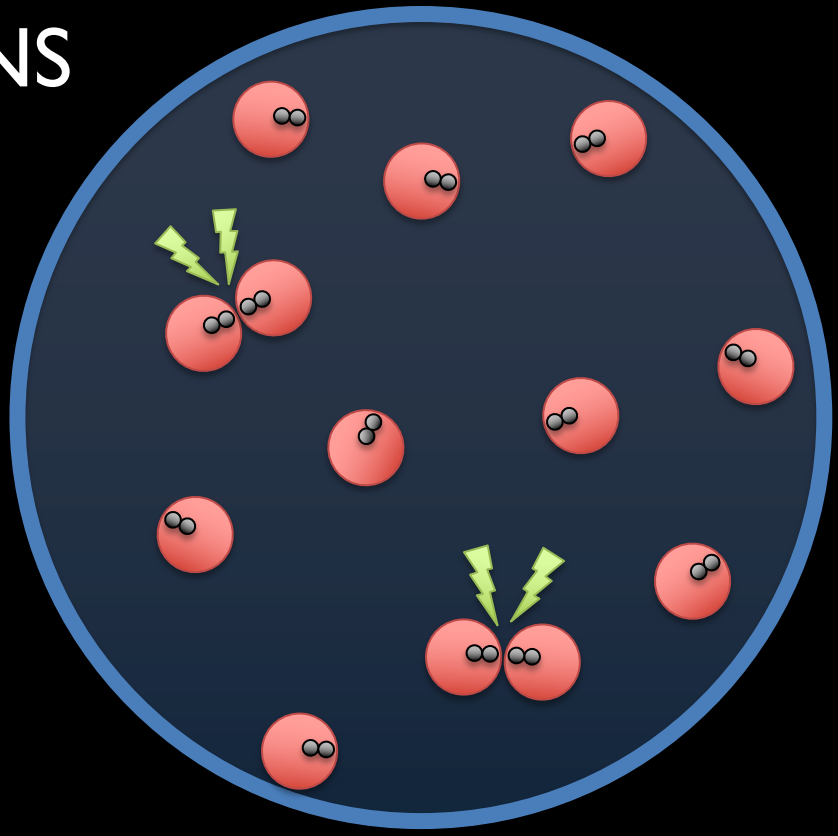
CASA0011: Agent-Based Modelling for Spatial Systems

