These slides with links:
https://cutt.ly/CA-ABM-Lsps

Modelling Landscape Dynamics

Cellular Automata & Agent-Based Models

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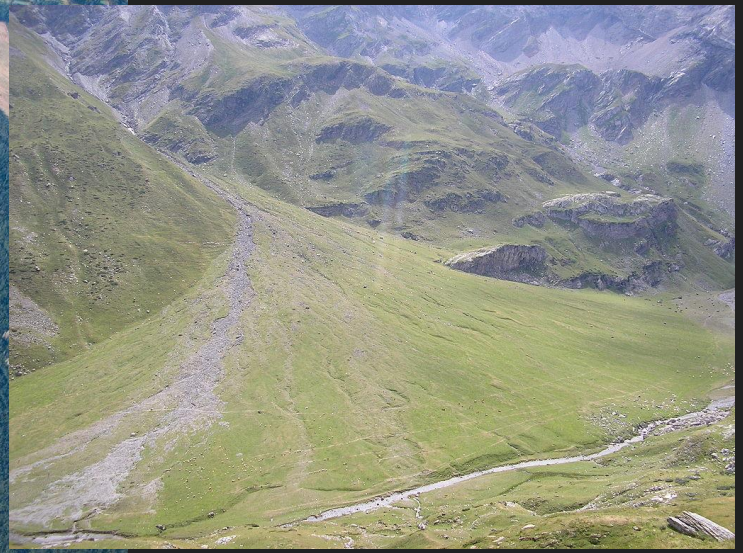
Geography

[Source: Gobeirne]



[Source: Ludo29]

Fluvial Landscapes

[Source: Marle039]

[Source: NASA]

Aeolian Landscapes

[Source: US NPS]

[Source: Yathin sk]

Ecological Landscapes

[Source: Taxiarchos228]

[Source: Andrecp]

Human Landscapes

Model Types

1. Conceptual
2. Scale or Analogue
3. Quantitative
4. Physically-based
5. Reduced complexity

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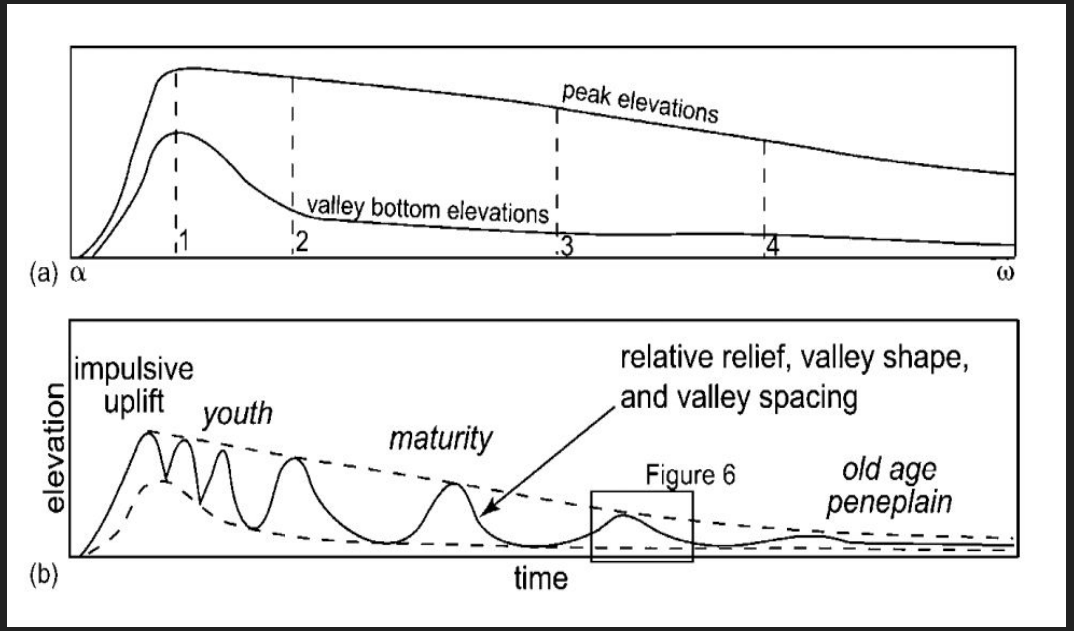

[Source: Pazzaglia (2003)]

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[Source: AxelHH]

Model Types

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Manning equation (1890s):

$$\bar{u} = \frac{R^{2/3} S^{1/2}}{n}$$

R is hydraulic radius of channel
S is slope of channel
n a dimensionless value for friction

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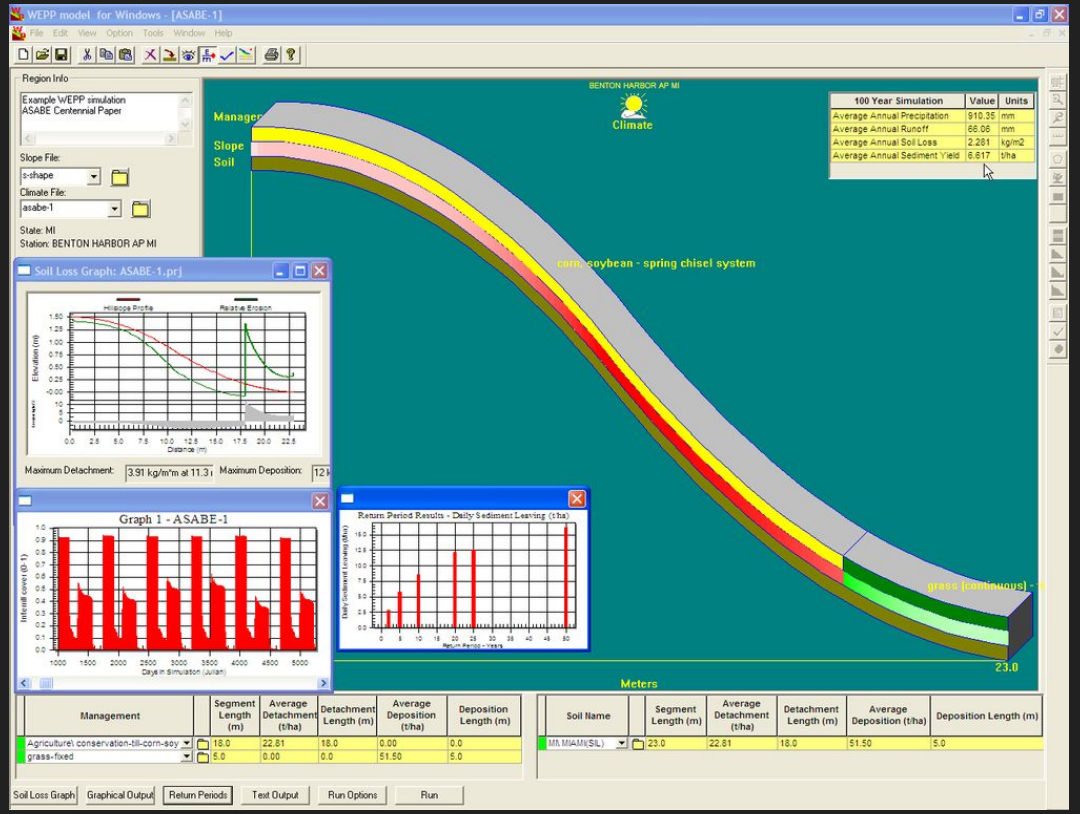

