(Spatial) Ecology and Evolution: Integrating Theory and Data

Otso Ovaskainen

OVERVIEW

. L1. Approaches to ecological modelling

. L2. Model parameterization and validation (stat)

. L3. Stochastic models of population dynamics (math)

. L4. Animal movement (math + stat)

. L5. Quantitative population genetics (math + stat)

. L6. Community ecology (stat)

mathematical biology group

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movements, populations, communities, genetics, evolution, bioinformatics

L1. Approaches to Ecological Modelling

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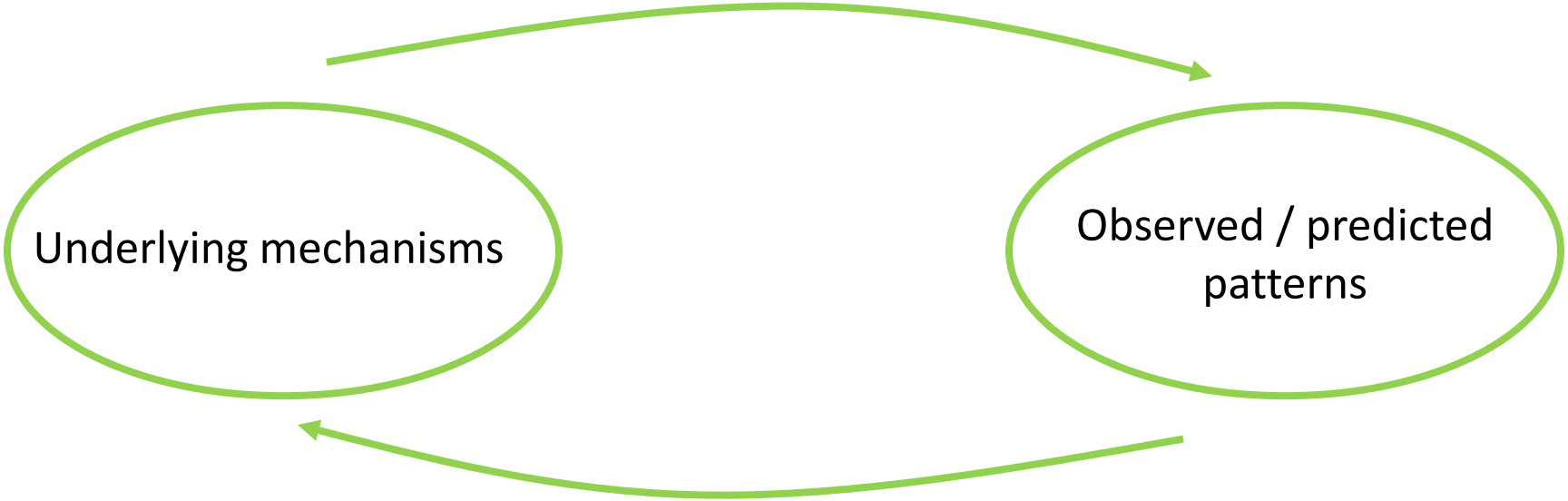
Approaches to ecological modelling

