SCUBE SPREADSHEET HELP

1 Basic usage

1. Enter the stand site index (cell *B6*). Enter the stand composition, as percentage of spruce by basal area (cell *B8*).
2. Enter the initial state in the green cells on line 17. For now, do not touch the *Relative Closure* cell; the calculated value should be OK, provided that the stand has not been previously thinned. If you changed it, the automatic initial closure calculation can be restored by selecting the cell and clicking the [Guess] button.
3. Enter the target breast-height age on line 18.

That's it! If you want a table for a series of ages, enter the ages on column *A* (perhaps using *autofill*, see the Excel/Open/LibreOffice Help). Then click the [Grow] button.

Site index can be estimated from the top height at any given age: Click on the site index entry (cell *B6*), then click the [Guess] button and enter the age and height as prompted.

Limit your entries to the green cells, unless you know what you are doing. After any change, all values are automatically recalculated.

Rows can be removed with the usual spreadsheet mark/delete procedures. Sometimes deleting breaks the formula references, click [Guess] to fix.

2 Thinning

1. Select a cell on the row corresponding to the thinning age, and click the [Thin] button. If the selection is outside the table, the bottom row will be used.
2. The system adds a row for thinning removals, and another for the situation after thinning. Enter the residual number of trees and basal area.

If the basal area after thinning is not known, for “typical” thinnings it can be estimated from the number of trees. Select the basal area cell, and click the Guess button. Similarly, the residual number of trees can be estimated from the basal area: select the trees/ha cell and click Guess.

To undo a thinning, simply delete the two rows (removals and after-thinning): select the rows on the left margin, right-click, and choose *Delete*. You may have to click on Guess to fix broken references.

3 Some details

- The right-hand side of the spreadsheet (the “Custom outputs” area) is available for calculating costs, revenues, carbon sequestration, wildlife carrying capacity, or whatever. Normal spreadsheet procedures can be used to produce graphs, etc., or even to perform optimizations with the *Solver* add-in.
- The model is based on data from (relatively) even-aged white spruce-dominated stands in the SBS zone. Limited data was available, consisting of two distinct groups of plots: (a) Planted experimental plots, less than 25 years-old, 100% spruce. (b) Permanent sample plots in natural stands, only one of them measured before age 25, with at least 70% spruce by basal area (average 80%). No consistent trends in composition were found, and the model assumes that it does not change significantly over the prediction interval. Although biological constraints ensure reasonable interpolation and extrapolation, considerable uncertainty remains.
- Predictions are on a net stocked area basis for relatively healthy stands, and do not consider losses due to serious pests, disease, fire, or storm damage. Planning should take into account those risks separately.
- Note that when $p < 100\%$ outputs are for the spruce component only, unlike TIPSY and VDYP 7, which report totals over all species. The merchantable volume and thinning estimates are from TADAM, based on TASS simulations.
- Breast-height age is defined here as number of growth rings at breast-height. When reaching breast height the number of rings jumps from 0 to 1, so the

age at breast height is taken as 0.5 years[1]. If this confuses you, just forget it, plus or minus a fraction of a year is not going to make much difference. The model does not work reliably below breast height.

- How does this work? The condition (or *state*) of the stand at any point in time is described by 4 *state variables*: top height, trees per hectare, basal area, and "relative closure". The state in the next row is determined by the current state and the age difference (and site). The model is "age-invariant", that is, age by itself has no effect. Given an initial state, the age reference point can be arbitrary (except for estimating site index). "Outputs" like volumes, etc., depend only on the current state.
- You can add your own outputs, see the standard output formulas for examples.
- Bare-land simulations are initialized at breast height, with zero basal area and closure proportional to the number of trees.
- What are closure and occupancy? Relative closure represents the extent of the "assimilation apparatus" relative to that in a closed-canopy stand. You can think of it as foliage biomass or leaf area index, although it may include also the root system. It is an unobserved variable, not present in the data base, estimated indirectly in the model. It is initially (at breast height) a fixed small amount per tree, and increases toward 1 (or 100%) at a rate depending on the current closure and site quality. On thinning, the relative closure is reduced in proportion to the basal area removed. Closure affects growth through the *occupancy*, the amount of resources captured by the stand. Think of it as light interception, although again, it includes also water and nutrients. In the model, the relative occupancy determines the gross volume increment relative to that in a closed stand with the same values for the other state variables (more precisely, gross increment of the product of basal area and height). At low densities, occupancy is linearly related to closure, but as closure increases its effect on occupancy diminishes (it is known that light thinnings have a negligible effect on gross increment per hectare). Specifically, the assumed relationship is $1 - \text{occupancy} = (1 - \text{closure})^{2.2}$.

[1] The BC Ministry of Forests has adopted this convention starting in 2004, incorporating it into several of the site index models included in the *SiteTools* package (http://www.for.gov.bc.ca/hre/sitetool).

- Note that there are no thinnings in the data base used for model development. The thinning effect predictions are necessarily speculative, although based on ecophysiological theory and experience with other species.
- Projections going back in time are allowed, but note that in nearly closed stands the estimation of previous closure levels can be inaccurate or impossible. Combining "ungrowth" with forward closure projections is left as an exercise for spreadsheet wizards.
- See the information at `http:forestgrowth.unbc.ca/scube` for further details on data sources, methods, and caveats.

4 User-accessible functions

The following functions are available for possible use in extensions or other applications. In Excel they are listed in the Insert Function dialog under the *Scube* or *User Defined* category, depending on version. In OpenOffice or LibreOffice they are not listed, but can be entered using the syntax below.

4.1 Outputs

Dbh(N, B): Quadratic mean dbh (cm), calculated from basal area and number of trees.

Volume(H, N, B): Total volume inside bark (m^3/ha).

MerchVol(H, N. B, limit): Merchantable volume inside bark up to specified limit diameter (m^3/ha). From TADAM.

4.2 Thinning

BafterThin(H, N, B, Nafter): Estimate basal area after thinning for "typical" thinning from below. From TADAM.

NafterThin(H, N, B, Bafter): Estimate trees/ha after thinning for "typical" thinning from below. From TADAM.

4.3 Transition functions

PredH2(H1, dt, q): Predict next top height (m). Uses age difference dt, and site quality parameter q.

PredN2(H1, N1, H2): Predict next density (trees/ha).

PredR2(H1, R1, H2, p): Predict next relative closure. p is the proportion of spruce.

PredB2(H1, N1, R1, B1, H2, N2, R2, p): Predict next basal area (m^2/ha).

4.4 Other

Site_Index(A, H): Estimate site index from age and top height.

qEstimate(H, A): Site quality parameter q estimate, from top height and age.

EstR(H, N): Estimate relative closure R for an unthinned stand, from height and density.

OfromR(R): Occupancy from closure.

RfromO(Omega): Closure from occupancy.

5 Contact

Updates, news and additional information at
http://forestgrowth.unbc.ca/scube
Please direct any questions, suggestions or comments to Oscar Garcia, (250)960-5004, garcia@unbc.ca

6 Acknowledgments and legalese

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Research Branch, and by the Forest Analysis and Inventory Branch of the British Columbia Ministry of Forests and Range.

This software is Open Source (http://www.opensource.org). Essentially, you can do whatever you want with it, except preventing others to do the same. Specifically, it is released under the MIT License: