Individual Tree Mortality Equations Incorporating Shade Tolerance

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2024-05-17

Equation Fitting

We fit a survival equation (probability of survival) of a Gompit form to observations for all species found in the `tree.csv` data set provided by John Kershaw.

$$p_{live} = 1 - e^{-e^{-\beta_1 + \beta_2 \frac{dbh}{(bal+1)} + \beta_3 shade^{\beta_4}}}$$

where: dbh = diameter at breast height (cm), bal = basal area per hectare in larger trees (m^2/ha), and $shade$ is a shade tolerance measure (Niinemets and Valladares 2006).

The equation was fit using an iterative fitting algorithm over each year of the remeasurement interval separately for conifers and hardwoods. The error minimized was the trees per hectare (`tph`) prediction error at the end of the remeasurement interval.

Species

The species groups in Table 1 (`OC` = conifers, `OH` = hardwoods) were used to fit the survival equation:

Table 1: Species Group Observations Available for Survival Equation

Species Group	N
OH	227776
OC	403960

Parameter Estimates

The fit statistics and parameter estimates for the species groups in Table 1 are in Table 2.

Table 2: Survival Equation Parameter Estimates

Species	n	MSE	b1	b2	b3	b4
OC	403960	3184.62	-1.1044947	1.8234465	-0.0000446	4.2372310
OH	227776	6290.50	-0.8539104	0.2982271	0.1299373	0.8356752

Equation Peformance

The following graph shows survival probability predictions for the conifer and hardwood groups to demonstrate the effects of `bal` and `shade`. The effect of larger trees on survival decreases as trees get larger; a small tree (say 5 cm) with 50 m^2/ha `bal` has a greater chance of dying than a large tree (say 15 cm). For this example, the tree is assumed to be 10cm `dbh`.

The conifer group β_3 parameter is negative and thus not biologically reasonable. Additionally, the parameter estimate has a negligible effect on survival estimates. This argues for removing the `shade` effect from the equation for conifers.