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A basal area increment model for individual trees in mixed species continuous cover stands in Iranian Caspian forests

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Introduction

- Iranian Caspian forests, mainly located on the northern slopes of the Alborz, are important because of environmental and economic reasons. The biodiversity in fauna and flora is high.

- There is an increasing tendency, also in other countries, to treat forests of this type, following the ideas of continuous cover management. However, a shortage of adapted growth models has delayed this effort, and few instructions for uneven-aged management have been issued so far.

Introduction

- Appropriate growth models are needed in order to make it possible to compare different management options. Then, the best option to guarantee optimal sustainable development and management can be derived.

- Growth models have a long history in forestry science. They express relationships between tree increment and explanatory variables. Sometimes, competition is considered as an explanatory variable. Different competition indices, CI, such as BAL and GCUM are used in various references.

Introduction

- Individual growth models can be developed for basal area increment or diameter increment.

- In this paper, the ambition is to develop and test a new basal area growth function to be used in mixed species continuous cover forests.

Study area

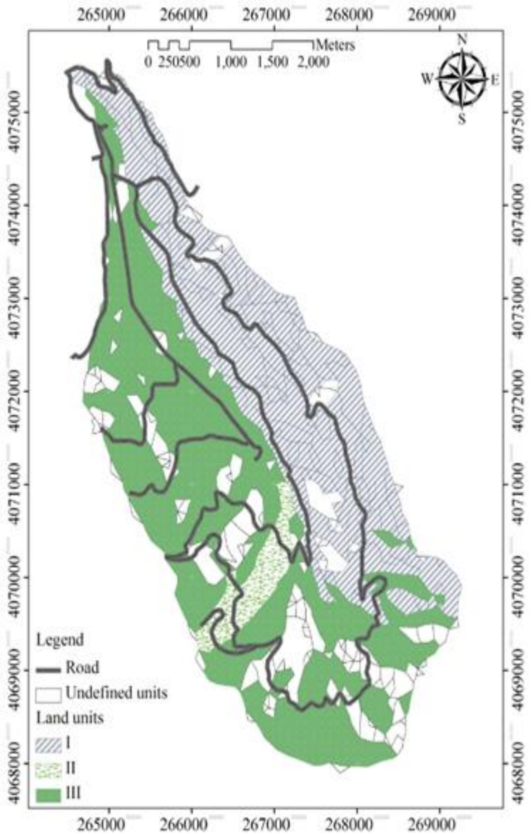

Fig. 1. Study area

Location:
District No 1
Sastkalate forests
Golestan province

Area:
1713 hectares

Elevation:
230 - 1000 m

Material and methods

- 140 circular plots, each with an area of 0.1 ha, were used. Every second plot from an already existing inventory network were selected. (The inventory was designed as a 300*400-meter network).

- In each plot, 3 to 5 increment cores from various species were extracted from witness trees.

Methods

- Totally 421 sample cores in this forest have been sampled and used for modeling.

- The witness trees were distributed over species in the following way:

- *Fagus orientalis* (Beech) (93)
- *Carpinus betulus* (Hornbeam) (106)
- *Parotia persica* (Iron wood) (68)
- *Acer velutinum* (Maple) (67)
- *Quercus castanifolia* (Oak) (51)
- *Alnus subcordata* (Alder) (36).

Methods

Table 1. Characteristics of the data set used for basal area increment modeling

Variable	Mean	Minimum	Maximum	Standard deviation
No. of trees per ha	211	10	750	117.98
Stand basal area, m^2 ha^{-1}	26.6	.00	95.97	12.86
Tree diameter,(D), cm	35.56	10	65	10.49
Basal area of trees larger than the investigated trees, m^2 ha^{-1}	16.113	0.7	41.8	0.87740 (Standard deviation for 0.1 ha plots)

Results

The basal area increment function and the statistical estimation

$$E\left(\frac{dx}{dt}\right) \approx E\left(\frac{\Delta x}{\Delta t}\right) = ax^{\frac{1}{2}} + bx^{\frac{3}{2}} + g\phi^{3}x^{\frac{1}{2}}$$

x is the basal area $(cm)^2$ of a particular tree, P. Δt is a time interval and Δx is the change of x during Δt. D is the diameter of P. $x = \frac{\pi}{4}D^2$. ϕ is the total basal area per ha (m^2/ha) of trees larger than P. ϕ is estimated from the 0.1 ha plot where P is located.