Dr Thomas OLÉRON EVANS
Dr Sarah WISE

thomas.evans.11@ucl.ac.uk
s.wise@ucl.ac.uk

Centre for Advanced
Spatial Analysis,
90 Tottenham Court Road



The ABM Course

Week 1: Introduction to ABMs

Week 2: Cellular Automata

Week 3: ABM Methodology

Week 4: Agent Behaviours

Week 5: ABMs as Research Tools

READING WEEK

Week 6: Modelling Competitive Agents

Week 7: Presenting Results

Week 8: Forecasting & Prediction

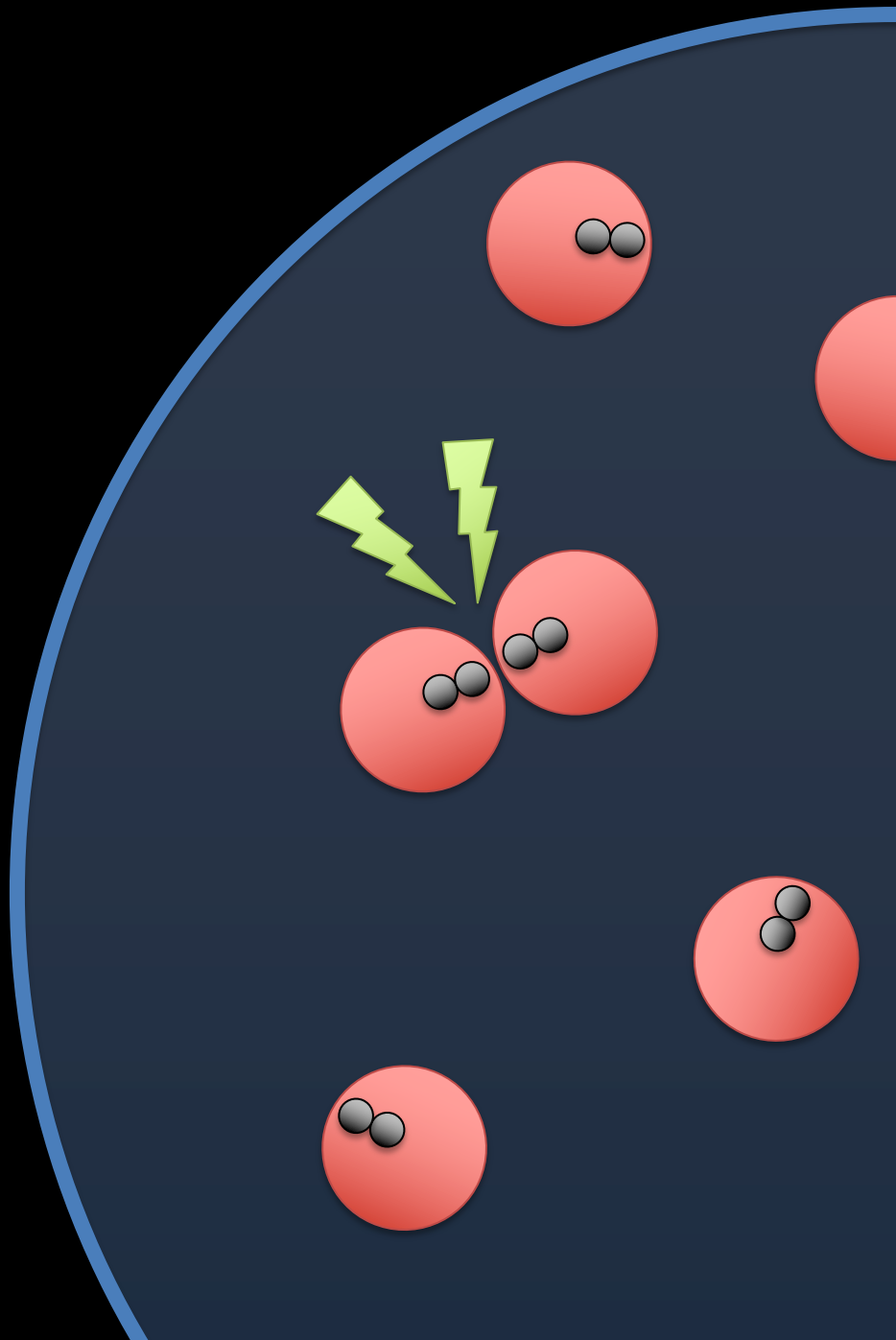
Week 9: Validation & Verification

Week 10: **Shared!**

OBJECTIVES

1. Discuss multi-scale modelling.

2. Explore how different kinds of models can be combined.

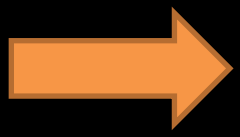


Course Objectives

You should...

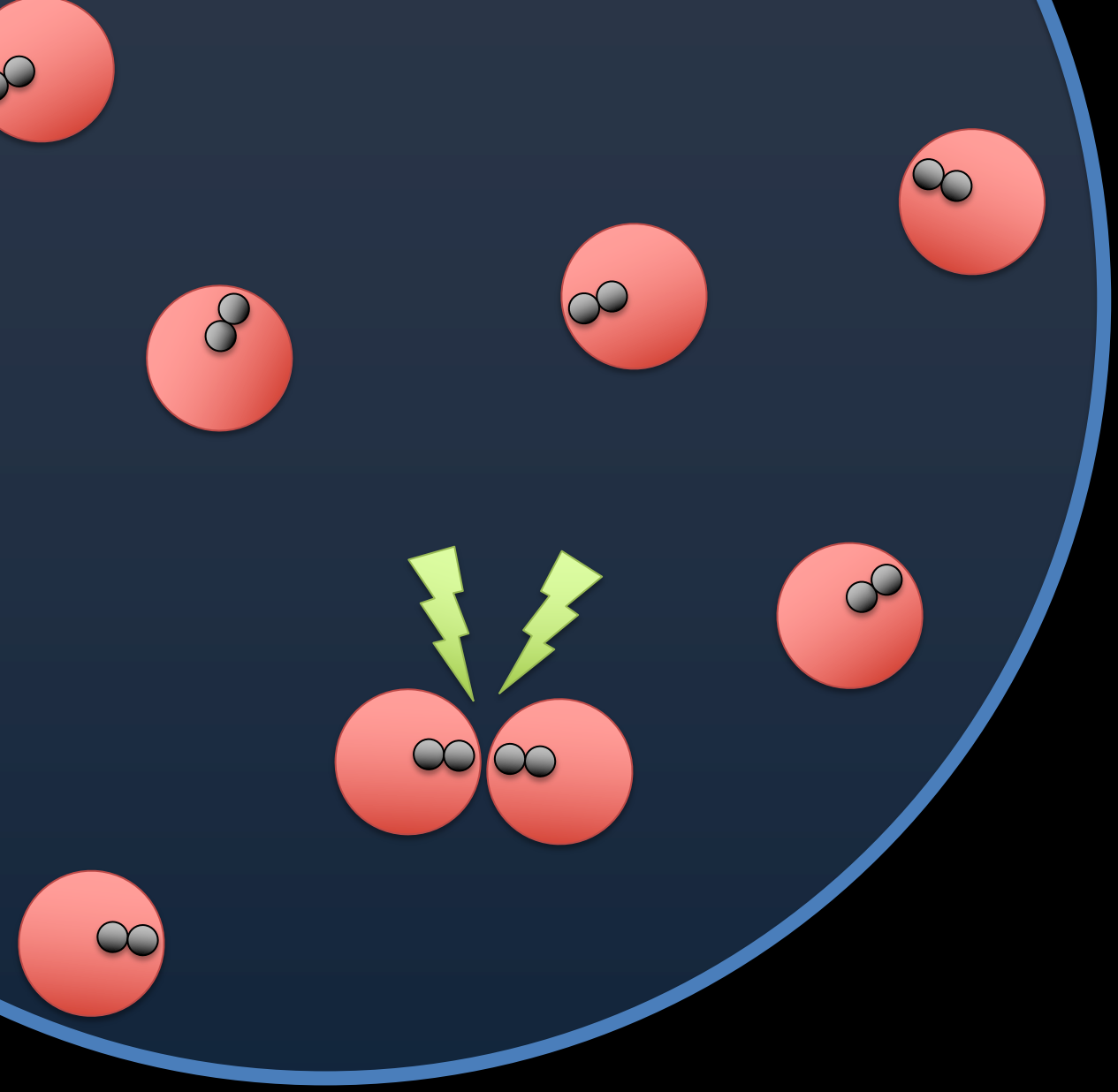
1. understand the principles of agent-based modelling (ABM)

