

Towards a ‘pattern language’ for spatial simulation models

David O’Sullivan

School of Environment
University of Auckland
Te Whare Wānanga o Tāmaki Makaurau
New Zealand

UCSB Geography
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1 Context

- A quick bio
- Research interests

2 A new book

- Reasons for writing it
- Overall outline

3 'Building-block' models

4 Towards a pattern language

- What is a pattern language?
- A preliminary example
- Outcomes

5 Concluding remarks

A quick bio

Education and career

1988 BA Engineering (Cambridge)

1996 MSc Cartography and GI Technology (Glasgow)

2000 PhD Architecture and Planning (University College London – CASA)

2000–04 Asst Prof Geography, Penn State

2004–07 Senior Lecturer, SGES, Auckland

2007–present Assoc Prof, School of Environment, Auckland

Some key contributions

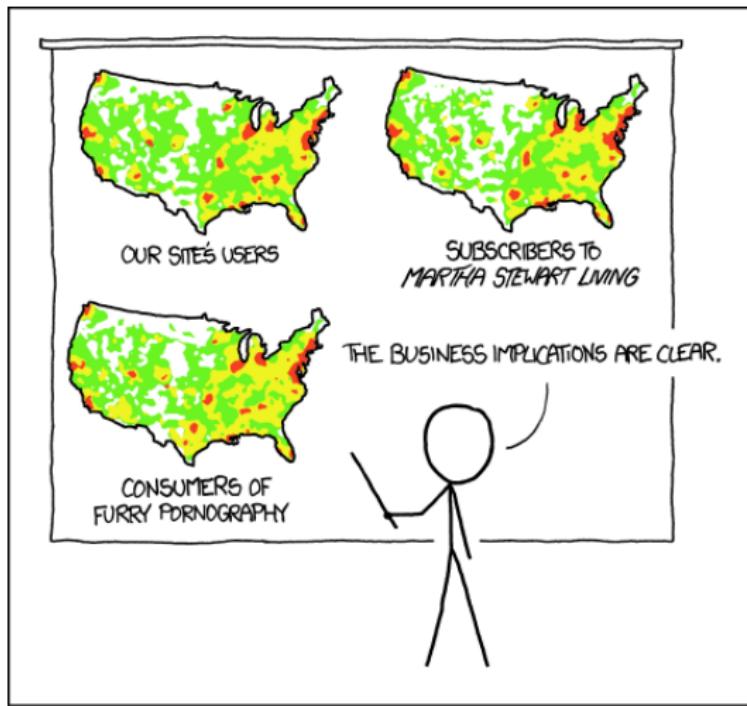
O'Sullivan D and Unwin DJ. 2010. *Geographic Information Analysis* 2nd edn. Wiley.

O'Sullivan D. 2004. Complexity science and human geography. *Transactions of the Institute of British Geographers* 29, 282–95.

Reardon SF and O'Sullivan D. 2004. Measures of spatial segregation. *Sociological Methodology* 34, 121–62.

O'Sullivan D. 2001. Graph-cellular automata: a generalised, discrete, urban and regional model. *Environment and Planning B: Planning & Design* 28, 687–705.

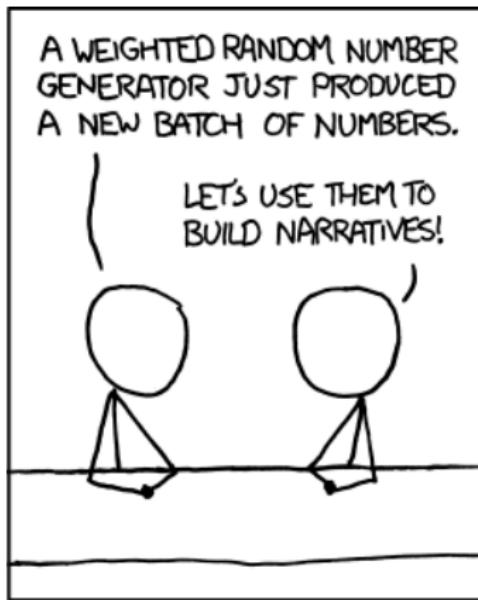
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... are wide ranging...

PET PEEVE #208:
GEOGRAPHIC PROFILE MAPS WHICH ARE
BASICALLY JUST POPULATION MAPS

My research interests...



ALL SPORTS COMMENTARY

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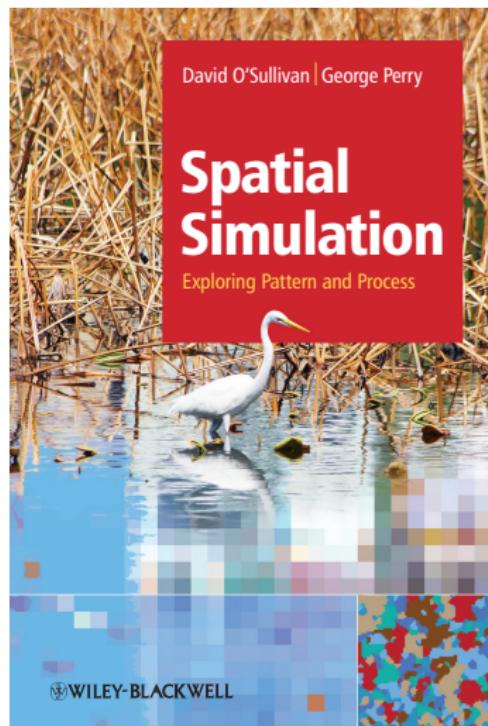
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LIBERAL-ARTS MAJORS MAY BE ANNOYING SOMETIMES,
BUT THERE'S NOTHING MORE OBNOXIOUS THAN
A PHYSICIST FIRST ENCOUNTERING A NEW SUBJECT.

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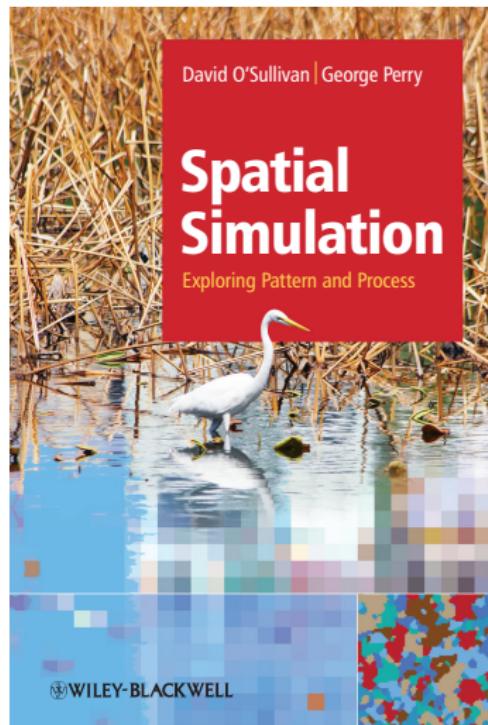
Spatial Simulation: Exploring Pattern and Process



Why we wrote this book

- Students (and many others) find it hard to get started
 - e.g., trapping on a pest-free reserve island
- Primary literature on simple models is challenging (mathematics, physics, statistics)
- A crazy idea that there are many models but that they might be built from only a few simple building blocks

