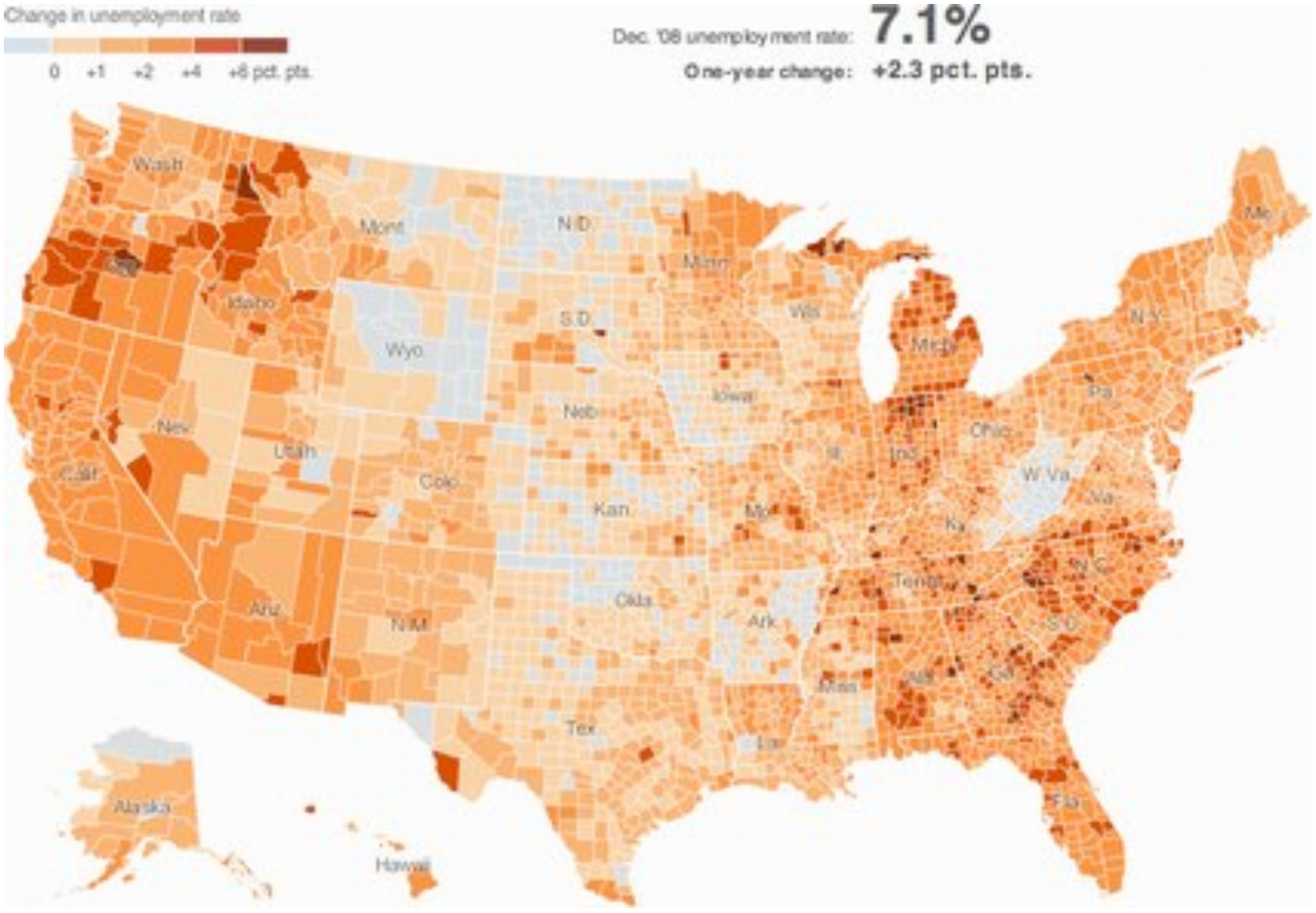
Lecture 6

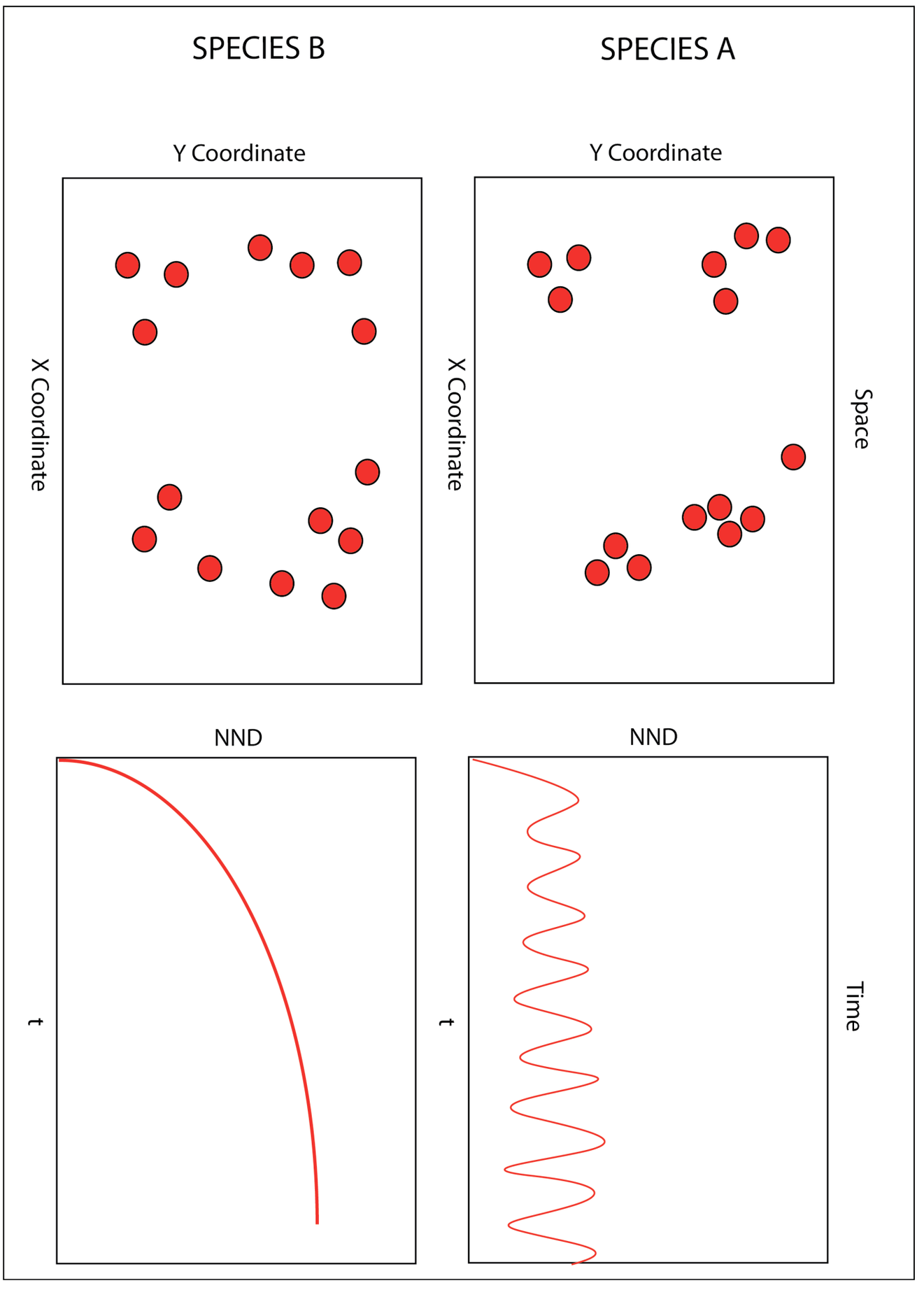
Modeling Patterns

Geog 490/590
Spatial Modeling
Spring 2015

Why are humans better at understanding patterns than processes?


Change in unemployment rate
0
+1
+2
+4
+6 pct. pts.
Dec. '08 unemployment rate: 7.1%
One-year change: +2.3 pct. pts.
Wash
Mont
N.D.
Minn
Idaho
S.D.
Wis
Mich
N.Y.
Me
Wyo
Iowa
Pa
Nev
Neb
Ohio
Utah
Ill
Ind
W.Va
Va
Calif
Colo
Kan
Mo
Ky
N.C.
Tenn
Ariz
N.M.
Okla
Ark
S.C.
Miss
Ala
Ga
Tex
La
Fla
Alaska
Hawaii

As a modeler, what kinds of patterns should you look for and how do you describe them?


SPECIES B
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Y Coordinate
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X Coordinate
X Coordinate
Space
NND
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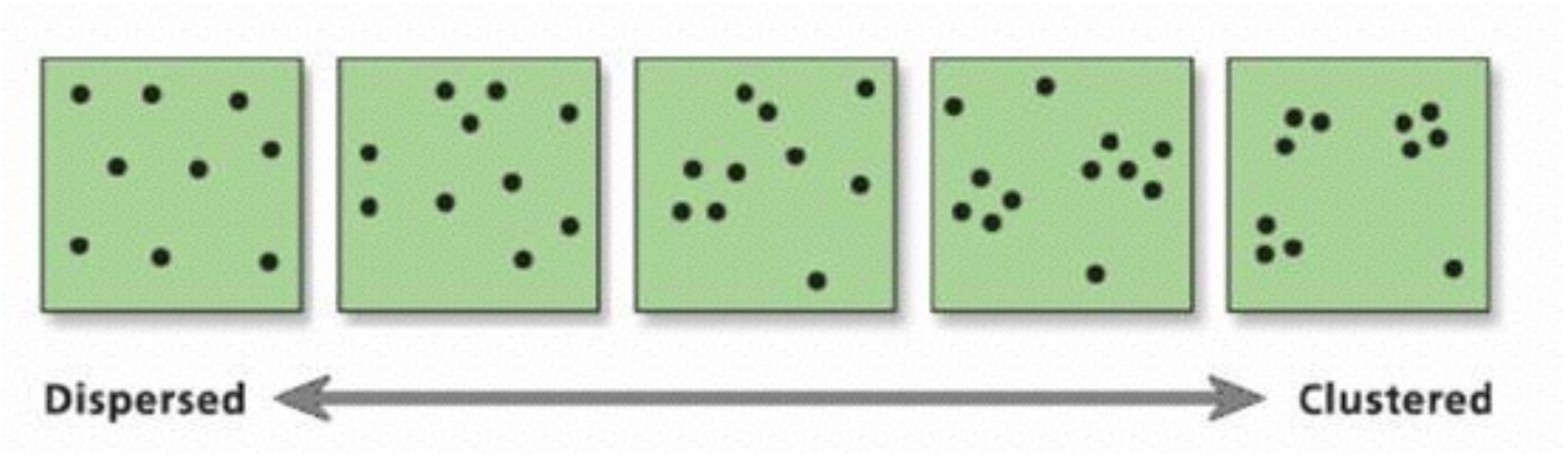
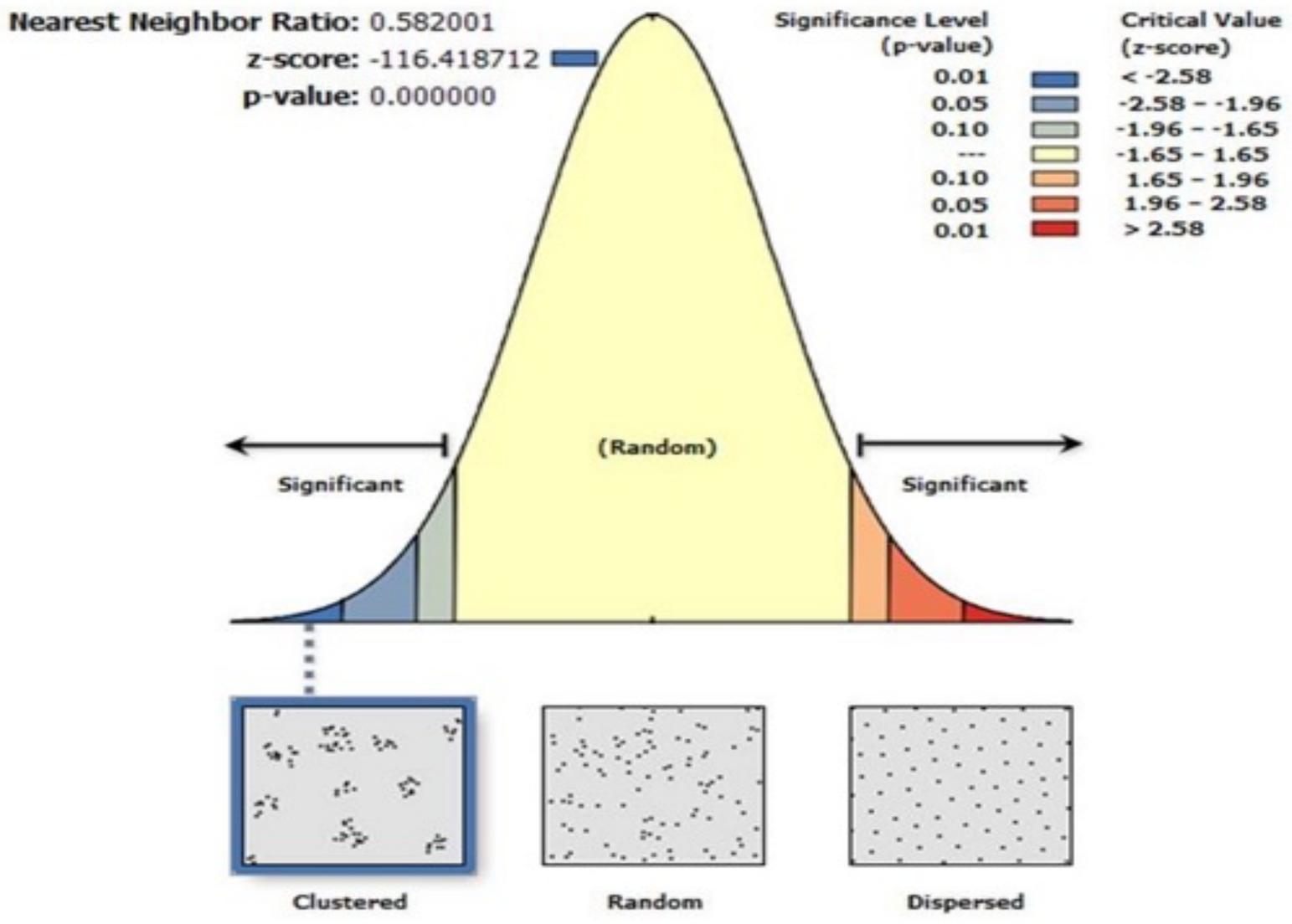
t
Time

