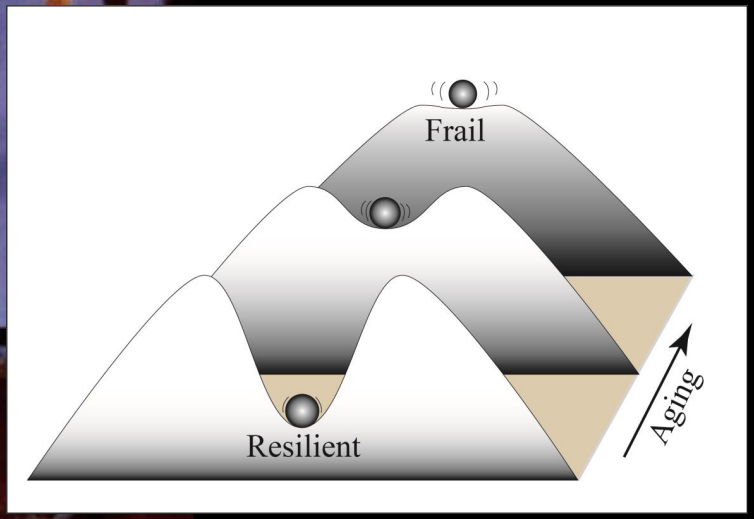
PNAS

Critical slowing down as early warning for the onset and termination of depression

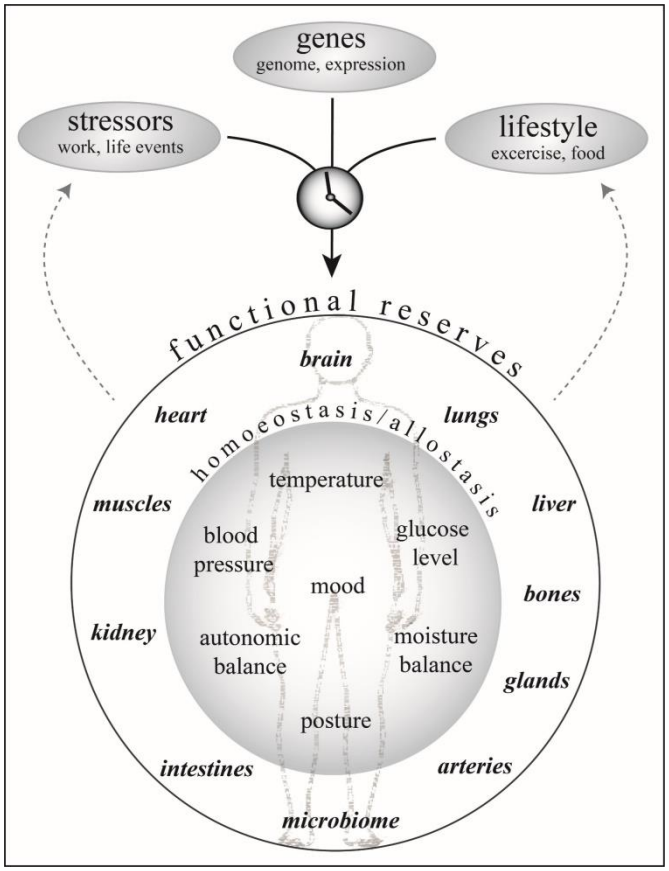
Ingrid A. van de Leemput[a,1,2], Marieke Wichers[b,1], Angélique O. J. Cramer[c], Denny Borsboom[c], Francis Tuerlinckx[d], Peter Kuppens[d,e], Egbert H. van Nes[a], Wolfgang Viechtbauer[b], Erik J. Giltay[f], Steven H. Aggen[g], Catherine Derom[h,i], Nele Jacobs[b,j], Kenneth S. Kendler[g,k], Han L. J. van der Maas[c], Michael C. Neale[g], Frenk Peeters[b], Evert Thiery[l], Peter Zachar[m], and Marten Scheffer[a]

[a]Aquatic Ecology and Water Quality Management, Wageningen University, 6700 AA, Wageningen, The Netherlands; [b]Department of Psychiatry and Psychology, School for Mental Health and Neuroscience, Maastricht University, 6200 MD, Maastricht, The Netherlands; [c]Department of Psychology, Psychological Methods, University of Amsterdam, 1018 XA, Amsterdam, The Netherlands; [d]Faculty of Psychology and Educational Sciences, KU Leuven–