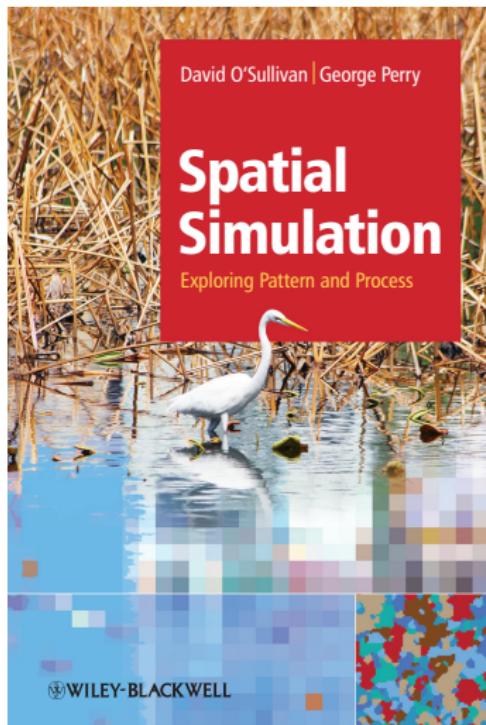
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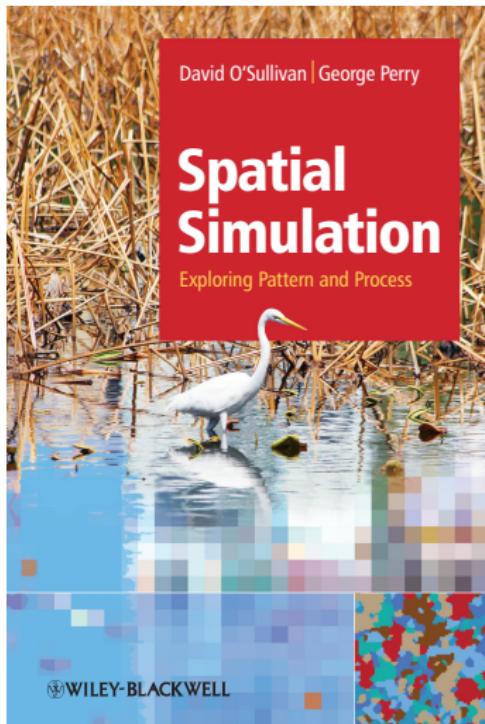
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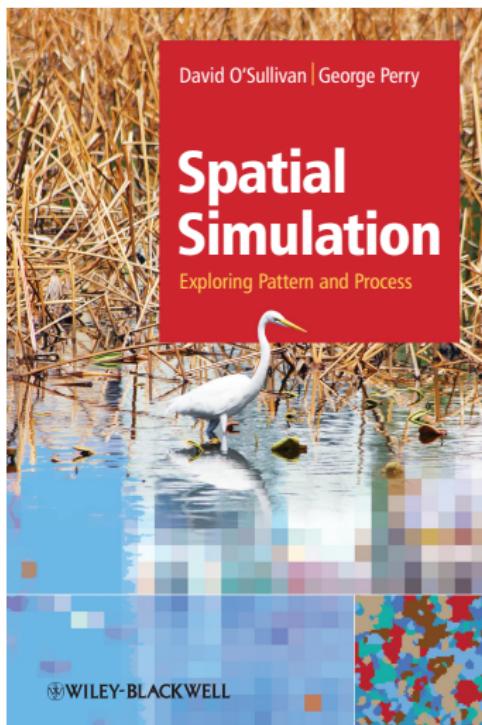
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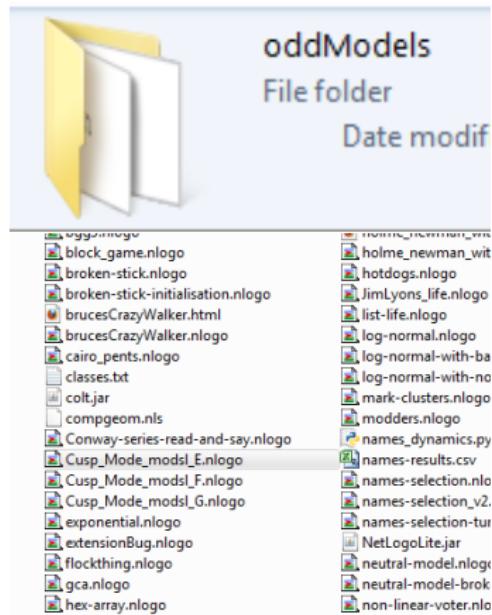
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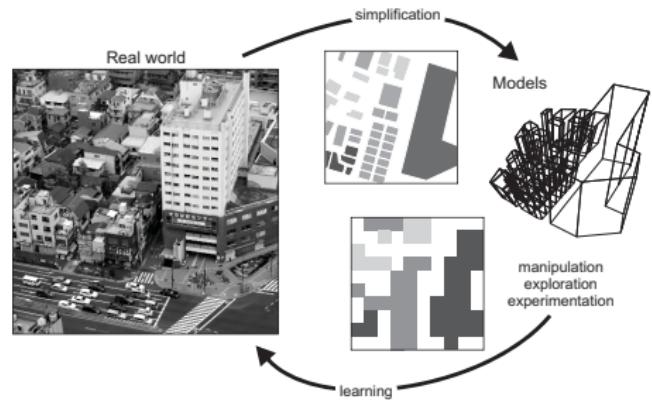


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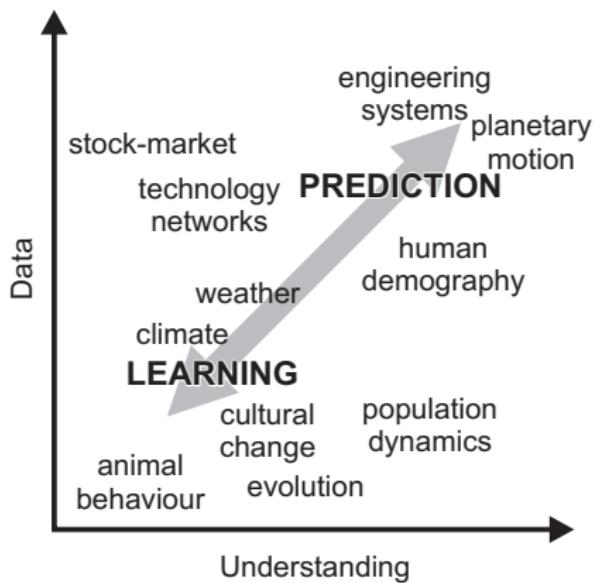
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- Why build models?
- Pattern, process, scale
- Three classes of 'building-block' models
- Representing time and space
- Uncertainty in models
- Example model weaving it all together



