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Technical note

Parameterization of the cultivation density of Austrian pine, Corsican pine and Douglas fir plantations

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ABSTRACT This note presents the application of the maximum stand basal area concept from the Assmann's theory to determine the intensity of thinning of even-aged forest stands. The proposed procedure is based on the observation that, all other factors being equal, the current annual increment of wood volume tends to increase as the ratio between the stand basal area and the maximum stand basal area (defined according to the Assmann's theory) increases up to a given maximum, and then decreases as the stand basal area approaches the maximum stand basal area. On the basis of this evidence, the equations for calculating the thinning intensity of Austrian pine, Corsican pine and Douglas fir plantations in Italy are developed and provided.

KEYWORDS: Silviculture, even-aged stands, reforestation, afforestation, thinning, Assmann's theory, Italy.

Introduction

The definition of the cultivation density (i.e. number of trees per unit of surface area) of even-aged forest stands through objective indices is an important aspect both for setting up experimental tests to compare different thinning regimes and for translating the results of the experimentation into operational indications useful for the management of this type of stands. The procedure presented here refers to Assmann's theory (1970), which defines variable density thresholds in relation to the maximum basal area of a forest stand where the latter is identified with the basal area reached, at different ages, by stands that have never been thinned and where the reduction in stand density occurs only due to natural mortality.

According to the hypothesis of Sterba (1987), taken up by Skovsgaard and Vanclay (2007) and by Corona and Nocentini (2009), the maximum basal area (*Bmax*) of an even-aged stand can be expressed as a function of its top height (*TH*, i.e. the mean height of the 100 largest trees per hectare), a parameter that sums up and integrates the influence of both the stand age and the site fertility (Husch et al. 2003). The estimate of this function can be carried out on the basis of data from large-scale forest datasets, proceeding to draw a curve such that the value of the stand basal area (*B*) of any survey point is at most equal to that indicated by the curve itself as a function of the corresponding *TH*.

This hypothesis is exploited in this technical note in order to provide experimental reference for identifying the cultivation density of Austrian pine (*Pinus nigra* Arnold), Corsican pine (*Pinus laricio* Poiret) and Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) plantations in Italy.

Method and results

Using the data from the latest Italian National Forest Inventory (accessed at www.inventarioforestale.org/it) as well as the data reported by Corona et al. (2025) for experimental plots of forest plantations in Italy, the maximum basal area curve was drawn for Austrian pine, Corsican pine forests and Douglas fir stands, according to the following equations (*Bmax* expressed in m²/ha, *TH* in m):

Austrian and Corsican pine stands,

$$Bmax = 100*(1-exp(-0.0925*TH))) \quad \text{(eq.1)}$$

Douglas fir stands,

$$Bmax = 120*(1-exp(-0.0975*TH))) \quad \text{(eq.2)}$$

By comparing the current annual increment of wood volume (*CAIvol*) of even-aged stands with the ratio between the basal area and the maximum basal area of these stands, it is likely to hypothesize that the *CAIvol* tends to increase with the increase of *B/Bmax* up to a given maximum, and then decreases as *B* approaches *Bmax*.

Based on the data reported by Corona et al. (2025), this trend can actually be observed in experimental forest plantation plots in Italy, with the maximum values of *CAIvol* occuring at:

(i) *B/Bmax* = 0.55-0.60 for Austrian pine stands

(ii) *B/Bmax* = 0.60-0.65 for Corsican pine stands

(iii) *B/Bmax* = 0.65-0.70 for Douglas fir stands

These values of the *B/Bmax* ratio represent a useful reference for identifying the cultivation density of plantation stands of Austrian pine, Corsican pine and Douglas fir in Italy, in order to optimize their productivity in terms of wood volume. Therefore, by combining the equations [1] e [2] with the thresholds (i), (ii) and (iii), the thinning intensity (*TI*, expressed as a percentage of current stand basal area) in a given even-aged stand with basal area *B* (expressed in m²/ha) and top height *TH* (expressed in m) can be calculated as follows:

Austrian pine stands,

$$TI = 100*(B-(57.5*(1-exp(-0.0925*TH))))/B$$

Corsican pine stands,

$$TI = 100*(B-(62.5*(1-exp(-0.0925*TH))))/B$$

Douglas fir stands,

$$TI = 100*(B-(69*(1-exp(-0.0975*TH))))/B$$

Example applications of the proposed procedure are shown in Table 1.

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Table 1 - Example applications of the proposed procedure for determining the thinning intensity of Austrian pine, Corsican pine and Douglas fir plantations in Italy.

Species	Stand basal area (*B*, m²/ha)	Stand top height (*TH*, m)	Thinning intensity (*TI*, %)	Basal area to be removed (m²/ha)
Austrian pine	67.8	17.4	32	21.8
Austrian pine	65.6	24.7	21	14.0
Corsican pine	80.9	24.7	31	24.8
Corsican pine	68.1	28.5	15	10.1
Douglas fir	82.3	34.9	19	15.6
Douglas fir	106.4	37.7	37	39.2

Considerations

The proposed procedure for determining the thinning intensity of Austrian pine, Corsican pine and Douglas fir plantations in Italy is carried out on the basis of dendrometric parameters (i.e. stand top height and basal area) which are easily measurable and considered significant indicators from the point of view of the growth and structural characteristics of even-aged stands.

Assman's theory was formulated to identify the cultivation density of forests for productive purposes: in this sense the optimum basal area is the basal area that produces the greatest positive increment differential with respect to non-thinned stands. However, since stand basal area is correlated with the degree of canopy cover (Husch et al. 2003), the procedure proposed here might also be useful for parameter-based cultivation treatments with different aims (e.g. to ascertain the effects of thinning on triggering renaturalization processes).

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