A RESILIENCE APPROACH TO RESOURCE MANAGEMENT AND GOVERNANCE

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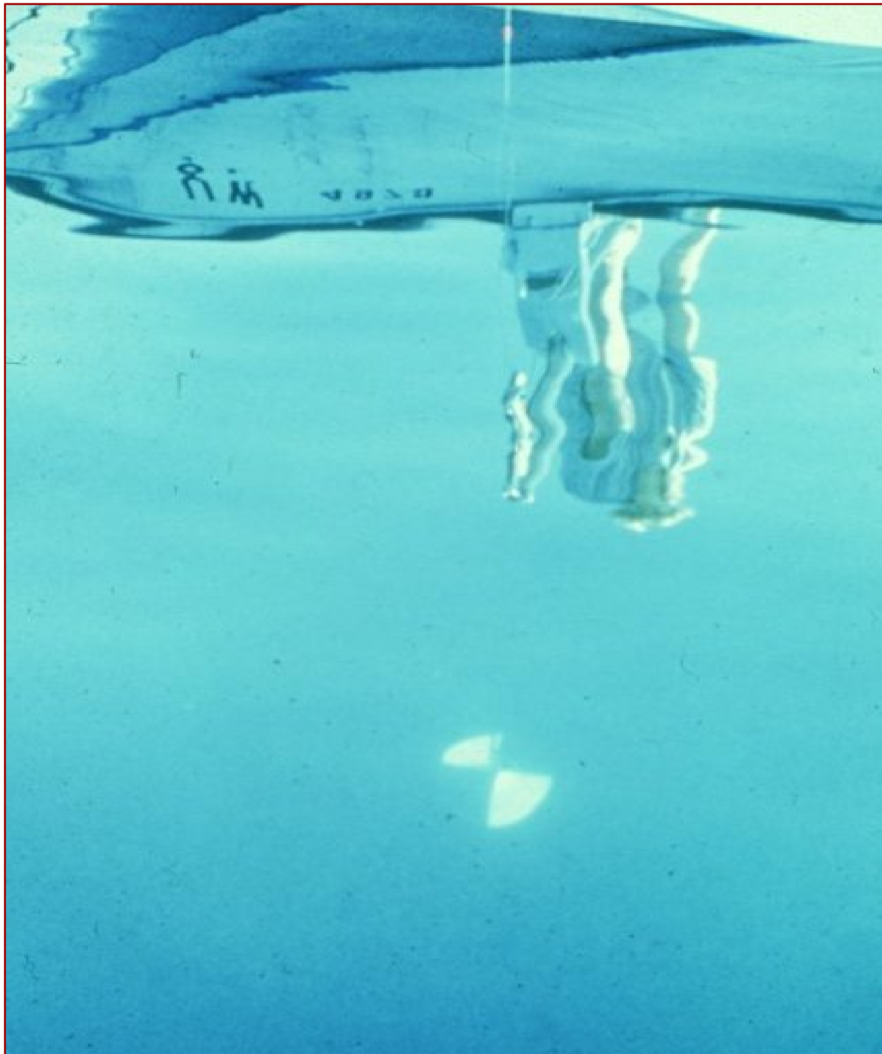
Tshwane/Pretoria April 06

Why is it, that despite the best of intentions….

Western Australian wheatbelt

rangelands in Australia

alternate states in N. Hemisphere lakes



How does this happen?

Proposition: **There are two paradigms for managing natural resource systems:**

- MSY (maximum sustainable yield, in one form or another)

- Resilience management and governance

Problem assumptions with MSY

- **mostly ignore extreme events**

- **problems from different sectors don't interact** (but partial solutions don't work)

- **change will be incremental and linear** (in fact, it's mostly lurching and non-linear)

- **keeping the system in some optimal state will deliver maximum benefits**. (There is no sustainable "optimal" state of an ecosystem, a social system, or the world. It is an unattainable goal.)

Key assumption underlying Resilience Management and Governance:

social-ecological systems have non-linear dynamics and can exist in alternate stability domains (regimes)

Sustainable use and development rests on three capacities of social-ecological systems :

- **resilience**
- **adaptability**
- **transformability**

Resilience

"The capacity of a system to absorb disturbance and re-organise so as to retain essentially the same function, structure and feedbacks – to have the same identity"

(remain in the same system regime)

Adaptability

The capacity of actors in the system (people, in SESs) to manage resilience :

(i) change the positions of thresholds between alternate regimes

(ii) control the trajectory of the system – avoid crossing a threshold (or engineer such a crossing)

Transformability

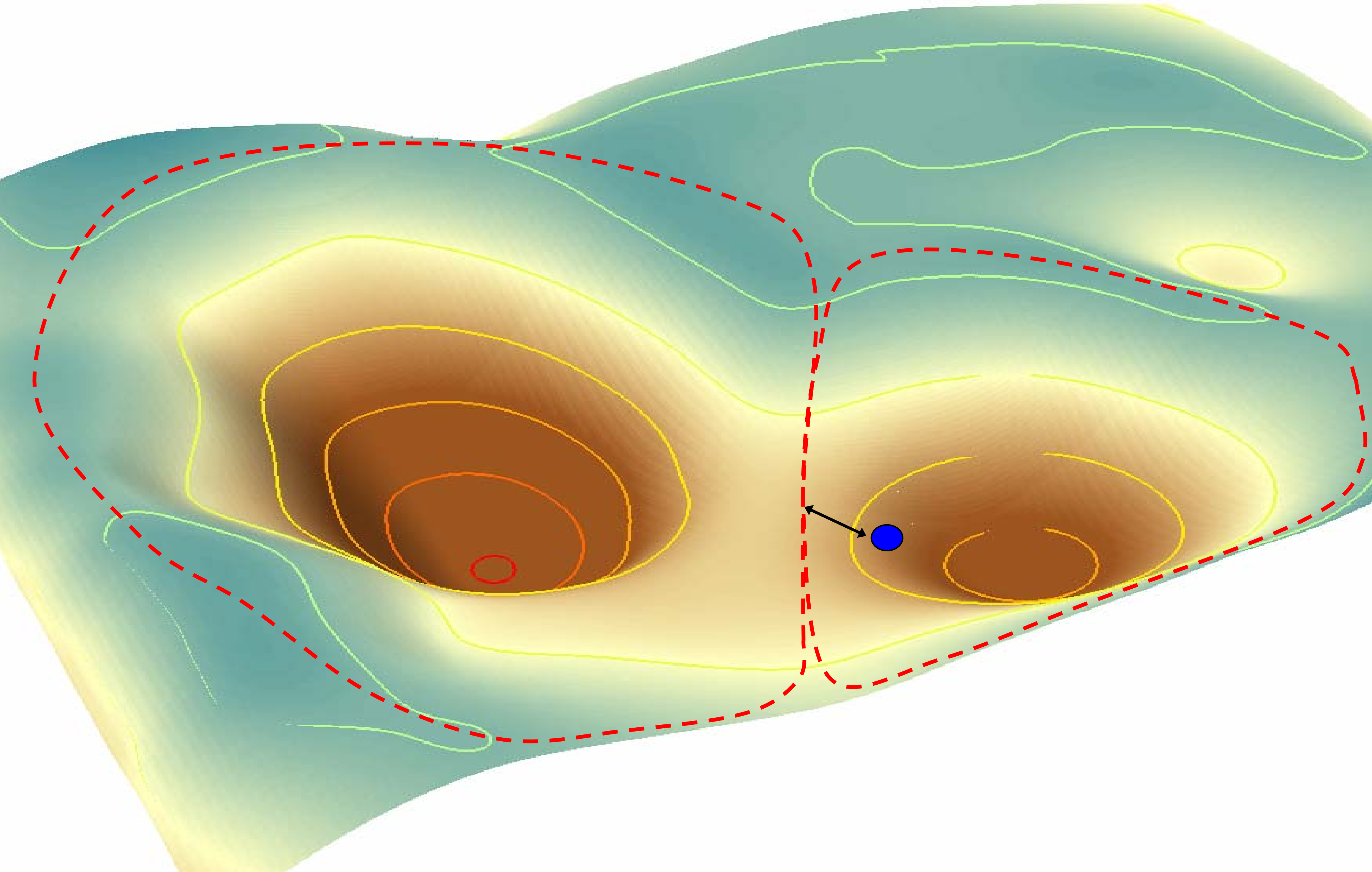
The capacity to become a fundamentally different system when ecological, social and/or economic conditions make the existing system untenable.

