Site quality, site index curves (SIC) and dominant height growth

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Summary

- What is the **site and the site quality**?
- How can we evaluate **site index**?
- Data available for developing **site index curves** (SIC)
- Types of site index curves
- Indirect methods for the development of site index curves
- Direct methods to estimate S

The need to quantify site quality

Chapt 7.1

Site and site quality

- ✓ **What is the site?**
  - Site refers to "an area considered in terms of its **environment**, particularly as this **determines the type and quality of the vegetation** the area can carry"

(Society of American Forests 1971)

- ✓ **Site quality can be evaluted through direct and indirect methods**
  - **Direct** or geocentric methods – site is evaluated by climate and soil characteristics
  - **Indirect** or phytocentric methods – site is evaluated by the analysis of the vegetation growing in the site
    - Indicator plants (namely shrubs)
    - I - Site index [*f*= *(hdom, t)*]
    - II - Site index [*f*= *(climate, soil)*]

Site quality evaluation

Using Site Index [*f*= *(hdom, t)*]

Assessing the productive potential is essential for forest management.

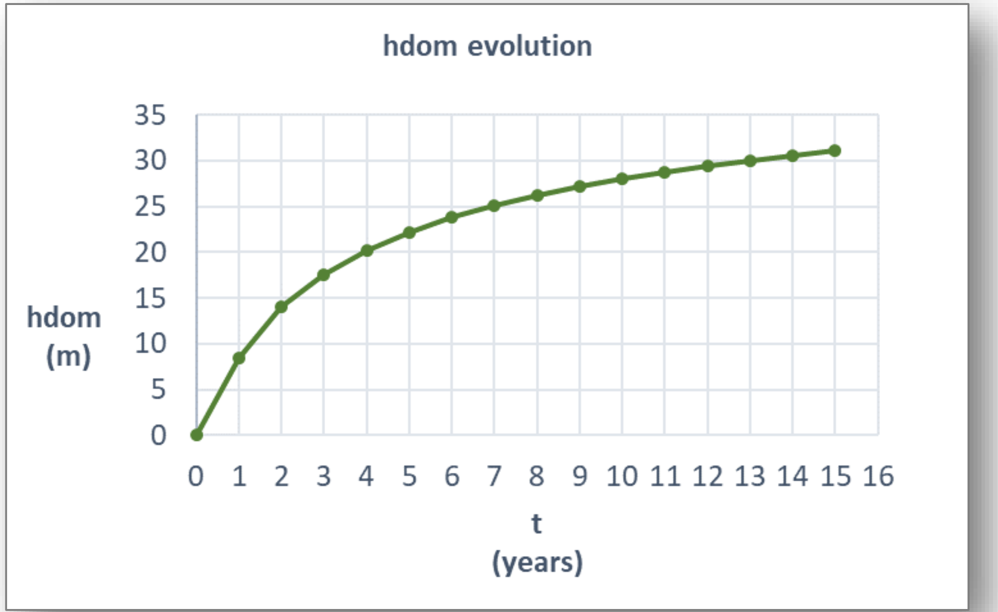
For modelling purposes site quality has to be expressed by a number, be objective and easily determined

What could be a measure of site quality?

Volume production is no feasible measure of site quality:

- Limited historic data available
- Not easily determined in forest practice
- Stand density dependent

