Conceptual Approaches to Scaling up: Fostering Discussion

Derek T. Robinson

2019/09/09

UNIVERSITY OF WATERLOO
FACULTY OF ENVIRONMENT

"While there is a rich body of conceptual studies as well as local case studies in different environments documenting how in local contexts land-use decisions are made, there [is] no global overview of how these characteristics and attitudes influence land-use decisions around the globe."

(Malek et al. 2019).

"... two main challenges: how to develop models that are generalizable and still applicable in specific cases, and how to scale up the processes of interactions of a few agents to interactions among many agents."

(Janssen and Ostrom (2006)

Scaling up ABMs

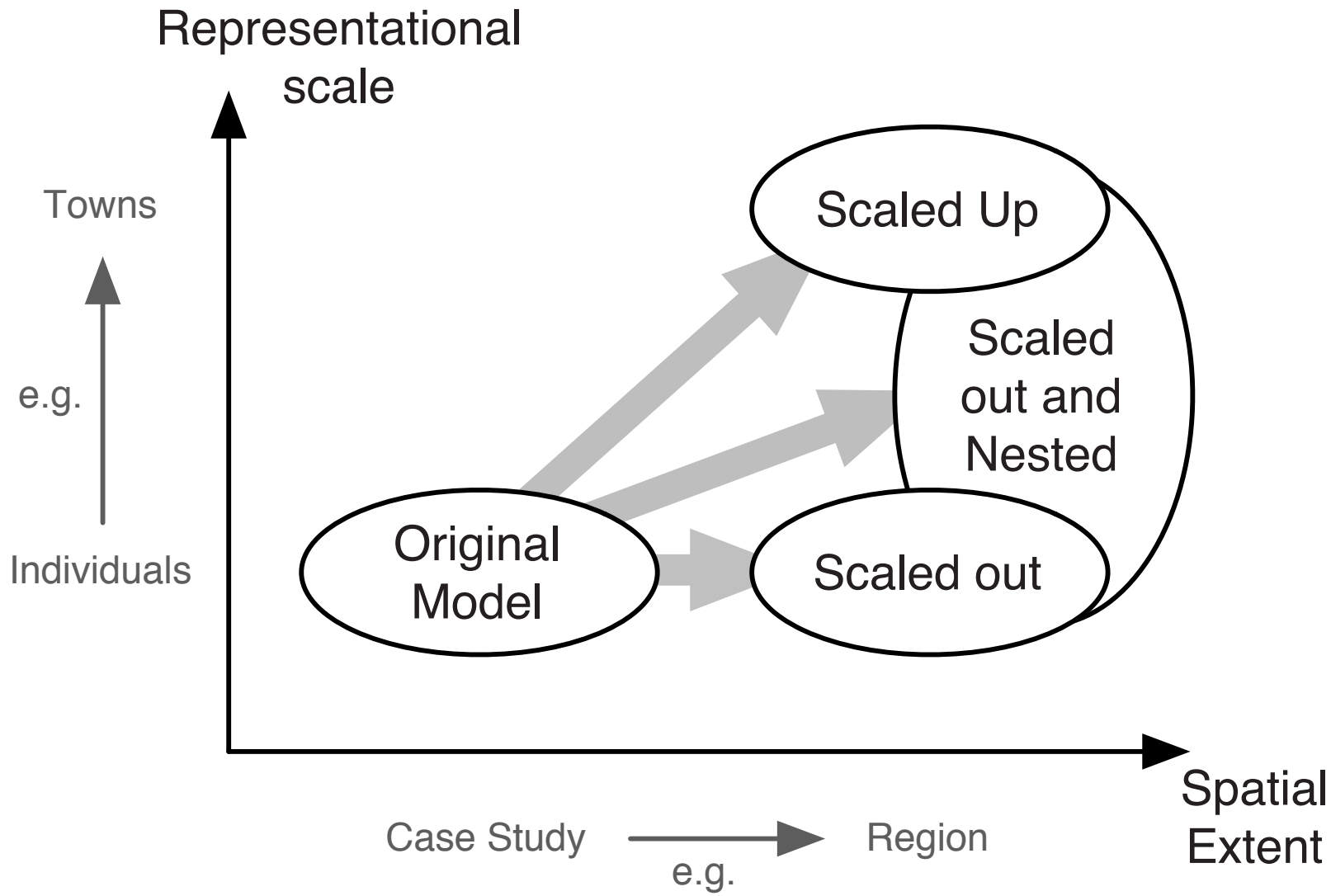
- How do we represent humans (individuals, households, firms) making decisions that drive land-use change across very large spatial extents (e.g., national, contental, or global)?