[Source]

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Advantages

- physical processes complete
- ‘real’ parameters

Disadvantages

- computationally ‘expensive’
- many parameters and coefficients

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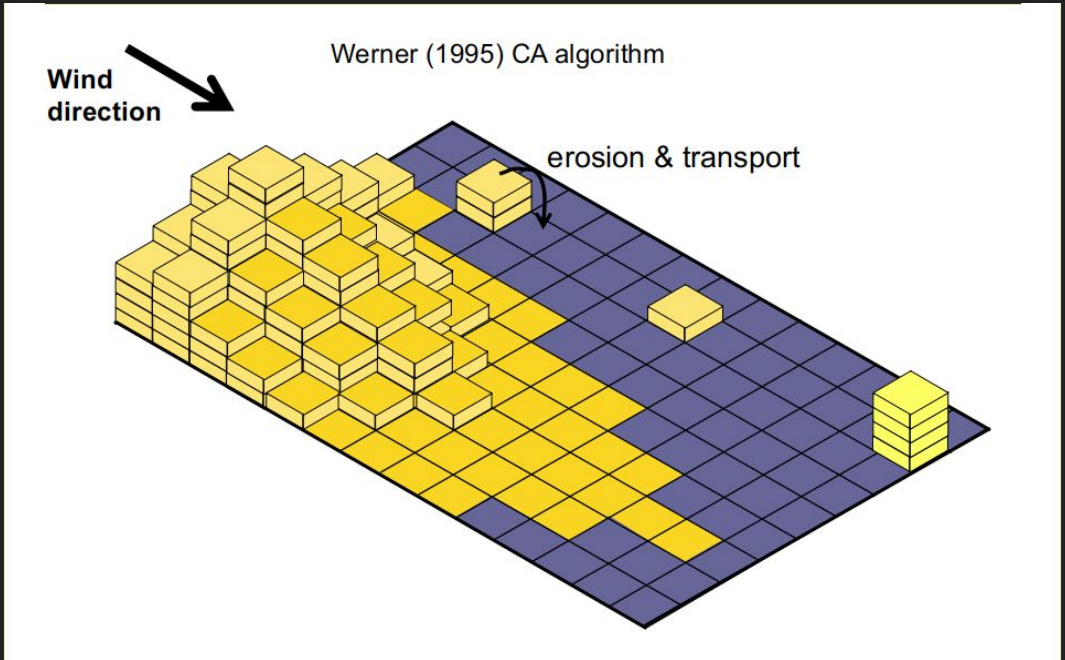


‘Bottom-Up’ Simulation

Discrete Element Models

- Geomorphology
- e.g. gravel-bed rivers, avalanches, debris flows

Individual-Based Models

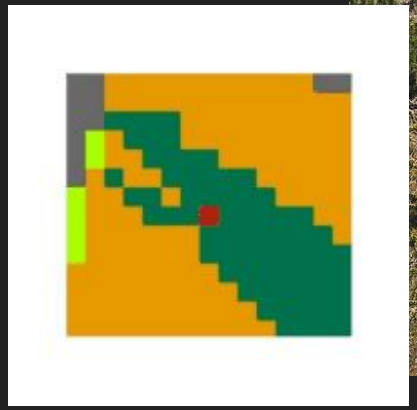
- Ecology
- e.g. foraging animals, forest growth/senescence

