



Introduction to Simulation

*Complex social dynamics in a
few lines of code*



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Outline

- ▼ Why model?
- ▼ General description
- ▼ Tutorial
- ▼ Modeling challenges



Why model?

What is a model?

A model is a human construct designed to help us understand the real world

What is a model?

$$\dot{\mathbf{p}} = m \frac{d\mathbf{v}}{dt} = \mathbf{F}, \quad \begin{cases} \dot{p}_x = m \frac{dv_x}{dt} = F_x \\ \dot{p}_y = m \frac{dv_y}{dt} = F_y \\ \dot{p}_z = m \frac{dv_z}{dt} = F_z \end{cases}$$

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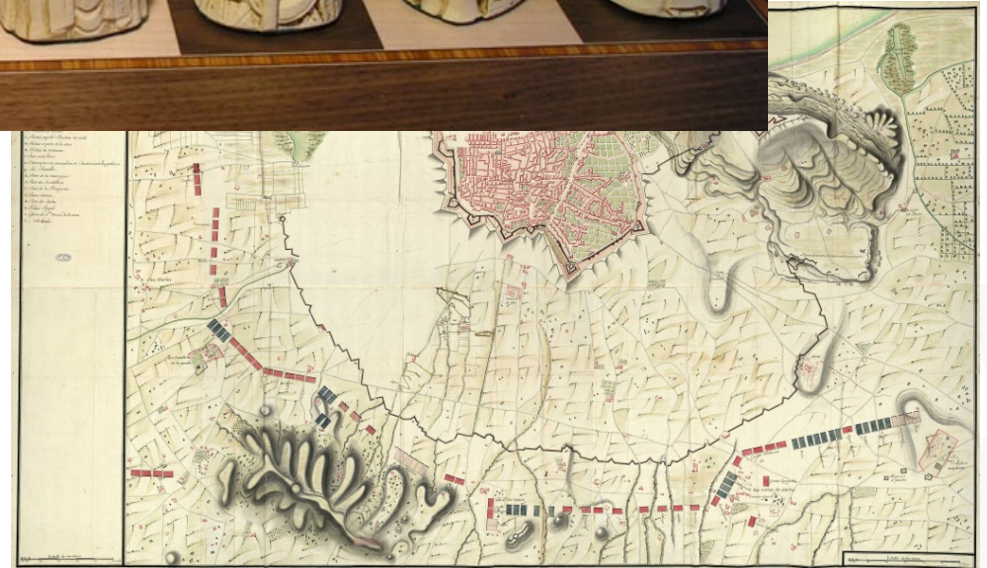
What is a model?

$$\dot{p} = m$$

A
US



elp



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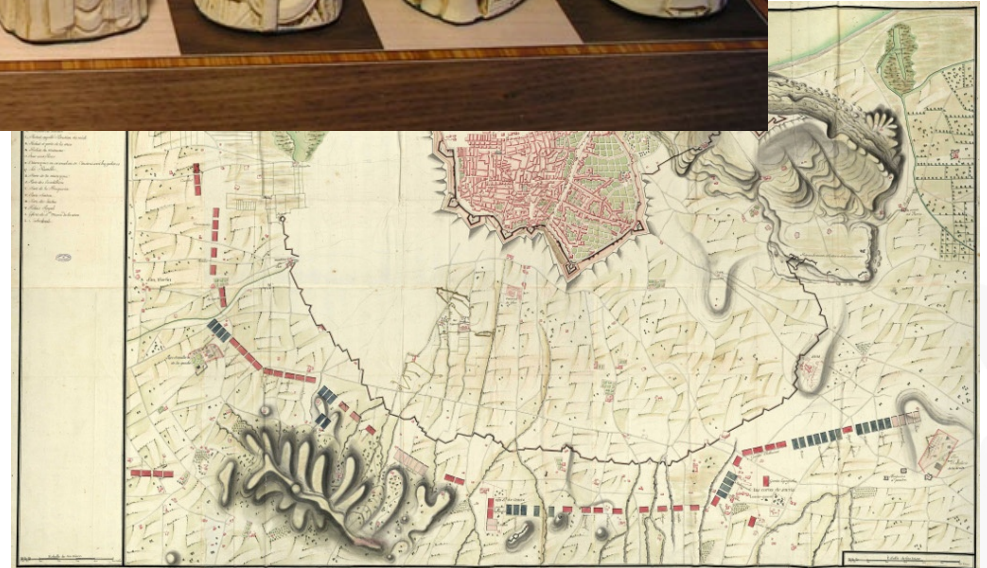
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"Capitalist production, therefore, develops technology, and the combining together of various processes into a social whole, only by sapping the original sources of all wealth - the soil and the labourer."

Karl Marx



Descriptive vs formal models

- ▼ Anyone who ventures a projection, or imagines how a social dynamic—an epidemic, war, or migration—would unfold is running a model.

Descriptive vs formal models

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- ▶ But typically, it is an implicit model in which the assumptions are hidden, their internal consistency is untested, their logical consequences are unknown, and their relation to data is unknown.

Formal models

- ▼ The use of formal models provides some advantages over natural language definitions:
 - ▼ Complete description of the dynamics of a system, including assumptions, variables and processes
 - ▼ Assessment of hypotheses given the available evidence
 - ▼ Comparison between competing explanations
- ▼ These properties allow us to compare and select formal models based on their **utility** and **parsimony**

Utility

"all models are wrong, but some are useful"
George Box

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"while a model can never be *truth*, a model might be ranked from very useful, to useful, to somewhat useful to, finally, essentially useless."

Burnham & Anderson

Parsimony

"Among competing hypotheses that predict equally well, the one with the fewest assumptions should be selected"

Ockham's razor

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Ockham's razor

"With four parameters I can fit an elephant, and with five I can make him wiggle his trunk."