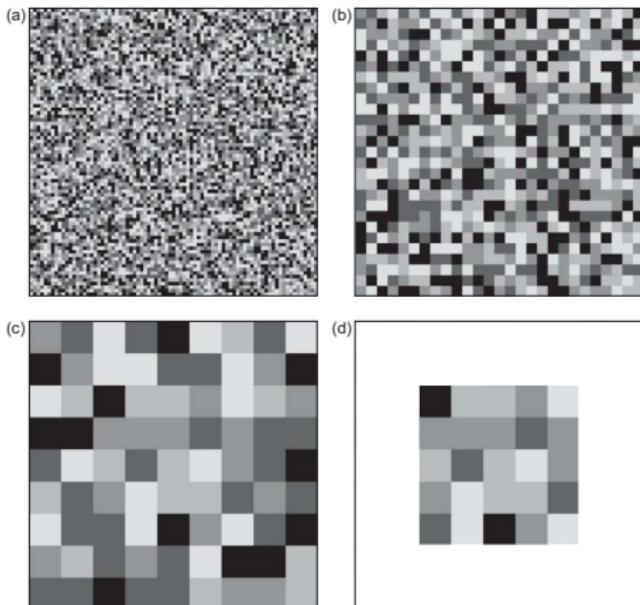
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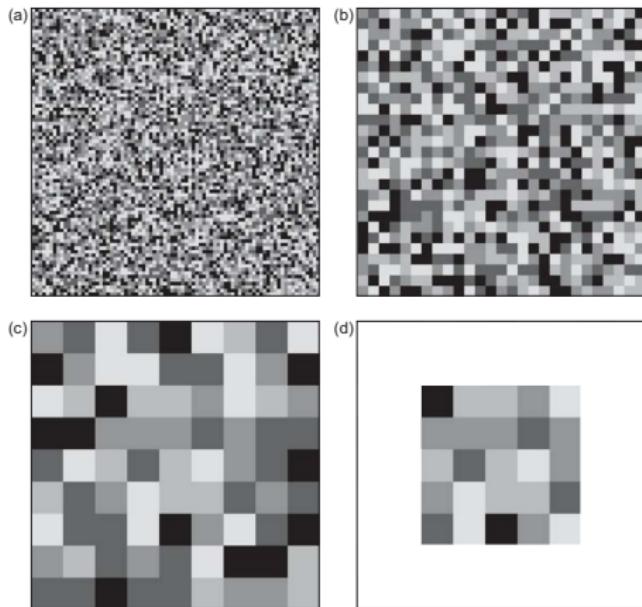
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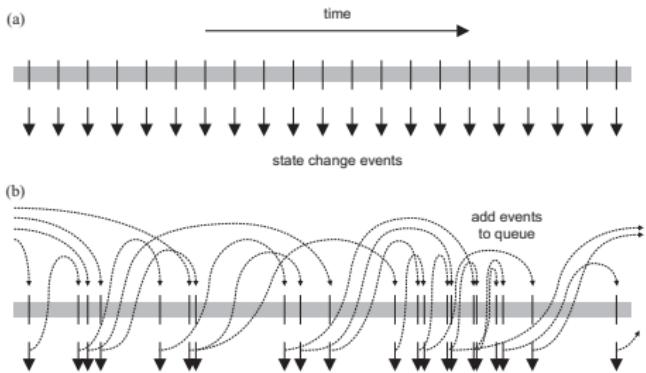
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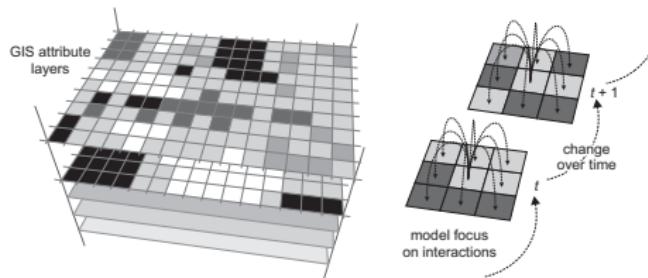
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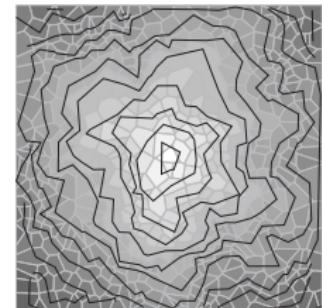
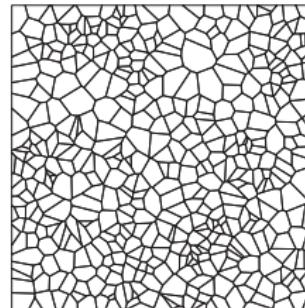
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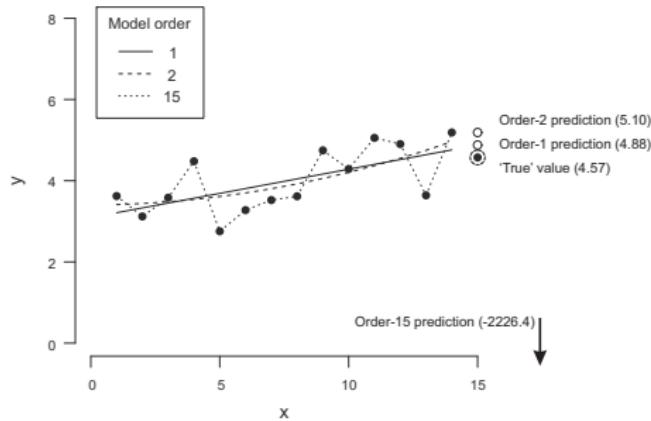
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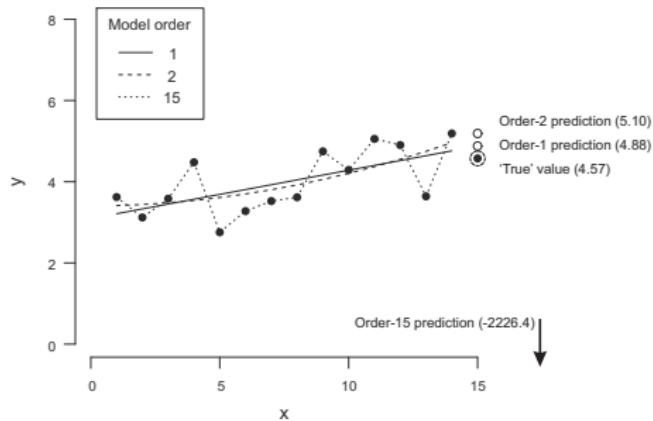
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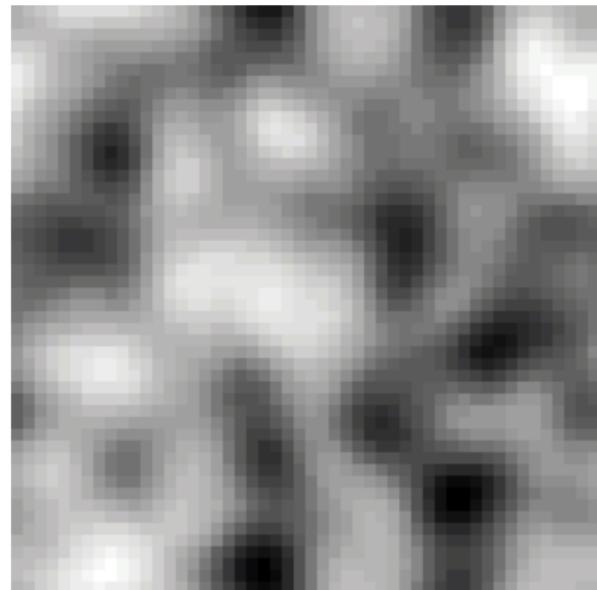
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- Localised averaging
- Majority rule
- Contact process
- Competing contact processes
- Succession
- Rock-scissors-paper
- Voter model
- Schelling model
- Spots and stripes
- Spatial prisoner's dilemma