Stand dominant height development has been widely used to assess **site index**



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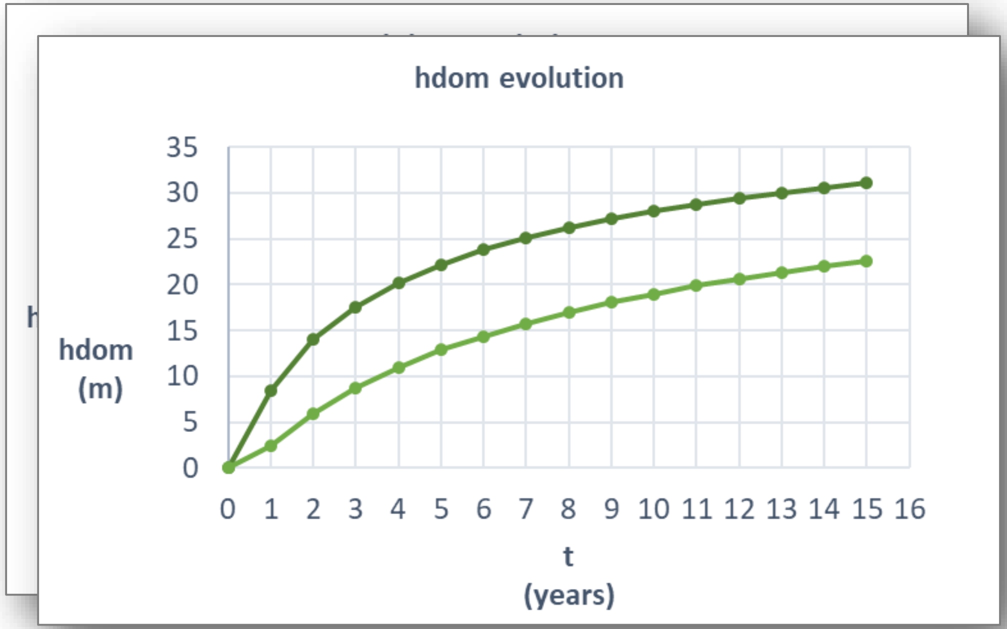

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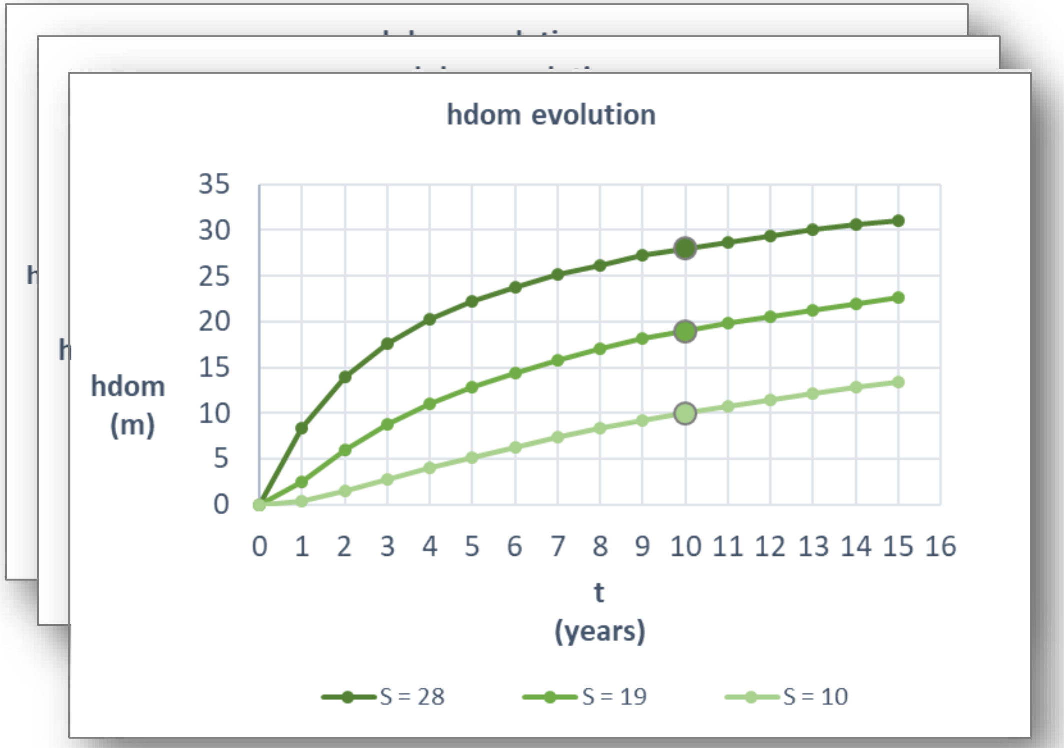