Deep Universality

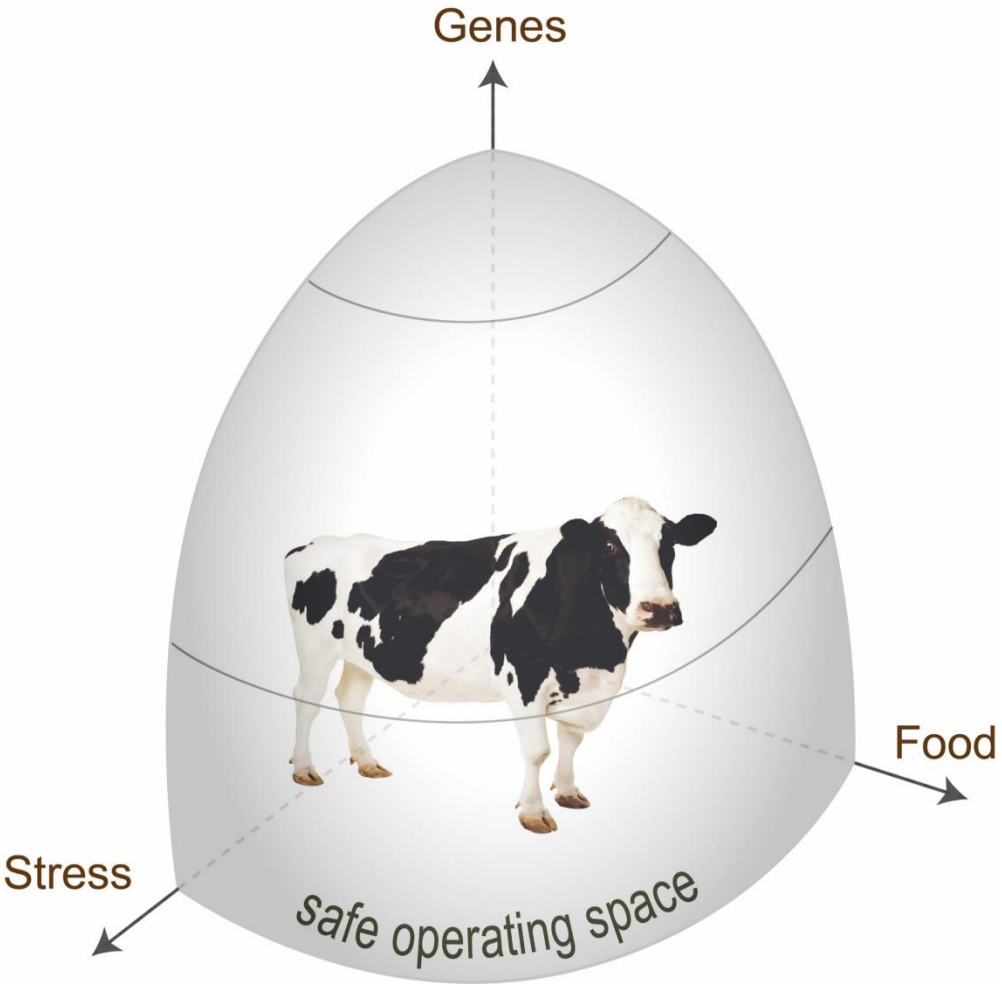


What kind of things can we do with this?



Scheffer et al. *Science Magazine*, 2015

What kind of things can we do with this?

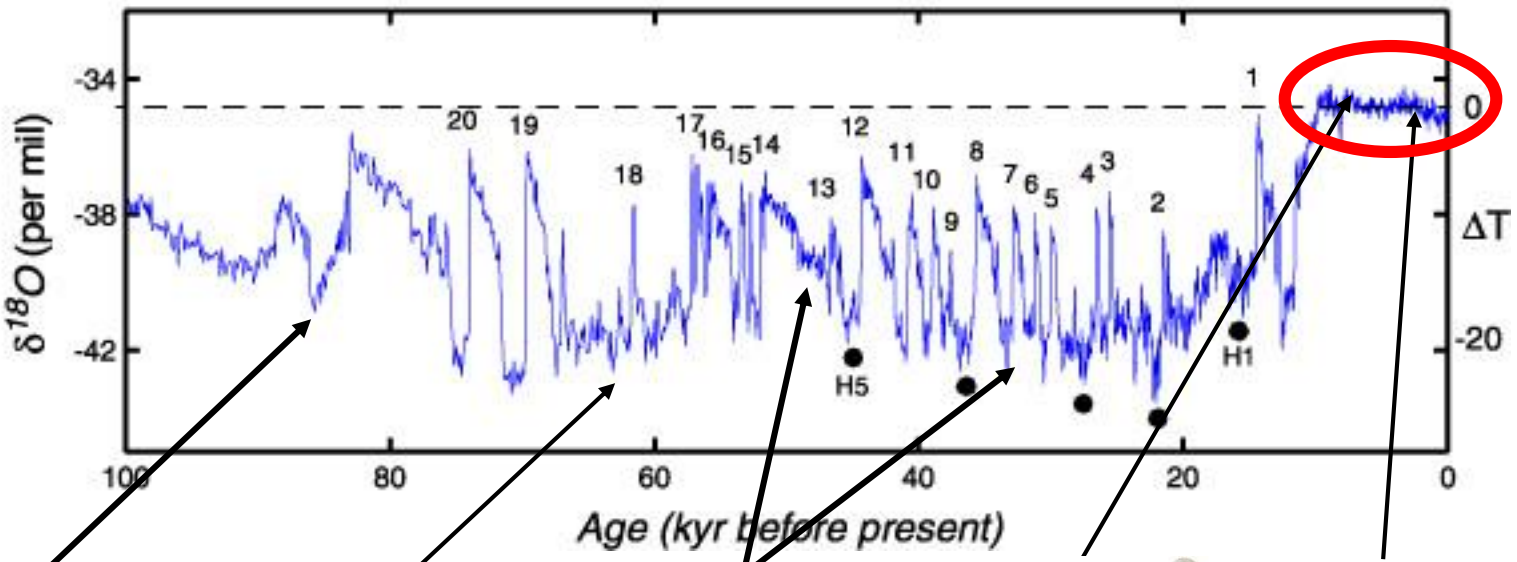


Quantify and Manage Resilience ?

What about the bigger picture ?