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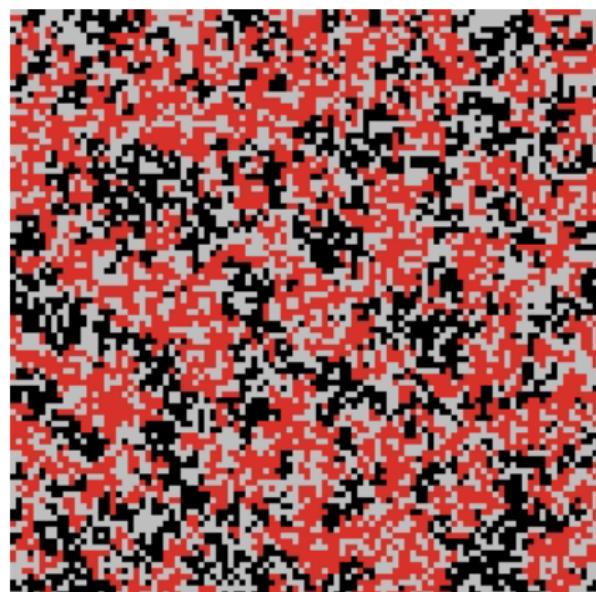
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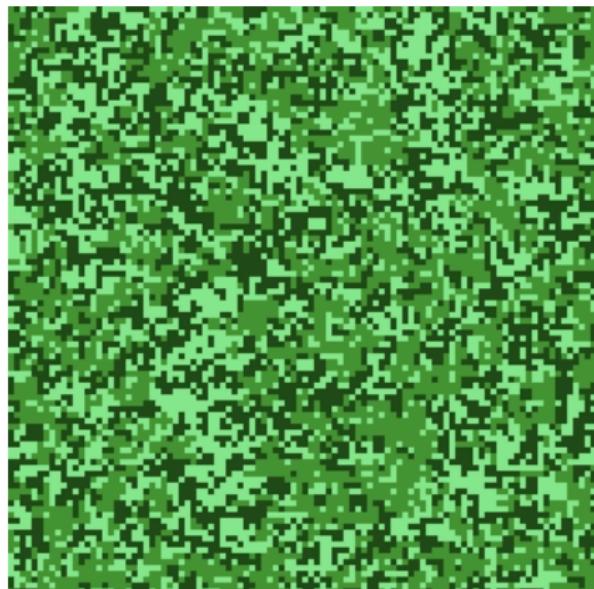
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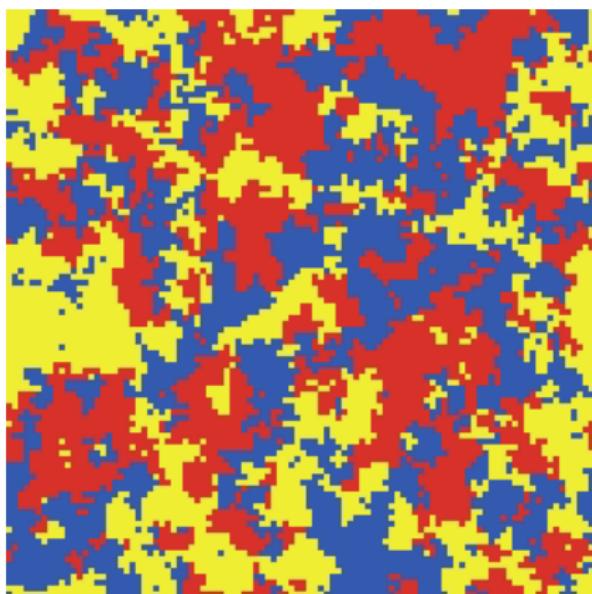
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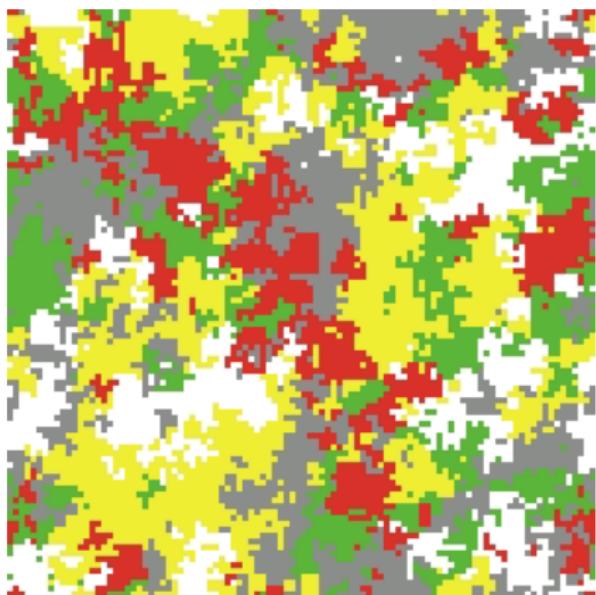
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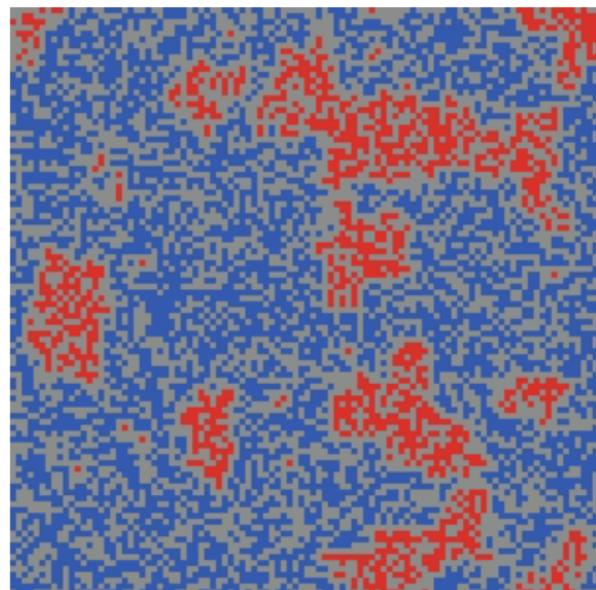
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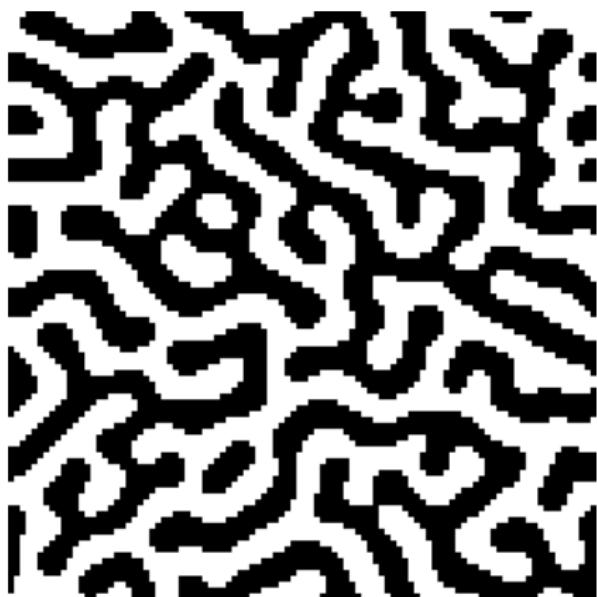
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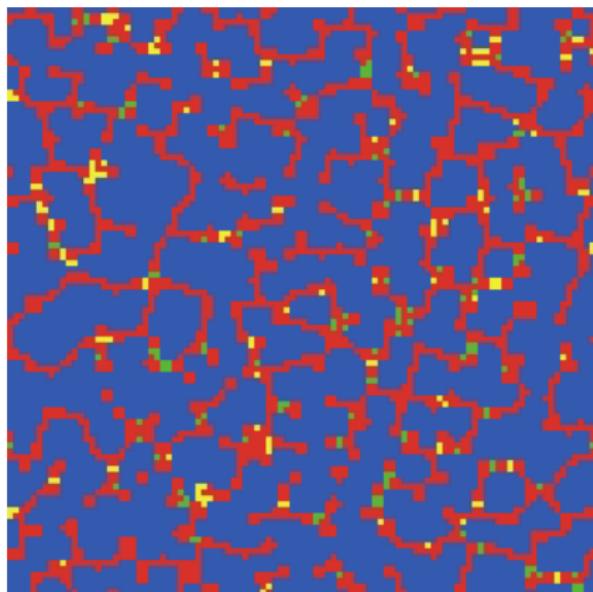
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2. Mobile individuals and groups