Agent-Based Models

- Social Science
- e.g. subsistence farming, urban populations

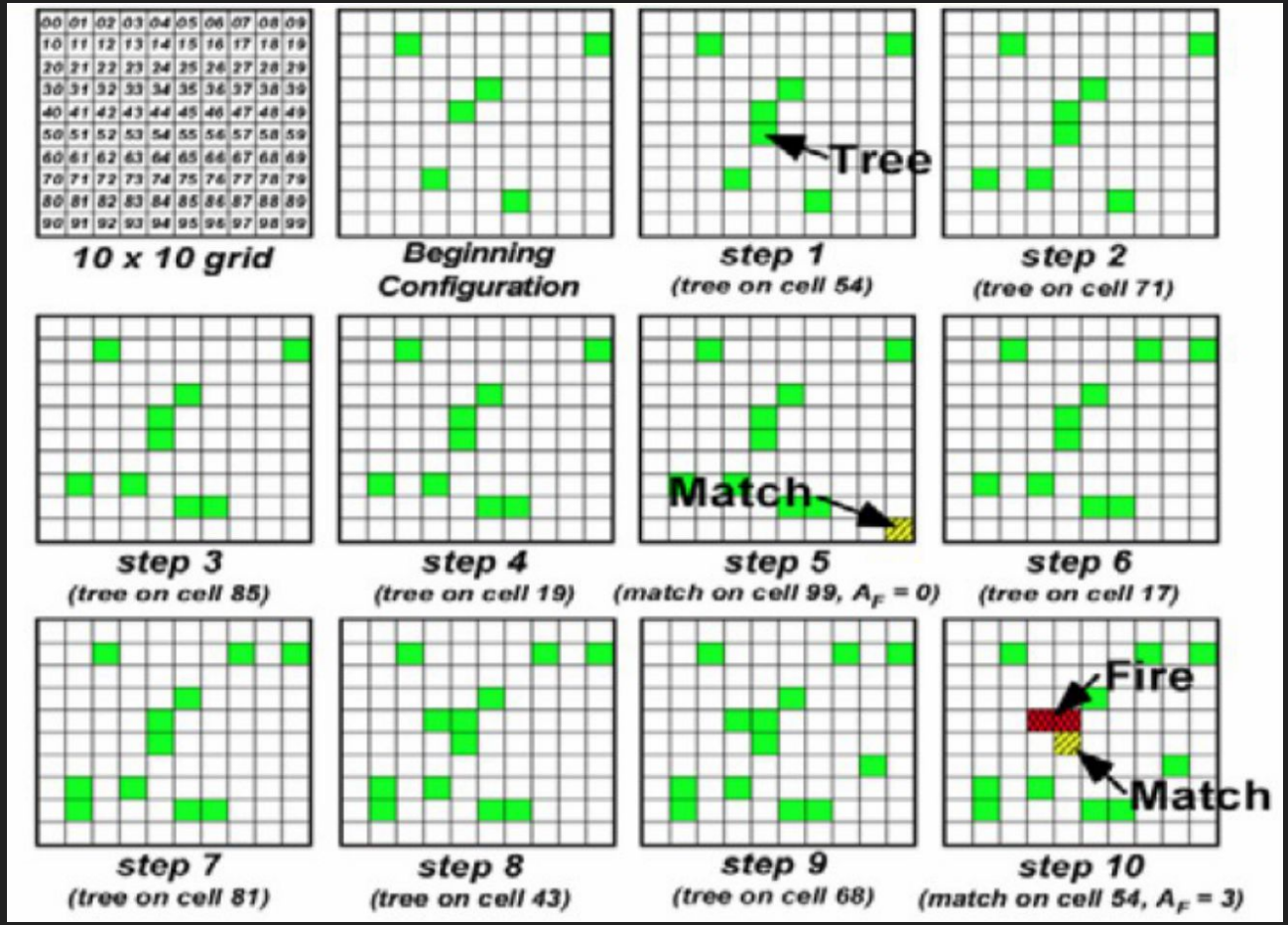
See Bithell *et al.* (2008) for review

What is a Cellular Automaton?



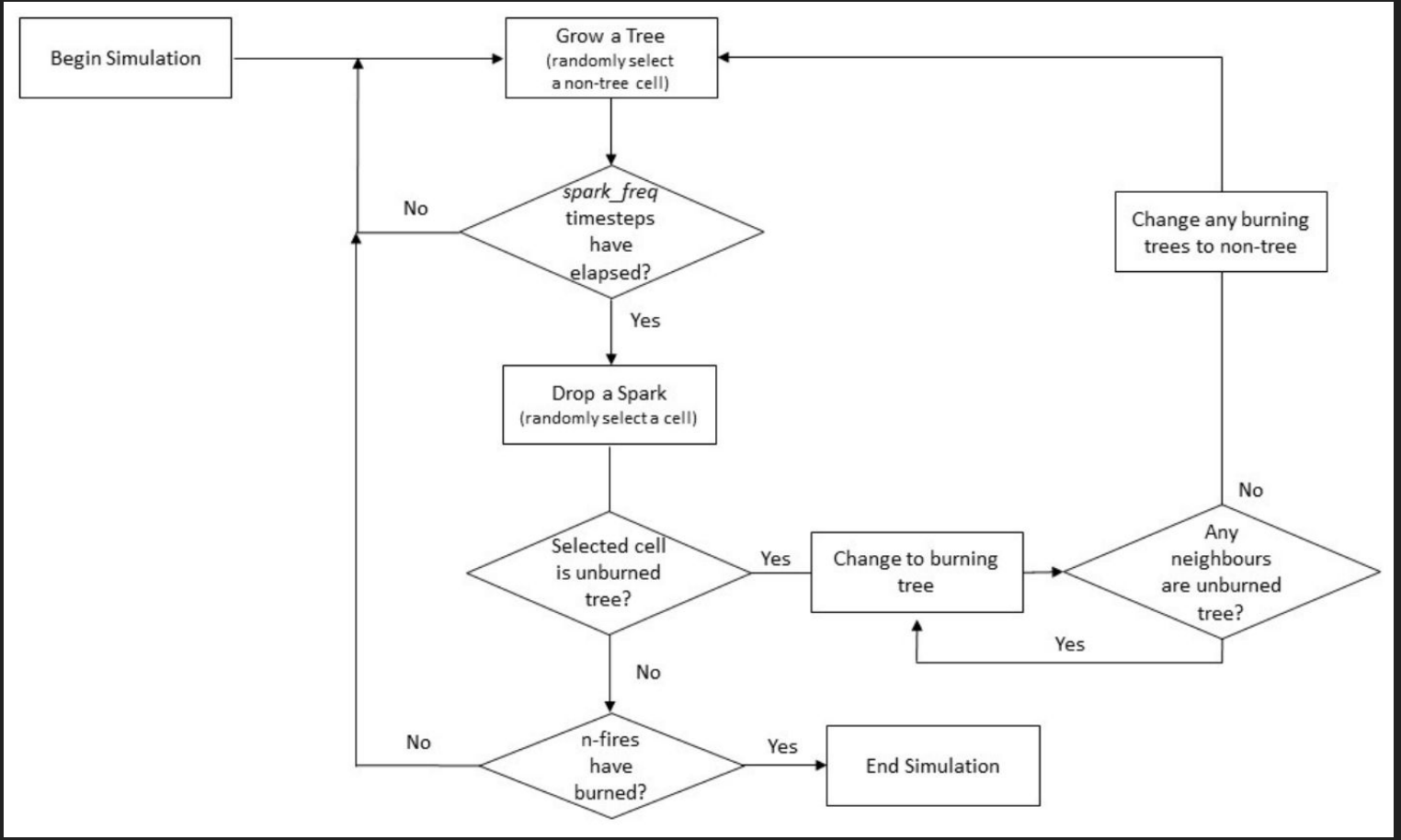
Grids of cells (pixels) that change state dependent on rules about their neighbours

The Forest Fire Cellular Automata (FFCA)



Millington et al. (2006)

FFCA Flowchart



Power-Law Frequency Area

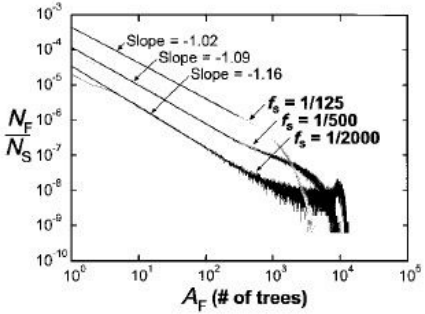


Fig. 1. Noncumulative frequency-area distributions of model forest fires for a grid size of 128 by 128 squares at three sparking frequencies. f_S = 1/125, 1/500, and 1/2000. The number of fires per time step (N_F/N_S) with area (A_F) is given as a function of A_F, the number of trees that were burned in each fire. For each sparking frequency, the model is run for $N_S = 1.638 \times 10^9$ time steps. The small and medium fires correlate well with the power-law relation (Eq. 1) with α = 1.02 to 1.18; $-\alpha$ is the slope of the best-fit line in log-log space and is shown for each sparking frequency. The finite grid-size effect can be seen at the smallest sparking frequency, f_S = 1/2000. At about A_F = 2000, fires begin to span the entire grid.