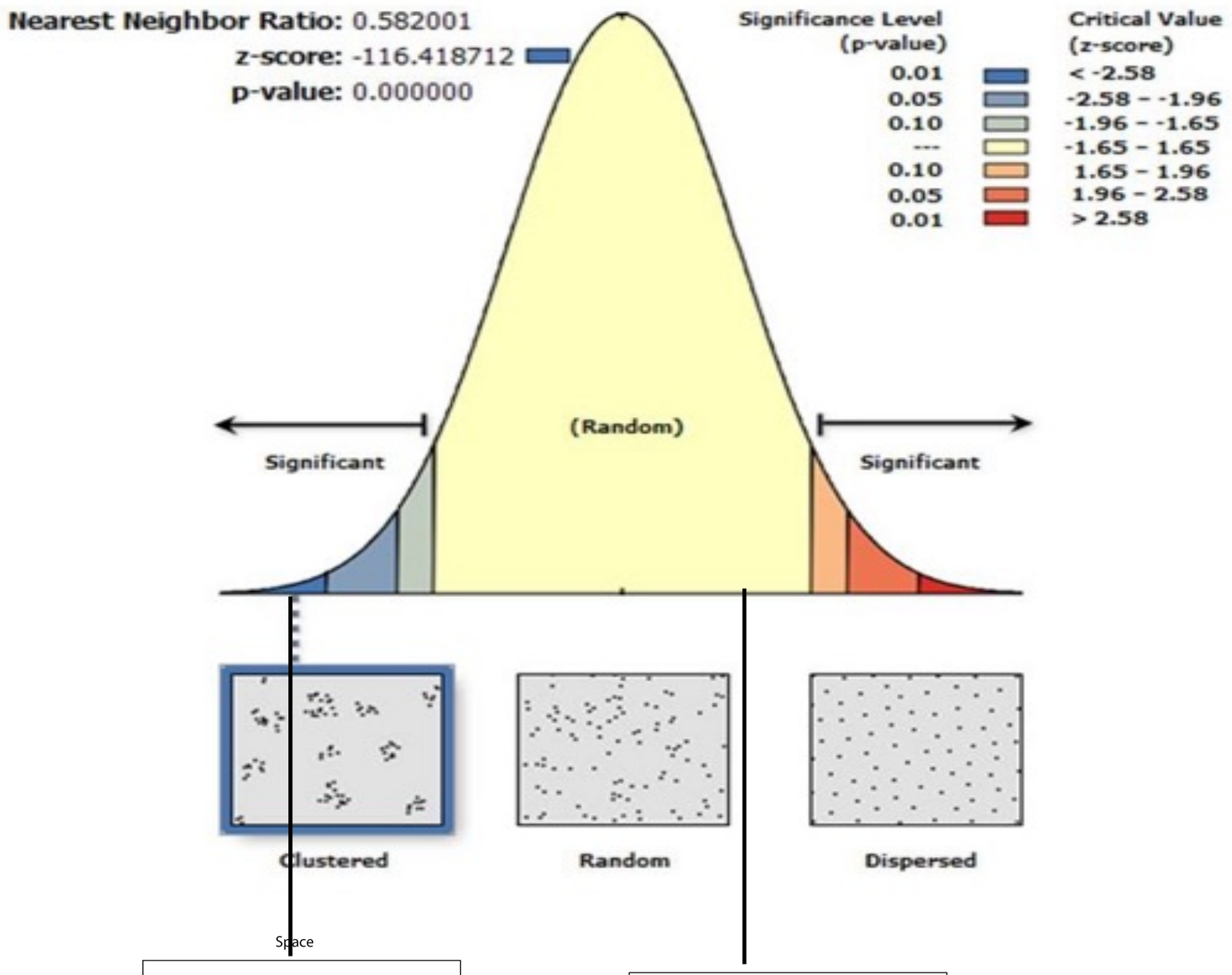
spatial patterns

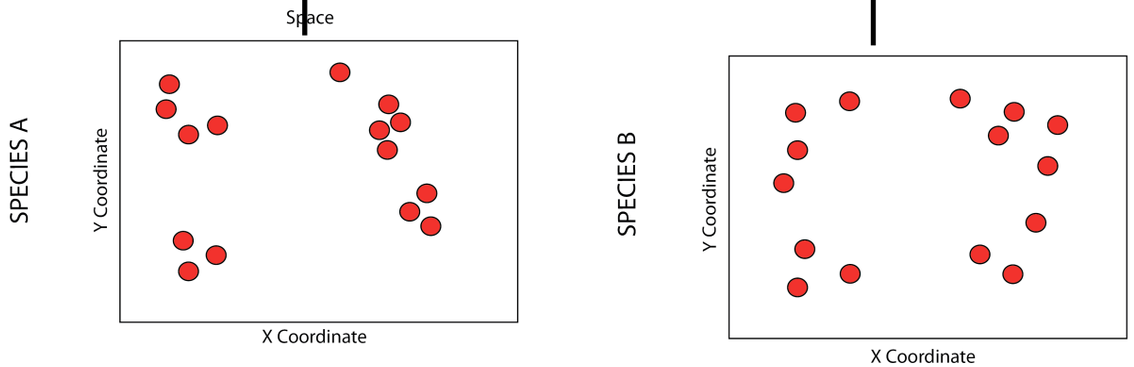


nearest neighbor analysis



nearest neighbor analysis





temporal patterns

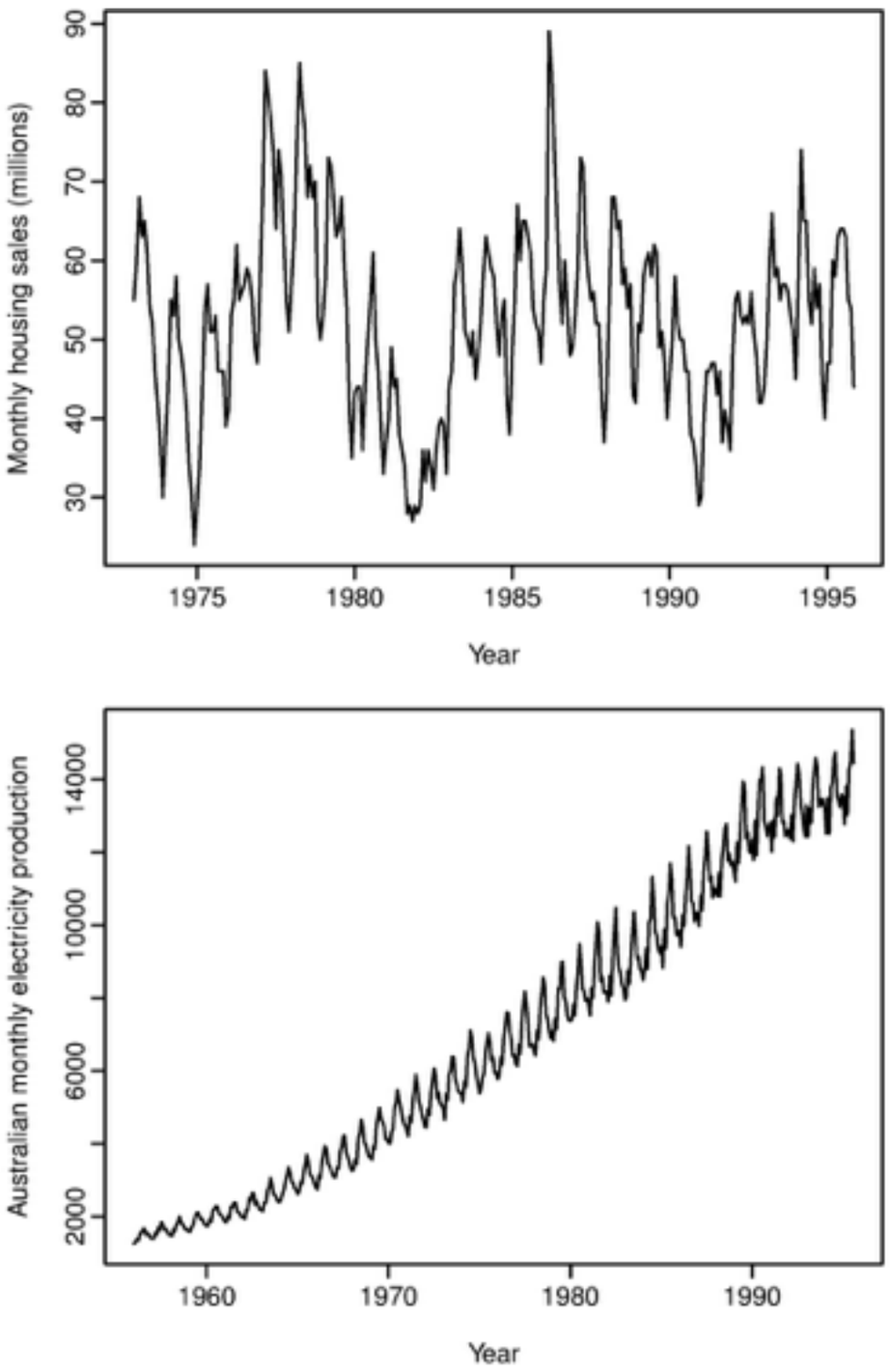
trend: long-term increase or decrease in the data that is not necessarily linear.