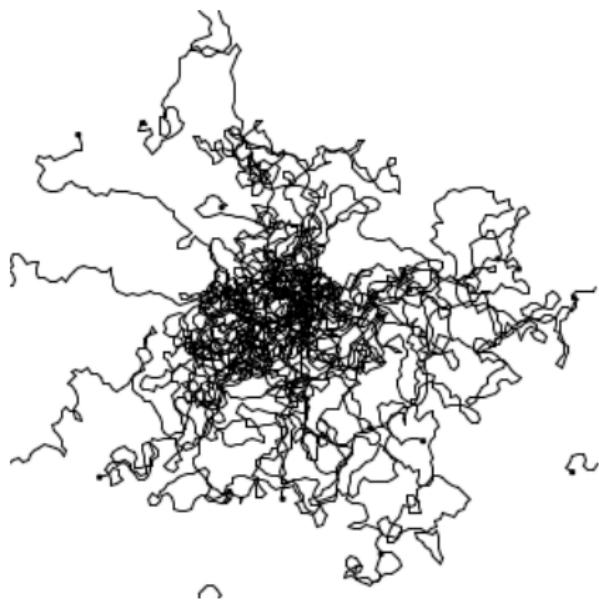
- Random walk

- Correlated random walk
- Lévy walk (heavy-tailed step lengths)
- Searching or foraging
- Search in a resource landscape
- Flocking



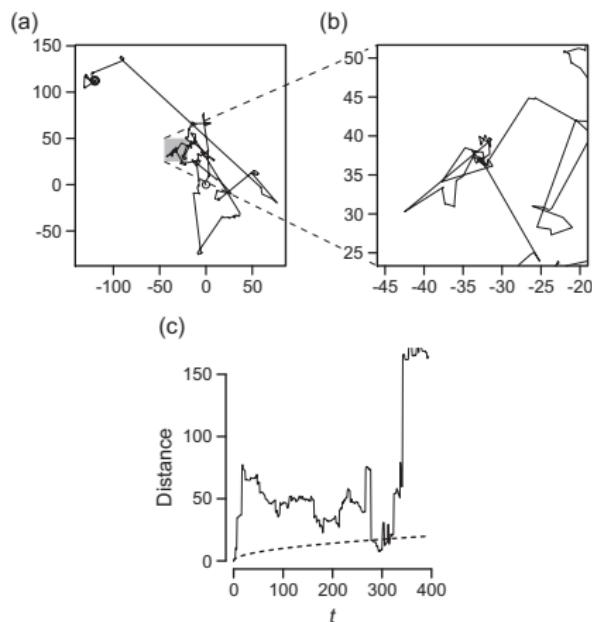
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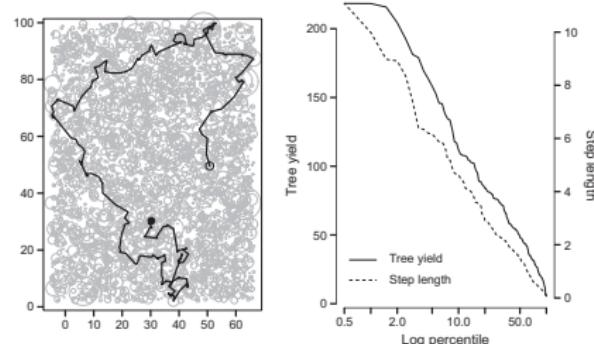
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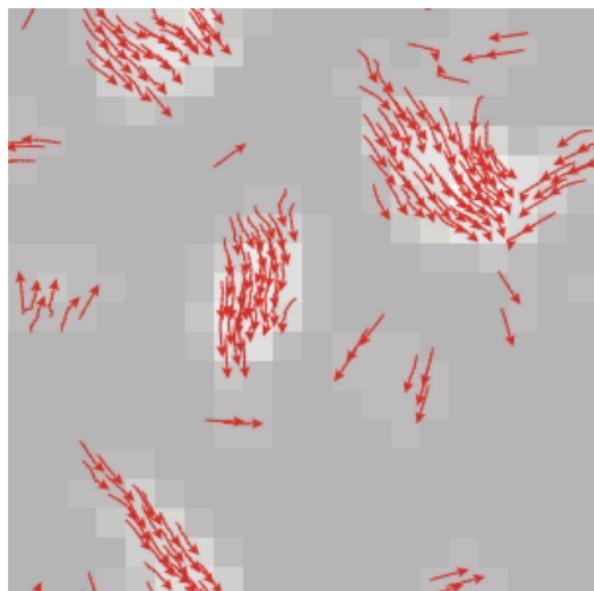
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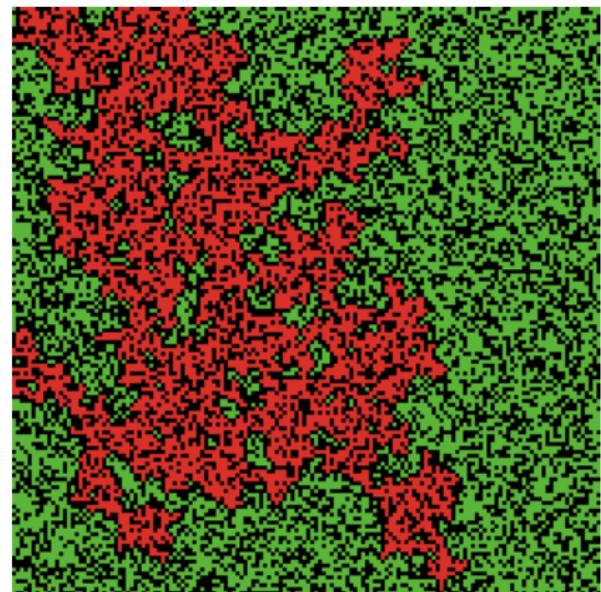
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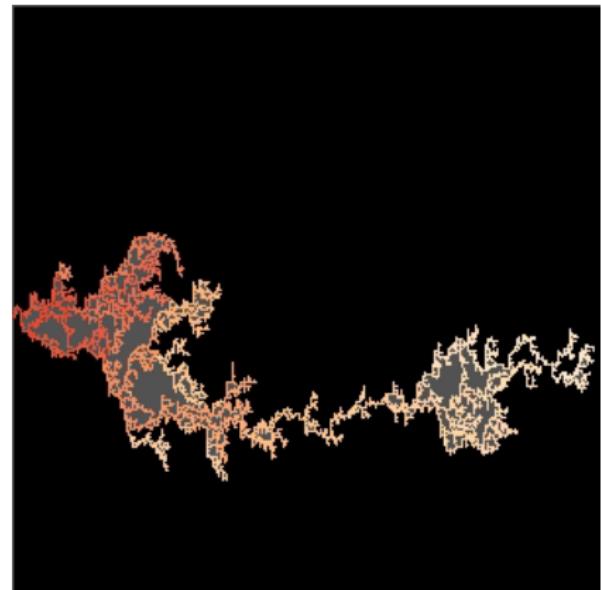
3. Processes of spread/growth in heterogeneous media

