

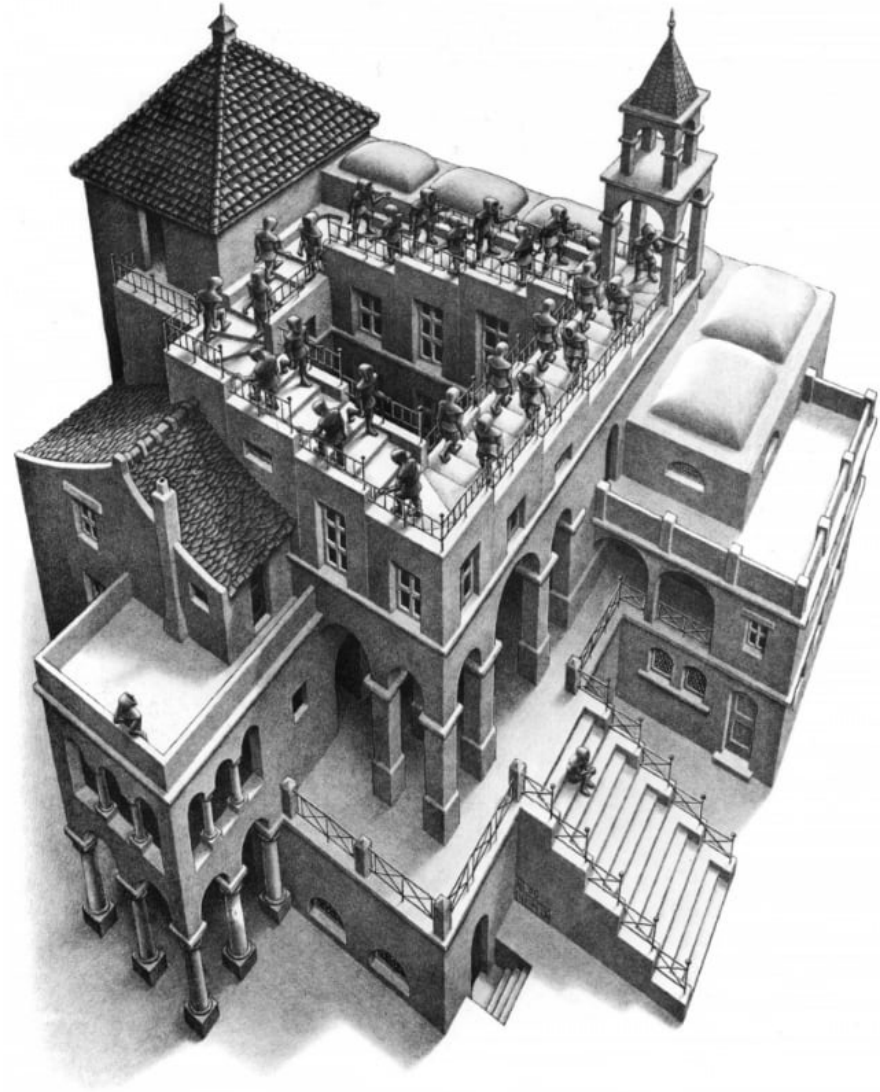
# Introduction to process-based forest modelling

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# Outline

1. Fundamental concepts
2. Modelling cycle
3. Overview of process-based forest models

M.C. Escher - Ascending and Descending, 1960



# 1. Fundamental concepts

# Models: What are they?

- *Model* - A simplification of reality constructed to gain insights into a set of attributes of a physical, biological, economic, or social system.
- *Conceptual model* - A **hypothesis** regarding the important factors that govern the behavior of an object or a process of interest.
- *Statistical model* - A numerical model **built using observations** within a probabilistic framework.
- *Mechanistic (or process-based) model* - A numerical model that explicitly **represents the understanding** of physical, chemical or biological processes.
- *Simulation model* - A numerical model that represents the development of a solution by incremental steps through the model domain.