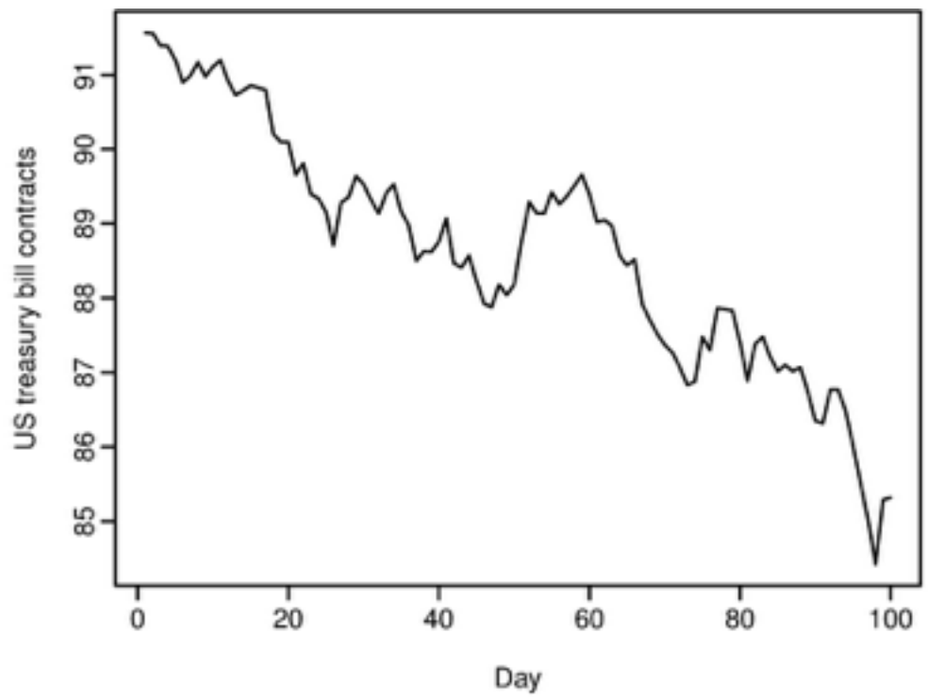
seasonal: when data series is influenced by fixed intervals of time.

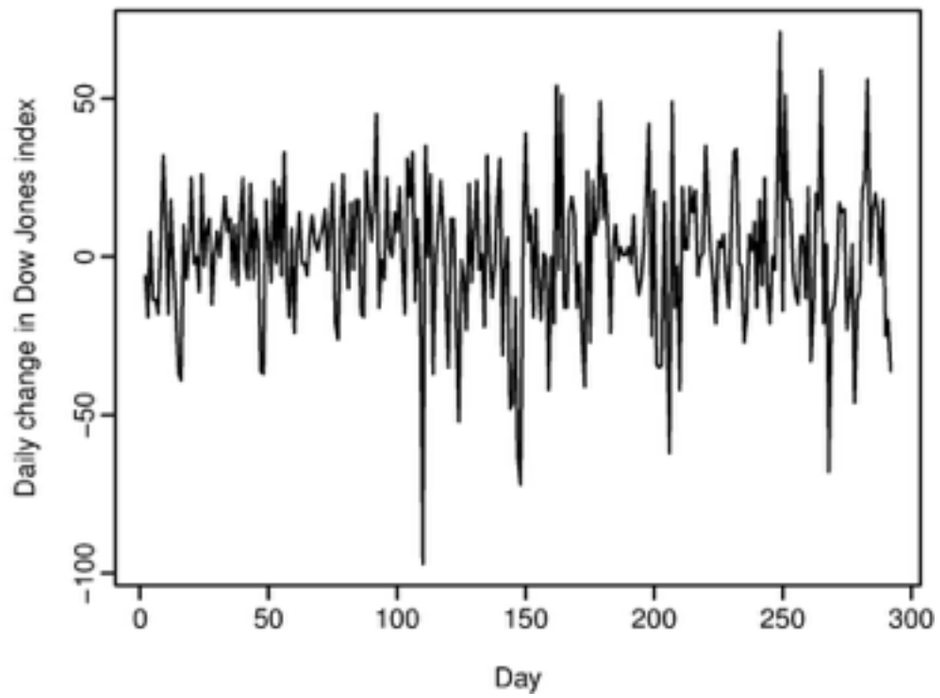
cyclical: data exhibits rises and falls that are not of a fixed time period.

random: no observable trend or pattern in the data.

temporal patterns







How do systems learn?

How do systems adapt?

What are the opposing forces that “keep the drift and tumult of history at bay”?

abstraction

reality

simple decisions

learning

abstraction

reality

rational agents

adaptation

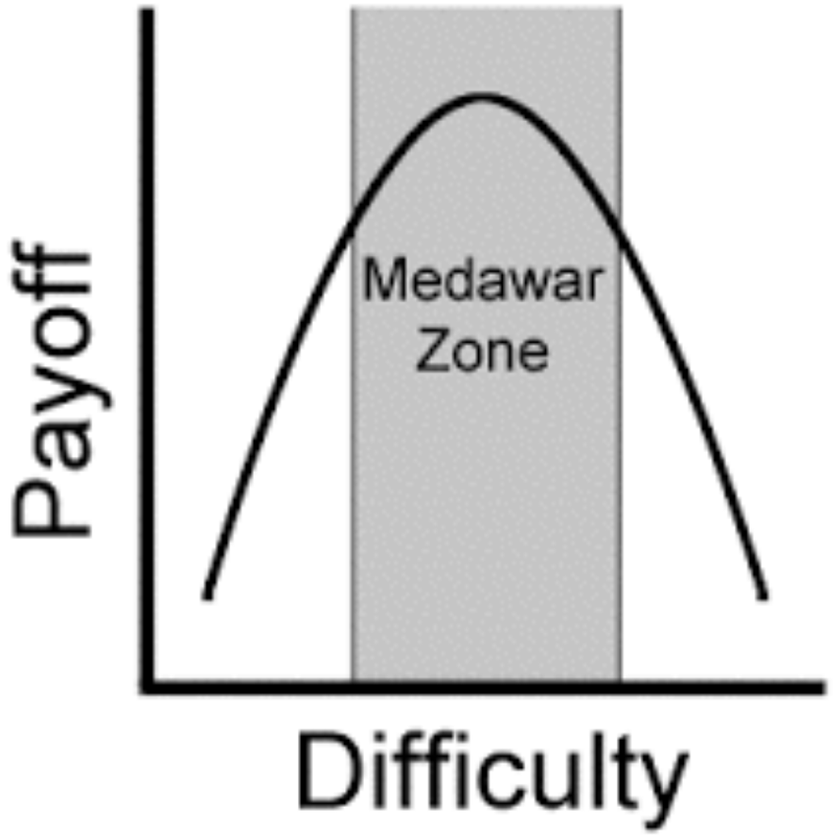
memory

Pattern-Oriented Modeling

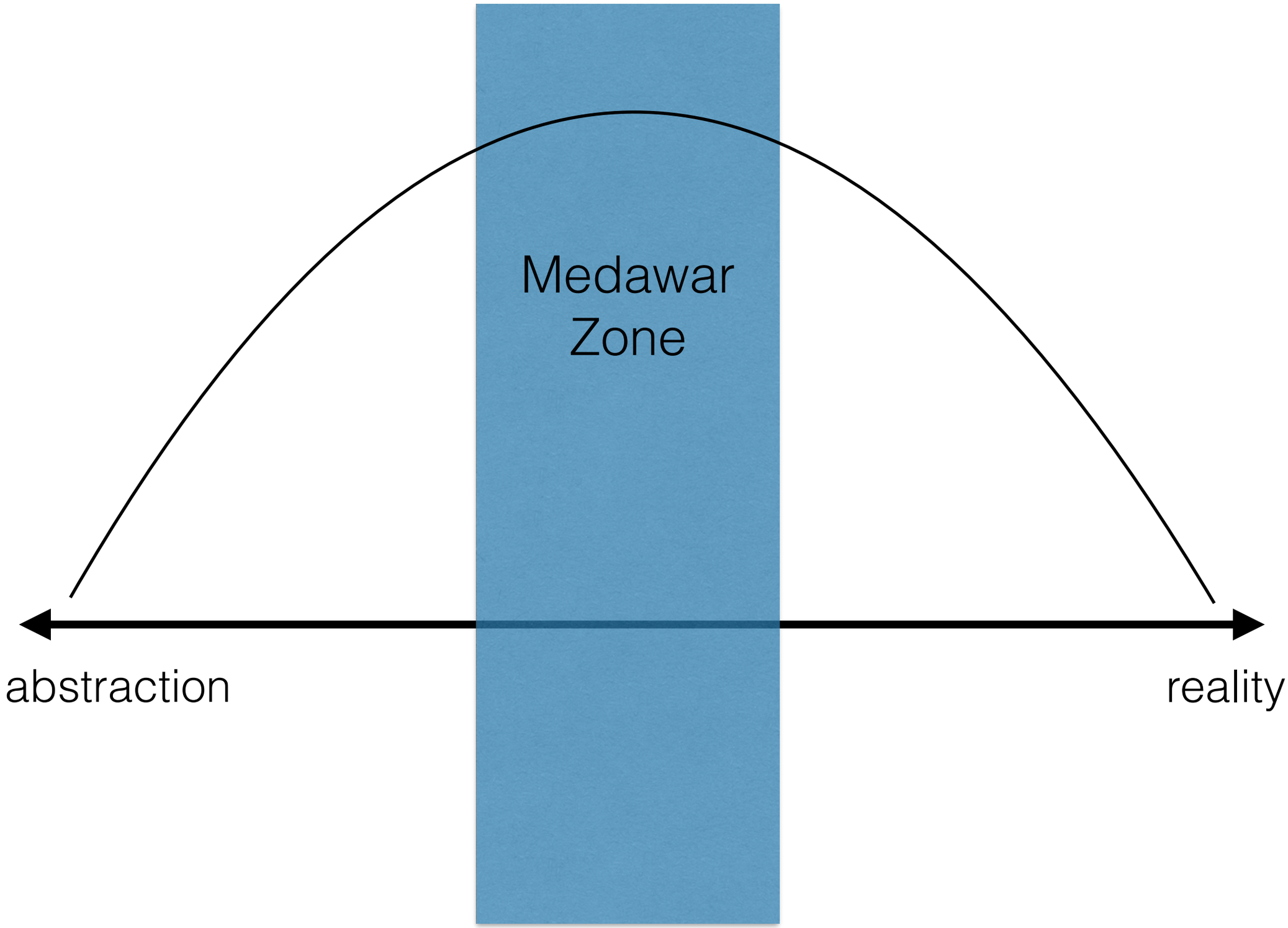
Objective:

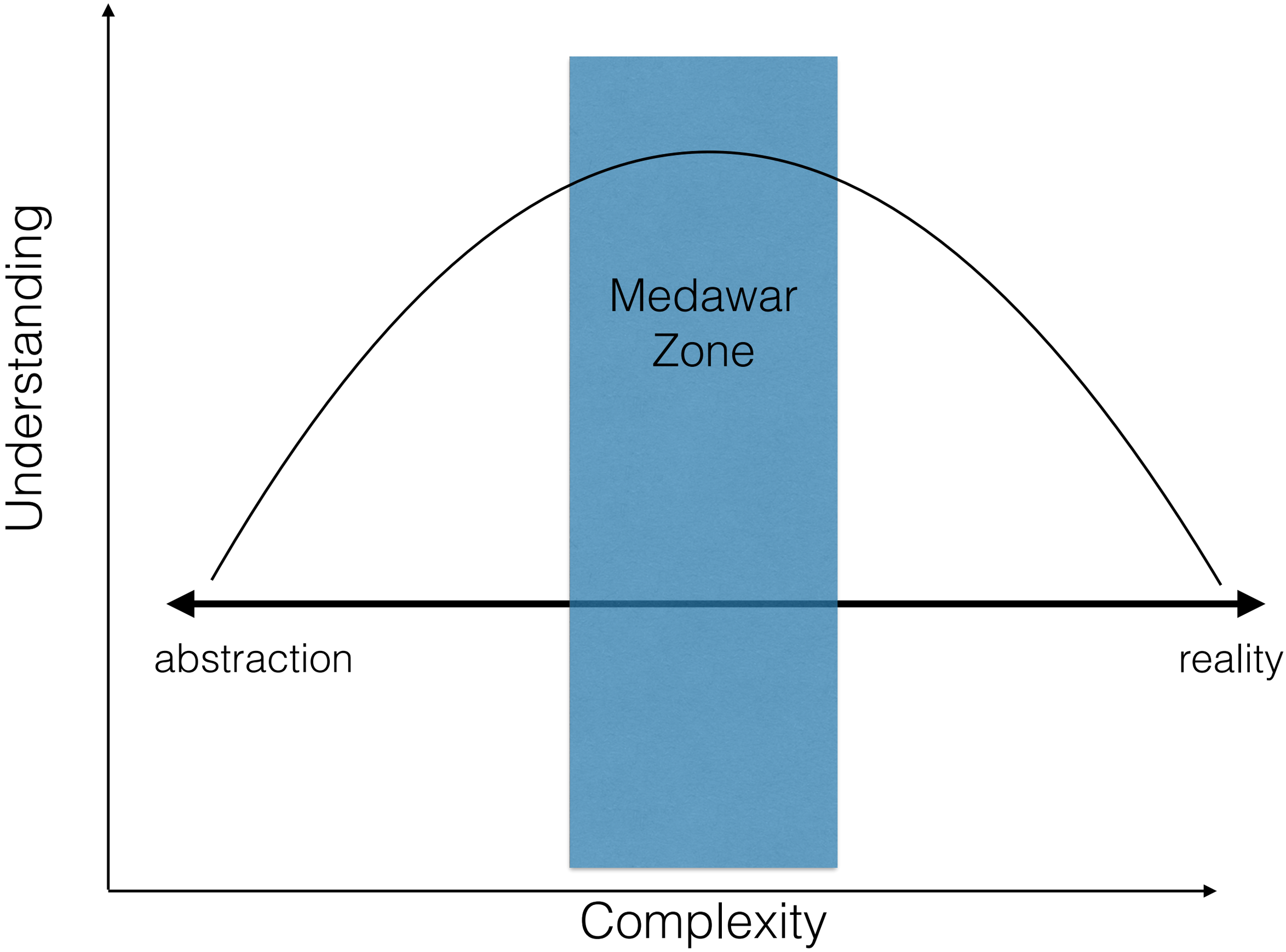
- Decode patterns that we consider to be indicators of the underlying structures and processes.
- Make bottom-up modeling more rigorous and comprehensive