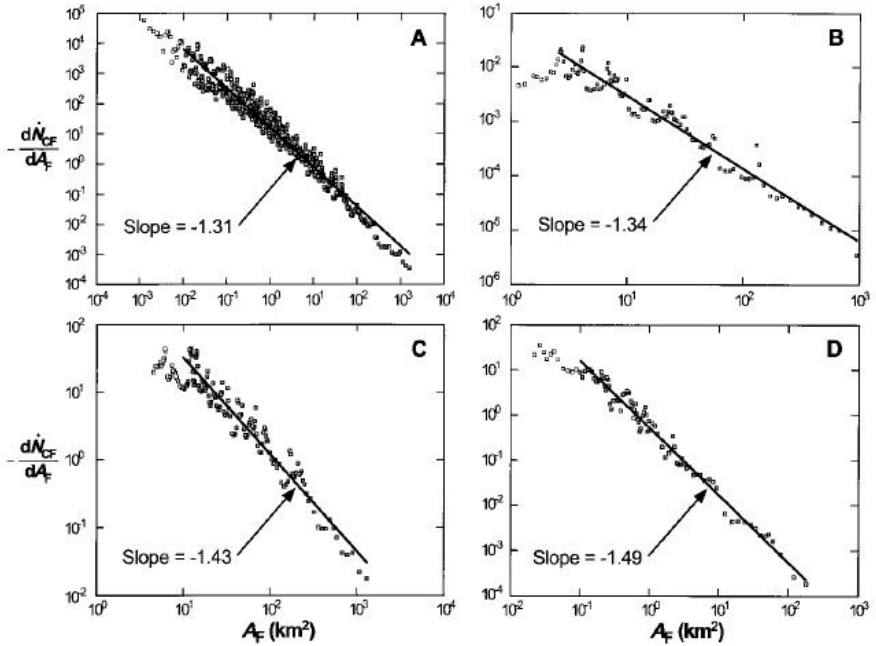
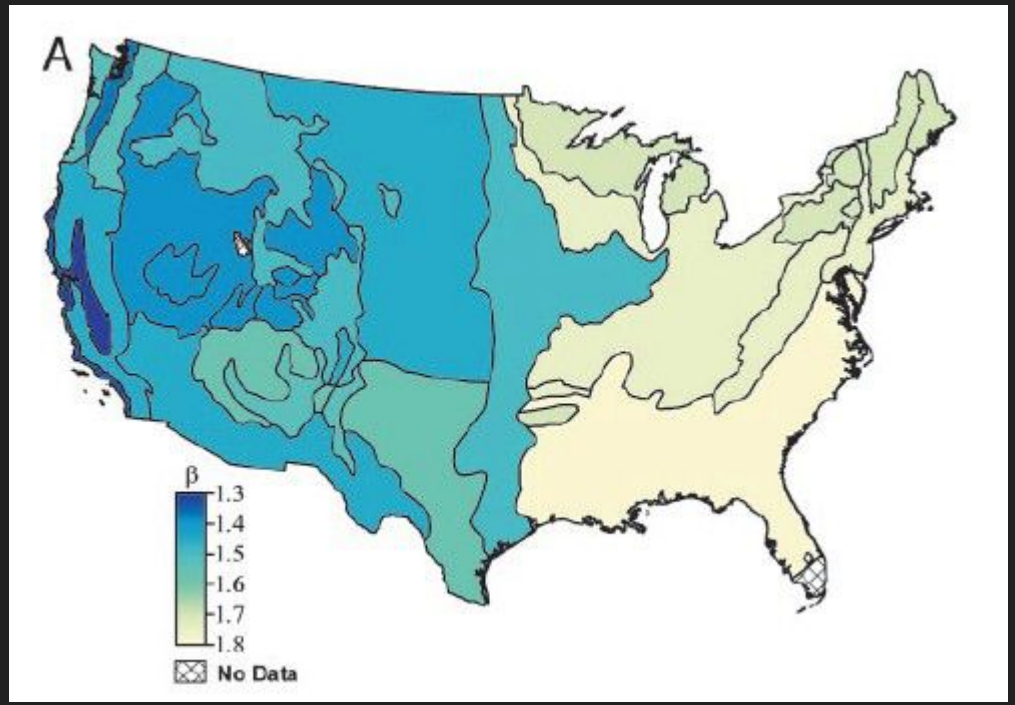


Fig. 2. Noncumulative frequency-area distributions for actual forest fires and wildfires in the United States and Australia: (**A**) 4284 fires on U.S. Fish and Wildlife Service lands (1986–1995) (*9*), (**B**) 120 fires in the western United States (1150–1960) (*10*), (**C**) 164 fires in Alaskan boreal forests (1990–1991) (*11*), and (**D**) 298 fires in the ACT (1926–1991) (*12*). For each data set, the noncumulative number of fires per year ($-d\dot{N}_{CF}/dA_F$) with area (A_F) is given as a function of A_F (*13*). In each case, a reasonably good correlation over many decades of A_F is obtained by using the power-law relation (Eq. 1) with α = 1.31 to 1.49; $-\alpha$ is the slope of the best-fit line in log-log space and is shown for each data set.

Malamud *et al.* (1998)