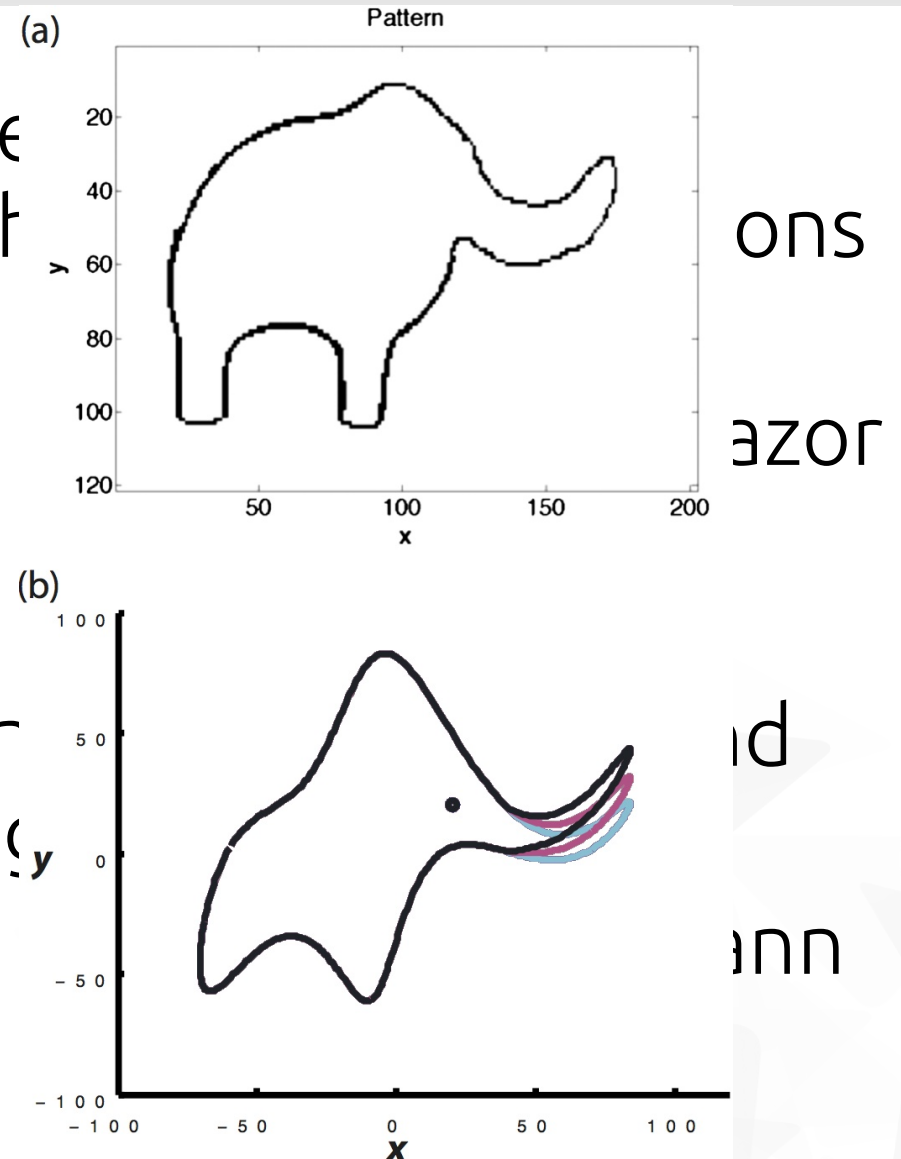
John von Neumann

Parsimony

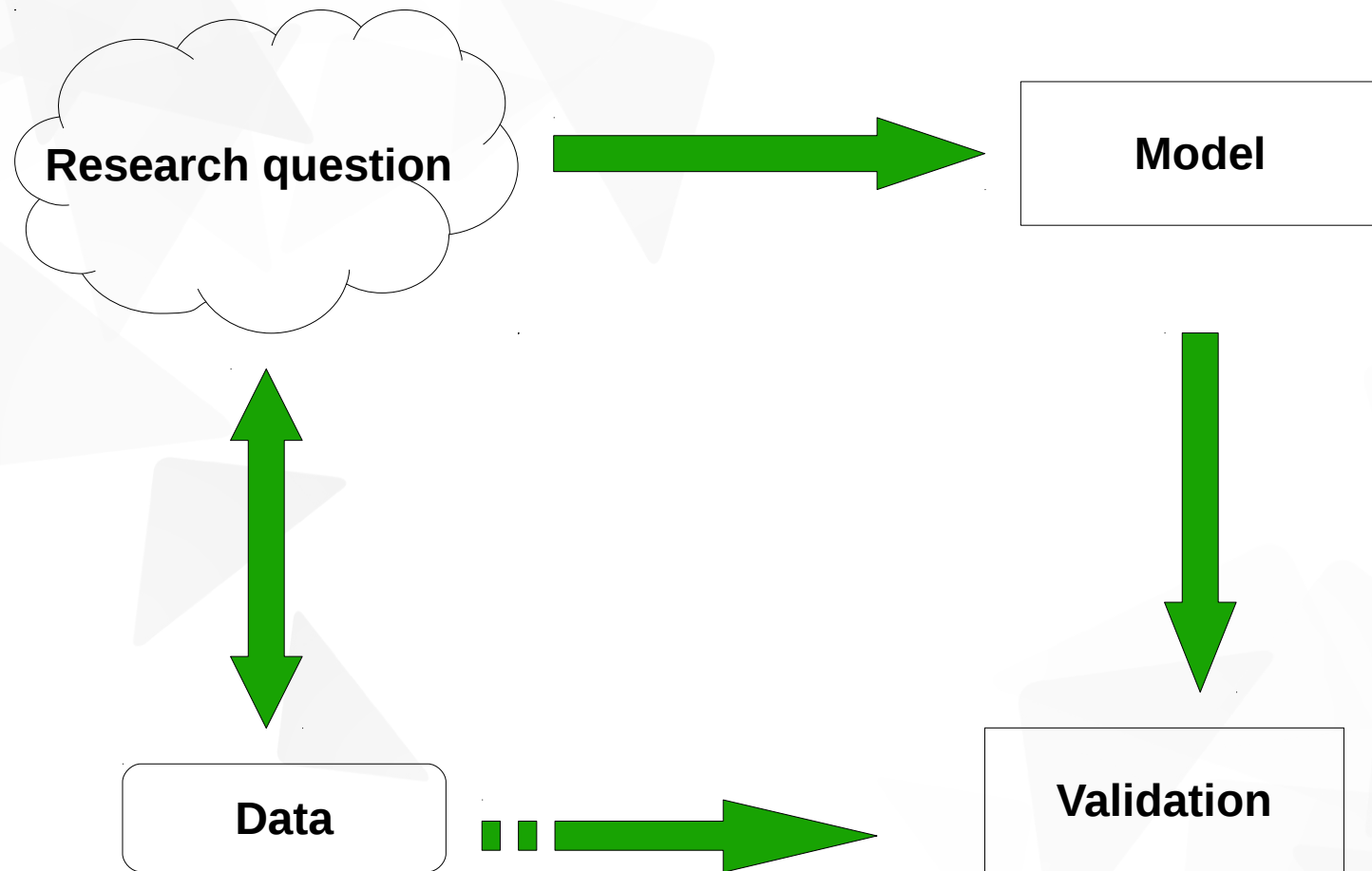
"Among competing hypotheses equally well, the one with the fewest parameters should be selected"