What is the Medawar Zone?




abstraction
reality


Medawar
Zone
abstraction
reality


Understanding
Medawar
Zone
abstraction
reality
Complexity

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A guide to increased creativity in research—inspiration or perspiration?

by Craig Loehle

Back to Introduction

This paper proposes strategies for promoting scientific creativity. After discussing the importance of selecting the right problem or question to investigate, the author examines ways of reducing blocks to creativity. He also advises against becoming an expert in a single, narrow field. The value of unhurried, undirected thinking, and the benefits of activities that give rise to reflective thought—such as walking—are also discussed.

There are four requirements for a successful career in science: knowledge, technical skill, communication, and originality or creativity. Many succeed with largely the first three. Those who are meticulous and skilled can make a considerable name by doing the critical experiments that test someone else's ideas or by measuring something more accurately than anyone else. But in such areas of science as biology, anthropology, medicine, and theoretical physics, more creativity is needed because phenomena are complex and multivariate.

Innovative scientists are held in high regard, but the means by which they achieve innovation are not spelled out in any manual for graduate students. Courses on the scientific method (which few biology students take anyway) do not mention the subject. Philosophers of science are more concerned with formal theory structure, proof, logic, and epistemology. Karl Popper (1963), for example, invokes the generation of alternative hypotheses but says nothing about where one is to get them.

The purpose of this article is to present certain strategies that may promote scientific creativity. The pressures on scientists today oppose truly creative thinking. Pressures to write grants, teach, and publish leave little time for undirected thinking. Industrial laboratories today are far more directed than in the past, particularly where costs per experiment are high. I also want to counter the widely held view that creativity is something one is either born with or lacks, with no hope of training.

Choosing a problem

Perhaps the most important single step in the research process is choosing a question to investigate. What most distinguishes those scientists noted by posterity is not their technical skill, but that they chose interesting problems. There is some guidance that may be given.

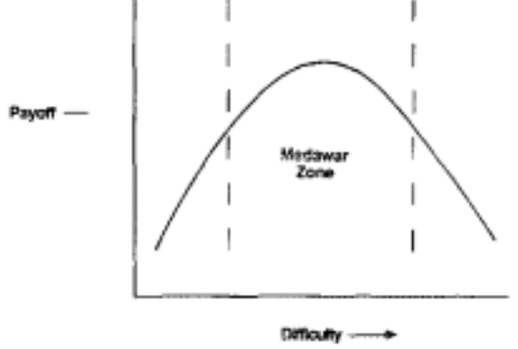


Figure 1. Relationship between degree of difficulty and payoff from solving a problem. Solving problems that are too easy does not advance science, whereas those that are too difficult may be impossible for other scientists to understand, i.e., they are premature. The Medawar zone refers to Peter Medawar's (1967) reference to science as "the art of the soluble."

Choosing a problem

Perhaps the most important single step in the research process is choosing a question to investigate. What

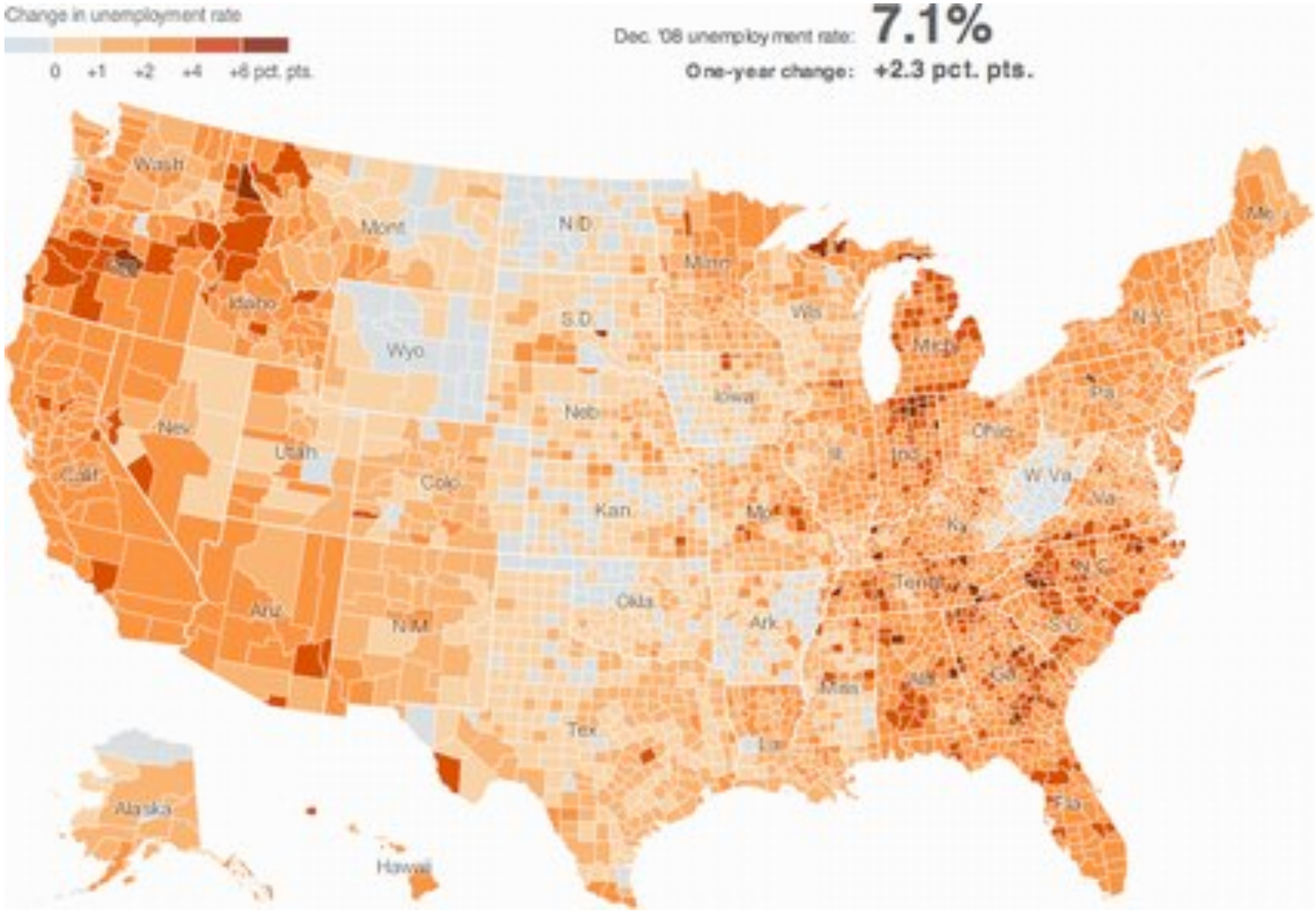
Benefits of Pattern-Oriented Modeling

1. Assist in model design by examining patterns at multiple scales

2. Contrasting alternative theories

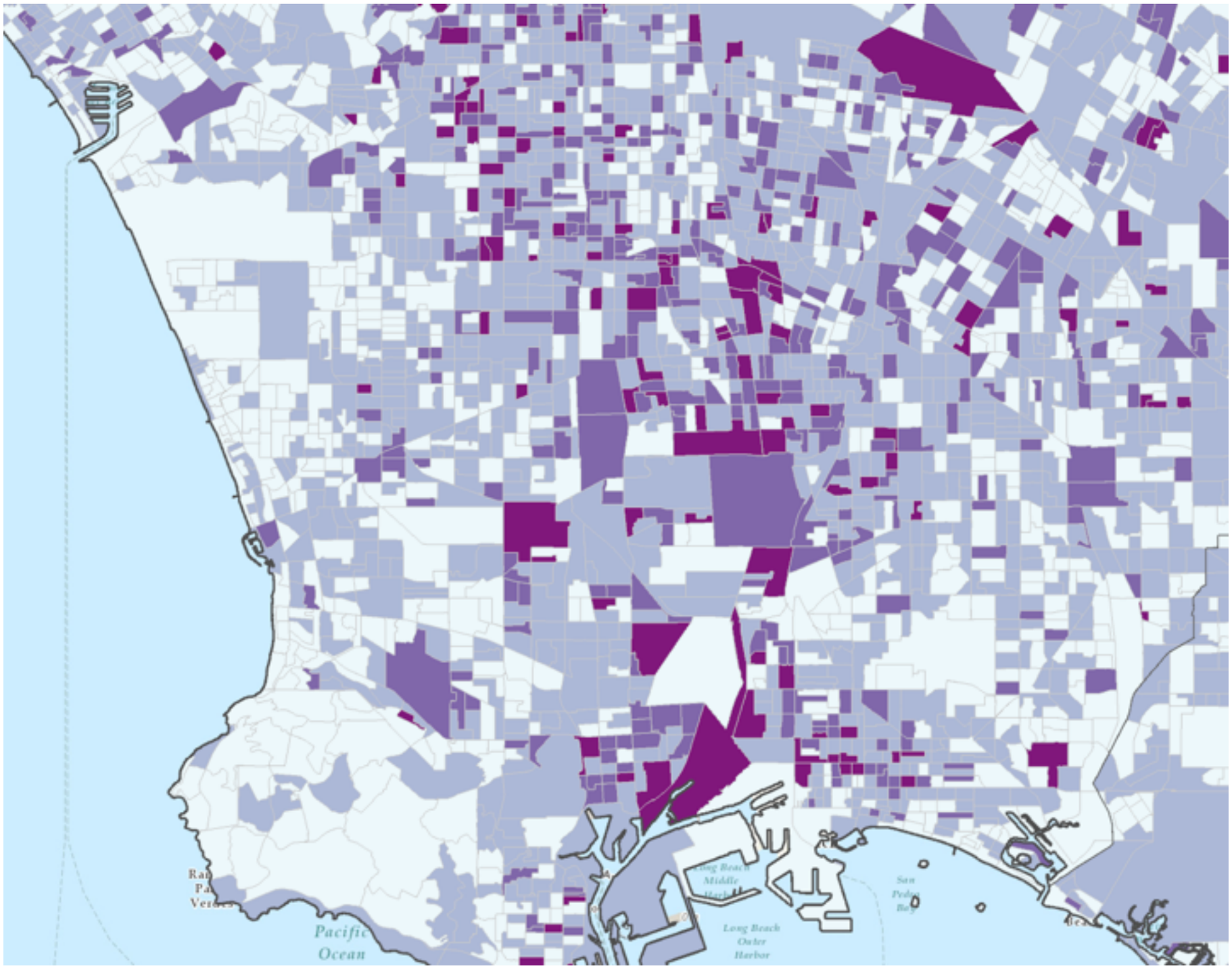
3. Cope with uncertainty

Patterns at Different Scales



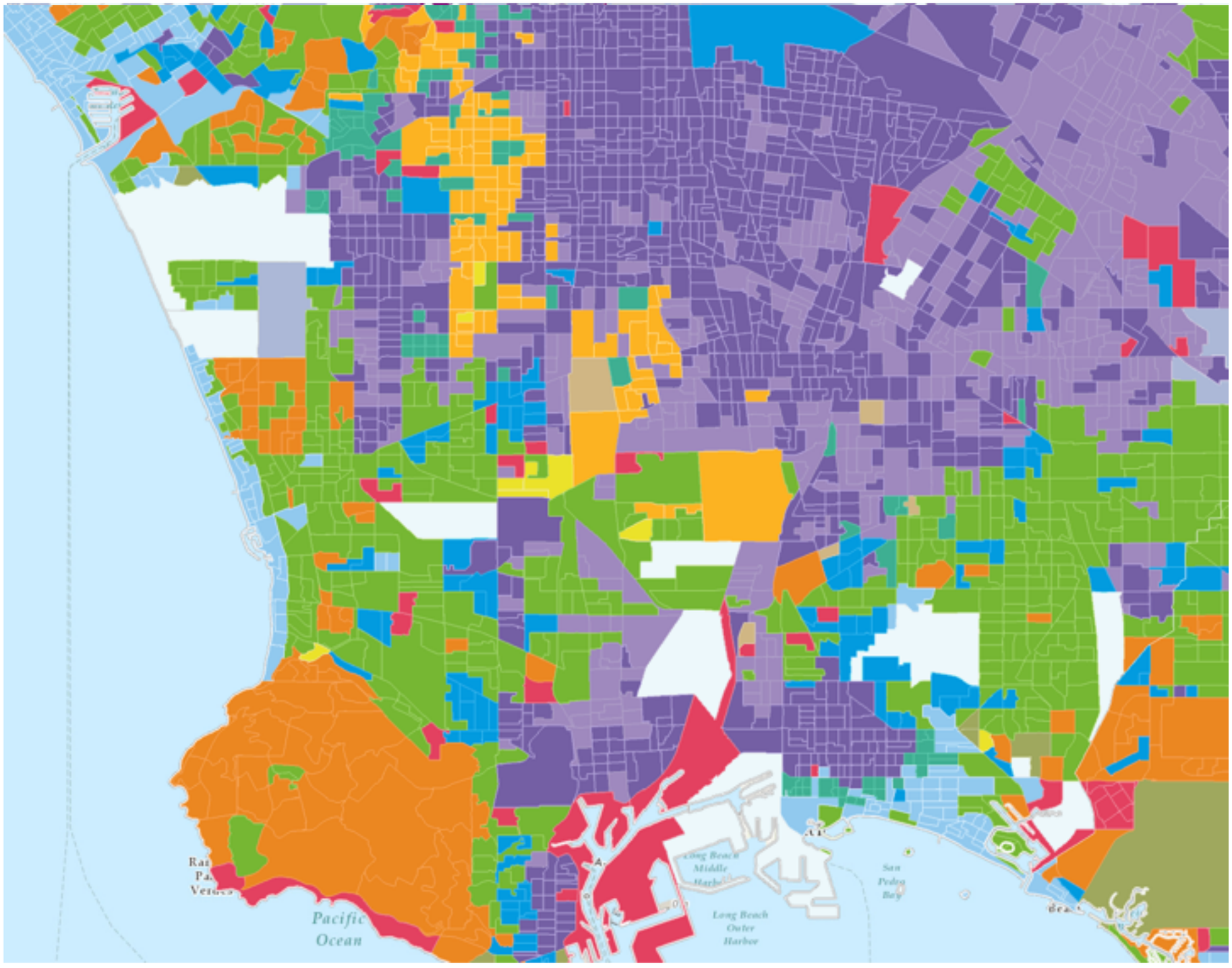
Patterns at Different Scales

Unemployment