Resilience of social traps

We live in interesting times



First migration of fully modern humans out of Africa

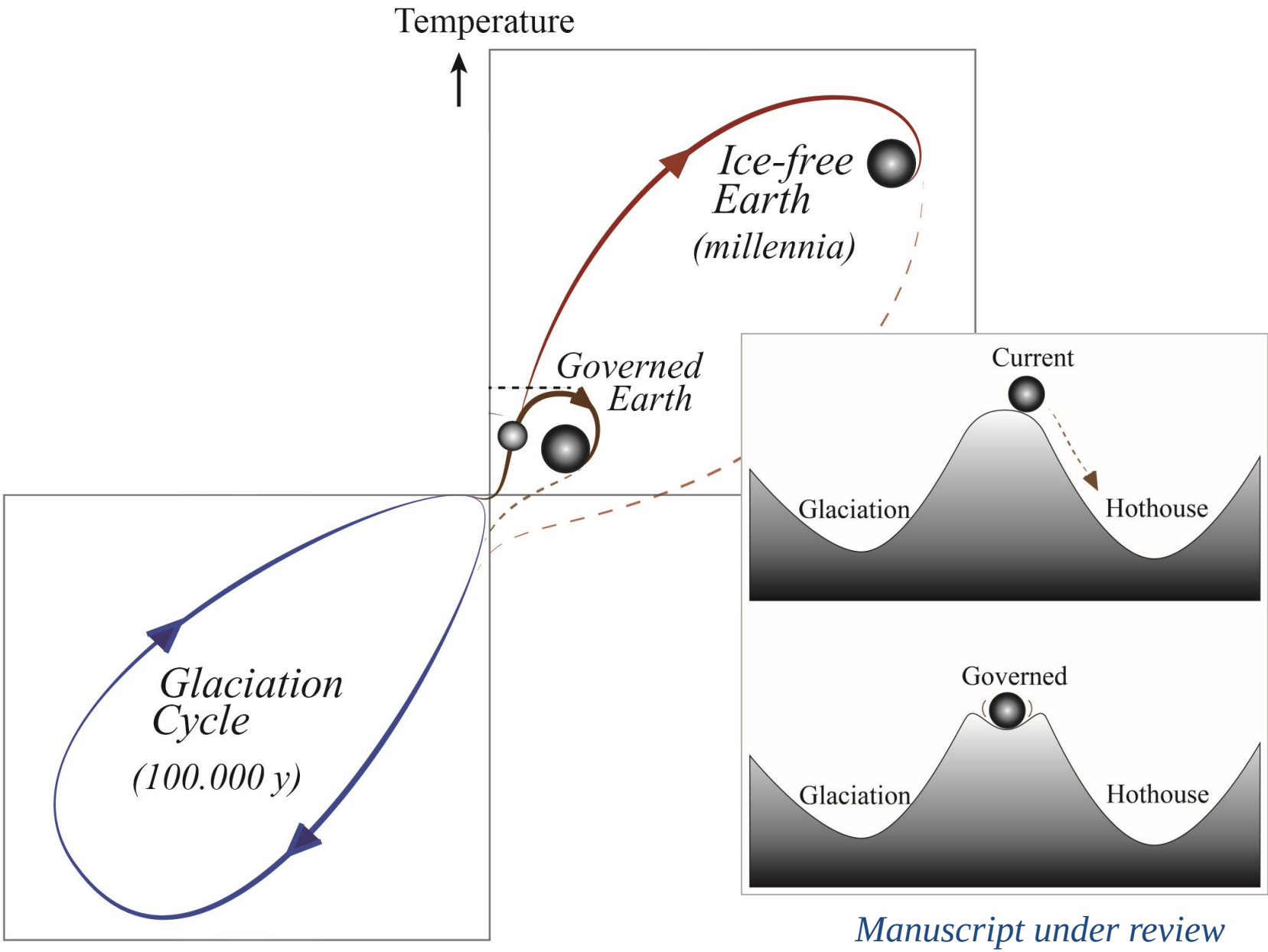
Aborigines arrive in Australia

Migrations of fully modern humans from South Asia to Europe

Great European civilisations: Greek, Roman

Young and Steffen. 2009. In: Chapin et al. (eds.). *Principles of Ecosystem Stewardship*. Springer