"With four parameters I can draw an elephant and with five I can make him wiggle"

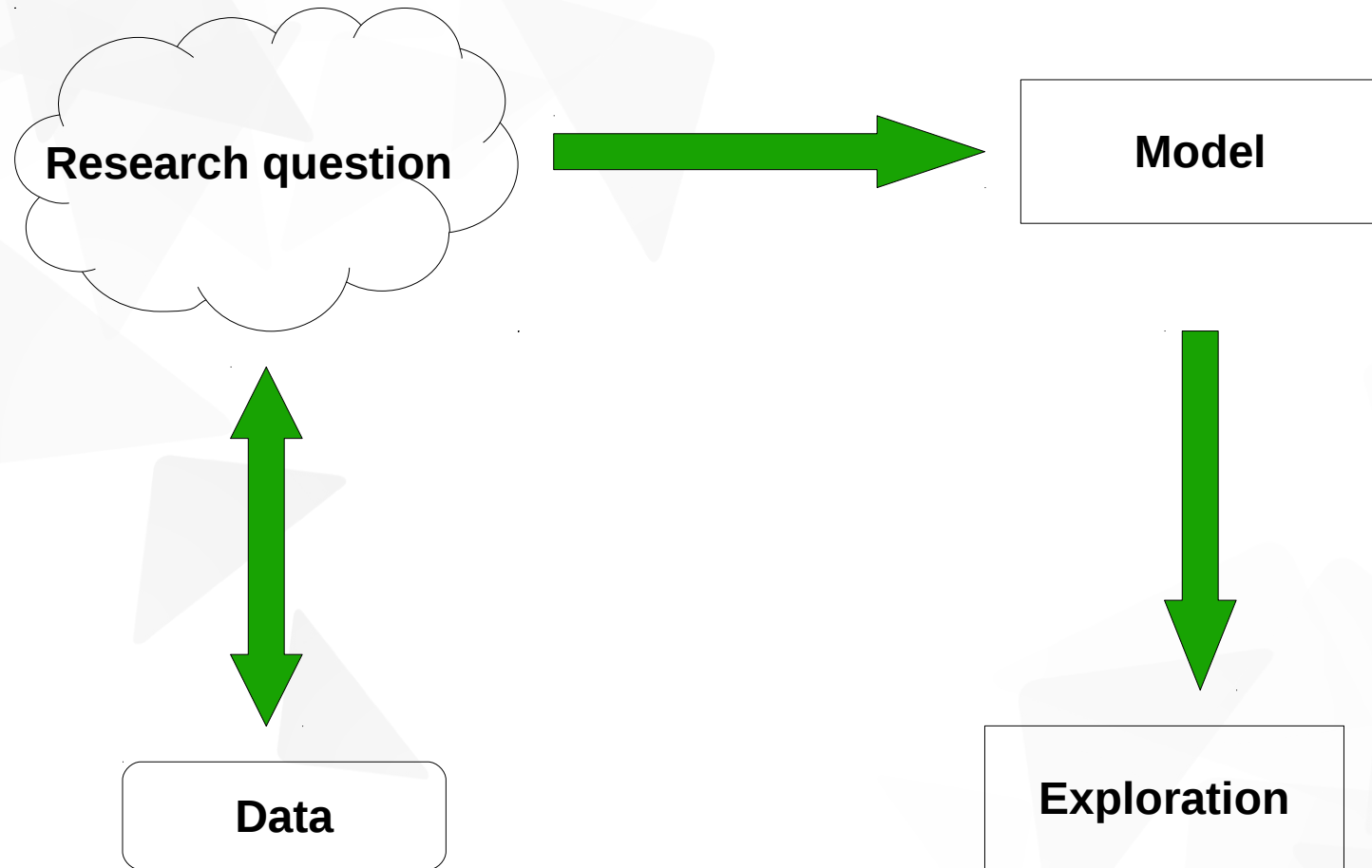
J. Mayer, K. Khairy, J. Howard (2010). "Drawing an elephant with four complex parameters."
American Journal of Physics 78.6: 648-649.



Method (hypothesis testing)



Method (theory-building)





A theory-building exercise

Competition between ideas



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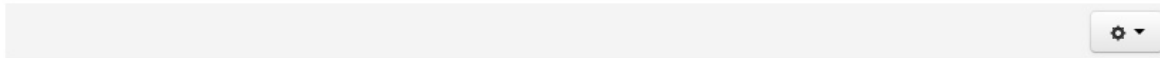
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Our History



Mission Statement

The mission of the Flat Earth Society is to promote and initiate discussion of Flat Earth theory as well as archive Flat Earth literature. Our forums act as a venue to encourage free thinking and debate.

Competition between ideas



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PROOF OF INTELLIGENT DESIGN.



CHECKMATE !