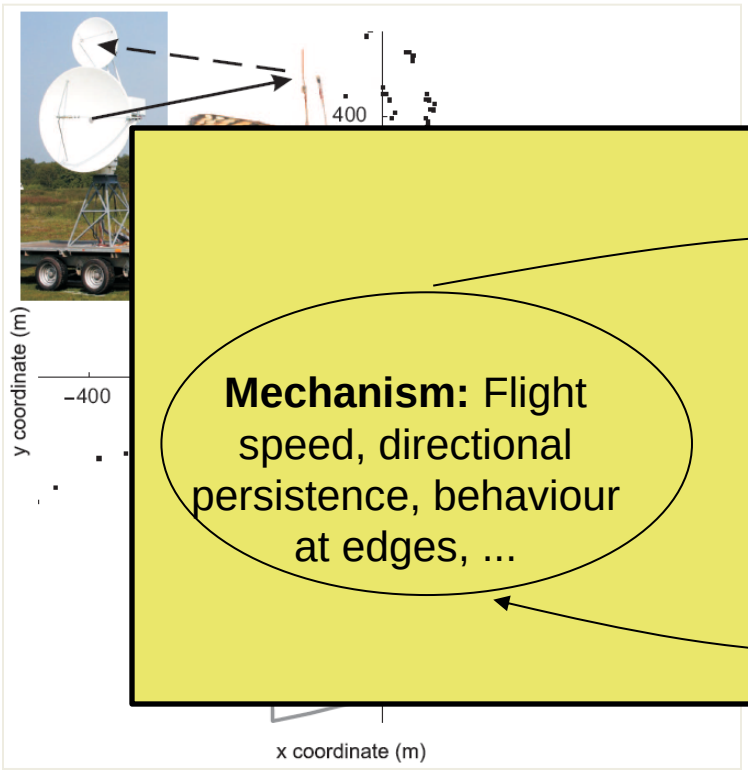
The forward approach: mathematical (mechanistic) modelling.
Aim: to understand causal relationships at the general level



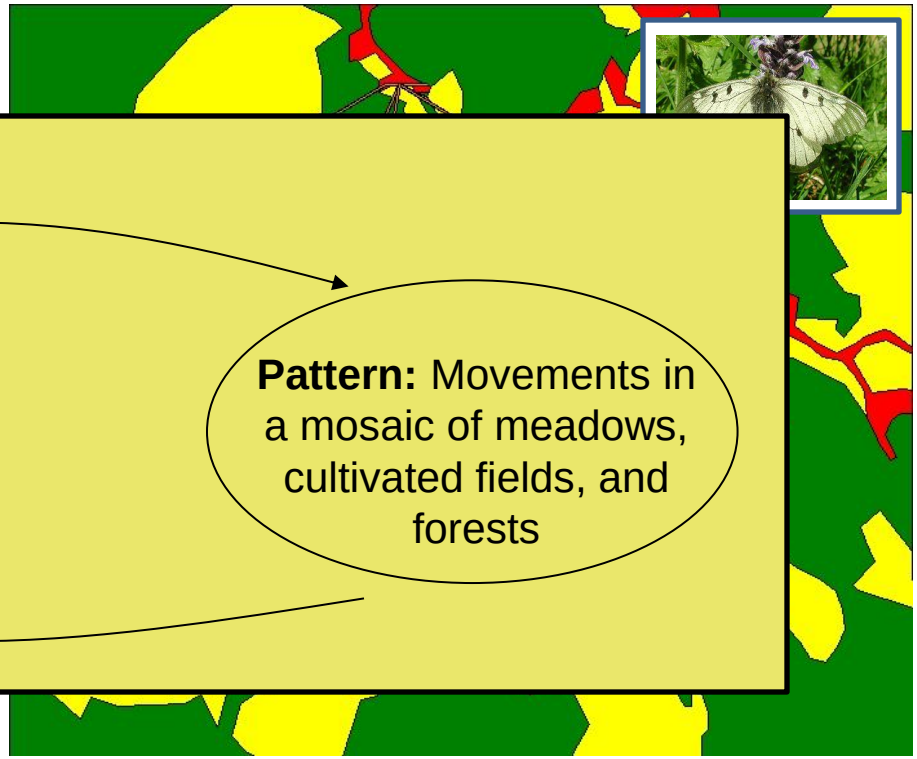
The inverse approach: statistical (phenomenological) modelling.
Aim: to find out factors shaping empirical data