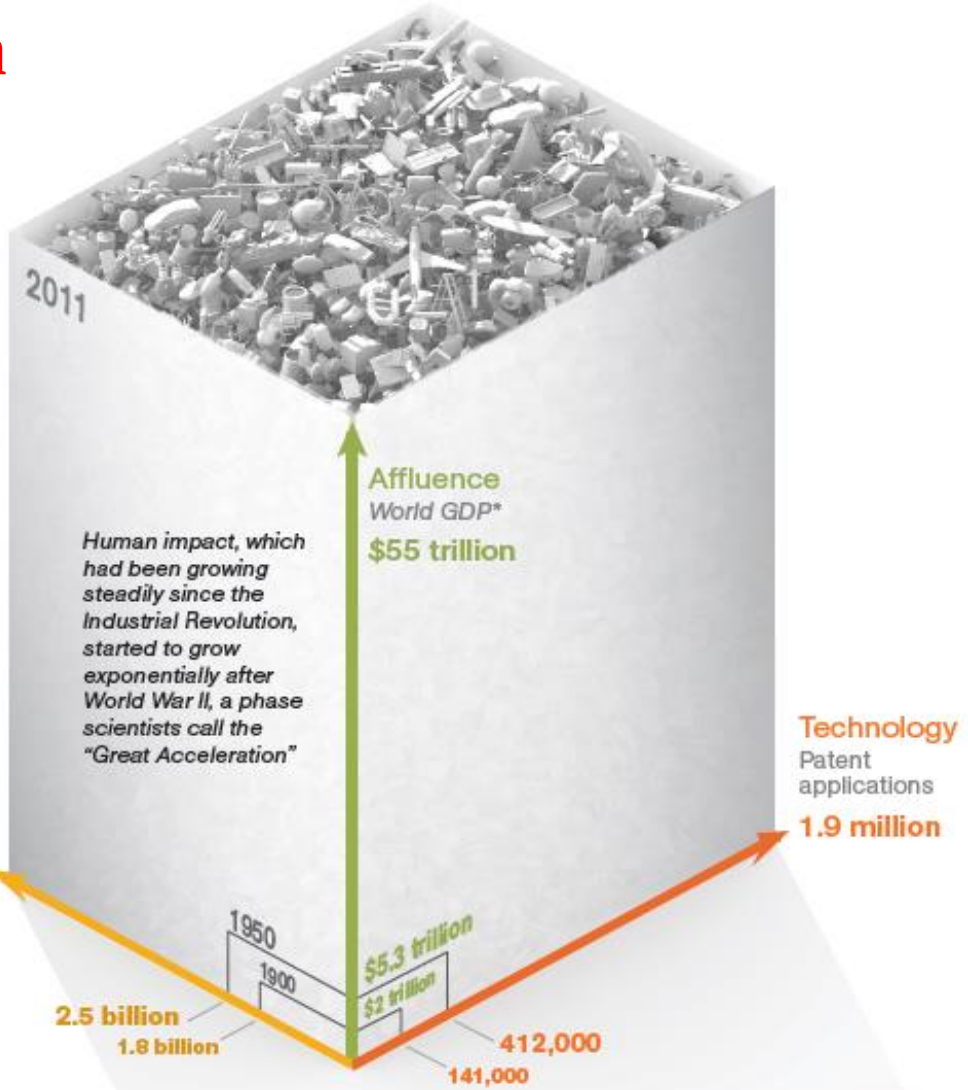
The Big Picture



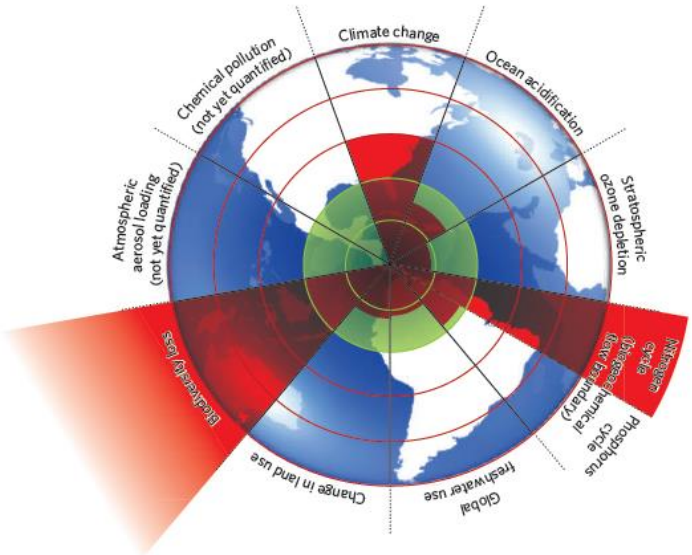
Manuscript under review

The Great Acceleration

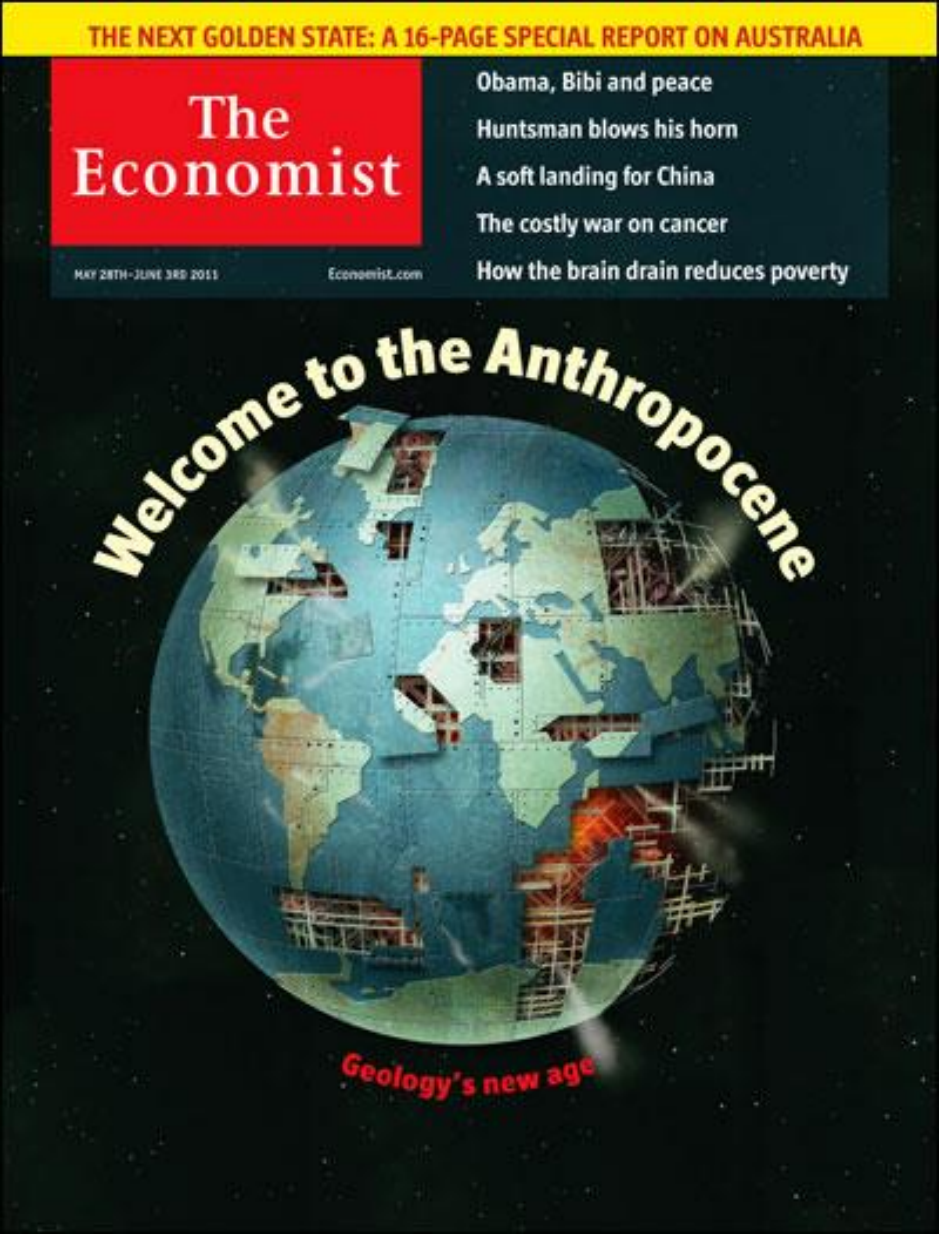
P x A x T = width times height times length of three boxes representing human impact in 1900, 1950 and 2011.



Planetary Boundaries



Rockström et al. 2009. Nature



Humans have changed the way the world works.

