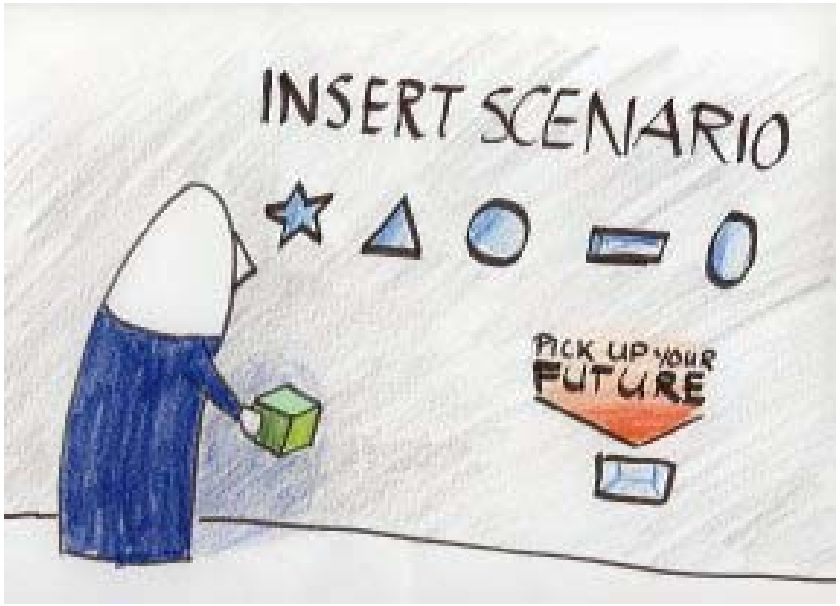
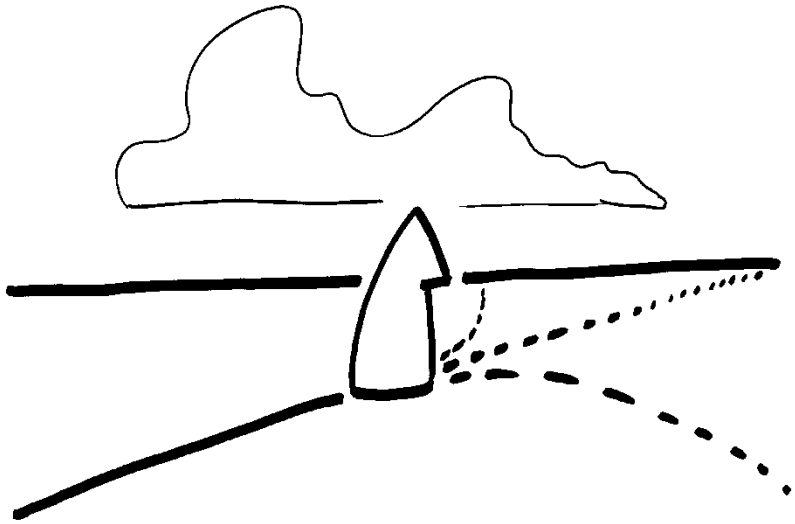
Scenario development

Concepts and examples





Kasper Kok – Wageningen University, the Netherlands

NONAM PhD course - Copenhagen, 22-26 August 2011

Scenario development in two lectures

Lecture 1 – Monday 22 August, 13:00-14:15
Background, overarching issues, concepts, definitions, tools
- Complex Systems
- Tools and methods to analyse complex systems
- Scenarios

Lecture 2 – Wednesday 24 August, 10:15-11:30
Practical examples + conclusions
- Exploratory scenario development – SAS approach
- Group model building - Fuzzy Cognitive Maps
- Normative scenario development - Backcasting

Conclusions

LECTURE 1

Scenario development

Underlying issues and concepts

Content

Lecture 1: an introduction

- Complex problems
- Complex System analysis
- Tools and methods to analyse complex systems
    - o Methods: Scale; interdisciplinarity, participation
    - o Tools: Models, scenarios
- Scenarios
    - Why
    - How
    - What/what not

The overarching problem

"The world is now moving through a period of extraordinary turbulence; the speed and magnitude of global change, the increasing connectedness of social and natural systems at the planetary level, and the growing complexity of societies and their impacts upon the biosphere result in a high level of uncertainty and unpredictability"
(Gallopin, 2002)

High speed of change	Lead to:
Increased connectedness	**High uncertainty**
Growing complexity	Unpredictability

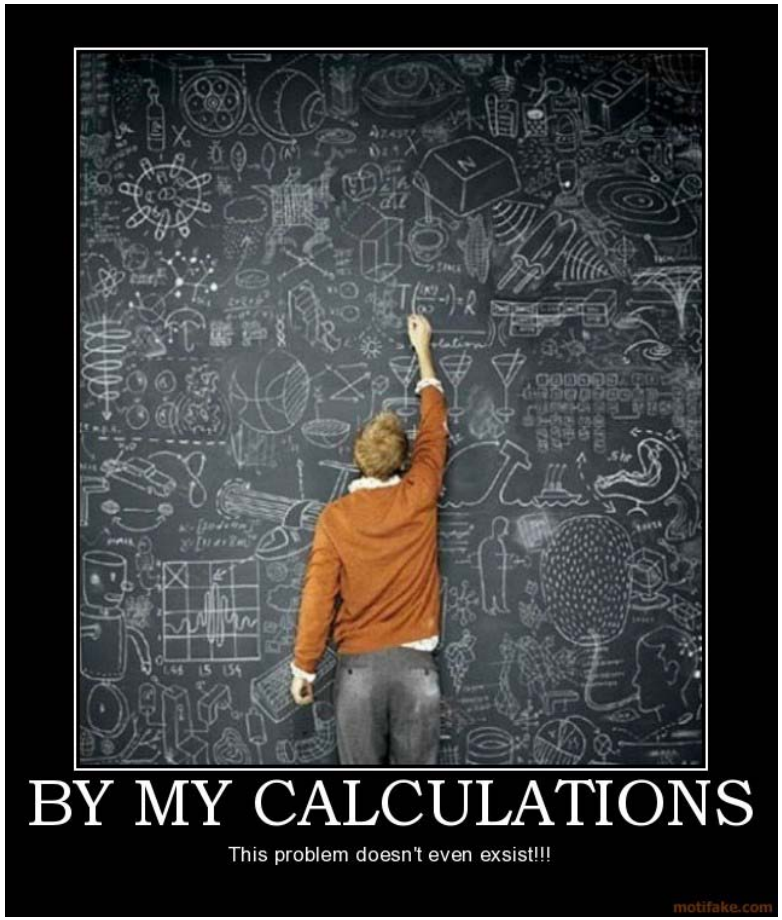
This calls for new types of scientific research

In my view, traditional (monodisciplinary, sectoral, research-for-research) science needs to be largely abandoned and replaced by:

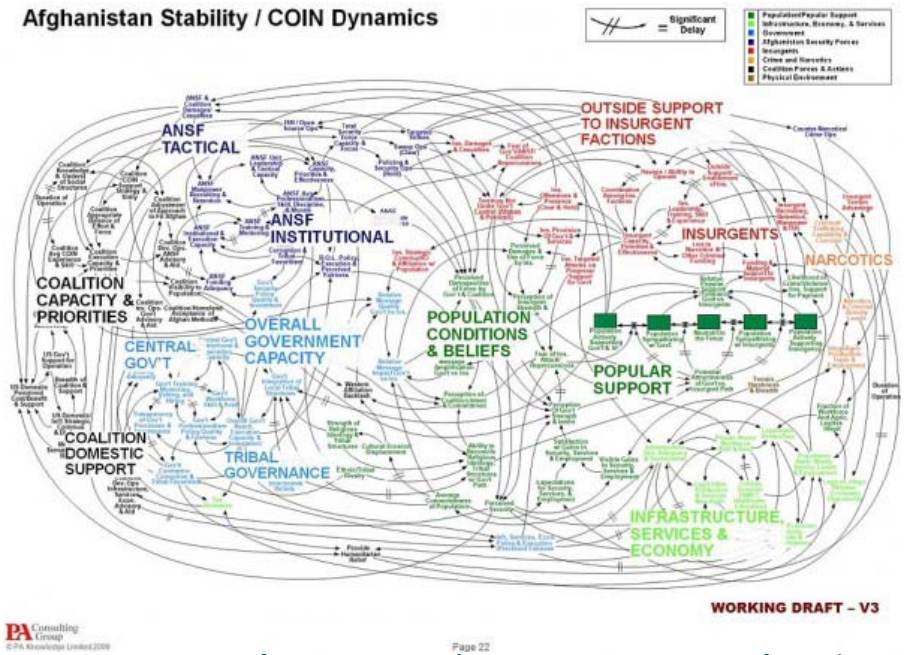
- Transdisciplinary
- Integrated
- Research-from and for-society science

(see also Mode II science, post-normal science, Integrated Assessment etc.)

Complex problems



Many issues to consider



Many relationships to include

Many perceptions to take into account

Complex or wicked problems

Wicked problem:

A problem that is difficult or impossible to solve because of incomplete, contradictory, and changing requirements. Because of complex interdependencies, the effort to solve one aspect may create other problems.

Complex problem:

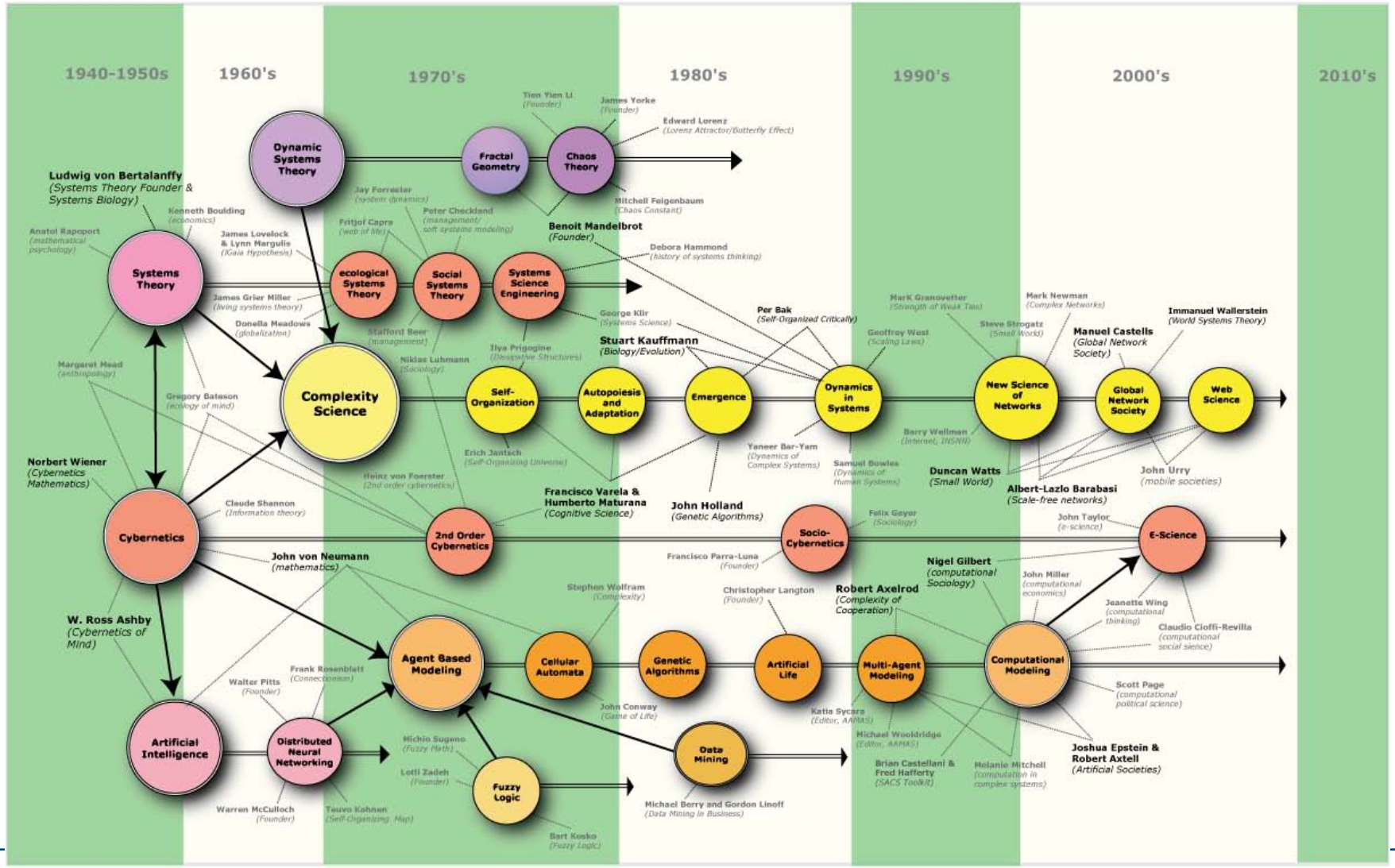
A problem with many relationships between parts that give rise to collective behaviour of the system.