Empirical approaches for studying butterfly movements

Harmonic radar



Spatial mark-recapture

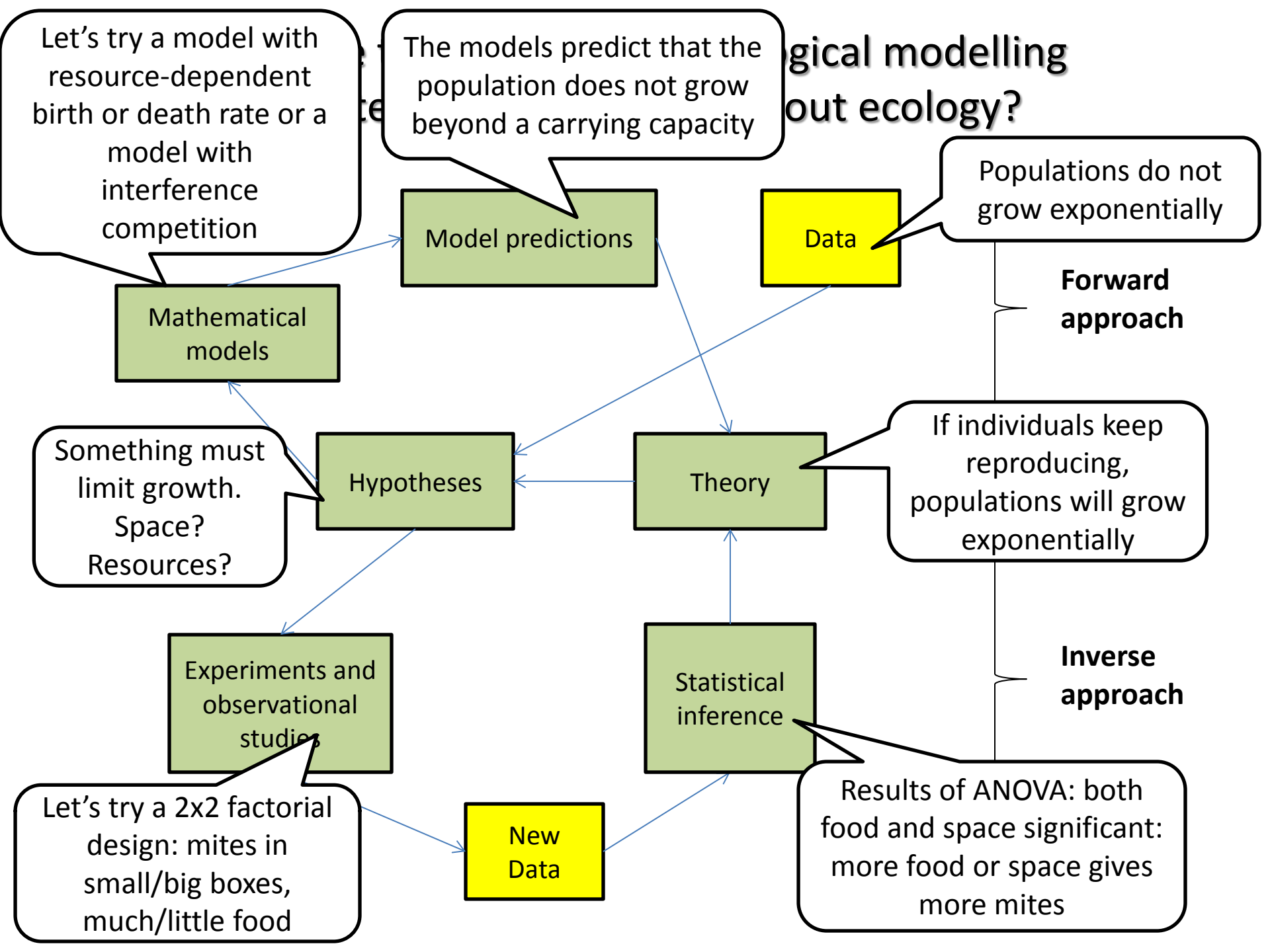


Mechanism: Flight speed, directional persistence, behaviour at edges, ...

