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A self-organising model of Macadamia with application to pruning in orchards

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Highlights: A self-organising model of a macadamia that responds to pruning was created using the L-system-based language Lpfg. QuasiMC was used to determine light distribution within the canopy and reaching the orchard floor. Macadamia is an evergreen sub-tropical tree in the family *Proteaceae* and presents modelling challenges because of the abundance of leaves and multiple axillary buds.

Keywords: Macadamia; self-organising; pruning; light distribution; high throughput computing.

The self-organising model (Palubicki et al., 2009) expressed using Lpfg (Karwowski and Prusinkiewicz, 2003) was used as the basis for a model of macadamia (*Macadamia integrifolia* Maiden & Betche) that could be used to explore canopy management options. The model was modified to include three leaves at each node and potentially multiple axial buds at each leaf. Sensing of the light environment to guide new growth was done by buds in the original implementation, but this was likely to cause difficulties during subsequent model development as macadamia are thought to have as many as five axillary buds (Bennell, 1984). Instead, leaves were added, using their midpoint to cause shadowing. The amount of light available for growth was sensed at the leaf level and used to represent vigour, which was then accumulated acropetally. Buds also sensed the light environment but only to provide demand in the subsequent redistribution phase. Tree models were initiated by reading in an initial structure digitised from a small tree and then allowed to develop for a number of years. Empirical relationships were derived from a set of 24 digitised trees after conversion to multiscale tree graphs (MTG) and analysis with the OpenAlea software library (Godin et al., 1999, Pradal et al., 2008). The ability to write MTG files was embedded within the model so that various tree statistics could be exported for each run of the model. To explore the parameter space a series of runs was completed using a high-throughput computing platform, HTCondor, (Thain et al., 2005). While this was run on a single machine, essentially in batch mode, it could be adapted to large collections of distributed computer resources. When combined with MTG generation and analysis with OpenAlea it provided a convenient way in which hundreds of simulations could be explored. We allowed the model trees to develop using self-organisation and simulated cultural practices such as hedging, topping, removal of the leader and limb removal. Using QuasiMC (Cieslak et al., 2008) we were able to assess changes in light distribution within the canopy and the light available at the orchard floor. The lessons learnt from this will be applied to other evergreen, tropical fruit and nut trees.

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