LOBDYN SPREADSHEET HELP

IMPORTANT: The top height (and site index) used by the model is about 77 cm higher than the more usual mean of dominants and codominants. Note also that for stands not 100% pure all numbers refer to the pine component.

1 Basic usage

Essentially, fill-in the green boxes, in any order.

1. Enter the stand site index (cell *B6*). Enter the stand composition, as percentage of pine 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 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 spreadsheet software Help). Then click the Grow button.

Site index can be estimated from the top height at any given age: Select 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.
- 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.
- When $p < 100\%$, outputs are for the pine component only.
- 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 in the *Custom outputs* area to the right, see the standard output formulas for examples. Additional output functions provided with this spreadsheet are listed in 4.1 below.
- 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 $1 - \text{occupancy} = (1 - \text{closure})^{2.3}$.
- 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/lobdyn` for further details on data sources, methods, and caveats.

4 User-accessible functions

The following functions are available for custom outputs or other uses. In Excel they are listed in the Insert Function dialog under the *LobDyn* or *User Defined*

category, depending on version. In OpenOffice or LibreOffice they are not listed, but can be entered using the syntax below. The arguments are: H = top height (m), N = trees/ha, R = relative closure (fraction), B = basal area (m^2/ha), D = quadratic mean dbh (cm), q = site quality parameter, p = proportion of pine.

4.1 Outputs

(Documented in http://forestgrowth.unbc.ca/lobdyn/auxiliary.pdf).

WARNINGS!

- Attempting to estimate bark from differences or percentages based on the inside bark and outside bark equations is likely to be unreliable, specially for younger stands.
- The board-foot equations do not behave sensibly for younger stands (age $<$ 10 years, or top height $<$ 7 m).

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).

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

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

MerchVolOb(H, N, B, limit): Merchantable volume outside bark up to specified limit diameter (m^3/ha).

BfInter(H, N, B): International 1/4" board-foot volume to a 6" top diameter (bf/acre).

BfDoyle(H, N, B): Doyle board-foot volume to a 6" top diameter (bf/acre).

BfScrib(H, N, B): Scribner Doyle board-foot volume to a 6" top diameter (bf/acre).

The following conversion factors may be used: 0.84 tonnes green weight per m^3 outside bark. 0.47 tonnes oven-dry wood per m^3. 0.23 tonnes of wood carbon per m^3. 0.84 tonnes of CO_2 wood sequestering per m^3.

4.2 Diameter distributions

(See http://forestgrowth.unbc.ca/lobdyn/auxiliary.pdf).

WARNINGS!

- *CVdbh* may be unreliable for young stands (age $<$ 10 years, or top height $<$ 7 m).
- Distributions based on plots can differ from those for whole stands. Use with care.

CVdbh(H, N, B): Coeeficient of variation of dbh.

MeanD(D, CV): Arithmetic mean dbh, from quadratic mean and CV

bWeibull(CV): Parameter b of Weibull distribution, from coefficient of variation.

aWeibull(Darith, b): Parameter a of Weibull distribution, from arithmetic mean dbh and parameter b.

WeibullF(x, a, b): Weibull distribution function (proportion $\leq x$), given the parameters a and b.

4.3 Thinning

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

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

4.4 Transition functions

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

PredN2(H1, N1, H2, p): Predict next density (trees/ha). p is the proportion of pine.

PredR2(H1, R1, H2, p): Predict next relative closure.

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

4.5 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.

AfromH(H, q): Age from height and site quality.

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

OfromR(R): Occupancy from closure.

RfromO(Omega): Closure from occupancy.

5 Contact

Updates, news and additional information at
http://forestgrowth.unbc.ca/lobdyn
Please direct any questions, suggestions or comments to Oscar García (garcia@unbc.ca) or Ralph Amateis (ralph@vt.edu).

6 Legalese

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