$\phi = \phi(x). \frac{d\phi}{dx} \le 0.$ There are three parameters in the function: $a > 0, b < 0, g < 0$.

Results

The parameters were determined via regression analysis

$$E\left(\frac{dx}{dt}\right) \approx E\left(\frac{\Delta x}{\Delta t}\right) = \underset{(42.115)}{1.3468}\, x^{\frac{1}{2}} - \underset{(-16.260)}{0.0000487}\, x^{\frac{3}{2}} - \underset{(-4.118)}{0.0000061632}\, \phi^3 x^{\frac{1}{2}}$$

$$- \underset{(-2.802)}{0.0791}\, K_F x^{\frac{1}{2}} - \underset{(-11.042)}{0.3116}\, K_C x^{\frac{1}{2}} + \underset{(5.028)}{0.2286}\, K_Q x^{\frac{1}{2}} - \underset{(-26.290)}{0.9932}\, K_P x^{\frac{1}{2}}$$

(Above, t-values are shown below the estimated parameter values.)

K_F, K_C, K_Q, K_P are the dummy variables

$K_i \in \{0,1\}\ \forall i$, representing different species.

If $(K_F = 0, K_C = 0, K_Q = 0, K_P = 0)$, then the function holds for maple and alder.

If $(K_F = 1, K_C = 0, K_Q = 0, K_P = 0)$, then the function holds for beech.

If $(K_F = 0, K_C = 1, K_Q = 0, K_P = 0)$, then the function holds for hornbeam.

If $(K_F = 0, K_C = 0, K_Q = 1, K_P = 0)$, then the function holds for oak.

If $(K_F = 0, K_C = 0, K_Q = 0, K_P = 1)$, then the function holds for iron wood.

Results

- **All estimated parameter values obtained the expected signs and were significantly different from zero (at the 95% level).**

- **Many of the parameters were determined with very high precision, which is shown by the t-values.**

Results

- The regression analysis also gave the following information, which, together with the analysis of residual diagrams, shows that the suggested functional form fits the empirical data very well:

$$R = 0.975,\ R^2 = 0.951,\ R_{adj}^2 = 0.950,\ F = 1144$$

- The standard deviation of the estimate is 112.055 (with ten years prediction).

