

# Individual Tree Mortality Equations Attempting to Incorporate Shade Tolerance

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## 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.

$$p_{live} = 1 - e^{-e^{-\beta_1 + \beta_2 \frac{dbh^{\beta_3}}{(bal+1)} + \beta_4 shade} \beta_5}$$

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.

Attempts to use  $shade$  in the model produced abiologic estimates for conifers (negative  $\beta_4$ ) and estimates for hardwoods that produced virtually no differences in survival probabilities. Therefore, we dropped  $shade$  from the equation:

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

## 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	227685
OC	403206

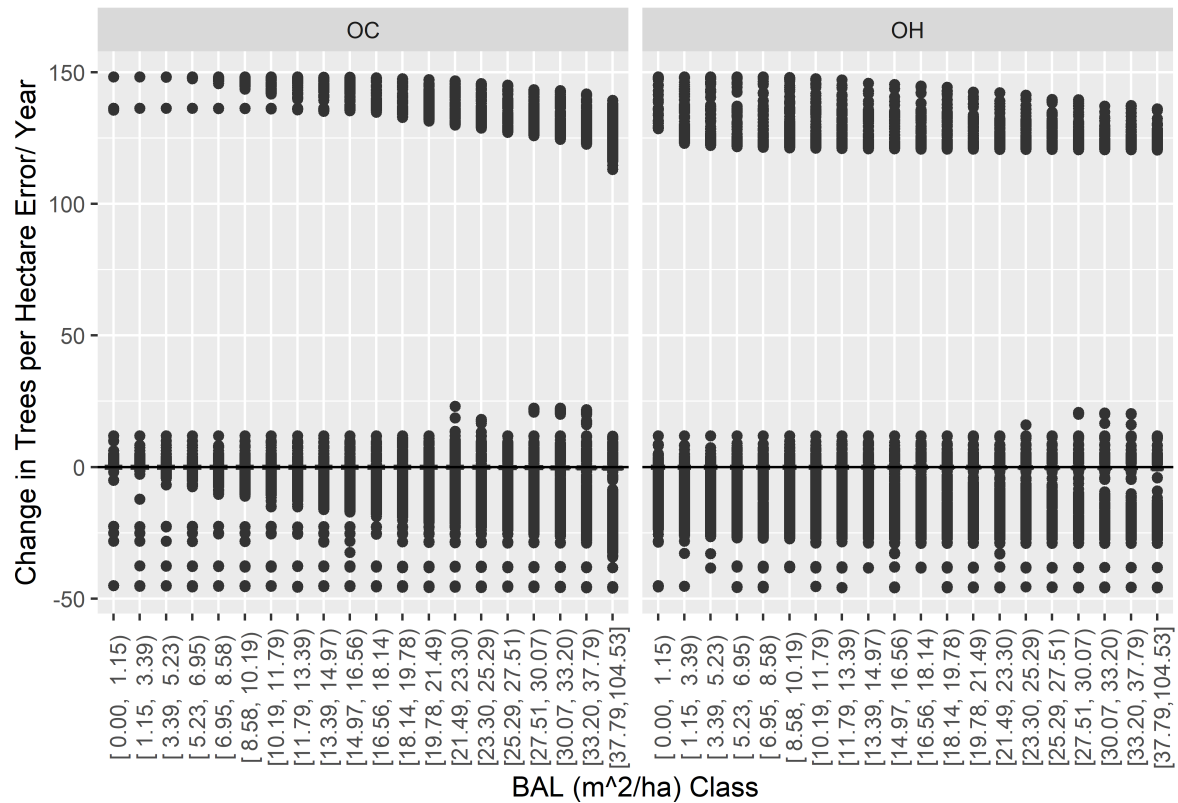
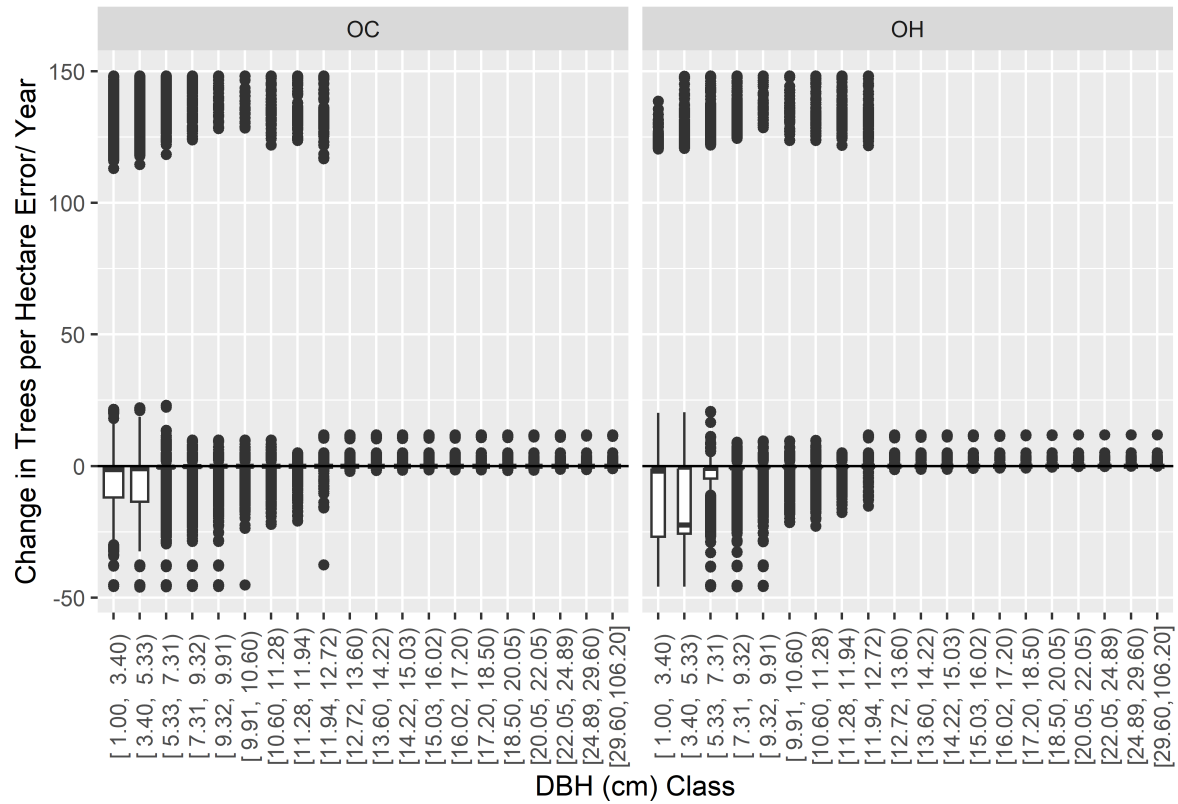
## Parameter Estimates