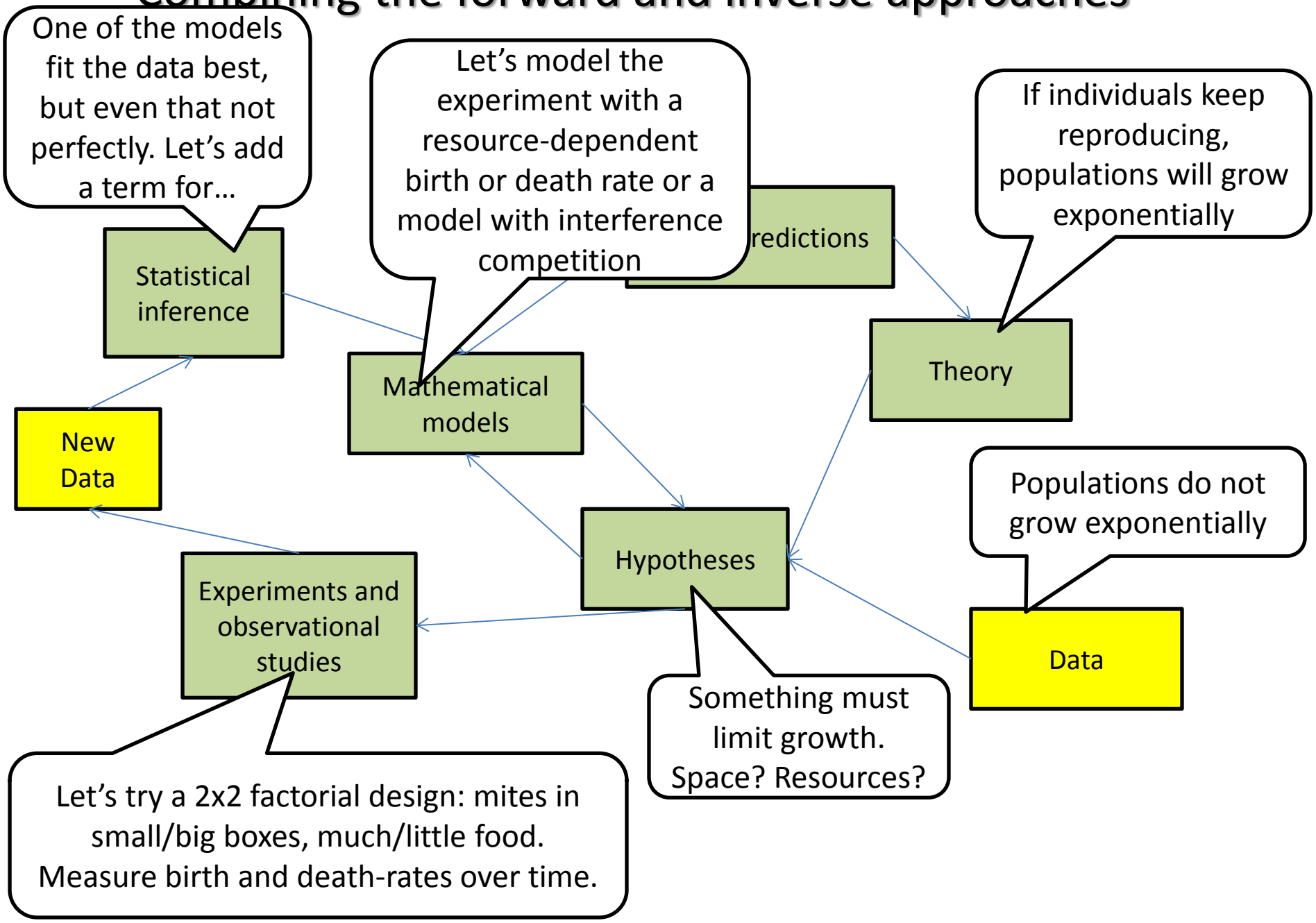
Pattern: Movements in a mosaic of meadows, cultivated fields, and forests

Ovaskainen, O. et al. 2008. Tracking butterfly movements with harmonic radar reveals an effect of population age on movement distance. *PNAS* **105**, 19090-19095.