S (*site index*) is the hdom (*dominant height*) at a chosen t (*age*)

Site quality evaluation

Using Site Index [*f*= *(hdom, t)*]

- Site index (S) is defined as the dominant height that the stand has, had or will have at a certain age, the base age

  - Therefore, the simulation of dominant height growth is intimately related with the prediction of site index

  - The site index concept assumes that the dominant height is not greatly affected by stand density or thinning treatments *(disregarding thinning from above)*

  - The set of curves that represent dominant height growth for the range of possible site indices is know as site index curves (SIC) -> families of growth curves

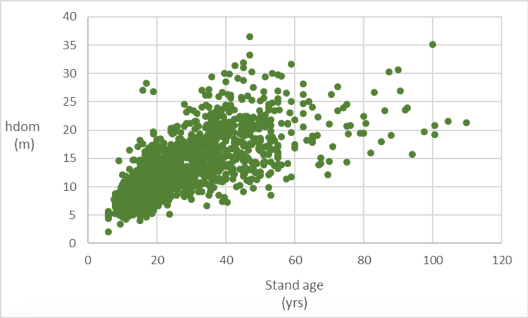
Site quality evaluation

Using Site Index [*f*= *(hdom, t)*]

- **Types of data** to build site index curves:

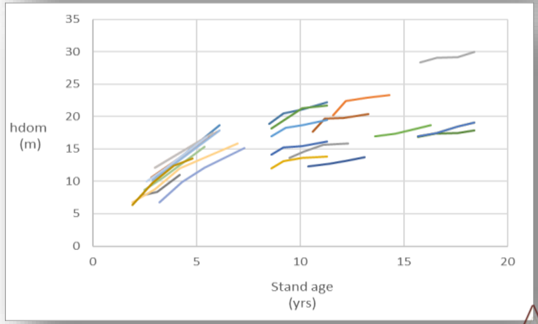
  ➔ a) **temporary plots**

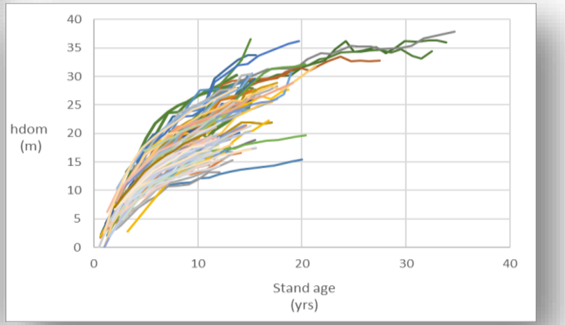
  Independent data pairs (hdom, t)



  ➔ b) **permanent and/or interval plots**

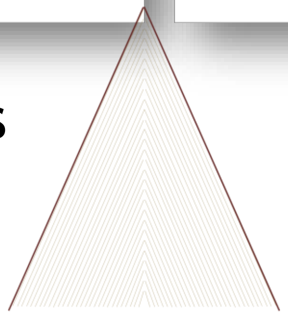
  Successive data pairs (hdom, t)





  ➔ c) **stem analysis techniques**

  Reconstruct height growth data of individual trees



Site quality evaluation

I - Using Site Index [*f*= *(hdom, t)*]