# Model components

- *Modules or sub-models* - An independent or self-contained component of a model.
- *State variables* - The dependent variables calculated within a model, which often **change over the simulation**.
- *Parameters* - Terms in the model that are **fixed during a model run** but can be changed in different runs.
- *Constants* - Terms that are **fixed values under all runs**, representing known physical, biological or ecological activities (e.g. the speed of light).

# Model assessment

- *Verification* - Examination of the implementation to ascertain that they truly represents the conceptual model and there are no inherent numerical problems.
- *Qualitative assessment* - Uncertainty in model predictions that **cannot be quantified** (i.e. about the theory underlying the model or the model design).
- *Uncertainty analysis* - Investigation of the effects of lack of knowledge or potential errors of inputs (e.g. climate forcing) on the model output.
- *Robustness* - The capacity of a model to perform well **across the full range of conditions** for which it was designed.
- *Sensitivity* - The degree to which the model outputs are **affected by changes in input parameters**.
- *Transparency* - The clarity and completeness with which data, assumptions, and methods of analysis are **documented**.

## 2. Modelling cycle

# Modelling tasks: Development

## 1. Problem formulation

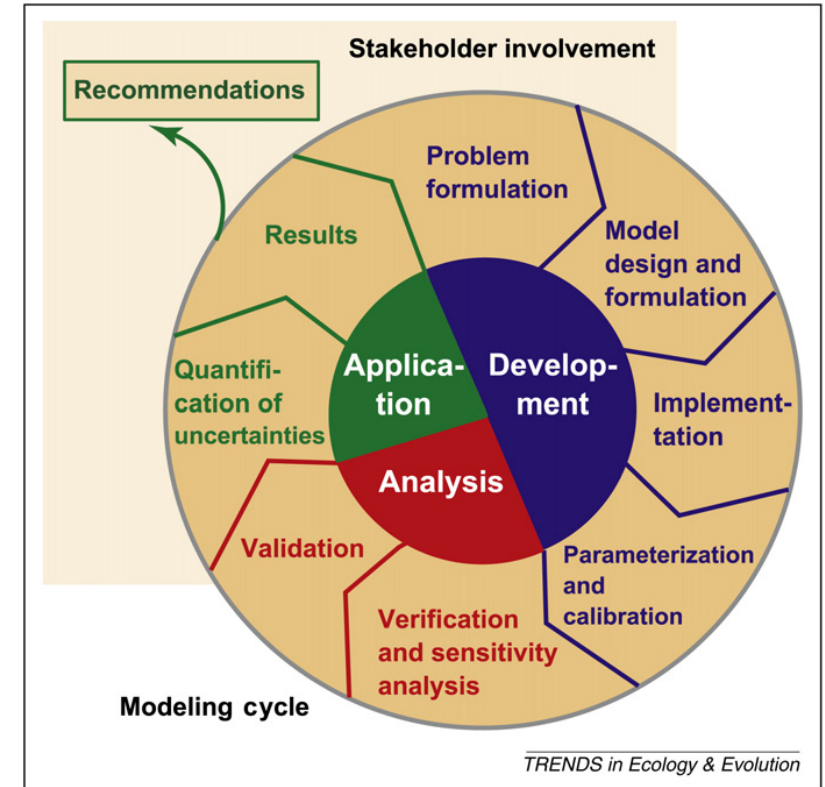
- Definition of objectives
- Definition of the spatio-temporal physical domain

## 2. Model design and formulation

- Data availability
- Use of existing vs. new model
- Conceptual model
- Use of existing modules