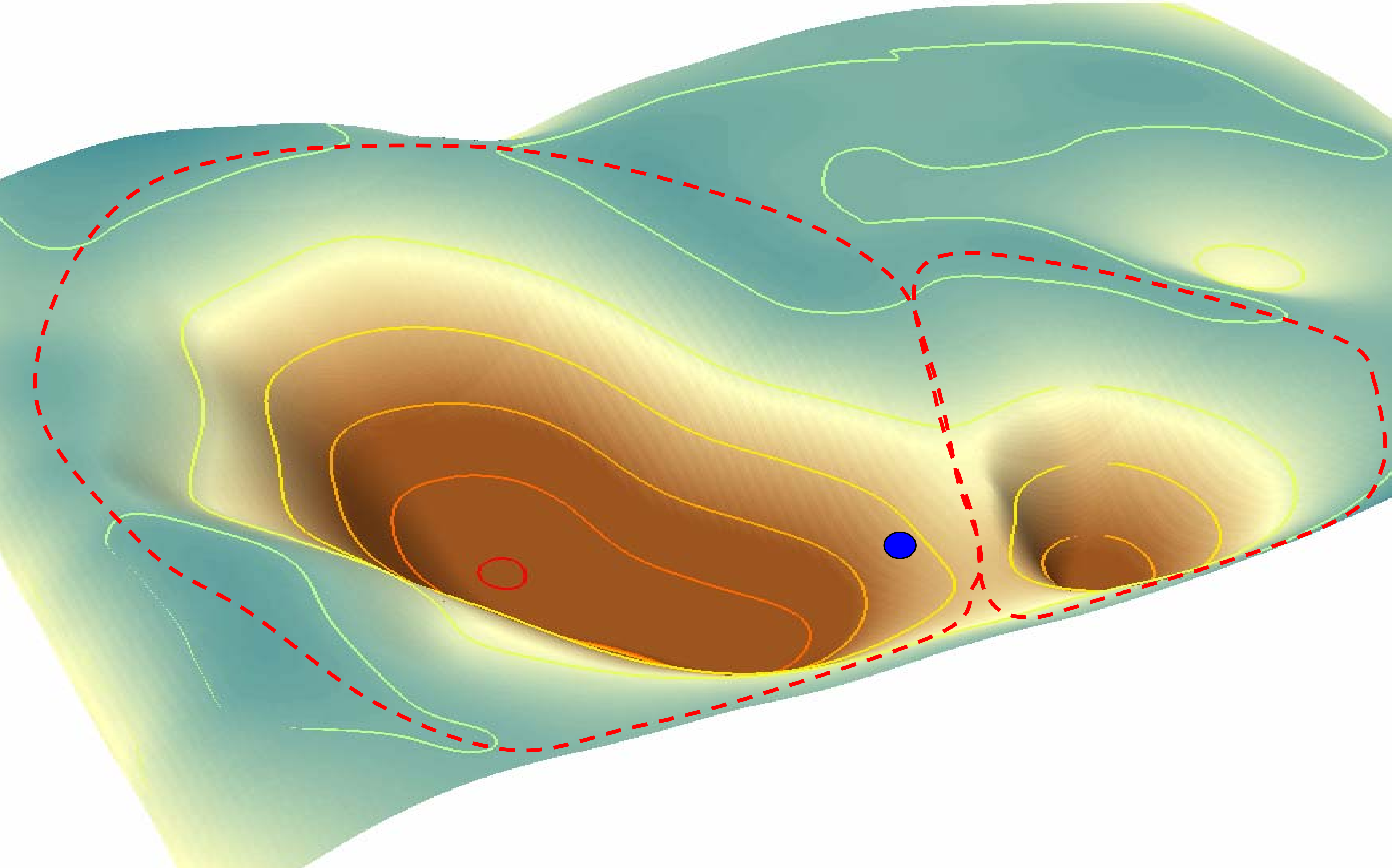
RESILIENCE

What determines resilience?

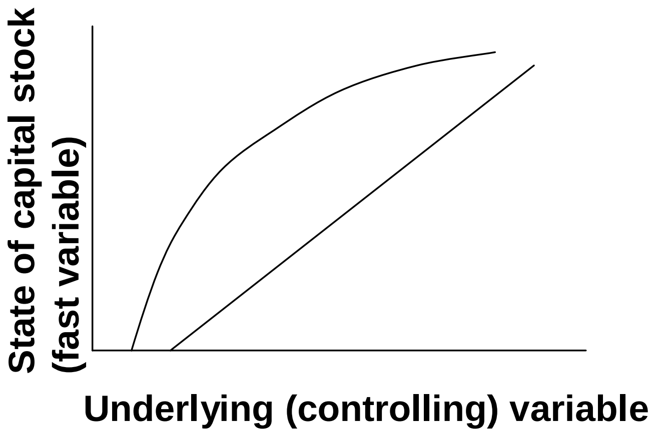
- Diversity
- Modularity (connectedness)
- Tightness of feedbacks
- Openness – immigration, inflows, outflows
- Reserves and other reservoirs (seedbanks,
  nutrient pools, memory)
- Overlapping institutions
- Polycentric governance

resilience places an emphasis on thresholds between alternate regimes of a system

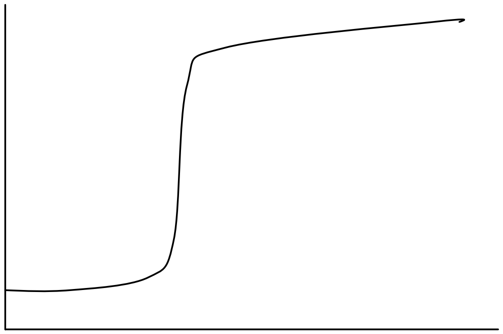




(a) **No threshold effect**

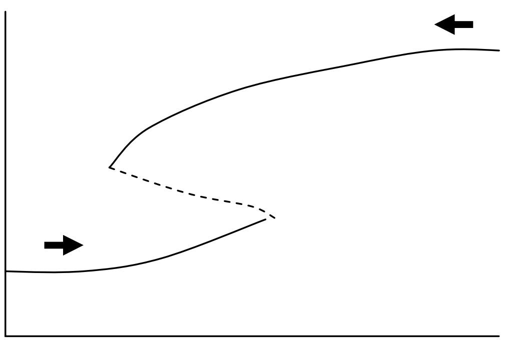


(b) **threshold, no alternate attractors (no feedback changes)**

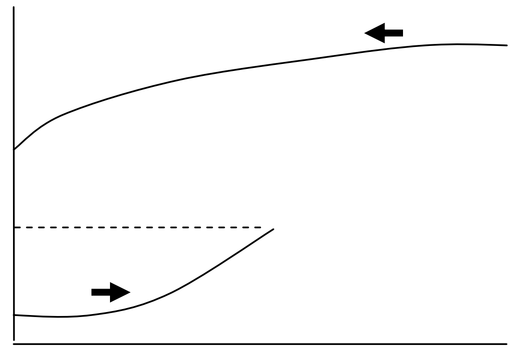


(c) **threshold, alternate stable states**