Results

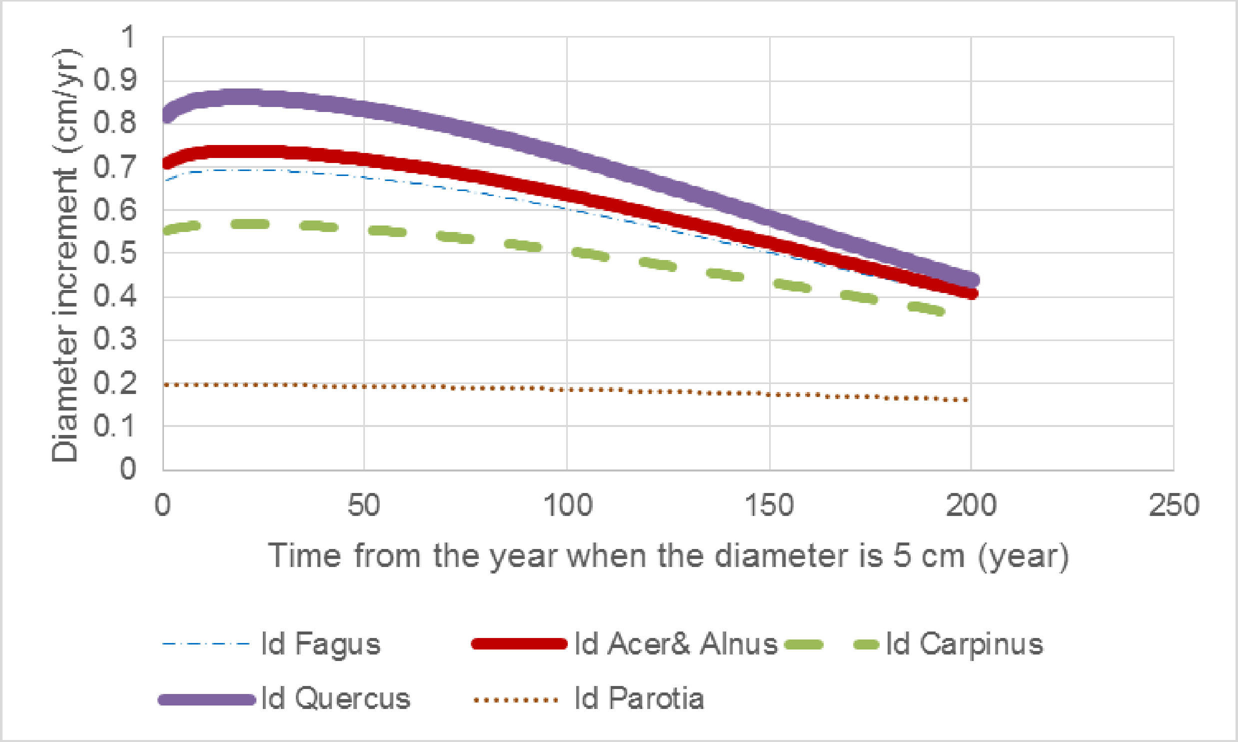

Fig. 2. Diameter increment as a function of time for different species without competition.

