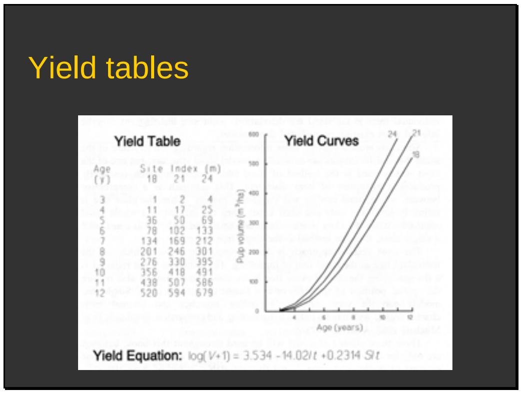
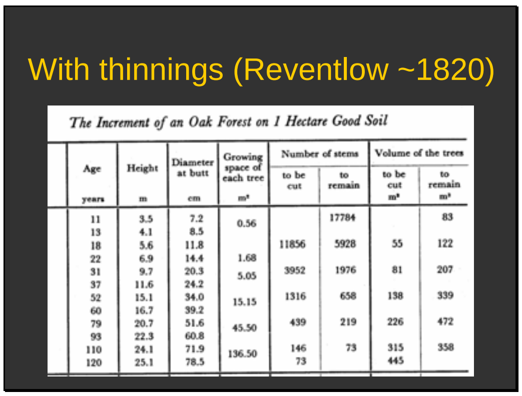


Age (y)	Site Index (m) 18	21	24
3	1	2	4
4	11	17	25
5	36	50	69
6	78	102	133
7	134	169	212
8	201	246	301
9	276	330	395
10	356	418	491
11	438	507	586
12	520	594	679

Yield over age relationship(s), for given site.

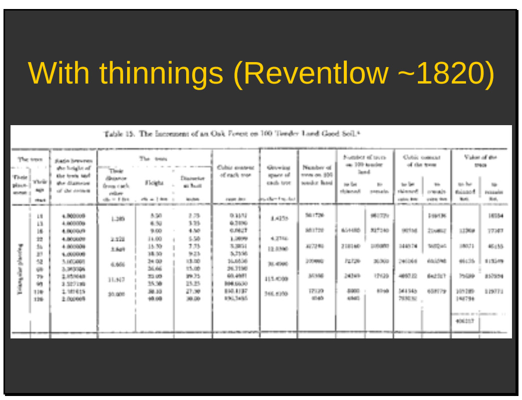


The Increment of an Oak Forest on 1 Hectare Good Soil

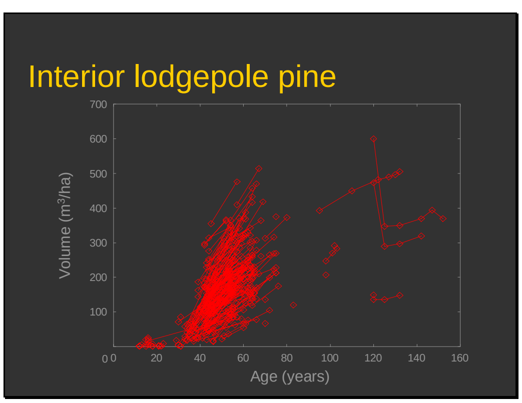
Age years	Height m	Diameter at butt cm	Growing space of each tree m²	Number of stems to be cut	Number of stems to remain	Volume of the trees to be cut m³	Volume of the trees to remain m³
11	3.5	7.2	0.56		17784		83
13	4.1	8.5					
18	5.6	11.8		11856	5928	55	122
22	6.9	14.4	1.68				
31	9.7	20.3	5.05	3952	1976	81	207
37	11.6	24.2					
52	15.1	34.0	15.15	1316	658	138	339
60	16.7	39.2					
79	20.7	51.6	45.50	439	219	226	472
93	22.3	60.8					
110	24.1	71.9	136.50	146	73	315	358
120	25.1	78.5		73		445	

Can be for managed stands; with one or a few thinning regimes.

Oak in Denmark, by C.D.F. Reventlow (1748-1827), abbreviated and converted to metric.