Complex system approach

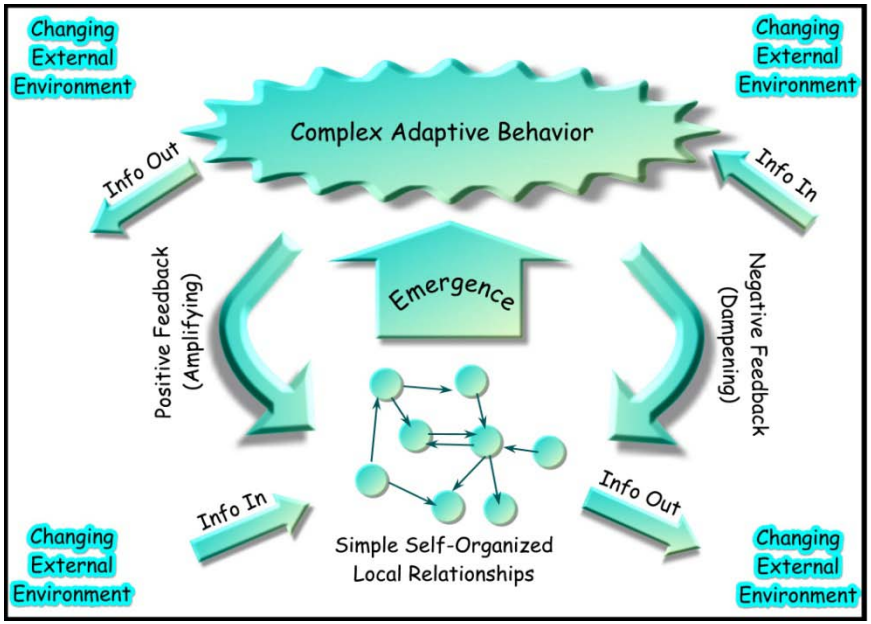
A broad term encompassing a research approach to problems in many diverse disciplines including computer science, AI, biology, sociology, etc.

Common elements are: mathematical system models, non-linear behaviour, holistic approach

A history of complexity science



And the relevant bit for today...



Complex Adaptive System

Endogenous-exogenous

Self-organisation

Emergent properties

Adaptive behaviour

Feedbacks

Methods and tools to tackle complex problems relevant to scenarios

Methods:

1. **Multi-scale** – Focus on cross-scale interactions
2. **Participation** - Social learning, negotiation, stakeholder perspectives
3. **Interdisciplinarity** – Focus on better integration of social factors

Tools:

1. **Models** – Spatially explicit
2. **Scenarios** – multi-scale, participatory storylines

Method:

Interdisciplinary Research

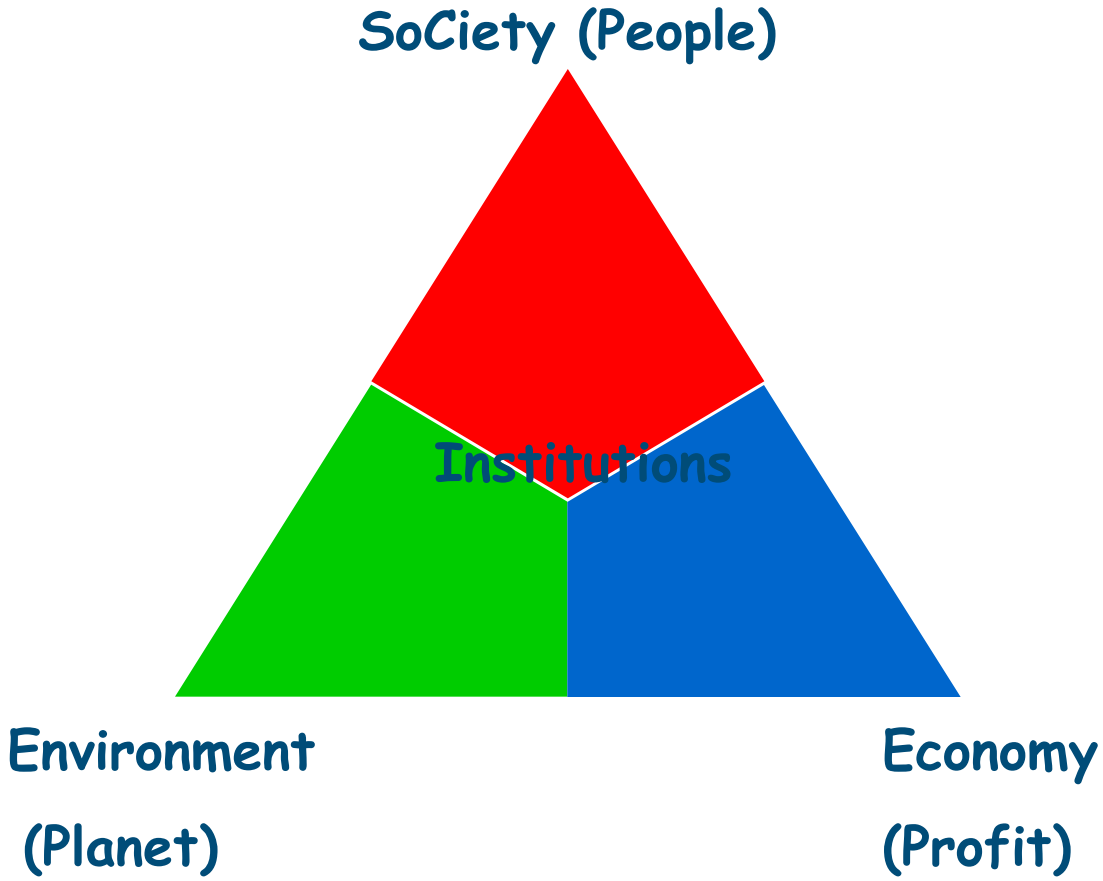
Method: Interdisciplinary research

Definition of Integration Assessment:

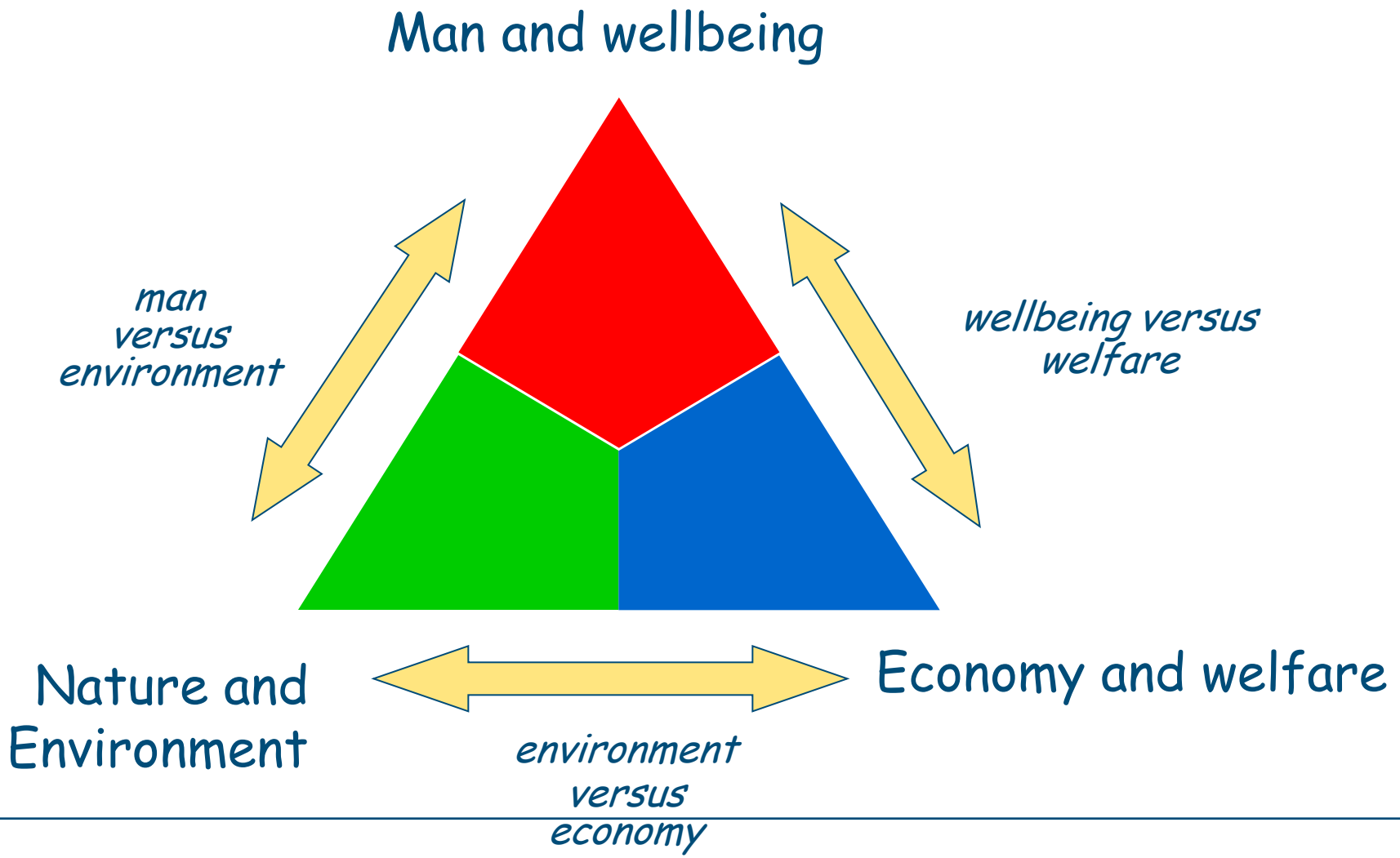
Integrated Assessment is an interdisciplinary process of structuring knowledge elements from ***various scientific disciplines*** in such a manner that all relevant aspects of a ***societal problem*** are considered in their mutual coherence for the benefit of ***decision-making***

International Centre for
Integrative Studies (ICIS)

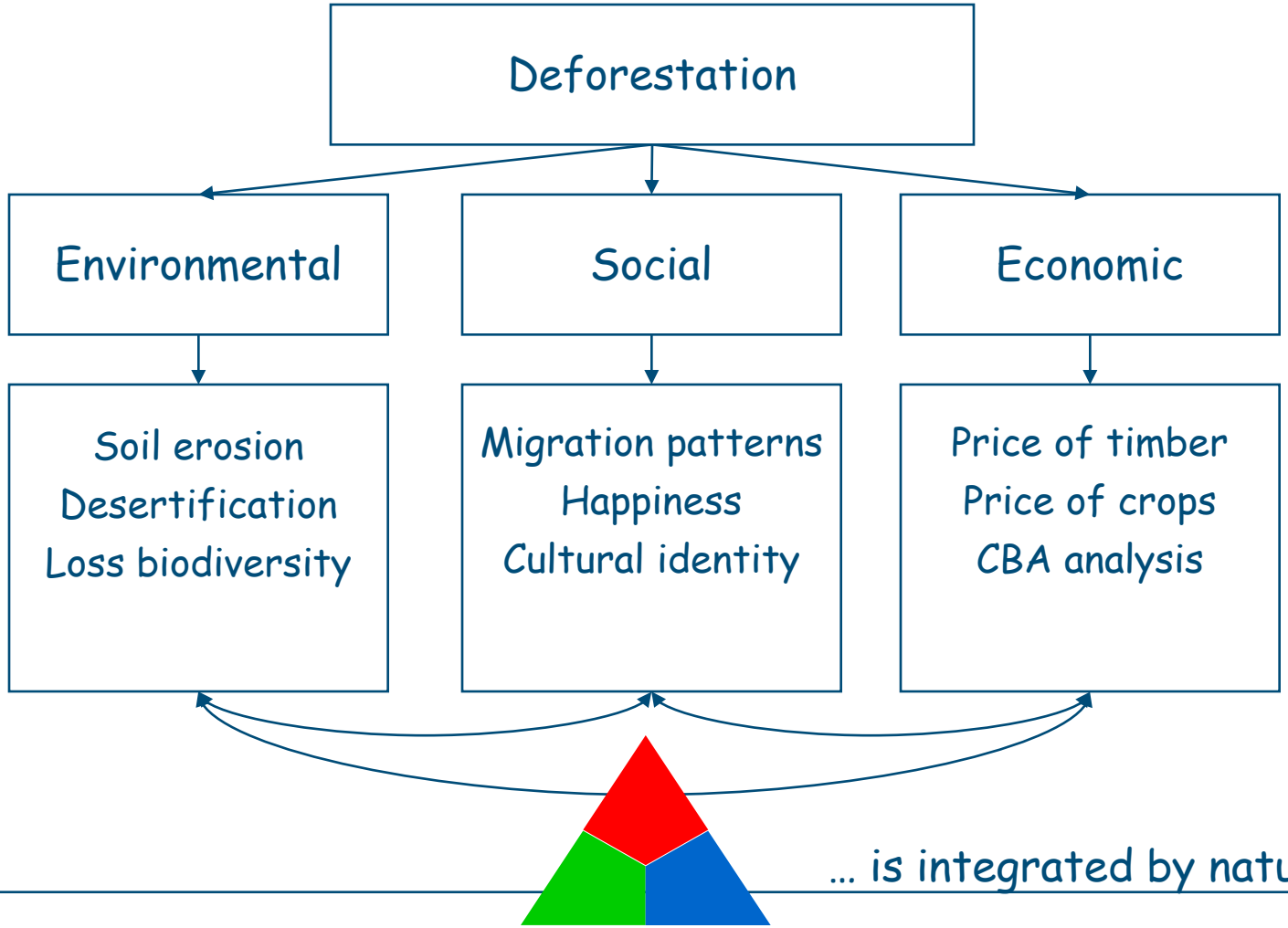
Interdisciplinarity: The SCENE Model / PPP