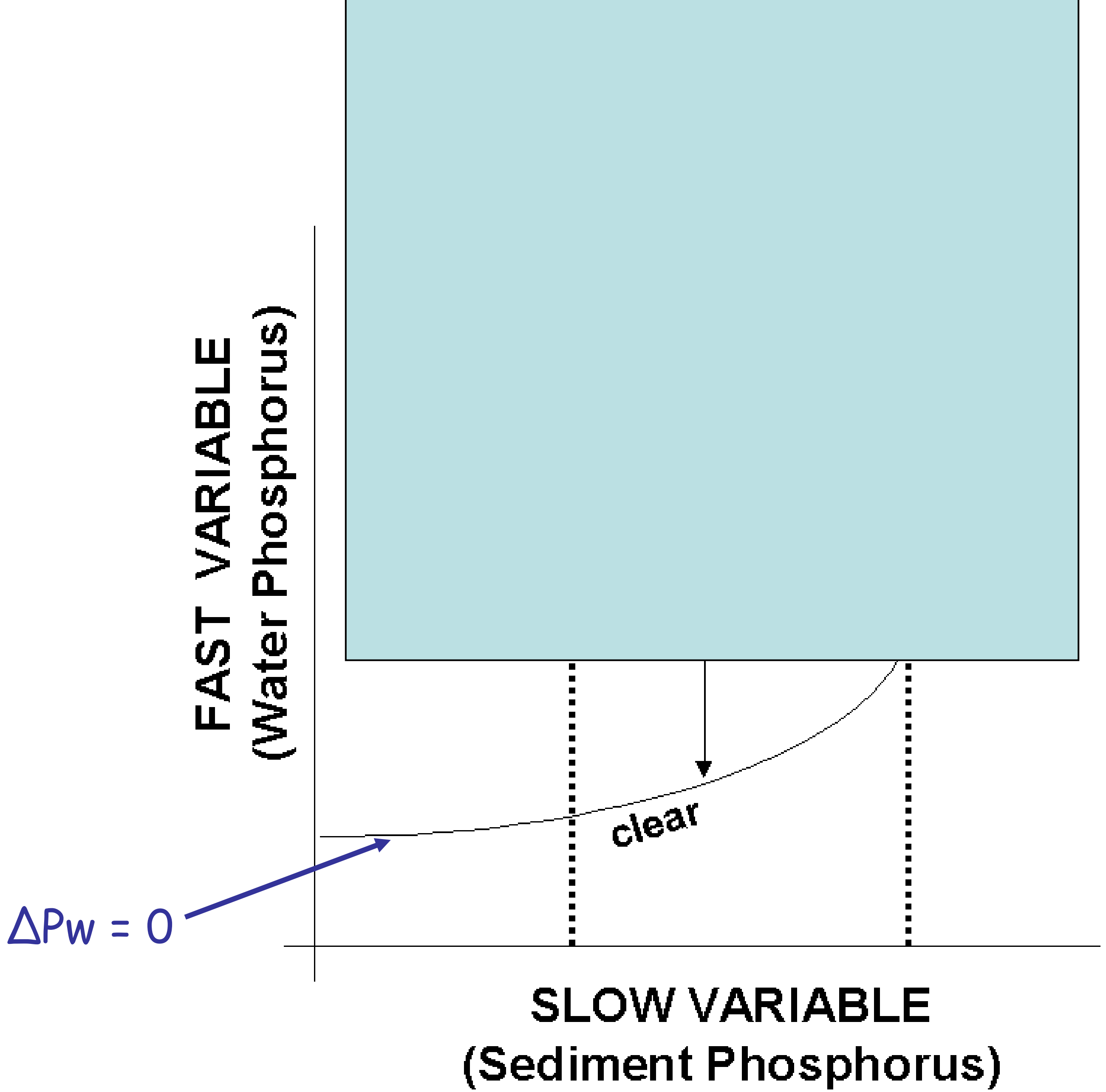
Reversible, with hysteresis



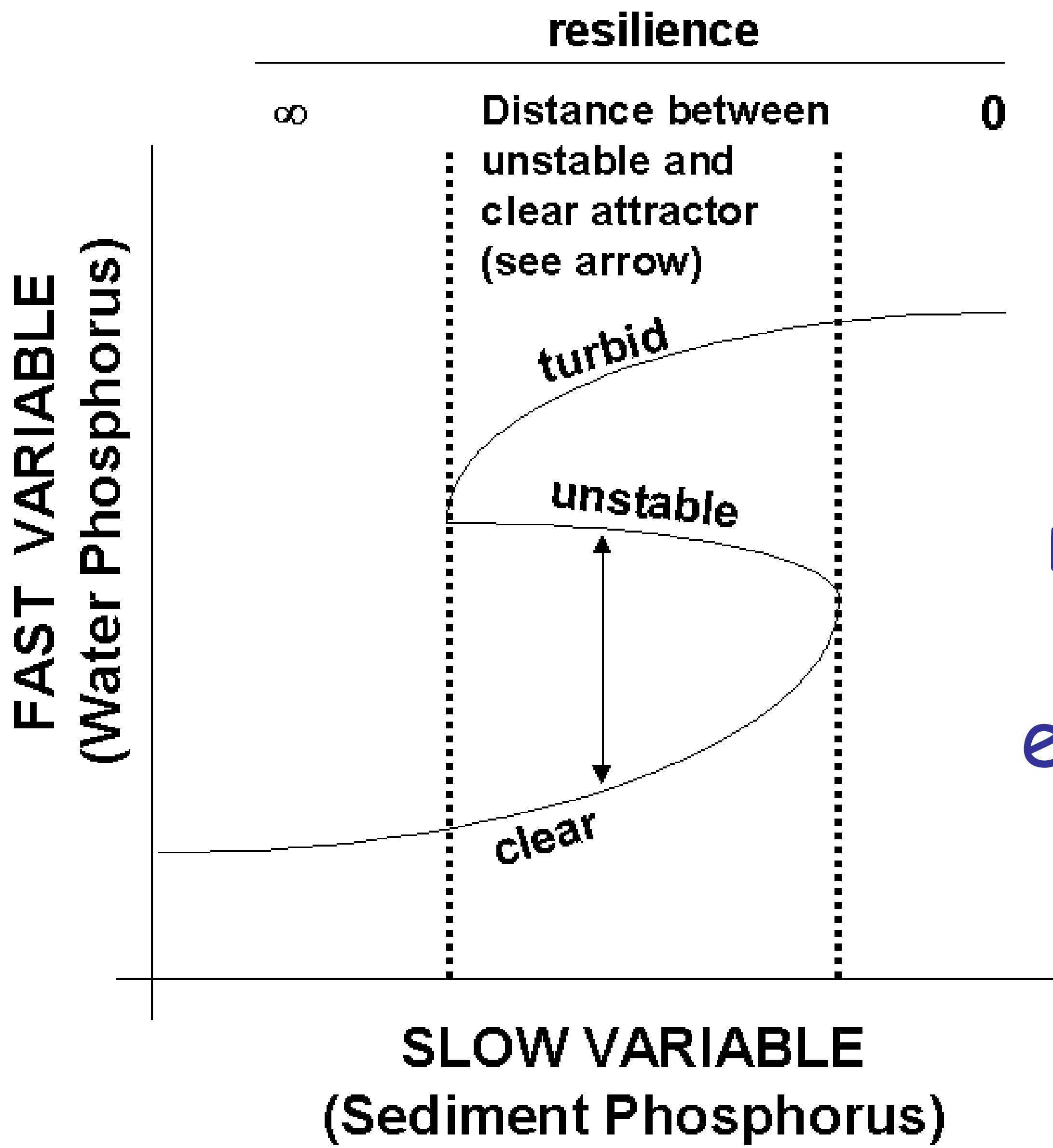
(d) **irreversible threshold change**



A THRESHOLD OCCURS WHERE THERE IS A CHANGE IN FEEDBACKS



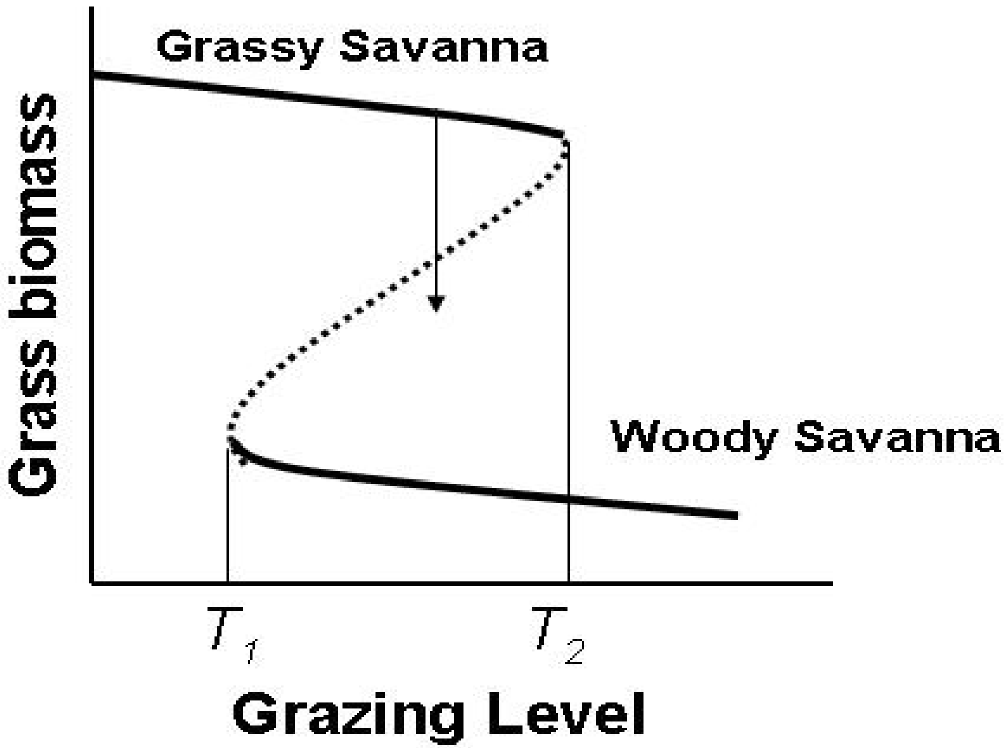
(courtesy Steve Carpenter)