2. be able to describe the type and range of systems to which ABM can be profitably and appropriately applied



3. be able to conceptualise and model urban systems with complex dynamics

4. show evidence of being able to translate these understandings into the practical methodology of modelling



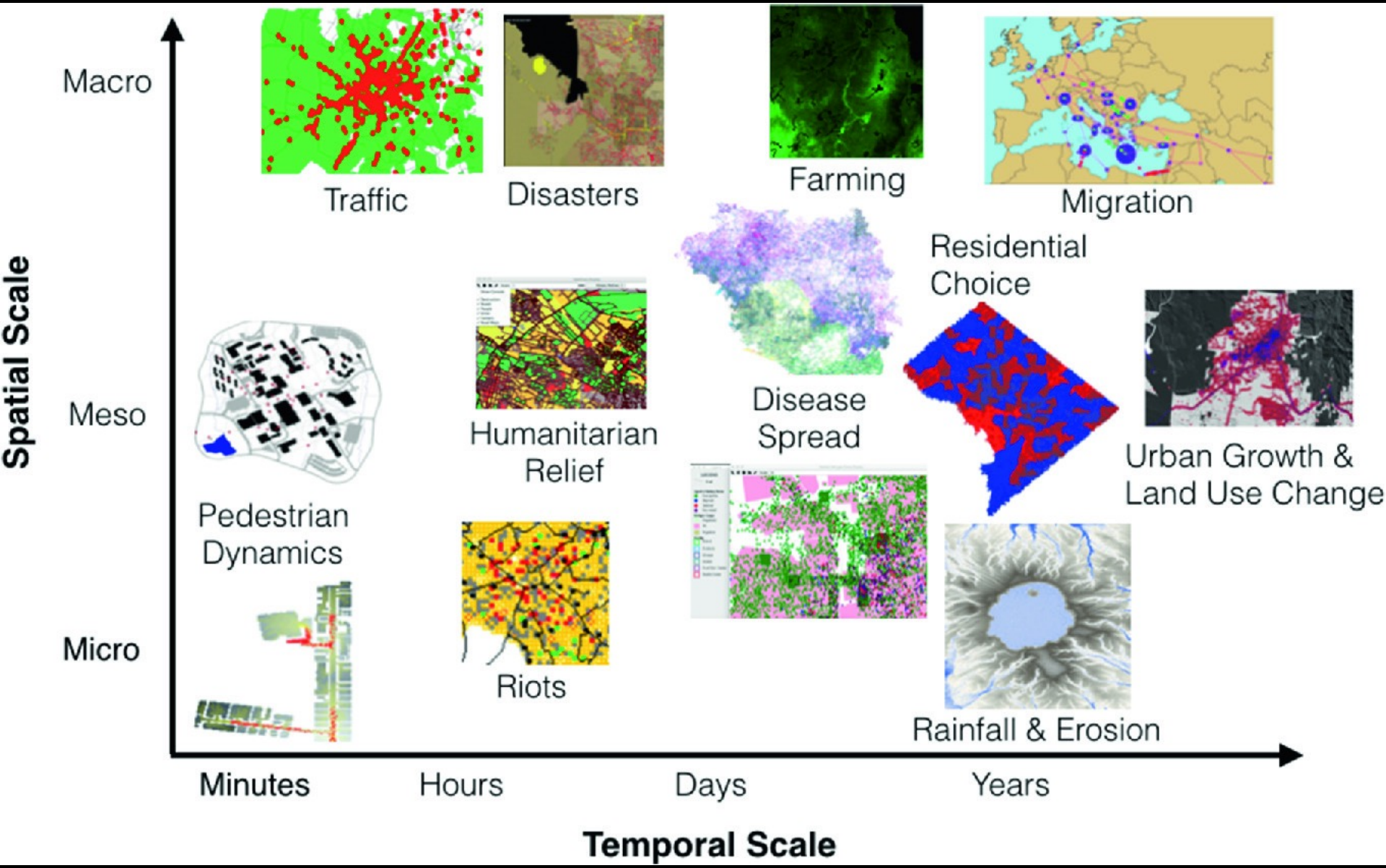
LECTURE 10
Part 1

MULTI-SCALE MODELLING

Review: Lecture 8

Modelling at different scales
– in both SPACE and TIME

- How do we choose the appropriate scale?
- How do we match the scales of space and time to one another?