## 3. Implementation

- Algorithmic design
- Model coding (e.g. C++)
- Profiling and code optimization





# Modelling tasks: Development

## 4. *Parameterization and calibration*

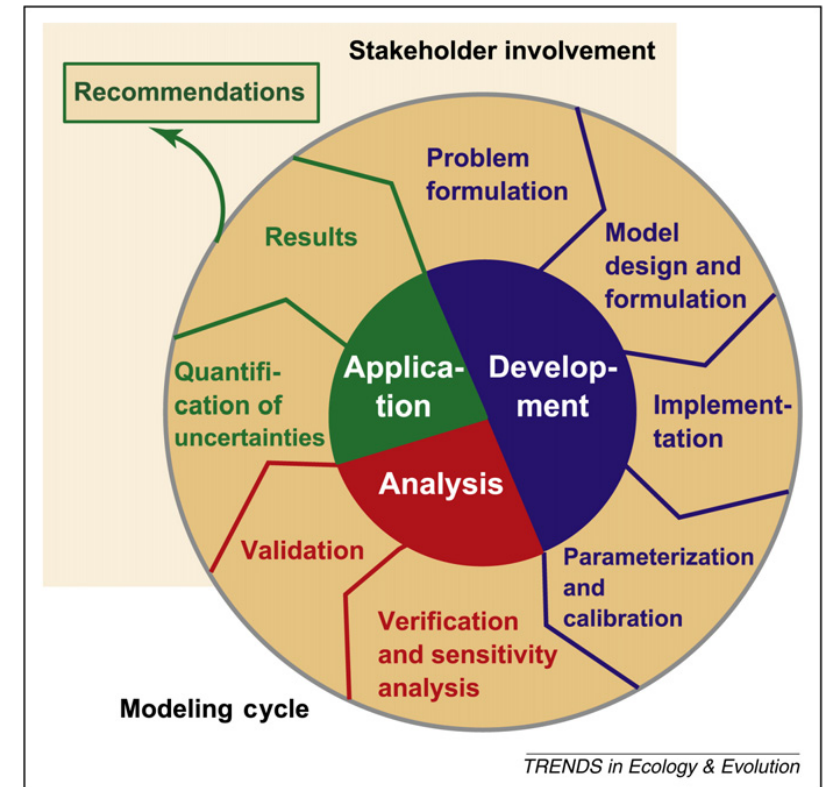
- Sources for direct parameter estimation
- Sources for parameter calibration
- Meta-modelling

## 5. *Model analysis*

- Verification and qualitative assessment
- Sensitivity/uncertainty analysis
- Formal evaluation (validation)

## 6. *Model application*

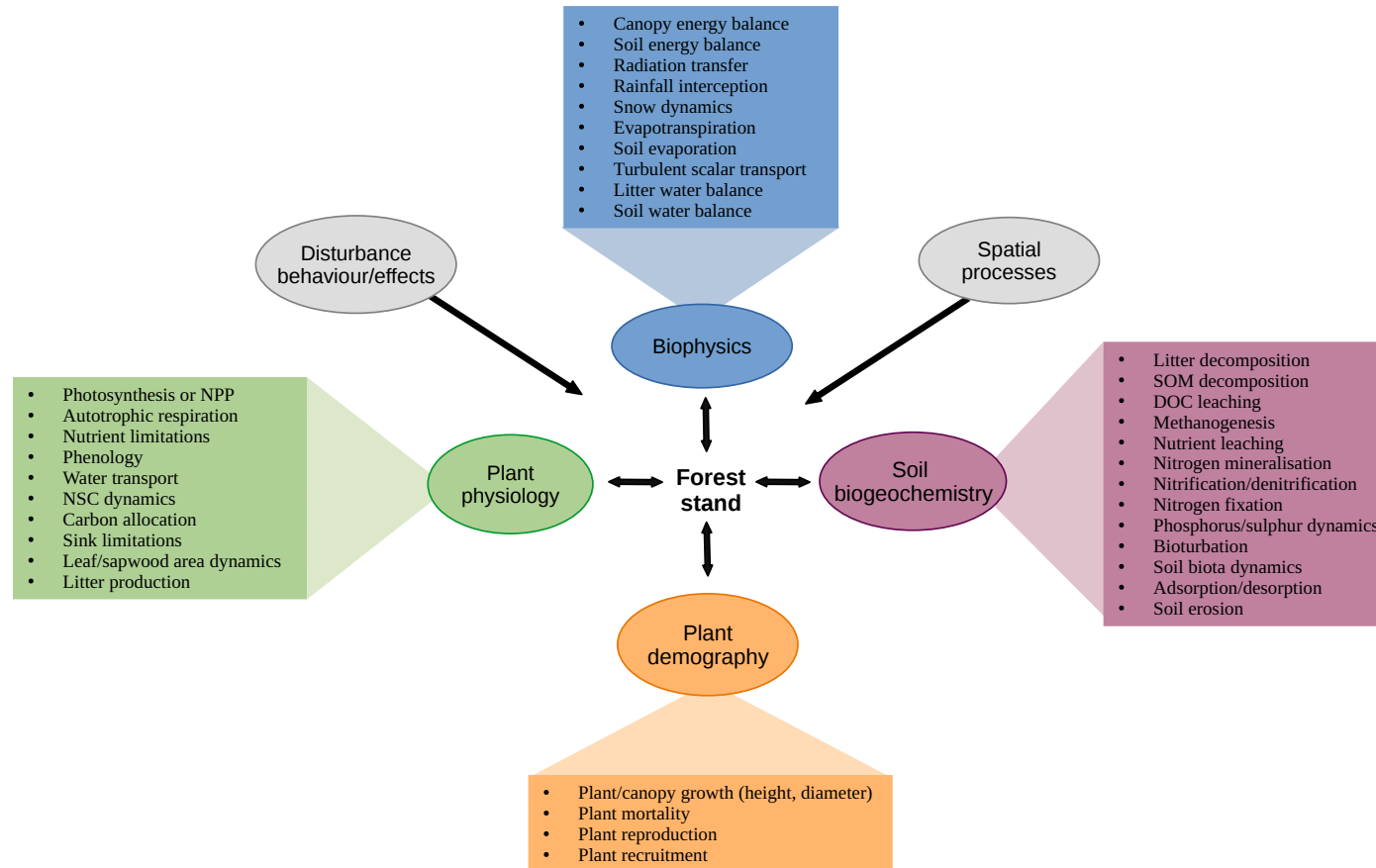
- Simulation and documentation
- Quantifying uncertainty
- Evidence for decision



### **3. Overview of process-based forest models**

# A typology of forest processes

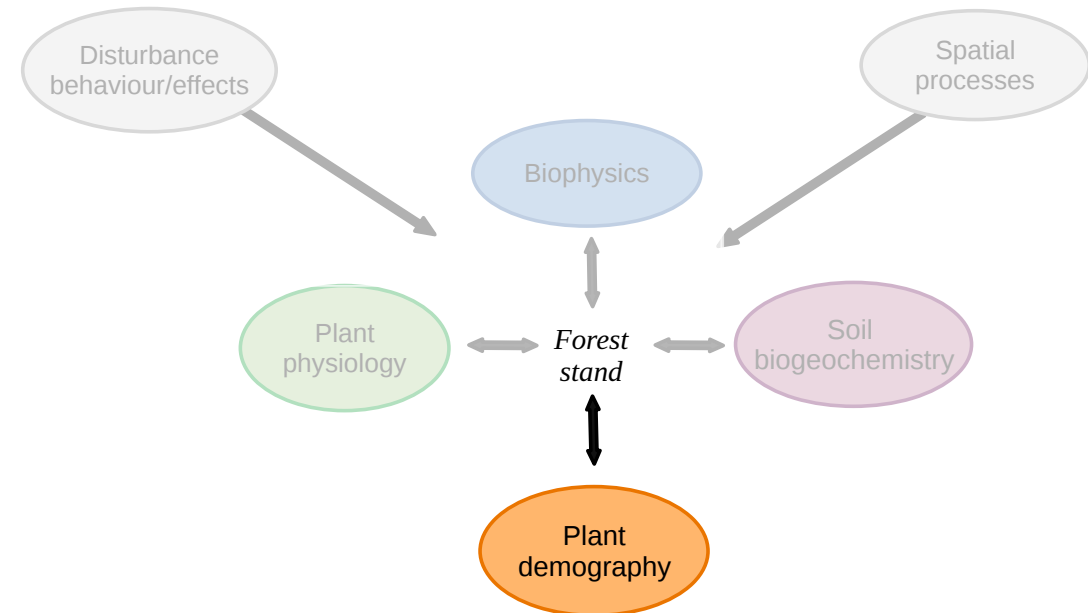
## Processes



# A typology of forest processes

## Forest gap models

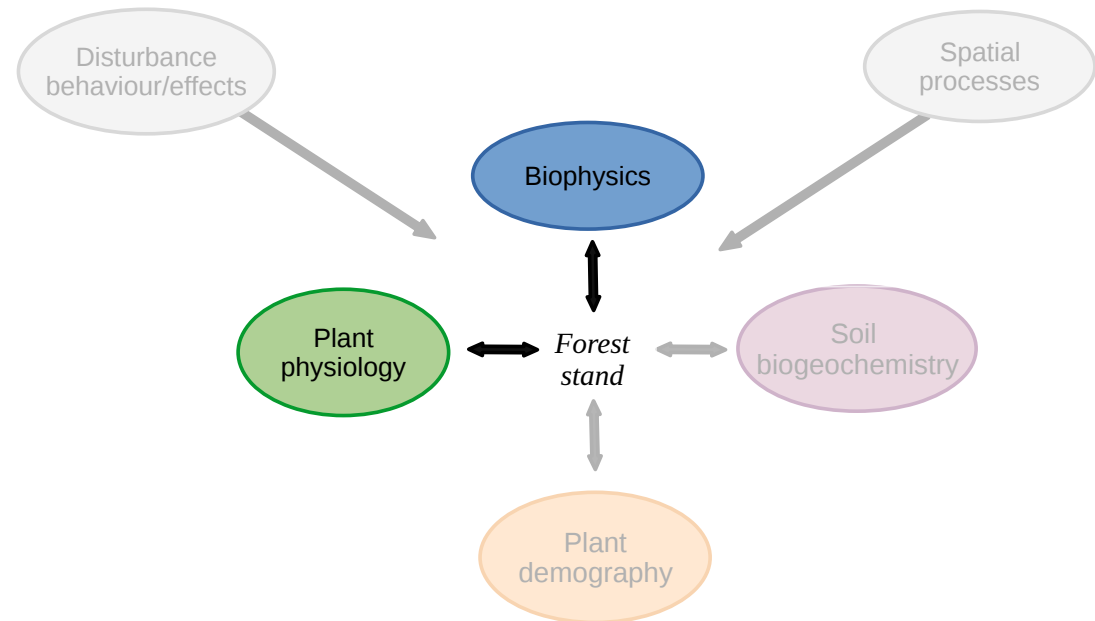
FORCLIM, FORCEEPS, GREFOS



# A typology of forest processes

## Soil-vegetation-atmosphere transfer model

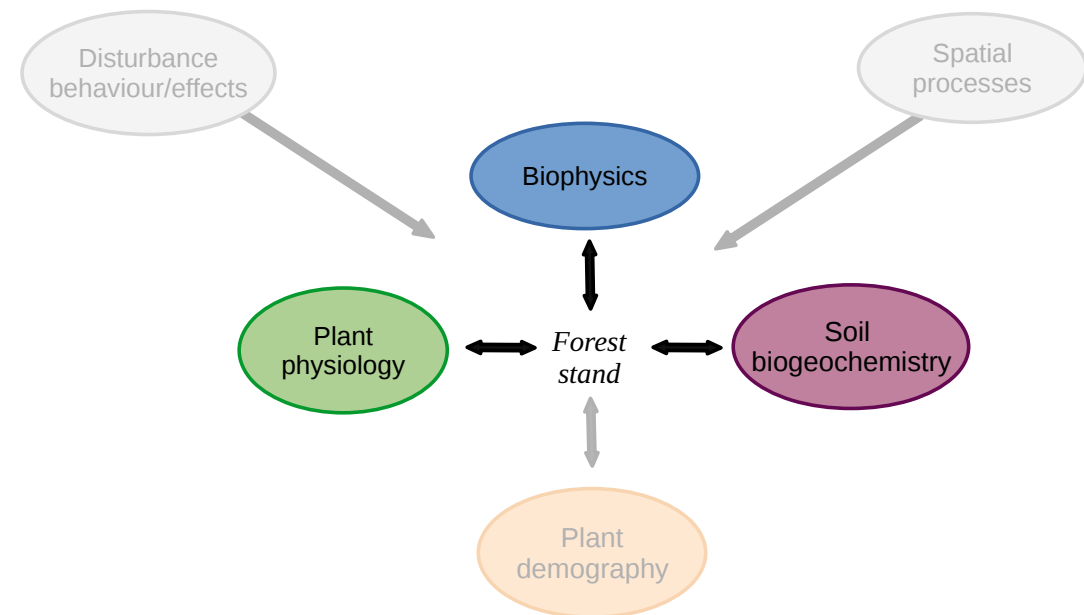
