5th joint Biometry workshop WGs „Ecology and Environment“, „Bayes Methods“, „Spatial Statistics“
(International Biometric Society, German Region) and WG “Biometry” (DVFFA, German Association of Forest Research Stations), 7-9 October 2015, University of Würzburg, Germany

How to quantify nutrient export: Additive Biomass functions for spruce fit with Nonlinear Seemingly Unrelated Regression

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Abstract

Quantifying nutrient removal during harvest operations is crucial to maintain long-term sustainability in forestry. To calculate the export of nutrients, which is part of the nutrient balance of forest stands, biomass functions are to be used. Since nutrient concentrations vary strongly between different compartments, biomass functions for all compartments are required. One desired characteristic of such compartment-specific biomass functions is additivity, i.e. the sum of the predicted compartment masses should equal the total biomass. The spruce dataset analysed encompasses approximately 1200 trees widely spreading in size and age, originating from five different (meta) studies spread over central Europe. The dataset comprises compartment masses for stump, coarse wood up to 7 cm in diameter (each with and without bark), branches (wood smaller 7 cm in diameter including bark) and needles. Although not strictly necessary to obtain additivity, but more efficient and resulting in lower variances, we used Nonlinear Seemingly Unrelated Regression (NSUR) to simultaneously fit the different compartment functions. Multiple imputation by chained equations (mice) has been applied upstream of model fitting, since the collected data varied in level of detail with respect to the compartments and because NSUR requires a rectangular dataset, i.e. the same number of observations for each compartment. Model results, fit with the predictors diameter at breast height (dbh) and height (h), show, that the parameters differ from the results of the complete case analysis. Secondly, the additivity trait could be attained, while not inflating the variance of the predictions. Beside the applied methods, comparisons to other functions and the application of the NSUR-system are shown.