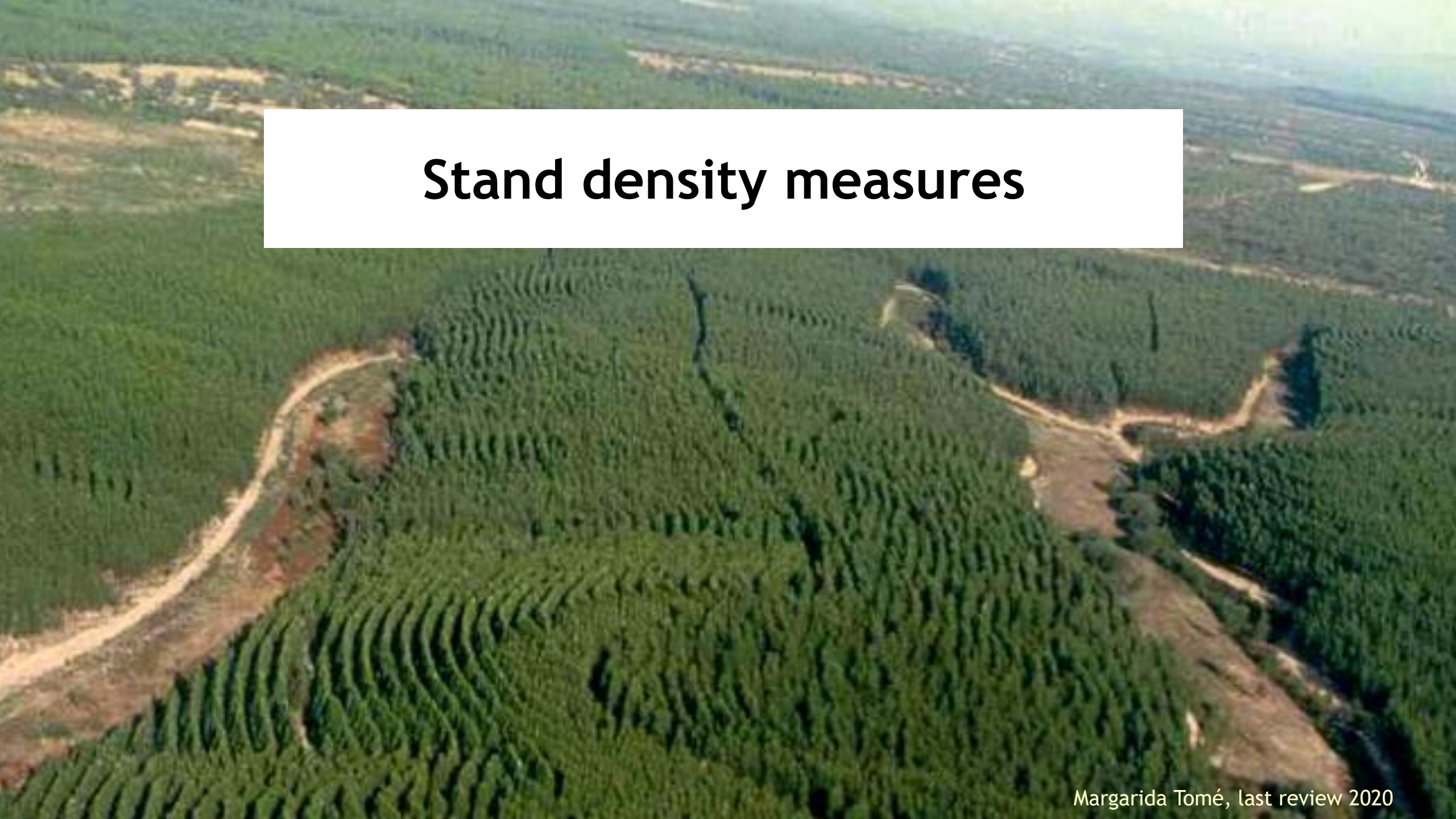
Stand density measures



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Stocking and stand density

- Although stocking and stand density are terms that are often applied interchangeably in forestry use, the two terms are not synonymous
  - Stand density denotes a quantitative measurement of the stand
  - Stocking:
    - Stocking refers to the adequacy of a given stand density to meet some management objective (Bickford et al. 1957)
    - Stands may be referred to as understocked, fully stocked, or overstocked
    - A stand that is “overstocked” for one management objective could be “understocked” for another

