Evaluating *Stand Density Index* in Southern Piedmont Silver Fir (*Abies alba* Mill.) stands

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International Conference on Modeling Forest Production

19-21, April 2004 – Vienna

Introduction

Forest stand density can be described by absolute or relative measures; relative density indexes compare an absolute stand density with a reference density in standard conditions or fulfilling specific management goals. They are based upon mathematical models of stand development, taking into account undisturbed or maximum competition-reaching stands.

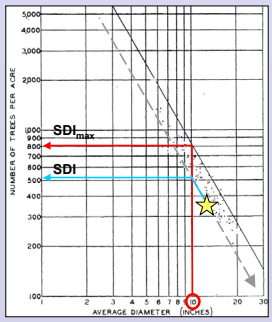
The aim of this research is to describe the ecological end silvicultural meaning of relative density measures, with a special focus on Reineke's Stand Density Index (SDI), in order to appreciate its effectiveness when applied to the Italian forest context.

STAND DENSITY INDEX (Reineke, 1933)

Stand Density Index (SDI) is based upon the inverse-proportional relation between number of plants per hectare and quadratic mean diameter (QMD) in pure, even-aged and undisturbed forest stands that undergo severe intraspecific competition. By analyzing stand structure of 14 different North American conifer stands in optimal competitive conditions, Reineke found that their density could be expressed by the following:

$$\log N = c - 1{,}605 \log d_m$$

The –1,605 slope was supposed to be a constant value among the different species; further researches brought the evidence that each species is characterized by a different slope value, with more tolerant species showing steeper slopes.



Stand Density Index is the number of individuals per hectare corresponding to a 25 centimetres quadratic mean diameter on a line with the same slope than the one described above and passing through the QMD and absolute density observed in the stand. Single tree or diameter-class SDI contributions can be summed up in order to calculate uneven-aged stands total SDI.

A species' maximum SDI expresses the upper limit of all possible combination of density and QMD that can be observed in monospecific stands and represents maximum achievable competition. Relative stand density comes from the comparison between maximum SDI and individual stands' SDI.

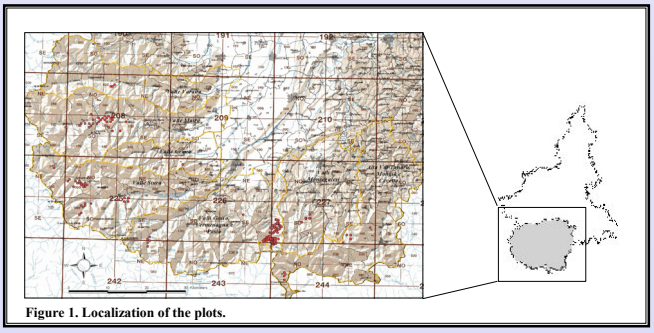


Figure 1. Localization of the plots.

Methods

The study area is represented by Silver Fir (*Abies alba* Mill.) stands in Southern Piedmont, Italy. Taking data from the last regional Forest Inventory we have chosen 173 plots in 7 different Forest Districts. The stands have different densities, site qualities and management regimes.

- The attention was focused on a linear size-density relationship with variable slope. Only monospecific stands (silver fir basal area greater than 80% of total basal area) were taken into account for the estimation of the species' self-thinning line. Among this reduced sample only stands undergoing severe intraspecific competition were retained, namely the ones with the higher density in each QMD class.
- Maximum density line was estimated by linear regression on a log-log scale between density and QMD in the selected stands (n=13). The slope of the line was used to calculate SDI in each stand; the summation method was used, since it can assess total SDI both for even-aged and uneven-aged stands.
- The greater SDI in the sample stands is proposed as the species' maximum value. Relative density of each stand was then expressed as a percentage by of the maximum.
- Correlations between SDI and several structure and site descriptors (elevation, species composition, uneven-agedness, site quality, regeneration frequency for each stand) were examined; SDIs were aggregated in relative density ranges and territorially referenced by means of a GIS software. Detailed maps were made representing each Forest District.

Results

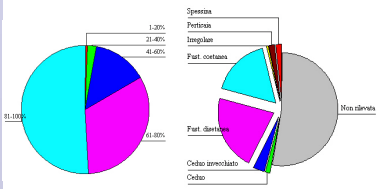


Figure 2. Crown cover and stand structure in the sample plots.

Minimum SDI	82
Maximum SDI	**1359**
Average SDI	660,3

Figure 4. Maximum SDI in Silver Fir stands (above), compared to values given by other researches (below).

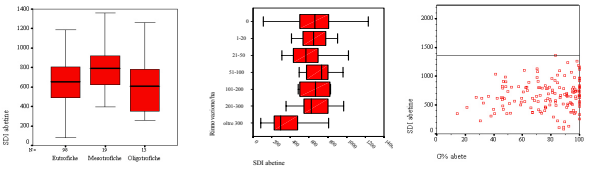


Figure 5. Relationships between SDI and site quality, regeneration frequency, specied composition of the stands.

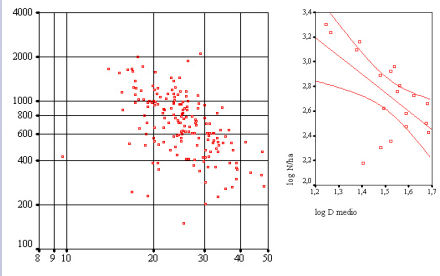
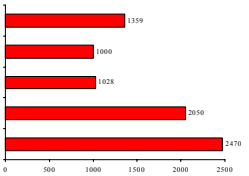
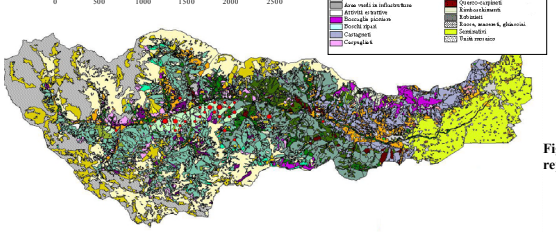


Figure 3. Relationship between maximum density and quadratic mean diameter in the sample stands. The slope of regression line is –1,491 (R^2 = 0,345).





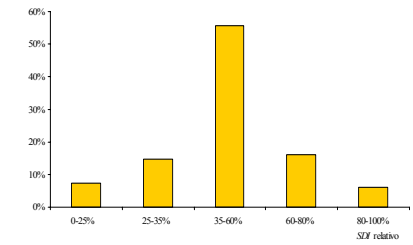


Figure 6. Relative density of Silver Fir stands (above) and its GIS representation for Maira Valley (left).

Discussion

The majority of examined stands is characterized by low relative densities: in 74% of the sample the Stand Density Index ranges from 25% to 60% of Silver Fir maximum SDI. This density range represents moderate competition conditions, above crown closure level but yet not causing self-thinning dynamics. We therefore hypotize that most stands are still undertaking resource competition levels lower than the species' achievable maximum; this description fits well to the structure of Southern Piedmont Silver Fir stands.

SDI supplies a satisfactory modelling of structure dynamics in Silver Fir stands; since it can be sensitive to different stand structures, SDI is considered an effective tool in describing the ecological and silvicultural features of forest stands. The informations given by SDI are enriched by its relationships with ecological variables such as composition of the stands, regeneration frequencies and site quality. The capability to measure stand development through time is an important step towards the application of more detailed models; further researches, to be led on more comprehensive study areas, are requested in order to validate described trends.