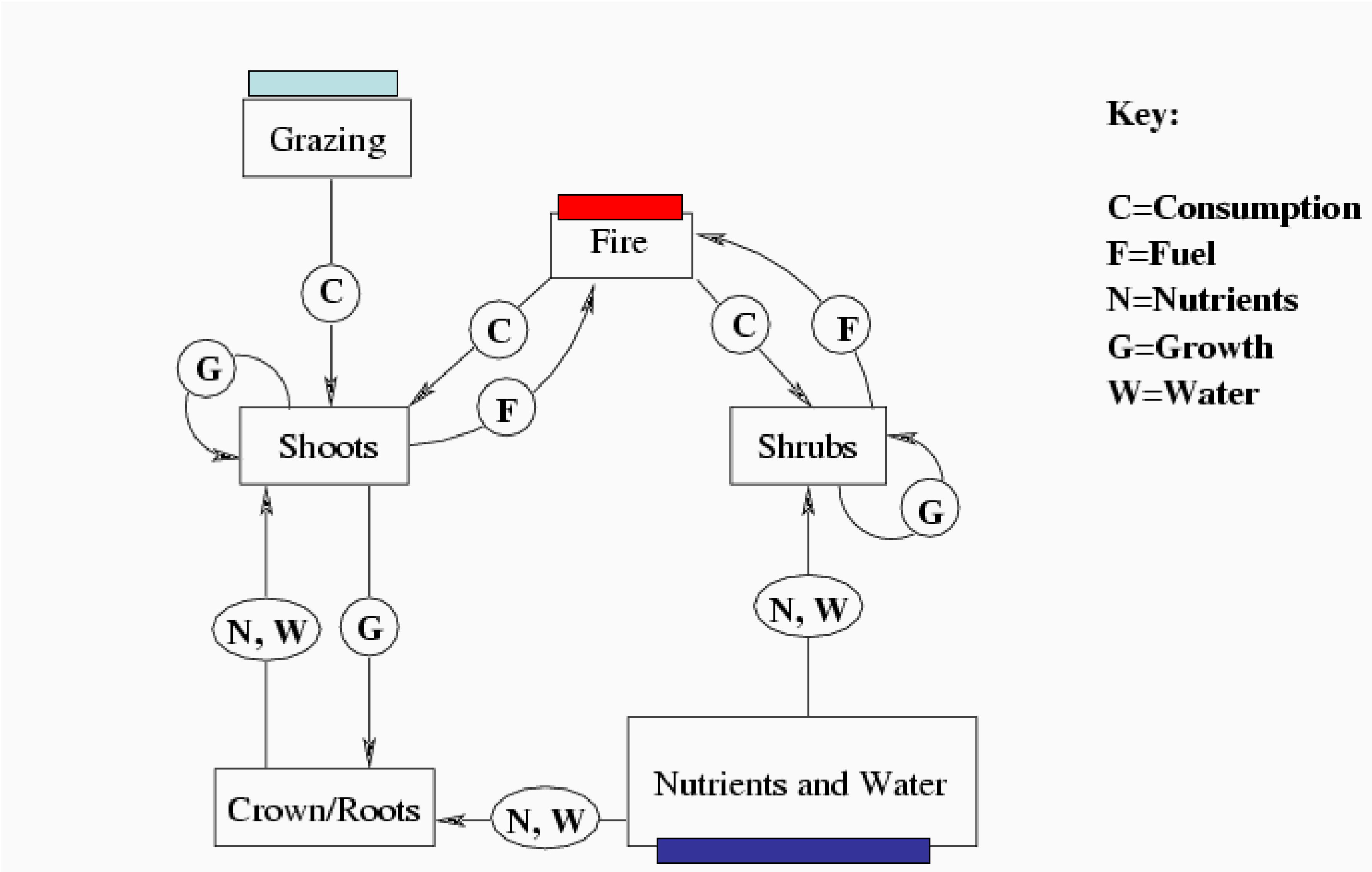
Alternate regimes in lake ecosystems

rangelands in Australia

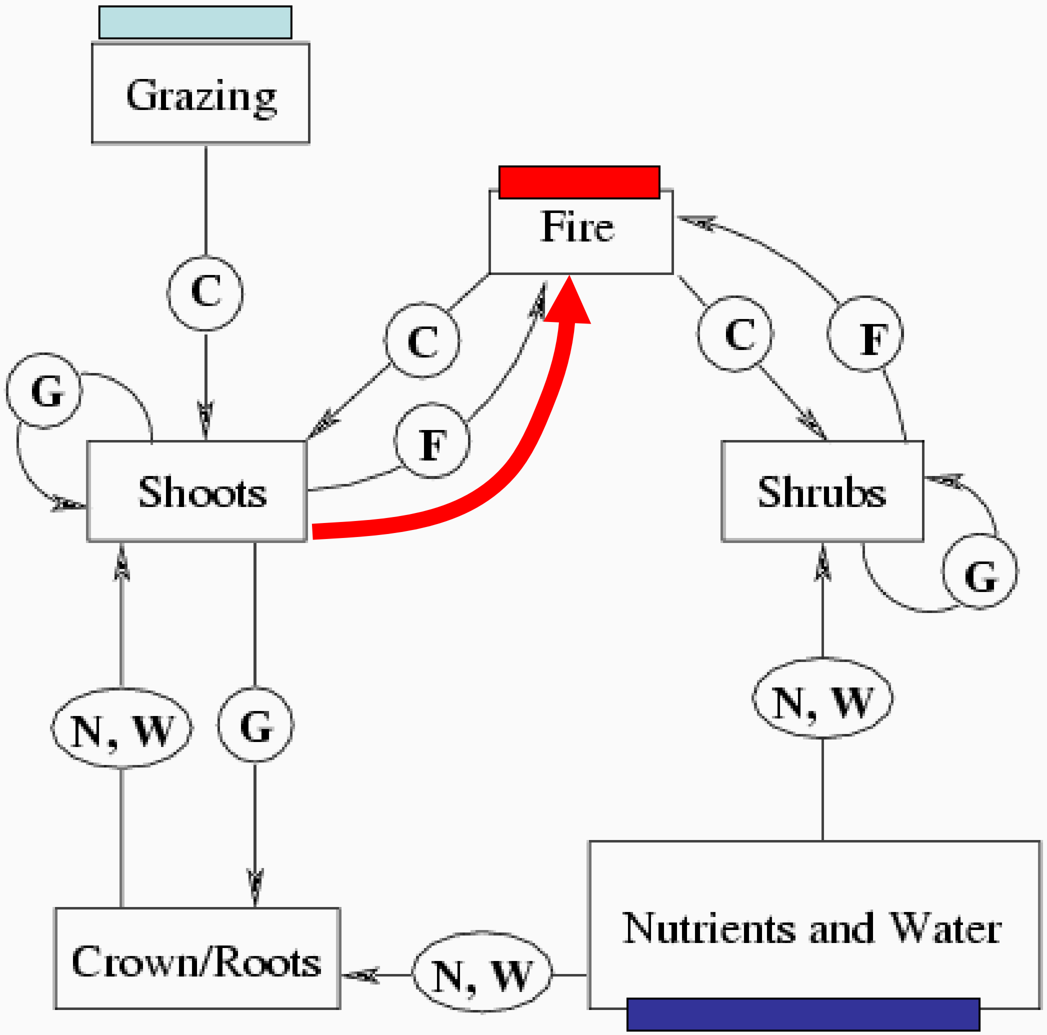
The net effect of increasing level of grazing on rangeland composition



Feedback changes?



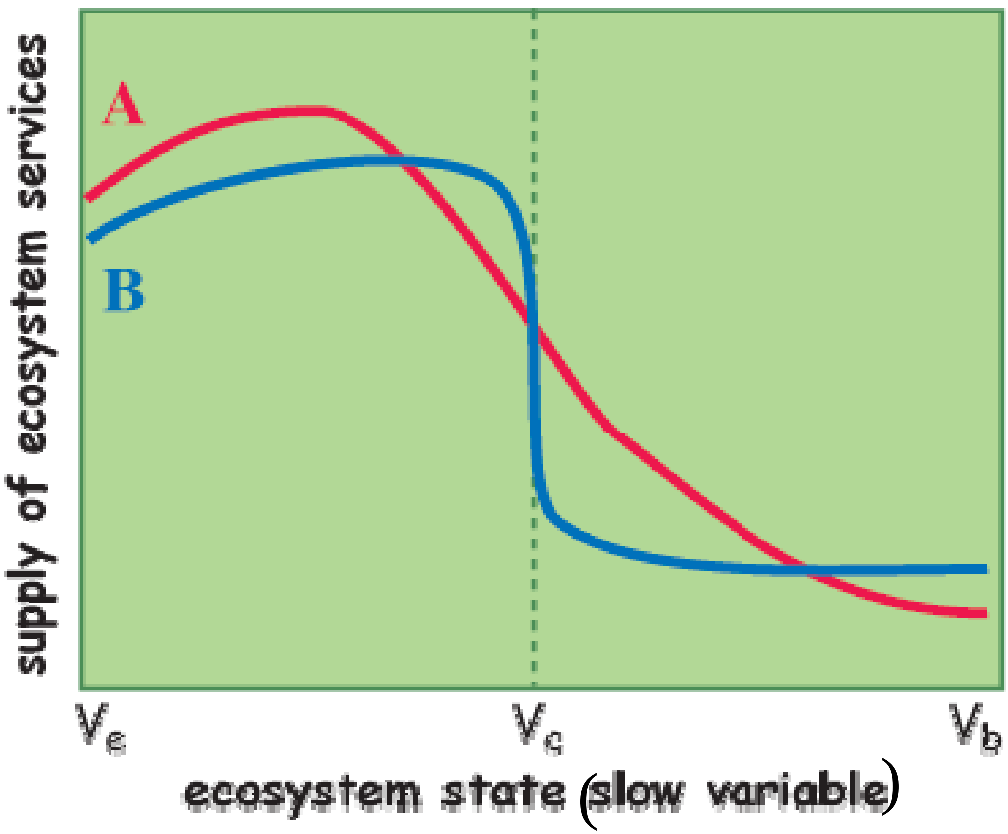
(Anderies et al. 2002. Grazing management, resilience and the dynamics of a fire driven rangeland. Ecosystems 5:23-44.)



Key:

C=Consumption
F=Fuel
N=Nutrients
G=Growth
W=Water

SYSTEM "REGIMES" VS OPTIMAL STATES



Supply of ecosystem services as a function of ecosystem state

B - lake services (fish, recreation) as a function of phosphate in mud
A - rangeland services (wool production from grazing) as a function of shrubs
Vc - critical threshold demarcating a shift from one attractor to another.

www.resalliance.org - thresholds database

Regime shifts have been recorded in:

- environmental condition – soils, lakes, rivers, marine
- population size /viability in:
  - plant populations
  - animal populations
  - human societies
- species composition (plants and animals)
- economic status /viability
- societal behaviour / social preferences

Controlling variables with threshold effects

Physical/chemical
- temperature (air, water, soil)
- water (rainfall, soil moisture, water table)
- nutrients, acidity, toxicity (in soil and water)

Biological

qualitative presence/absence
- top predators
- introduced species

quantitative continuous (slow changing) variable
- biomass (vegetation)
- species population size (plants, animals)
- biological process (predation, herbivory)

Feedback changes involved in regime shifts

controlling variable	associated feedback changes
Rainfall	– evapotranspiration; leaching; water table level
Temperature	– soil moisture (E/T); germination (microclimate); symbiosis (coral bleaching)
Nutrients	– O_2 in water (decomposition); competition (plant species)
Acidification	- calcification (diatoms)
Vegetation	- water interception (cloud forests); infiltration rates; water tables; nutrients (legumes); soil temp (insulation)
Landscape cover	- immigration/emigration rates; reproduction; survival
Herbivory	- regeneration; competition; fire (fuel)
Harvesting	- recruitment (depensation); E/T (forests)
Frequency (fires, fallows)	- seed bank viability; regeneration time
Predation	- recovery (depensation); herbivore behaviour (spiders, wolves)
The economy (markets)	- income:cost ratios; debt:income ratios
Social preference	- subsidies / taxes (through change in government)

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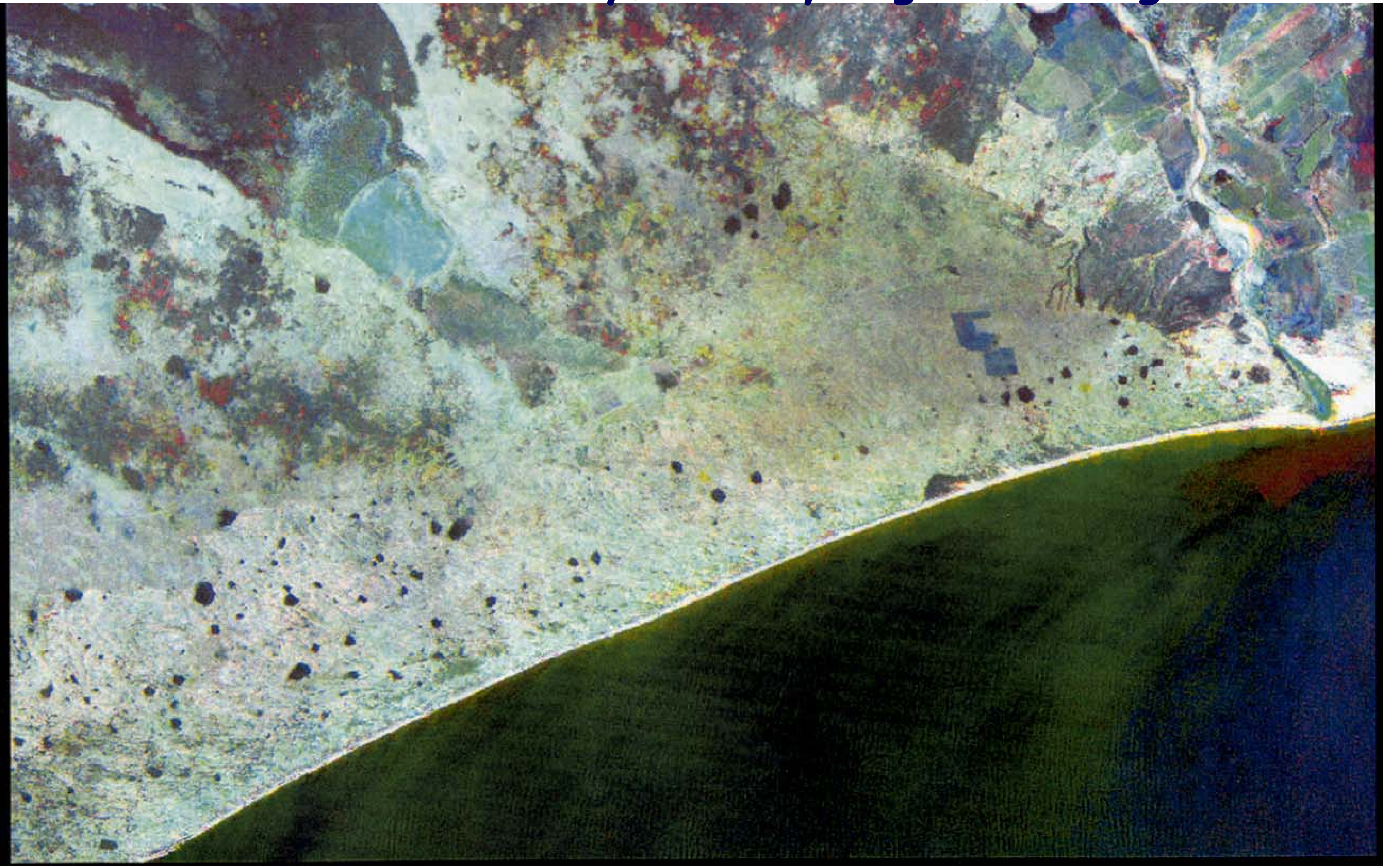
Multiple regime shifts