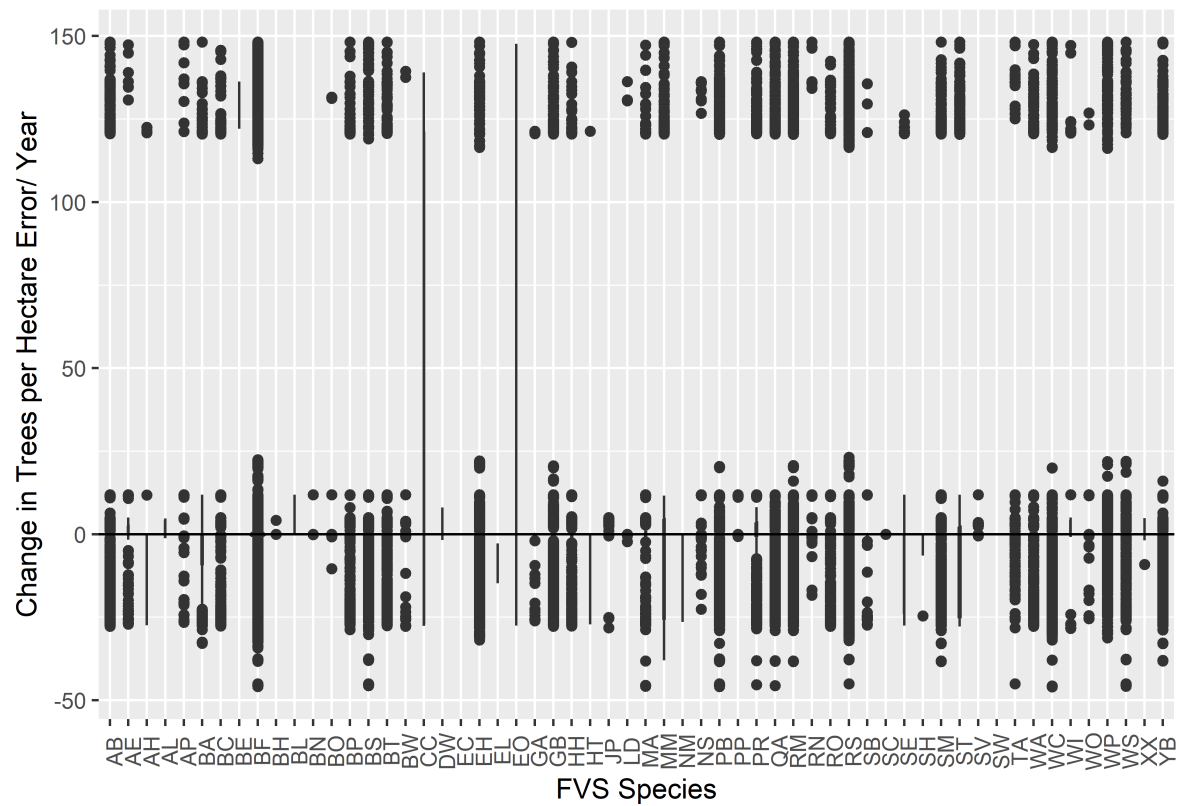
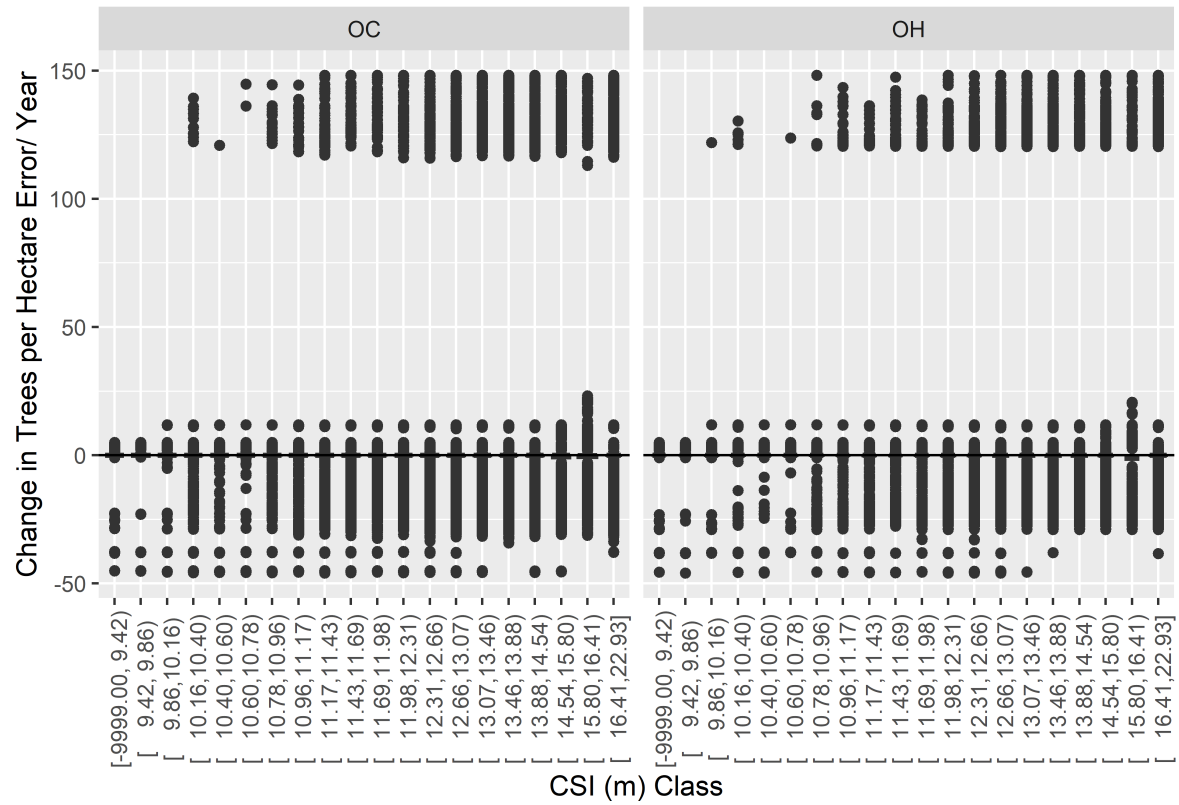
The fit statistics and parameter estimates for the species groups in Table 1 are in Table 2.