Quantifying stand density

- Stand density is a quantitative term describing the degree of stem crowding within a stocked area
- It can be expressed in absolute or relative terms
  - Absolute measures of density are determined directly from a given stand without reference to any other stand
  - Relative density is based on a selected standard density, usually the “fully stocked” stand or the open-grown trees (the extremes)

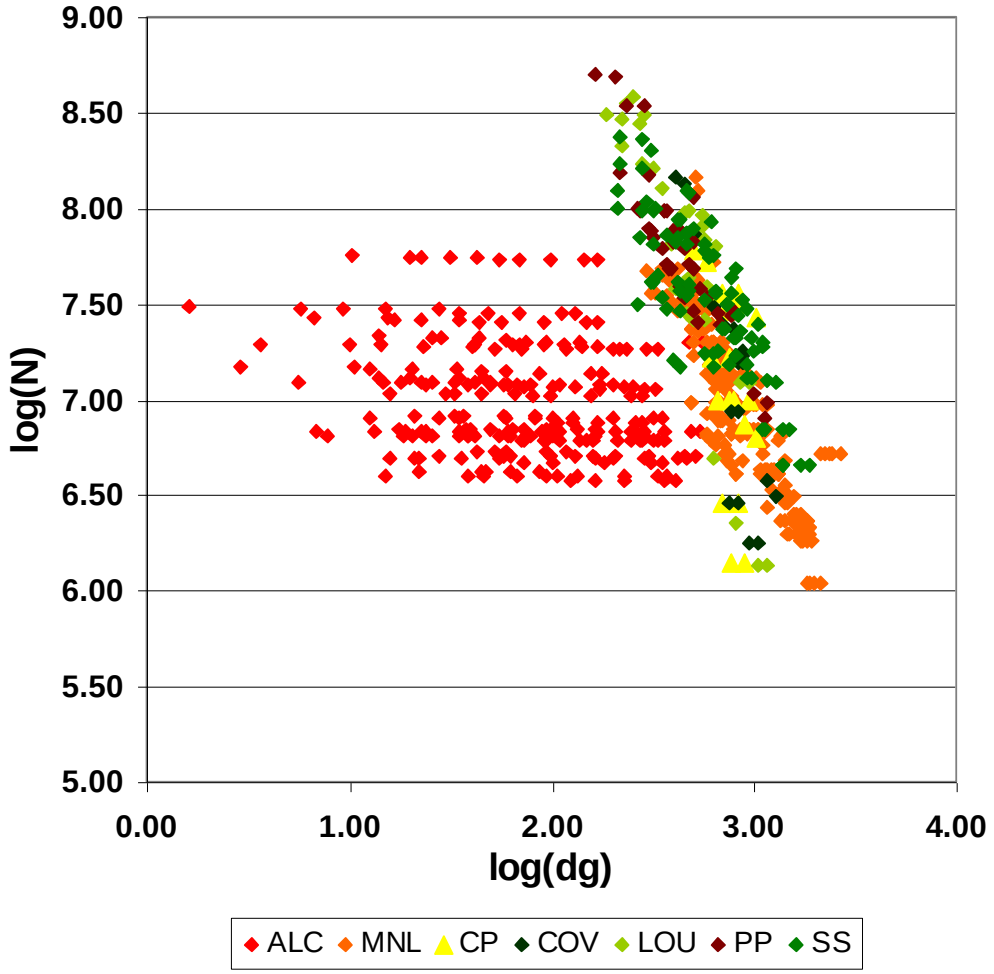
Quantifying stand density

- Absolute measures of stand density
  - Basal area
  - Number of trees per ha
- Relative measures of stand density
  - Stand density index
  - Crown competition factor
- Other stand density measures
  - Relative spacing
  - Spacing factor
  - Percent crown cover

Stand density index (SDI)

- SDI evaluates stand density by comparing it with the maximum density for a stand with the same quadratic mean dbh (*dg*) – limiting situation or self-thinning line
- For any given *dg* there is a limit to the number of trees per unit that can be carried
- Reineke (1933) noted that for a variety of species the slope of the limiting line was approximately -1.6 on the log-log scale

Stand density index (SDI)