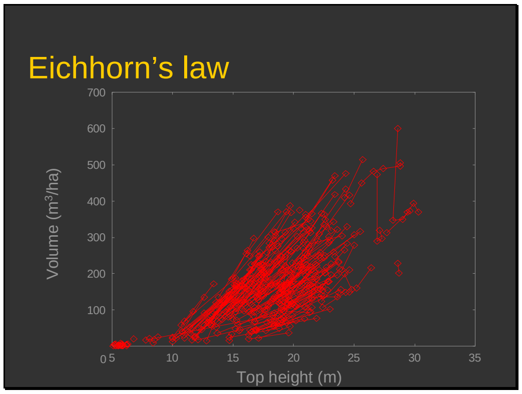


Original, including growing space calculations and monetary values.

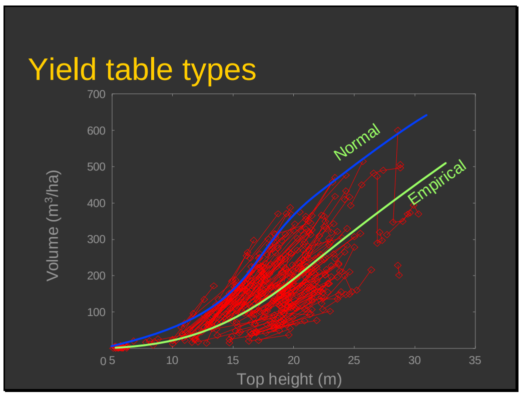


PSP data for Interior stands with lodgepole pine as leading species, utilization limit 7.5 cm. From VDYP6 overlay data file.

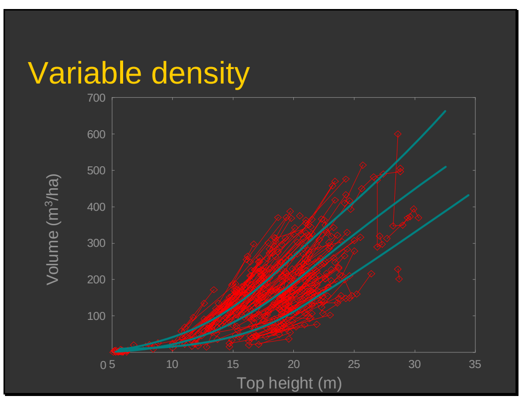
Spread due to site?



Eichhorn (1904): "volume at a given height is roughly the same in all sites". Graphing over height should reduce site effects.
Remaining variability probably due largely to different stockings (stand "density").



Well stocked: **normal** yield tables.
Average observed: **empirical** yield tables.
Various ad-hoc procedures to generate predictions for other stockings.



Yield = f(t, "density")
"Density": number of trees, basal area, crown closure, or density indices.
Usually assumed that the density measure does not change much over time.
Example: VDYP6, with % crown cover as measure of density.

VDYP

$$V = b_0 + b_1 H + b_2 H t + b_3 H^2 C + b_4 t C$$

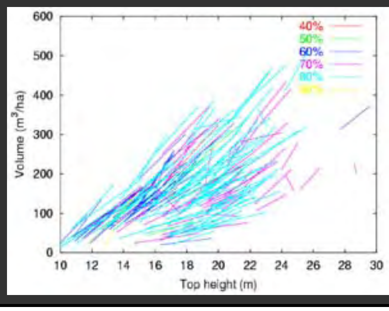
if $t > t_c$, multiply by $1 - b_5\sqrt{\frac{t - t_c}{H}}$

smooth-out the "kink" at t_c

$$D = D_0 + b_6 H + b_7 H t + b_8 H^2 C + b_9 t C$$

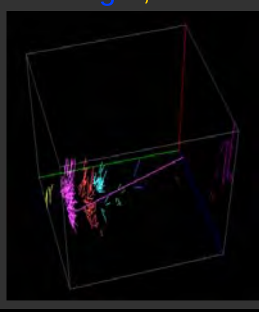
For natural stands, AAC.
Need also site index curves to estimate *H*.
Different function coefficients depending on species and Coast/Interior.
t_c = 120 years for lodgepole pine.
D_0 is the merchantable limit diameter.
Computer program includes various utilization limits, harvesting losses and decay allowances.
Being be replaced by VDYP7, a whole stand dynamical model. See: www.for.gov.bc.ca/hts/vdyp

Crown cover %



With this data, crown cover does not seem to explain much of the dispersion.