- Percolation, e.g. fire
- Invasion percolation
- Eden growth
- Modified Eden growth with noise reduction
- Diffusion-limited aggregation



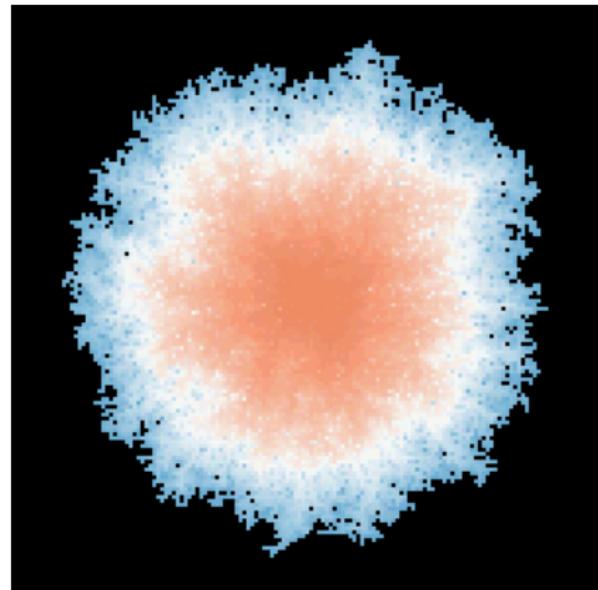
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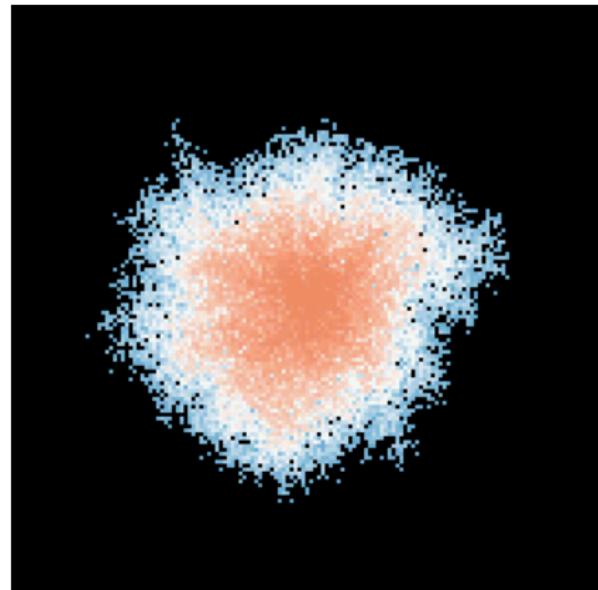
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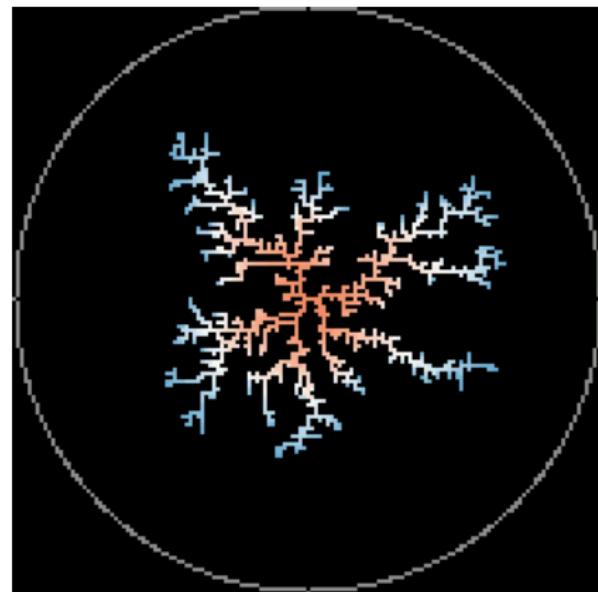
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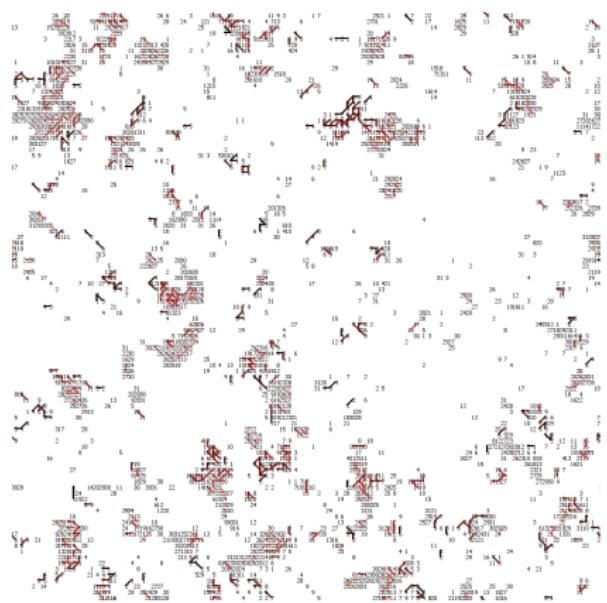
- Predator on a pest-free island: random walk + voter model patchy landscape
- Model of gentrification as interacting succession processes (with Cheng Liu)
- Models of aboriginal (Australian) use of landscape (with Simon Holdaway, Ben Davies, Tom Brughmans, Iza Romanowska)

```
;; random walk
to step
  move-to one-of neighbors4
end

;; voter model
to create-world
repeat n [
  ask patches [
    set state [state] of one-of neighbors4
  ]
]
end
```