Interdisciplinarity: Bridging Paradigms

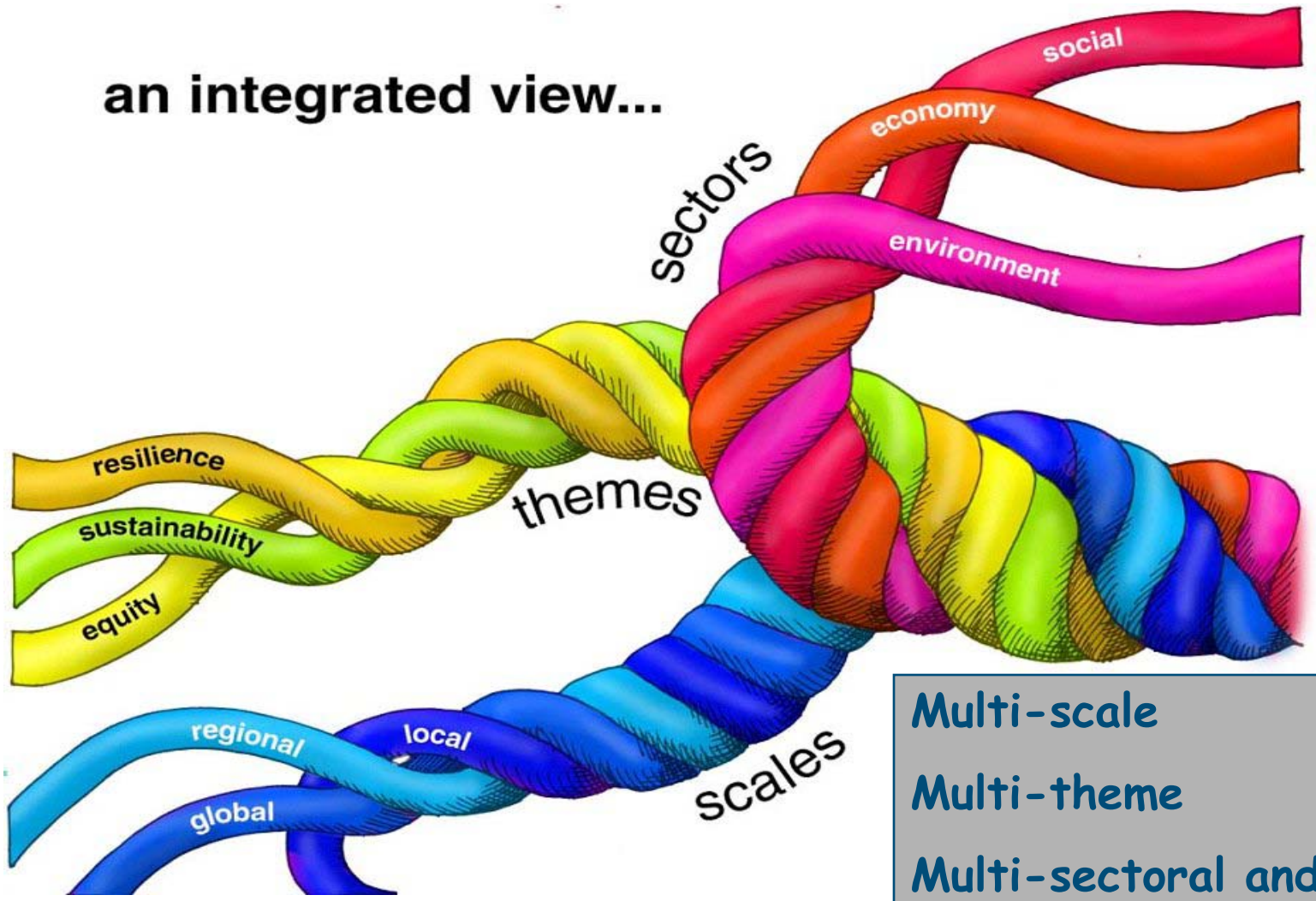


Interdisciplinarity: A societal problem…



… is integrated by nature

Interdisciplinarity: an integrated view



Multi-scale

Multi-theme

Multi-sectoral and thus

Multi-disciplinary

Method:

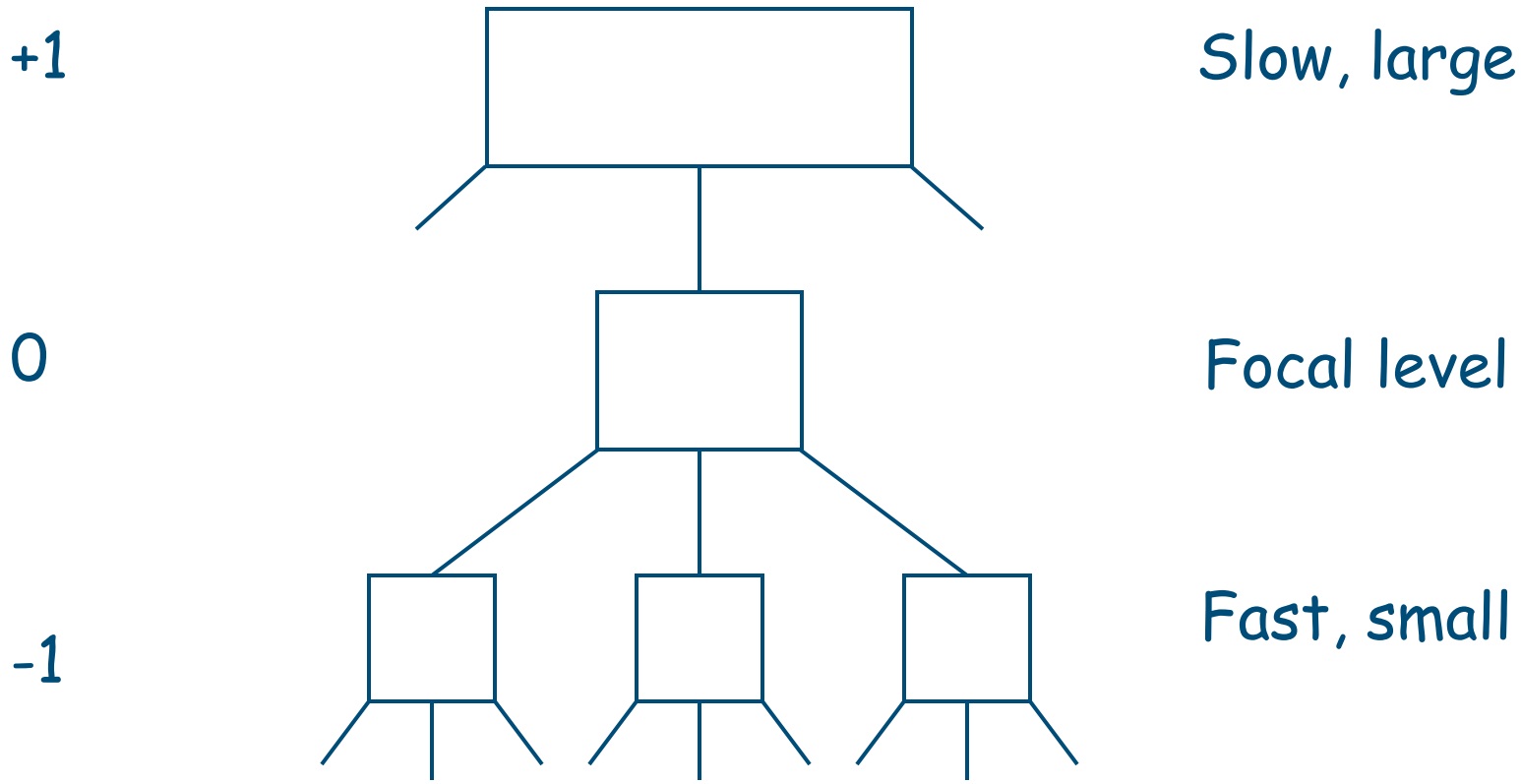
Multi-scale research

Scales and levels

Level:
Level of organisation inherent to the system
Also referred to as *functional scale*

Scale:
Level of observation
With two components, *temporal* and *spatial scale* that both have two aspects, *resolution* and *extent*

Functional scale or hierarchically nested levels



Functional scale:

The Hierarchy Theory

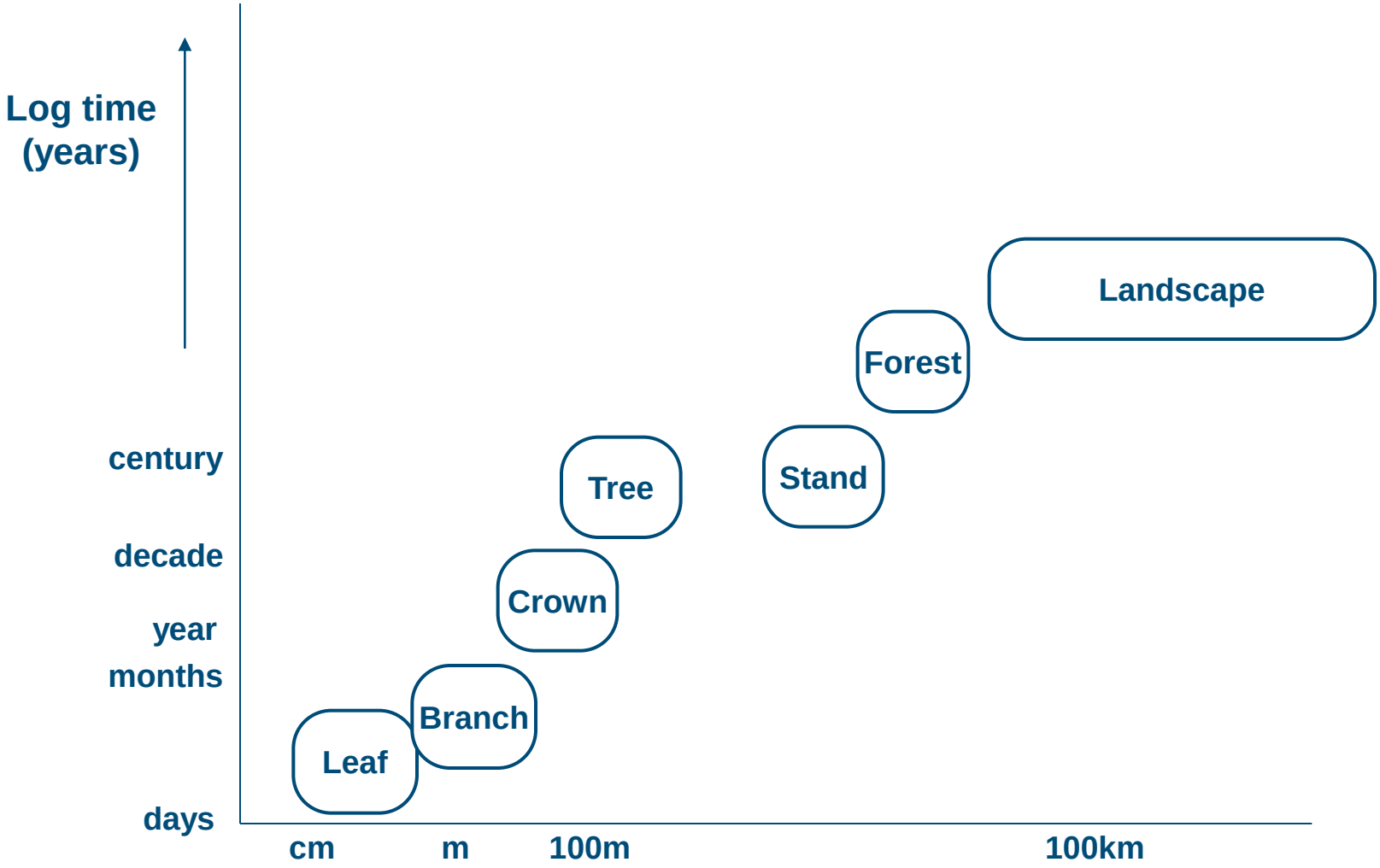
- Emerged as part of a movement toward a general science of complexity
- Rooted in various other disciplines but operationalised by ecologists in the 1970s and 1980s
- Key references:

Allen, T. F. H. and T. B. Starr. 1982. Hierarchy: perspectives for ecological complexity. University Chicago Press.

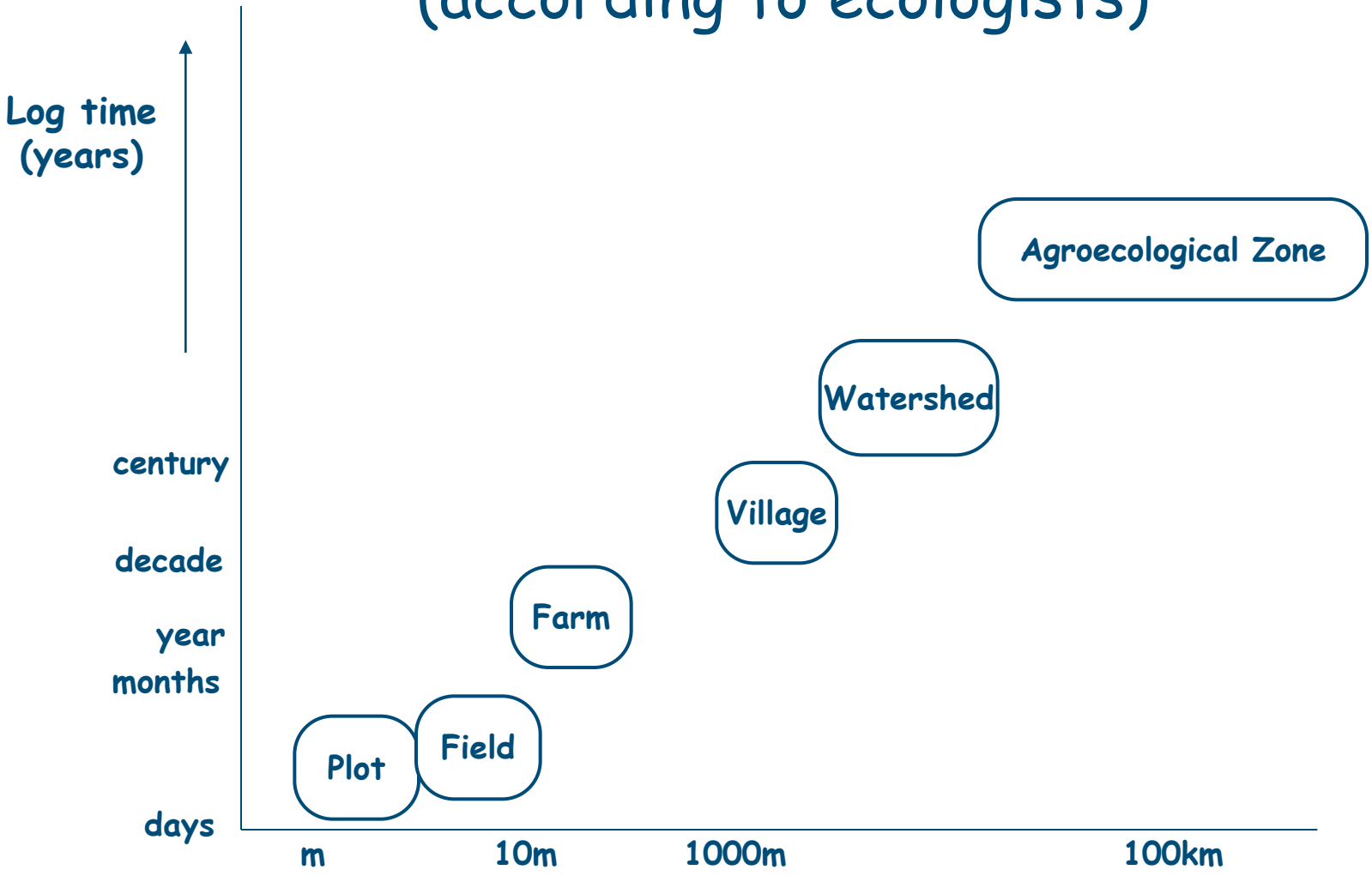
Allen T. F. H. and T. Hoekstra. 1992. Toward a unified ecology. Columbia University Press.

O'Neill, R.V., D. DeAngelis, J. Waide and T. F. H. Allen. 1986. A hierarchical concept of ecosystems. Princeton University Press.

Examples of functional scales



Analogy with land use systems (according to ecologists)

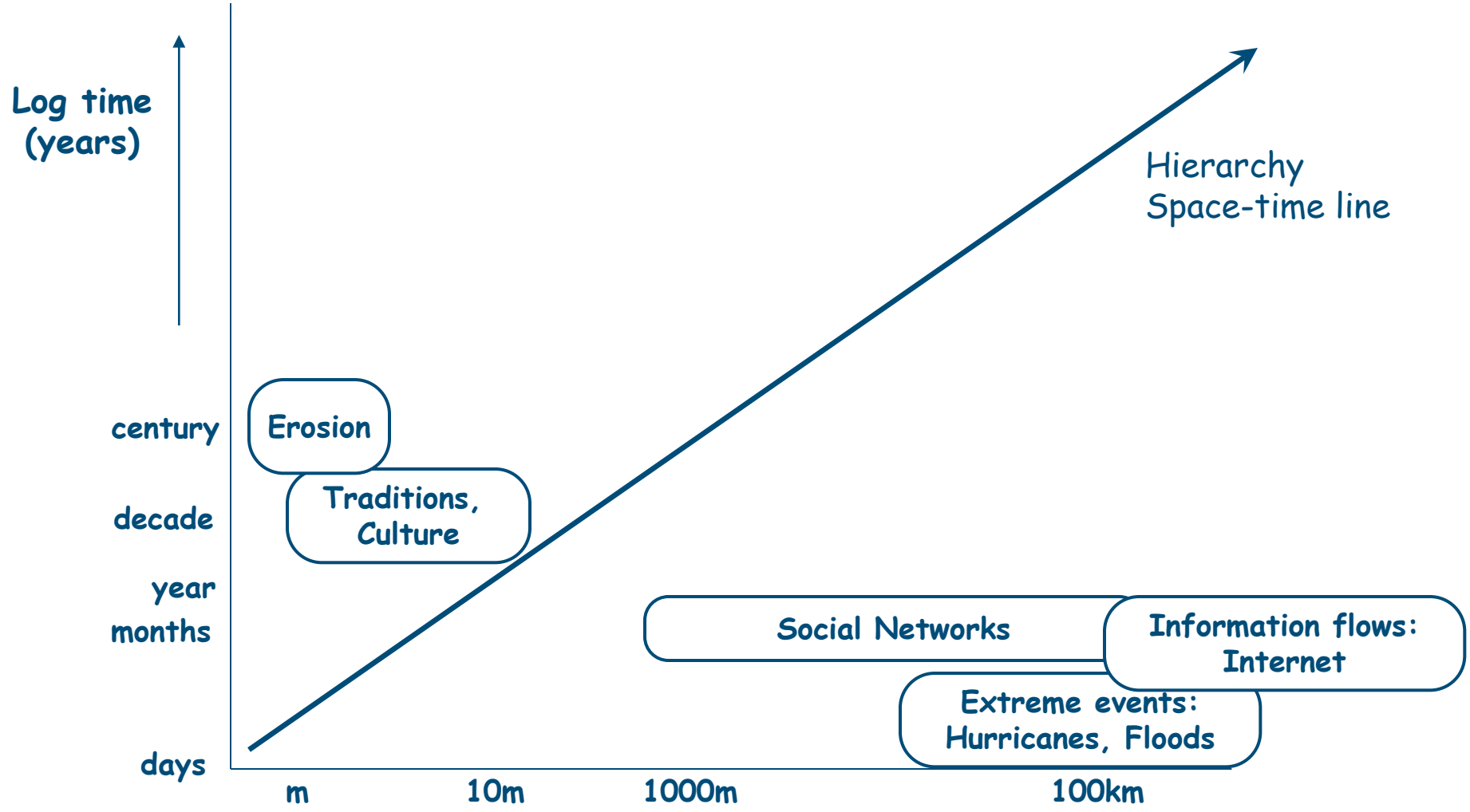


Ecosystem ≠ Land use system

- Both consider interactions of 'flora' and 'fauna'
- Both are complex systems

- Ecosystems are 'goal free'
- Humans drive land use change
  - traditions
  - cultural identity
- Land use systems are open
  - information flow
  - energy flow (manpower, fertilisers)

And thus…

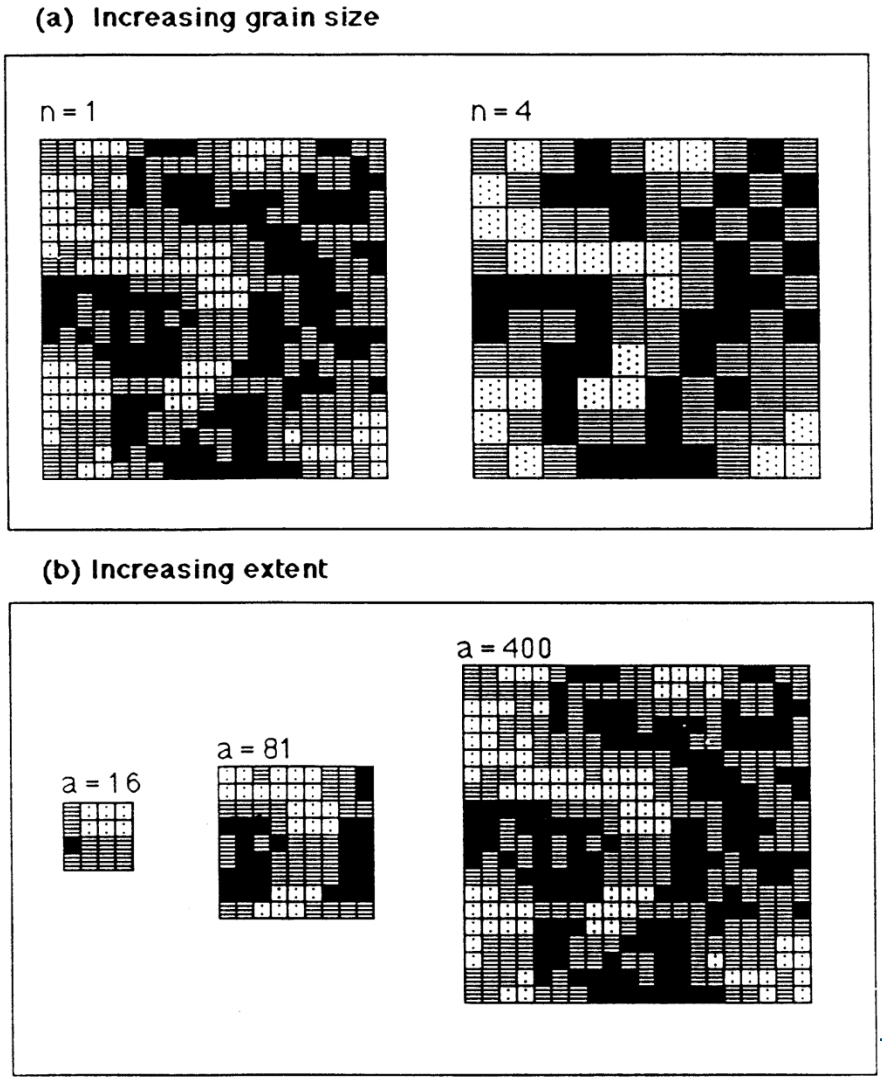

Log time
(years)
century
decade
year
months
days
Erosion
Traditions,
Culture
Hierarchy
Space-time line
Social Networks
Information flows:
Internet
Extreme events:
Hurricanes, Floods
m
10m
1000m
100km
Log space
(meters)

Hierarchy Theory: to use or not to use?