Competition between ideas



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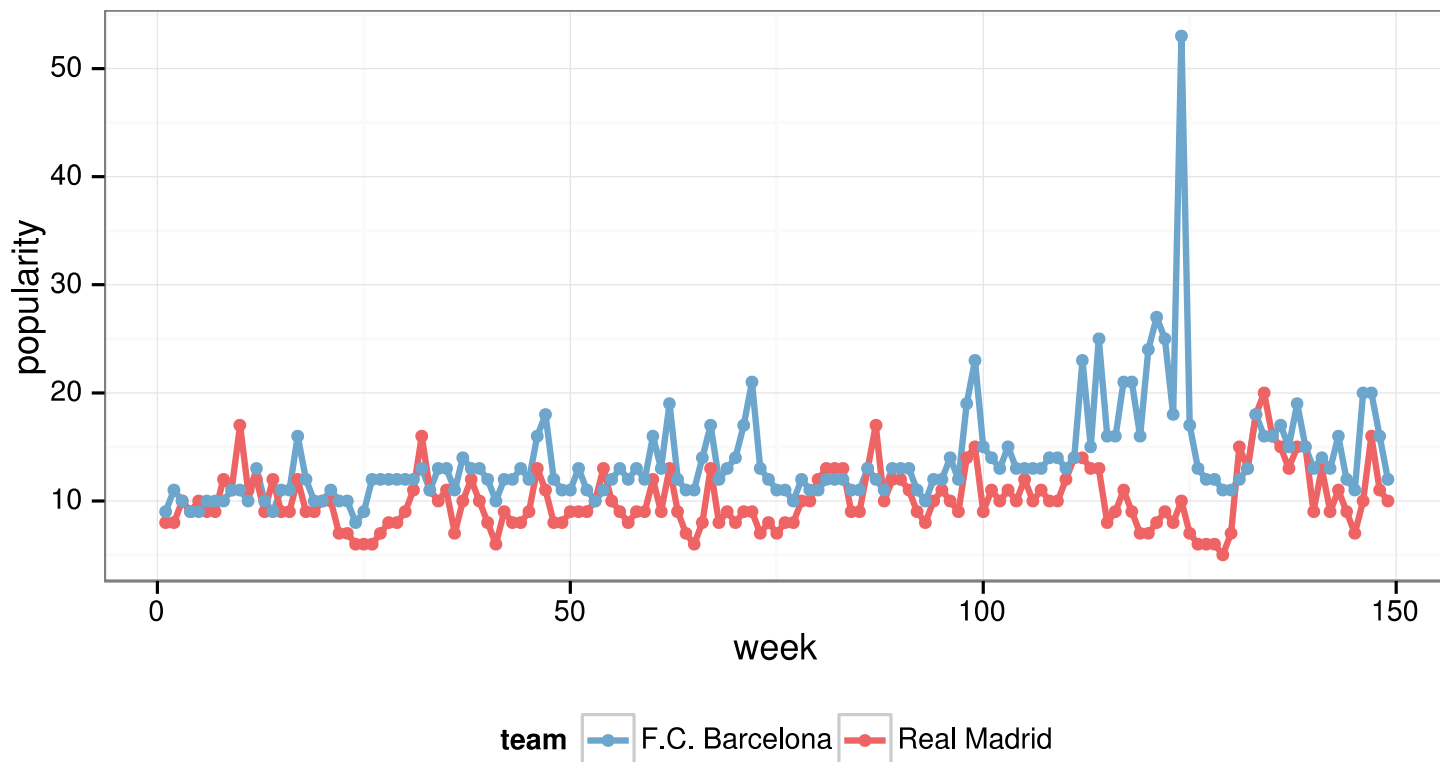
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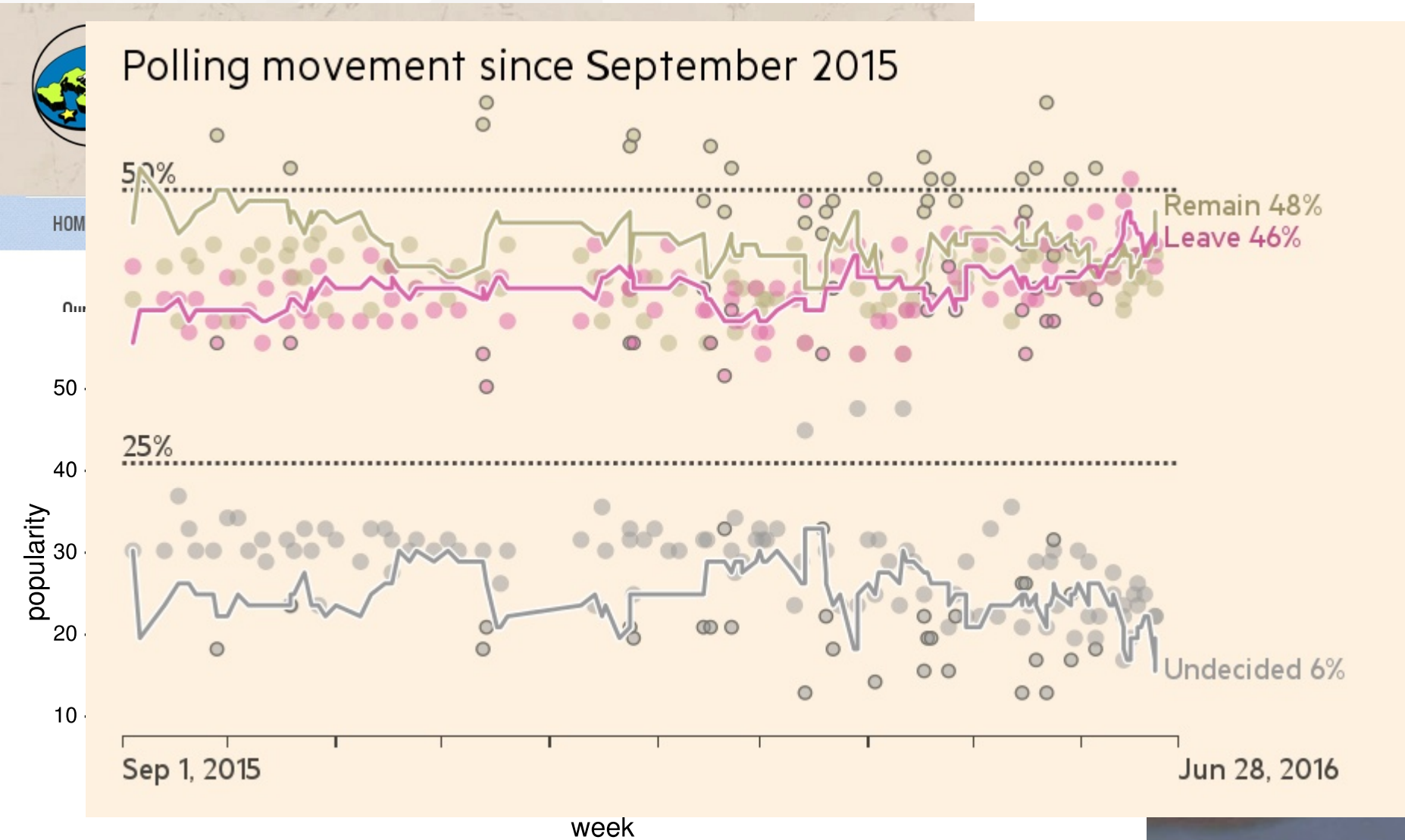