Now they have to change the way they think about it, too

Hysteresis in public attitude

Social Contagion

INSIGHTS | PERSPECTIVES

SCIENCE GALLEY

OVERLINE

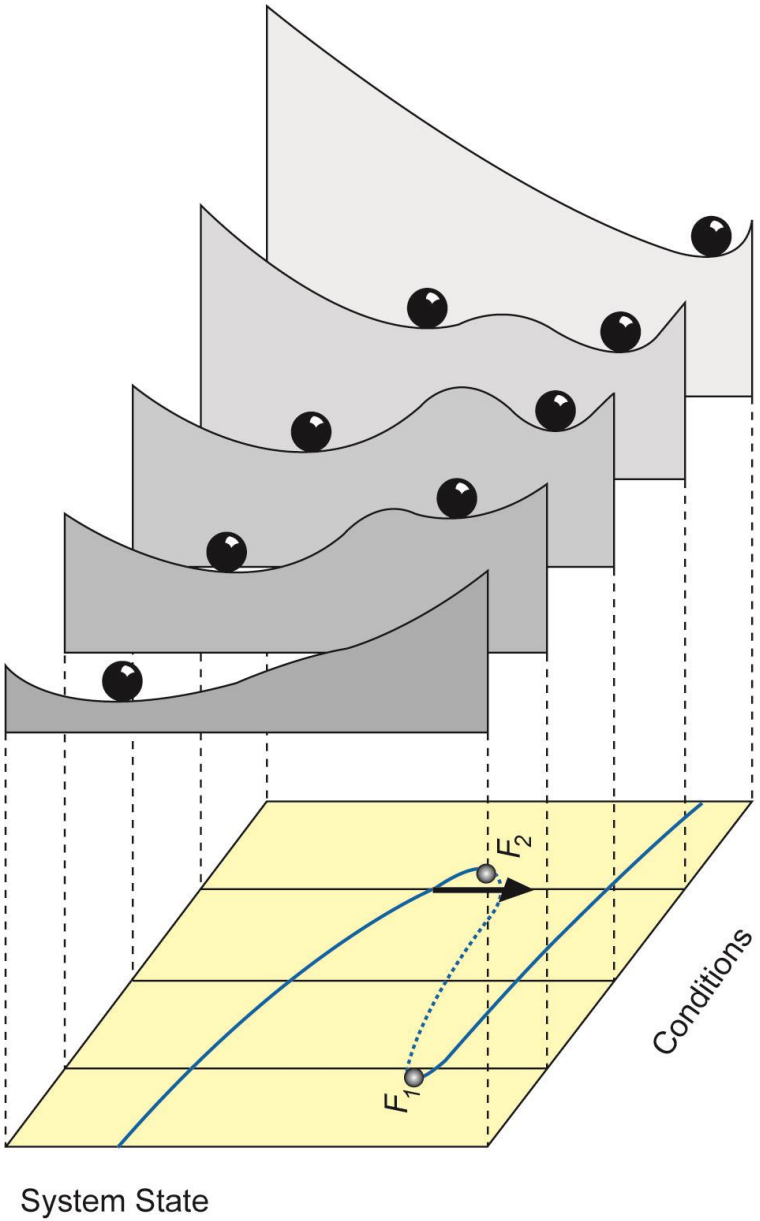
Social norms as solutions

Policies can influence large-scale behavioral tipping points

By Karine Nyborg[1*], John M. Anderies[2], Astrid Dannenberg[3,4], Therese Lindahl[5,6], Caroline Schill[5,6], Maja Schlüter[6], W. Neil Adger[7], Kenneth J. Arrow[8], Scott Barrett[9], Stephen Carpenter[10], F. Stuart Chapin III[11], Anne-Sophie Crépin[5,6], Gretchen Daily[12], Paul Ehrlich[12], Carl Folke[5,6], Wander Jager[13], Nils Kautsky[14], Simon A. Levin[15], Ole Jacob Madsen[16], Stephen Polasky[17], Marten Scheffer[18], Brian Walker[19], Elke U. Weber[20], James Wilen[21], Anastasios Xepapadeas[22], Aart de Zeeuw[5,23]

Science Magazine
October 2016

Critical Transitions in Society



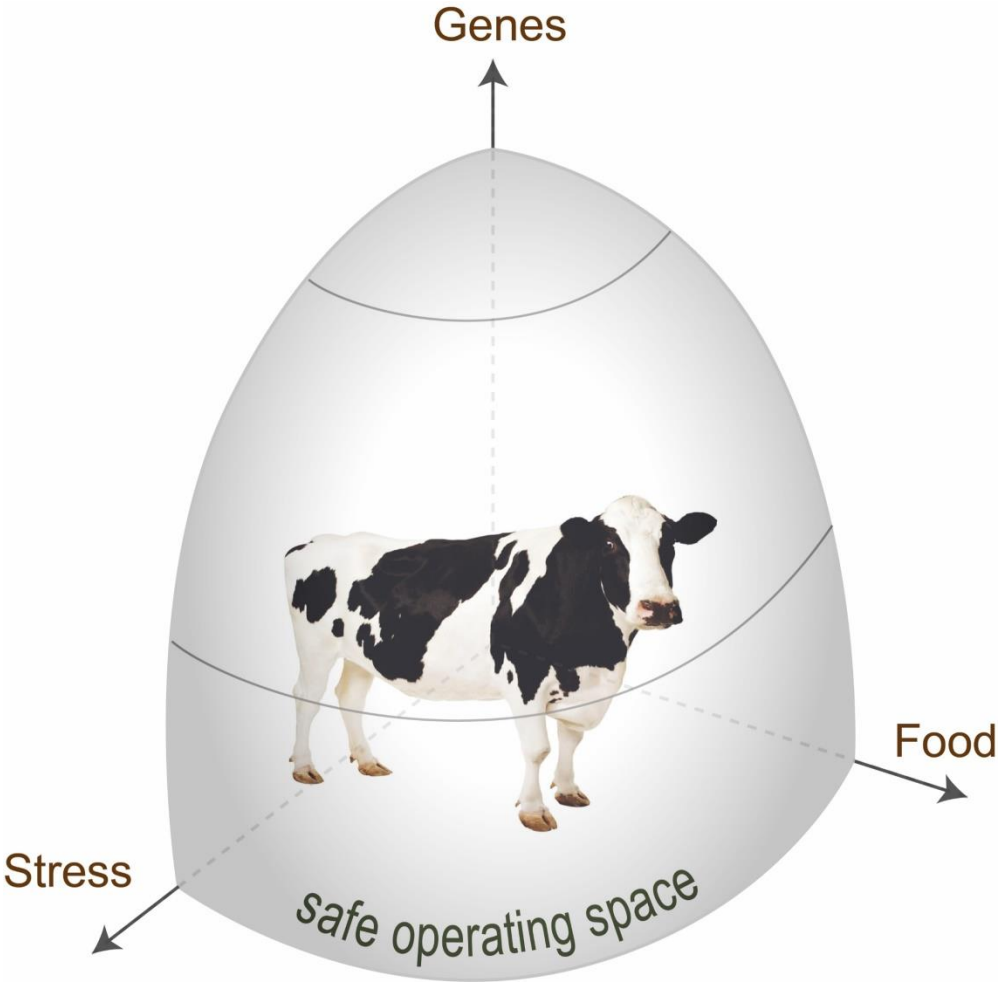
Footbinding

Public Smoking

Radical Change can only be

Invoked at a Tipping Point

Rethinking the Cow



Tipping Points in Health

Slowing Down of Recovery as Generic Risk Marker for Acute Severity Transitions in Chronic Diseases