Crooks, A., Heppenstall, A., Malleson, N., Manley, E. (2021). Agent-Based Modeling and the City: A Gallery of Applications. In: Shi, W., Goodchild, M.F., Batty, M., Kwan, MP., Zhang, A. (eds) Urban Informatics. The Urban Book Series. Springer, Singapore. https://doi.org/10.1007/978-981-15-8983-6_46

Combining MULTIPLE SCALES

The model can encompass multiple **scales** of processes. This is especially important in patterns which occur over different scales.

Here, you can have scale over different:

- Spaces (eg building, streetscape, city).
- Timesteps (eg observation, planning, goal-setting).
- Social units (eg individual, family, community, nation).
- Combinations of these (eg individuals leading organisations, influenced by relationships with one another over time).

Example: virus on a network

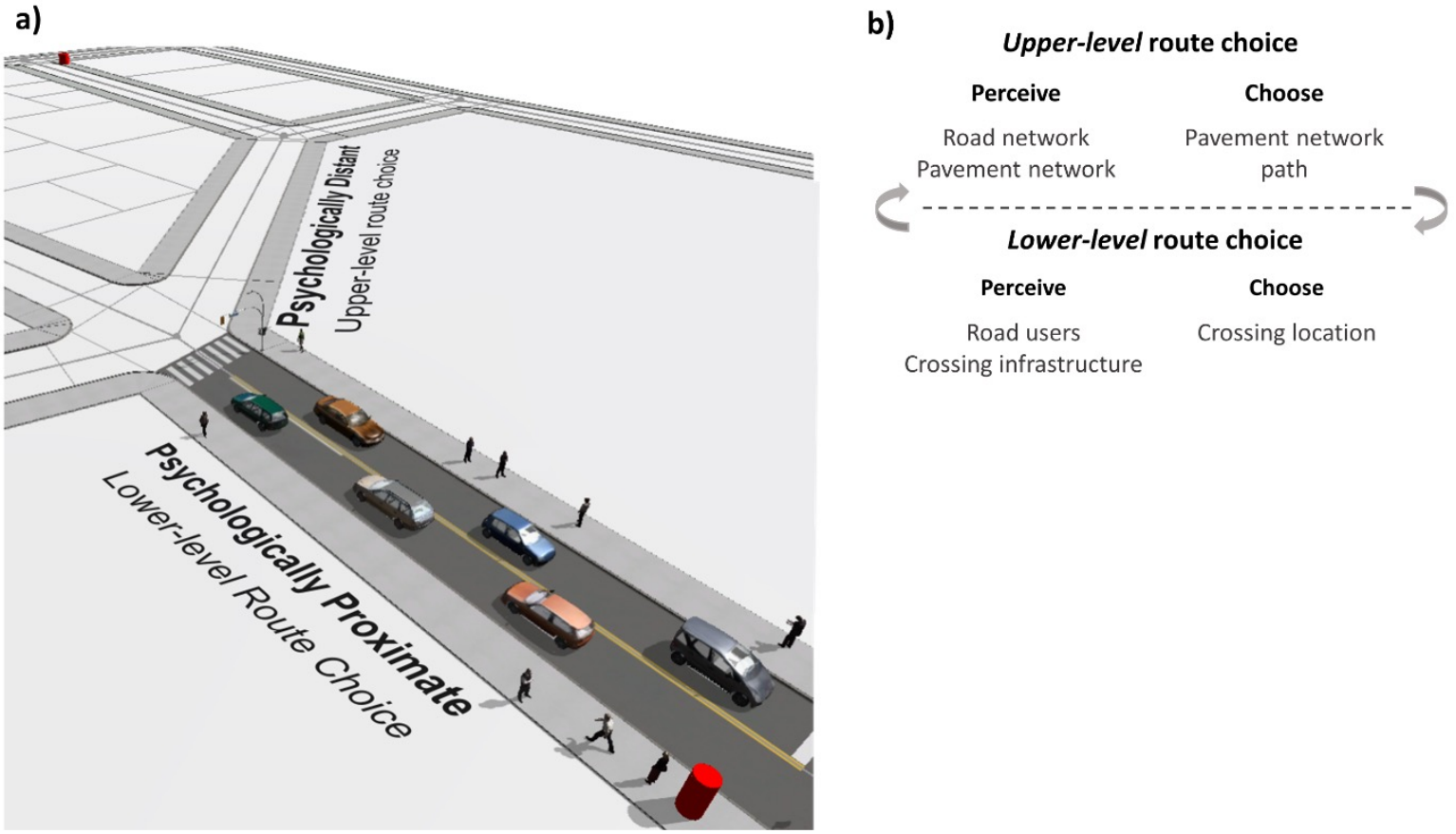
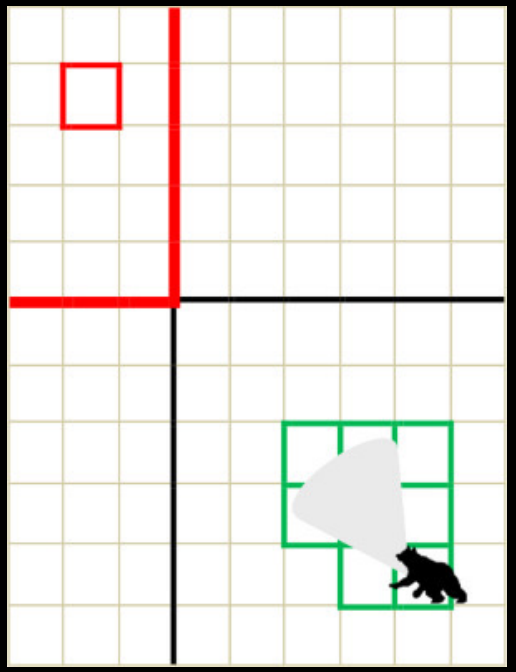