- Robert O'Neill questions the unifying capabilities*
- Aspects of the land use system have different scale properties
- To use... But with caution

*O'Neill, R. V., and A. W. King. 1998, Homage to St. Michael; or, why are there so many books on scale?: Pages 3–15 in D. L. Peterson and V. T. Parker (editors). Ecological scale: theory and applications. Columbia University Press, New York.

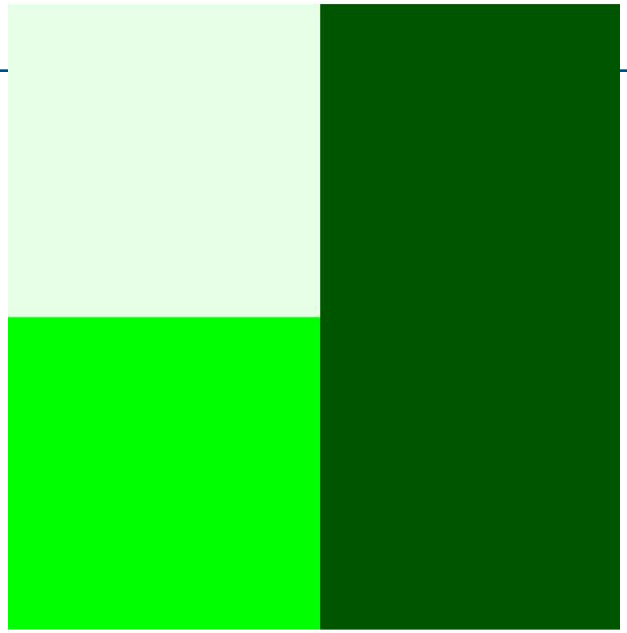
Spatial scale



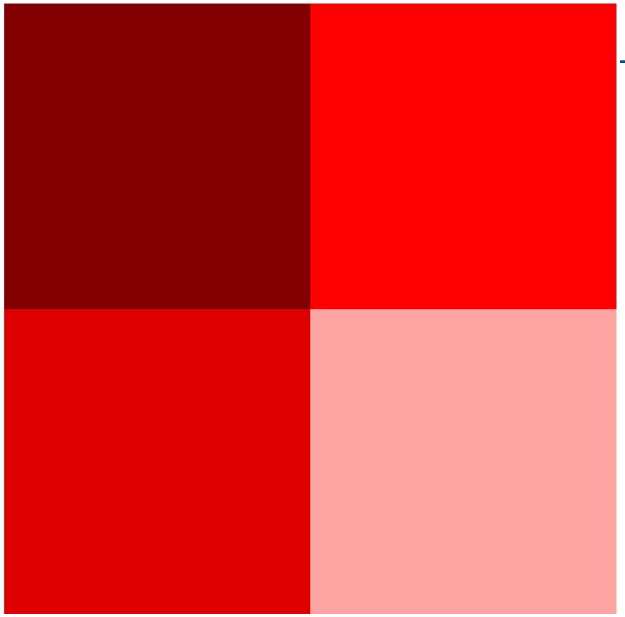
Key concepts (from ecology)

Modifiable Areal Unit Problem (MAUP)

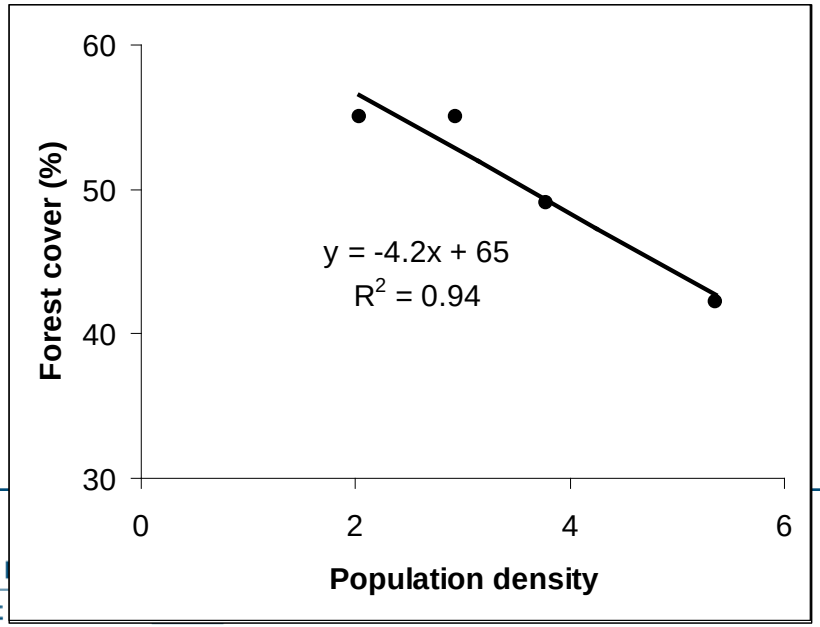
Ecological fallacy: The mistake of assuming that where relationships are found among aggregate data, these relationships will also be found among individuals or households, or vice versa.



2 x 2



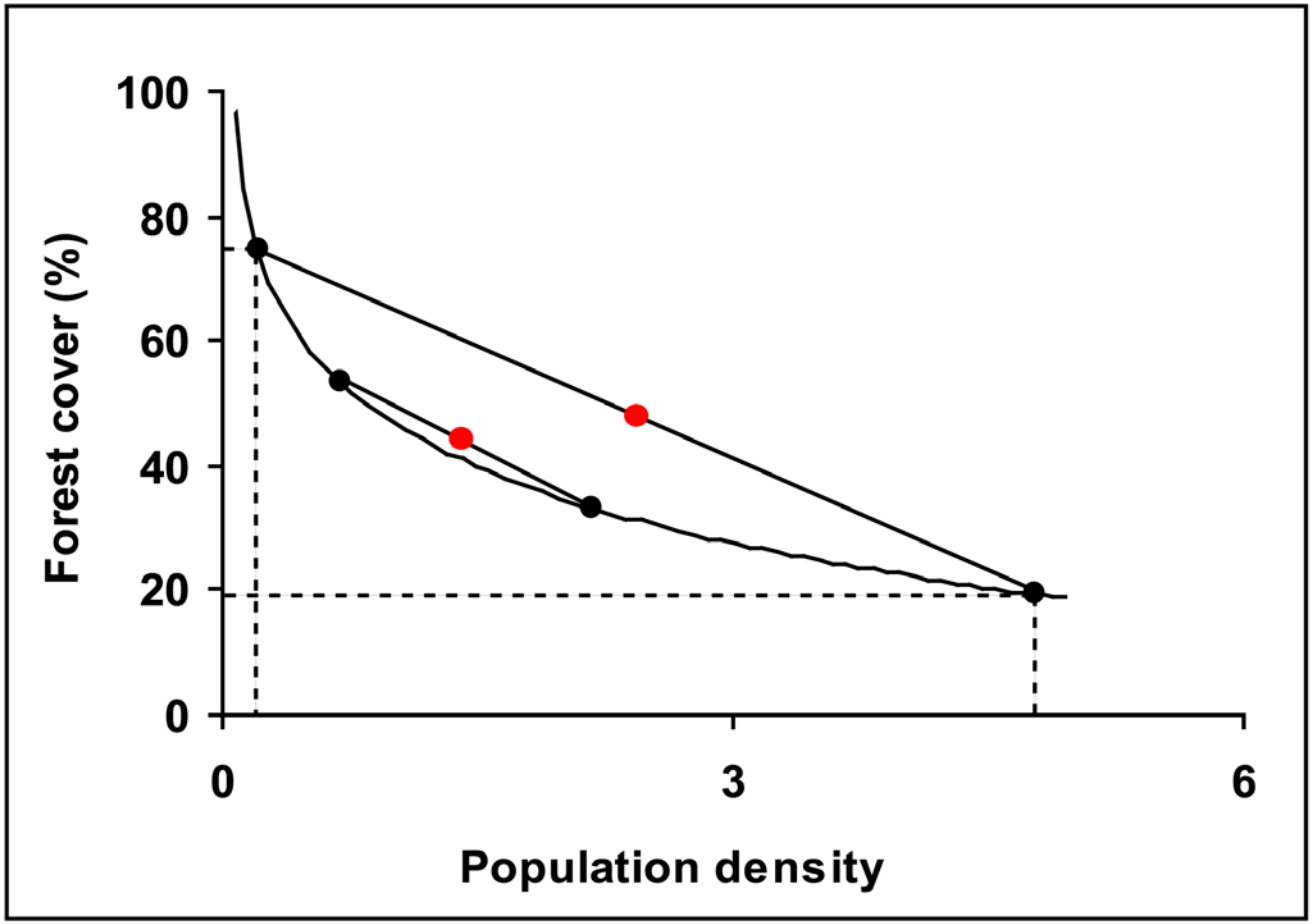
Forest cover



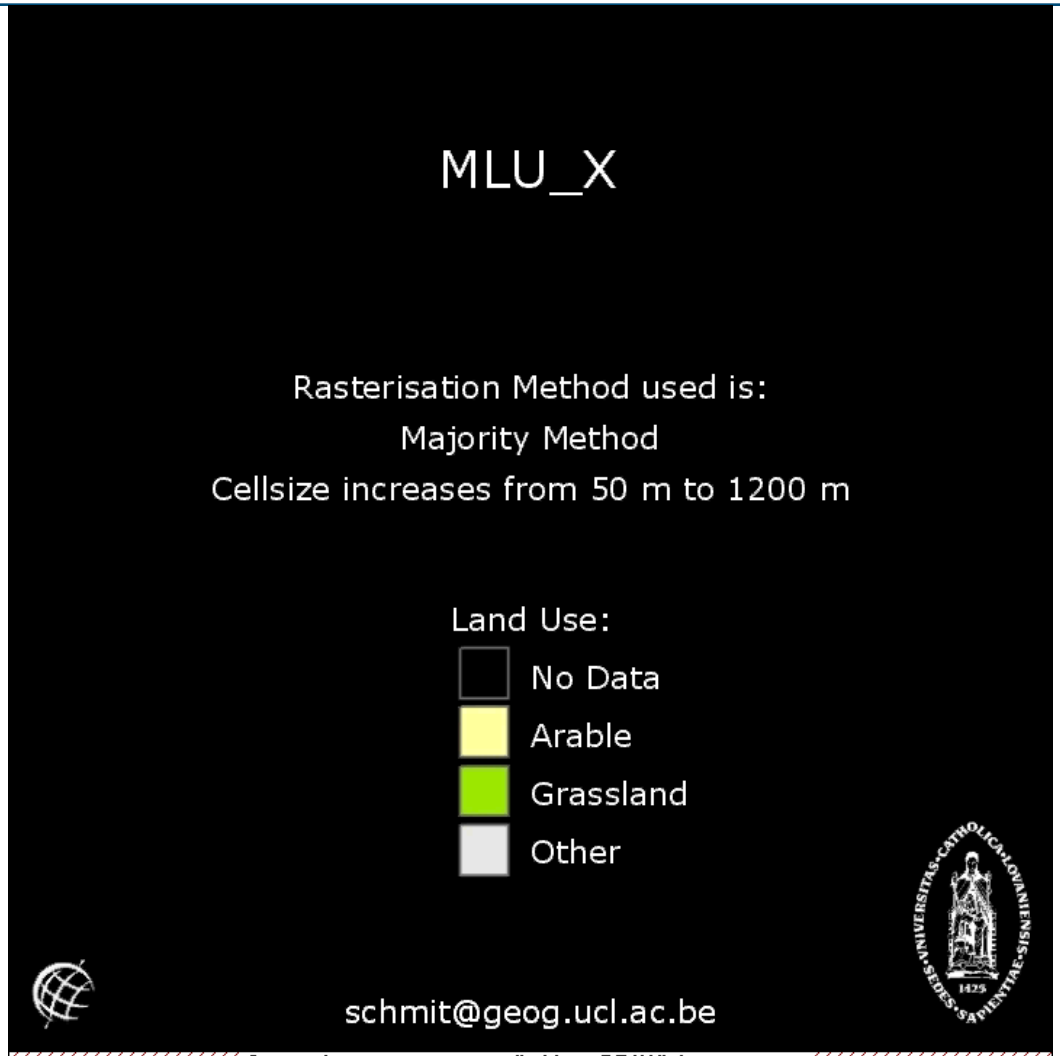
Population density

Hypothetical aggregation error by upscaling non-linear relationships

Theoretical underpinning (Rastetter, 1992)



Spatial scale – Dominant cells



Conclusions - scale

- "Scale" has been on the (land use modelling) agenda for > 20 years, but it is still relevant!
- Attention shifted from "multi-scale" to "cross-scale", and from "downscaling" to "upscaling"
- Multi-scale methods and models are now common
- Ecological theory is still dominating, but new concepts are being developed
- The scale concept is intrinsically linked to:
    - Non-linearities
    - Feedbacks
    - Aggregation/disaggregation

