Spatial correlation as leading indicator of catastrophic shifts

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[transitions]

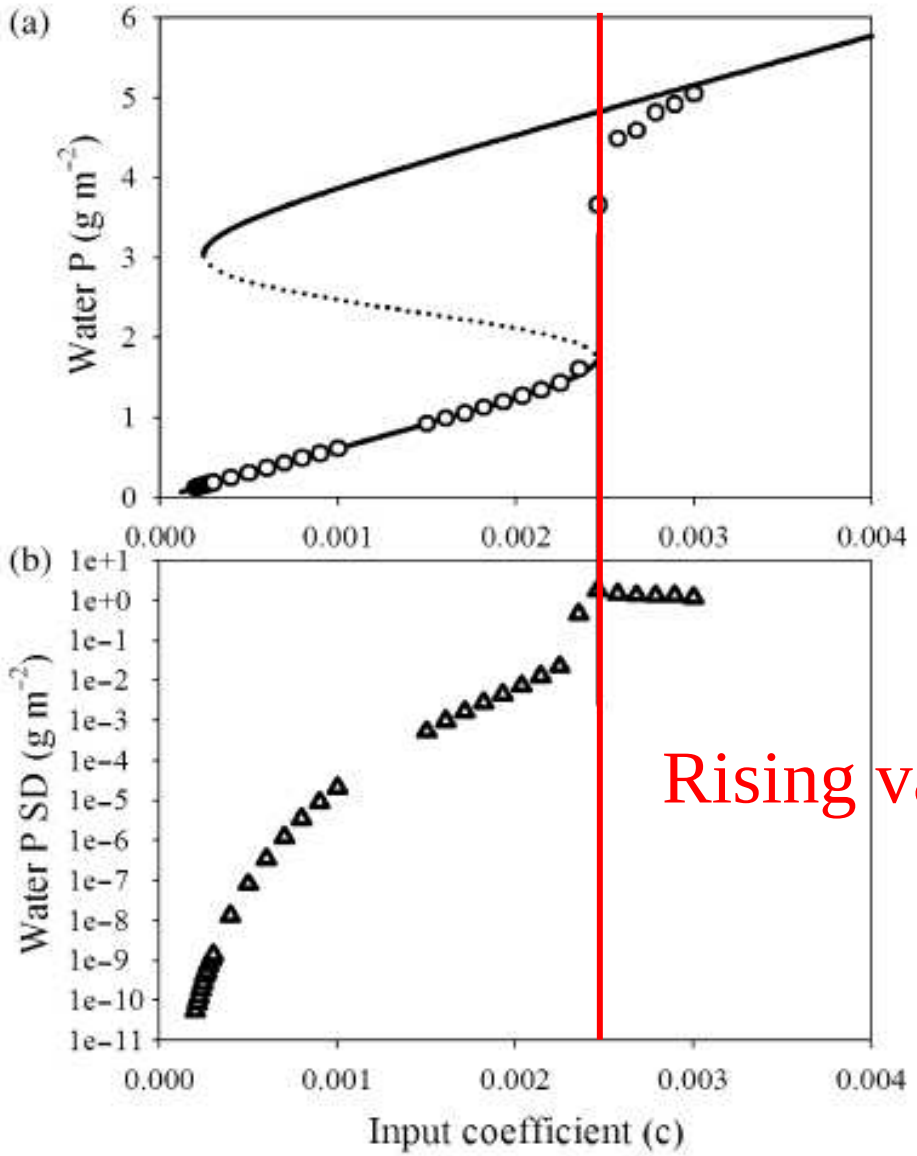
Can we foresee if a system approaches a transition?

Early Warning Signals (EWS)

as Indicators of Resilience

Indicators of transitions in time

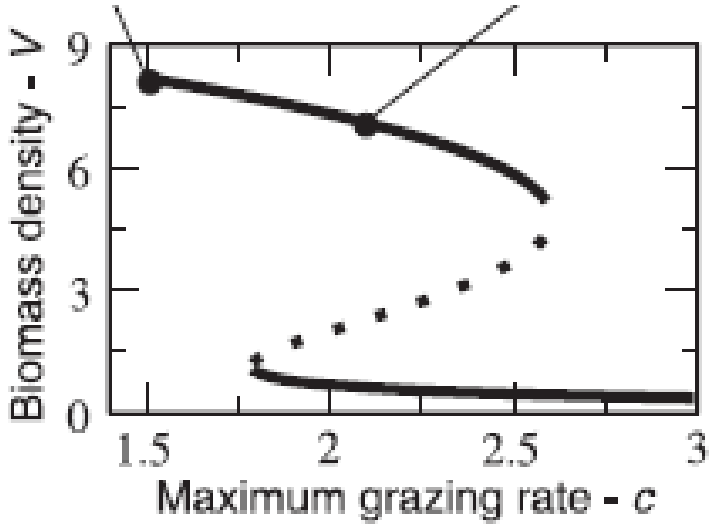
Indicators of transitions in time

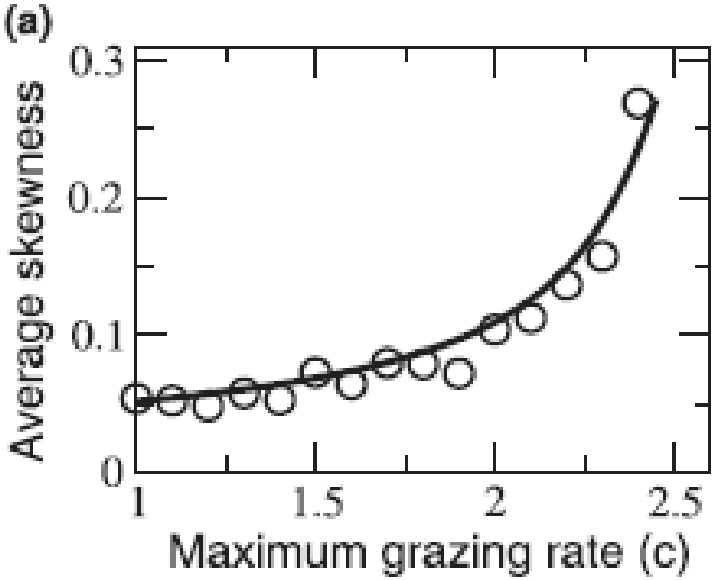


Rising variance

Carpenter & Brock, 2006

Indicators of transitions in time



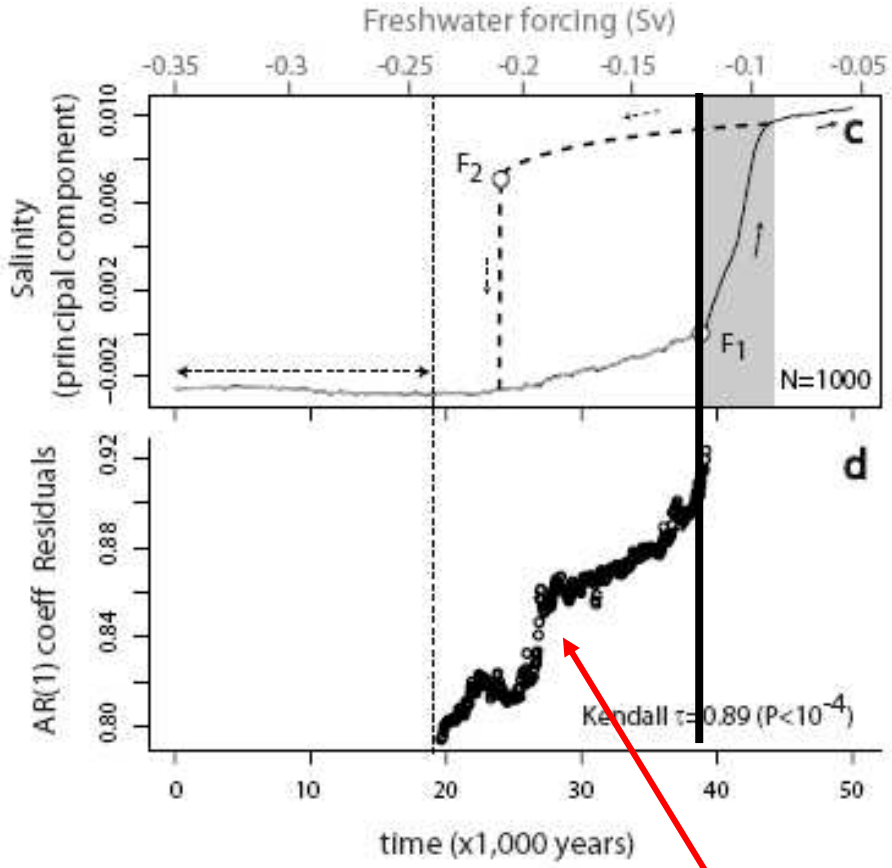


Increasing skewness

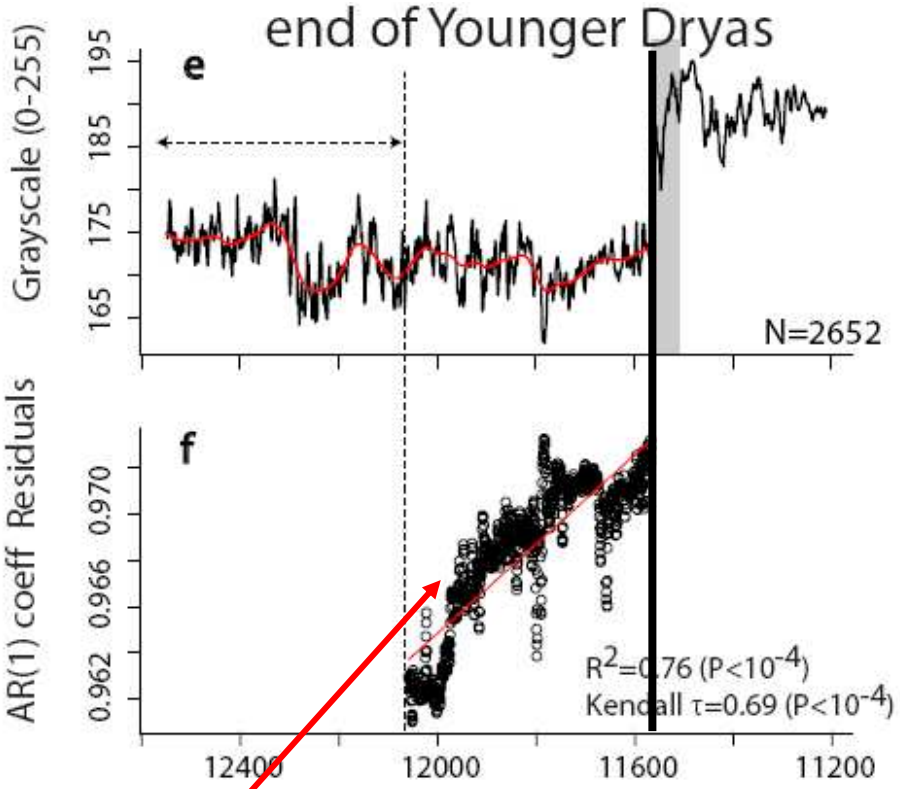
Guttal & Jayaprakash, 2008

Indicators of transitions in time

Model prediction



Data

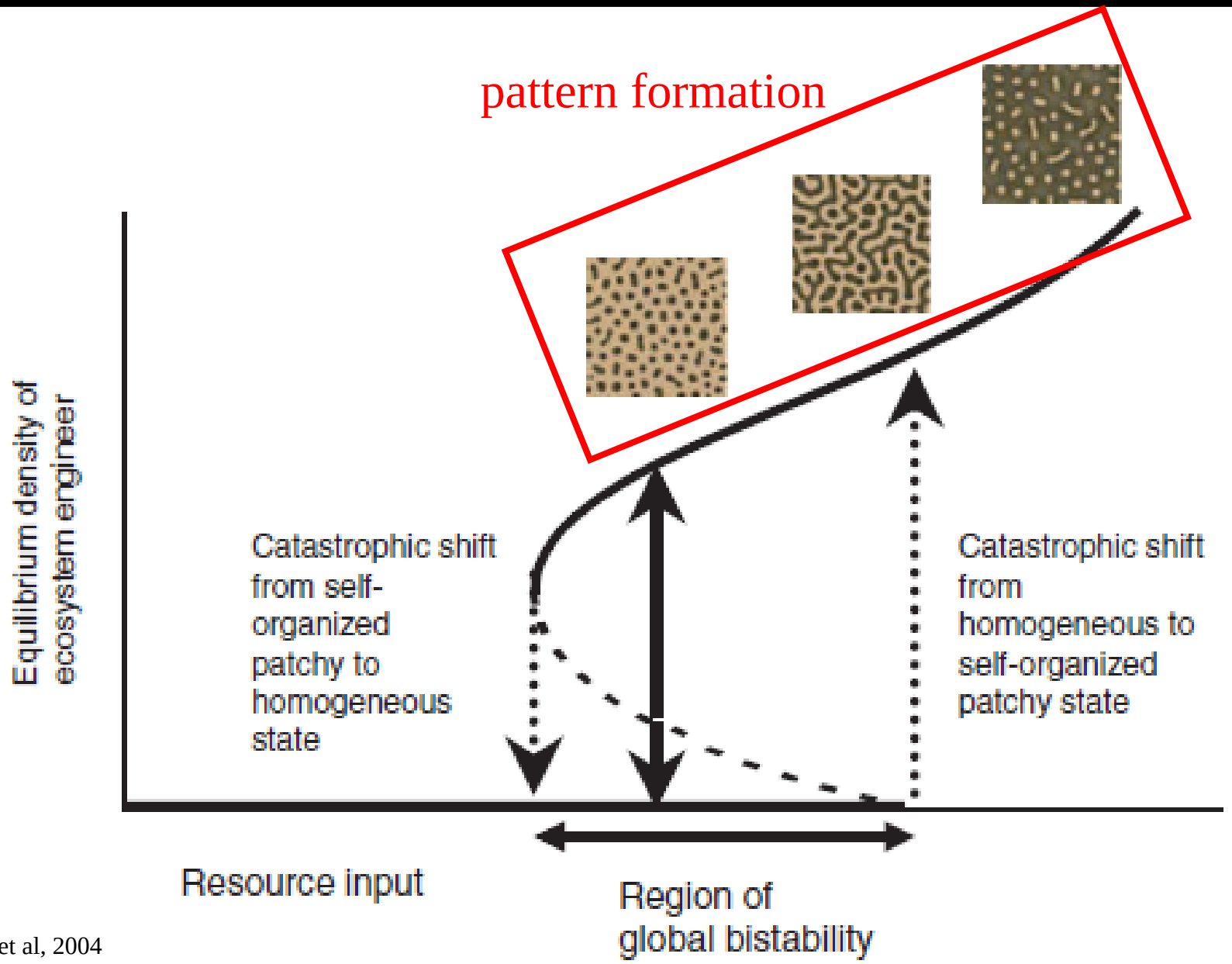


Increasing autocorrelation at-lag-1

Dakos et al., 2008; Held & Kleinen, 2004

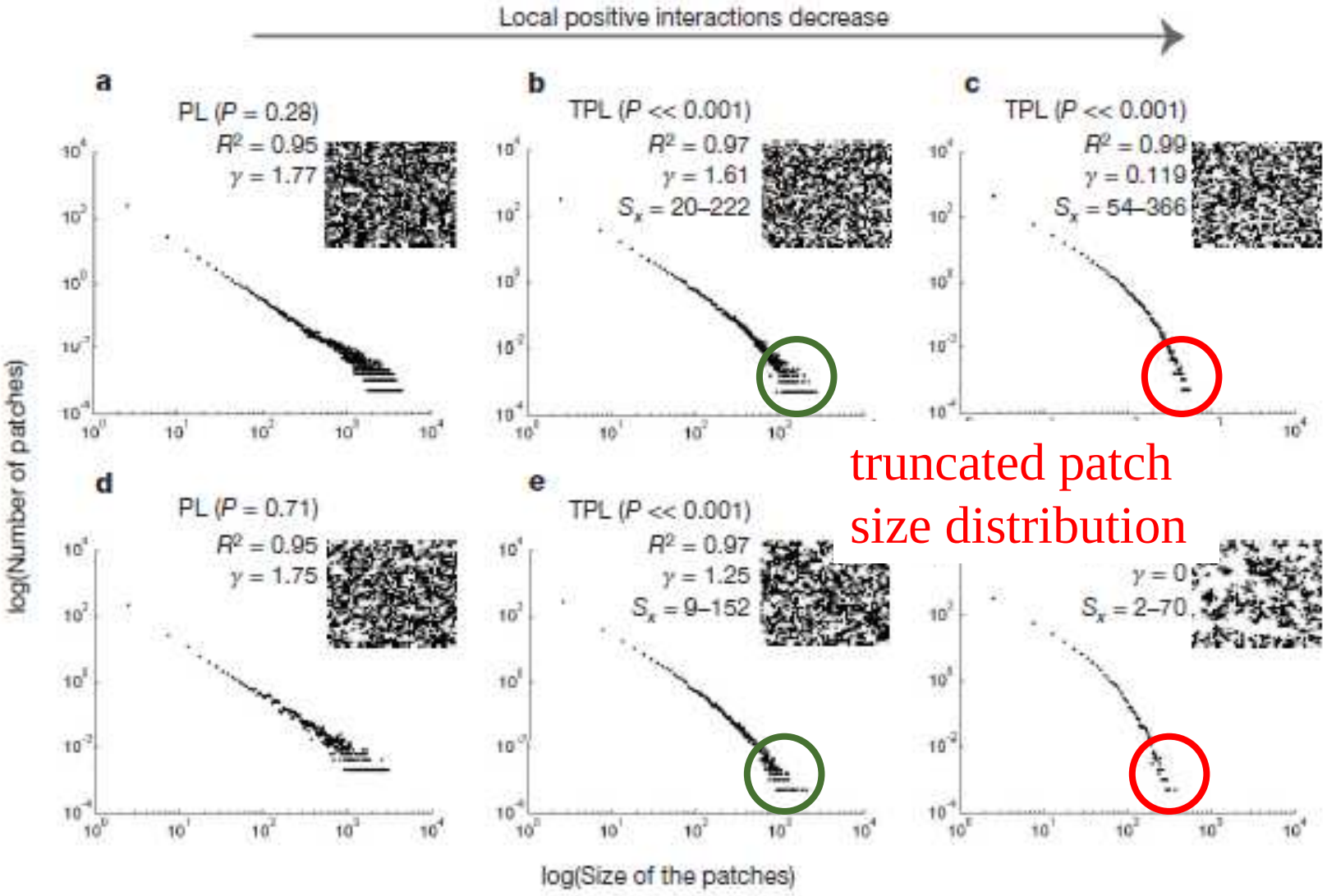
Indicators of transitions in space

Indicators of transitions in space



Rietkerk et al, 2004