Spatial Patterns of Statistics

Variation in frequency-area distributions across USA



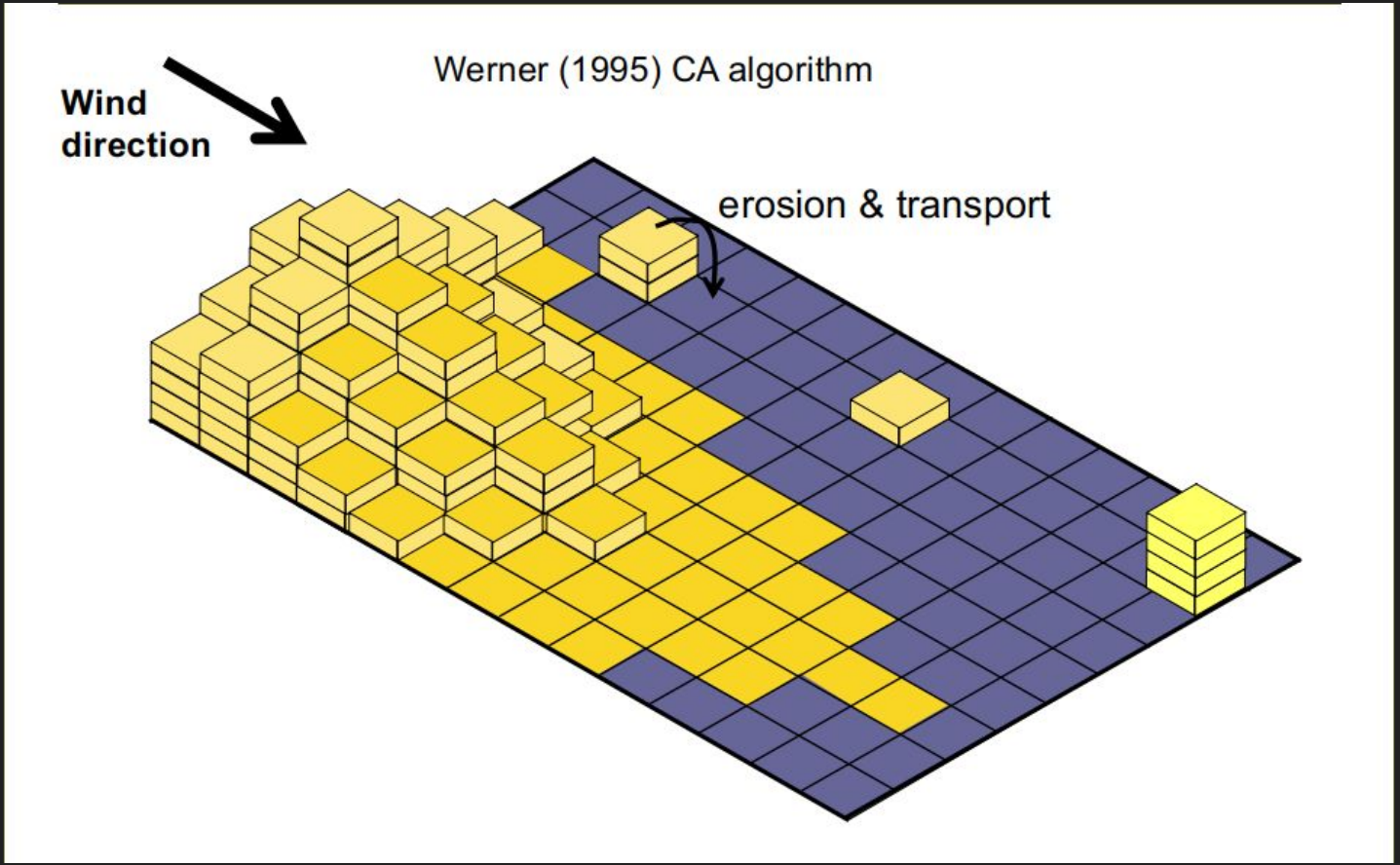
Malamud *et al.* (2005)

[Source: Marle039]

[Source: NASA]

Aeolian Landscapes

Dune 3-D Cellular Automaton



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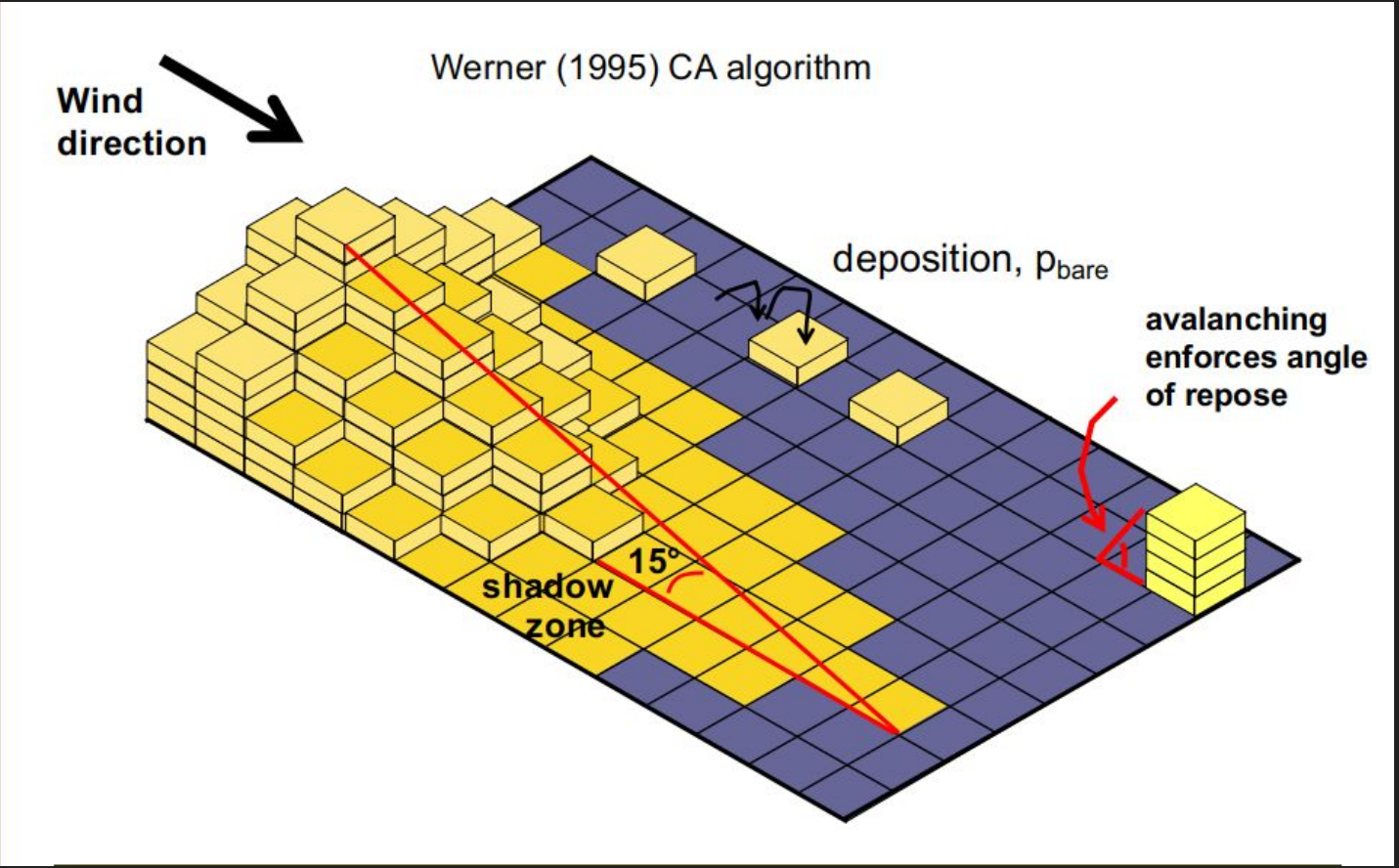
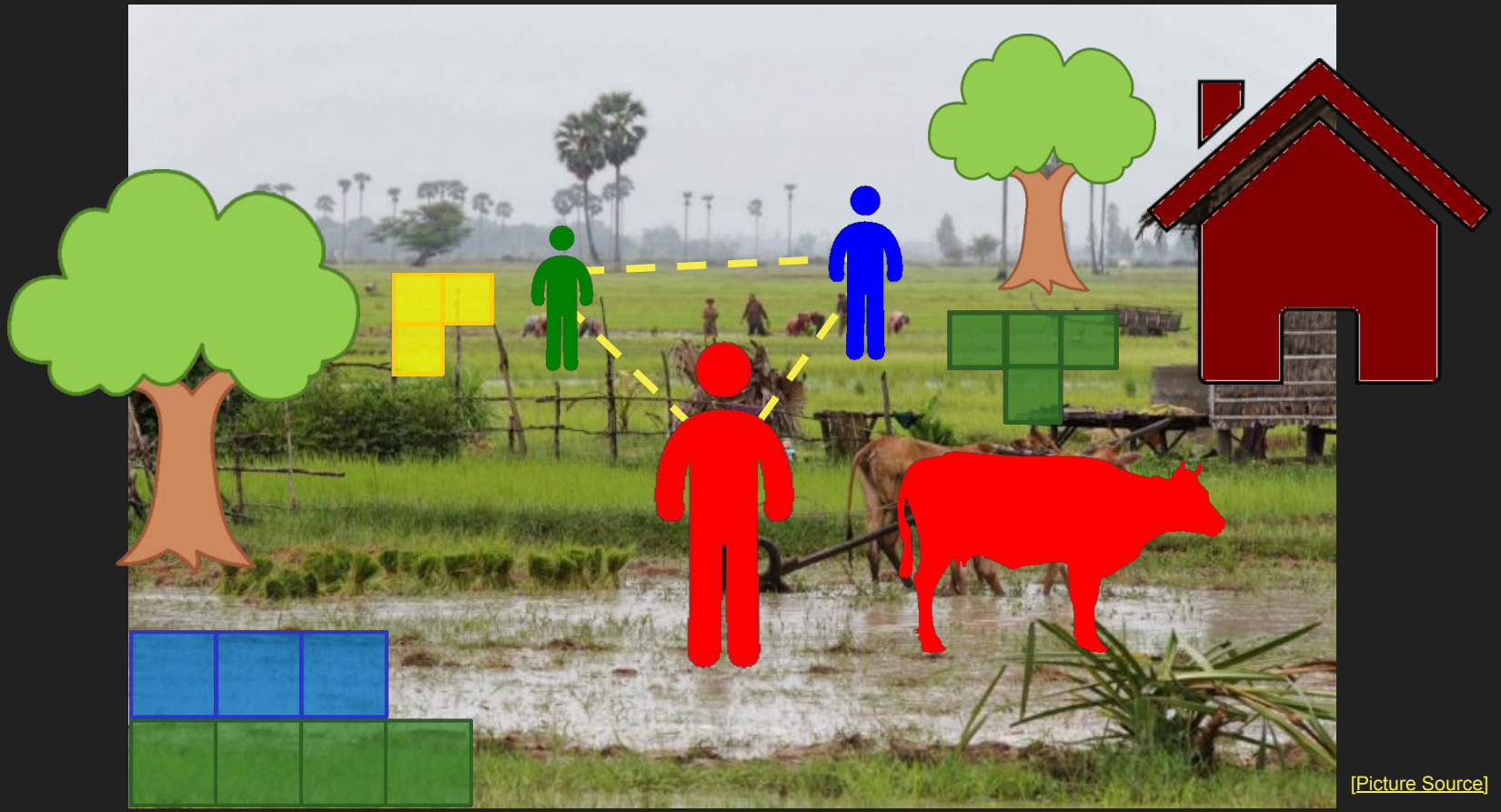