Tool:
Scenarios

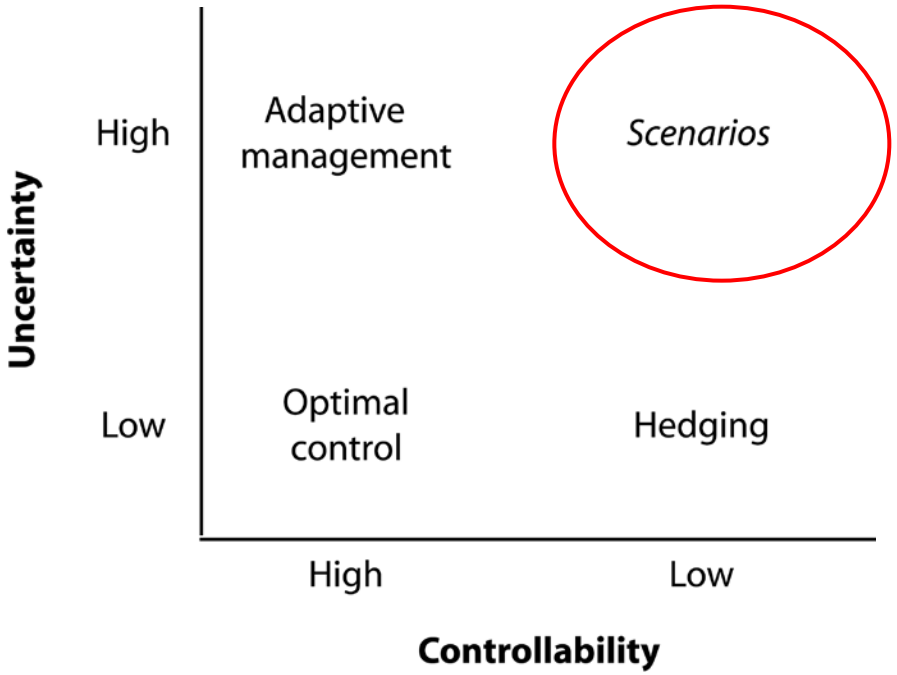
Scenarios - background

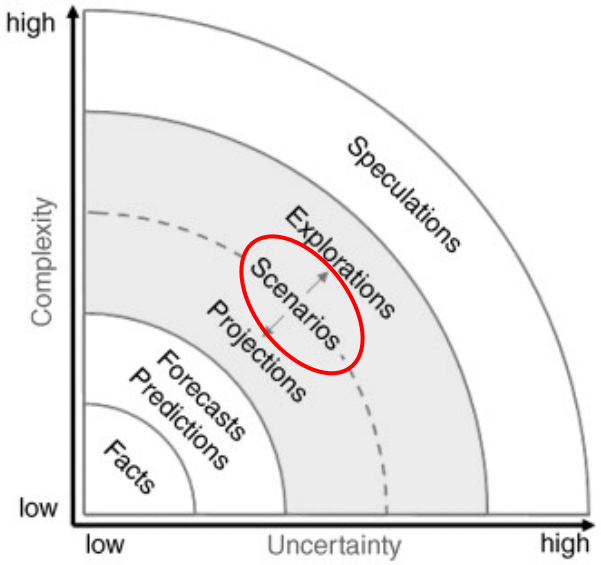
- 'Scenario' comes from the dramatic arts. In theater: it is an outline of the plot; for a movie: a scenario details relevant to the plot (before 1940s)
- Roots trace back to the Manhattan project (1940s)
- Kahn & Weiner used scenarios in a series of strategic studies for *military planning* purposes (1950s)
- Scenarios were refined at Royal Dutch/Shell and Shell became a leader of the scenario approach to *business planning* (1970s and 1980s).
- First scientific scenarios: Limits to Growth (1972)
- First global environmental scenarios: Global Scenario Group (1990s)
- Today, scenario development is used in a large variety of different contexts ranging from political decision-making, to business planning, to local community management, and to global environmental understanding

Scenarios – when to use?

"The world is now moving through a period of extraordinary turbulence; the speed and magnitude of global change, the **increasing connectedness** of social and natural systems at the planetary level, and the growing complexity of societies and their impacts upon the biosphere **result in a high level of uncertainty** and unpredictability" (Gallopin, 2002)

Scenarios – when to use?





	Low uncertainty	High uncertainty
High causality	Predictive	Explorative
Low causality	Projective	Speculative

Scenarios – when to use?

Scenarios are a good tool when:

- Uncertainty is high, and

- Controllability is low, or
- Complexity is high, or
- Causality is high

Scenarios - definition

There are many definitions, with only partial agreement. Two important ones are:

- Scenarios are *plausible* descriptions of how the future may develop, based on a *coherent* and *internally consistent* set of assumptions about key relationships and driving forces. (focus on system description)
- Scenarios are *credible*, *challenging*, and *relevant* stories about how the future might unfold that can be told in both words and numbers. (focus on value for end users and other stakeholders)

Scenarios - purpose

Environmental scientists (focus on results):

Scenarios are a good tool for an integrated analysis of a complex problem. Scenarios provide in-depth insight in complex societal problems.

Social scientists (focus on process):

Scenarios are a good tool for communication, conflict management, and long-term participation. Scenarios provide an excellent tool for communication.

Scenarios – types (van Notten et al., 2003)

A Project goal - exploration vs decision support:

I. Inclusion of norms? : descriptive vs normative

II. Vantage point: forecasting vs backcasting

III. Subject: issue-based, area-based, institution-based

IV. Time scale: long term vs short term

V. Spatial scale: global/supranational vs national/local

WHY? and FOR WHOM?

Scenarios - types

B Process design – intuitive vs formal:

VI. Data: qualitative vs quantitative

VII. Method of data collection: participatory vs desk research

VIII. Resources: extensive vs limited

IX. Institutional conditions: open vs constrained

HOW?

Scenarios - types

C Scenario content - complex vs simple:

X. Temporal nature: chain vs snapshot

XI. Variables: heterogeneous vs homogenous

XII. Dynamics: peripheral vs trend

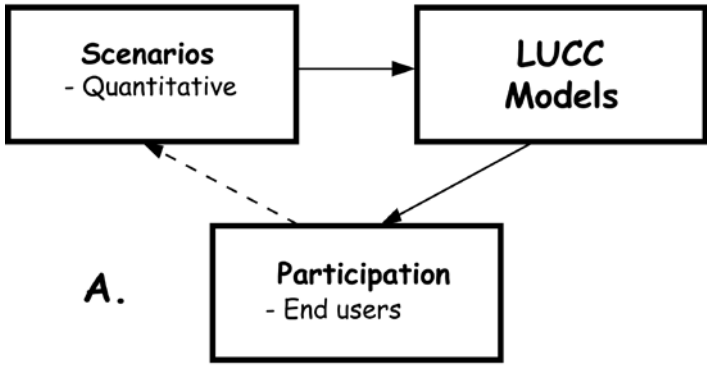
XIII. Level of deviation: alternative vs conventional

XIV. Level of integration: high vs low

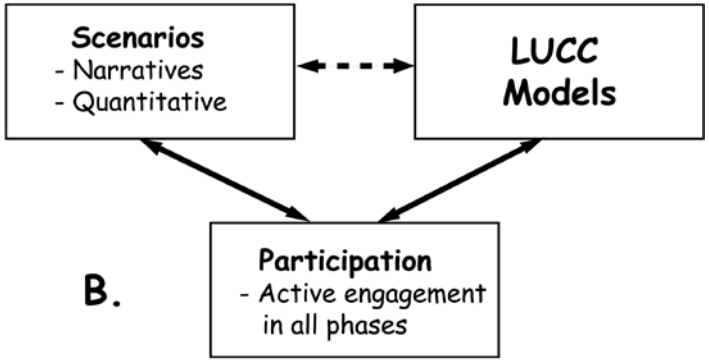
WHAT?