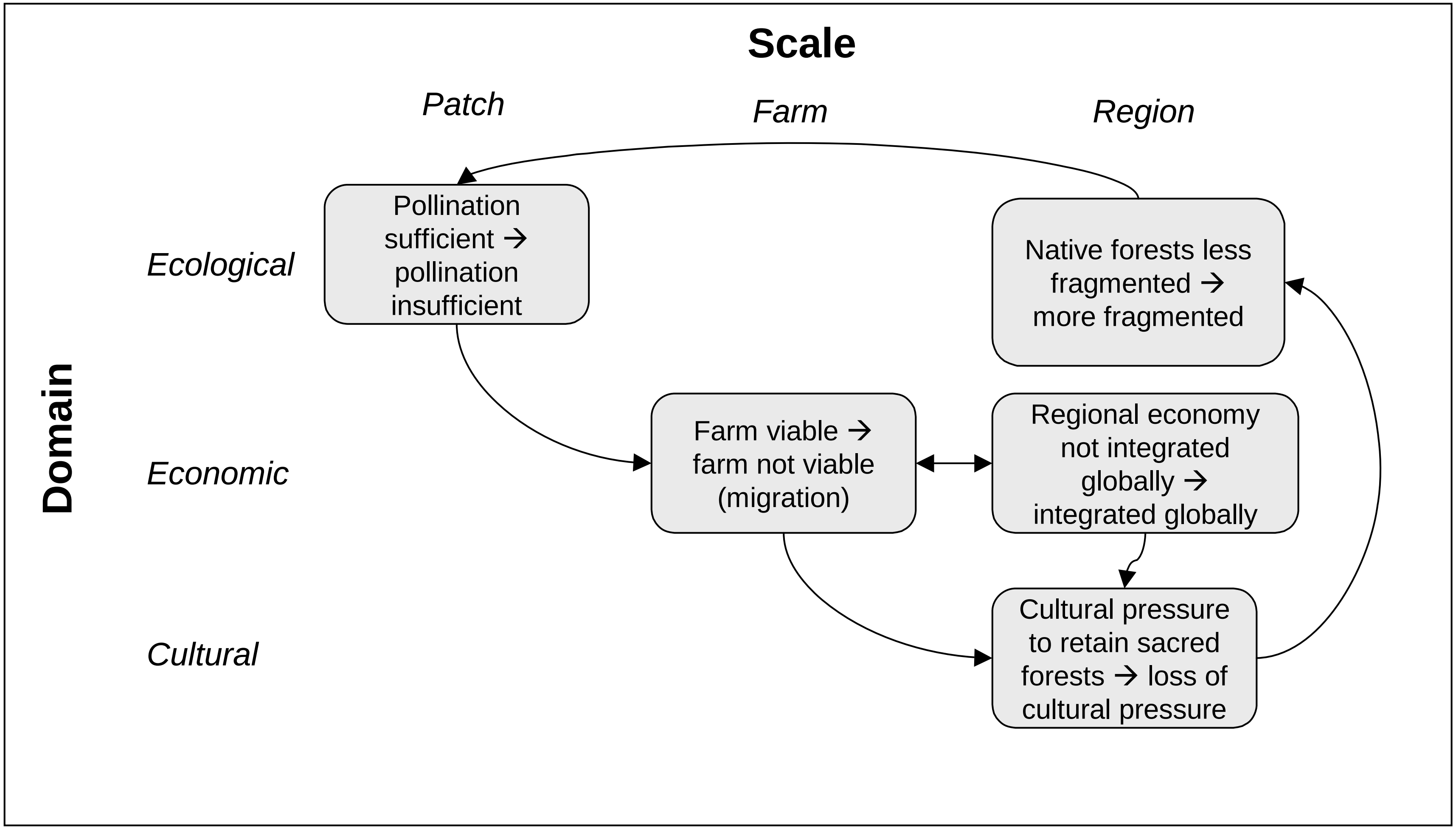
Sacred Forests – alafaly, Androy region, Madagascar



Tombs in sacred forests

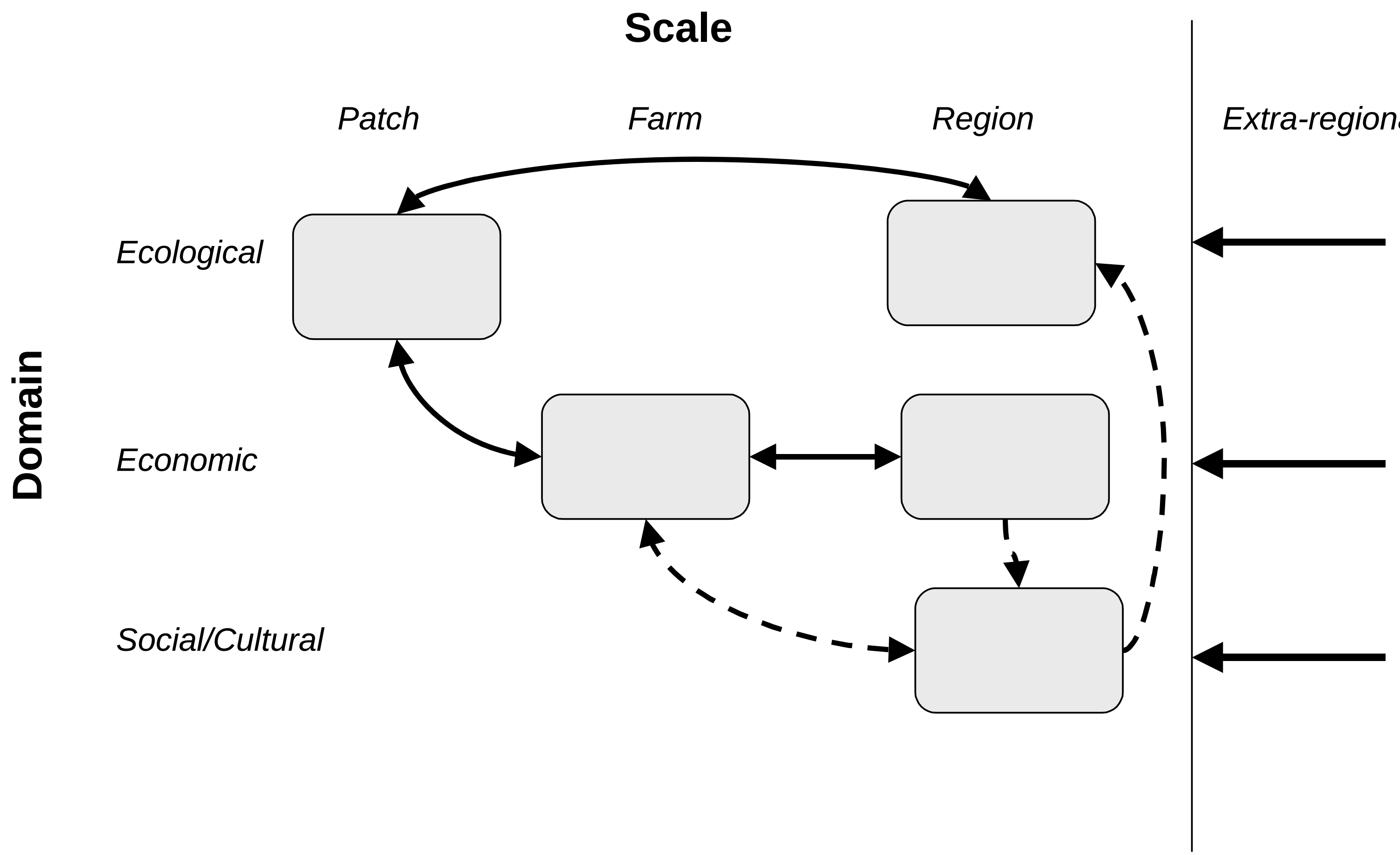
Sacred forest approx. 150 ha surrounded by agricultural land
(mainly beans and some maize)

Thresholds in the Androy region of Madagascar



Multiple, interacting thresholds

(Causse Mejan in France, a catchment in SE Australia, southern Madagascar, Western Australia wheatbelt)