Figure 3.1: a) Diagram illustrating the CLT route choice framework. Red pillars indicate an origin and destination. Within the psychologically proximate environment road users and crossing infrastructure can be perceived. The psychologically distant environment is perceived as more abstract. **b)** Summary of *upper-level* and *lower-level* route choice. Grey arrows indicate interaction between levels.

Sargoni, Obi Thompson. 2023 'Multi-Scale Pedestrian Navigation and Movement in Urban Areas'.

Over a range of scales

Zubiria Perez, Alejandra, Christopher Bone, and Gordon Stenhouse. 2021. 'Simulating Multi-Scale Movement Decision-Making and Learning in a Large Carnivore Using Agent-Based Modelling'. *Ecological Modelling* 452 (July): 109568. https://doi.org/10.1016/j.ecolmodel.2021.109568.



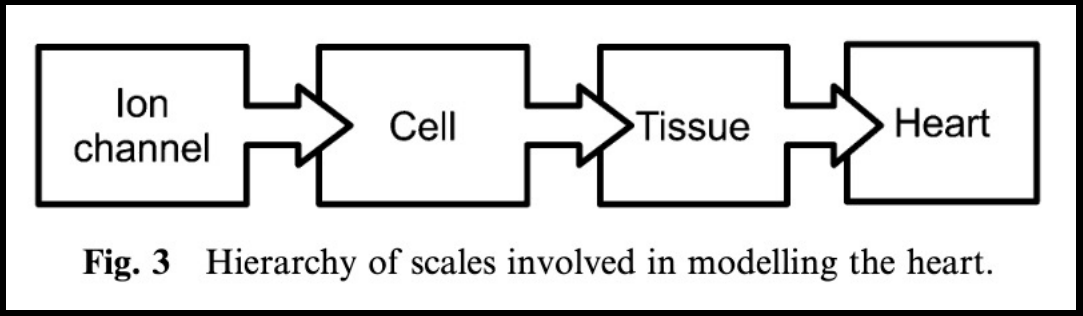
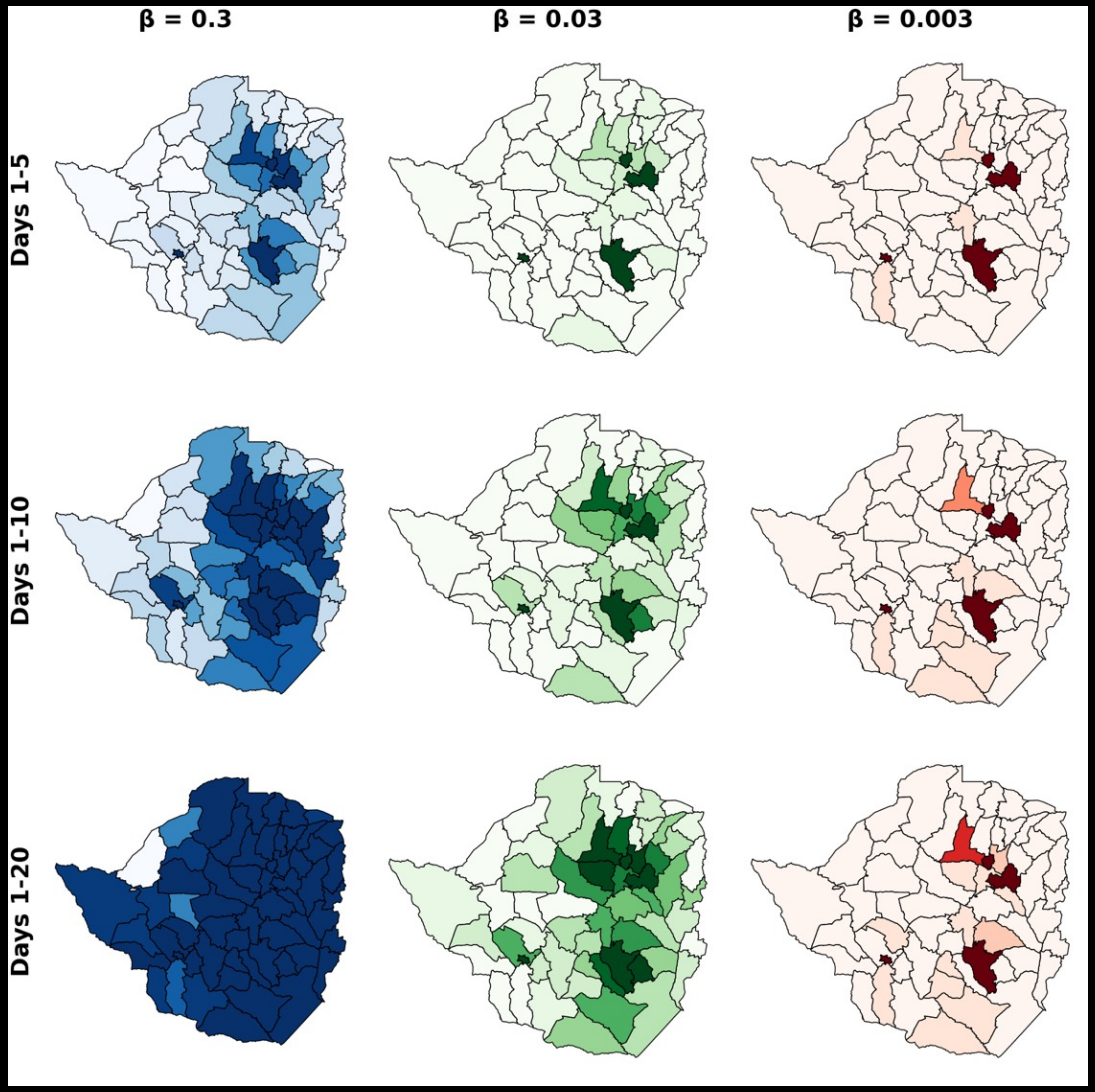