Maritime pine
data - PORTUGAL

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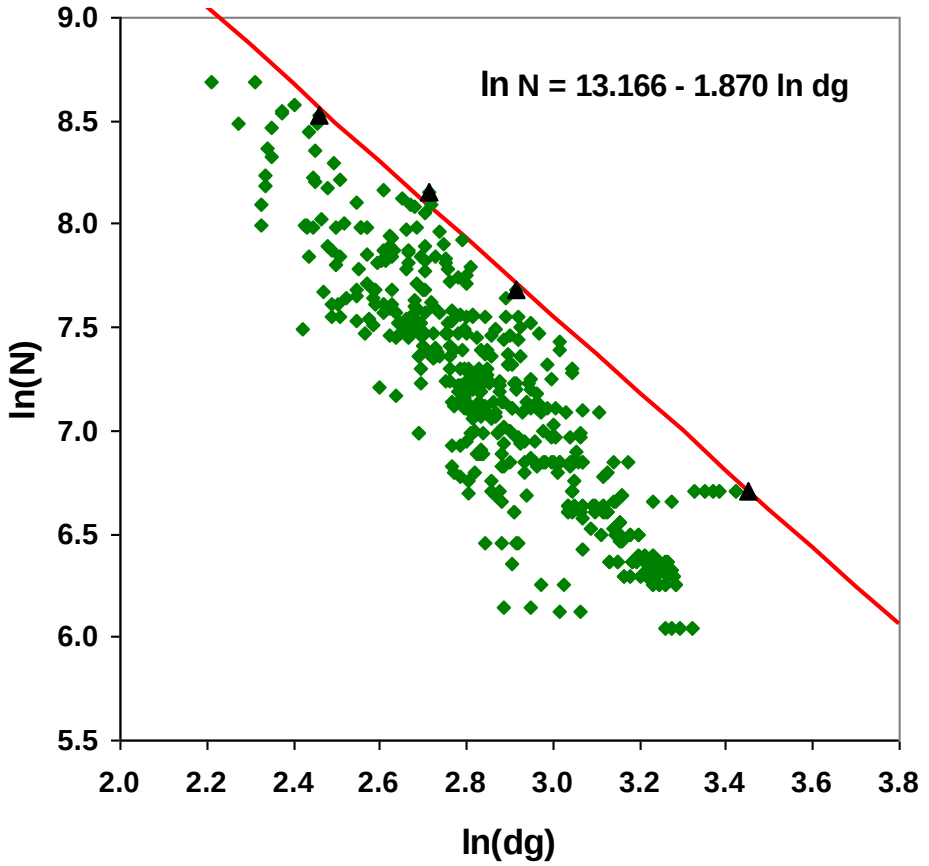
Stand density index (SDI)



Maritime pine
data - PORTUGAL

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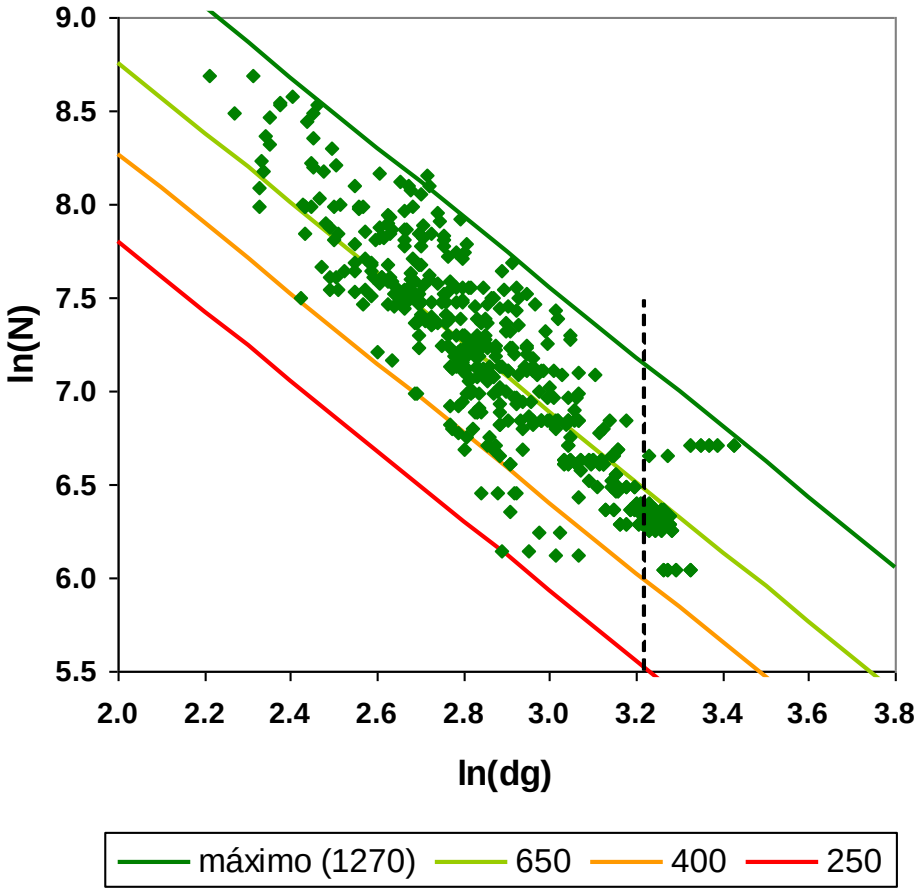
Stand density index (SDI)