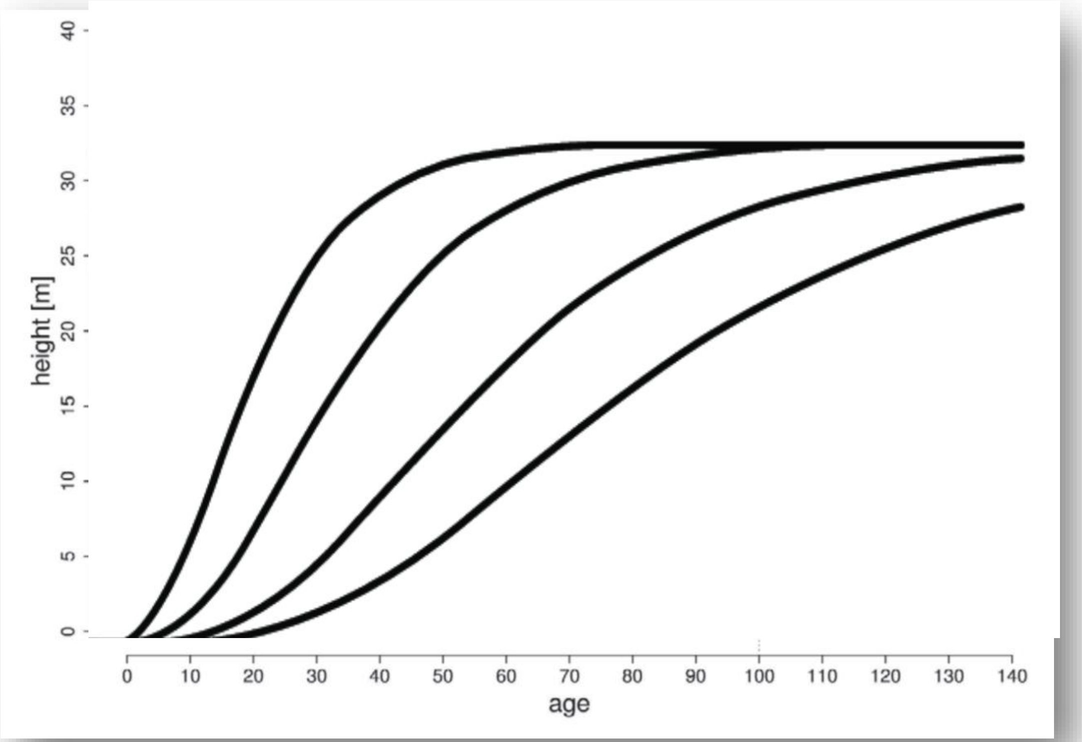
- **Types of site index curves:**

➔ According to the relationship between the curves that represent different site indices, the site index curves can be:

- **Anamorphic -** assume a common shape for all site classes.

For many species, height growth exhibits pronounced sigmoid shapes on higher-quality sites, and "flatter" shape on lower-quality sites

- **Polymorphic -** curves display different shapes for different site-index classes



Site quality evaluation

I - Using Site Index [*f= (hdom, t)*]

- **Methods for developping site index curves:**

➔ Can be grouped as follows:

- **Guide-curve method** *(chap 7.4)*

$$hdom = S\, e^{-14.2234\,(1/t\,-\,1/40)}$$

- **Parameter prediction method** *(chap 7.5)*

$$hdom = S\,\frac{1 - e^{(b_0\,S\,t)^{b_1}}}{1 - e^{(b_0\,S\,t_b)^{b_1}}}$$

- **Difference equations** *(chap7.8.1)*

$$hdom = A\left(\frac{S}{A}\right)^{\left(\frac{t_b}{t}\right)^{m}}$$

Or by a combination of methods

Site quality evaluation

I - Using Site Index [*f*= *(hdom, t)*]

