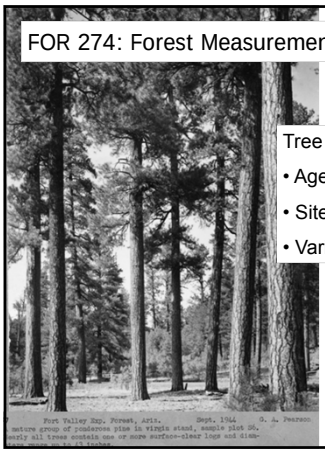
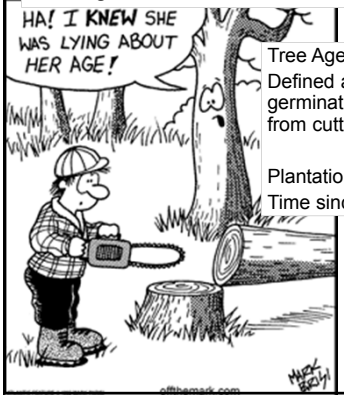
FOR 274: Forest Measurements and Inventory



Tree Age and Site Indices

- Age
- Site Indices
- Variable Radius Plots

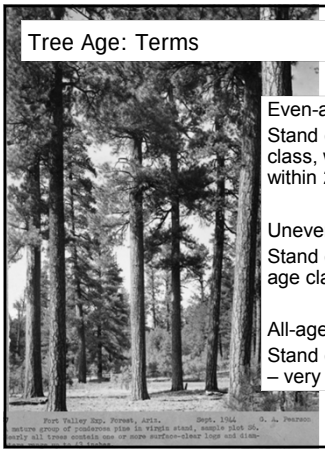
Tree Age: Introduction



Tree Age:
Defined as the time elapsed since germination (or budding of sprout from cutting)

Plantation Age:
Time since year established

Tree Age: Terms

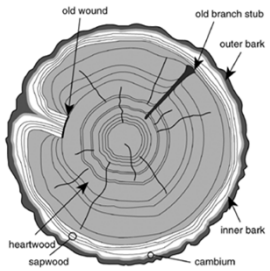


Even-aged stand:
Stand comprised of a single age class, where range of tree age is within 20% of rotation age

Uneven-aged stand:
Stand comprised of three or more age classes

All-aged stand:
Stand comprised of all age classes – very rare

Tree Age: Tree Rings



How Tree Rings Form:

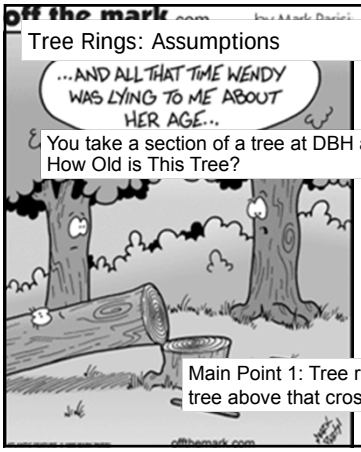
Each year, the cambium adds a new layer of wood.

Large (often light) cells are produced in the spring and small (often dark) cells are produced in the summer

The result is tree rings!

In general, one ring is produced per year

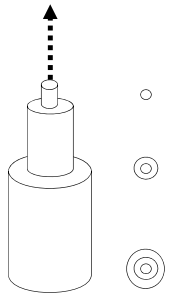
Tree Rings: Assumptions



You take a section of a tree at DBH and find it has 20 rings - How Old is This Tree?

Main Point 1: Tree ring counts gives age of tree above that cross-section

Tree Rings: Assumptions



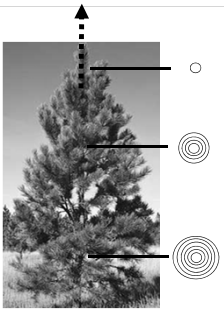
Tree Growth:

As the tree grow upwards each year a new ring is produced at points above that which the tree previously had growth.

Newest (highest) parts of the stem will have less rings than older (lowest) parts of the stem

Tree age (at DBH) = Tree Ring Count (at DBH) +
years for tree to achieve breast height

Tree Rings: Example



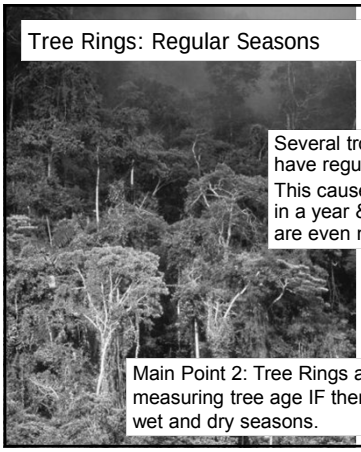
Age of this tree:

Ring at 1 year

Rings at 3 years

Rings at 8 years

Tree Rings: Regular Seasons

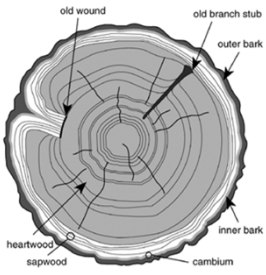


Several tropical regions do not have regular dry and wet seasons:

This causes variable rings formed in a year & sometimes no rings are even noticeable

Main Point 2: Tree Rings are ONLY useful for measuring tree age IF there are regular alternating wet and dry seasons.

Tree Rings: Common Problems



Slow-Growth Species:

Rings may be too closely packed, making it difficult to count

Incomplete/Absent Rings:

A problem in several species – for example Larch.

Tree Rings: Common Problems

False Rings:

Tree response to abnormal weather patterns or defoliation after a disturbance may cause an extra “false” ring to occur

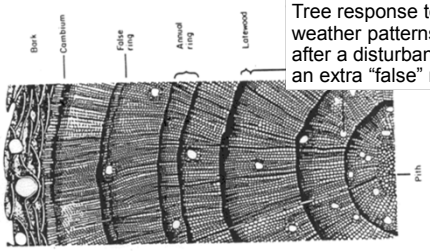


Figure 1. Cross-section of a young conifer stem showing wood structure. (From Fritts, 1979.)

Tree Rings: Common Problems

Identifying False Rings:

In false summer rings the cell walls are larger, but the cells are not – causing the “black banding look”

The “Real” Transition between spring and summer wood is sharper than is seen with False Rings

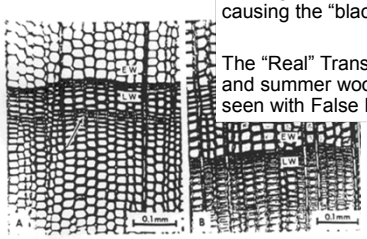
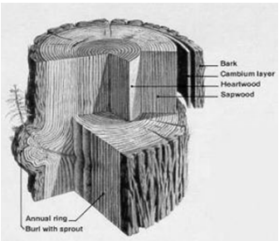


Figure 2. Annual growth rings showing earlywood (EW), latewood (LW) and false rings (arrows). (From Fritts, 1979.)

Tree Age: Measurement

Using Cookie Sections:

If a tree is felled, cookie sections can be cut and the tree age evaluated by analyzing the rings

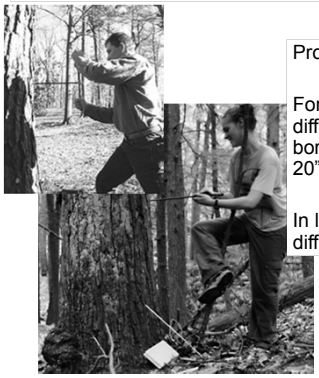


Tree Age: Measurement with Tree Cores

Using Increment Bores:

- A hollow tube with a cutting bit is screwed into the tree
- Inserting the cutting bit forces a section of the tree into the hollow tube
- The contents of the hollow tube can then be extracted and analyzed

Tree Age: Measurement with Tree Cores



Problems with Large Trees:

For trees > 32” diameter it is difficult to use an increment bore as they are typically 16-20” in size

In larger trees it is sometimes difficult to “hit the center”.

Tree Age: Measurement with Tree Cores

Repetition:

Usually one core is taken per tree at breast height

Multiple cores would enable a more accurate measurement of tree growth but would take more time

Tree Age: How Large a Core Do You Need?