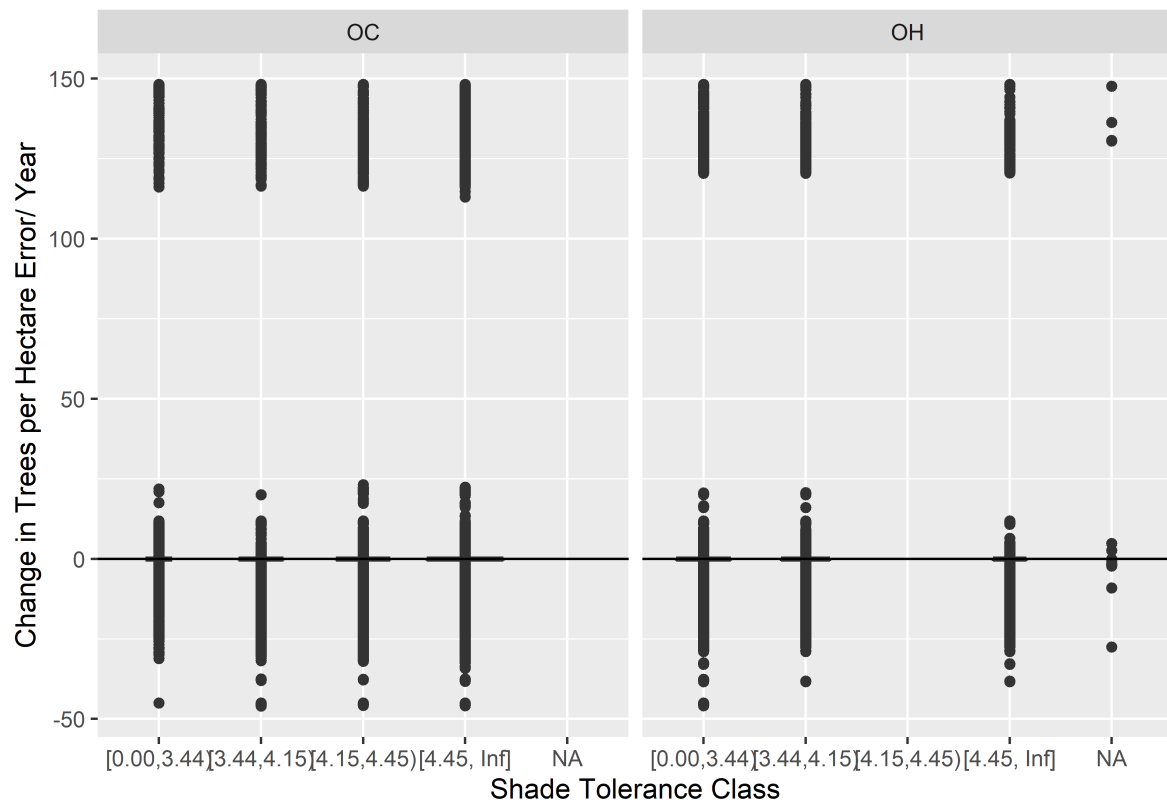
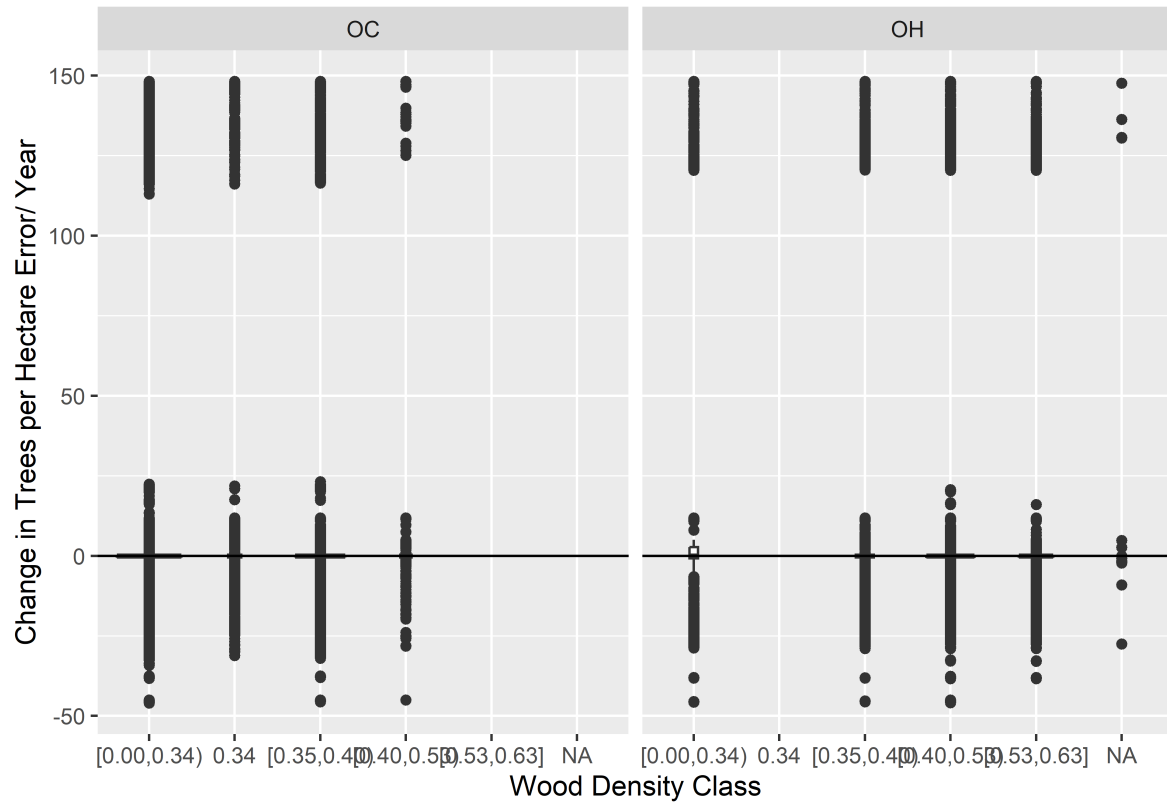
Table 2: Survival Equation Parameter Estimates

