DIVERSIFIED SPECIES TECHNICAL NOTE

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Discretised Growth Models for *Eucalyptus fastigata*: Building Blocks for Optimal Silvicultural Strategies

Summary

Optimising for silvicultural strategies through use of mathematical models is a complex task. Nonlinear functions are notoriously hard to optimise, although in some cases, where the optimisation algorithm does not require derivatives, they may still be used.

The Chapman-Richards' generalised von Bertalanffy's model, which is normally used to model growth (because of its flexibility to simulate both the first-order and second-order curves) has nonlinear parameters which are hard to identify and ultimately difficult to control in an optimisation framework. It is an empirical, continuous-time model with an allometric exponent that introduces nonlinearity to the estimated variables (Ratkowsky, 1983). These parameters then become difficult to estimate using conventional function optimisation algorithms such as the Quasi-Newton or Levenberg Marquard method. Even if it is possible to estimate the parameters using these conventional methods, it is difficult to determine a "stable", closed-form function that would have a growth of zero at age zero.

Using a different approach to the problem, discretised growth models for *Eucalyptus fastigata* were estimated as follows (Chikumbo and Stewart, 2007):

(a) Pool the data from all the experimental plots;
(b) Observe the general trend of the data from a graphical plot of stand basal area against time, and mean height against time;
(c) Fit a statistically valid Chapman-Richards' generalised von Bertalanffy's model, using genetic algorithms (which work much better in a nonlinear environment, identifying a closed form function at all times);
(d) Estimate an equivalent discrete-time dynamical model (i.e., a difference equation with linear parameters) from a time-series dataset with a fixed time interval ($t = \{0, 1, 2, 3, ...\}$) generated from the continuous-time function in (c); and
(e) Estimate parameters of the discrete-time dynamical model in (d) as a function of initial stand density, through on-line recursive identification (Ljung, 1997).

The results obtained for the stand basal area and mean height models are promising as shown in the following diagrams, and will be cross-validated with independent data to demonstrate their suitability for simulation, before being used in an optimisation framework for determining silvicultural strategies.

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Note:
This report should NOT be read in isolation to DS023 - as it is only an update to the work in progress.