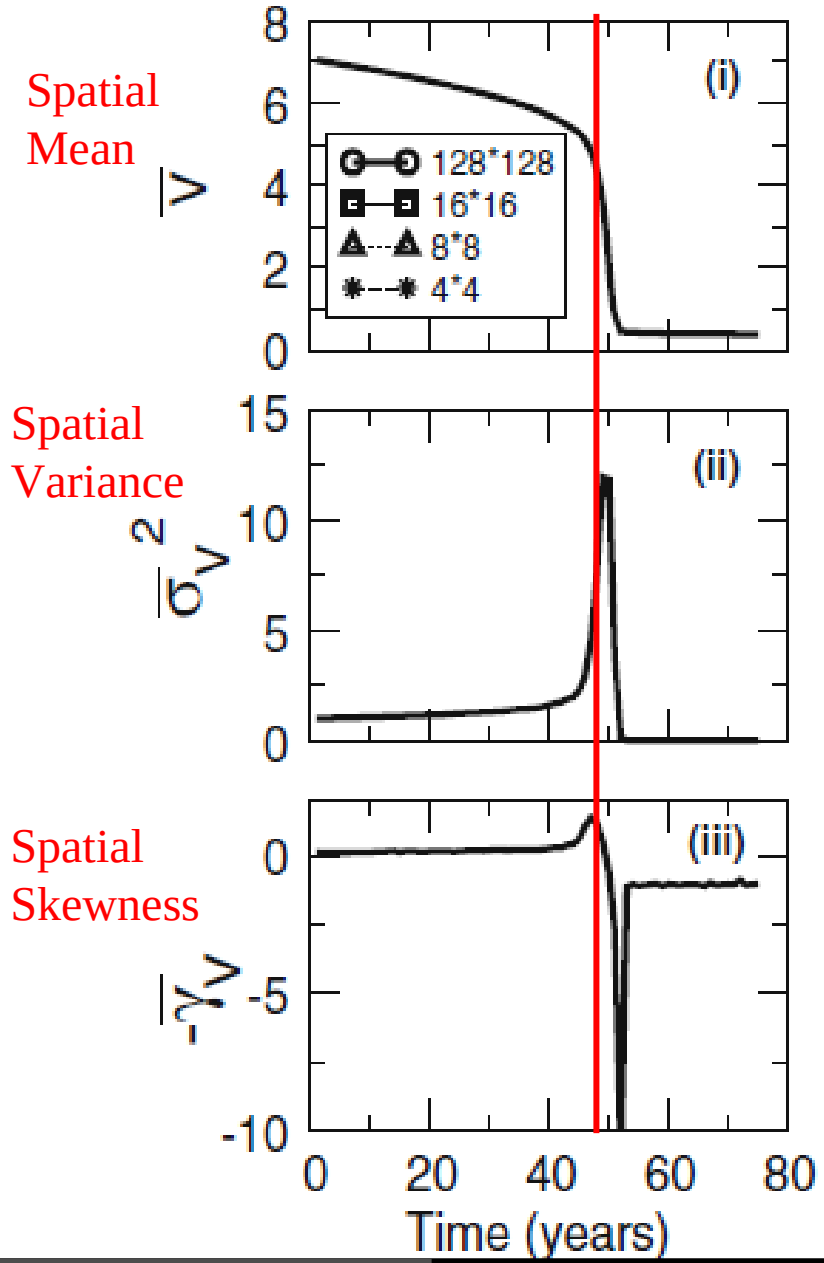
Indicators of transitions in space



truncated patch size distribution

Kéfi et al, 2007

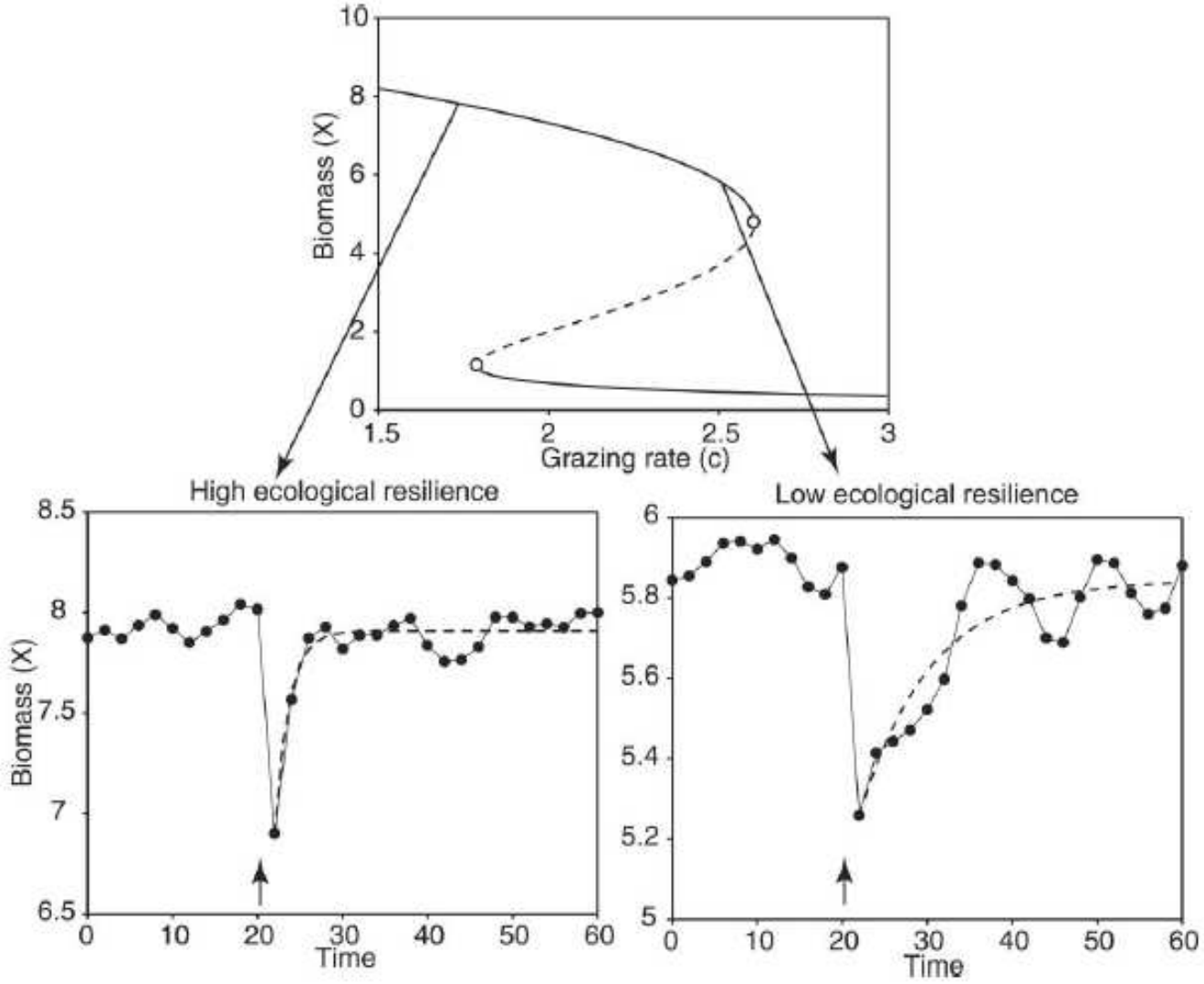
Indicators of transitions in space



Guttal & Jayaprakash, 2008