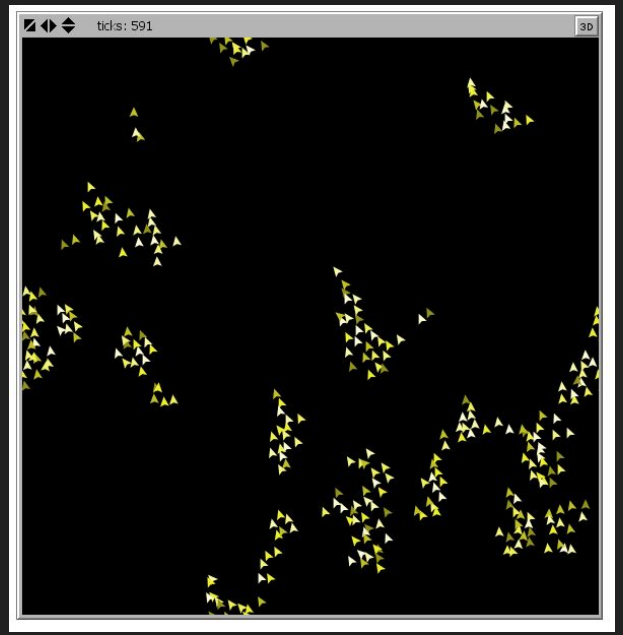
What is an Agent-Based Model?



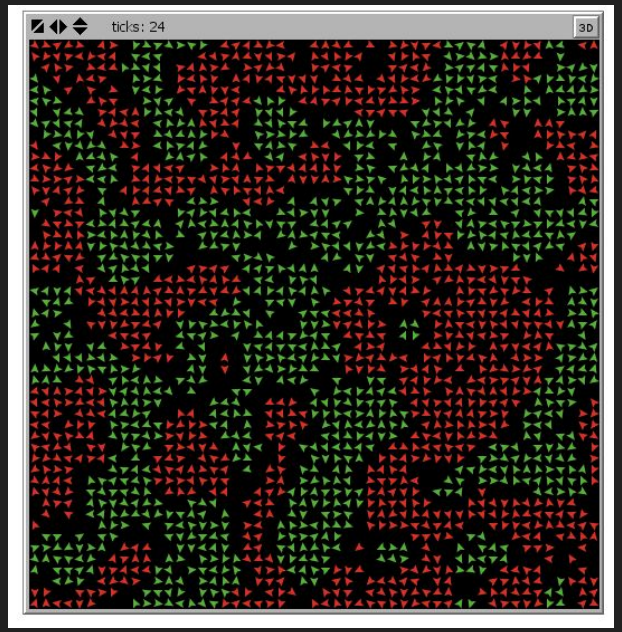
[Picture Source]

Roots in Complexity Theory

Flocking



Segregation



Agent-Based Models

Discrete, heterogeneous ‘agents’