BILJOU, MuSICA, CANVEG



# A typology of forest processes

## Forest biochemical model

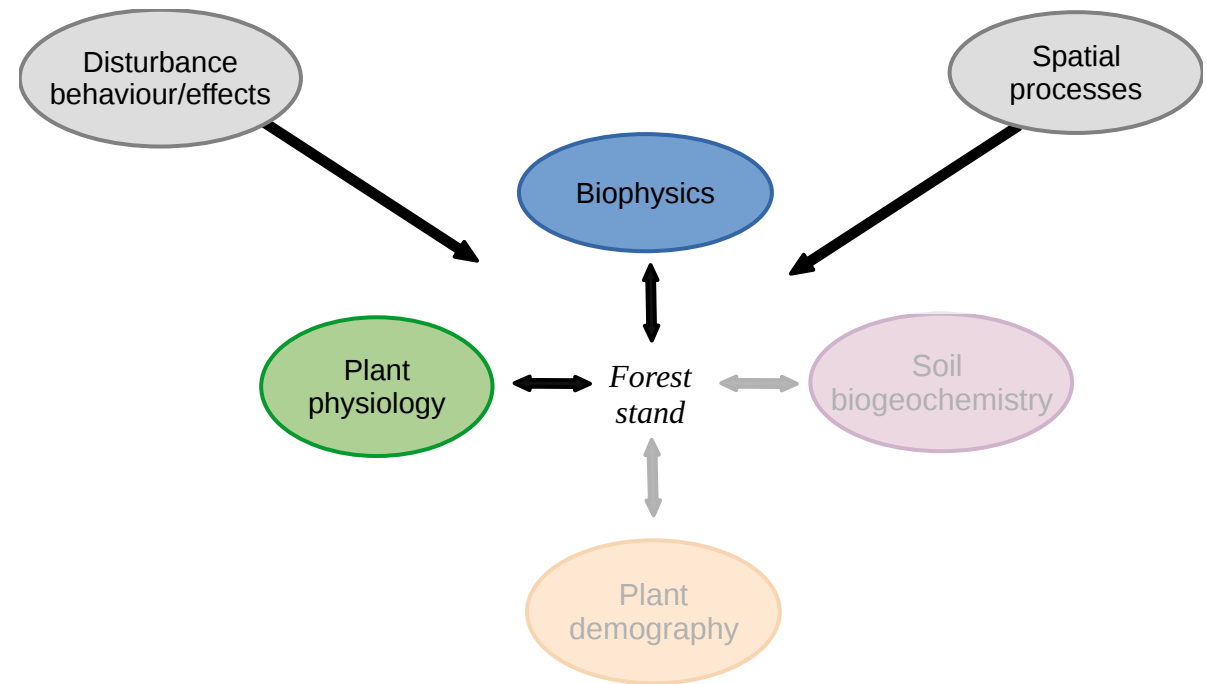
CASTANEA, GOTILWA+, FOREST-BGC



# A typology of forest processes

## Watershed ecohydrological model

RHESYS, ECH2O, Tethys-Chloris



M.C. Escher - Ascending and Descending, 1960

