FSTY-405 — Lab 7

Distance-independent models

Name: . . . .

Objectives

Basic workings of aspatial tree-level (aka non-spatial or distance-independent individual-tree) growth models.

Answer the questions in the spaces provided, attach printouts, and hand in at the end of the lab for marks. Include your name in the title of all graphs.

Model

We use the following simple tree dbh increment equation of Martin and Ek (Vanclay, p.163), modified to use 5-year instead of yearly increments:

$$\Delta d = (1.42 d^{2/3} - 0.246 d) \mathrm{e}^{-0.0392 B} \ , \tag{1}$$

where d is tree dbh (cm), B the stand basal area (m^2/ha), and Δd is the 5-year dbh increment. Note a common convention in Forest Mensuration: lower-case for tree variables, and upper-case for variables at the stand level.

Assume a 5-year probability of mortality given by a simple *logistic*, similar to those in Chapter 9 of Vanclay's text:

$$p = 1/[1 + \exp(0.08 d \sqrt{N/B} - 6)] \ . \tag{2}$$

Here N is the number of trees per hectare. Essentially, mortality decreases with relative dbh (quadratic mean dbh is proportional to $\sqrt{B/N}$).

Use gnuplot to graph Δd and p over d (take $B = 15$ m^2/ha, $N = 800$ tph). Use a range of 0 to 80 cm for d. Label the graphs appropriately, and **attach**. Make sure you understand what all this means.

Implementation in Excel

We shall organize a spreadsheet thus:

```
 Tree    Year 0     Year 5    ···
number  d  w  bw   d  w  bw   ···
  1
  2
  3
  ⋮
 40
 /ha
```

We have 40 trees from a 0.05 ha sample plot. Time goes from left to right[1]. For each time we have the list of tree diameters, their expansion factors (weights, i.e., how many trees per hectare each tree represents), and the respective basal area per hectare (tree basal area times weight). The bottom row is for the values per hectare (mean dbh, N, B).

Initialization

Initialize the diameter list with random numbers. We want a bell-shape distribution with a mean of about 15 cm, and a coefficient of variation (CV, standard deviation as % of the mean) of some 30 - 40%, which would be typical of dbh distributions. Excel has only uniform random numbers between

[1]This is time from the start of the simulation, not age. The stand could be uneven-aged.

0 and 1, generated with the function `RAND()`. We can get roughly what we want by adding together three of these numbers. It can be shown that the CV of this sum is 33% (the variance of the uniform distribution is 1/12). The mean is $3 \times 0.5 = 1.5$, so we multiply by 10 to get each random dbh: `10*(RAND()+RAND()+RAND())`.

So that the numbers do not change with each re-calculation, generate the 40 random diameters with this formula somewhere in the spreadsheet, and use *cut* and *paste special* to copy only the values into the Year 0 `d`-column. Sort in ascending order. Calculate the arithmetic[2] mean dbh, standard deviation and coefficient of variation. Write them here: $D = \ldots\ldots\ldots$, SD $= \ldots\ldots\ldots$, CV $= \ldots\ldots\ldots$. Are these as expected?

Now the expansion factors. It is a random plot of $0.05 = 1/20$ ha, so each tree represents 20 tph. Fill the `w` column with 20. For the mortality we need the number of trees per hectare, N. Compute it at the bottom of the column.

We will also need the basal area per hectare, B. The B represented by each tree equals its basal area $b = \pi(d/200)^2$ times its expansion factor. Calculate the $b * w$, and $B = \ldots\ldots\ldots$.

Projection

The dbh for each tree at year 5 clearly equals its initial value plus the 5-year increment. The estimated increment is given by equation (1). Calculate the values (recall the use of $ for absolute row references).

The number of trees/ha represented by each tree (expansion factor) is reduced by the mortality predicted by equation (2). The new value may be calculated as the old one times the survival proportion $1 - p$. Do it.

To prepare for the next iteration, you need also the new N and B at year 5.

Repeat for years 10, …, 30. At year 30: $N = \ldots\ldots\ldots$, $B = \ldots\ldots\ldots$. If you want, you could calculate also the mean dbh, but note that, unlike

[2] Unless stated otherwise, in forestry *mean dbh* usually means the quadratic mean, $\sqrt{\sum d^2/n}$. In other words, the dbh of the tree of mean basal area.

in year 0, this time you would have to use a weighted average because the expansion factors vary.

Print your worksheet and attach.

Graphics

Graph the tree diameters over time (all together). What do you see?
. . . .
. . . .
. . . .

Calculate accumulated expansion factors (from smallest to largest diameter). Graph these over tree diameter. Note that these are the cumulative dbh distributions. Explain.
. . . .
. . . .
. . . .

Hint: Look at your increment and mortality graphs from page 2.

More

In general, aspatial models operate essentially as we have done here. Only that our equations were particularly simple, not to obscure the ideas with irrelevant detail. A few models use, in addition to the tree dbh, its height and/or crown length.

It is also common to use variables such as the basal area of largest trees (BAL). This is the sum of the basal areas of all the trees which are larger than the subject tree (note that this is a tree-level quantity, but commonly the lower-case convention is not followed). To use it, we would have needed an extra table column for each year. To see how it works, include a column with the BAL's for year 10. The BAL for the 18th tree is: . . . . m^2/ha.