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June 6-10 2011
Avignon - FRANCE

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Prediction of annual tree growth and survival for thinned and unthinned even-aged maritime pine stands in Portugal from data with different time measurement intervals

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1. INTRODUCTION

The Portuguese national forest strategy (Direcção Geral dos Recursos Florestais, 2006) proposed a specialization of the Portuguese forest territory according to three main functions: wood production, multifunctional systems and protected areas. Wood production is mostly related with pure even-aged stands of two species, the maritime pine (Pinus pinaster, Ak.) and the blue gum (Eucalyptus globulus Labill.). Sustainable forest management of these productive areas requires adequate prediction of wood stocks and growth. An annual individual tree survival and growth model is presented for pure even-aged stands of maritime pine in Portugal, using data with irregularly spaced measurement intervals and considering thinning effects. The model is distance-independent and assuming variable rates of growth and survival.

A PROBLEM

Available data sets for fitting individual tree models frequently have measurement intervals greater than 1 year and many times these intervals are irregularly spaced. Also thinning can occur between measurements. This causes difficulty when modelling annual tree growth and survival.

2. MATERIAL AND METHODS

2.1 Data from thinning experiments

- 145 growth series
- Irregularly time-spaced measurements
- 40367 observations for diameter growth
- 20520 observations for height growth

Modelling approach

Logistic regression:

- $p_i = 1 / (1 + e^{-y_i})$ (annual survival probability of the $i$th tree)
- $p_i = p_i(t_i)$ (survival probability for the period of duration $t_i$)

Cao (2000) methodology:

Models structured as a series of equations from the start to the end of the growth period of duration $t_i$. Two modelling approaches were tested:

1. Modelling future value of $y$ using difference equations:

- $y_i = f(y_{i-1}, \ldots, y_{i-t_i}, \ldots, y_{i-1})$
- $y_i(t_i)$ = $f(y_{i-1}(t_{i-1}), \ldots, y_{i-1}(t_{i-t_i}), \ldots, y_{i-1}(t_{i-1}))$


- $\Delta y_i = f(y_i, t_i, \ldots, y_i, t_i)$
- $\Delta y_i = f(y_i, t_i, \ldots, y_i, t_i)$

Parameter estimation


Survival Function

Diameter Growth Function

Height Growth Function

3. RESULTS

Selected equations (Modelling approach 2 performed slightly better)

The survival probability function:

$\phi(t) = \sigma / (1 + e^{-\sigma})$ (annual survival probability of the $i$th tree)

The diameter growth function:

$D_i = \sigma / (1 + e^{-\sigma})$ (annual diameter growth of the $i$th tree)

The height growth function:

$H_i = \sigma / (1 + e^{-\sigma})$ (annual height growth of the $i$th tree)

4. DISCUSSION

In the selected equations, tree survival and growth are predicted using tree attributes, stand variables reflecting the competition levels and also variables related to the site. The parameters present logical signs which is important for biological realism.

The area under the receiving operating characteristic curve (ROC) for the survival probability function was 0.94, indicating a very good discrimination capacity between the categories live and dead.

The variable that was tested, accounting for the thinning intensity and the duration of its effect, was significant to explain diameter growth. However no evidence of significant effect was found for the height growth. The diameter and height growth functions presented a promising performance as evaluated using PRESS residues.

The obtained results in the evaluation of the individual tree growth and survival model recommend the use of this model for practical applications.

REFERENCES