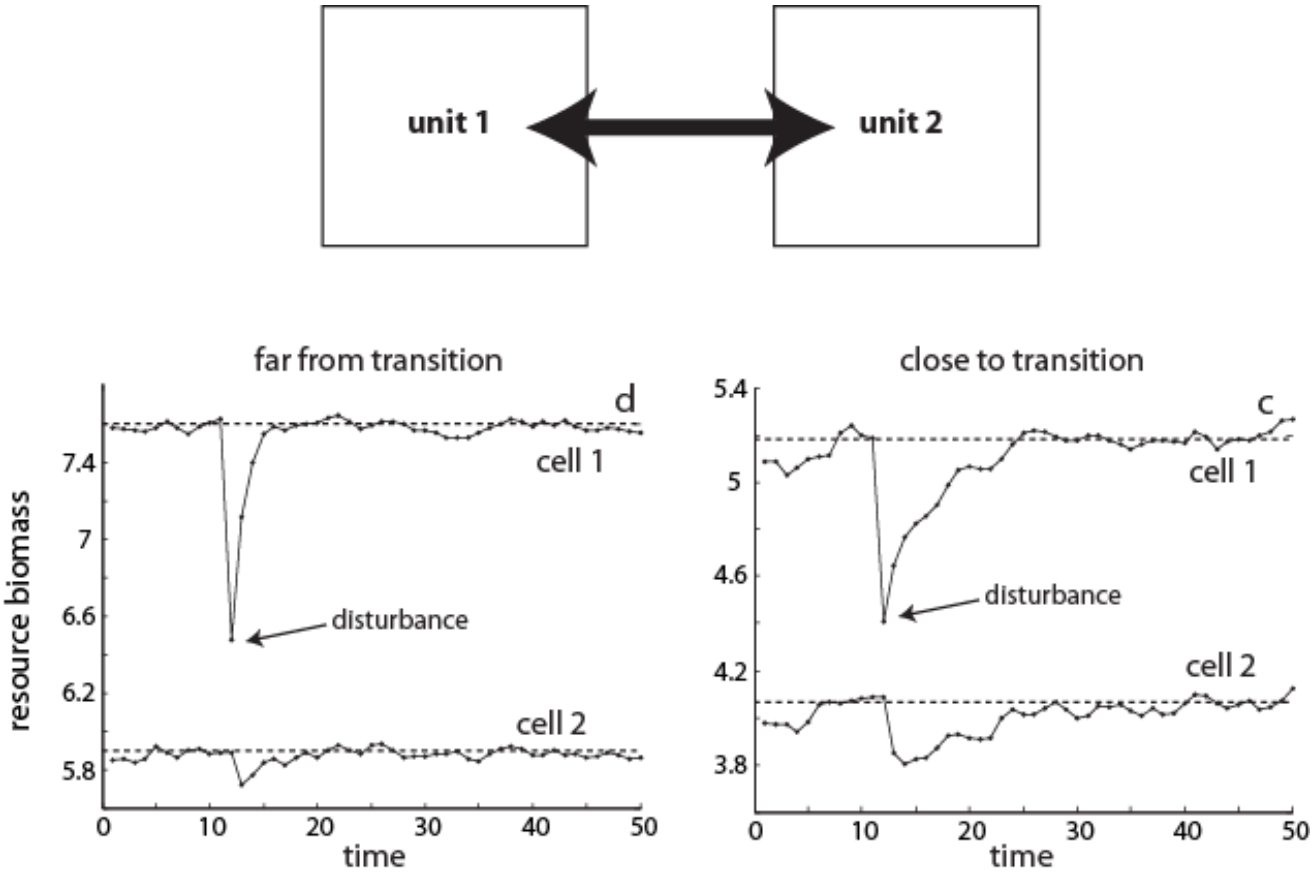
Correlation in Space as an Early Warning Signal?

Critical slowing down prior to a transition



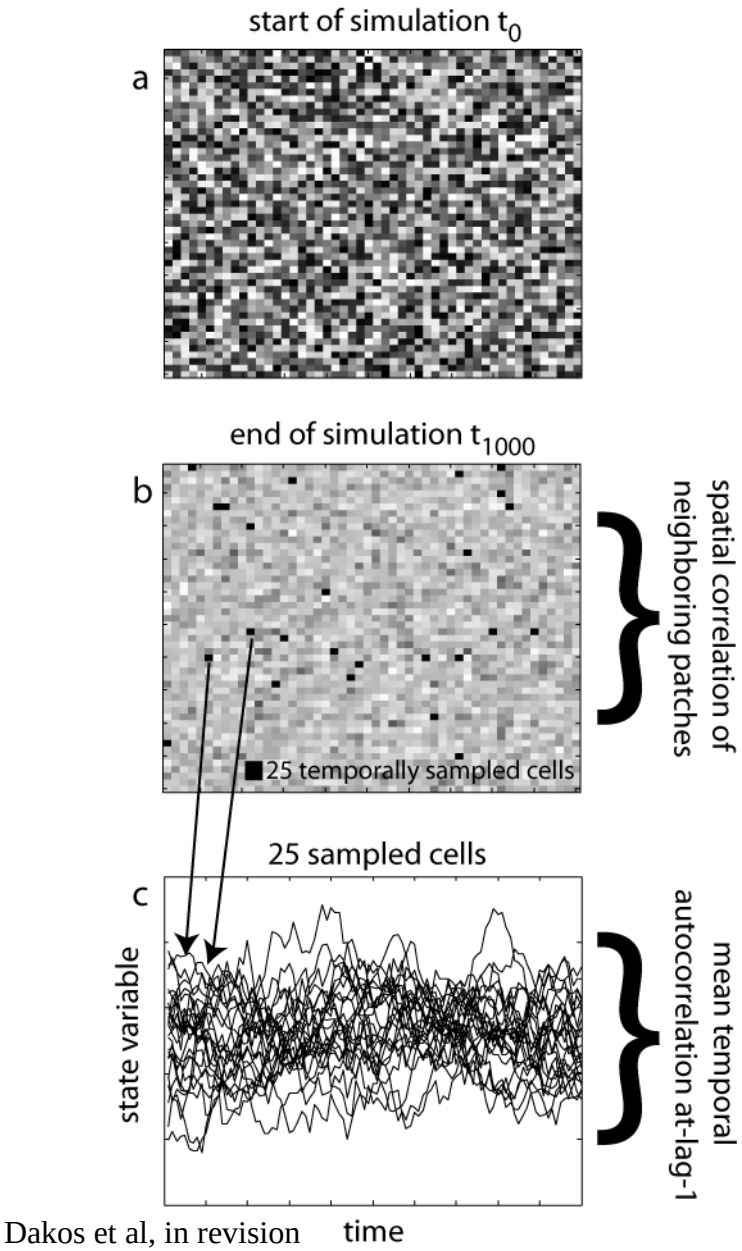
Van Nes & Scheffer, 2007

Slowing down in space?