Why do we want to do this?

- More is different (Anderson 1972)
- Close the system
  - Represent processes endogenously that we typically represent exogenously (e.g., migration, telecoupling)
- Quantify processes and outcomes of potential scenarios at large spatial extents (e.g., policy introduction)
- Some processes are not place based (e.g., global market prices)
- Improve global models lacking endogenous human decision-making

Ideal scaling method would

- cover large geographic areas
- be scale independent
- be applicable at different spatial units (e.g., DAs to CSDs or CSDs to CDs, CAN census)
- require as little data as possible
- clear to enable replication by others
- can be validated
- provide a level of heterogeneity that takes advantage of the ABM approach
- be standardized across space and time, which may require general classifications for global applications to accommodate for differences in data detail and availability (e.g., IPCC Tier 1-3)

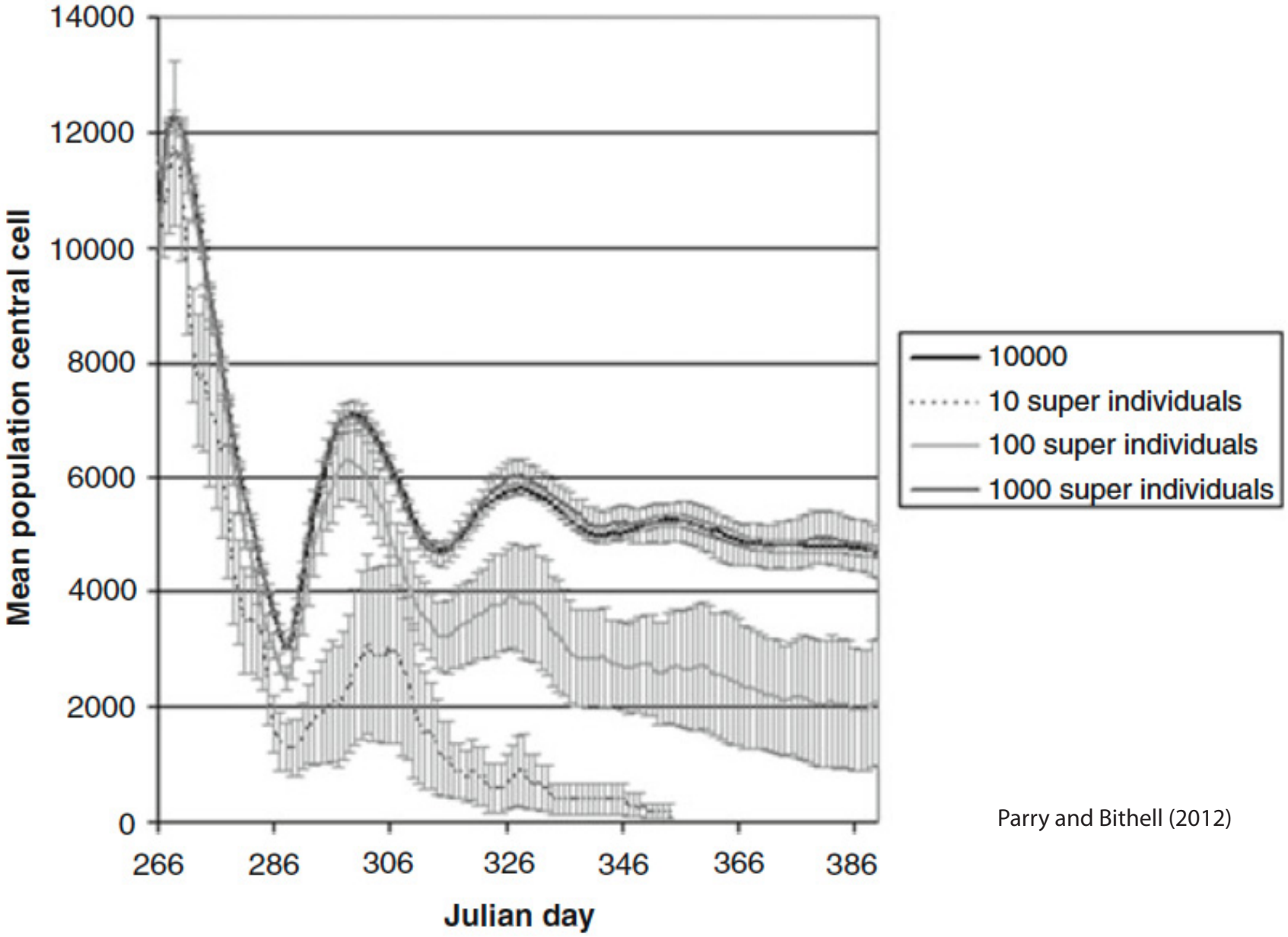