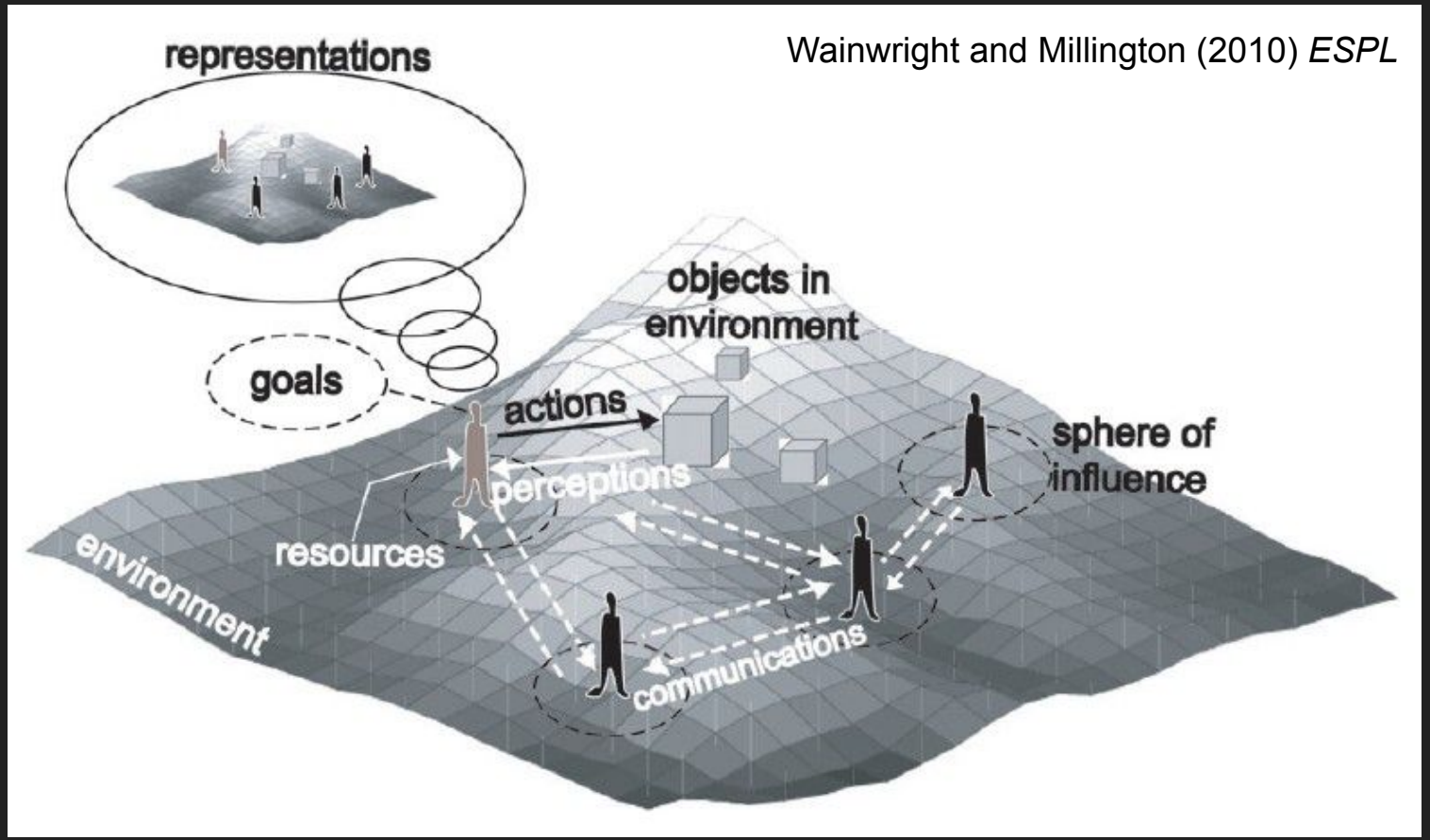
- Goals & Behaviours
- Attributes
- Interacting

Useful when the system has ‘organised complexity’

- iterative or hierarchical organisation of actors
- middle-numbered – not many many, not very few

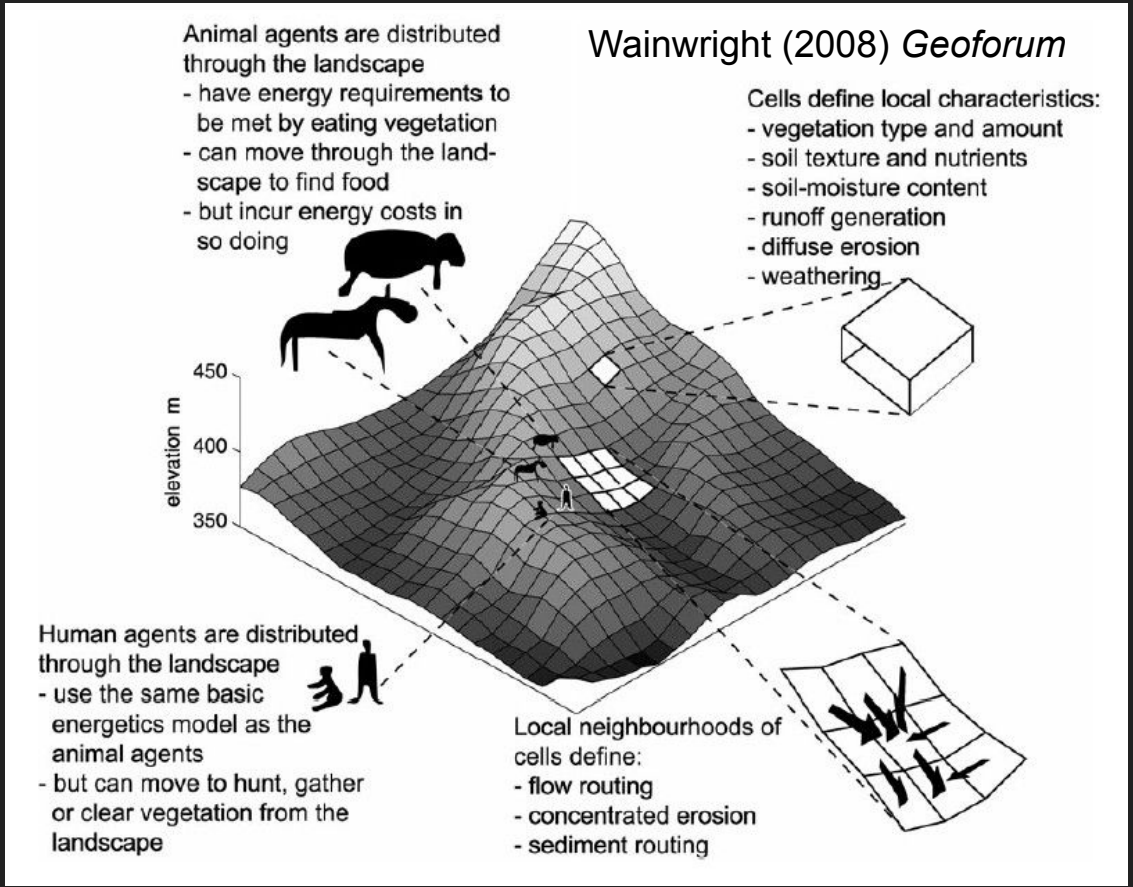
Read more in O’Sullivan *et al.* (2012)