Kinzig et al (2006, in press) Special Issue of Ecology & Society

There is a cost to resilience

short term cost of foregone extra 'yield'

vs.

cost of being in an alternate regime
(cost x prob. of a regime shift)

cost of maintaining resilience (relatively easy to estimate)

vs.

cost of *not* maintaining it (difficult to estimate)

Adaptive cycles and 'panarchy'

4 key points:

-The 'cycle' isn't always a cycle, but the four phases are repeatedly observed
-Cross-scale effects are frequently the cause of inability to cope
- Persisting with the status quo (the "K" phase) leads to big losses in system capitals (and therefore human wellbeing)
- ***They are important because they strongly influence when and how to intervene in a SES***


CLOACA MAXIMA
DIEDE INIZIO ANCHE
ALLO SCAVO DI CANALI SOTTERRANEI
ATTRAVERSO I QUALI TUTTA L'ACQUA CHE
SCOLA DALLE VIE SI VERSA NEL TEVERE
ED E QUESTA UN OPERA MIRABILE
CHE SUPERA OGNI DESCRIZIONE...

<u>"The Collapse of Complex Societies"</u> (J. Tainter)

As societies grow and develop they confront problems that need to be solved

In solving them, they increase complexity

Complexity costs

When the costs exceed the benefits of the solutions, societies collapse

Debasement of the Roman Silver Currency

0—269 A.D.

Dangers of K-phase behaviour

- increases in "efficiency" (remove apparent redundancies, OSFA solutions)
- subsidies not to change (rather than *to* change)
- sunk costs effects
- increased command-and-control (less and less flexibility)
- pre-occupation with process (more and more rules)
- novelty suppressed, little support for experimentation
- rising transaction costs
- increasing consequences of partial solutions

resilience declines

Success in intervening in a social-ecological system at a particular focal scale depends on where it is in the adaptive cycle, and the states of the system at higher and lower scales

policy
financial (subsidies, infrastructure, technology, ..)
management actions / techniques

Limitations of science in understanding and managing linked social-ecological systems

- how to envision or model true novelty (mutation vs. re-combination)?

- "**wicked**" problems – no definitive formulation, no unique solution (..each attempt to create a solution changes the understanding of the problem - the problem definition evolves as new solutions are considered requires 'adaptive project management' - Rittel and Webber '73)

Beyond science -- the world of imagination; can art help?

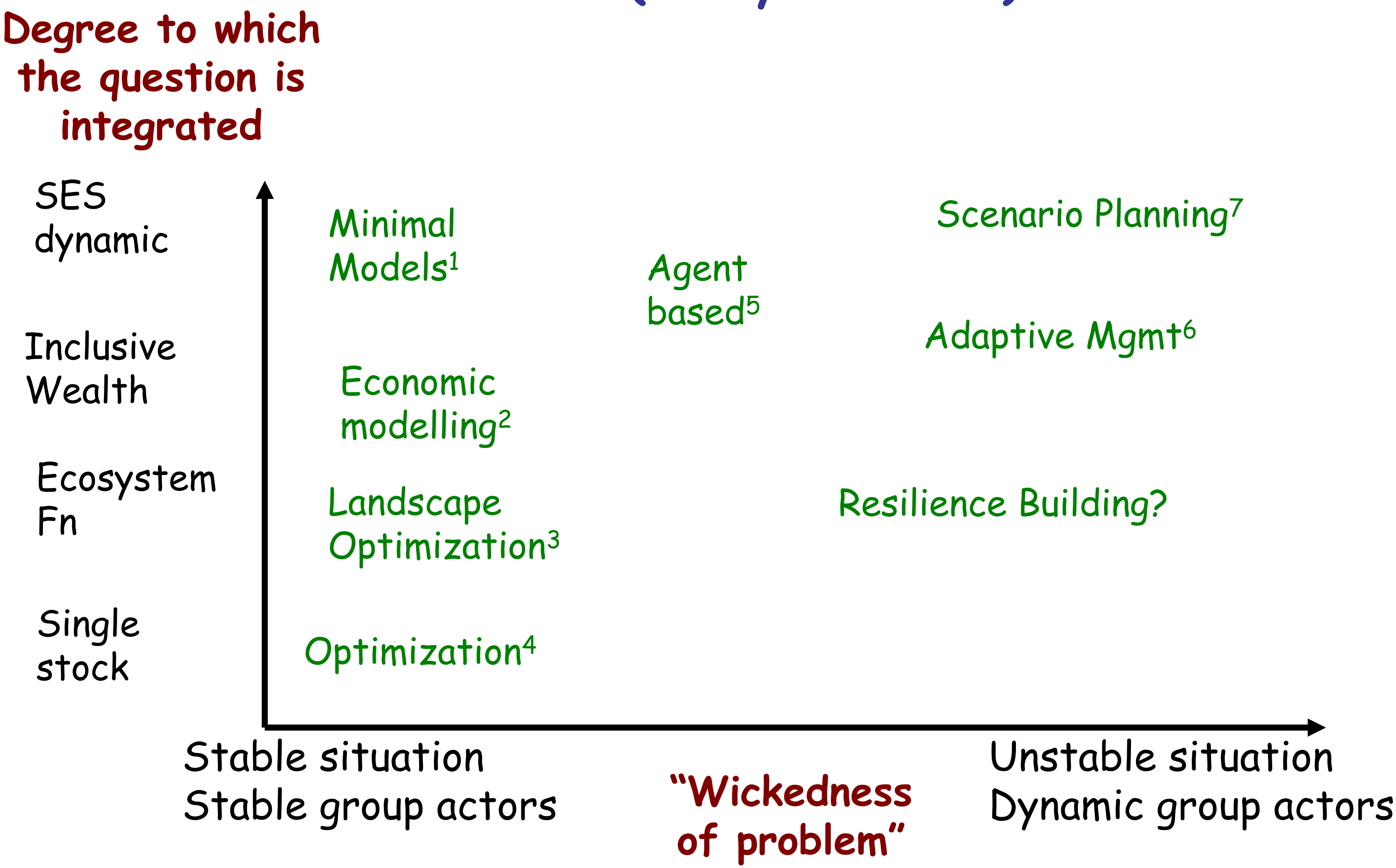
International Resilience Symposium and Art Exhibition

Stockholm, April 13 - 17 2008

The main messages:

- sustainability ≈ resilience, adaptability, transformability
- policy and management need to focus on the attributes that determine these three properties
- alternate regimes are the norm; pay attention to feedbacks that change suddenly at some level of a controlling (slow) variable
- "optimal" states reduce resilience -- top-down, command-and-control management doesn't work for very long
- adaptive cycles and panarchy effects determine the success of interventions
- there are limits to a scientific analysis of R, A and T; can art help?

Approaches to Modelling SESs
(Garry Peterson)



Transaction costs rise during a K phase

-in ecosystems, the proportion of production used for metabolism (respiration) increases

-in social systems, the proportion of energy, time and inputs used for running the system increases

How much of a system's intake (income) is being used for metabolism?

the "HOT" model (J. Doyle, SFI)

general vs. specified resilience

resilience of what, to what?