Evaluation of Some Weibull Parameter Estimation Methods for Characterizing Stem Distribution and Site Quality in a Tropical Mixed Forest of Southern Nigeria

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Abstract: Weibull distribution is the most suitable function used in characterizing diameter distribution, especially in planted forests. However, the suitability of this function in natural forests has rarely been tested. There is also paucity of information on the most appropriate Weibull parameter estimation method(s) in natural forests in Nigeria. Similarly, assessment of site quality in natural forest has remained a challenge because of difficulty in determining tree ages. Moreover, the applicability of site form (SF) method for site quality evaluation in natural forests has not been sufficiently proven elsewhere. Therefore, this study evaluated parameter estimation methods for tree diameter characterization in a natural forest. Site quality of the different locations in Oban Forest was also assessed using the SF method. Systematic sampling technique was adopted for plot locations in the four study sites (*Aking*, *Ekang*, *Erokut* and *Ekuri*). Four transects of 2 km long at 600 m apart were laid in each of the four study sites. Five 50 m × 50 m plots were demarcated alternately along each transect at 400 m intervals. A total of 16 transects and 80 sample plots were used for the study. Tree diameters, at breast height ≥10 cm, base, middle and merchantable limit and total height (TH) were measured to compute quadratic mean diameter (D_q), stand density, stem volume (SV) and slenderness co-efficient (SC). Trees were identified and classified into genera and families. Soil samples were collected from 25 sub-plots of size 0.01ha within each of the sample plots at 0-15 and 15-30 cm depths using soil auger. The samples were air-dried and a composite soil sample was then formed per plot and analyzed using standard laboratory procedures. Data were statistically analyzed using descriptive statistics, correlation and regression analyses. The fitted models were assessed using co-efficient of determination (R^2), root mean square error (RMSE), ANOVA and t-test. Moment, percentile, hybrid and maximum likelihood Weibull parameter estimation methods were evaluated using negative log-likelihood (mLogL) statistic. A total of 131 tree species distributed among 113 genera and 41 families were identified. *Strombosia postulata* had the highest relative density (RD) of 4.9%. *Andira inermis*, *Baphia obanensis*, *Drypetes gossweileri*, *Hymenodictyon pachyantha*, *Oxystigma mannii*, *Scottellia coriacea*, *Strephonema mannii*, *Zenkerella citrina* and *Ziziphus espinosa*, were sighted only in *Ekuri* site with RD of 0.06%, 0.45%, 0.11%, 0.17%, 0.06%, 0.17%, 0.17%, 0.28% and 0.17%, respectively. About 76% of the species were locally threatened, 21.4% were rare, while 2.3% were occasional with only *S. postulata* being frequent. The species richness index was 2.38. For pooled data, there were 152±9 stems/ha with a mean basal area of 24.27±11.87m^2/ha. On site basis, *Ekuri* had highest stems/ha of 173±51 while *Erokut* had the least (143±39). *Ekang* had the highest mean SV/ha of 3847.14±2.16 m^3 with a least of 2127.71±1382 m^3/ha in *Erokut*. *Ekuri* had the highest of 62 stems/ha with high SC (SC: >80). The least of 37 stems/ha with high SC were recorded in *Erokut*. About 45, 50, 50 and 43 stems/ha at *Aking*, *Ekang*, *Erokut* and *Ekuri*, respectively had moderate SC (SC: 70-80). There were 66, 52, 56 and 84 trees/ha with low SC (SC: <70) in the four sites. The SF of 23.18 m, 26.52 m, 21.70 m and 23.69 m were obtained for *Aking*, *Ekang*, *Erokut* and *Ekuri*, respectively. Tree BA, SV and SF had positive and significant correlation with most of the soil physico-chemical parameters. For instance, SV correlated with soil organic matter (r = 0.995*), calcium (r = 0.99*) and silt (r = 0.95*). The most suitable height-diameter model was logarithmic (TH = -14.759 + 11.339lnDbh) with R^2 and RMSE of 0.51 and 4.462, respectively. The most suitable SV model was polynomial (SV = -2.4585 + 0.0063Dbh + 0.0117Dbh^2) with R^2 and RMSE of 0.85 and 2.207, respectively. The percentile-based method was the best for Weibull parameters estimations. For this method, the 25^{th} and 95^{th} was the most appropriate percentile pair (with least mLogL of 53.71±6.09), with D_q as the only suitable predictor for Weibull parameters.