Scenarios – a changing role

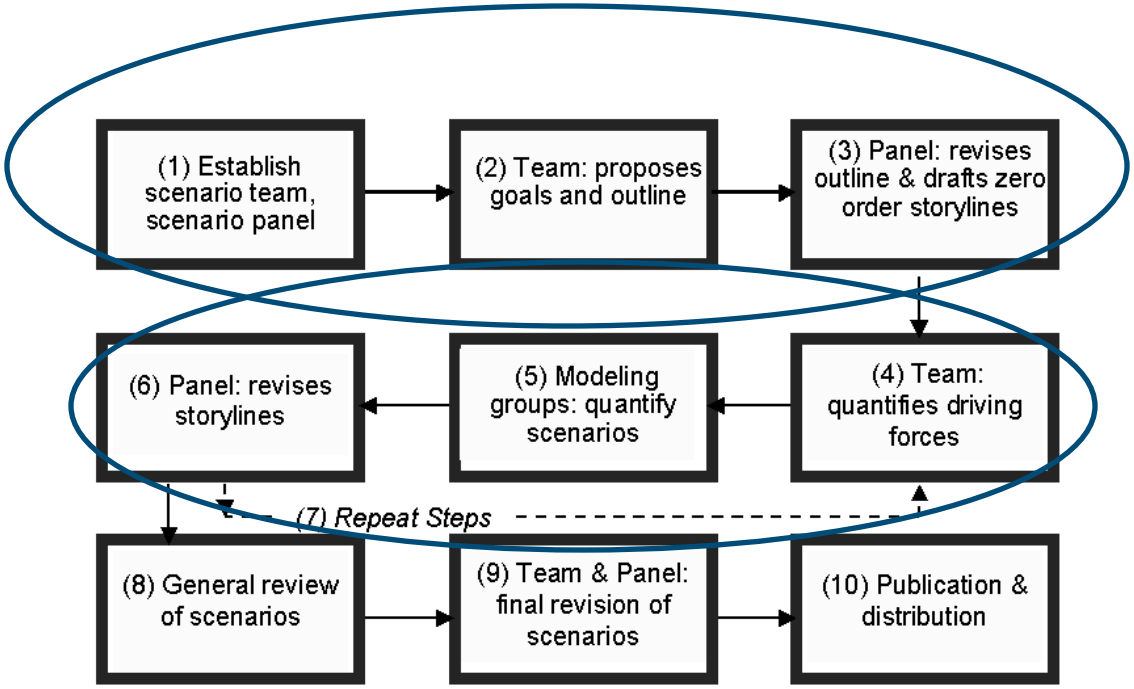
Traditional approach



Integrated approach



Story-And-Simulation approach



Narrative storylines

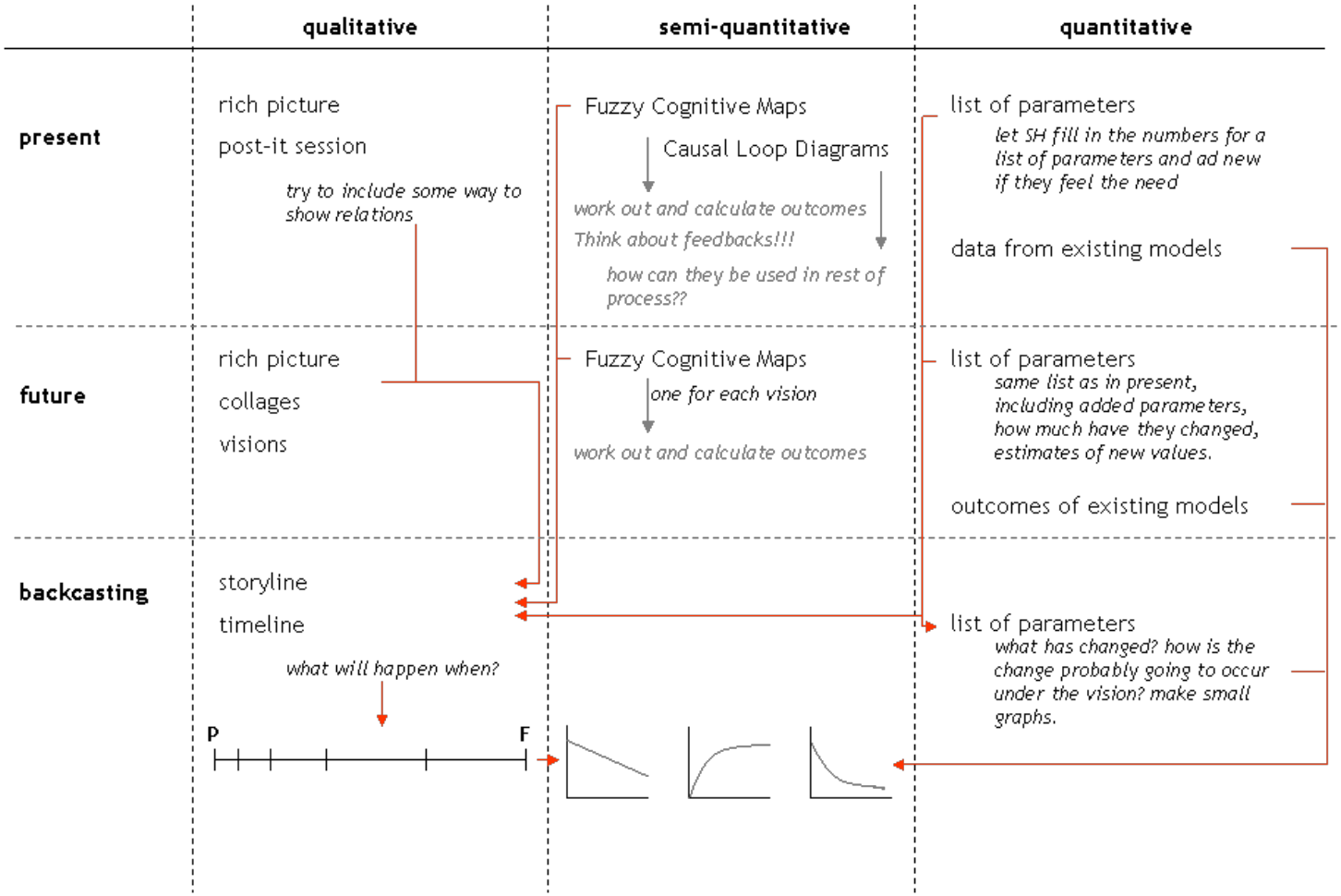
Model runs

Two types of scenarios

The goal is to develop and combine:
Qualitative scenarios, or ***narrative storylines***. Thus, we expand our mental model beyond conventional thinking and trend extrapolation, and include more surprising developments. The relevant question that scenarios can answer is not whether an event *could happen*, but what we could do *if it did happen*.

Quantitative scenarios, based on **spatially explicit models**. Thus, we bring together the state of the art on data and modelling techniques leading to detailed model explorations.

A toolbox of methods



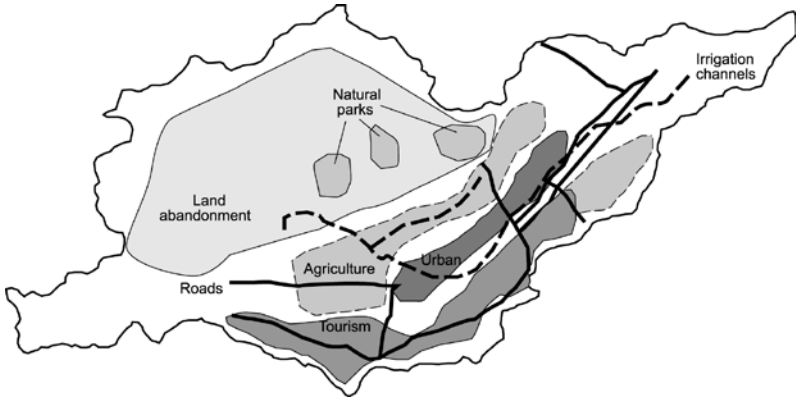
Scenarios – examples: qualitative

END
MARKET 1st 2023 → 2050

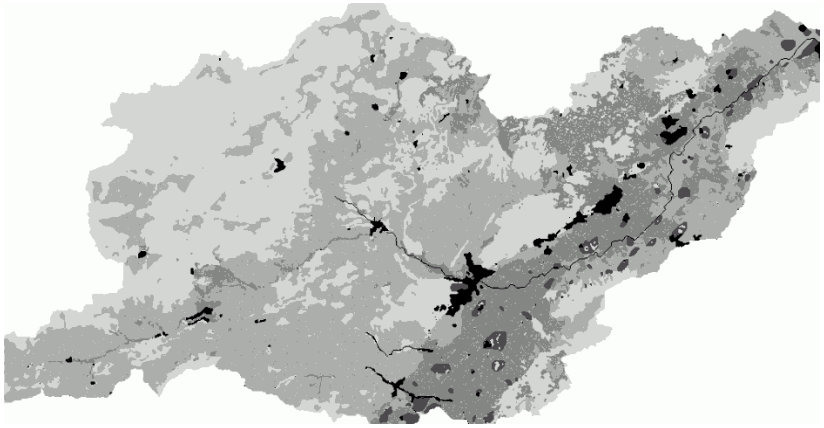
No subsidies for agriculture
Population movement to urban areas with abandonment of rural areas
Manufacturing - increasing scandals of water pollution
- reintervention of government.
Electricity - Continuing trend from middle period (+ some new innovations)
Widespread privatisation of water supply + treatment.
Agriculture - Entrenchment of industrial agriculture in Europe.
Pockets of high pressure on water resources
Locally agriculture outcompetes other sectors
Increasing inter-basin water transfer (now economically viable)
Mass. low level treatment of ag wastes to make ecologically attractive products.
Domestic - Continuing increase in price of water.
Intensive local competition between domestic + agricultural sectors
Increasing economic incentives to improve water use efficiencies + new water saving technologies.

Scenarios – examples: qualitative

Scenarios – examples: qualitative



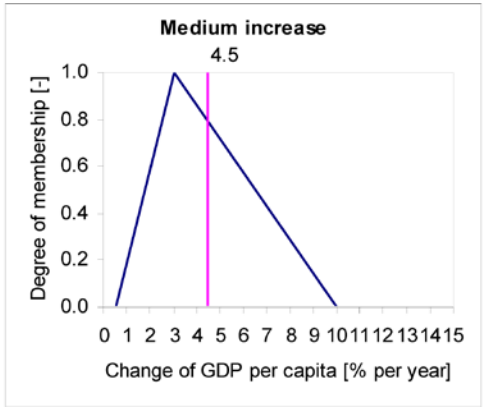
Stakeholder product



Model Output

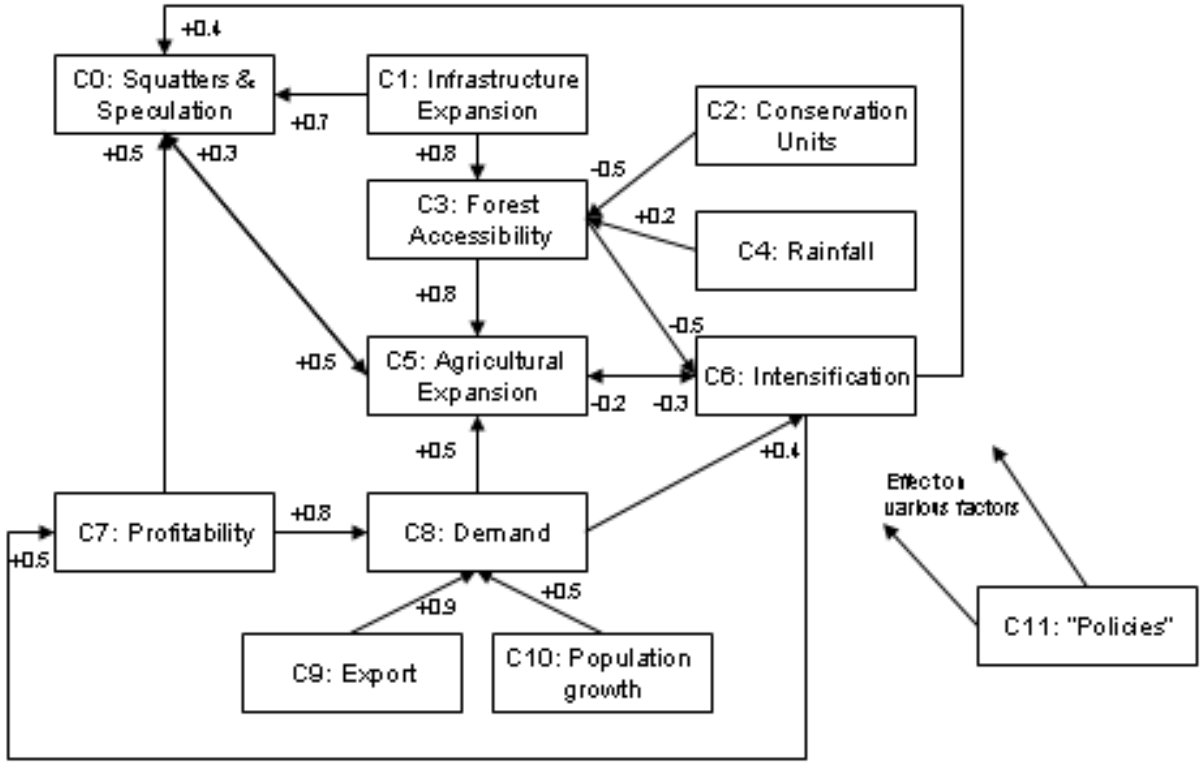
Scenarios – examples: from qualitative to quantitative

Region	Markets First	
	2005-2025	2025-2050
WE	Medium increase	Low increase
CE	Medium increase	Low increase
EE	Medium increase	Medium to high increase

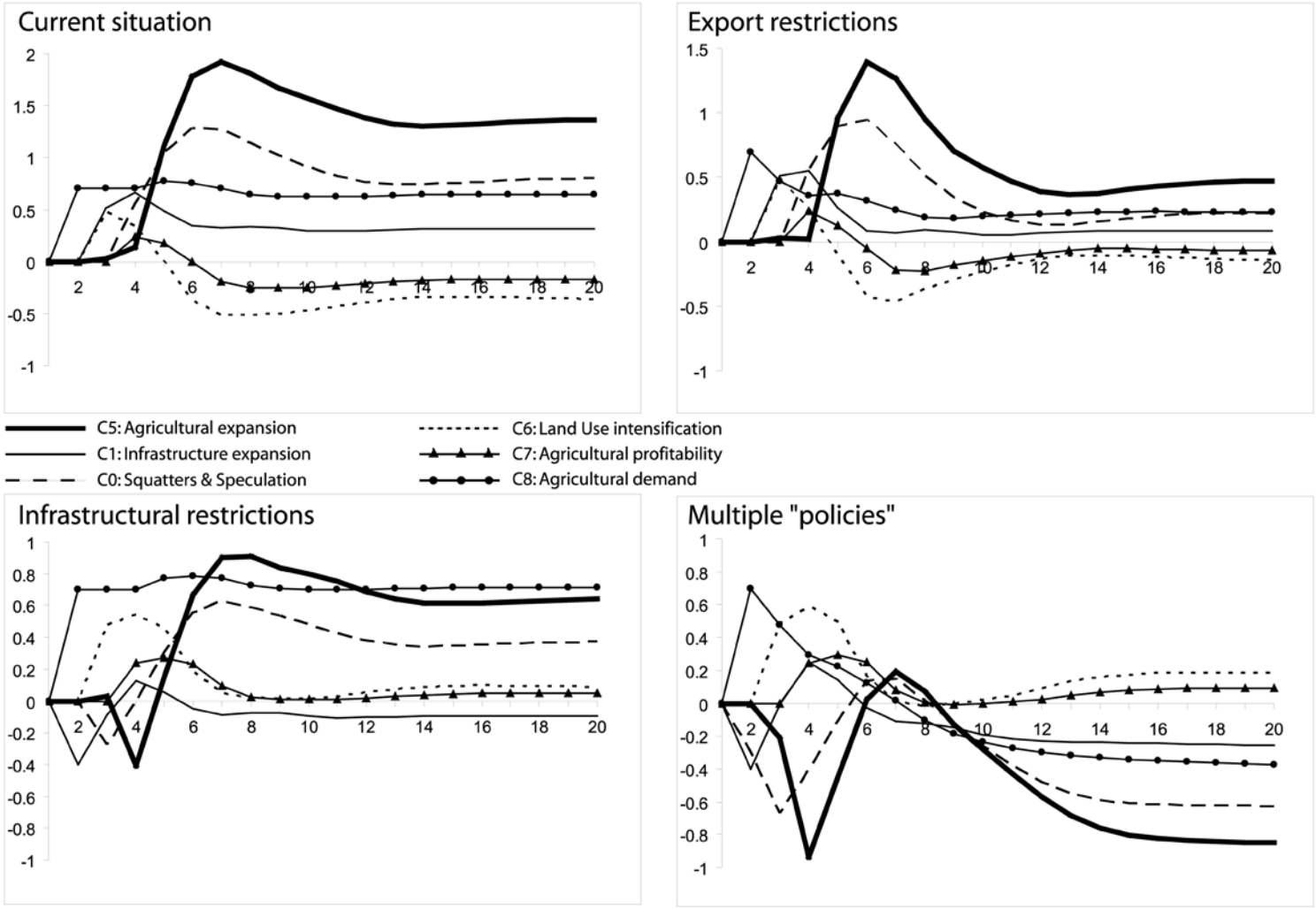


Region	Markets First	
	2005 - 2025	2025 - 2050
WE	+ 4.5	+ 2.3
CE	+ 4.5	+ 2.3
EE	+ 4.5	+ 2.3 -4.5

