

## Technical Report

# Developing fully compatible taper and volume equations for all stem components of *Eucalyptus globoides* Blakely trees in New Zealand

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## EXECUTIVE SUMMARY

**Background:** Individual-tree taper and volume equations are essential for forest management. They provide estimates of volume that are incorporated into plot-level volume equations and also into growth and yield models to estimate volumes per hectare in forest crops. Moreover, taper equations allow forest managers to estimate dimensions of logs that can be cut from stems in their forests when they have measured diameters at breast height and heights of trees in inventories. Compatible taper and volume equations have the property that the same individual tree volume can be estimated either from the tree volume equation or by integrating the taper equation. Durable eucalypt species such as *Eucalyptus globoidea* Blakely, however, have especially valuable heartwood and so managers require estimates of the volumes and shapes of heartwood zones within trees. Simple overall wood taper and volume equations would therefore be inadequate.

**Methods:** 74 *Eucalyptus globoidea* trees were destructively sampled in 8 different trial plots throughout New Zealand. Tree age was 7 to 29 years old, the DBH was 11 to 67.6 cm and the height was 7.2 to 35.4 m. All trees were felled and lengths and taper diameters outside bark were measured. To measure taper diameters of heartwood and sapwood, discs were cut at irregular intervals along the stem. The heartwood and sapwood components were identified by applying methyl orange dye and quantified using ImageJ analysis. In this study we extended compatibility so that sums of estimated volumes of separate components of stems, bark, sapwood and heartwood, would equal overall tree volume estimates. In addition, taper equations were made for outside bark, inside bark and heartwood that were compatible with their respective volume equations. Parameters of five volume equations for whole stem, whole wood, bark, sapwood, and heartwood as well as taper equations for whole stem, stem wood and heartwood were simultaneously estimated to create a fully compatible system.

**Results:** Root mean squared error (RMSE) of volume models was 0.12 m<sup>3</sup> for heartwood, 0.05 m<sup>3</sup> for sapwood, 0.15 m<sup>3</sup> for wood inside bark, 0.11 m<sup>3</sup> for bark, 0.14 m<sup>3</sup> for wood including bark. RMSE of taper models was 2.6cm for heartwood, 2.3cm for wood inside bark and 2.5cm for wood including bark.

**Conclusions:** A compatible system of multiple taper and volume equations can be fitted with minimal bias and acceptable levels of precision through simultaneous fitting of parameters. Jack-knife validation of the fitted models yielded very similar levels of precision and bias to those encountered when fitting models with the entire dataset.