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Self -Thinning in Forests and Plantations

M. Gowsalya[1*], M. Mathivanan[2]

[1]M.Sc. Scholar
[2]Ph.D. Scholar
(Forestry), FC&RI, TNAU, Coimbatore, India

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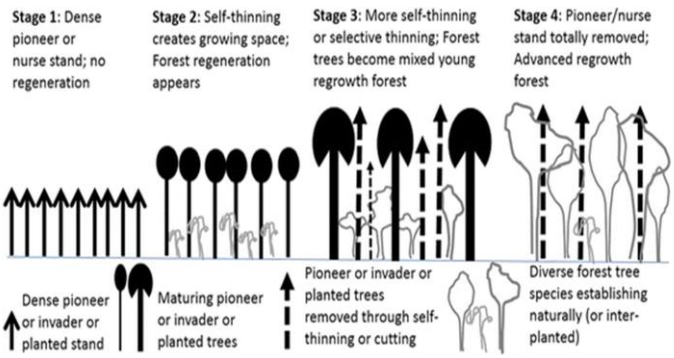
INTRODUCTION

The mortality caused by competition among trees within a stand is called self-thinning. (Yoda et al. 1963). Self-thinning is the natural process whereby numbers of trees per unit area decrease as average tree size increases over time. It is a process intrinsic to all forest and plant communities w hose composition and structure are influenced by competition for growing space. Whereas self-thinning is a process, the term stand density refers to various expressions of the absolute or relative amounts of an attribute of tree populations (e.g. numbers of trees or stand basal area) per unit land area.

Trees at a competitive disadvantage die from crowding and suppression as crowns expand and tree size increases (Johnson et al. 2002). Thus, self-thinning refers to the reduction in tree numbers over time due to density-dependent mortality as the plants increase in size (Yoda et al. 1963). Self-thinning is a continuous process during stand development whose intensity increases as the stand basal area approaches a maximum.

Self-thinning in forest and plantation



Self-thinning

- ❖ The -3/2 power rule of self-thinning
- ❖ Reineke's equation

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The -3/2 power rule of self-thinning and Reineke's equation

Self-thinning line is based on the relation between average total plant biomass and number of plants per unit area in single-species populations undergoing density-dependent mortality.The best known and most widely used for describing the self-thinning relationship are those of Reineke's equation, and 3/2 power law of self-thinning.

In Reineke's equation, it described the relationship between the number of trees per unit area and quadratic mean diameter at breast height in even-aged stands of full density, whereas it described the relationship between mean plant biomass (or volume) and numbers per unit area in (Hynynen, 1993). The self-thinning rules of Reineke and Yoda - are useful and widely used in forest growth and yield models to predict natural mortality. The two rules are basically the same in that both are used to quantify a maximum stand density for a given stand size.

Fixed slope between the logarithm of size and the logarithm of density regardless of species, age, and site quality in fully stocked stands. The debate can be explained by the variety of statistical methods that has been used to analyze the species self-thinning line.

The self-thinning rule predicts that for a crowded, even-aged plant population, a log-log plot of total plant mass against plant density will give a straight line of slope. It has been described as one of the more general principles of plant population biology, but the evidence supporting it has recently come under close critical scrutiny.

The -3/2 power rule of self-thinning

The -3/2 power rule of self-thinning has been called "one of the more general principles of plant population biology". The -3/2 power rule relates plant size to density when density-dependent mortality (self-thinning) is occurring, in such a way that populations decline in density as plant size increases. These concomitant changes can be described by the equation:

$$w = kN^{-a}$$

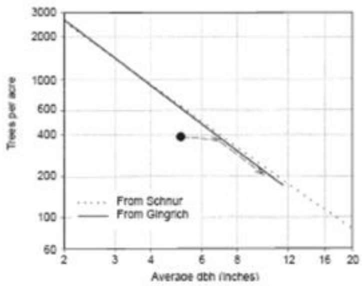
Where w is the average mass per plant (in grams), N is the plant density (number per square metre), and k and a are constants.

When transformed to logarithms, this becomes

$$\log w = \log k - a \log N.$$

Where w is mean plant biomass,N decreasing population density, κ a species-specific constant,the slope γ is −3/2.

This implies, for example, a 17% increase in mean plant biomass is always associated with a 10% decrease in population density, regardless of species, stand spatial structure or initial density. Such models can be empirically derived by regression analysis and other statistical methods (Weller, 1987) using data from temporary or permanent field plots from undisturbed stands encompassing a wide range of average stand diameters within a given forest type. Data from permanent plots with repeated measurements are preferred because periodic mortality is actually observed, which reduces assumptions about the self-thinning process (Zeide, 1987).



Stands selected to define a line or limit of average maximum stand density should be at or near the upper limits of stand density with respect to their average diameter. The resulting line showing number of trees per acre by mean stand dbh is sometimes interpreted as a self-thinning line, or line of 100% relative density (Fig.). The line provides a useful definition of the upper limits of stand density because the number of trees per unit area and mean dbh are highly correlated.

The rule consists of two parts

- There is the interspecific size-density relationship, where the extreme combinations of plant mass and density follow a -3/2 power relationship, a trend that has been assumed to hold true over nine orders

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of magnitude of density, from mosses to trees (Weller, 1989).

- ❖ Secondly, there is the thinning line for populations of individual species undergoing density-dependent mortality (Yoda et al. 1963), which has also been assumed to have an exponent of -3/2 with variations about this value being regarded as random (with some exceptions, e.g., populations under low light [Lonsdale and Watkinson 1982]).

Principle of self-thinning

The principle of self-thinning is most easily described by the temporal changes that occur in the numbers of trees in undisturbed even-aged stands. However, self-thinning also occurs in uneven-aged stands. According to this principle, the finite growing space of a stand is occupied by progressively fewer trees as average tree size increases with stand age.Trees at a competitive disadvantage die from crowding and suppression as stands approach a limiting number of trees of a given average size that can coexist within an area.

- ❖ As stands reach the stem exclusion stage of development, tree crowns expand to fill the available growing space.
- ❖ Crown expansion continues until an upper limit of tree crowding is reached.
- ❖ Thereafter, stands follow a relatively predictable course of density-dependent tree mortality as numbers of trees per unit area decrease with increasing average tree size.
- ❖ It is generally assumed that the combined effects of crown expansion and tree mortality are compensatory so that canopy closure is always maintained except in the presence of 'irregular' mortality.
- ❖ The latter may be caused by such factors as air pollution, high winds, flooding, epidemic insect and disease outbreaks, and other factors.

CONCLUSION

Self-thinning consequently appears to be heavily influenced by tree geometry, which is continually changing to meet requirements for structural resistance to bole breakage as crown mass increases (McMahon, 1973). For example, one side of a tree crown may expand into the gap created by the death or removal of one of its neighbours, resulting in an expanded but non-symmetrical crown. Trees that survive self-thinning acquire new resources (space, light, soil moisture and nutrients) as a consequence of spatial adjustments resulting from the death of neighbouring trees and differential growth rates among competing survivors.

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