The knowledge of the diameter distribution structures in forestry is an important metric for an efficient management for forest resources. This study reports the fitting of empirical diameter frequency distribution in natural stands of Brutian pine in Southern Turkey. The Johnson’s $S_B$ function was used as the theoretical distribution. Two distinct methodologies were used to obtain all four parameters that define the $S_B$ distribution families: i) a parameter recovery method (4-PRM); and ii) a new approach based on full non-conditioned (that is, without restrictions) maximum likelihood estimation (FMLE). The non-conditional FMLE uses all the available observations of individual diameters of the trees, while the 4-PRM is supported by summaries of the diameter data; such as mean, median, and basal area. To the best knowledge of the authors, the full maximum likelihood approach was never attempted for the $S_B$ distribution. Adequacy of reproducing the empirical diameter distributions with both methods was analyzed and assessment for quantitative differences or similitude’s of adequacy of fitting among the two approaches was performed. Results show a good performance of both 4-parameter estimation methods. The differences in the Error Index were not statistically significant, among FMLE and 4-PRM with respect to the total basal area estimates. When the analysis was accomplished by diameter classes, statistically significant differences were registered, with the non-conditional MLE performing better than the parameter recovery approach. The selection of one method is dependent on the detail of the available data and on the objectives. The major advantage of the 4-parameter recovery procedure over the FMLE relies on the reduced level of input information required. For description of actual diameter structures, the FMLE is the preferable method allowing to better mimic the empirical distribution with less computational efforts.