Main Point 3: The length of a core taken depends on what period of tree growth you are interested in

Tree Age ➔ Full Core Length

Rate of Growth say for Past 5 or 10 Years ➔ Maybe only ½ core

Tree Core Applications: Dendrochronology

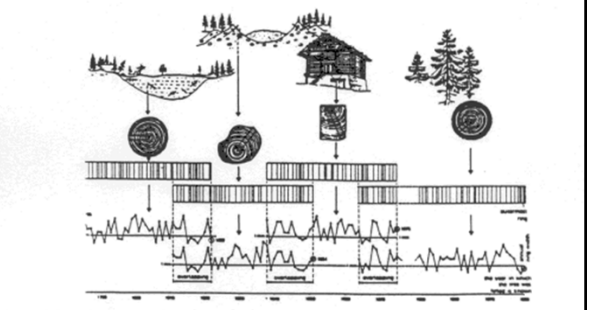
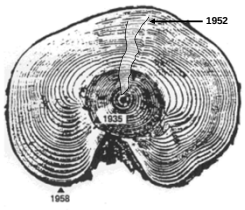


Figure 6. Cross-dating of live trees with dead or fossil trees allows the construction of long reference chronologies. (From Schweingruber 1988.)

F. Schweingruber's 1988 *Tree Rings: Basics and Applications of Dendrochronology.* D. Reidel, Dordrecht, The Netherlands, 276 pp

Tree Core Applications: Charting Disturbances

When did Disturbances Occur?



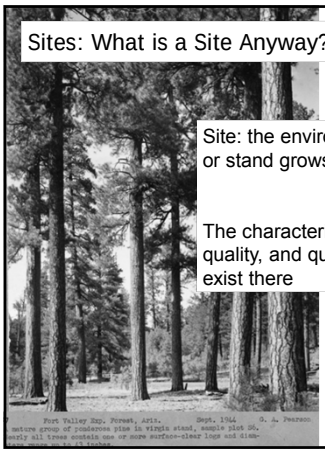
Where scars cut across un-warped rings:
Date is the latest affected date

Where the rings are warped:
Date of the disturbance is when the warping first started

Figure 7. Fire-scarred trees can give us an accurate date of past fire events. (From Schweingruber 1988.)

F. Schweingruber's 1988 *Tree Rings: Basics and Applications of Dendrochronology.* D. Reidel, Dordrecht, The Netherlands, 276 pp

Sites: What is a Site Anyway?



Site: the environment or area where a tree or stand grows

The characteristics of a site drive the type, quality, and quantity of vegetation that can exist there

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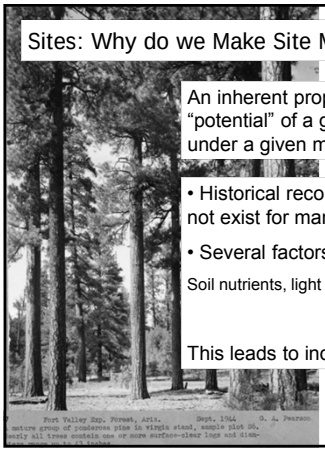
Sites: Why do we Make Site Measurements?



An inherent property used to predict the "potential" of a given site to produce products under a given management prescription

- Historical records of productivity data do not exist for many forests
- Several factors affect productivity:

Soil nutrients, light availability, topography, etc

This leads to indirect methods

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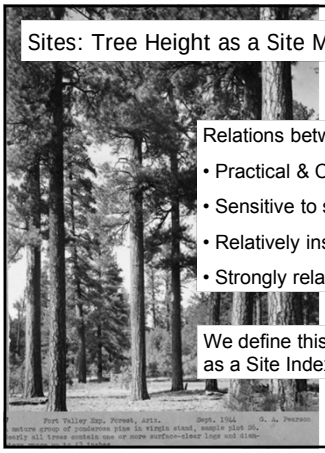
Sites: Tree Height as a Site Measurement



Relations between Tree Height and Age:

- Practical & Consistent
- Sensitive to site characteristics
- Relatively insensitive to thinning intensity
- Strongly related to volume

We define this measurement of a site as a Site Index

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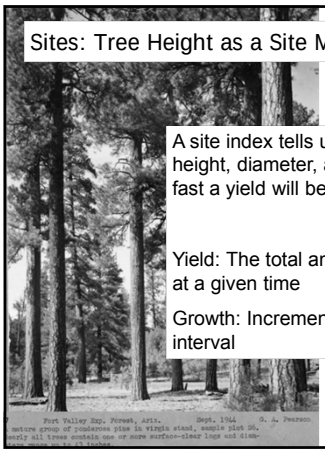
Sites: Tree Height as a Site Measurement

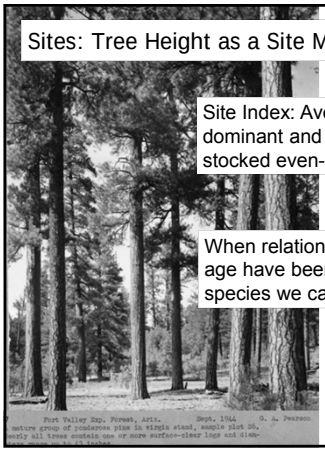


A site index tells us how fast trees grow in height, diameter, and crown widths and how fast a yield will be obtained from the site

Yield: The total amount available for harvest at a given time

Growth: Incremental increase in a unit time interval

Sites: Tree Height as a Site Measurement



Site Index: Average total height of dominant and codominant trees in well-stocked even-aged stands

When relations between tree height and age have been established for certain species we can produce predictive curves

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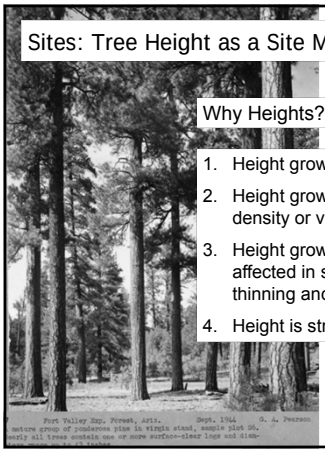
Sites: Tree Height as a Site Measurement



Why Heights?

1. Height growth is sensitive to site quality
2. Height growth is less affected by stand density or varying species compositions
3. Height growth among trees are generally affected in similar ways in response to thinning and treatments
4. Height is strongly correlated to volume

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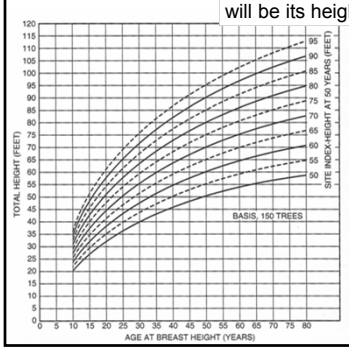
Sites: Species-Specific Height Index Curves

Q: Tree is 20 years old and 45 feet, what will be its height at 70 years?



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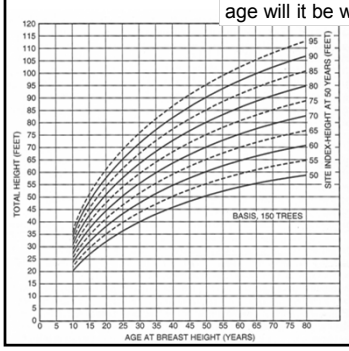
Sites: Species-Specific Height Index Curves

Q: Tree is 30 years old and 50 feet, what age will it be when its height is 75 feet?



