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Review

Comparison of estimation methods to obtain ideal distribution of forest tree height

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ABSTRACT

Yield tables are the most widely-used guides for establishing the management of forests with even-aged stands. The ideal or balanced curves determine the number and size of feet that should appear in a forest with certain characteristics. These curves have traditionally been defined and applied to uneven-aged stands, and relate diameter with number of stems. However it is also possible to construct similar curves to manage stands composed of even-aged units. This paper proposes and compares alternative methodologies, based on yield tables, for establishing distribution curves for height/number of stems for *Pinus sylvestris* L. Based on the yield tables for this specie, it can be seen that the "direct" methods correspond more closely to the original chart, but also require highly complex calculations. However, estimation methods based on the use of kernel functions are generally simpler and can produce similar results, with the correct choice of smoothing parameter.

Contents

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1. Introduction

1.1. Background

Forestry management is based on models of population dynamics which explain or illustrate the evolution of a forest stand under particular conditions. One of the most common methods used to support the management of forest stands is what are known as yield tables, which represent the evolution over time of dasometric variables according to different cutting regimes and qualities (site index) in even-aged stands. These tables contain a scenario of mortality and cutting which is generally presented in discrete time intervals of 5, 10 or 20 years, and track the growth of trees in the forest stands, together with the successive processes of elimination. Once the age of a plot or management unit is known, the values for density, basal area, dominant height, etc., that the stand should present can be determined by using the information in these tables. However, it is a complicated task to determine the age of a forest with accuracy, and if there is no reliable information available on the age of the forest, the yield tables cannot be applied directly to the different stands.

According to Matthews (1989), Yorke (1992) and Garfitt (1995) it is only possible to determine the age of the different groups or units in a forest for very homogeneous stands such as those in monospecific reforestation projects, or stands which have been rendered homogeneous through treatment. If the tree groupings are of a fixed and controllable size, the growth of existing and reforested stands may be guided merely by following the yield tables for this species, site index and type of treatment.

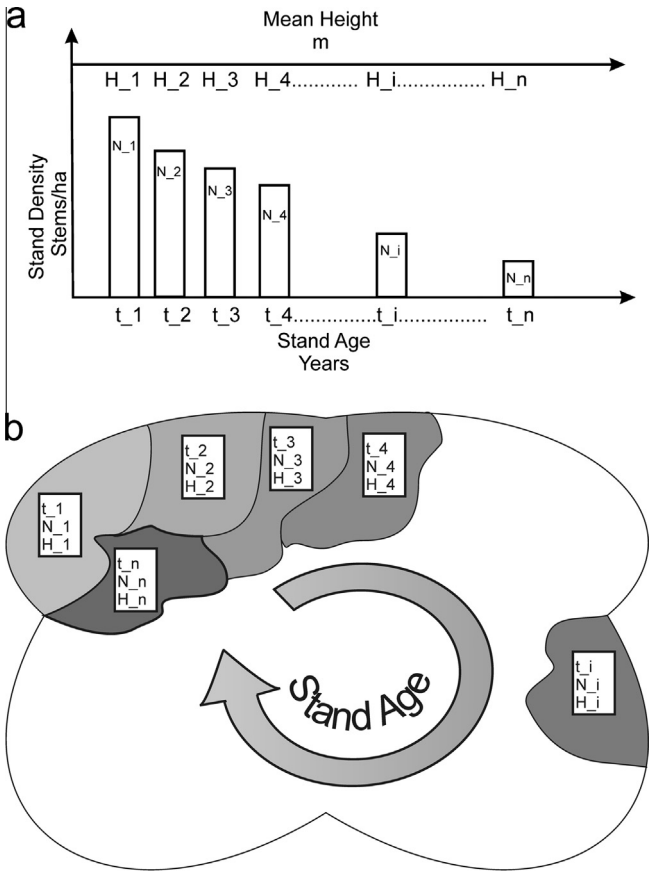

Fig. 1. (a) Variation, over time, in number of stems, *N*, and mean height, *H*, of an even-aged stand; (b) spatial variation of *N* and *H*, over time, of an even-aged stand with all the ages of (a).

Unfortunately this information not always is easy to obtain. This is the case when there has been no previous forest management plan and the ages of the stands are unknown, and/or the characteristics of the forest make it impossible to monitor closely the surface distribution of the different age groups it contains. This also occurs when are defined units or copses of small size which in practice they cannot be delimited. These scenarios are frequent when managing forests where the aim is to increase biodiversity or landscape value by generating a large number of even-aged, small-sized units distributed irregularly throughout the space (Smith et al., 1997; Schütz, 2002). In these cases management cannot be guided by yield tables, as these require a precise knowledge of the ages of the various groups. It is therefore necessary to have a reference model which is expressed in terms of diameter or height distribution, and which does not include the age variable. This model must contain a method of relating number of stems with size. As well as enabling the definition of the ideal state of the forest stand, it must also allow comparison with data from a field inventory in which the ages of the different areas sampled are not usually known.

The model defined by García-Abril et al. (1999) fulfils these requirements and has been partially implemented. The stages of this model are described in the subsections below.

1.1.1. Conceptual definition of the reference situation

The ideal state of the forest stand, based on the yield table, is reached when a stand is obtained which is formed by a series of grid squares of different ages in such a way that all the ages are equally represented over the area. When this situation is reached, the temporal evolution shown in the yield table is transformed into a spatial evolution (Fig. 1(a) and (b)).

1.1.2. Quantitative description of the reference situation

The tree size distribution function is used as a descriptor of the ideal situation. This distribution establishes number of feet in size class which should be present in the ideal situation. A stand in which all the ages are equally represented should have a specific distribution of trees by size class. This reference curve or "balanced curve" constitutes the quantitative description of the ideal state to be achieved.

Generally the size of a tree is studied using the diameter at breast height (dbh), as it is the easiest variable to measure. However, for a description of the size of the tree, this variable is analogous to other variables such as height.

1.1.3. Operative management methodology

An important feature of the model is that it does not involve the need for strict monitoring of the ages of the different groups. The management objective is not defined for unit based on its age; the ultimate goal is rather to achieve an overall distribution of sizes at the stand or forest level which is equal to that of the reference situation for the same quality. This management model has the advantage of permitting actions to be implemented when the