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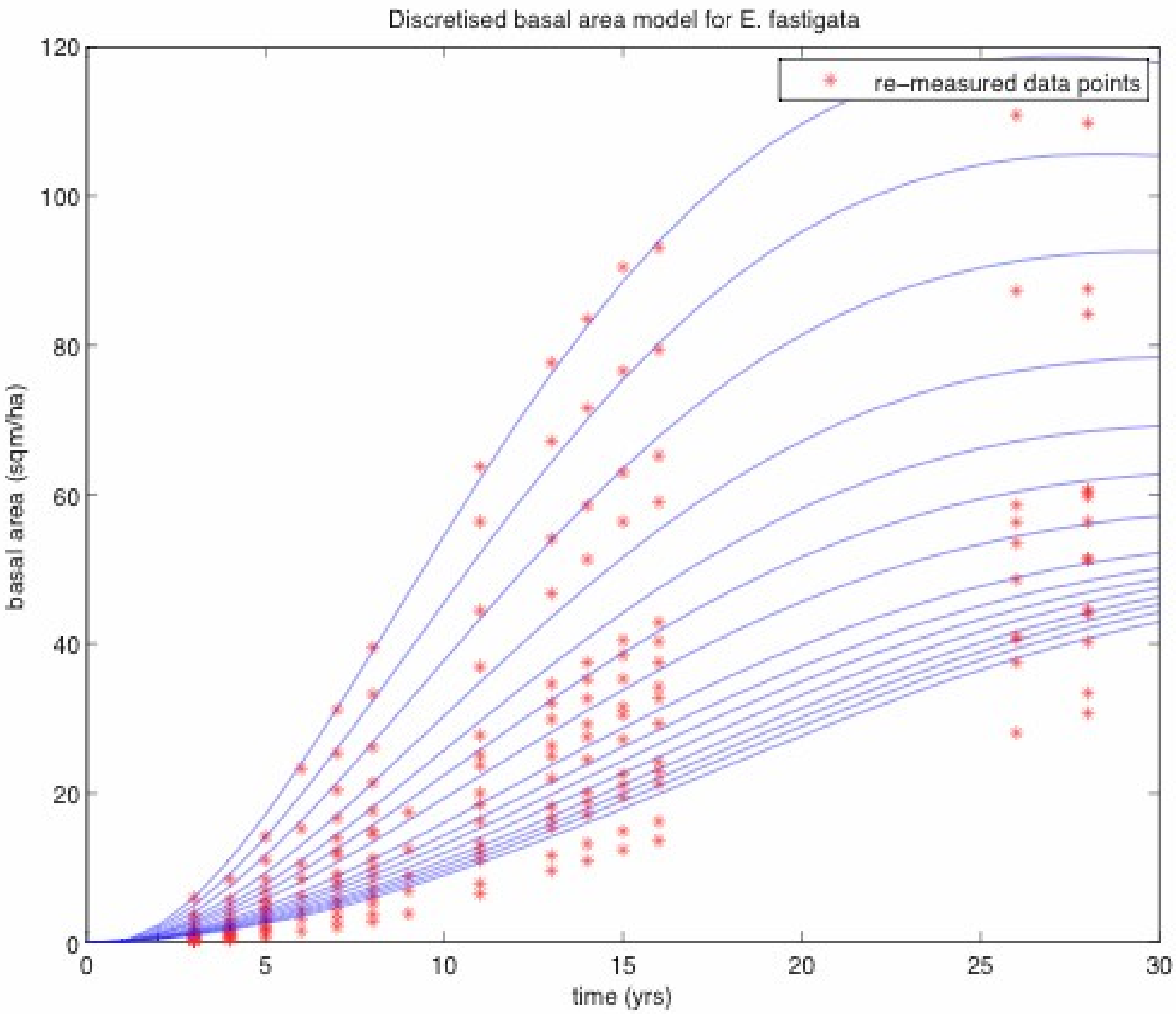
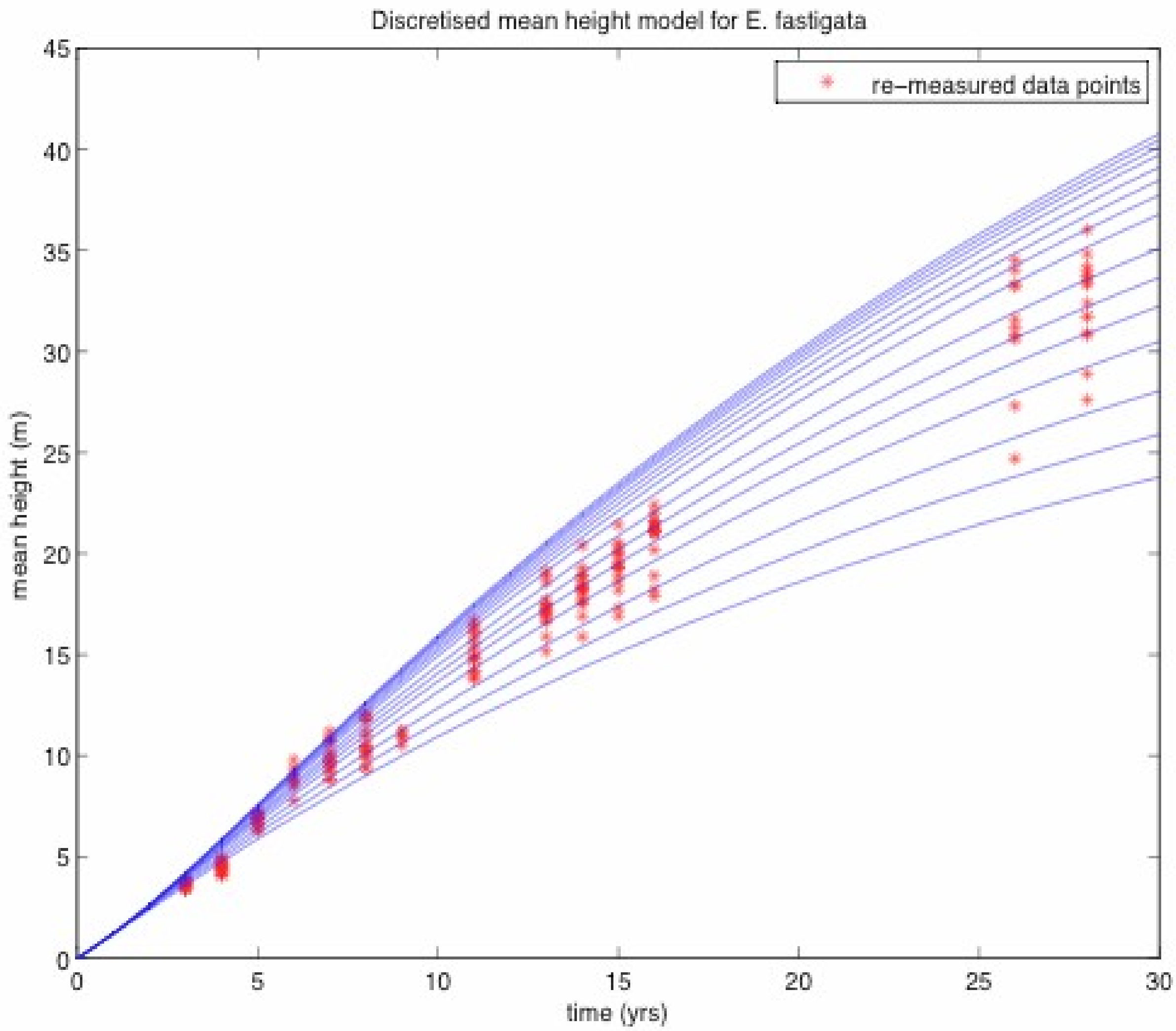

Discretised basal area model for E. fastigata
re−measured data points
basal area (sqm/ha)
time (yrs)
0
20
40
60
80
100
120
0
5
10
15
20
25
30



References

Chikumbo, O. and Steward, G. (2007), A stand basal area model for plantation grown New Zealand kauri, *Ecological Modelling* **209** (2007): 367-376.

Ljung L. (1987), *System Identification: Theory for the User*. Prentice Hall, NJ.

Ratkowsky, D.A. (1983), *Handbook of Non-Linear Regression Modelling: A Unified Practical Approach*, Marcer Dekker, Inc., New York and Basel.