Agent-Based Models



Wainwright and Millington (2010) *ESPL*

Agent-Based Models



Good Modelling Practices (Malamud and Baas, 2012)

Model construction

1. select appropriate model type/strategy
2. parsimony (‘Occam’s Razor’)
3. dimensional analysis
4. benchmark testing

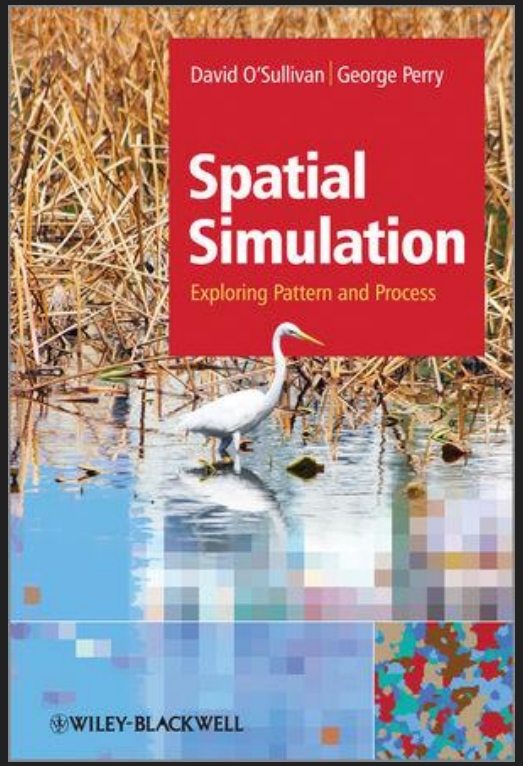
Model running

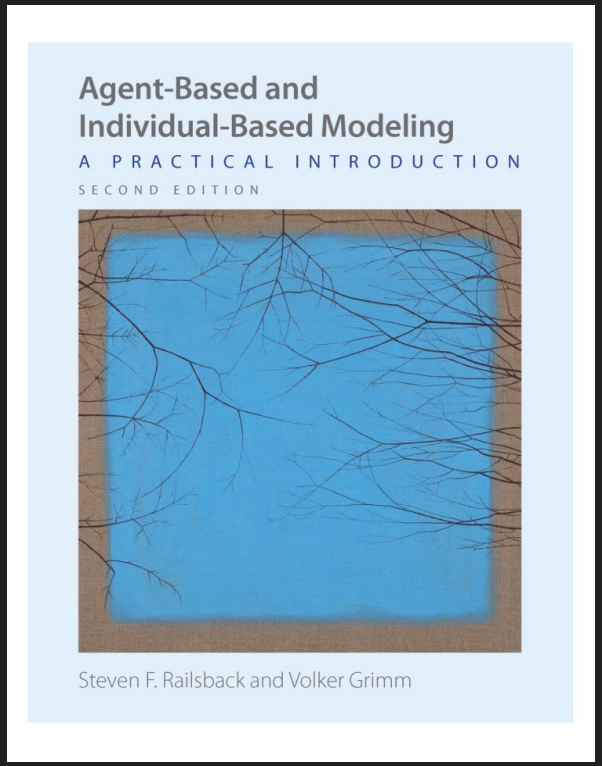
5. sensitivity analysis
6. calibration
7. data exploration
8. uncertainty assessment
9. consider alternatives

Modelling vs Models

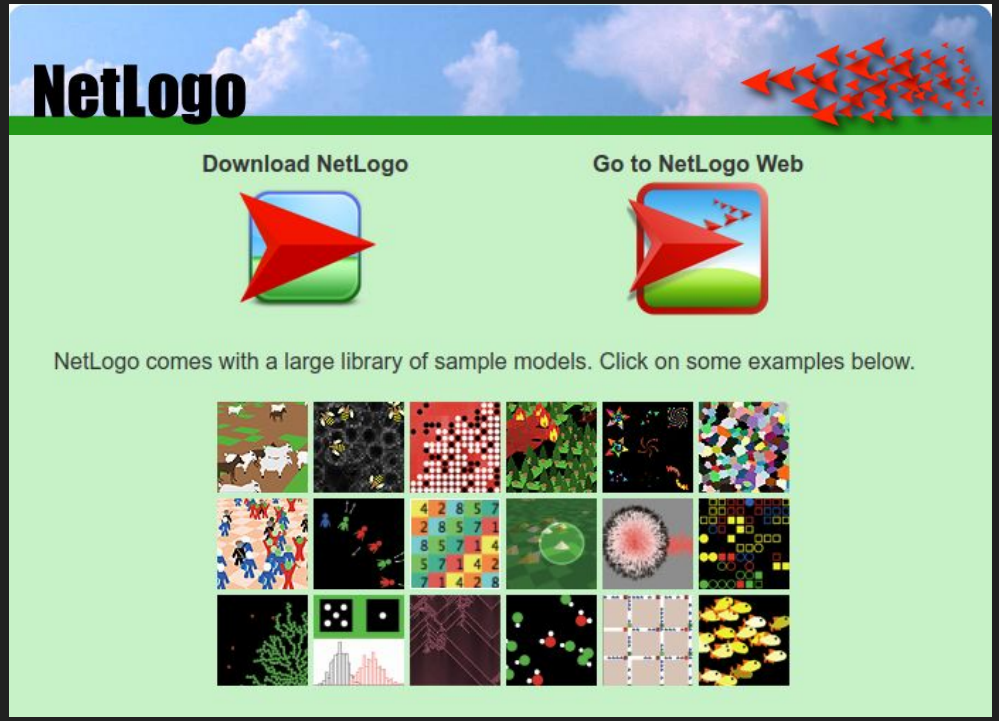
- Parameters and algorithm details need to be investigated thoroughly
- These inquiries can lead to fundamental questions and insights
- Many interesting science and application questions arise during model development
- The journey is often more fruitful than the destination! (e.g. by-products of the space race [not velcro])

CA & ABM Resources





CA & ABM Resources



NetLogo is freely available to download or run online - try it!

My example tutorials here