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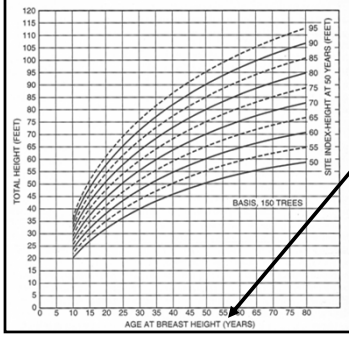
Sites: Species-Specific Height Index Curves

A Note on Age …



Age can be:

- Age at DBH
- Plantation Age
- Total Age

If total age used, remember to add the years of growth to DBH

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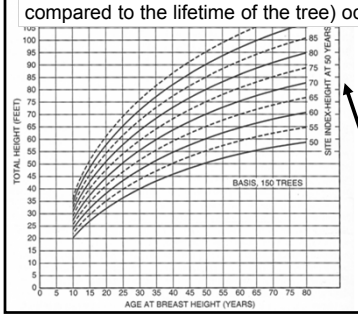
Sites: Species-Specific Height Index Curves

Standard Site Index age values:

The height of the stand at which the mean annual growth (as compared to the lifetime of the tree) occurs



Western Forests: 100 yrs

Eastern Forests: 50 yrs

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Sites: Other Index Curves

A Soil Depth and Elevation Site Index:

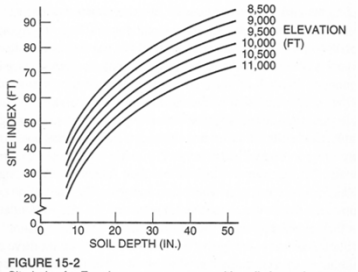

FIGURE 15-2
Site index for Engelmann spruce on granitic soils in northern Colorado and southern Wyoming in relation to soil depth and elevation. *(From Sprackling, 1973.)*

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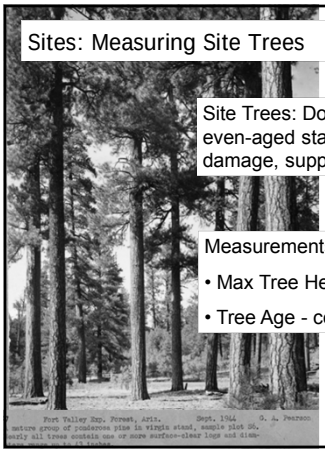
Sites: Measuring Site Trees



Site Trees: Dominant or Co-dominant in even-aged stands with no evidence of damage, suppression, forking, or deformity

Measurements:

- Max Tree Height – clino/hypsometer
- Tree Age - corer

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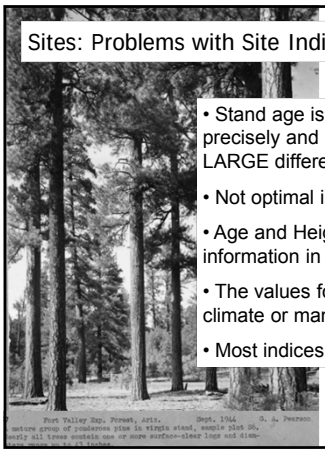
Sites: Problems with Site Indices



- Stand age is difficult to measure precisely and small errors can lead to very LARGE differences
- Not optimal in non even-aged stands
- Age and Height may not provide enough information in some sites
- The values for a site can change due to climate or management activities
- Most indices are species specific

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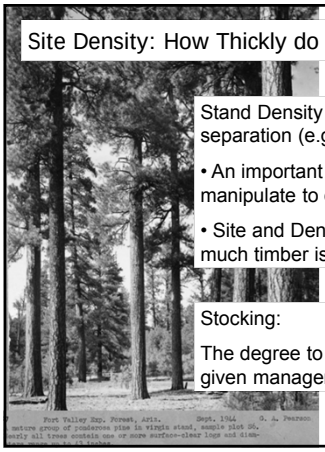
Site Density: How Thickly do Trees Grow?



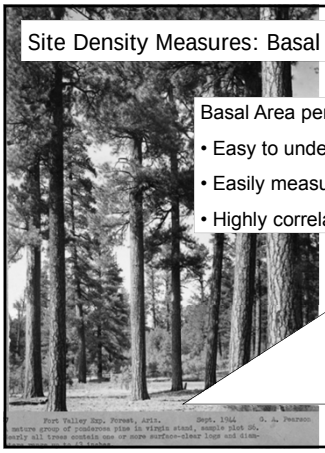
Stand Density - stem spacing and separation (e.g., stems per acre)