PROOF OF INTELLIGENT DESIGN.



CKMATE !

Competition between ideas



team F.C. Barcelona Real Madrid

SIGN.

KMATE !


Research question

What is the impact of size and attractiveness in the competition between two mutually exclusive ideas?

System dynamics

- ▼ Models of complex systems with:
 - ▼ Stocks
 - ▼ Flows
 - ▼ Feedback loops

Lotka-Volterra

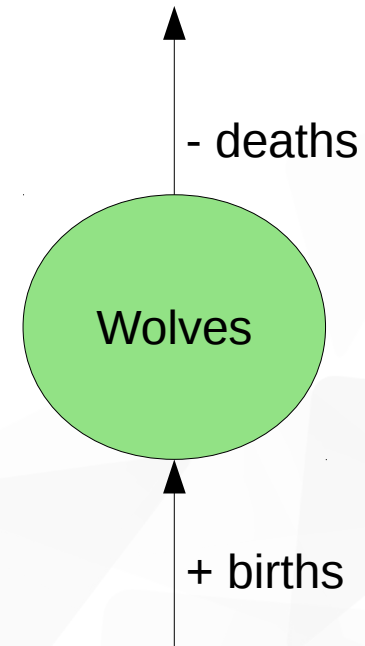
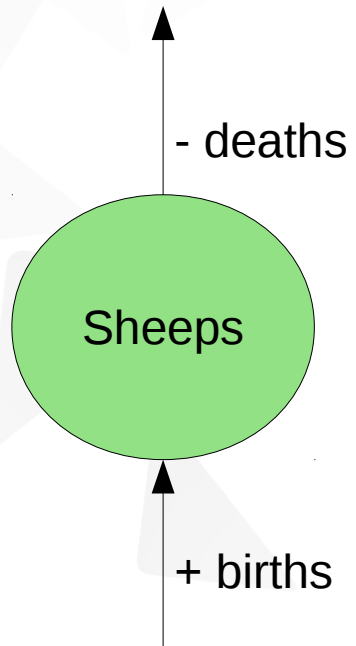


Sheeps

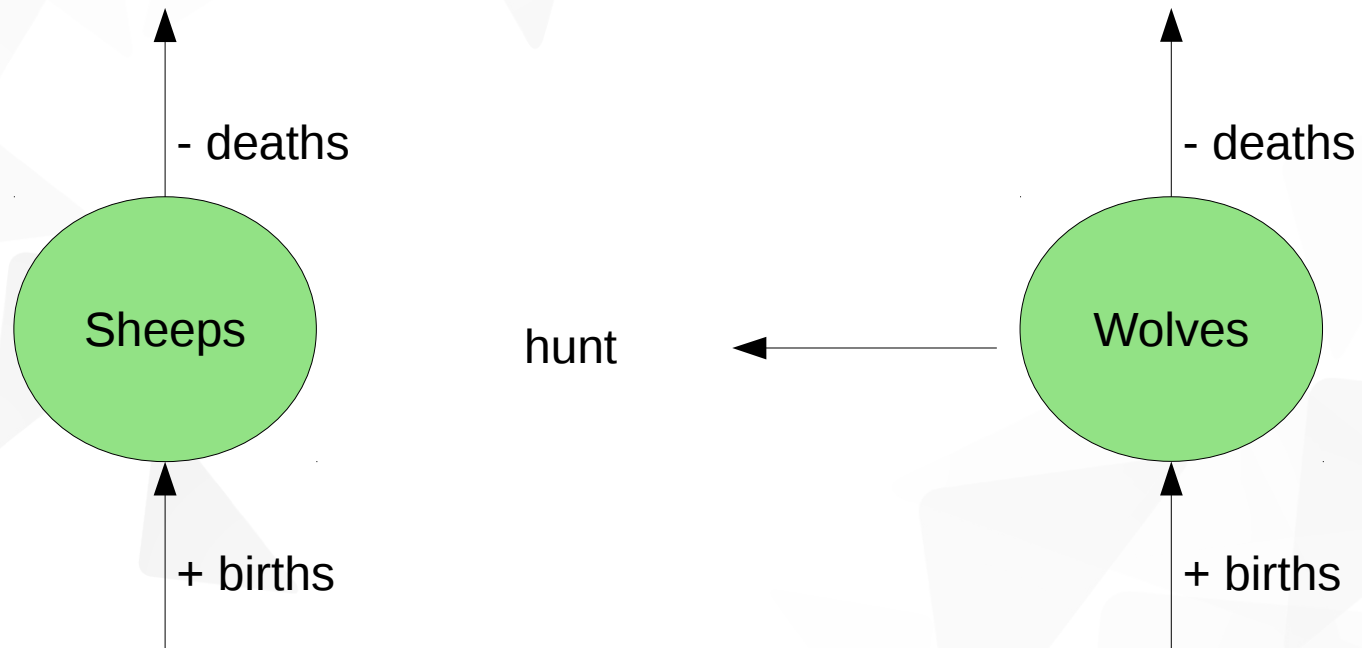
The diagram illustrates the Lotka-Volterra model with two green circles. The circle on the left is labeled 'Sheeps' and the circle on the right is labeled 'Wolves'. The background features a light gray header and footer, and a white central area with faint, abstract geometric shapes.

Wolves

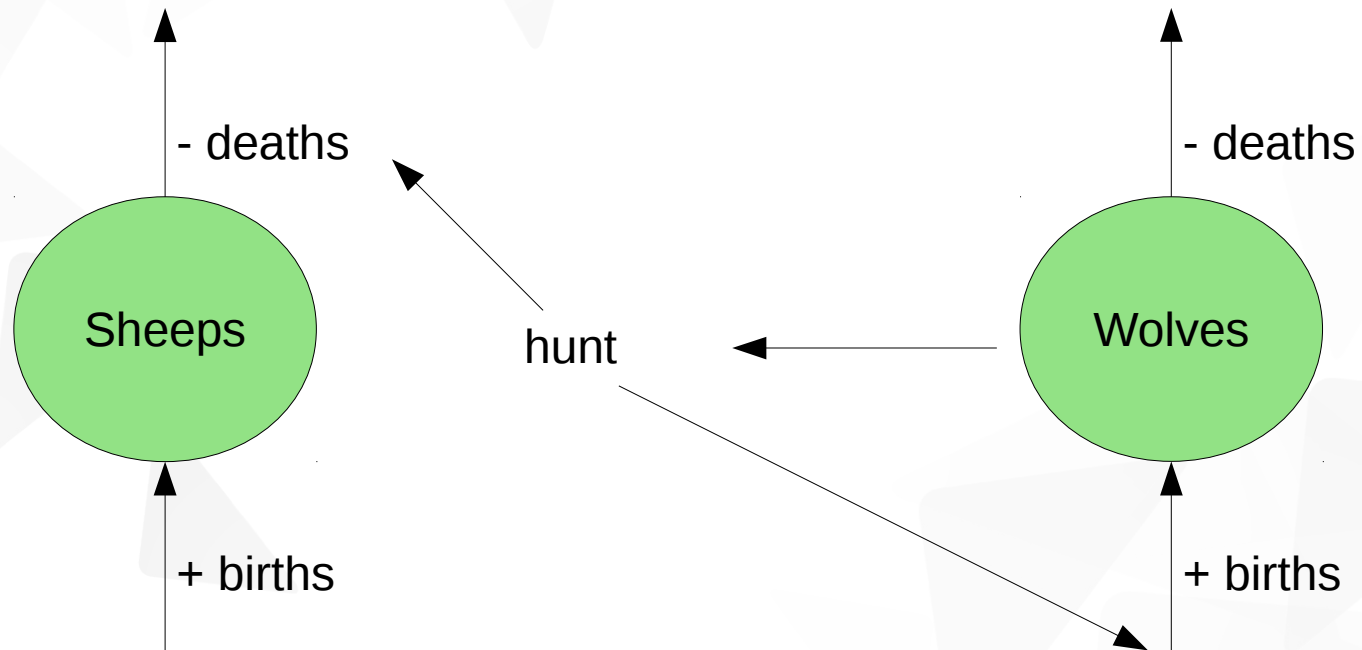
Lotka-Volterra



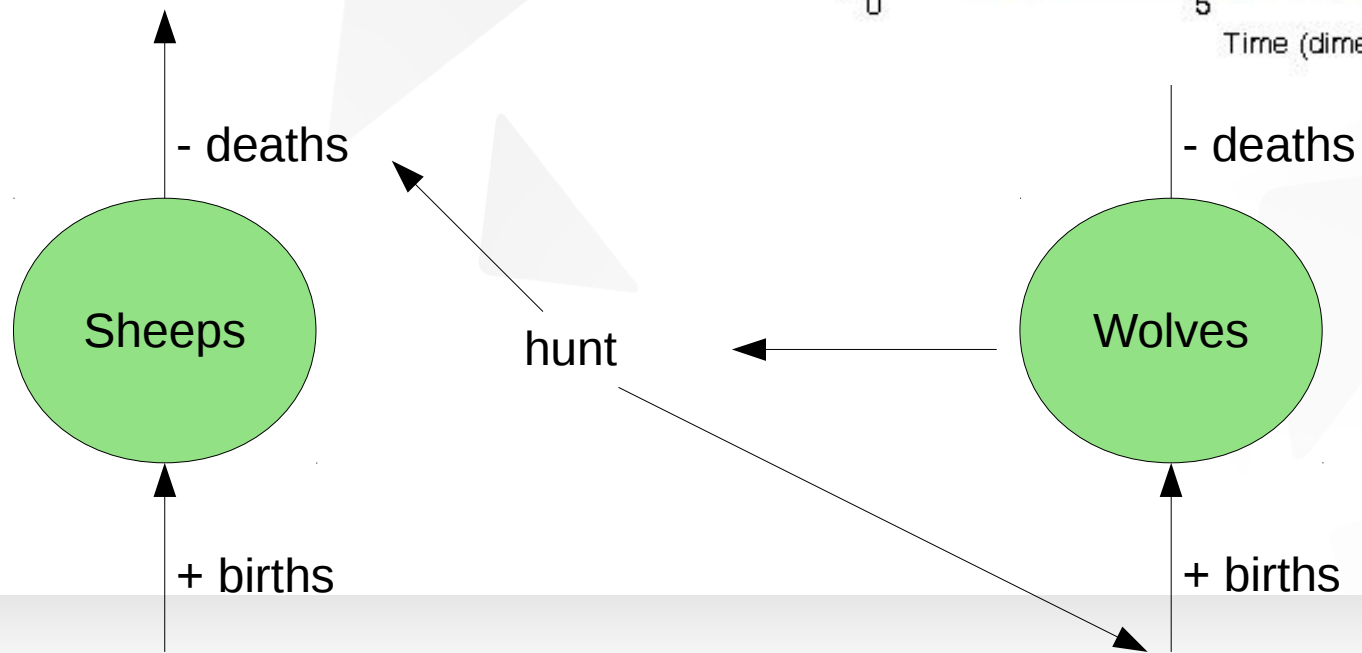
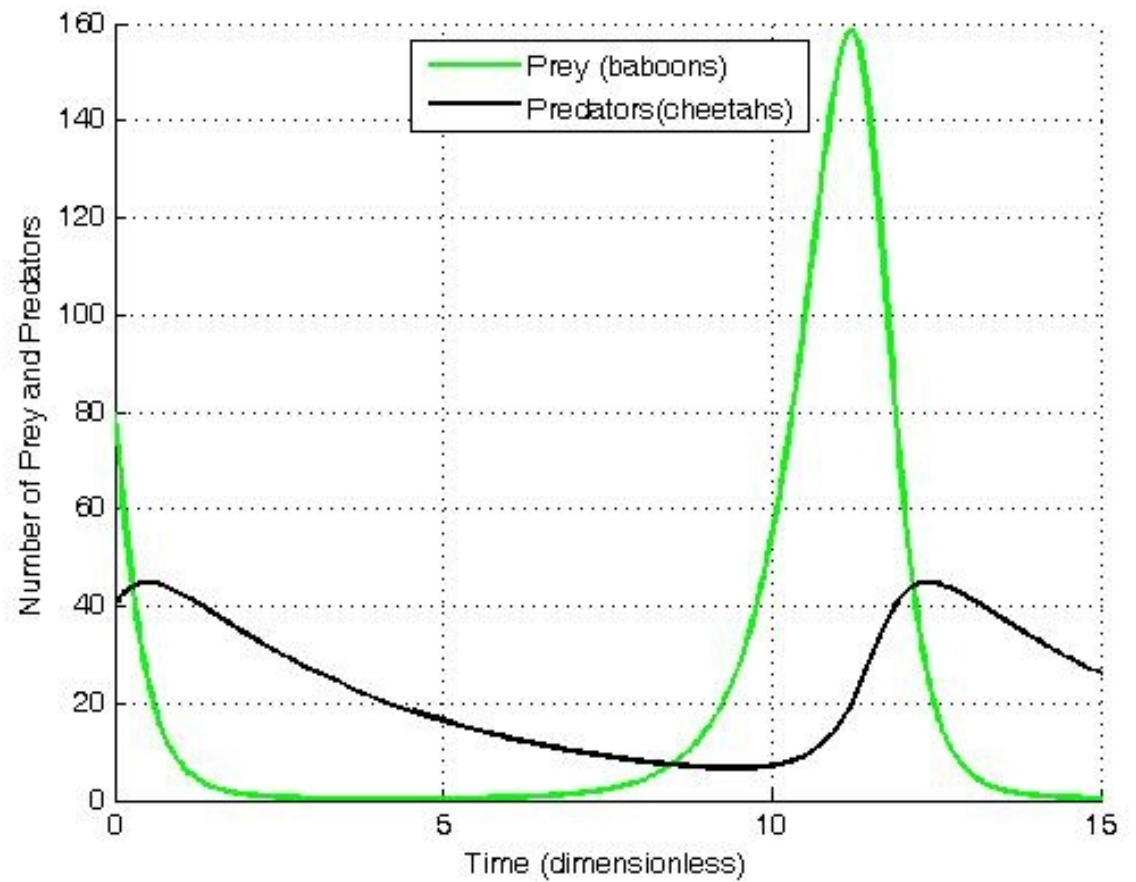
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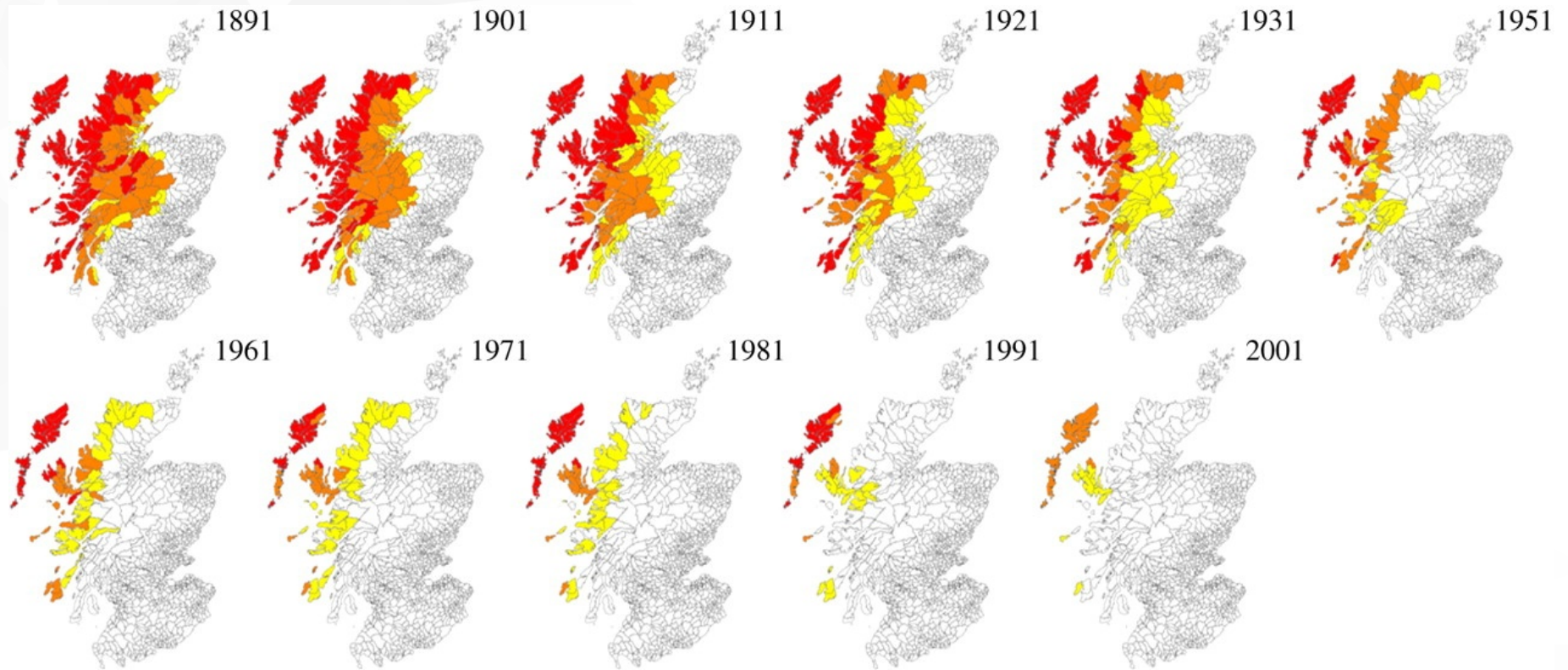
Lotka-Volterra



Lotka-Volterra



Beyond ecology



Kandler, Anne, Roman Unger, and James Steele. "Language shift, bilingualism and the future of Britain's Celtic languages." *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 365.1559 (2010): 3855-3864.

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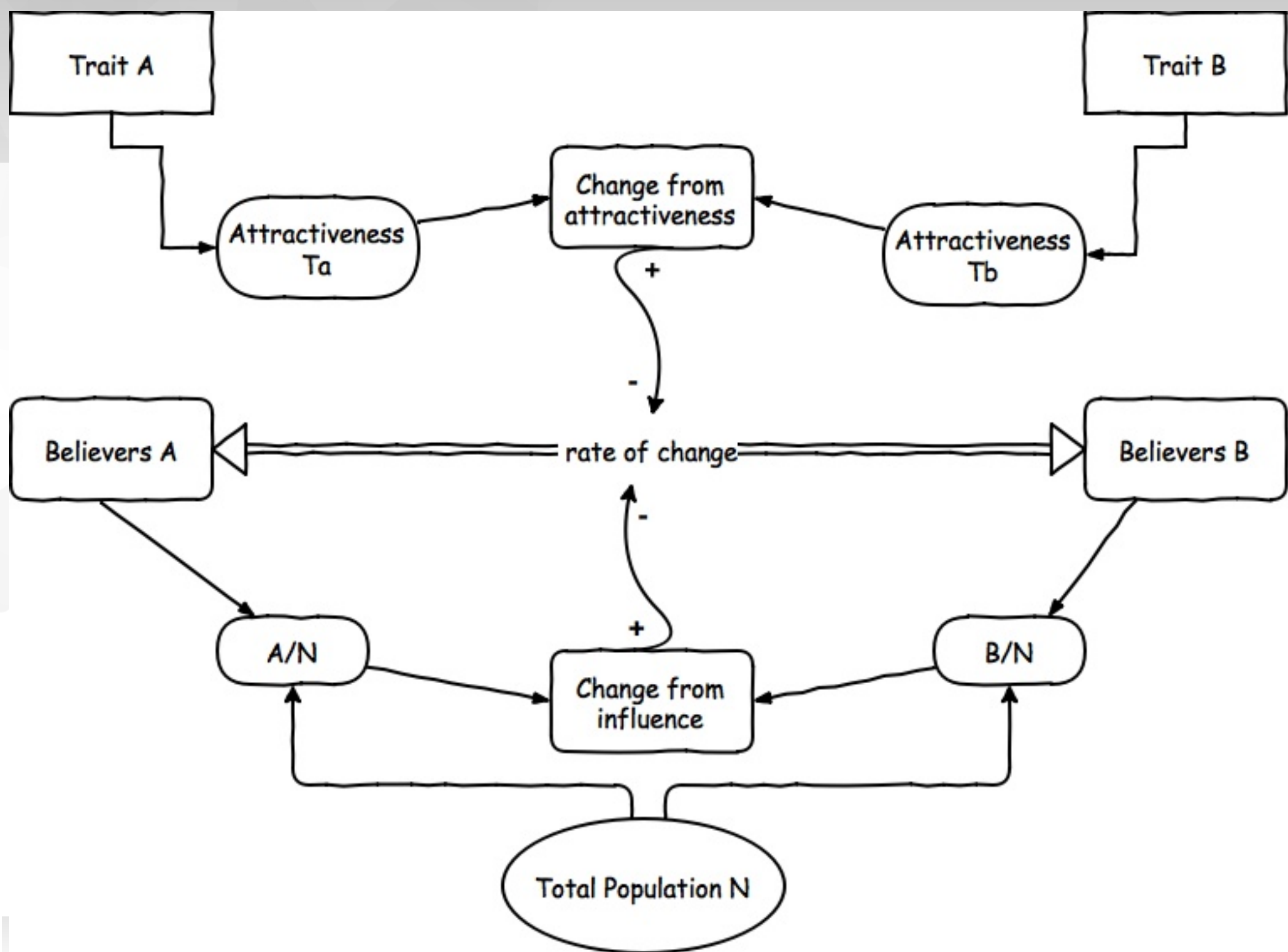
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- ▼ The model is ran over a number of time steps
- ▼ Each individual can change their trait depending on payoff-biased transmission
- ▼ Payoff of a trait is based on a) popularity and b) internal attractiveness





Tutorial



Modeling challenges

Group 1 – The 'undecided' challenge

What if there was an 'undecided' group in the population? Think of elections. You may only be able to vote option A or option B (like in the Brexit referendum) but equally you may decide not to go voting at all, therefore becoming an 'undecided'.

You can imagine that, for example, once the attractiveness of a given option falls below a certain threshold some of the believers do not want to follow it anymore but equally they may not want to sign up to the other option straight away.

Or perhaps, initially everyone is 'undecided' and each option needs to attract followers.

Group 2 – The 'population' challenge

What if the population size was not static? Think of football fans. Once the national team makes it to the quarter finals everyone seem to become interested in football.

At each time step the total number of people may grow or shrink depending on a newly defined function. Perhaps, at every time step the population grows by the same amount or the increase depends on the difference in attractiveness between the cultural options, or one of the options crosses a certain attractiveness threshold?

What would happen if one of the options was less attractive but was able to 'produce' more believers?

Group 3 – The 'resilience' challenge

Occasionally even the most unexpected things happen. Think of a political party. They may be thinking they are sailing smoothly to a victory in the next elections but instead a political earthquake happens and a large proportion of their supporters shifts alliances.

Some parties seem to be resilient to such catastrophic events, while others succumb to them easily. Some characteristics increase and some decrease the resilience of each option. Often, it matters if the option is particularly strong or weak at the time of the event.

Similarly, different types of events (a sudden shift of believers, a sudden drop in attractiveness, etc) may have different effects?

Thank you!

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