Marcel G. M. Olde Rikkert, MD, PhD[1]; Vasilis Dakos, PhD[2]; Timothy G. Buchman, PhD, MD[3]; Rob de Boer, PhD[4]; Leon Glass, PhD[5]; Angélique O. J. Cramer, PhD[6]; Simon Levin, PhD[7]; Egbert van Nes, PhD[8]; George Sugihara, PhD[9]; Michel D. Ferrari, MD, PhD[10]; Else A. Tolner, PhD[10]; Ingrid van de Leemput, MSc[8]; Joep Lagro, MD, PhD[11]; René Melis, MD, PhD[1]; Marten Scheffer, PhD[8]

nature COMMUNICATIONS

ARTICLE

Received 23 Jan 2014 | Accepted 9 Jun 2014 | Published 8 Jul 2014

DOI: 10.1038/ncomms5344 OPEN

Tipping elements in the human intestinal ecosystem

Leo Lahti[1,2], Jarkko Salojärvi[1,*], Anne Salonen[3,*], Marten Scheffer[4] & Willem M. de Vos[1,2,3]

PNAS

Critical slowing down as early warning for the onset and termination of depression

Ingrid A. van de Leemput[a,1,2], Marieke Wichers[b,1], Angélique O. J. Cramer[c], Denny Borsboom[c], Francis Tuerlinckx[d], Peter Kuppens[d,e], Egbert H. van Nes[a], Wolfgang Viechtbauer[b], Erik J. Giltay[f], Steven H. Aggen[g], Catherine Derom[h,i], Nele Jacobs[b,j], Kenneth S. Kendler[g,k], Han L. J. van der Maas[c], Michael C. Neale[g], Frenk Peeters[b], Evert Thiery[l], Peter Zachar[m], and Marten Scheffer[a]

[a]Aquatic E
Psychology
Psychologi

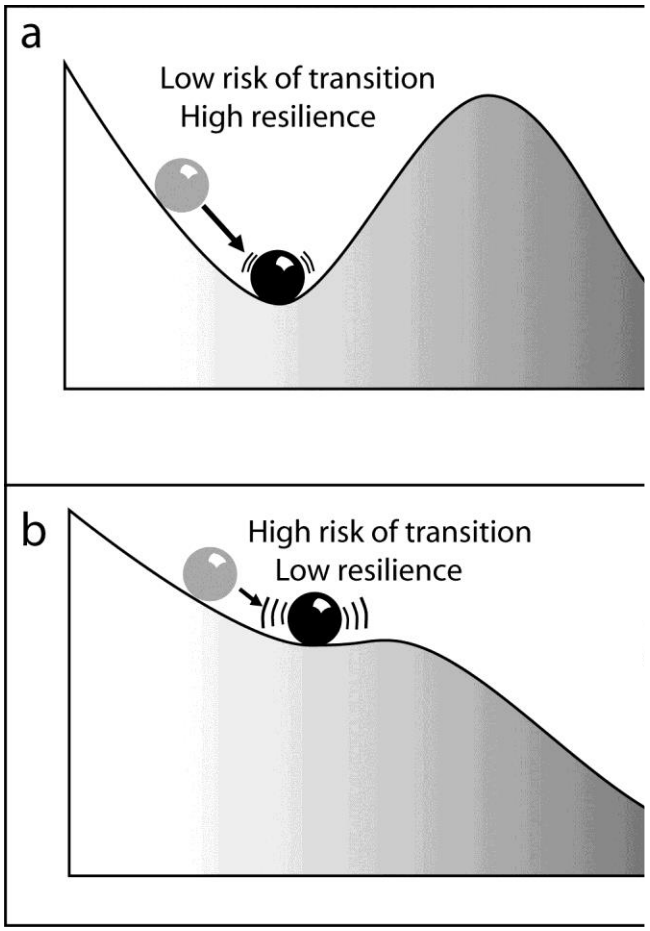
Migraine Strikes as Neuronal Excitability Reaches a Tipping Point

Marten Scheffer[1]*, Albert van den Berg[2], Michel D. Ferrari[3]

1 Department of Aquatic Ecology & Water Quality Management, Wageningen University, Wageningen, the Netherlands, **2** MESA+ Institute for Nanotechnology, University of Twente, Enschede, the Netherlands, **3** Department of Neurology, Leiden University Medical Centre, Leiden, the Netherlands

So far Critical Slowing Down .....

Subtle signs close to equilibrium



What about more Wildly Stochastic Systems ?

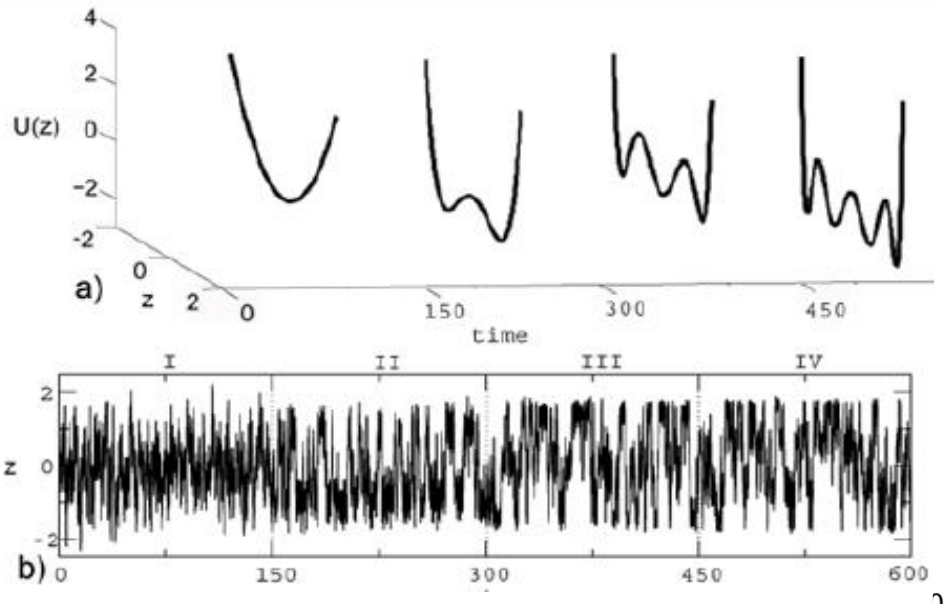
‘Flickering’