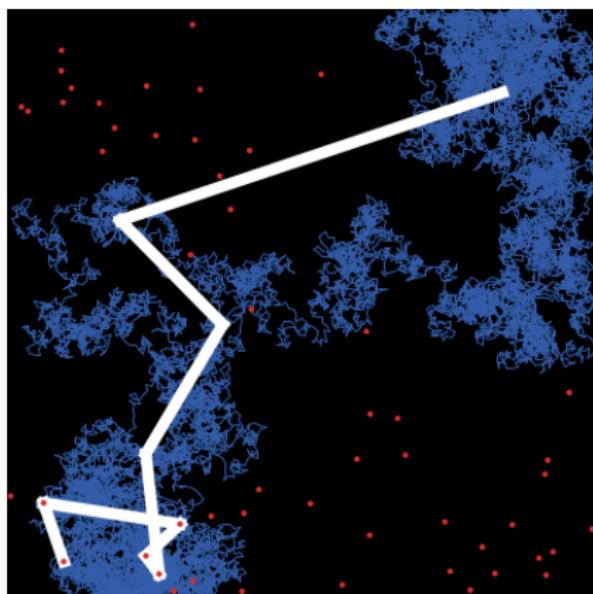
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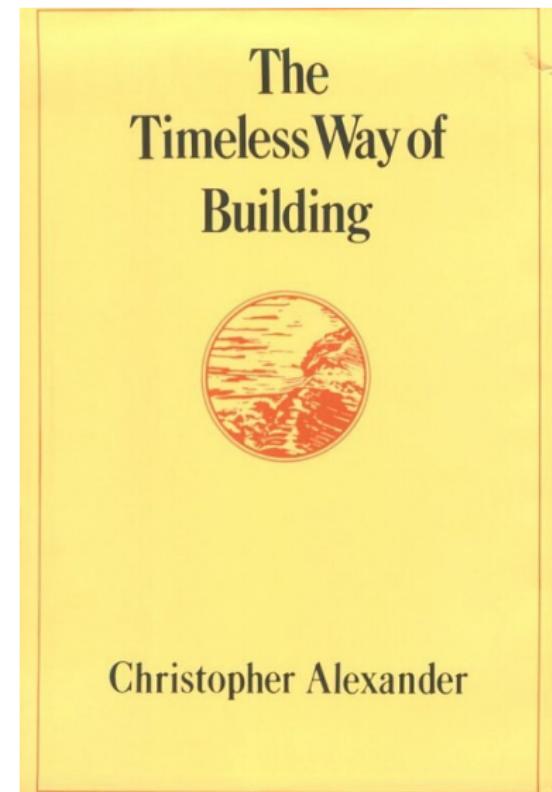
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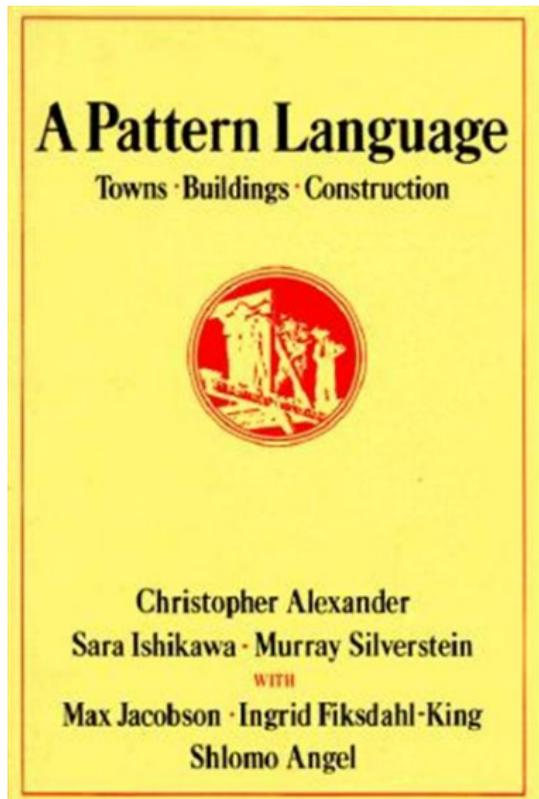
Christopher Alexander's pattern language

Alexander's concept of a pattern language is presented in *The Timeless Way of Building* (1979)

- Patterns of events *every place is given its character by certain patterns of events that keep on happening there* (p 54)
- Patterns of space *These . . . are always interlocked with certain geometric patterns in the space* (p 75)
- A pattern language *is a system which allows its users to create an infinite variety of . . . buildings, gardens, towns* (p 186)
- The structure of the language *is created by the network of connections among individual patterns* (p 305)



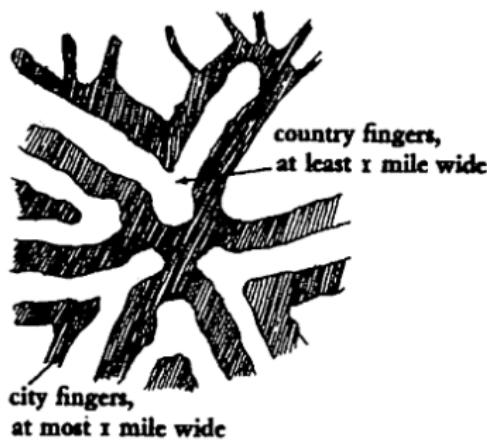
Alexander's pattern language



Before spelling out the underlying theory Alexander with others, presented a language of 253 patterns in *A Pattern Language* (1977). These design patterns each describe *a problem... and the core of the solution to that problem* (p x) For example:

- City country fingers (p 25)
- Light on two sides of every room (p 749)
- Old people everywhere

Alexander's pattern language



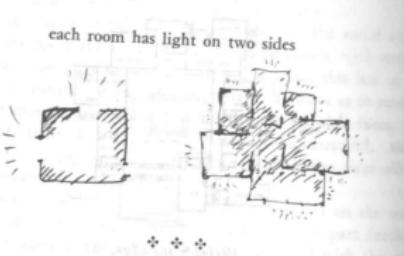
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Alexander's pattern language

Locate each room so that it has outdoor space outside it on at least two sides, and then place windows in these outer walls so that natural light falls into every room from more than one direction.

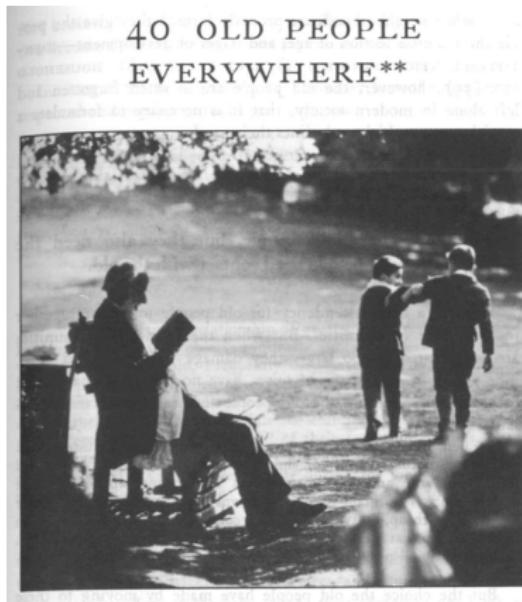
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40 OLD PEOPLE
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Patterns in computer science

- Alexander's notion has successfully translated across to software engineering
- Formalisation of what a pattern is, remains elusive
- The early focus tended to be on individual patterns
- Some more recent work has shifted the focus to languages

From the present perspective, like Alexander's original formulation, the emphasis on design problems may not be entirely appropriate

