Diameter and death of whorl and interwhorl branches in Atlas cedar (Cedrus atlantica Manetti): a model accounting for acrotony

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Abstract

Introduction Branch size and branch status (dead or alive) are important characteristics closely related to tree growth and wood quality. The aim of this study was to design models for the diameter and status of branches in Atlas cedar (Cedrus atlantica Manetti).

Material and methods The models were developed from data collected on a set of 32 trees with a wide range of heights (from 3 to 36 m), girths (from 13 to 226 cm), and ages (from 20 to 95 years). A single general segmented model was designed for both whorl and interwhorl branch diameter, taking into account the tree and annual growth unit random effects.

Results The model’s “potential x reducer” form describes the maximum branch diameter profile along the tree and the acrotonic gradient observed in annual shoots. The diameter and status of every branch were modeled based on the vertical position on the trunk and on the height of the base of the living crown. The tree diameter and the branch diameter were used as additional explanatory variables in the branch diameter model and the branch status model, respectively.

Conclusion The model structure is sufficiently general to be suited after re-parameterization for many coniferous species with interwhorl branches such as Spruces, Firs, and Larches.

Keywords Branch diameter · Branch death · Nonlinear mixed model · Acrotony · Cedrus atlantica

1 Introduction

Living crown development is of great importance for characterizing both tree growth potential and wood quality. Living branches support foliage, where photosynthesis and carbon assimilation occur. The photosynthetic capacity is thus directly related to branch size and branch survival. These two features may be used as inputs for process-based models (e.g., Perttunen et al. 1998) or as outputs of growth models distributing biomass or allocating carbon to the different compartments of the tree (e.g., Mäkelä 2002; Letort et al. 2008). Branch growth dynamics are closely related to stem growth, stem form, and bole volume.

The diameter and the death of branches on a tree stem have a strong effect on aesthetic and mechanical wood properties. The insertion of primary branches on the bole results in knots in wood. Knots increase the heterogeneity of lumber or veneer, decrease the mechanical strength properties, and are a drawback for most wood transformations and valorization processes. Branch diameter and branch status, living or dead, determine knot size and knot type, tight or loose, which are