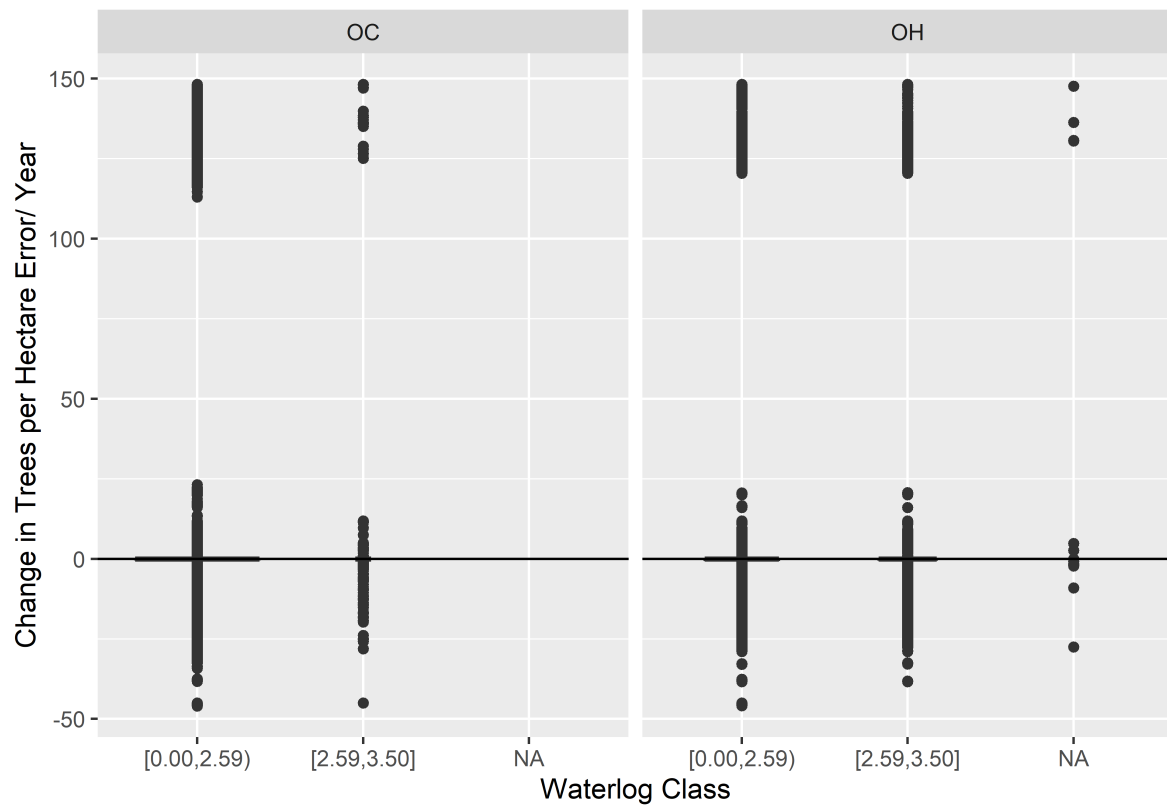
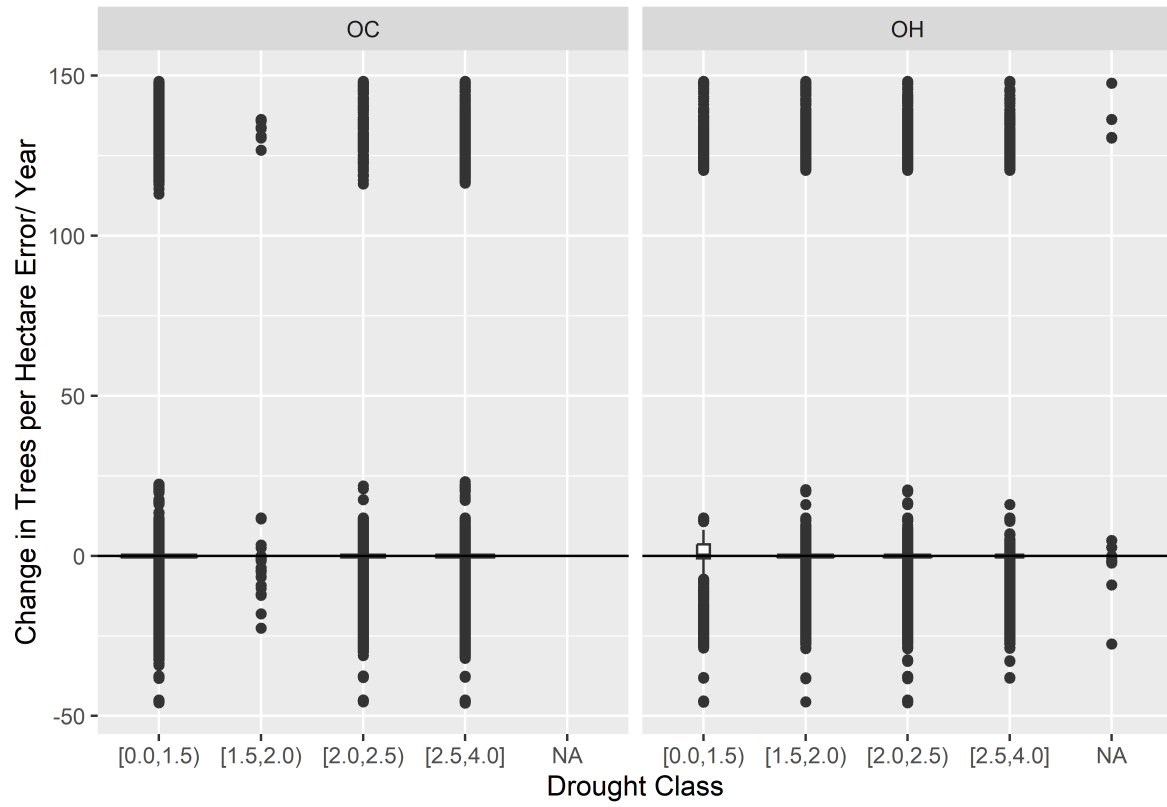
Species	n	MSE	b1	b2	b3
OC	403206	3187.22	-1.014932	3.8469604	0.6235787
OH	227685	6454.66	-1.161789	0.0127806	2.6447751

## Residual Analysis









## Equation Performance

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  $\beta_4$  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.