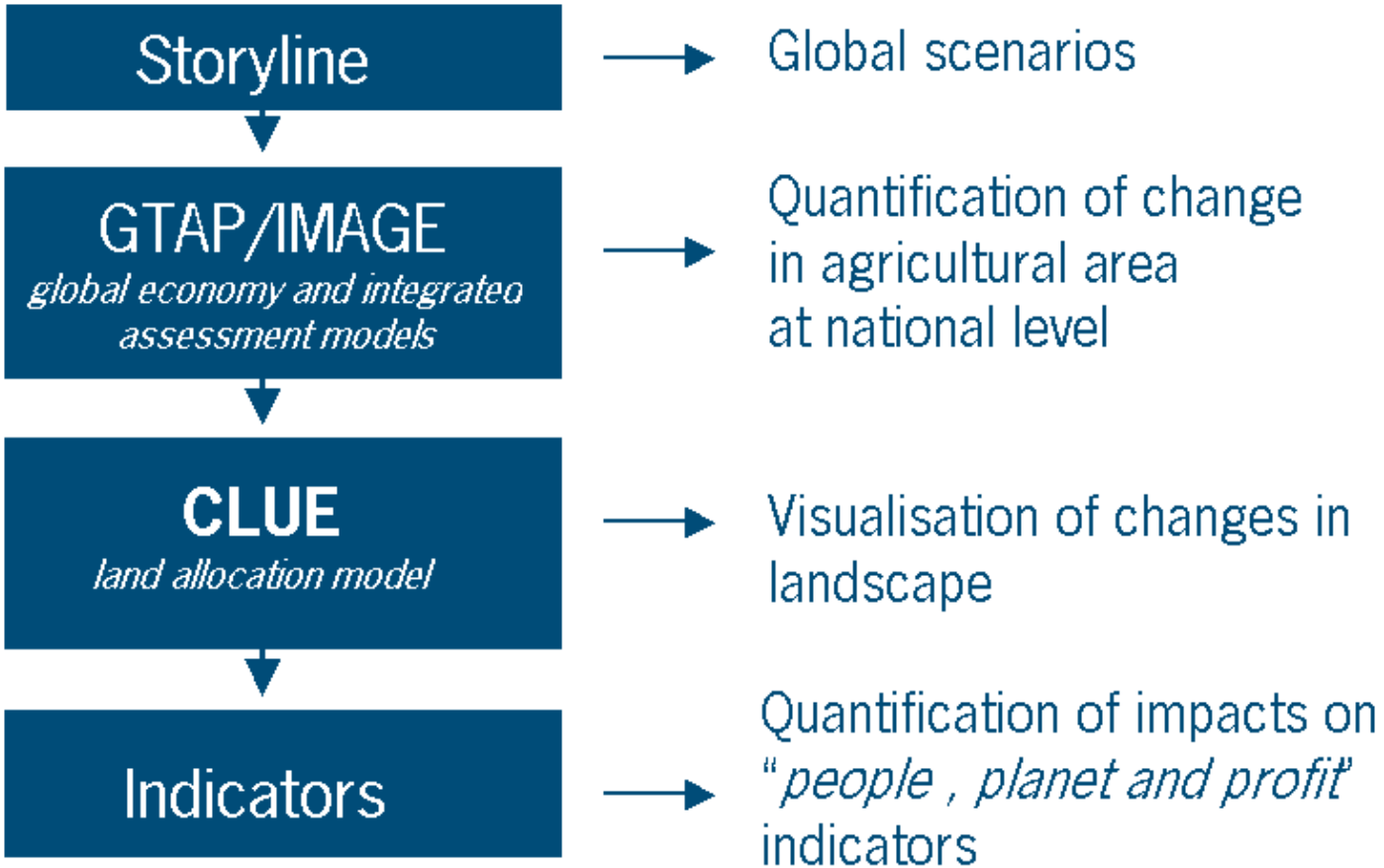
Scenarios – examples: semi-quantitative (FCMs)

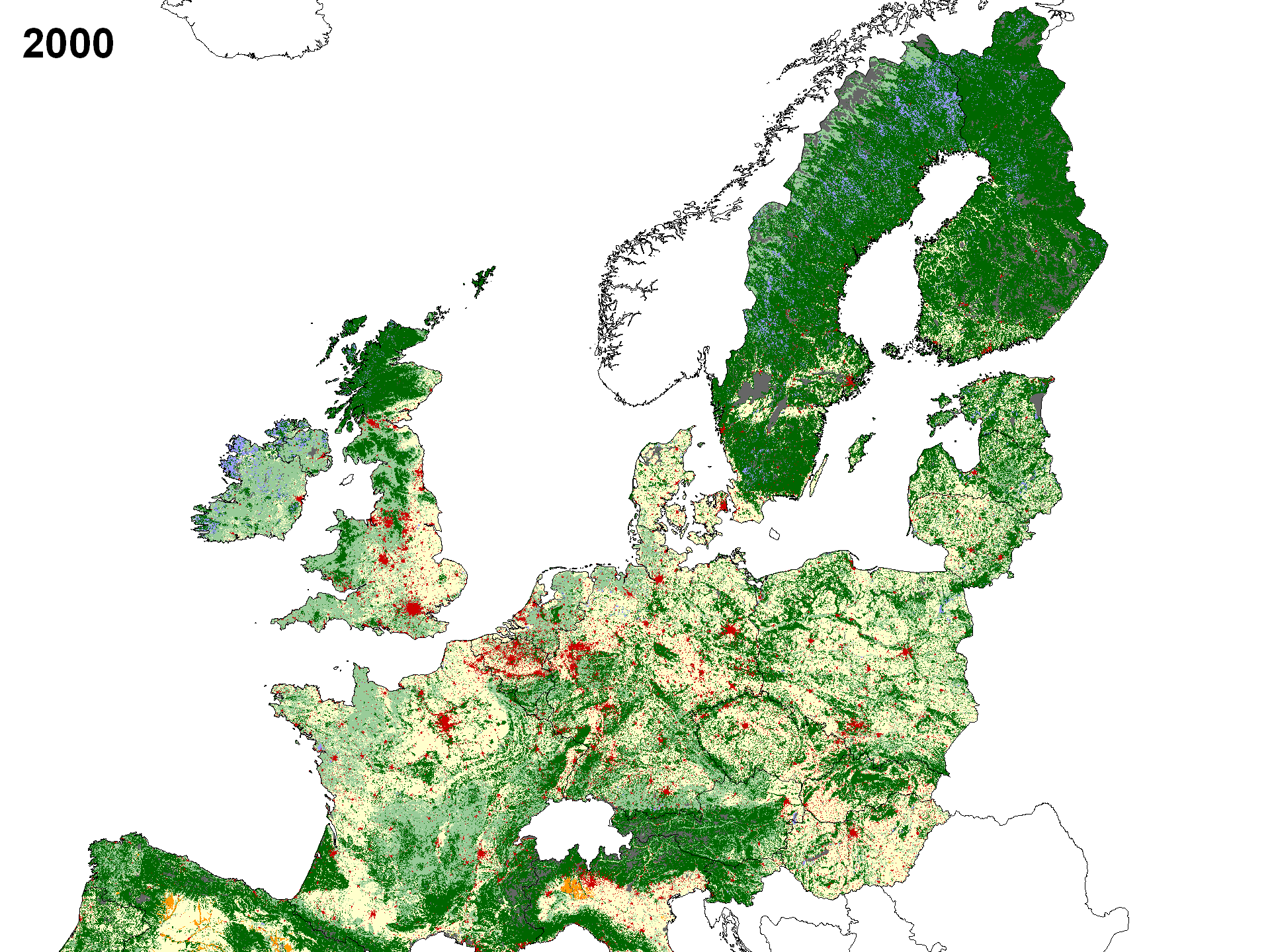


Scenarios – examples: semi-quantitative (FCMs)

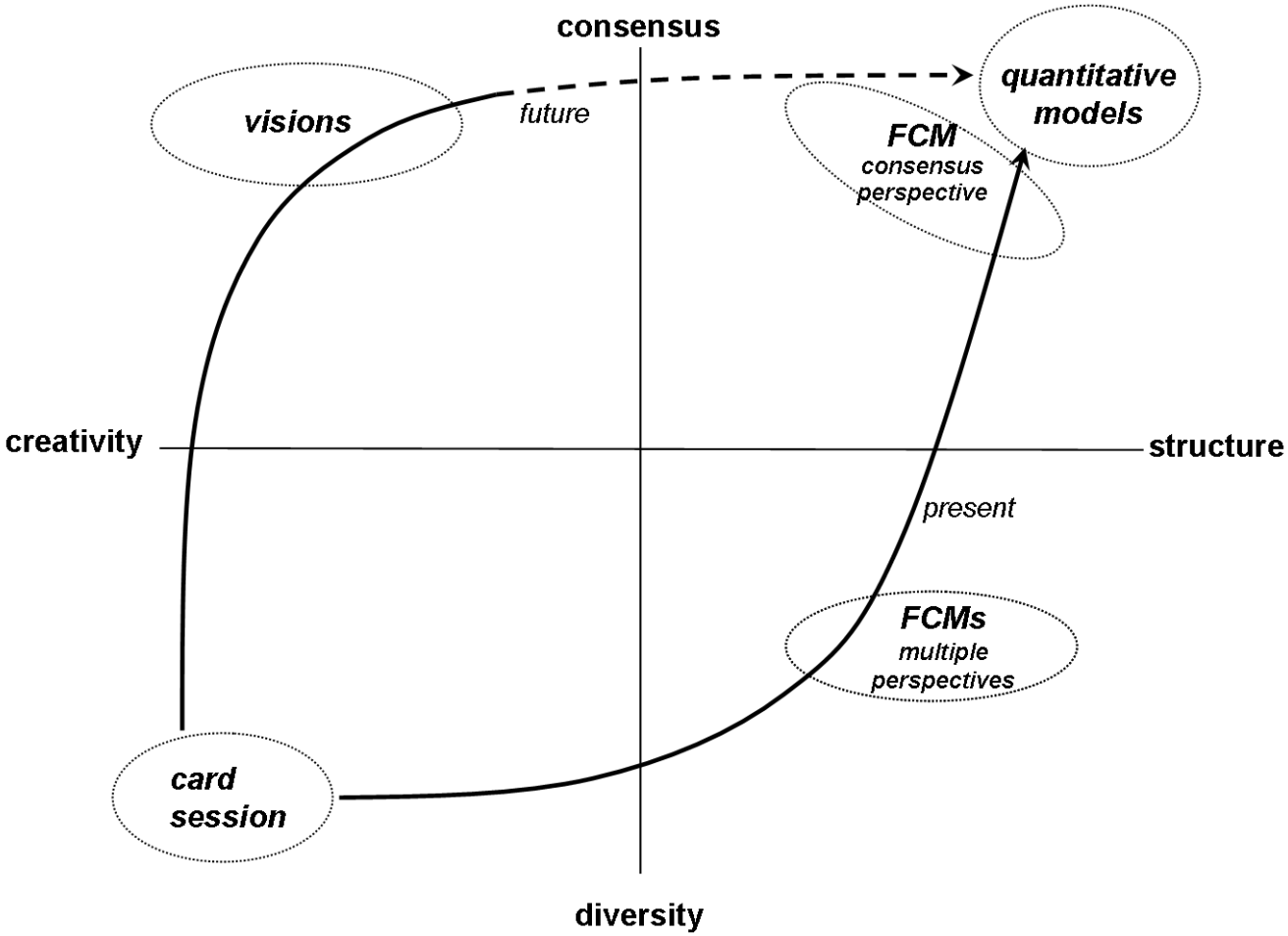


Scenarios – examples: quantitative spatial models




2000

Scenarios – towards a toolbox



Summarsing

- Many of today's problems are complex or wicked
- This creates a fundamental uncertainty on the direction of future changes
- Scale, multi/transdisciplinarity, and stakeholder participation are issues to taken into account
- Scenario development has emerged as a key tool to address the uncertainty
- There are various definitions and many types of scenarios, with a lack of consensus
- SAS, linking models and scenarios through stakeholder participation, is an important approach that is gaining popularity.
- A toolbox of scenario development methods and tools is needed

Conclusions

- Scenario development is an exciting, rapidly growing research arena that deserves to maintain its importance
- Examples will be presented on Wednesday
- In my view you came to the right place!

Questions?