**FOREST MODELS:**

This course assumes that students have some knowledge of Forestry, Forest Inventory and Statistics (basic level), in particular:

**Silviculture:** notion of forest stand, forest management techniques (from planting/regeneration, to thinning, clearing, regeneration cuts) and the principles of growth and yield. Students should consult the study material of the Silviculture I and Silviculture II UCs or a Silviculture textbook.

**Forest Inventory:** knowledge of tree and stand variables, with particular emphasis on measures of stand density. Students can consult the study material of the UC Forest Inventory (1st cycle) (https://fenix.isa.ulisboa.pt/courses/iflore-564938523283921) or the review powerpoints available on the UC Forest Models website.

**Statistics:** knowledge of descriptive statistics, probability density functions, linear regression.

The course is organized in 12 modules/chapters:

# Overview of forest models and simulators as a support to sustainable forest management in a global change context

## Why are forest models needed?

## Evolution of silviculture and of forest management

## Components of forest models and simulators

## Evolution of forest models and respective typology

## Current forest models and sustainable forest management

## The FORMODELS database

## The FCTOOLS website and the sIMfLOR platform

## Forest simulators at different spatial scales

# Data for the development and validation of forest models

## Permanent and interval plots (semi-permanent)

## Temporary plots

## Continuous forest inventory

## Total and partial stem analysis

# Forest productivity evaluation

## Factors influencing forest productivity

## Productivity management

## Evaluation of forest productivity: direct and indirect evaluation

## Site index curves

## Site index models

# Allometric relationships and growth functions

## Allometric relationships

## Empirical versus biologically based growth functions

## Theoretical growth functions: Lundqvist-Korf, Richards, Hossfeld IV, other

## Zeide decomposition of growth functions

## Simultaneous modeling of several individuals (trees or stands)

## Formulating growth functions without age explicit

# The FCTOOLS website, the sIMfLOR platform and the standsSIM.md simulator

# Stand models

## Whole stand models: GLOBULUS

## Stand models with diameter distribution simulation: PBRAVO

# Individual tree models

## Inter-tree competition

## Simulation of tree mortality

## Algorithms for thinning simulation

## The AllTreeSpecies model: PINASTER, PINEA and CASTANEA

## The cork oak model: SUBER

# Management oriented process-based models: 3PG

## Description of the original 3PG

## The 3PGpjs37.xlxs simulator

## Improving the Calculus Module

# Regional and large-scale forest simulators

## The standsSIM-sd regional simulator

## European Scale forest simulators (emphasis on the EFISCEN scenario model)

# Evaluation/validation of models

## Theoretical aspects related to the construction of the model

## Logic of the model structure from the biological point of view

## Characterization of model errors: bias and accuracy, modeling efficiency, trends in model errors, statistical tests

# Statistics applied to the development of forest models

## Installing R and RStudio

## Reading and manipulating data files

## Linear regression

## Nonlinear regression

## Logistic regression

# Calibration of process-based models (using the 3PG model as an example)

## Selecting the data to calibrate and validate the model

## The importance of a precise characterization of the sites

## Literature search for the values of the “observed” parameters

## Identification of data to empirically estimate the “statistical” parameters

## Tunning of the remaining parameters