Quantitative Markers of Phase Change, and Modelling the Size and Complexity of Trees

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ABSTRACT

Quantitative markers of ontogenetic phase change were sought to track the restoration of the adult state in plants of *Metrosideros excelsa* (pohutukawa) that had been rejuvenated by micropropagation (plantlets). The potential markers of leaf carbon isotope discrimination and tree architecture were examined in association with leaf morphology for plantlets, and juvenile and adult plants at a range of temperatures (32/24, 24/16 and 16/8 °C day/night). Changes in leaf morphology of plantlets and juvenile plants that were indicative of vegetative phase change were associated with a decrease in carbon isotope discrimination. Phase change, judged by these two markers, occurred most rapidly at 24/16 °C, and in plantlets faster than in juvenile plants. Adult plants showed long-term stability.

It was hypothesised that phase change could be quantified by changes in plant growth rate, expressed through canopy topological size and complexity parameters. A model of tree architecture (the Metrosideros Model) was developed that would allow tree size and 2D structural complexity to be recorded and analysed quantitatively. A further hypothesis was that juvenile plants and plantlets must attain a certain size and/or structural complexity before passing to the adult state and this was evaluated using the Metrosideros Model. Dynamics of growth and structural change were examined using both non-linear and linear analyses. The Metrosideros Model was successfully tested, confirming the hypothesis of quantitative differences between juvenile plants, plantlets and adult plants in structural complexity and branching patterns. The model was able to separate parameters of plant size from those of structural complexity. Complexity was indicative of ontogenetic state, and tracked the progress of phase change in juvenile plants and plantlets independently of temperature. Adult plant parameters of structural complexity, as $\delta^{13}C$, also remained stable at all temperatures. On the other hand, the growth rate of size parameters was not associated with phase change, but was responsive to temperature.

It was concluded that while leaf morphology, carbon isotope discrimination and crown architecture can be used to track phase change, each relates to a program of

change that might occur largely independently of others. Crown architecture was less affected by temperature than were leaf characteristics, and was, therefore, the most reliable marker of phase change of those studied.

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A_p	Partial Asymmetry
ANOVA	Analysis of variance
$\delta^{13}C$	Composition of carbon isotope ^{13}C
Δ	Carbon isotope discrimination against ^{13}C (Farquhar et al., 1989)
GLP	Growth lag period
MCON	Mean Centrifugal Order Number
PSAD	Proportional Sum of Absolute Deviations
PDB	Pee Dee belemnite
TAI	Tree Asymmetry Index
VPD	Vapour pressure difference

Plate 1 *Metrosideros excelsa* (pohutukawa), the New Zealand Christmas tree