Volume *vs* Height, Cover

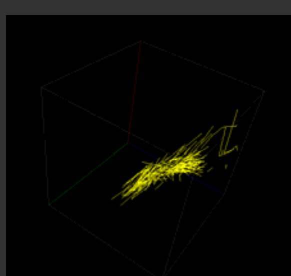


Try VRML models in the website.

3-D confirms that crown cover does not help much.

Disclaimer: this data set is of uncertain origin and quality, and may not reflect on the model's general performance.

Volume *vs* Height, Number



Number of trees would seem more helpful. But that would require also a mortality equation.

Trees per hectare, computed from the recorded basal area and mean dbh, appear mostly to increase with height. Seemingly due to ingrowth, i.e., trees that appear when reaching the lower tree size sampling limit (basal areas in the file might include only trees larger than 7.5 cm dbh).

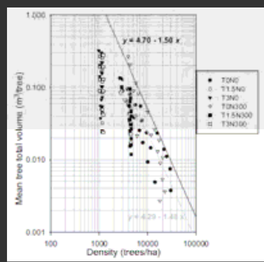
A dynamical model would predict the direction of movement from the current state, instead of whole trajectories directly.

Stand density indices

- Site occupancy, crowding
- Stocking, density
- Indices:
  - Relative spacing (Wilson, Hart-Becking): spacing / *H* I $H^{-1} N^{-0.5}$
  - Reineke (1936): $D^{1.6} N$
  - 3/2 self-thinning law: $vN^{1.5}$ I $D^2 H N^{1.5}$
  - Crown competition factor (CCF), etc.
- 1-dimensional. $D^{\alpha} H^{\beta} N^{\gamma}$! (D, H, N)

Traditionally, a number of "density indices" have been devised attempting to reduce dimensionality (e.g., Clutter et al, Chapter 3; Vanclay, p.175). Not really necessary from a system dynamics point of view.

Self-thinning



Variable density yield tables

- V = f (t, “density”)
- Simple density measures (e.g. N, B, C) vary over time → 3-D
- Find density indices that are relatively stable (for unmanaged stands)
- More flexibility and accuracy require:
  - Dynamic models
  - More than 2 dimensions

FIGURE 4.1 The title page from the first edition of *Flatland*, published in 1884, hints at the book's whimsical nature.

Abbott (1884) described a two-dimensional world, and its peculiarities and limitations.
E-book available, in various formats, from http://www.web-books.com/Classics/AuthorsAD/Abbott/Flatland/Home.htm, http://abbott.thefreelibrary.com/Flatland, http://www.gutenberg.org, etc.

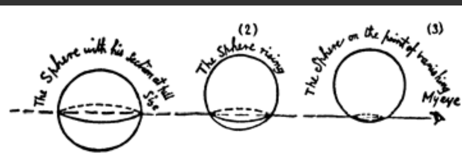
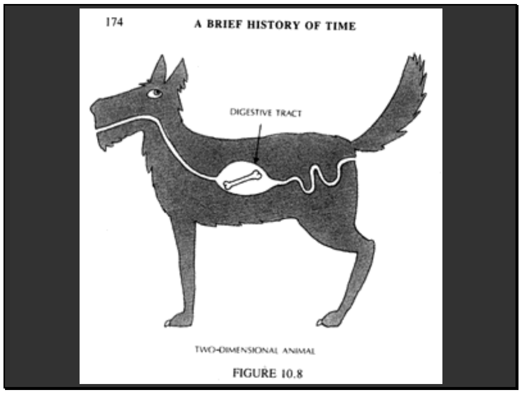


FIGURE 4.2 To a Flatlander, a Sphere passing through Flatland appears as a circle of changing diameter.

Abbott, 1884.
Sometimes, mysteries can be understood by stepping out into a higher dimension.



Some things do now work in 2-D.
Stephen Hawking, in “A Brief History of Time”, argues that life would not be possible in 2-D, among other things because a dog would fall apart ☺

Yield tables

- “Static” *vs* dynamic models
- Yield tables in BC:
  - VDYP
    - Natural stands, mean net observed yields
    - To be replaced by VDYP7, a dynamic model
  - TIPSY
    - Tables generated with TASS
    - Various initial densities, thinnings
    - To be replaced by new version of TASS
    - Healthy, well-stocked research plots
- Forest estate modelling

Yield tables still used, useful in many instances.
Forest estate models communicate with growth models through yield table files.