Modelling Forest Ecosystems (2024/2025)

Check your knowledge

Important considerations:

The students can use the questions below to check if they have already achieved the required level of knowledge. These questions **do not** restrict the topics and/or the questions format to be included in the final test to be taken by students.

Please note that the topics addressed in **questions marked (X) were not lectured in 2024/2025**. For this reason, it is not compulsory for students to approach them and the topics they address will not be included in the final test to be taken by students.

1. Growth and yield models – structure and typology

1.1. Explain the importance of forest growth models for forest management.

1.2. What are the components (or modules) of a management-oriented growth and yield model? Give a brief explanation of the role of each module. Note that the modules are not mathematical equations.

1.3. In a forest model there are different types of state variables: external variables, principal variables and derived variables. Explain the differences between these types of variables giving examples of each one of the variables' types.

1.4. Describe the differences between stand models, stand models with diameter distribution simulation and individual tree models, specifying the differences in terms of the growth modules of each of the above-referred models. Give examples. You may consider models presented and used in classes and / or models you and your colleagues have researched and presented in the homework's.

1.5. Explain the differences, from a conceptual/structure point, between empirical and process-based models. Explain the advantages and limitations of each one of these model types. Give one example for each one of these types of models. Give examples. You may consider models presented and used in classes and / or models you and your colleagues have researched and presented in the homework's.

1.6. Establish the difference between forest growth models and forest simulators which. Remember that the latest can be developed/applied at different spatial levels, ranging from a stand to a country. Explain the objectives of application of forest simulators at each one of these spatial levels.

1.7. List and describe the main stages in a forest model development.

1.8. Distinguish the characteristics and usability of stand simulators and landscape simulators.

2. Data to develop forest growth models

2.1. Explain the difference between permanent plots, interval plots and temporary plots.

2.2. Why does a good data set for forest growth models development include permanent plots and designed silvicultural trials?

2.3. Explain the concept behind stem analysis. Can this methodology be applied to any tree species? And what about climatic regions?

*2.4. **(X)** Stand table projection*

2.4.1. Explain the reasoning behind stand table projection

2.4.2. Can this method ne used for long term projections of stand development?

*2.5. **(X)** Total stem analysis*

2.5.1. Explain how the tree height growth can be obtained using stem analysis. And what about the dominant height growth?

2.5.2. Is stem analysis an appropriate method to study stand basal area growth? Justify, comparing it with its appropriateness to study dominant height growth.

2.5.3. Justify the need to apply the Carmean's correction.

3. Allometric relationships and growth functions

3.1. What is an allometric relationship? Explain its importance for the forest growth models.

3.2. What is a growth function and why is this type of functions appropriate to simulate tree and stand growth?

3.3. What is the suitable shape for a growth curve to be used for modelling the evolution of a tree variable? How many stages should it include? Describe them.

3.4. Assume you want to fit a growth function to predict the growth of dominant height and the growth of volume. Could you choose the same growth function (e.g. Lundqvist-Korf) to be applied to both these variables? What differences would both functions have?

3.5. Distinguished empirical growth functions from analytical or functional growth functions. Give one example for each one of these types of growth functions.

3.6. What is the importance and applicability of the method developed for formulating growth functions without age explicit?

3.7. Use the Lundqvist function and formulate it without age explicit.

3.8. Differentiate the concepts of growth and yield of a forest stand. Comment how these two concepts are taken in the carbon credits market.

3.9. How do forest models help to establish or predict the best rotation interval for a forest stand managed for timber production? Present one limitation associated to this concept.

3.10. Simultaneous modelling of a set of functions

3.10.1. Consider a growth function with 3 parameters. If you allow that one of the parameters take 6 different values and plot the respective values over time, you obtain a graph with a family of 6 curves. These curves correspond to one of the methods that can be used to simultaneously model a set of plots. Identify the method and justify your answer. Do you know another method that can be used for the simultaneous modelling of a set of plots?

3.10.2. Consider the following equation that is part of the GLOBULUS model presented below in Equation 1. Is it a growth function or an initialization/prediction equation? Justify your answer.

3.10.3. In your opinion does the function presented in Equation 1 correspond to a family of curves? Justify and, in case your answer is affirmative, say in which of the two methods that can be used to simulate families of curves is based this function.

Equation 1

$$G_2 = A_g \left(\frac{G_1}{A_g} \right)^{\frac{t_1^{n_{g0}+n_{gn}\frac{N_1}{1000}}}{t_2^{n_{g0}+n_{gn}\frac{N_2}{1000}}}}$$

$$A_g = 0.1586\ S^2$$

$$n_{g0} = 3.6893 - 1.0288\ ln(S)$$

$$n_{gn} = 0.1024$$

4. Site productivity and site index modelling

4.1. What methods can be used to develop site index curves? Briefly describe each one of the methods discussing their strengths and weaknesses.

4.2. Consider the site index curve presented in Equation 2. Which of the methods to model families of growth curves has been used to develop the site index curves presented in the previous question?

4.3. Using equation 2, describe the steps to take that will lead you to find a general expression for any S value. Determine that expression using Equation 2.

Equation 2

$$\text{hdom}_2 = 61 \left(\frac{\text{hdom}_1}{61} \right)^{\left(\frac{t_1}{t_2} \right)^{0.3955}}$$

4.4. Growth functions and site index modelling. Why do we need to make the simultaneous modelling of the dominant height growth of several permanent plots (modeling of families of curves)? Briefly explain the methods available for this purpose.

4.5. Consider the following site index curves from Equation 3. In which of the methods explained in 4.1 are these site index curves based? Justify.

Equation 3

$$\text{hdom}_2 = \frac{20.7216}{1 - \left(1 - \frac{20.7216}{\text{hdom}_1} \right) \left(\frac{t_1}{t_2} \right)^{1.4486}}$$

5. Growth and yield models – modules and components

5.1. Explain the main difference between whole stand models and stand models with diameter distribution simulation.

1. Consider the following functions used in the GLOBULUS 2.1 model for basal area initialization and projection in the Centre Coastal region (Table 1). Which one of the functions 1) and 2) is the initialization and the projection function? Justify.

Table 1. Functions used in the GLOBULUS 2.1 model for basal area initialization and projection in the Centre Coastal region

Function 1	Function 2
$G = A_g e^{-k_g\left(\frac{1}{t}\right)^{ng}}$	2) $G_2 = A_g \left(\frac{G_1}{A_g}\right)^{\frac{t_1^{ngi}}{t_2^{ng2}}}$
$A_g = A_{gQ}\ S^2$	AgQ: 0.1586
$n_{gi} = n_{g0} + n_{gS}\ \ln(S) + n_{gn}\frac{N_i}{1000}$ $(i = 1,\ 2)$	ng0: 3.6354; ngS: -1.0288; ngn: 0.1024
$k_g = k_{g0} + \frac{k_{gS}}{S} + k_{gnp}\frac{N_{pl}}{1000} + k_{gf}\ \frac{100}{S\sqrt{Npl}}$	kg0: -5.5311; kgS: 177.9; kgn: 0.5408; kgf: 16.015

5.2. Explain how the stand volume and biomass are estimated in stand models with simulation of diameter distributions.

5.3. Explain the method used in these two types of models (whole stand models and stand models with simulation of diameter distributions) to simulate a thinning

*5.4. **(X)** What is a competition index? Establish the distinction between distance-dependent and distance-independent competition indices, justifying its importance for the individual tree models.*

5.5. In an individual tree model, stand volume is a principal or derived variable? Justify.

*5.6. **(X)** Give a brief explanation about the area potentially available competition index, focusing: 1) methods for the selection of competitors; 2) the computation of the index;*

3) how can asymmetric competition be taken into account. (note that this question applies to any of the competition indices "families")

5.7. What are the methods that can be used to simulate individual tree diameter at breast height growth? Give a brief explanation of each one of the methods that you presented.

*5.8. **(X)** Explain one of the methods used to simulate a thinning in an individual tree growth model.*

*5.9. **(X)** Explain one of the methods used to simulate mortality in an individual tree growth model.*

6. (X) Management-oriented process based and hybrid models

6.1. Can you give a brief explanation of the 3PG module of biomass production? In your explanation you must focus: 1) the conversion of solar radiation into biomass; 2) the light use efficiency and how it is affected by the environment and other factors; 3) how is the NPP obtained from the GPP

6.2. Explain how is site quality considered by the 3PG model.

6.3. The 3PG model makes use of a series of modifiers. Explain the modifier concept and establish the relationship of modifiers with the answer given to the previous question.

6.4. Biomass allocation – what is it and what is its importance for the 3PG model.

6.5. In the 3PG model, what is the relationship between the biomass allocation and the water and nutrient restrictions?

7. (x) Regional and large scale simulators

7.1. StandsSIM under the scenario driven mode (StandsSIM.sd)

7.2. Explain in your own words what is the main difference between these 2 different simulators mentioning the required inputs, functioning, potential users and geographic application range.

7.3. Describe what you think would be an interesting application of StandsSIM.sd

7.4. "Simulation tools can be continuously updated and or improved". If you had to propose an improvement to StandsSIM.sd, what would it be?

8. Evaluation/validation of forest models

8.1. Can you establish the difference between model verification and model validation?

8.2. Can you give some examples of analyses that can be made to evaluate the logic of the model structure and of its biological reality?

8.3. List two relevant model conditions that you must verify after fitting a model and explain how you can verify them.

8.4. When characterizing model error, we should analyze the bias and the precision. Can you explain the difference between these two concepts?

8.5. Why is it important to look for tendencies in the model error and how can this be made?

8.6. Explain the difference between continuous and categorical variables

8.7. ***(X)*** *The first step in the development of a model is the exploratory data analysis. At this stage it is important to check the relationship between the dependent variable that we want to model and each one of the candidate regressors. Explain the difference of this analysis for continuous and categorical variables.*

8.8. ***(X)*** *Are you able to explain why the best model between a dependent variables and a set of possible regressors is not the model with all the variables?*

8.9. ***(X)*** *Which algorithms do you know for the selection of good subsets of variables to be used in a model of a dependent variable and many possible candidate regressors?*

8.10. During the comparison of candidate models we must look at the model fitting but also at its prediction ability. Give examples of statistics that are used for each one of these evaluations.

8.11. Do you think that it is important to use nonlinear regression? Why?

8.12. Explain the differences between press residuals, cross validation and resampling methods.