- An important variable that foresters manipulate to develop a stand
- Site and Density together define how much timber is expected to be produced

Stocking:

The degree to which a stand meets a given management objective

Site Density Measures: Basal Area per Acre



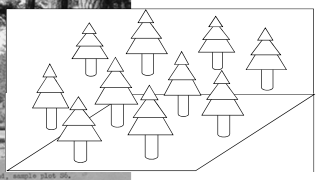
Basal Area per Acre:

- Easy to understand
- Easily measured from point sampling
- Highly correlated with volume and growth

Site Density Measures: Trees per Acre

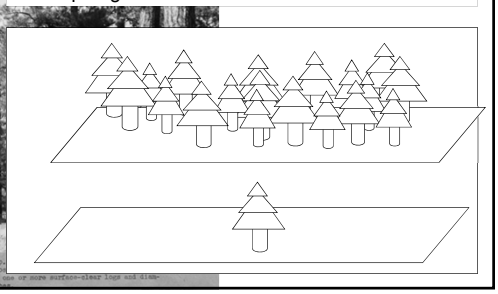
Trees per Acre:

- Plantation measure
- Limited value in natural stands



Site Density Measures: Crown Competition Factor

Area available to the average tree in a stand as compared to the maximum area it would use if it were open grown



Site Density Measures: Crown Competition Factor

The CCF can be calculated by:

A = stand area,
n_i = number of trees in i^{th} dbh class (from stand table), and
dbh_i = median of i^{th} dbh class.

Site Density Measures: CCF Example

The following data was collected from 5 1/10 acre plots (a=0.5)

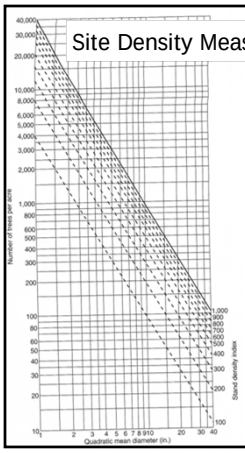
dbh	n_i	$dbh_i * n_i$	$dbh^2 n_i$
4	50	200	800
5	45	225	1125
6	43	258	1548
7	20	140	980
8	17	136	1088
9	11	99	891
10	5	50	500
Total	**191**	**1108**	**6932**

Site Density Measures: The Stand Density Index

Stand Density Index (SDI):
- Developed by Reineke in 1933
- Uses diameter, D_q, of tree with the average BA (quadratic mean diameter) and number of trees per unit area (N)
- For each species different fully stocked even-aged stands with the same D_q have ~ maximum N

To calculate D_q:
- For each DBH calculate basal area
- Calculate mean basal area
- Re-calculate what DBH would give that mean basal area

Site Density Measures: The Stand Density Index



Stand Density Index (SDI):
- Constant slope
- Intercept varies with species

$\log N = -1.605 \log D_q + k$

N = number of trees per acre

D_q = Quad Mean Diameter

k = species constant

Via Mathematical Gymnastics!!!

$$SDI = N(D_q/10)^{1.065}$$

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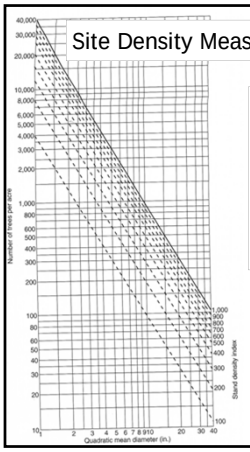
Site Density Measures: The Stand Density Index



Use:

Parallel Lines - Equal Stand Density

Convert number of trees at any quadratic mean diameter, D_q, to the equivalent density at a D_q = 10”

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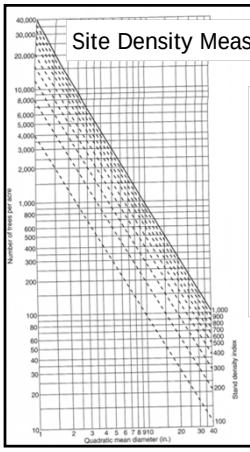
Site Density Measures: The Stand Density Index



Maximum SDI by Species in natural stands:

Redwood = 1000

Douglas Fir = 595

Longleaf Pine = 400

Stocking = SDI Actual / SDI Maximum

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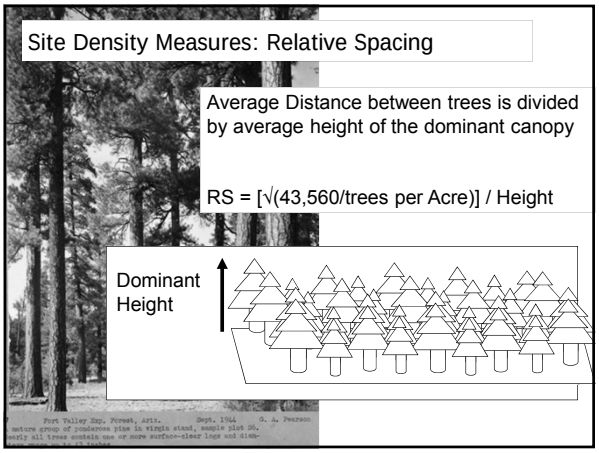
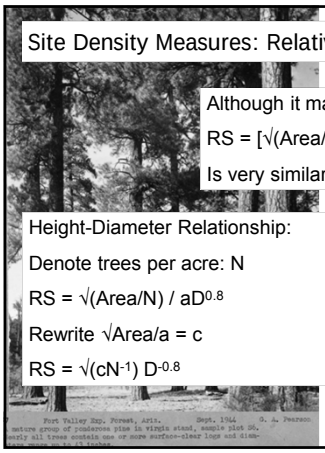
Site Density Measures: Relative Spacing



Average Distance between trees is divided by average height of the dominant canopy

RS = [√(43,560/trees per Acre)] / Height

Site Density Measures: Relative Spacing



Although it may not look like it, but

RS = [√(Area/trees per Acre)] / H

Is very similar to SDI.

Height-Diameter Relationship: $H=aD^{0.8}$

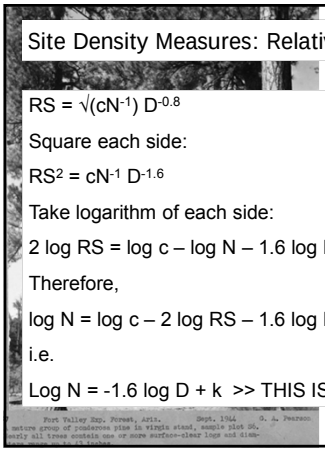
Denote trees per acre: N

$RS = \sqrt{(Area/N)} / aD^{0.8}$

Rewrite √Area/a = c

$RS = \sqrt{(cN^{-1})}\ D^{-0.8}$

Site Density Measures: Relative Spacing



$RS = \sqrt{(cN^{-1})}\ D^{-0.8}$

Square each side:

$RS^2 = cN^{-1}\ D^{-1.6}$

Take logarithm of each side:

$2 \log RS = \log c - \log N - 1.6 \log D$

Therefore,

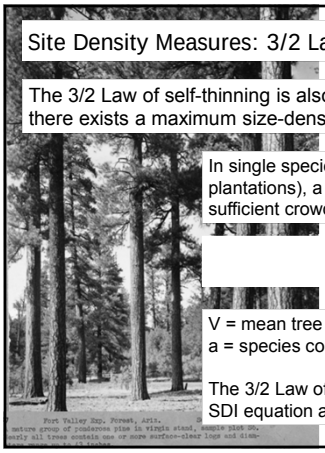
$\log N = \log c - 2 \log RS - 1.6 \log D$

i.e.

$\log N = -1.6 \log D + k$ >> THIS IS THE SDI EQUATION !!!

Site Density Measures: 3/2 Law of Self-Thinning

The 3/2 Law of self-thinning is also based on the concept that there exists a maximum size-density relationship.



In single species and even-aged stands (e.g., plantations), a stage will be reached of sufficient crowding that self-pruning occurs

V = mean tree volume
a = species constant

The 3/2 Law of Self-Thinning is equal to the SDI equation and is widely used in ecology