2018 Mike Strub Challenge – Tree List Mortality Projection

This year's challenge is to develop a plot based individual tree model for use in projection of inventory data. Two models of this type have been proposed by Pienaar and Harrison (1988) and Cao and Baldwin (1999). Their models along with constant probability and an example model with three parameter values are described in the following table:

model	source	equation	mean fit likelihood	mean test likelihood
1	Pienaar and Harrison (1988)	S=1-k/d^2	0	0.5673
2	Cao and Baldwin (1999)	S=1-k/exp(d)	0	0
3	Mean tree survival	S=n/m	0.5102	0.5102
4	Exponential, α=1	S=1-1/exp(k*d^α)	0.5588	0.5411
5	Weibull, α=3	S=1-1/exp(k*d^α)	0.6057	0.5767
6	Weibull, α=5	S=1-1/exp(k*d^α)	0.5854	0.5803

S is the probability of survival, d is tree diameter at breast height at the beginning of the growth period and k is a parameter determined from estimated plot survival in trees per unit area. For this challenge k will be determined from the observed number of trees that survive the projection period. If m is the number of trees on the plot at the start of the growth period and n is the number of trees at the end of the growth period, k can be estimated from the following equations for models 1 and 2.

$$S_i = 1 - kf\left(d_i\right)$$

$$n = \sum_{i=1}^{m} S_i = \sum_{i=1}^{m} 1 - kf\left(d_i\right)$$

$$n = m - k\sum_{i=1}^{m} f\left(d_i\right)$$

$$k = \frac{m-n}{\sum_{i=1}^{m} f\left(d_i\right)}, k = \frac{m-n}{\sum_{i=1}^{m} \frac{1}{d_i^2}}, k = \frac{m-n}{\sum_{i=1}^{m} \frac{1}{\exp\left(d_i\right)}}$$

The k must be calculated numerically for models 4, 5 and 6. A fit and test plot are described in the following table and enumerated in the challenge spreadsheet.

plot	survival	age at the start of growth period	age at the end of growth period	n at the start of growth period	n at the end of growth period	average dbh of trees that live	average dbh of trees that die	plot size
fit	0.600	20	41	60	36	7.61	5.76	0.0988
test	0.600	15	36	60	36	6.33	5.22	0.1

A measure of the goodness of fit of each model can be based on assuming individual tree mortality over the projection period follows the Bernoulli distribution. The geometric mean survival likelihood (ML) can be calculated from:

$$\overline{L} = \exp\left\{ \frac{\sum_{i=1}^{m} \left[I_i \ln(S_i) + (1 - I_i) \ln(1 - S_i) \right]}{m} \right\}$$

S_i is the estimated survival of tree i from the equations described above. I_i is one if tree i survives and is zero if tree i dies. The first table above gives the ML for the six example models and both testing and fitting plots. The challenge spreadsheet illustrates the calculation of k and α as well as the calculation of ML. If any S_i is less than or equal to zero or greater than or equal to one then ML must be zero, hence ML for this case is not calculated in the spreadsheet in this case. Also notice that the last three models are all Weibull CDF with alpha equal 1, 3 or 5. Alpha equal to 3 is optimal for the fit plot while alpha equal to 5 is optimal for the test plot. The challenge is to find the values of alpha that maximizes ML for the fit and test plots. A tiebreaker is to find a model that has highest ML on the test plot when parameters like alpha are fit from the fit plot.

Submit model entries along with parameter estimates to strub@mcfns.com before October 28, 2018.

References:

Cao, Q. V. and V. C. Baldwin, Jr. 1999. A new algorithm for stand table projection models. For. Sci. 45(4):506-511.

Pienaar, L. V., W. M. Harrison. 1988. A stand table projection approach to yield prediction in unthinned even-aged stands. For. ScI. 34(3):804-808.