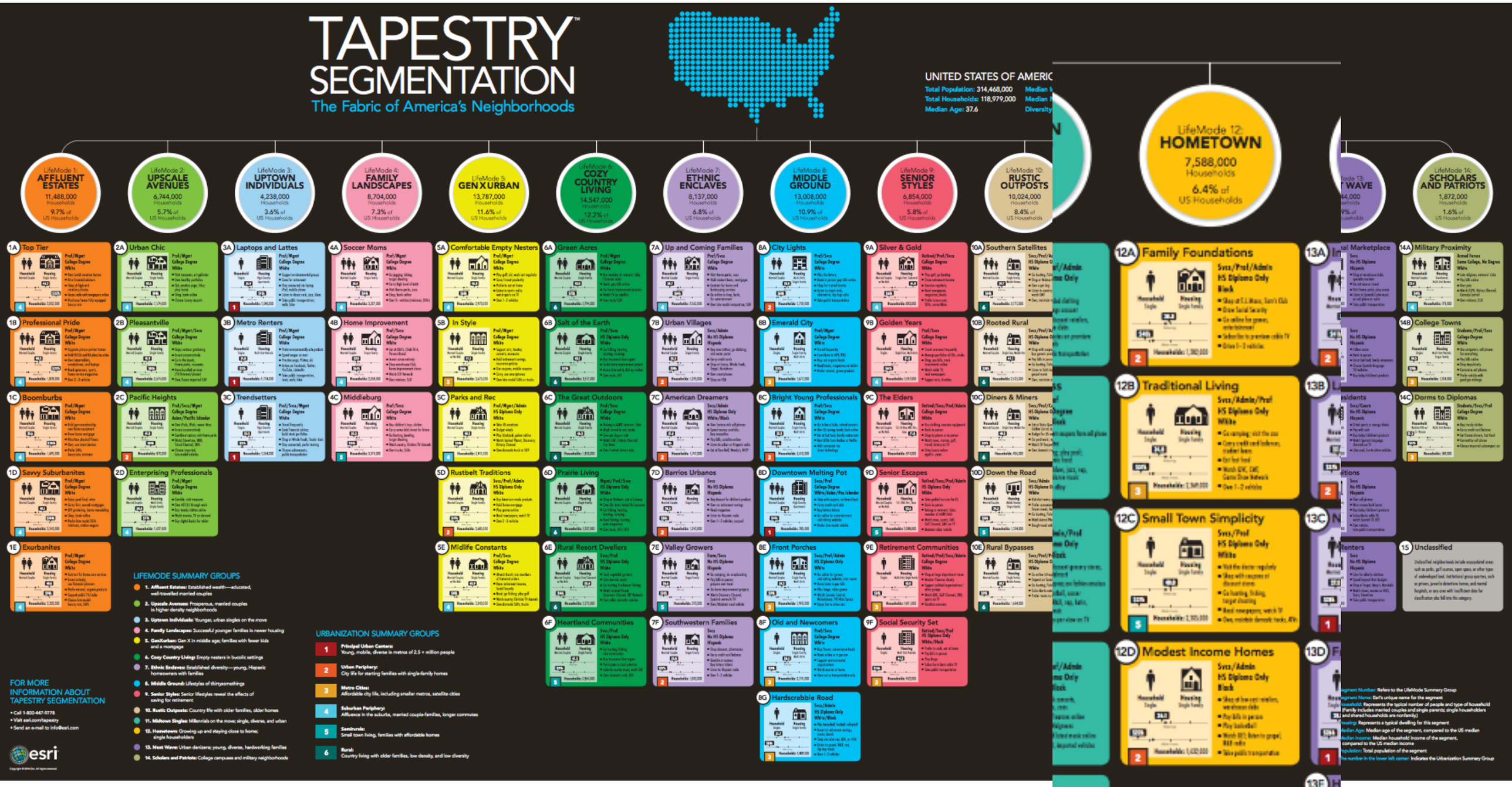


Patterns at Different Scales

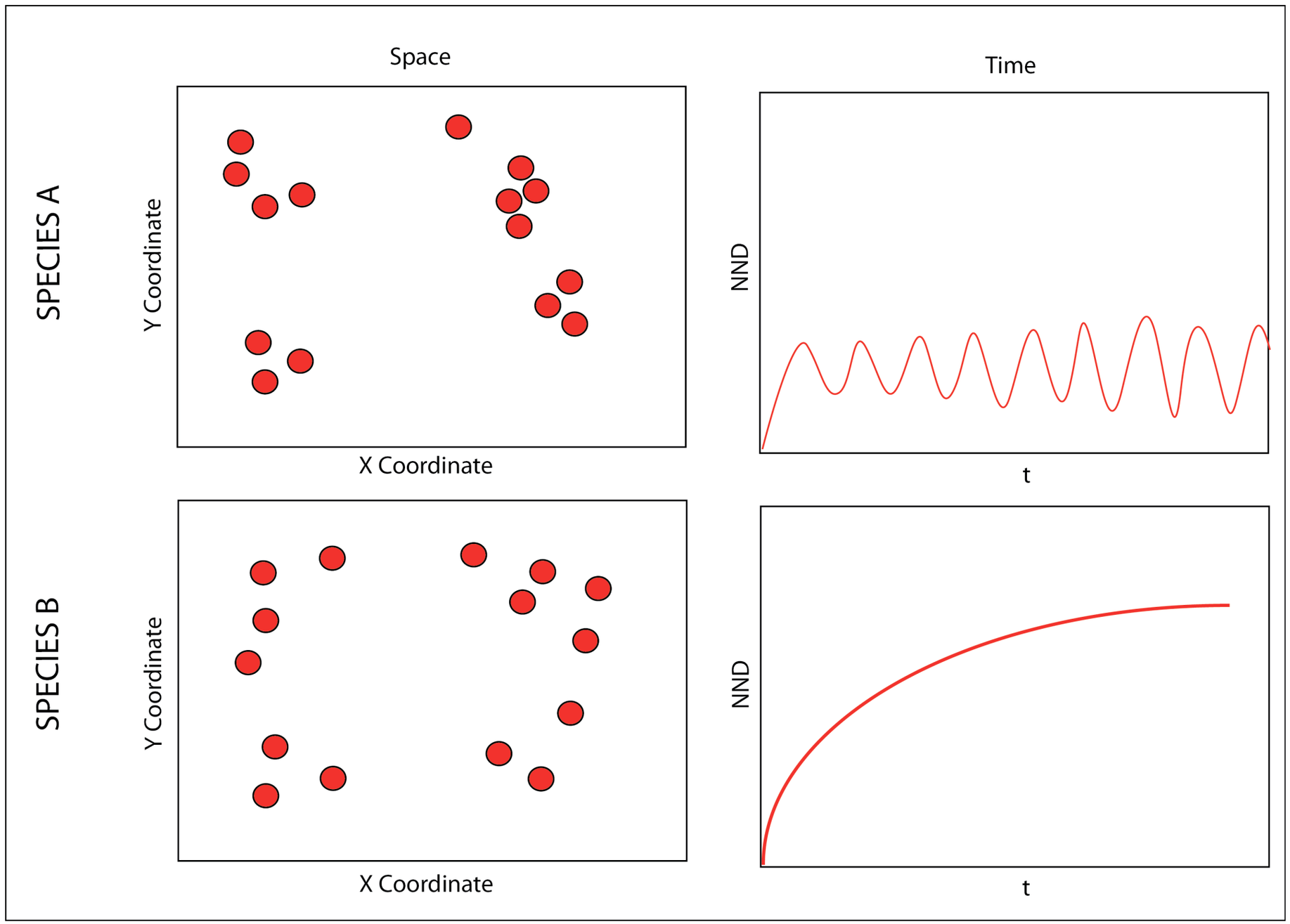
Tapestry Segmentation



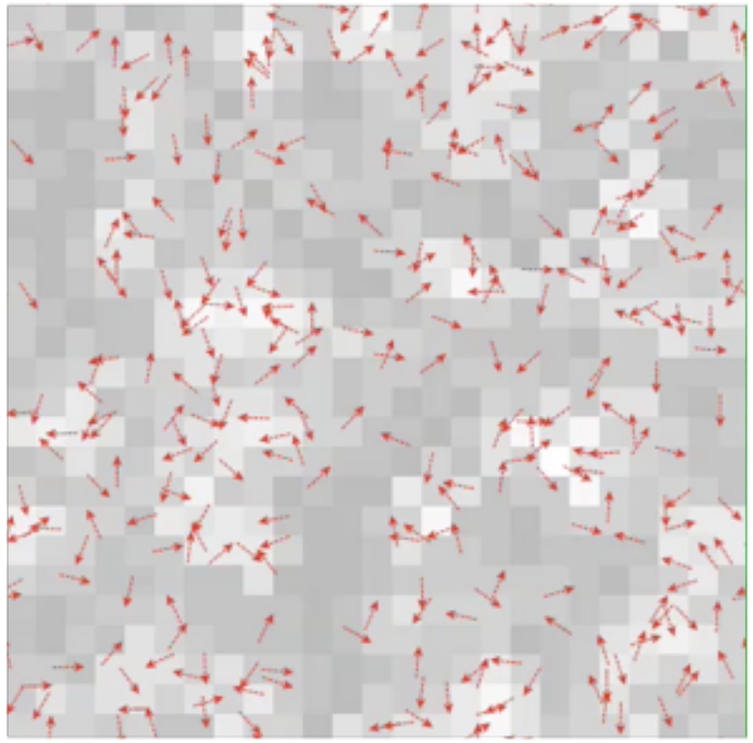
Patterns at Different Scales

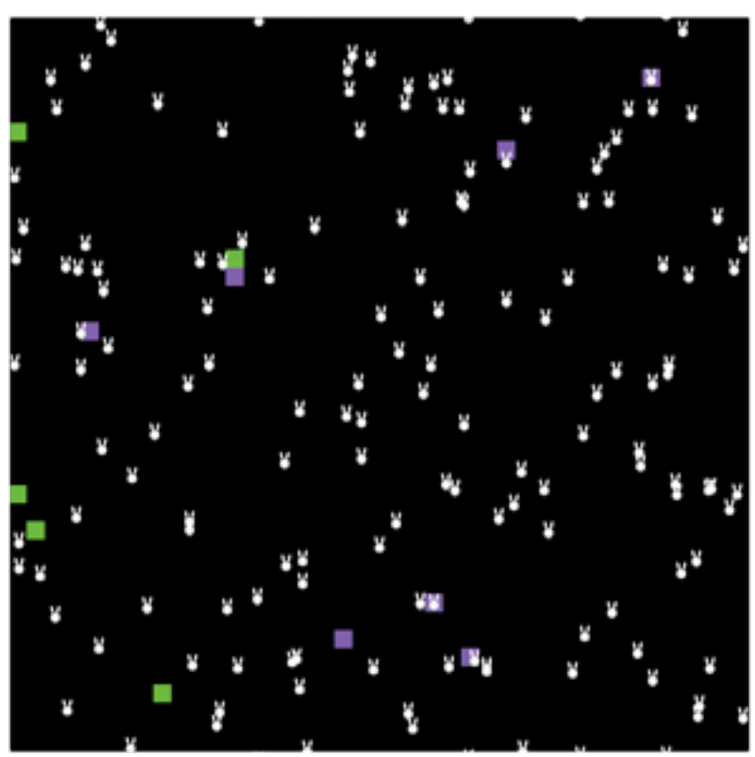


Contrasting Theories



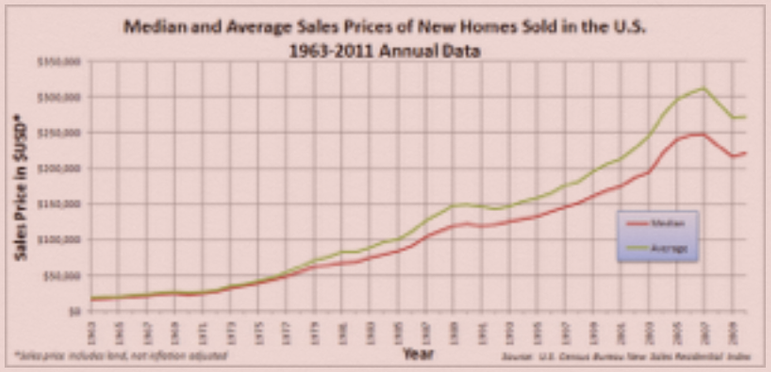
Contrasting Theories

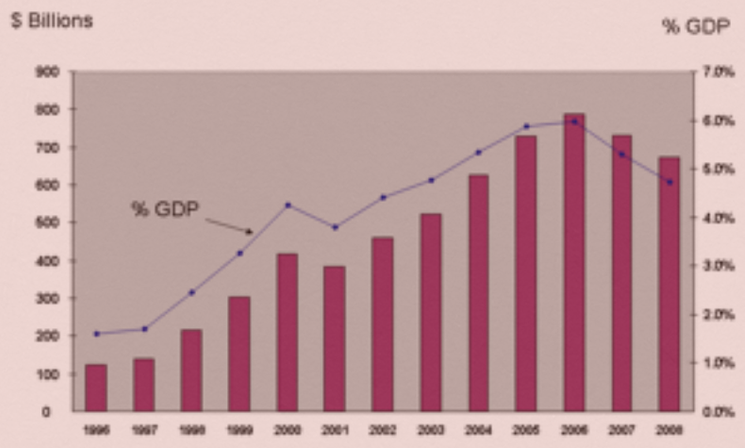