Results

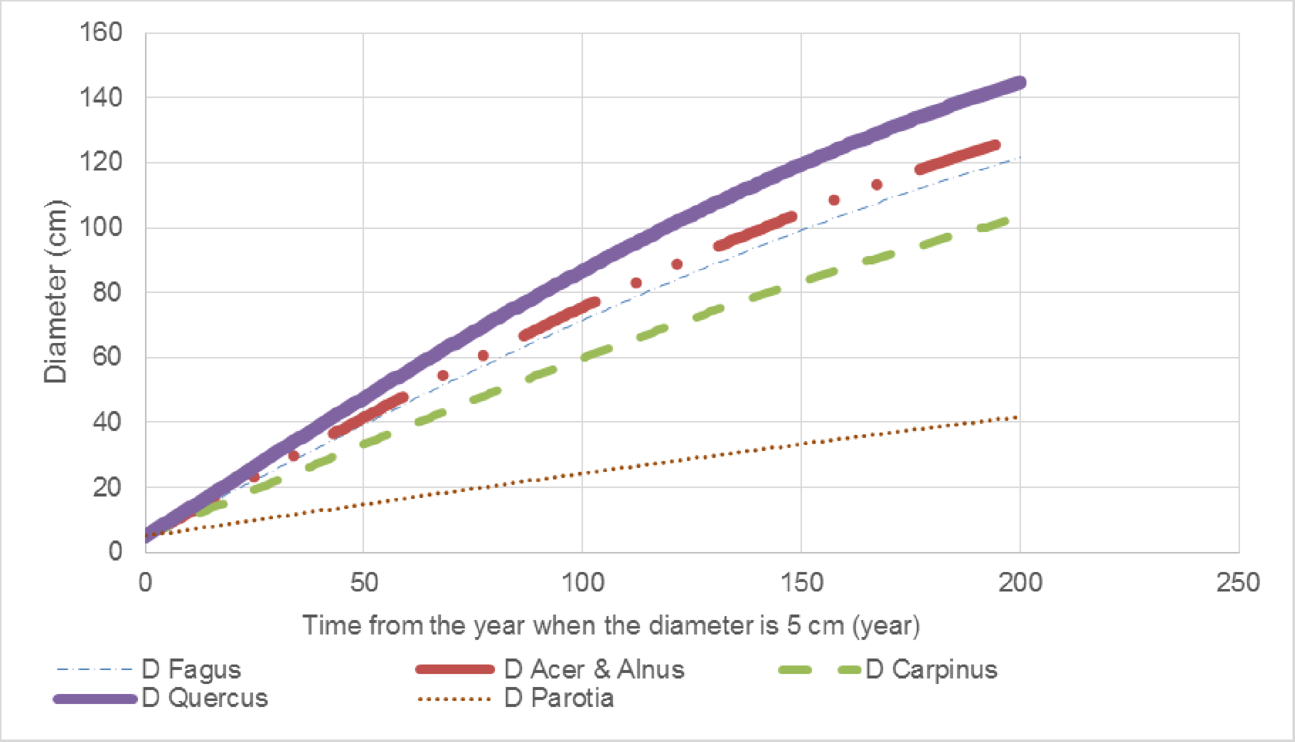

Fig. 3. Diameter development as a function of time for different species without competition.

Results

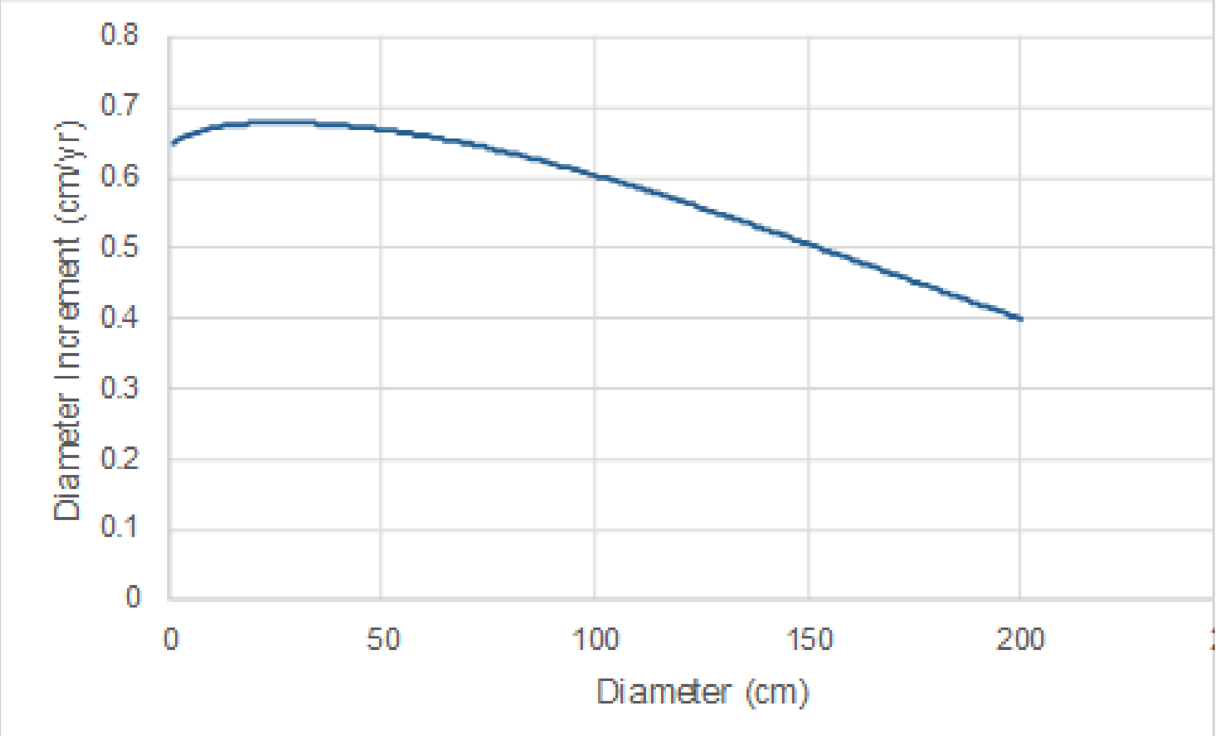

Fig. 4. Diameter increment as a function of diameter for beech in case ϕ=max (20-1/6*D, 0)

Results

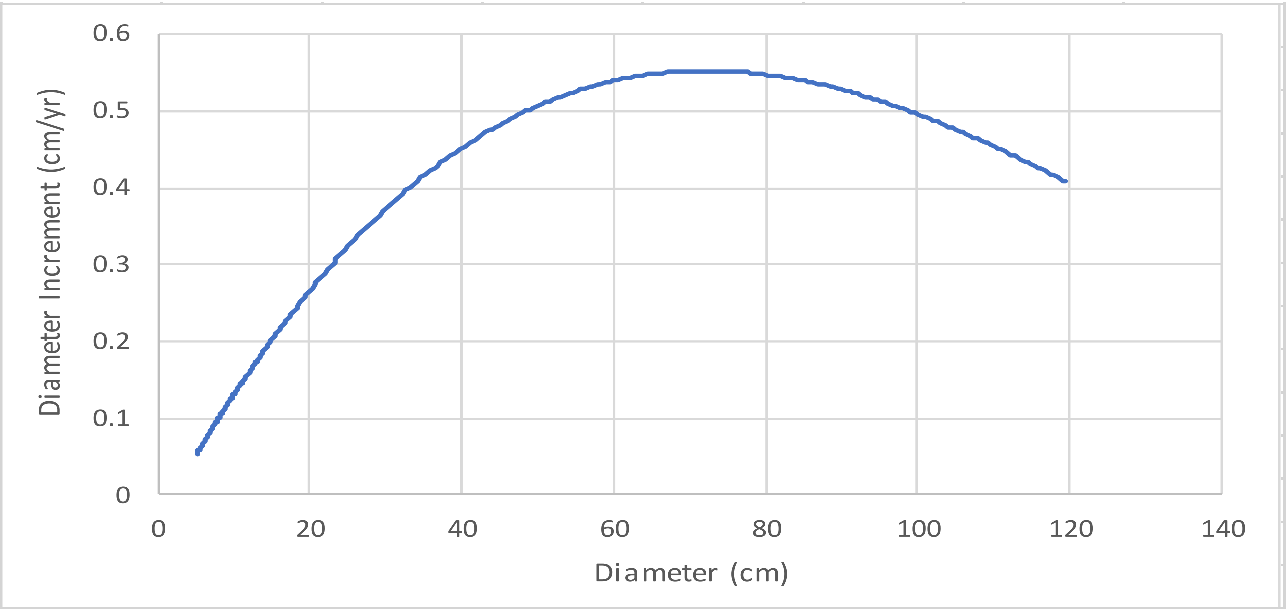

Fig. 5. Diameter increment as a function of diameter for beech in case ϕ =max (60-1/2*D, 0)

Discussion

- The function estimated in this paper includes competition in a way that makes sure that the basal area increment is strictly positive only for basal area levels between zero and the maximum level.

- The new function leads to stable solutions, which is not always the case with other types of increment functions.

Conclusions

- Forests are dynamic biological systems that continuously change over time. We have to understand the principles behind these changes, in order to manage the forests in the best possible way.

- Now it is possible to predict basal area and diameter developments of six different hardwood species under different levels of competition in mixed species continuous cover stands of the Iranian Caspian forests.

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