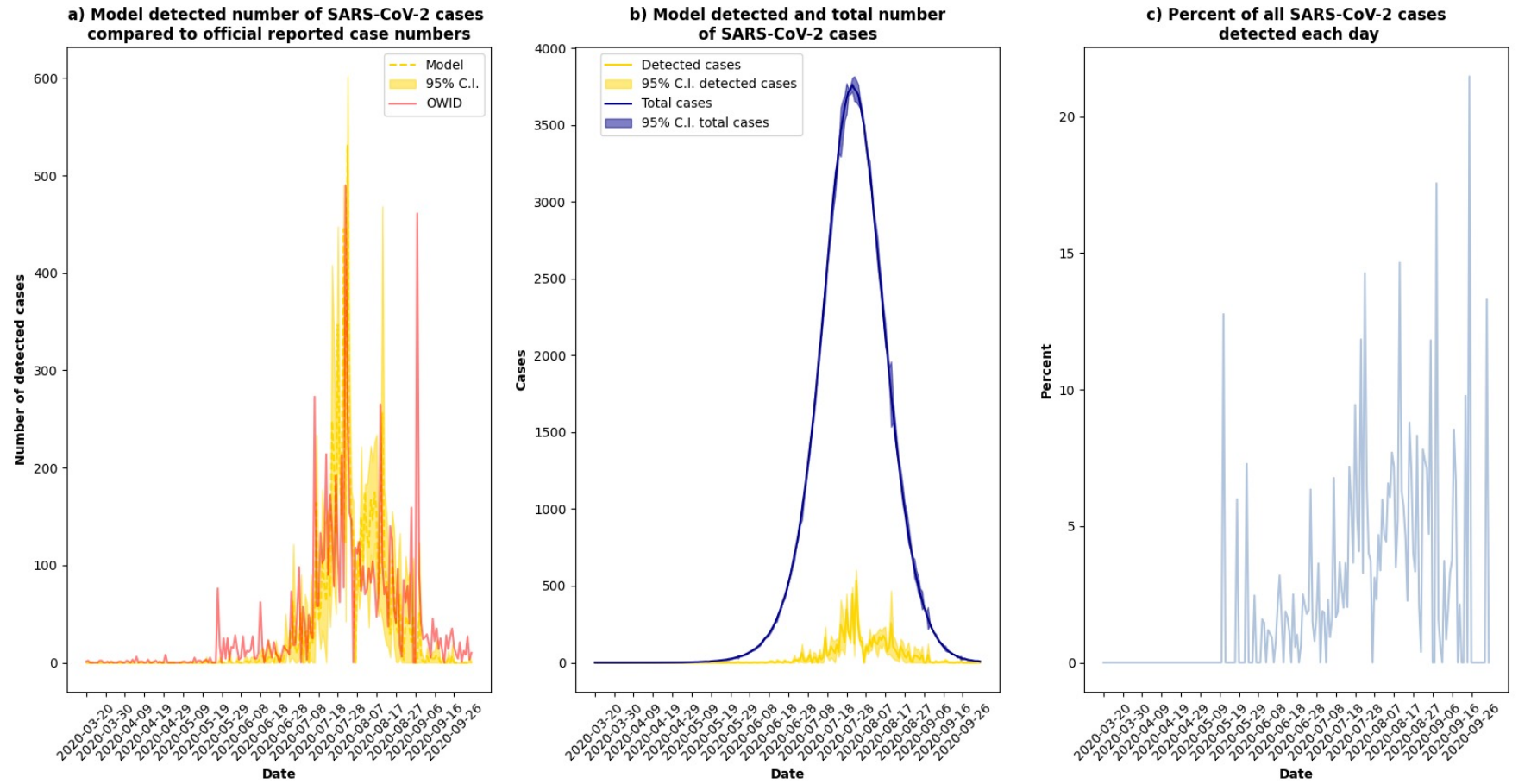
Fig. 3 Hierarchy of scales involved in modelling the heart.