Rounsevell, M., Robinson, D.T. and D. Murray-Rust (2012) From actors to agents in socio-ecological systems models. Philosophical Transactions of the Royal Society B 367: 259-269. DOI: 10.1098/rstb.2011.0187

Scaling Up

- Fewer agents cover larger spatial extents
  - Individual super (Parry and Bithell 2012) or meta (Holland 1992) agents
    - We are only concerned with the scale of decisions and spatio-temporal outputs at this level
    - This is all the data we have
    - Agents are designed for this scale (e.g., municipal, province or state agents)
  - Super agent as a collection of agents
    - Selected from a distribution of sample or population agent characteristics, but then how do we ensure internal consistentcy and correlation among those characteristics?
    - Maintain cursory representation of agents and their characteristics represented by super agent, but decisions are made only by super agents

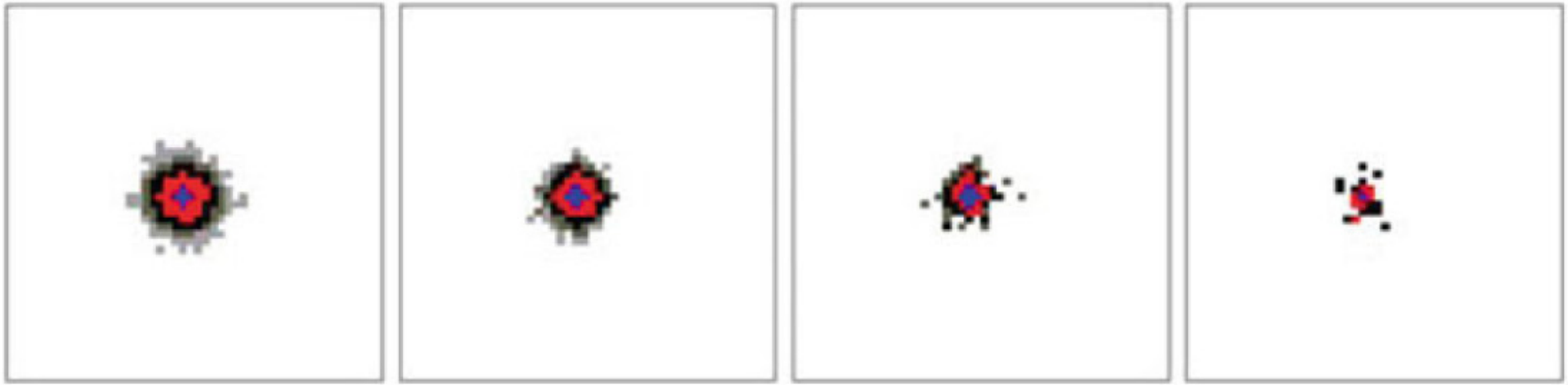
Super agents



Parry and Bithell (2012)