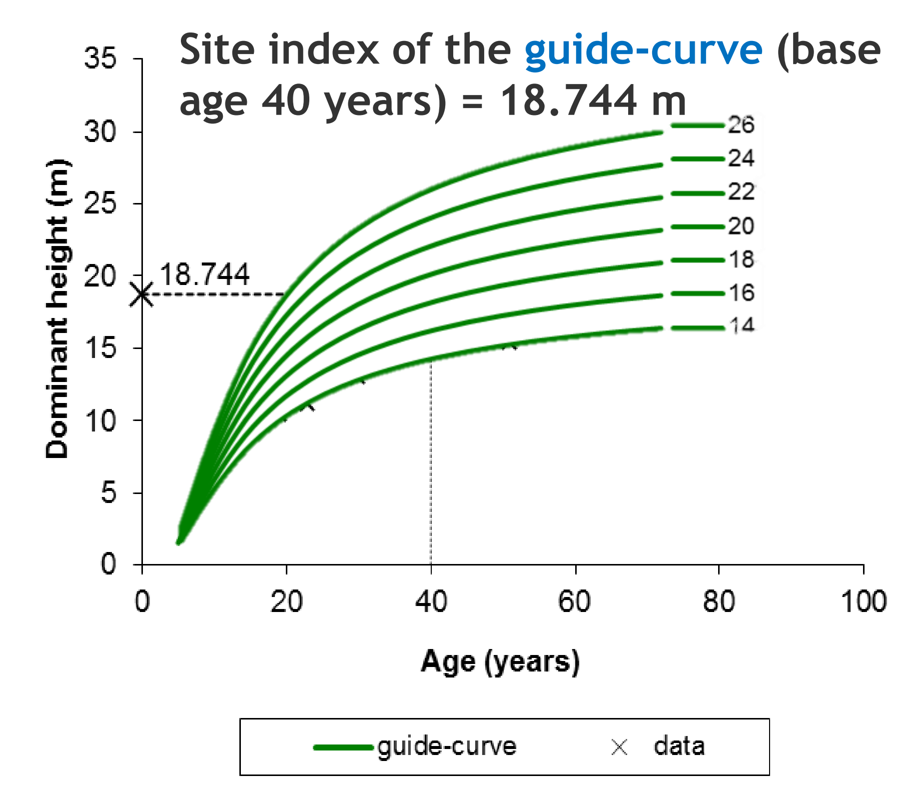
- **Methods for developping site index curves:**

→ Can be grouped as follows:

- **Guide-curve method** *(chap 7.4)*
  - adaptation of the graphical methods to the regression analysis techniques
  - based on fitting the selected growth curve (guide-curve) to the whole data set (of temporary plots)
  - The curve for any site index S is located at a distance from the guide-curve proportional to the distance between S and the site index of the guide-curve (**anamorphic curves**)

$$hdom = S\ e^{-14.2234\left(\frac{1}{t}-\frac{1}{40}\right)}$$

$$hdom = e^{3.2865}\ e^{-14.2234\ \frac{1}{t}}$$



Maritime pine Guide-curve, Oliveira (1985)

Site quality evaluation

I - Using Site Index [*f*= *(hdom, t)*]

- **Methods for developping site index curves:**

→ Can be grouped as follows:

- **Parameter prediction method** *(chap 7.5)*

$$\mathrm{hdom} = A\ \mathrm{e}^{-k\left(\frac{1}{t^m}\right)} \Rightarrow \mathrm{hdom} = (\boldsymbol{a_0} + \boldsymbol{a_1 S})\ \mathrm{e}^{-k\left(\frac{1}{t^m}\right)}$$

  - can only be used when there is a set **of long term growth series** (has been essentially applied with stem analysis data)
  - equivalent to modelling a family of curves by expressing the parameters as a function of stand/site variables
  - developed with the purpose of obtaining **polymorphic** site index curves

It implies 4 stages:

- *Estimating S for each plot*
- *Fitting the growth curve to the data of each plot*
- *Establishing the relationship between the parameters obtained for each plot and the respective S*
- *Fitting the final model with some parameter(s) expressed as a function of S*

Site quality evaluation

I - Using Site Index [*f= (hdom, t)*]

- **Methods for developping site index curves:**

  → Can be grouped as follows:

  - **Difference equations & Parameter prediction method**

Example with the Lundqvist function:

$$\mathrm{hdom}_2 = (a_0 + a_1 S)\left(\frac{hdom_1}{(a_0 + a_1 S)}\right)^{\left(\frac{t_1}{t_2}\right)^m}$$