No Critical Slowing Down

but if you have a lot of data you may still find

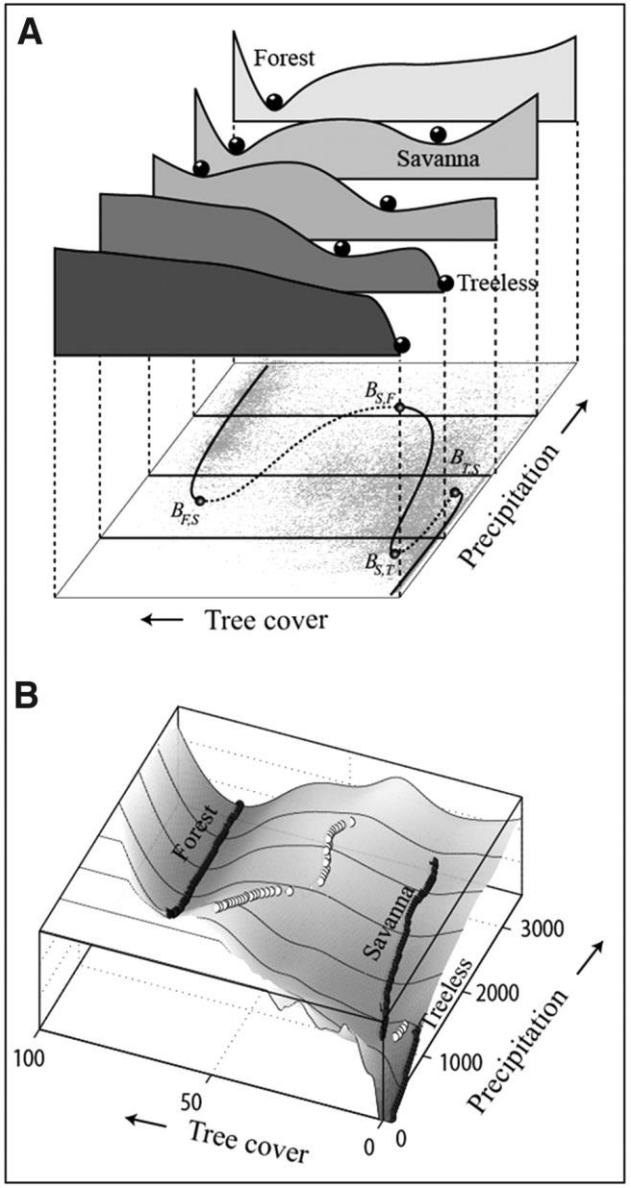
Hints of Alternative States and their resilience