Patches become more dependent one on another:
Start to appear similar not only to themselves but also to their neighbors

Three simple spatial explicit bistable models



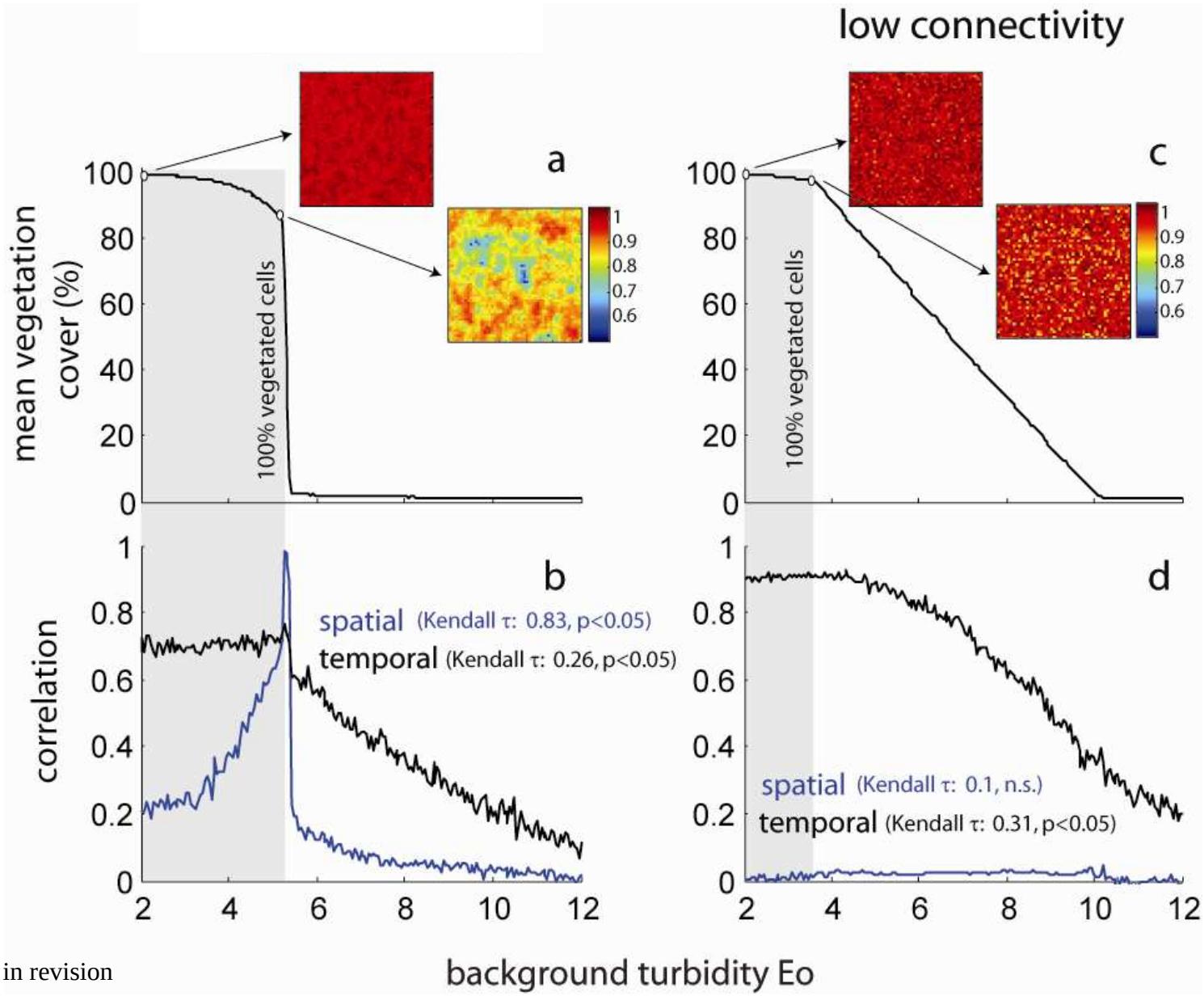
Dakos et al, in revision

- Overharvesting model
(May, 1977)
- Eutrophication model
(Carpenter et al, 1999)
- Vegetation-turbidity model
(Scheffer, 1998)

Estimate and compare spatial and temporal correlation indicators:

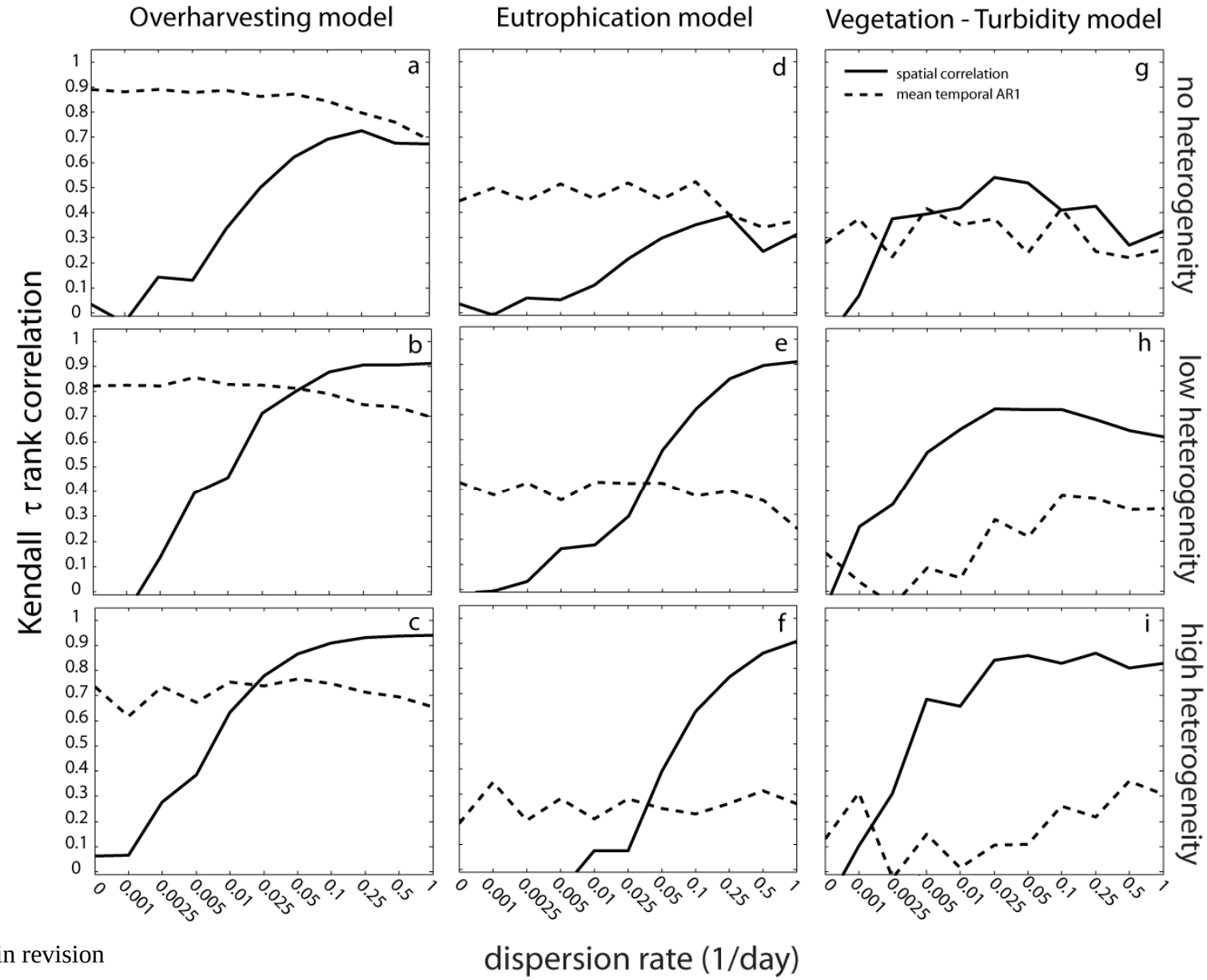
- temporal autocorrelation at-lag-1
- spatial correlation of neighbors

Spatial and Temporal correlations vs. Connectivity



Dakos et al, in revision

Spatial or Temporal correlation as indicator?



Dakos et al, in revision

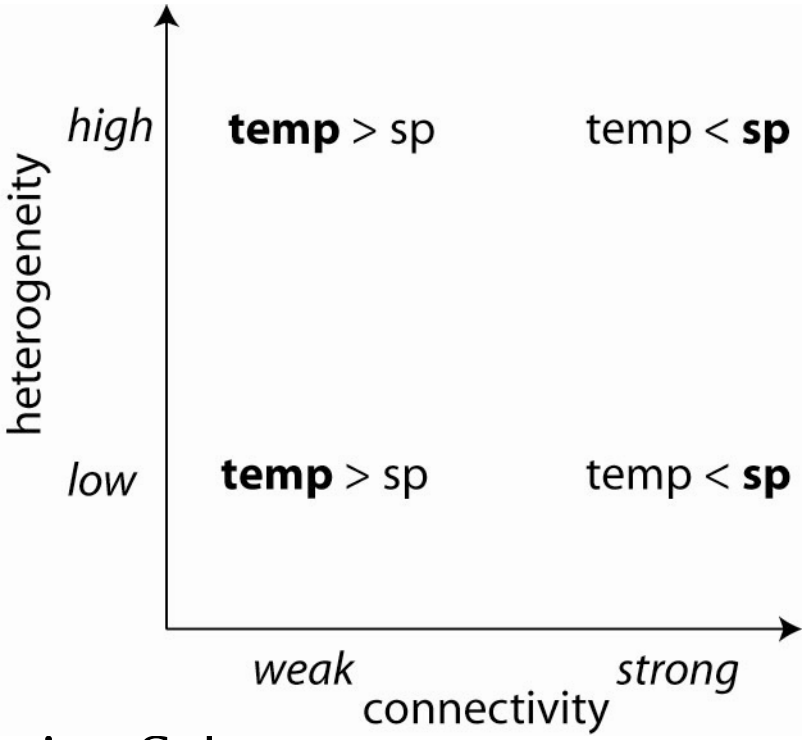
Take home message #1

- Spatial correlation between neighbors increases prior to a transition due to "slowing down" in space.
  Slowing down makes neighboring patches to become more similar to their neighbors through diffusion.
- Spatial correlation can qualify as early warning signal for system transitions and may be used as an indicator of resilience.
- However it is a relative measure and should be treated as system specific.

Take home message #2

- Estimating ecosystem resilience: Spatial or Temporal correlation?

depends on strength of diffusion and heterogeneity among patches



Designing Monitoring Schemes:

- Spatial correlation uses snapshots (aerial photos)
- Temporal correlation requires continuous monitoring (costly and difficult)