Example with the Lundqvist function:

$$\mathrm{G}_2 = (a_0 + a_1 S)\left(\frac{G_1}{(a_0 + a_1 S)}\right)^{\left(\frac{t_1}{t_2}\right)^m}$$

Parameter prediction method is a term only applied when developping site index curves, otherwise it is referred to as "expressing the parameters as a function of stand/site variables"

Site quality evaluation

I - Using Site Index [*f*= (*hdom*, *t*)]

- **Limitations of [f= (hdom, t)] site index curves:**

  - ✓ Exact stand age is often difficult to determine in field situations, and small errors can cause large changes in the site index estimate
  - ✓ Concept of site index is not suitable for uneven-aged stands
  - ✓ Site index alone may not provide a valid estimate of the growing capacity for a particular site
  - ✓ Site index may change due to environmental and climatic variations or management activities *(changing the management objective may interfere with harvest age)*
  - ✓ Site index for one species can not be translated into a usable index for a difference species on the same site

Site quality evaluation

II - Using Site Index [*f*= (*climate*, *soil*)]

- Site index estimates independent of stand variables (examples) :

1. ***Pinus pinaster*** in Portugal (Marques, 1991):

1.a) S = *f* (**topographic, edaphic, climate**) (R^2=0.544)

$$S = 10.7214 + 0.780177 \ \overline{T}_{min}(autumn) + 0.0246574 \ K + 0.00672025 \ Porosity - 0.00441198 \ Sand$$

1.b) S = *f* (**species in the understory**) (R^2=0.144)

$$S = 17.64 - 0.862 \ Chamaespartium + 0.870 \ Pteridium$$

Site quality evaluation

II - Using Site Index [*f*= (*climate*, *soil*)]

- Site index estimates independent of stand variables (examples) :

2. ***Pseudotsuga menziesii*** *in* Portugal (Fontes et al., 2003):

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2.a) $S = f$ (**region, topographic, edaphic, climate**)

$$S = 16.805 + 0.000008 \ \ Waterdeficit \ \ Rad + 4.375 \ \ North - 0.000006 \ \ (alt)^2 -$$
$$3.103 \ \ SAxMAxAm + 2.319 \ \ MinhoLitoral$$

SAxMAxAM – ecological regions in Portugal (Pina Manique e Albuquerque, 1954)
MinhoLitoral - dummy variable for region (0,1), 1 if located Minho Litoral

Site quality evaluation

II - Using Site Index [*f= (climate, soil)*]

- Site index estimates independent of stand variables (examples) :

3. ***Quercus suber*** *in* Portugal (Paulo et al., 2015):

3.a-c) $S = f$ (**topographic, edaphic**)

$$S = 26.63463 + 1.82950\ sandy - 73.91054 \frac{1}{soil\ depth} - 0.00423\ insolation$$

$$S = 33.66346 + 2.14654\ sandy - 36.36852 \frac{1}{subsoil\ depth} - 0.00653\ insolation$$

$$S = 35.98420 + 2.81039\ sandy - 0.00816\ insolation$$

Soil depth - requires opening a soil profile and improves the quality of the model substantially
Insolation - the amount of solar radiation reaching a given area

Site quality evaluation

II - Using Site Index [*f*= *(climate, soil)*]

- Site index estimates independent of stand variables (examples) :

4. ***Eucalyptus globulus*** *in* Portugal (Nguyen, 2021):

4.a *S* = *f* (**topographic, edaphic, climatic**)

$$S = 18.693 + 0.017\,\mathbf{ET} - 1.488\,\mathbf{Litos} - 1.535\,\mathbf{Luvis} + 0.078\,\mathbf{Hum} - 0.097\,\mathbf{Rad} - 0.002\,\mathbf{Alt}$$

evaporation (ET)
lithosols (Litos)
luvisols (Luvis)
humidity (Hum)
radiation (Rad)
elevation (Alt)