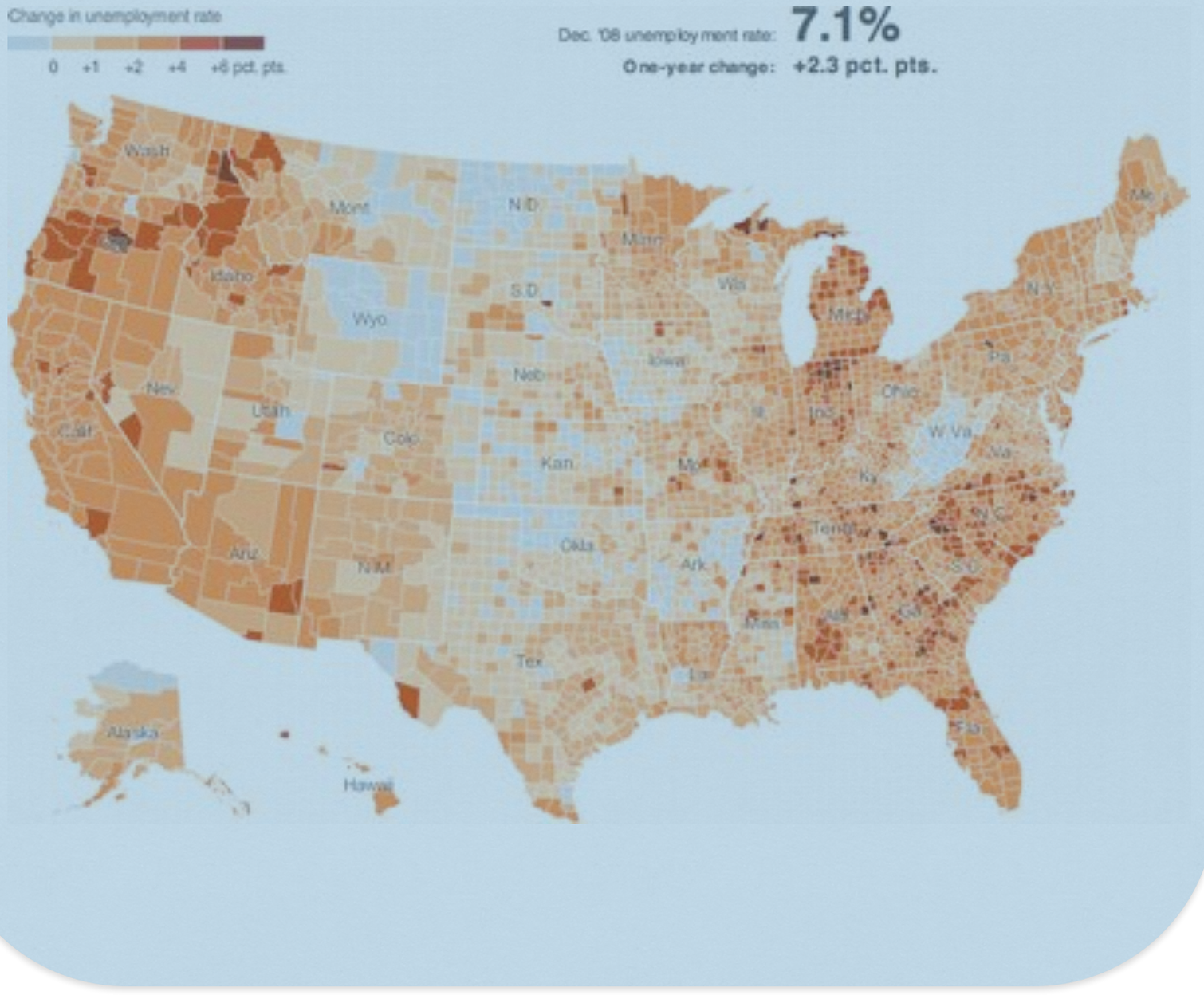
Contrasting Theories

Theories





Pattern

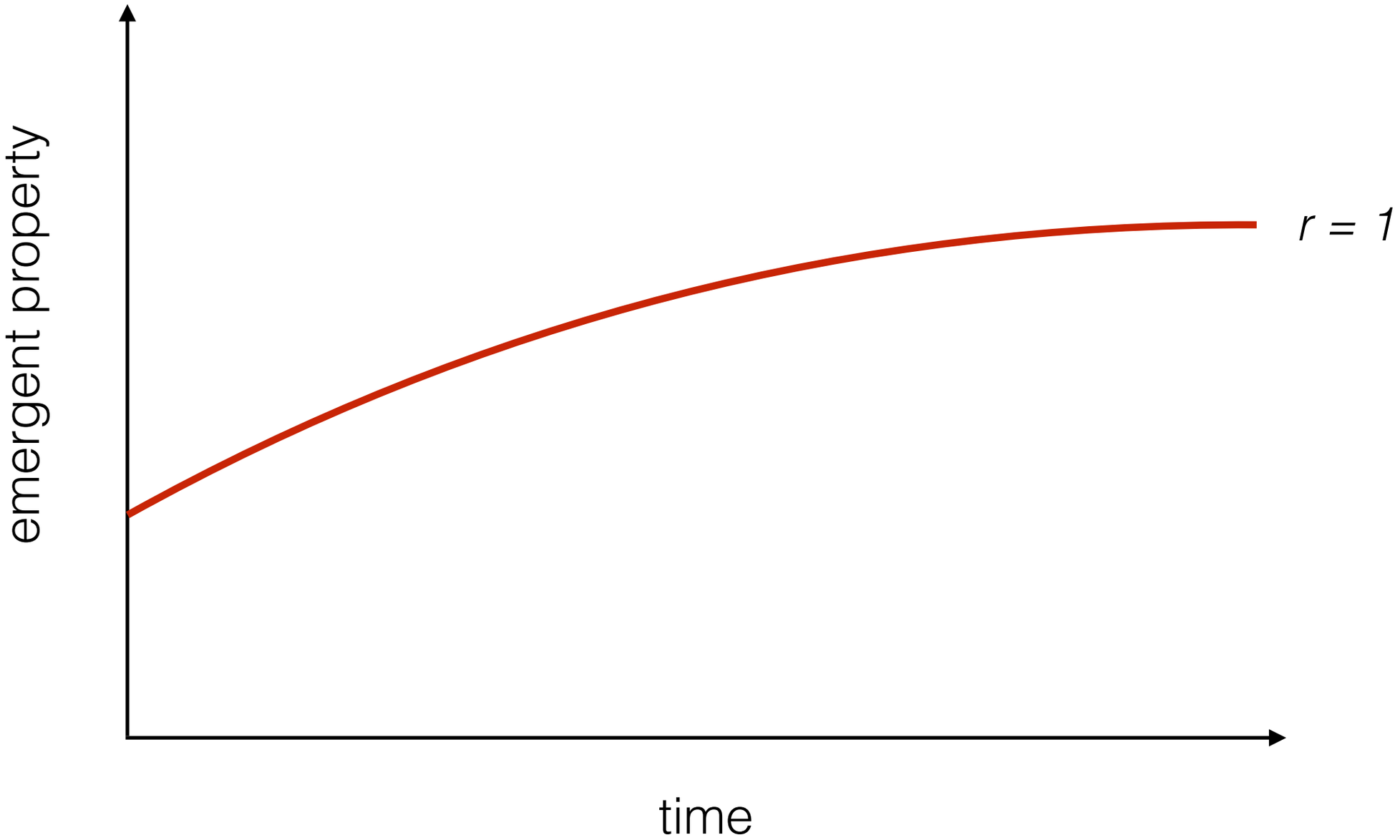


Coping with Uncertainty

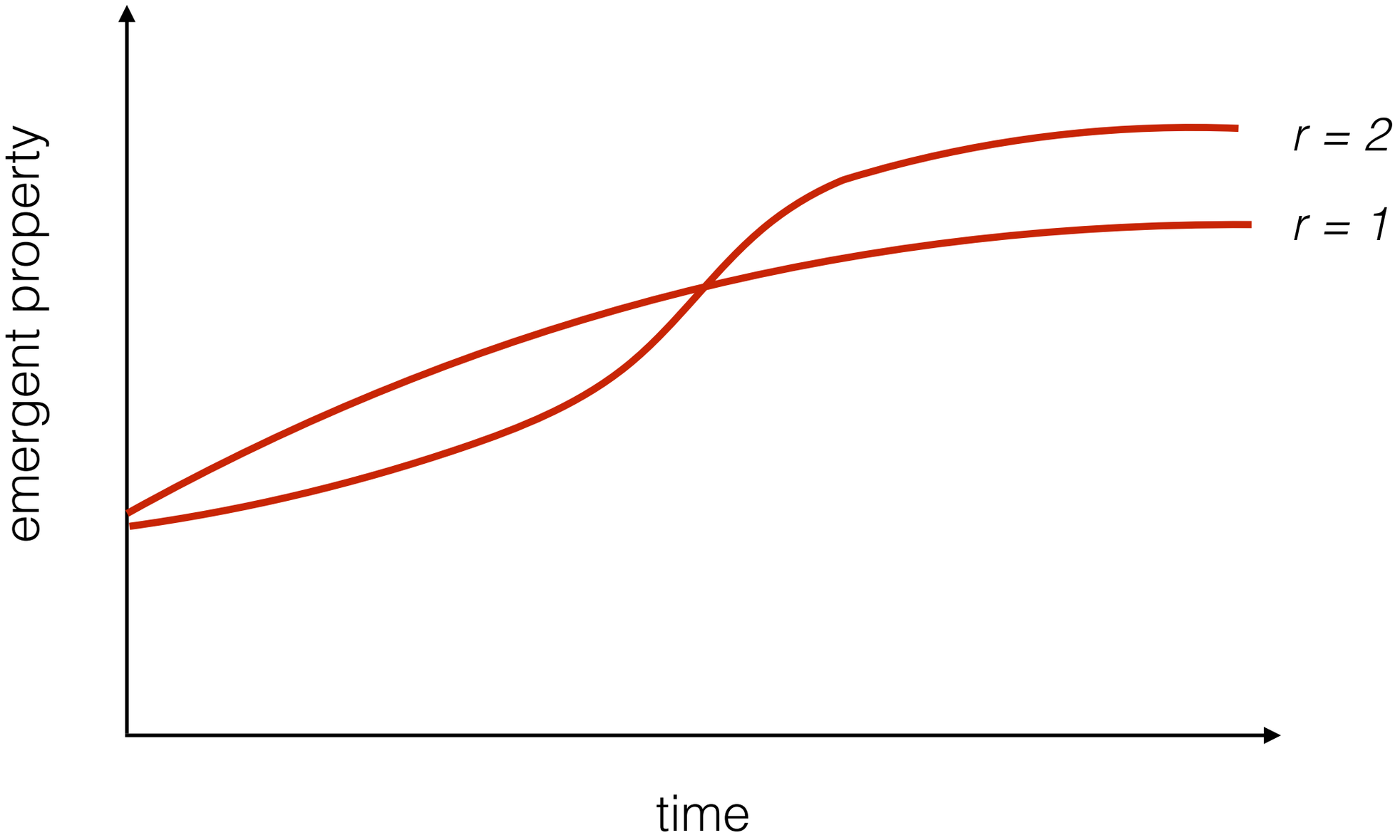
POM help us deal with uncertainty by:

- making models more structurally realistic
- making model parameters interact in ways that more accurately emulates reality