Dada, Joseph O., and Pedro Mendes. 2011. 'Multi-Scale Modelling and Simulation in Systems Biology'. *Integrative Biology* 3 (2): 86. https://doi.org/10.1039/c0ib00075b.

50% Sample



Wise, Sarah, Sveta Milusheva, Sophie Ayling, and Robert Manning Smith. 2023. 'Scale Matters: Variations in Spatial and Temporal Patterns of Epidemic Outbreaks in Agent-Based Models'. *Journal of Computational Science* 69 (May): 101999. https://doi.org/10.1016/j.jocs.2023.101999.



Manning Smith, Robert, Sarah Wise, and Sophie Ayling. 2023. 'Calibration in a Data Sparse Environment: How Many Cases Did We Miss? (Short Paper)'. In *12th International Conference on Geographic Information Science (GIScience 2023)*. Vol. 277. Leeds, UK. https://doi.org/10.4230/LIPICS.GISCIENCE.2023.50.

Want to read more?

Lippe, Melvin, Mike Bithell, Nick Gotts, Davide Natalini, Peter Barbrook-Johnson, Carlo Giupponi, Mareen Hallier, et al. 2019. 'Using Agent-Based Modelling to Simulate Social-Ecological Systems across Scales'. *GeoInformatica* 23 (2): 269–98. https://doi.org/10.1007/s10707-018-00337-8.