- SDI is based on the comparison of the number of trees in the stand and the maximum number of trees it could sustain according to the self-thinning line
- SDI assumes that an understocked stand is located in a logN-logdg line parallel to the self-thinning line but with a smaller intercept

Stand density index (SDI)



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Stand density index (SDI)

- The intercept for a stand can be obtained as

$$\ln N = k - 1.870 \ln dg$$

$$k = \ln N + 1.870 \ln dg$$

- The index is “normalized” by using the dg=25 as a basis for comparison

$$\log SDI = k - 1.870 \log 25$$

Stand density index (SDI)

- The expression for SDI in a particular stand is then obtained:

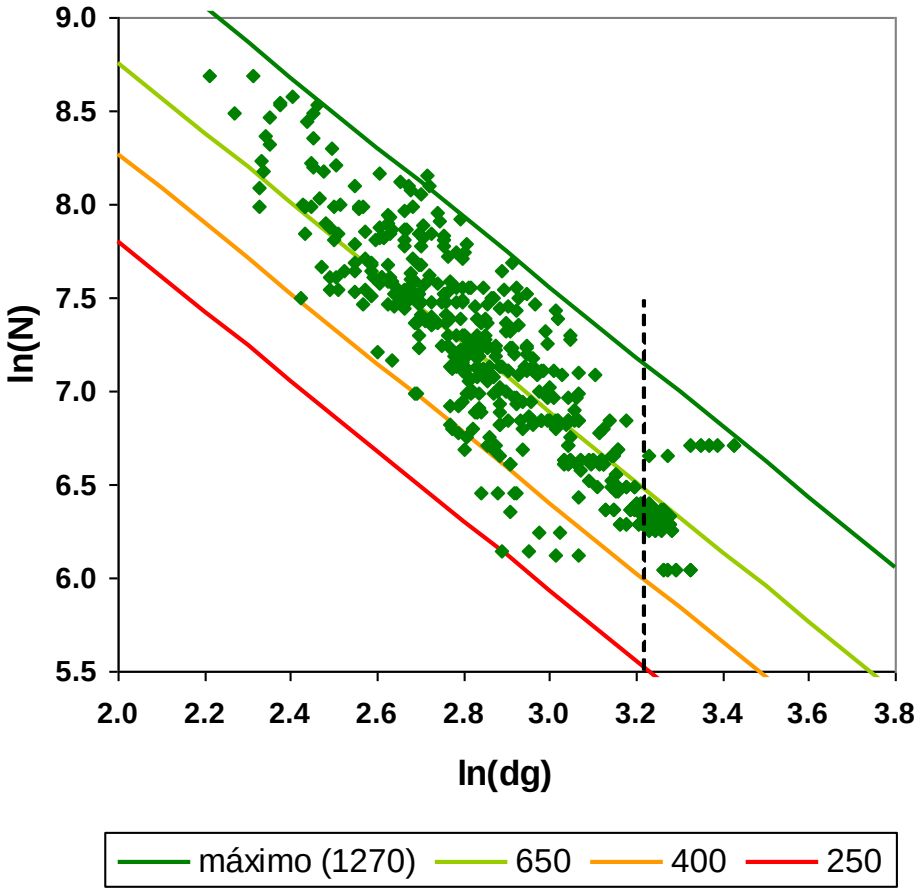
$$\log SDI = -1.870 \ \log \ 25 + k$$

$$k = \ln \ N + 1.870 \ \ln \ dg$$

$$\ln \ SDI = -1.870 \ \ln \ 25 + \ln \ N + 1.870 \ \ln \ dg$$

$$SDI = N \left(\frac{dg}{25} \right)^{1.870}$$

Stand density index (SDI)



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Crown competition factor (CCF)

- CCF reflects the relationship between the area available for the average tree of the stand and the maximum area that the tree could use if it was growing in open space (open-grown tree)
- The computation of CCF requires the study of the relationship between crown width of an open-grown tree (cw_{og}) and its dbh (d_{og}), usualy linear:

$$cw_{og} = b_0 + b_1 d_{og}$$

Crown competition factor (CCF)