Super Agents

- Spatial results

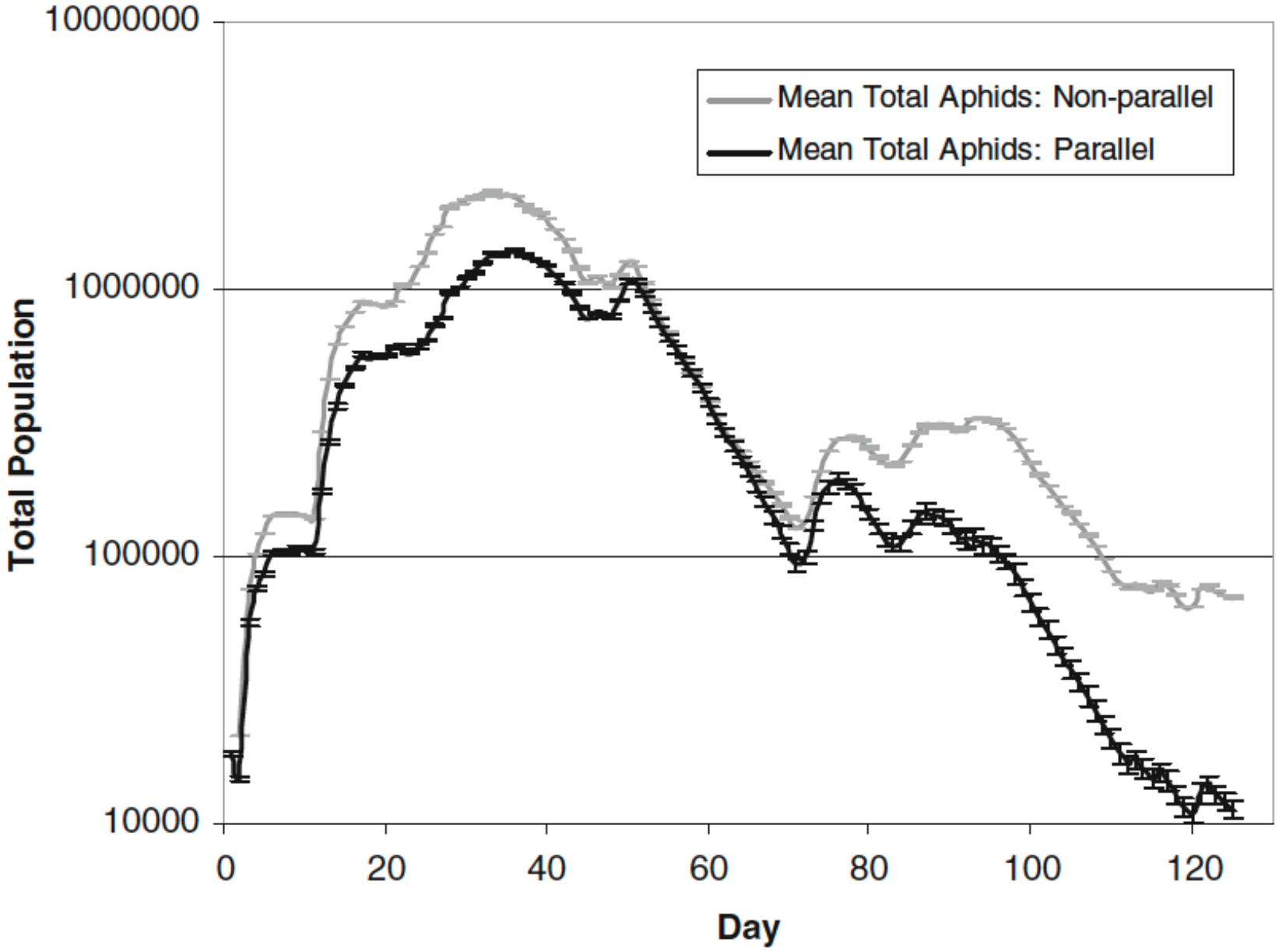


10,000 individuals, density at 20 days: (l-r) Individual-based simulation, super-individual simulation scale factor 10, 100 and 1,000

Scaling Out

- Represent as many agents as possible, which probably requires HPC
- Representative sample of detailed agents whose results are applied with a scaling factor/coefficent/expansion factor to the population

Scaling Out


10000000
1000000
100000
10000
Total Population
0
20
40
60
80
100
120
Day
Mean Total Aphids: Non-parallel
Mean Total Aphids: Parallel

Discussion items…

- Are all macro agents institutions?
- When to scale up versus scale out?
- Do we have examples to illustrate methods or can we implement examples?
- OR do we want to develop a uniform framework and apply it to different locations?
- Do we want types of agents and/or variability in agent characteristics for scaling out or hierarchical agents for scaling up?
- Where should and shouldn't we scale up (e.g., dynamic mesh, areas of low activity scale up versus areas of high activity)?
- What is our benchmark for validation or ensuring our approach is well done?
- How would a global scale (scaled up ABM) help society?
- How would a global scale (scaled up ABM) advance science?
- How to go from Malek et al. 2019 typology of 6 decision-making agent types to operationalized model with available data