Nondestructive sampling of *Eucalyptus globulus* and *E. nitens* for wood properties; II. Fibre length and coarseness

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Abstract. Within-tree variation in fibre length and coarseness was studied in fifty trees of *E. globulus* and *E. nitens* to develop a non-destructive sampling strategy. Trees, aged 5 to 9 years, were sampled across a range of sites in southern Australia. Simulated core samples were removed at six fixed heights easily accessible from the ground (0.5, 0.7, ... 1.5 m) and at eight percentage heights (0, 10, 20, ... 70%). Whole-tree values, calculated from percentage height data, were correlated with the core data to determine the optimal sampling height. Core samples were found to be reliable predictors of whole-tree fibre length, but results were variable for fibre coarseness. Simulated cores taken from the recommended sampling heights explained 87% and 71% of variation in whole-tree fibre length for *E. globulus* and *E. nitens* respectively and 54% and 45% of the variation in whole-tree fibre coarseness. Fibre length at all fixed heights showed good correlations with whole-tree values at all sites for *E. globulus*. For *E. nitens* the correlations were slightly lower and variable across sites. Results for fibre coarseness varied across sampling heights and sites for both species. The recommended sampling height for fibre length is 1.5 m for both species, whilst for fibre coarseness, the recommended sampling heights are 0.9 and 1.1 m for *E. globulus*, and 0.9 and 1.3 m for *E. nitens*. Radial orientation of cores was not important and neither fibre length nor coarseness were related to tree size or basic density. To estimate stand mean fibre length to an accuracy of ±5% would require sampling 9 whole trees or taking cores from 13 trees for *E. globulus* and 4

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whole trees or cores from 8 trees for *E. nitens*. For estimating stand mean fibre coarseness, 10 whole trees of *E. globulus* and 7 whole trees are needed for *E. nitens*. Core sampling for stand mean coarseness would require more trees: 13 to 21 for *E. globulus* and 11 to 16 trees for *E. nitens*.

**Introduction**

Fibre length and fibre coarseness are recognised as important pulp and paper properties. Fibre length influences paper strength, particularly tear, and paper machine runability (Watson and Dadswell 1961; Jackson 1988), while fibre coarseness, the mass of oven-dry material per unit length of fibre, is related to papermaking properties of pulpwood fibres. Assuming constant fibre diameter, coarser fibres generally have thicker cell walls, are stiffer and more inflexible, resist collapse during paper making and, therefore, form bulkier, more porous and rougher sheets.

Sampling of wood from tree breeding programs is usually restricted to non-destructive techniques, such as removing a 5–12 mm diameter increment core. The practical problem is that the values of wood properties obtained from the sample should be representative of the whole tree. For a sampling method to be effective and efficient, several key issues must be addressed including determining the best place to remove the core, whether this is consistent across sites and ages, how well the core sample predicts the whole-tree value, whether the direction in which the core is removed is important, how many trees should be sampled and whether trees should be stratified by size class. Breast height sampling has been the most widely used procedure, partly due to its simplicity. It has been shown to predict whole-tree values quite adequately for wood density in *E. globulus* (Raymond and MacDonald 1998), in *E. grandis* (Ferreira 1972; Barrichelo et al. 1983), in *E. nitens* (Purnell 1988) and for density, fibre length and coarseness in *E. regnans* (Raymond et al. 1998). A study by Rudman et al. (1969), however, found that breast height sampling was unrepresentative of the whole-tree density and fibre length of *E. regnans*. Breast height fibre length was also found to be unreliable in predicting whole-tree fibre length of *E. grandis* Bhat et al. (1990) and *E. globulus* Valente et al. (1992).

Developing a representative non-destructive sampling technique relies on examining the patterns of within-tree variation along the stem (longitudinal variation) for each wood and fibre property (Raymond and Muneri 2001). For fibre length, the most commonly reported pattern of longitudinal variation in eucalypts is curvilinear, with fibres increasing in length from the base of the tree to a point somewhere up the stem followed by a decline towards the top of the tree (Wilkes 1988). This pattern has been confirmed for *E. globulus* (Ridoutt and Sands 1993), *E. grandis* (Bamber et al. 1969; Bhat et al. 1990), *E. nitens* (Hudson et al. 1995 and 1996a) and *E. regnans* (Bisset and Dadswell 1949; Raymond et al. 1998). In contrast, Valente et al. (1992) and Hudson et al. (1997) found fibre length to decrease with tree height in *E. globulus*, whilst Taylor (1973) found no definite longitudinal trend in *E. grandis*. The few published studies for fibre coarseness indicate that this property declines with tree height. In a study examining 5 annual rings in a 7-year-old *E. globulus*, Hudson et al. (1997) reported a decrease in coarseness with tree height, but coarseness increased at 50 or 60% height level before declining again to the tree top. In *E. grandis*, coarseness showed a steady decline with tree height (Muner and Balodis 1997). In *E. regnans*, coarseness was relatively stable between 15 and 70% tree height but