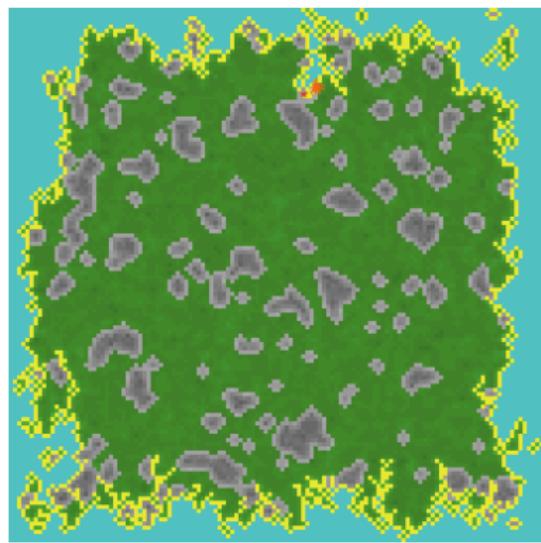
From building-block models to patterns

- Our building-block models are (spatial) pattern focused
- 'Pattern' approach requires a multi-aspect, multi-scalar perspective
- For example, a *mobile entity* pattern might also require...
 - Behavioural patterns
 - (with apologies to The Clash) *Should I stay or should I go?*
 - *Choose a target*
 - *Select a path*
 - or Statistical patterns to choose a distance/direction
 - and Spatial context patterns
 - *Network* (planar, spatial, non-spatial)
 - *Regular lattice*
 - *Toroidally-wrapped space*
- ...and together these could compose a language

leGUME: Grand Unified Model of Everything

Island resource exploitation by human hunter-gatherers

- Island shape by '*erosion invasion percolation*'
- Low value resources *local averaging*
- High value resources *percolation patches*
- Hunting *biased random walk*
- Base relocation *should I stay or should I go*



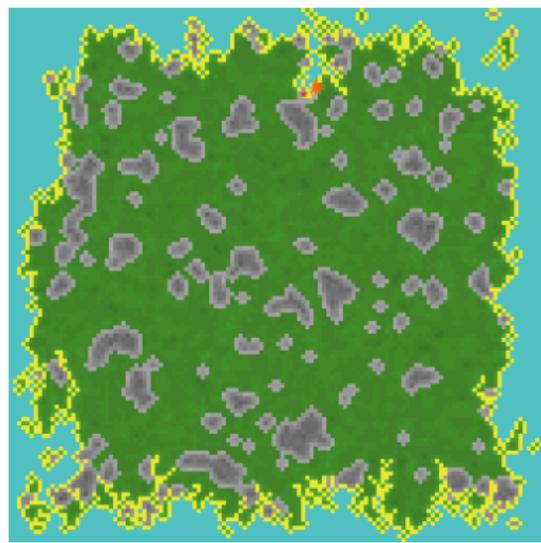
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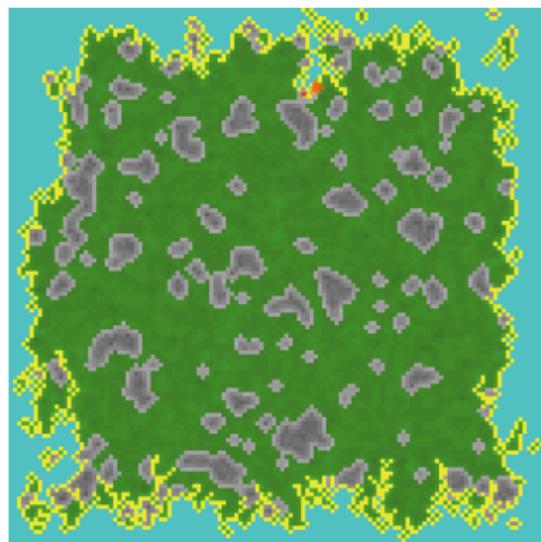
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- Low value resources *local averaging*
- High value resources *percolation patches*
- Hunting *biased random walk*
- Base relocation *should I stay or should I go*



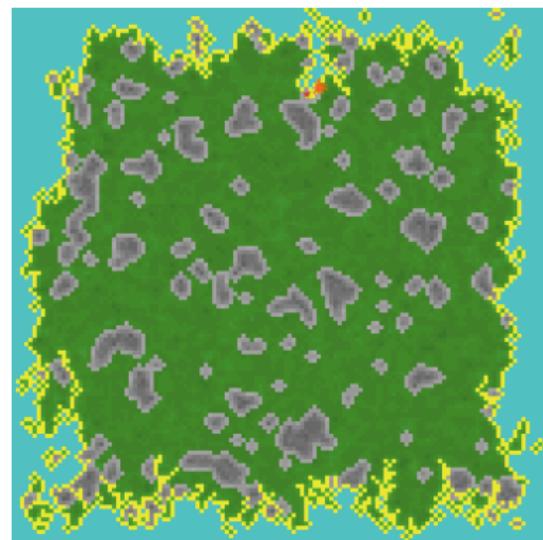
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leGUME: Grand Unified Model of Everything

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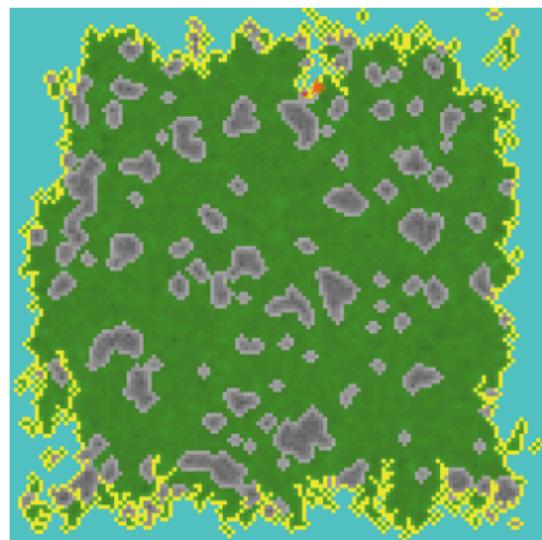
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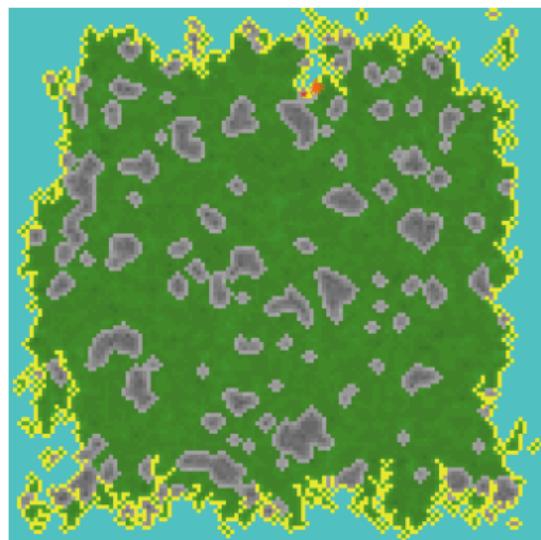
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Outcomes

- More rapid development of a complicated model
- Produces a degree of modularity
- Allows rapid exploration of possible models
- Perhaps an approach to exploring structural uncertainty?

Closing thoughts

- We know a lot about simple spatial processes
- This approaches tries to synthesize and leverage that knowledge
- The ‘building-blocks’ are a first cut
- How a pattern language should be structured is rather unclear
- ... ‘pattern’ might just be an overloaded term...

Acknowledgments

- Questions?
- Comments?

See <http://patternandprocess.org>

