Organizer

INRA

Public support

Silva Mediterranea

FAO

Région PACA

Département de VAUCLUSE

AVIGNON

Sponsors

FIBRE EXCELLENCE TARASCON

Conference secretariat

Chair of the organizing committee:
Eric Rigolot (eric.rigolot@avignon.inra.fr)

The address of the conference secretariat is
National Institute for Agronomic Research (INRA), Mediterranean Forest Ecology Research Unit (UR629), Site Agroparc, Domaine de Saint Paul, 84914 Avignon Cedex 9 (France)

Contacts during the conference :

Eric Rigolot +33 (0)6 79 74 00 74.
Marie-Claude Bouhedi: +33 (0)6 80 17 75 28
Emmanuelle Degrima: +33 (0)7 86 50 39 22

https://colloque.inra.fr/medpine4

medpine4

4th International Conference on Mediterranean Pines

PROGRAM & INFORMATION

June 6-10 2011
Avignon - FRANCE

www.colloque.inra.fr/medpine4

INRA Région PACA Département de VAUCLUSE AVIGNON Silva Mediterranea

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

Luís Nunes[1], José Tomé[2], Maria Patrício[1], and Margarida Tomé[2]

[1] Centro de Investigação de Montanha (CIMO), ESA. Instituto Politécnico de Bragança. Campus de St.ª Apolónia, Apartado 1172, 5301-854 Bragança, Portugal.
[2] Centro de Estudos Florestais (CEF). Instituto Superior de Agronomia, Universidade Técnica de Lisboa. Tapada da Ajuda, 1349-017 Lisboa, Portugal.

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*, Ait.) 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

Location of the thinning experiments (O)

Data from thinning experiments

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

Individual tree growth and survival model

- Survival Function
- Diameter Growth Function
- Height Growth Function

Modelling approach

Logistic regression:

$p_i = \left(1+\exp(d_i, X_i, \beta)\right)^{-1}$ - (annual survival probability of the *ith* tree)

$p_{i,j} = \prod_{t=1}^{j} p_{i,t}$ - (survival probability for the period of duration *j*)

Cao (2000) methodology:

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

1. Modelling future value of y using difference equations:

- $y_{i1} = f(y_{i0}, t_0, t_1, X_{i0}, \boldsymbol{\beta}) + \varepsilon_{i1}$,
- if $I_{gp1}=1$, then $y_{i2} = f(y_{i1}, t_1, t_2, X_{i1}, \boldsymbol{\beta}) + \varepsilon_{i2}$, else $y_{i2}=y_{i1}$,

…

- if $I_{gpj-1}=1$, then $y_{ij} = f(y_{ij-1}, t_{j-1}, t_j, X_{ij-1}, \boldsymbol{\beta}) + \varepsilon_{ij}$, else $y_{ij}=y_{ij-1}$,
- $y_{\_final} = y_{ij} + \eta_{ij}$,

2. Modelling increment of y using Zeide (1993) differential equations:

- $\Delta y_{i1} = f(y_{i0}, t_0, X_{i0}, \boldsymbol{\beta}) + \varepsilon_{i1}$,
  $y_{i1} = y_{i0} + \Delta y_{i1}$,
- $\Delta y_{i2} = f(y_{i1}, t_1, X_{i1}, \boldsymbol{\beta})\, I_{gp1} + \varepsilon_{i2}$,
  $y_{i2} = y_{i1} + \Delta y_{i2}$,

…

- $\Delta y_{ij} = f(y_{ij-1}, t_{j-1}, X_{ij-1}, \boldsymbol{\beta})\, I_{gpj-1} + \varepsilon_{ij}$,
  $y_{ij} = y_{ij-1} + \Delta y_{ij}$,
- $y_{\_final} = y_{i0} + \sum_{t=1}^{j} \Delta y_{it} + \eta_{ij}$,

y_{ij} – diameter or height of *ith* tree in the period *j*; t_i – age; X_{ij} – stand variables (competition, site, …); $\boldsymbol{\beta}$ – model parameters; ε_{ij} and η_{ij} – random error; I_{gp} – indicator variables (j-1) for the growth period.

Parameter estimation

Survival Function and Diameter Growth Function: Simultaneous fit in SAS/ETS PROC MODEL (SAS Institute Inc., 2008), with the SUR (seemingly unrelated regression) method. An algorithm was used to continuously update stand-related explanatory variables. A fixed cutoff was used to convert survival probability in a living or dead tree.

Height Growth Function: Independent fit in SAS/ETS PROC MODEL (SAS Institute Inc., 2008), using non linear generalized least squares and the updated stand variables.

A factor to account for the thinning effect was tested:

$$[G_r/G_{at}\,(1-0.1\,t_{st})]\, I_{t_{st}<10}$$

G_r – basal area removed by thinning; G_{at} – basal area after thinning; t_{st} – time since thinning; I_{tst} – indicator variable, which is 1 if $1<t_{st}<10$ and 0 otherwise.

3. RESULTS

Selected equations (Modelling approach 2 performed slightly better)

The survival probability function:

$pi=(1+\exp(-9.267-0.204\,di+0.066\,G+0.077\,G_{>d}))^{-1}$

The diameter growth function:

$\Delta d_{ij}=\exp(1.296+0.204\ln(d_{ij})+ m\ln(t_j))$,

where,

$m=-0.903+0.101d/dg+0.006hdom-0.007G_{>d}+0.145\,(G_r/G_{at})(1-0.1t_{st})\, I_{t_{st}<10}$

The height growth function:

$\Delta h_{ij}=\exp(1.275+0.274\ln(h_{ij})+ m\ln(t_j))$,

where,

$m=-1.490+0.207\,d/h+0.022hdom+0.093\,G_{>d}/G$

di – diameter (cm); *hi* – height (m); *G* – stand basal area ($m^2\,ha^{-1}$); $G_{>d}$ – basal area of trees larger than the subject tree ($m^2\,ha^{-1}$); t_j – stand age; *dg* – quadratic mean diameter (cm); *hdom* – dominant height (m); ***m*** – parameter related to the decline component, being a power function of age.

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 residuals.

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

REFERENCES

-Cao, Q.V., 2000. Prediction of annual diameter growth and survival for individual trees from periodic measurements. For. Sci. 46: 127-131.
- Direcção Geral dos Recursos Florestais, 2006. Estratégia Nacional para as Florestas. DGRF, Lisboa. 159 p.
-SAS Institute Inc., 2008. SAS/ETS® 9.2 User's Guide. SAS Institute Inc. Cary, NC.
-Zeide, B., 1993. Analysis of growth equations. For. Sci. 39 (3): 594-616.