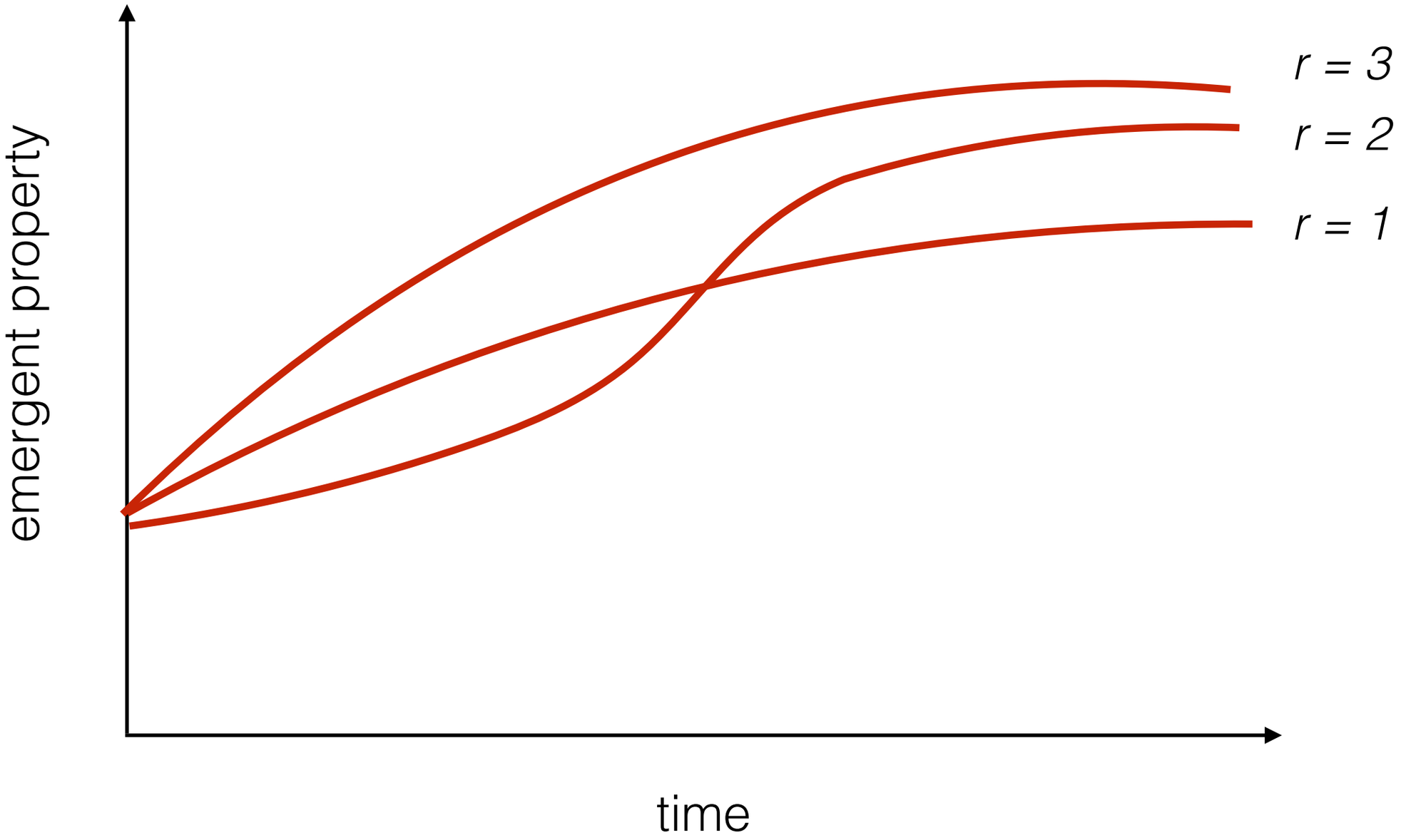
Uncertainty



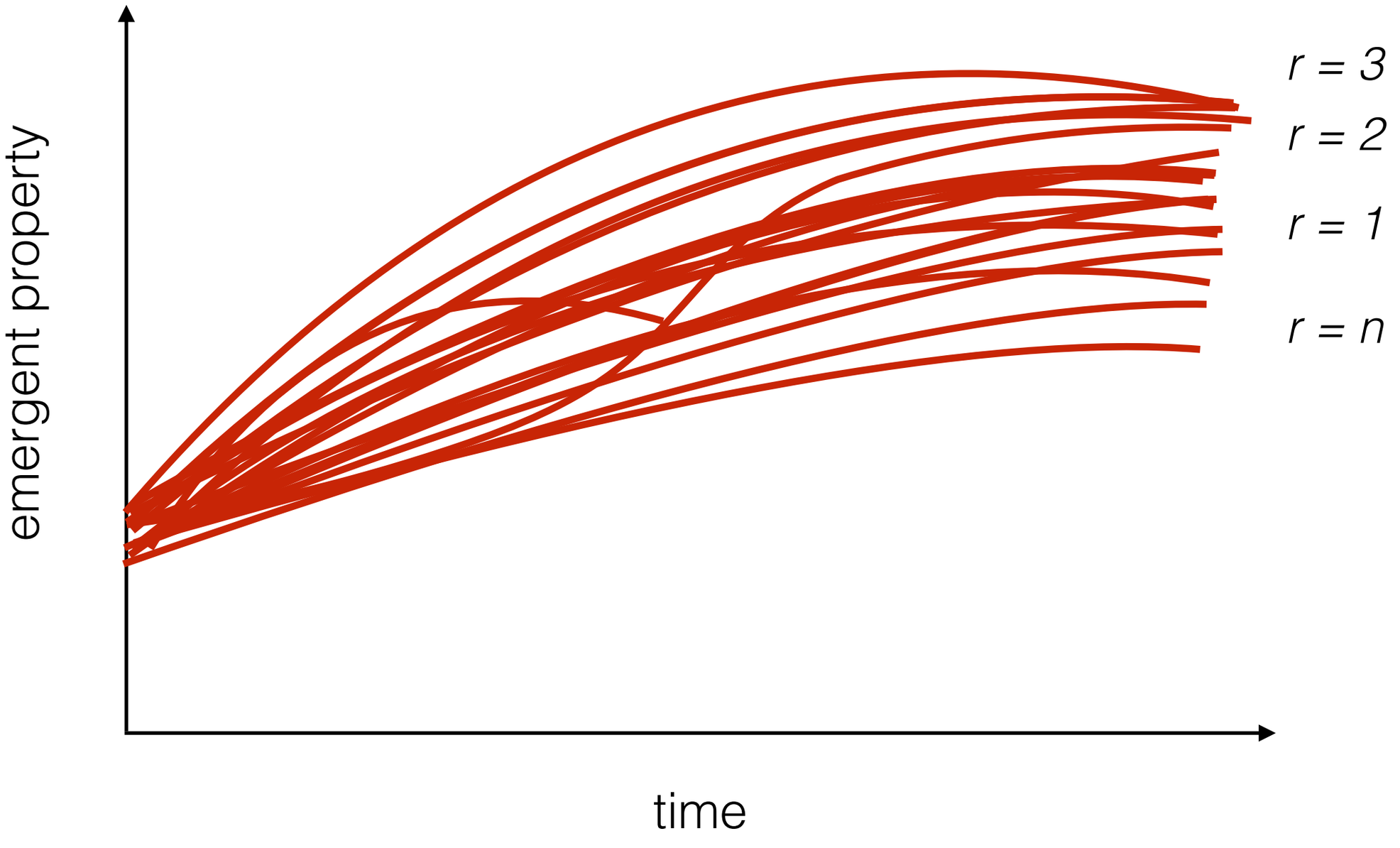
Uncertainty



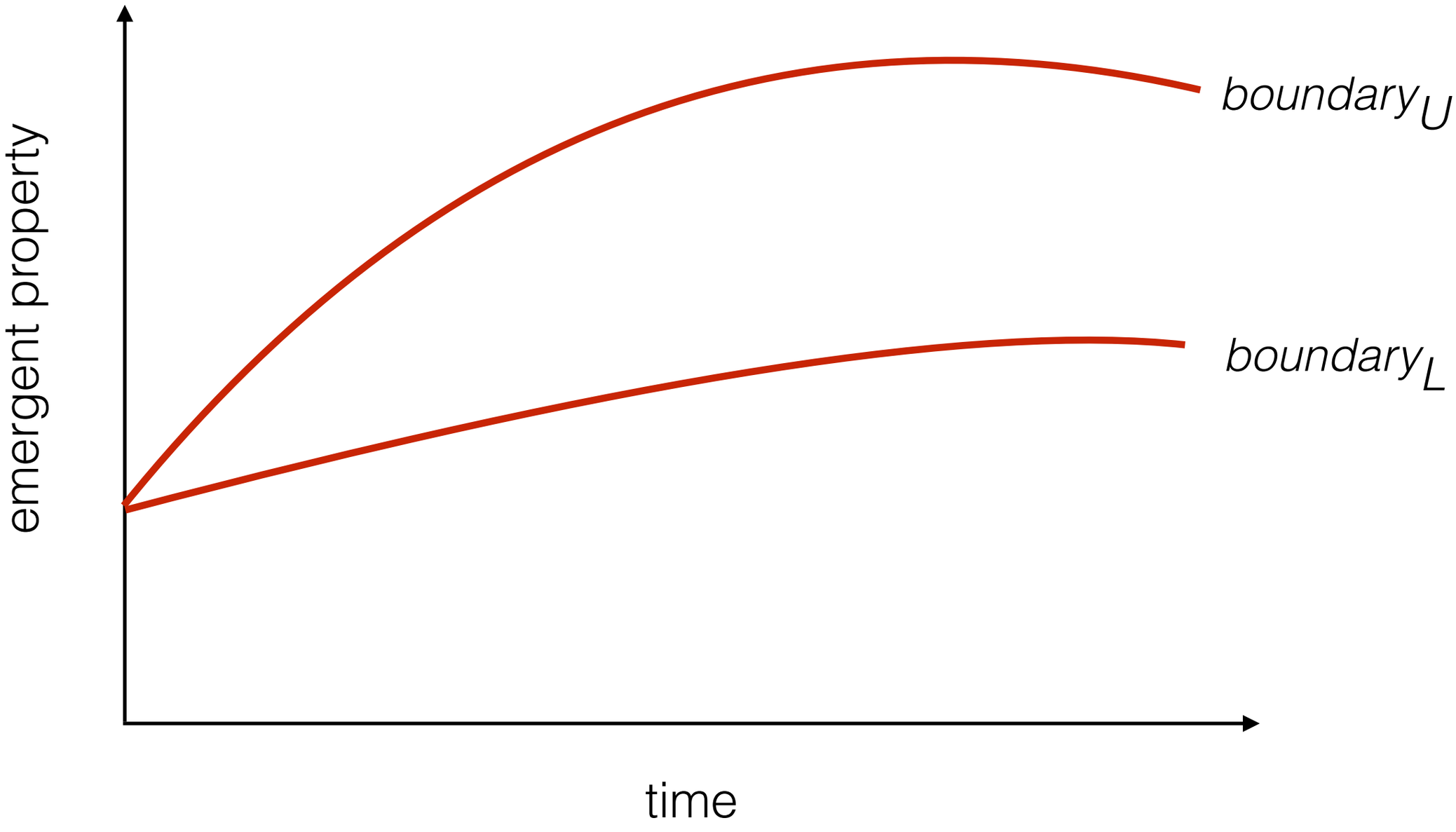
Uncertainty



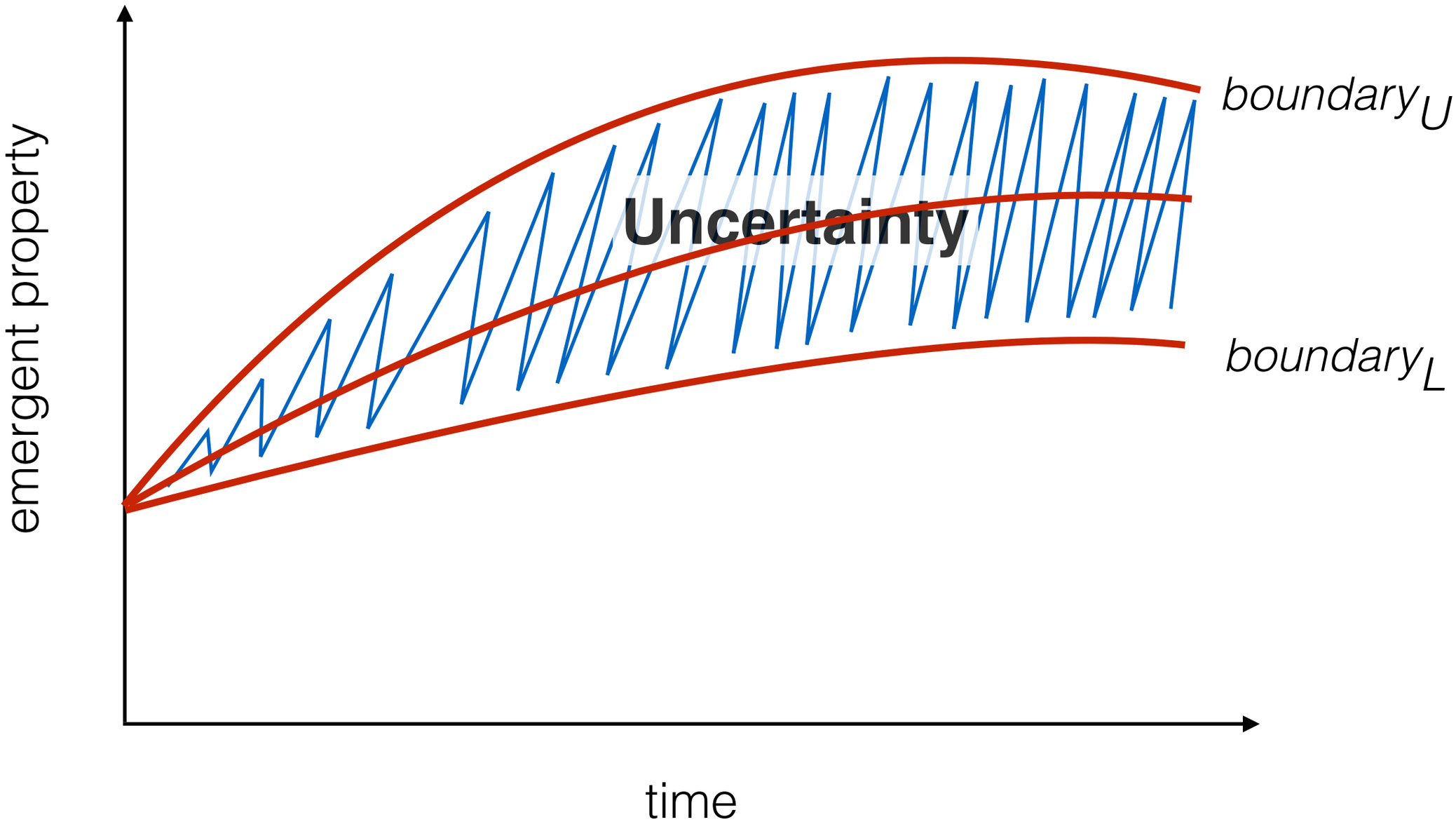
Uncertainty



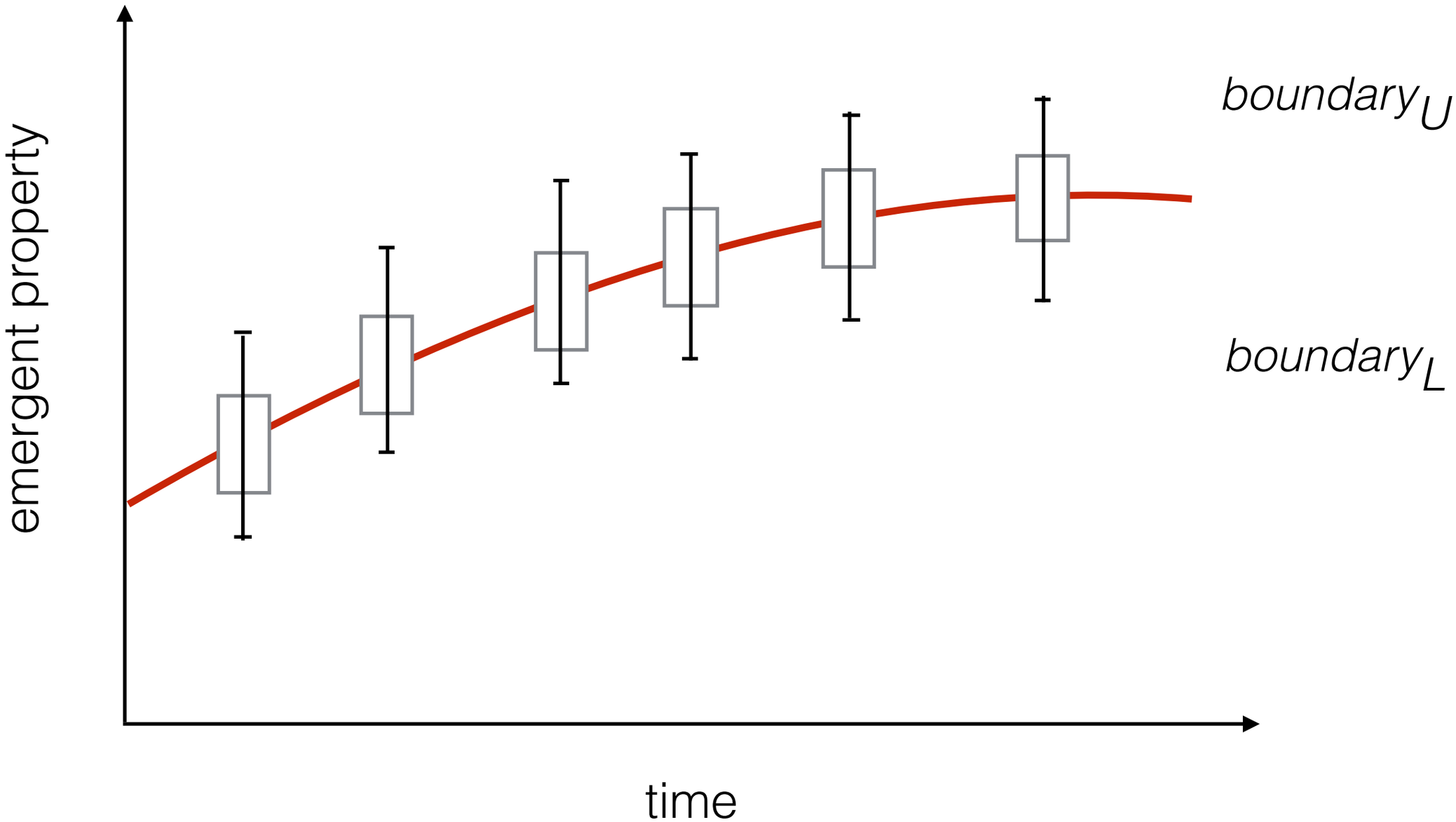
Uncertainty



Uncertainty



Uncertainty



Concluding Remarks on POM

Bottom-up models are virtual laboratories where controlled experiments distinguish noise from signal in the system's organization. In particular, experiments contrasting hypotheses for the behavior of interacting agents will lead to an accumulation of theory for how the dynamics of systems from molecules to ecosystems and economies emerge from bottom-level processes. This approach may change our whole notion of scientific theory, which until now has been based on the theories of physics. Theories of complex systems may never be reducible to simple analytical equations, but are more likely to be sets of conceptually simple mechanisms (e.g., Darwinian natural selection) that produce different dynamics and outcomes in different contexts. POM thus may lead us to an algorithmic (*37*), rather than analytical, approach to theory.

References and Notes

1. "Agent-based complex systems" (ACSs) are often referred to as "complex adaptive systems," but we prefer ACS because it is not clear whether systems

potent species populati
organisms, resource dyr
these to disturbance ev
terns need not be strikin
terns can be powerful ir
we can easily identify a p
out a strong pattern (e.g
set of weak patterns: sex
or, size, etc. Each of th
excludes many individua
12. J. Watson, *The Double H*
the Discovery of the Str
New York, 1968).
13. A search for "(indivi
oriented) and model*"
agent-oriented) and mo
database (title, abstrac
"individual-based" recor
records. A review of
records indicates that m
ecological (*38*).
14. Examples include individ
management (*39*) and
(*40*); see also the POM r
bottom-up reviews in the
15. C. Wissel, *Theoretische*
(Springer, Berlin, 1989).
16. C. Wissel, *Ecol. Model.* 6
17. C. Neuert, C. Rademache
V. Grimm, *Natursch. Lan*
18. C. Rademacher, C. Neue
V. Grimm, *For. Ecol. Ma*
19. B. P. Zeigler, *Theory o*