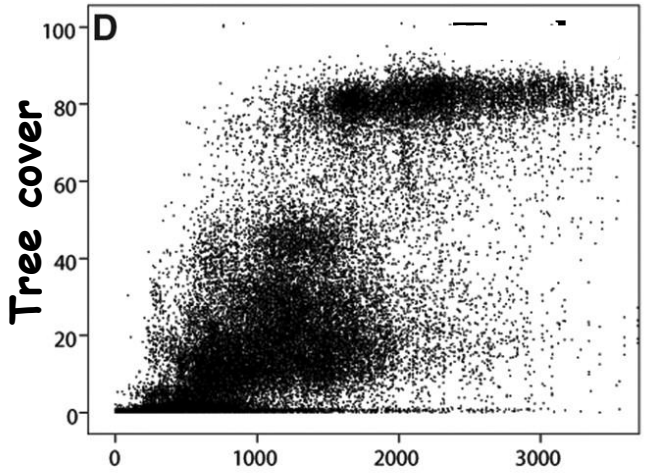
Livina et al Clim. Past. 2010



We can use Spatial Information

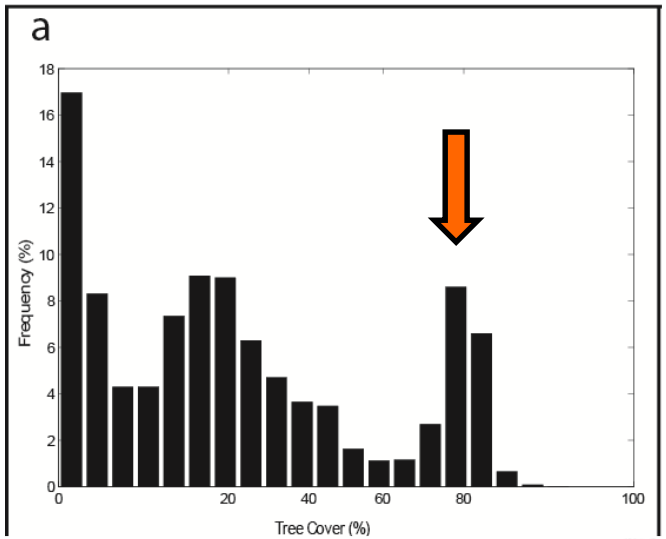
Space ⟺ Time

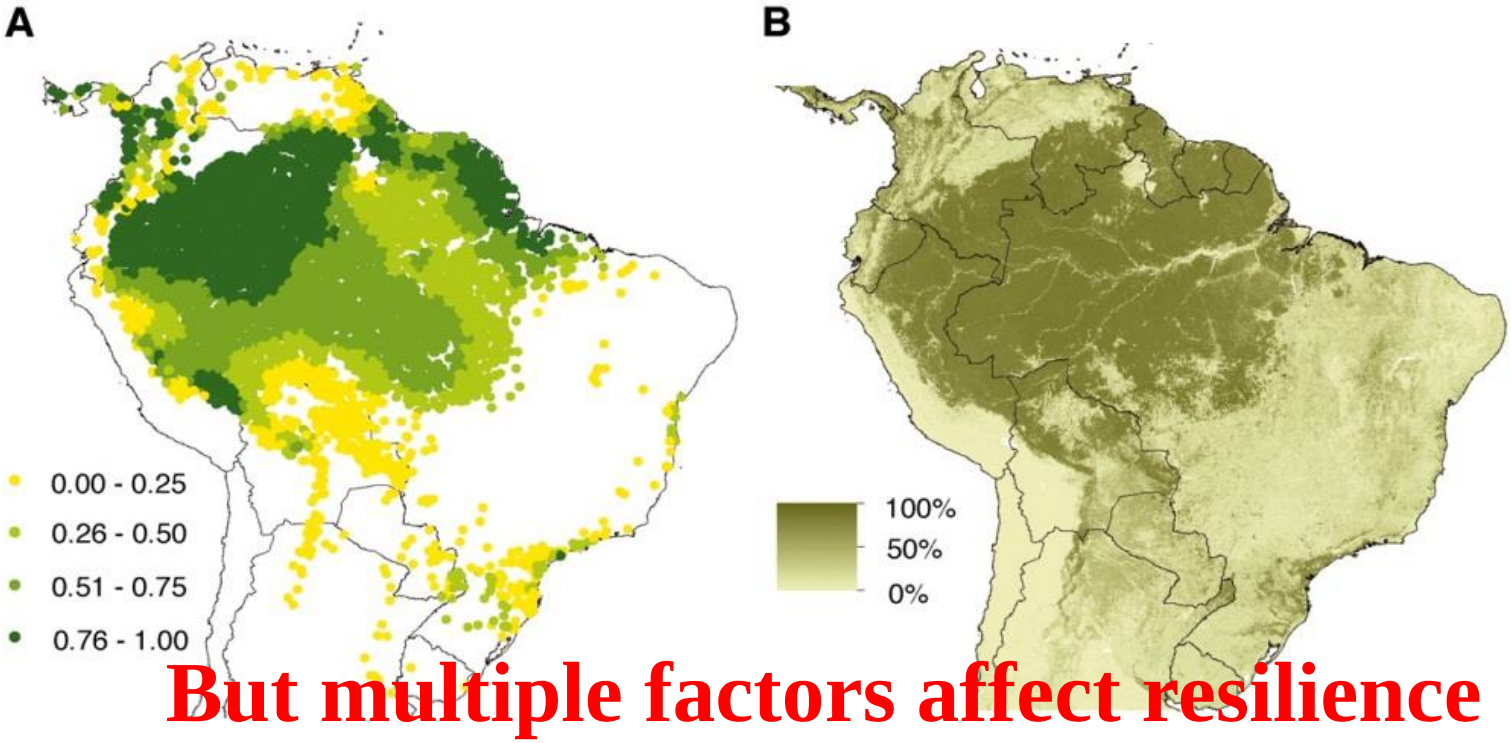




Hirota, Holmgren, VanNes & Scheffer Science 2011

Predict Resilience from Rain ?





But multiple factors affect resilience

So if possible, estimate resilience ‘directly’ on the spot ...

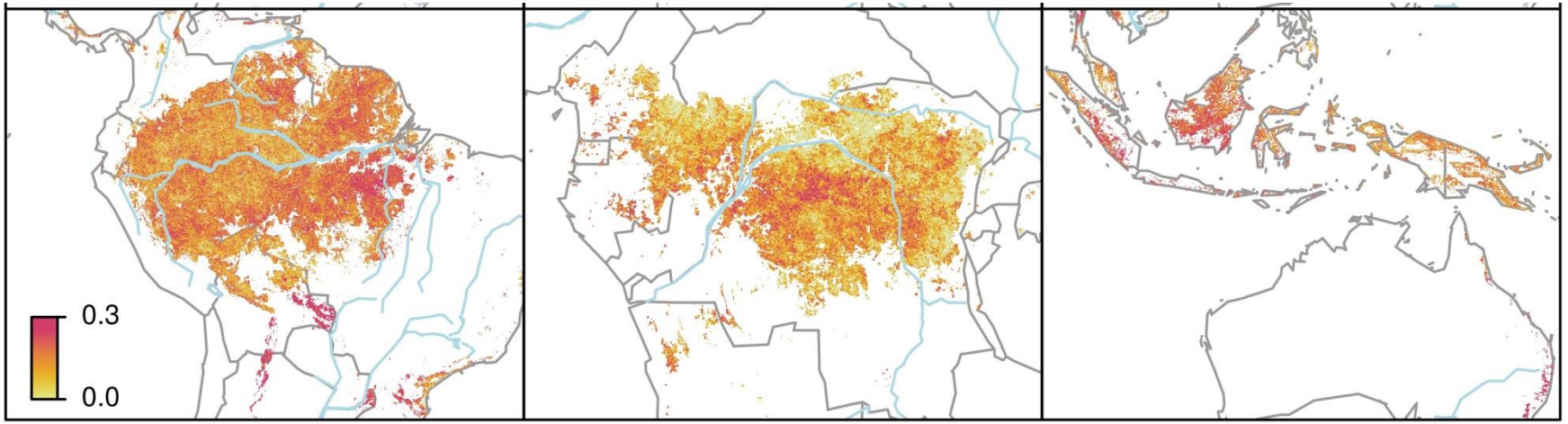
nature climate change

LETTERS

PUBLISHED ONLINE: 5 SEPTEMBER 2016 | DOI: 10.1038/NCLIMATE3108

Remotely sensed resilience of tropical forests

Jan Verbesselt[1]*, Nikolaus Umlauf[2], Marina Hirota[3,4,5], Milena Holmgren[6], Egbert H. Van Nes[3], Martin Herold[1], Achim Zeileis[2] and Marten Scheffer[3]*



But what can you do with that ?