- The crown of an open grown tree ocupies the area ca_{og}:

$$ca_{og} = \pi \frac{cw_{og}^2}{4} = \pi \frac{\left(b_0 + b_1 d_{og}\right)^2}{4}$$

- CCF is then computed as the sum og the caog values for all the trees in the stand, expressed as a percentage of the plot area:

$$CCF = \frac{100}{A_p} \sum_{i=1}^{N} ca_{og_i}$$

Relative spacing (Rs)

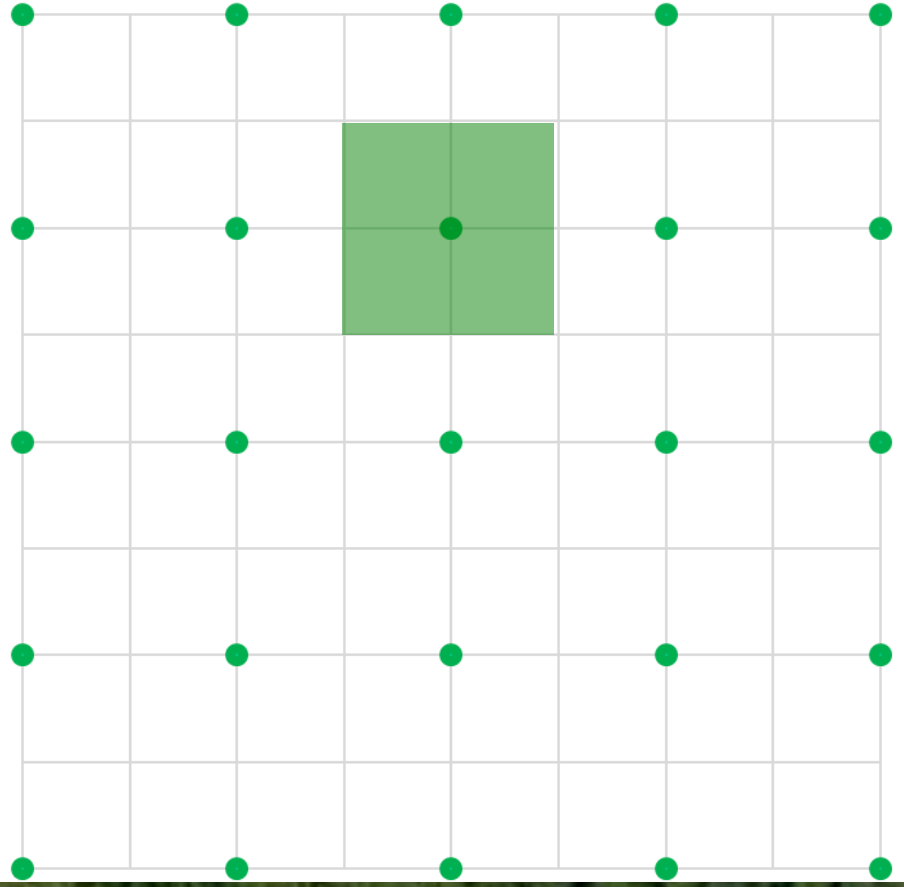
- RS is a stand density measure that relates the mean distance between trees with the dominant height
- It is based on the assumption that the stand density must decrease as the stand developes (the dominant height increases)

$$Rs = \frac{\text{average distance between trees}}{hdom}$$

Relative spacing (Rs)- the Wilson factor (Fw)

- Assuming that the trees are regularly spaced, the area available per tree is:

$$\text{Area per tree} = \frac{10000}{N}$$



Relative spacing (Rs)- the Wilson factor (Fw)

- Assuming that the trees are regularly spaced, the area available per tree is:

$$\text{Area per tree} = \frac{10000}{N} \quad \Rightarrow \quad \text{dist}_{mean} = \sqrt{\frac{10000}{N}}$$

- The relative spacing can be written in the form usuually known as wilson factor

$$Fw = \frac{\sqrt{1000/N}}{hdom} = \frac{100}{hdom\ \sqrt{N}}$$

Spacing factor (Sf)

- *Sf* is a stand density measure that relates the average distance between trees to the crown width of the average tree:

$$Sf = \frac{\text{average distance between trees}}{cw_{mean}}$$

- If a regularly spaced stand is assumed, *Sf* comes as:

$$Sf = \frac{100}{cw_{mean}\sqrt{N}}$$

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Crown cover(*Cc*)

- Crown cover (*Cc*) is a stand density measure that computes the percentage of area covered with crowns :

$$Cc = \frac{\sum_{\text{all trees}} \text{crown area}}{\text{Plot area}} \; 100$$

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