COMBINING MODELS

SLEUTH model

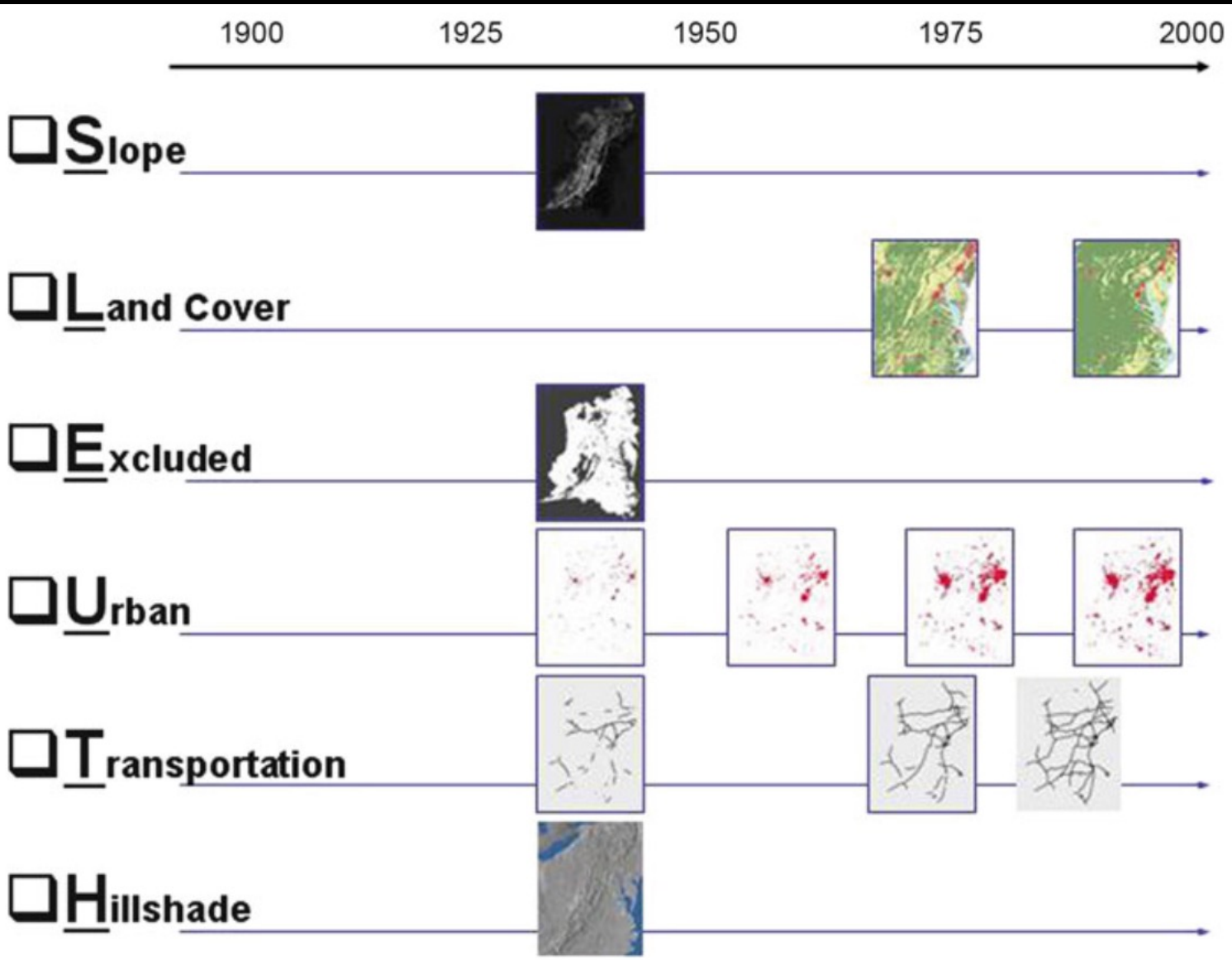


Fig. 62.2 Input data for the SLEUTH model. Minimum layers are topographic slope, two land use maps, one exclusion map, four urban extent maps, two transportation maps, and a hill-shaded background image. Data shown are for the Environmental Protection Agency's Mid Atlantic Regional Assessment study area

Clarke, Keith C. 2014. 'Cellular Automata and Agent-Based Models'. In *Handbook of Regional Science*, Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-23430-9_63

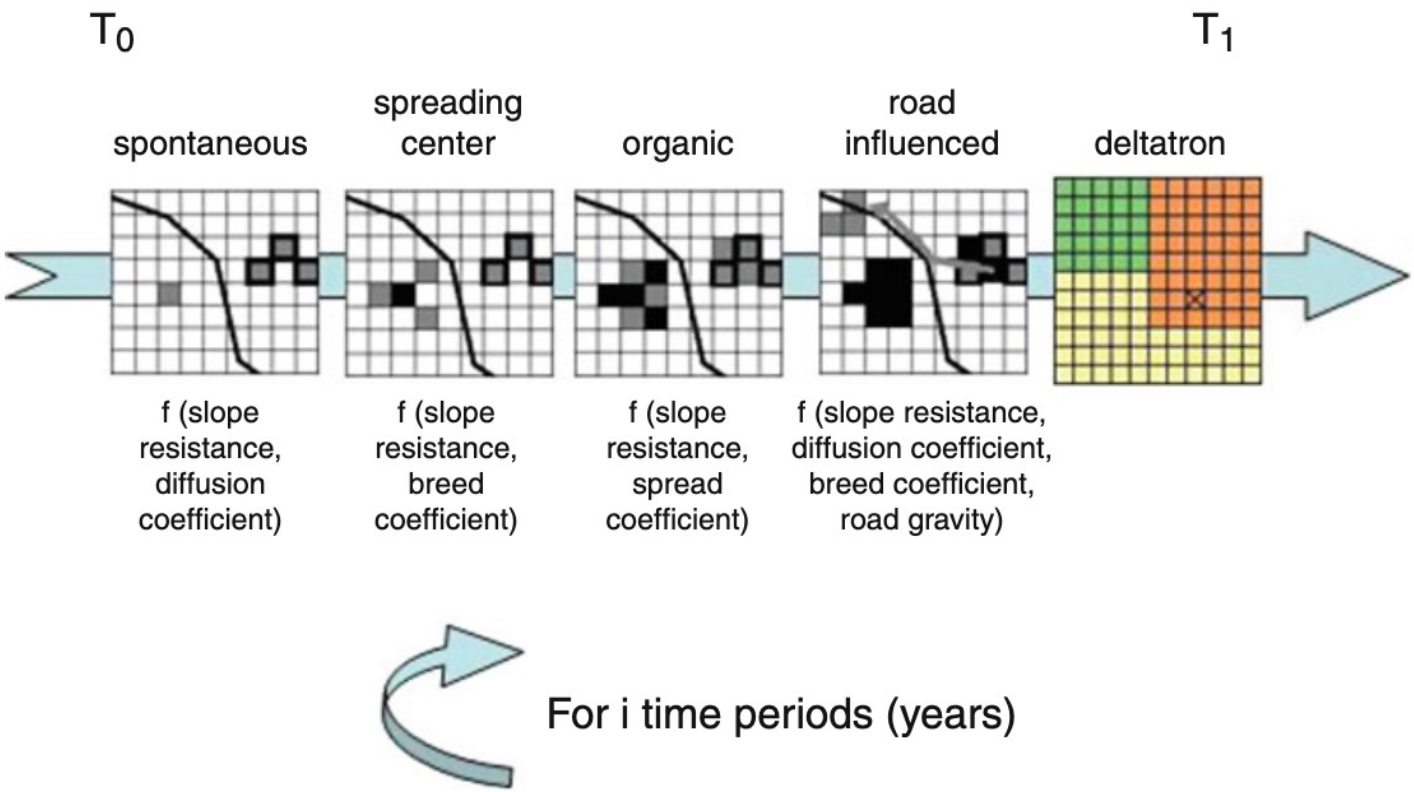


Fig. 62.3 At each cycle in the CA model, five sets of behavior rules are enforced. These are controlled by the factors and parameters shown and are applied in sequence for each one "year" iteration of the model

Clarke, Keith C. 2014. 'Cellular Automata and Agent-Based Models'. In *Handbook of Regional Science*, Berlin, Heidelberg: Springer. https://doi.org/10.1007/978-3-642-23430-9_63

https://github.com/swise5/takamatsu

THANKS!