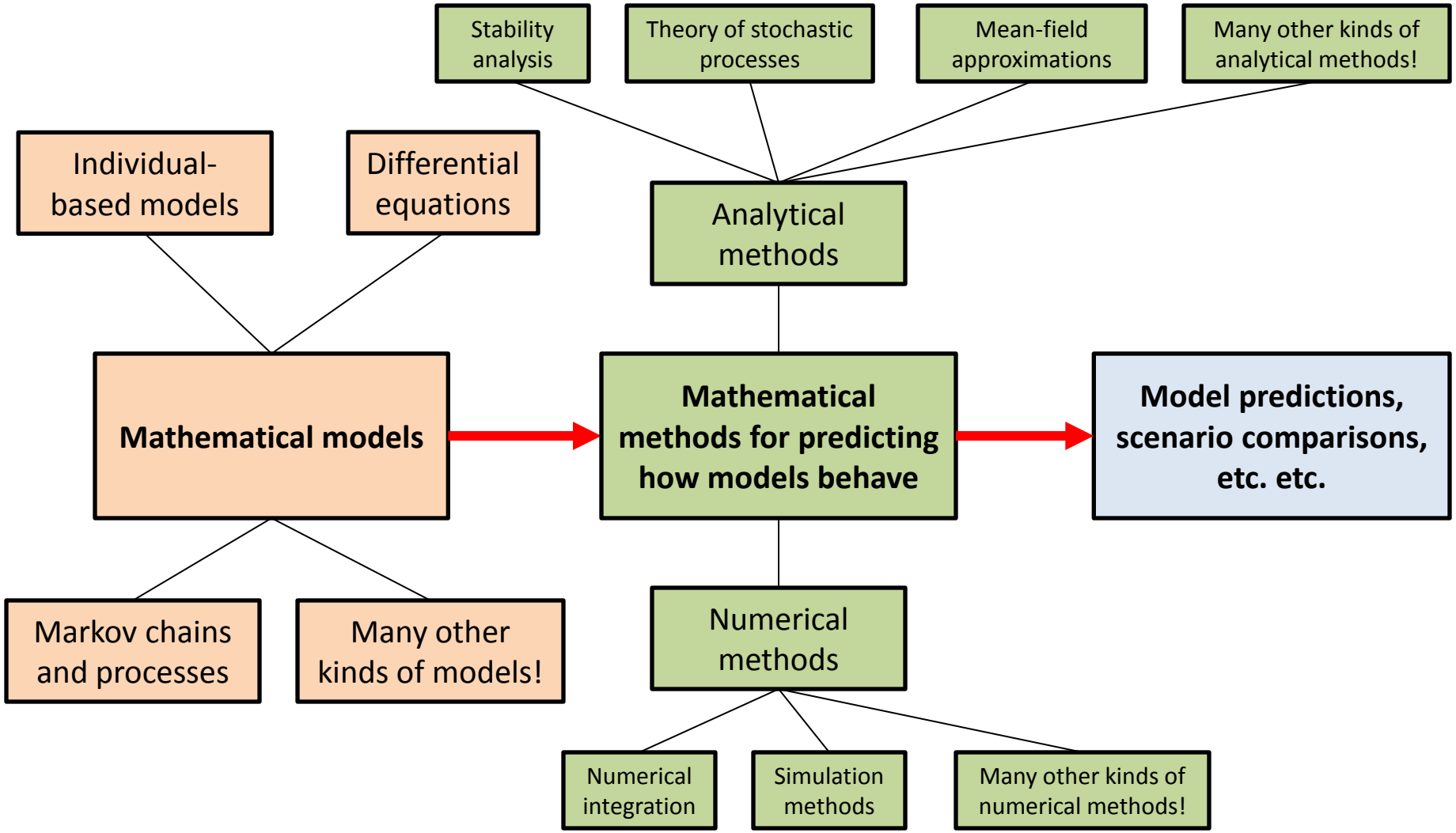
Ovaskainen, O. et al. 2008. An empirical test of a diffusion model: predicting clouded apollo movements in a novel environment. *American Naturalist* **171,** 610-619.


gical modelling
out ecology?
Let's try a model with resource-dependent birth or death rate or a model with interference competition
The models predict that the population does not grow beyond a carrying capacity
Model predictions
Data
Populations do not grow exponentially
Mathematical models
Forward approach
Something must limit growth. Space? Resources?
Hypotheses
Theory
If individuals keep reproducing, populations will grow exponentially
Experiments and observational studies
Statistical inference
Inverse approach
Let's try a 2x2 factorial design: mites in small/big boxes, much/little food
New Data
Results of ANOVA: both food and space significant: more food or space gives more mites

Combining the forward and inverse approaches

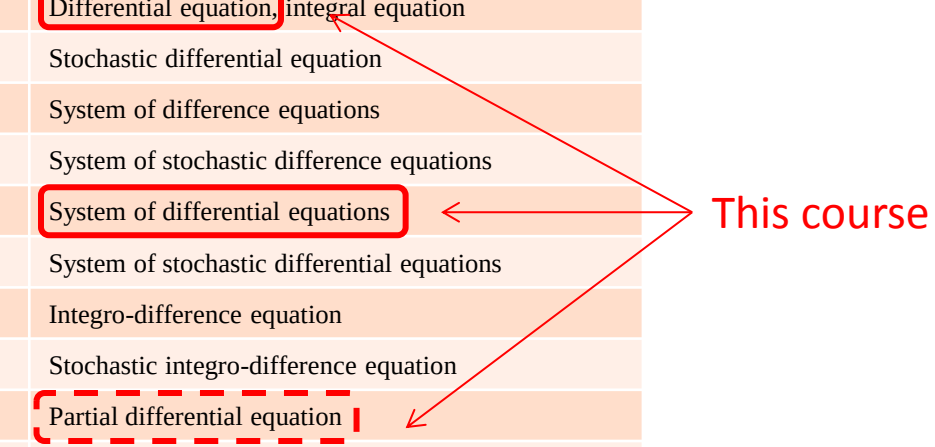


Mathematical models and methods in ecological modelling

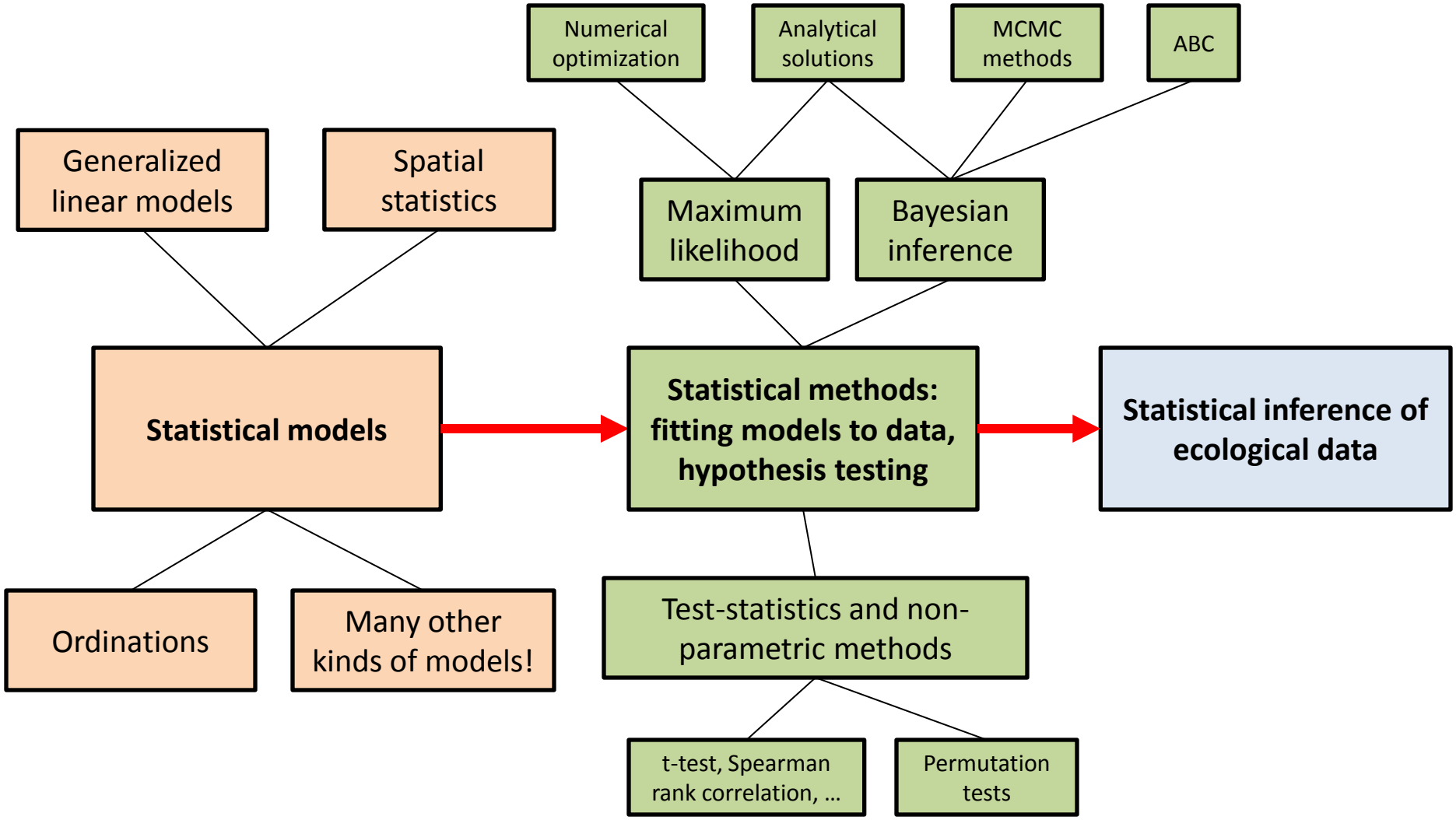


There are many kinds of mathematical models!

Variables	Structure (e.g. space)	Time	Stochasticity	Model type(s)
discrete	no	discrete	no	-
			yes	Markov chain
		continuous	no	-
			yes	Markov process
	discrete	discrete	no	-
			yes	IBM on grid or patch network, SPOM
		continuous	no	-
			yes	IBM on a grid or patch network, SPOM
	continuous	discrete	no	-
			yes	IBM in continuous space
		continuous	no	-
			yes	Spatio-temporal point process
continuous	no	discrete	no	Difference equation
			yes	Stochastic difference equation
		continuous	no	Differential equation, integral equation
			yes	Stochastic differential equation
	discrete	discrete	no	System of difference equations
			yes	System of stochastic difference equations
		continuous	no	System of differential equations
			yes	System of stochastic differential equations
	continuous	discrete	no	Integro-difference equation
			yes	Stochastic integro-difference equation
		continuous	no	Partial differential equation
			yes	Stochastic partial differential equation



Statistical models and methods in ecological modelling



L1: take home messages

- There are many approaches to ecological modelling!
- Think critically why you play with mathematical models! Just because you can (and you like it), or because that helps to learn about ecology?
- Find your own modelling philosophy!

Markku has a data-driven modelling philosophy which he likes to summarise as 'whatever works'.