Light and shade

Modelling the growth of *Tradescantia fluminensis*

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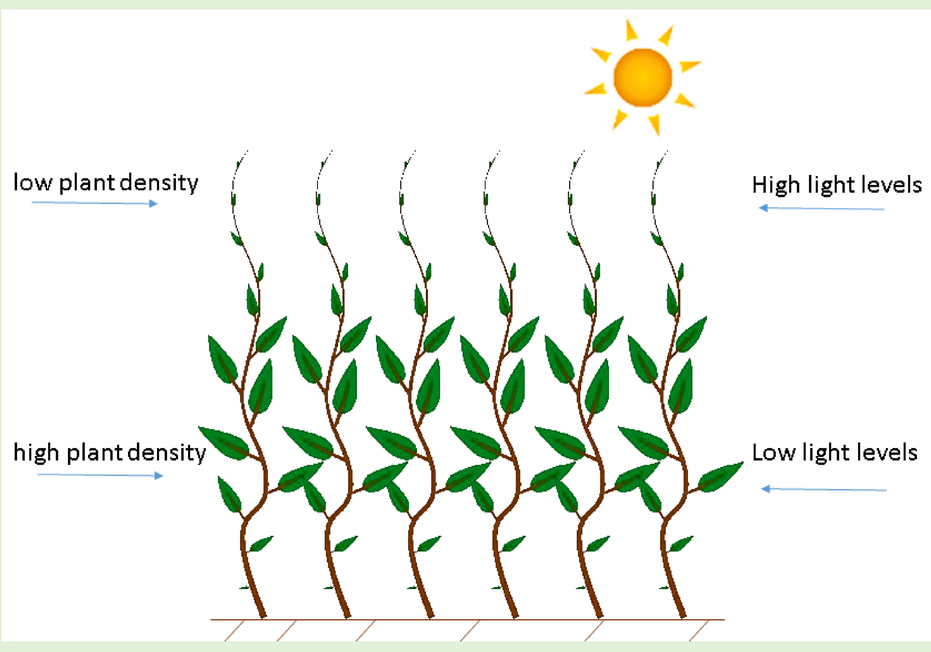
Introduction

Tradescantia fluminensis is an invasive plant species in New Zealand, Australia and parts of the United States. Its ability to form dense mats on the forest floor prevents the regeneration of native species, promoting the degradation of natural ecosystems.

An invasive *T. fluminensis* mat growing in native forest in New Zealand

We develop a model of the vertical variation in plant density and light intensity within a *T. fluminensis* mat. We parameterise the model partly using experimental data collected from individual plants. We verify that model predictions for the density and light profiles are qualitatively consistent with the data.

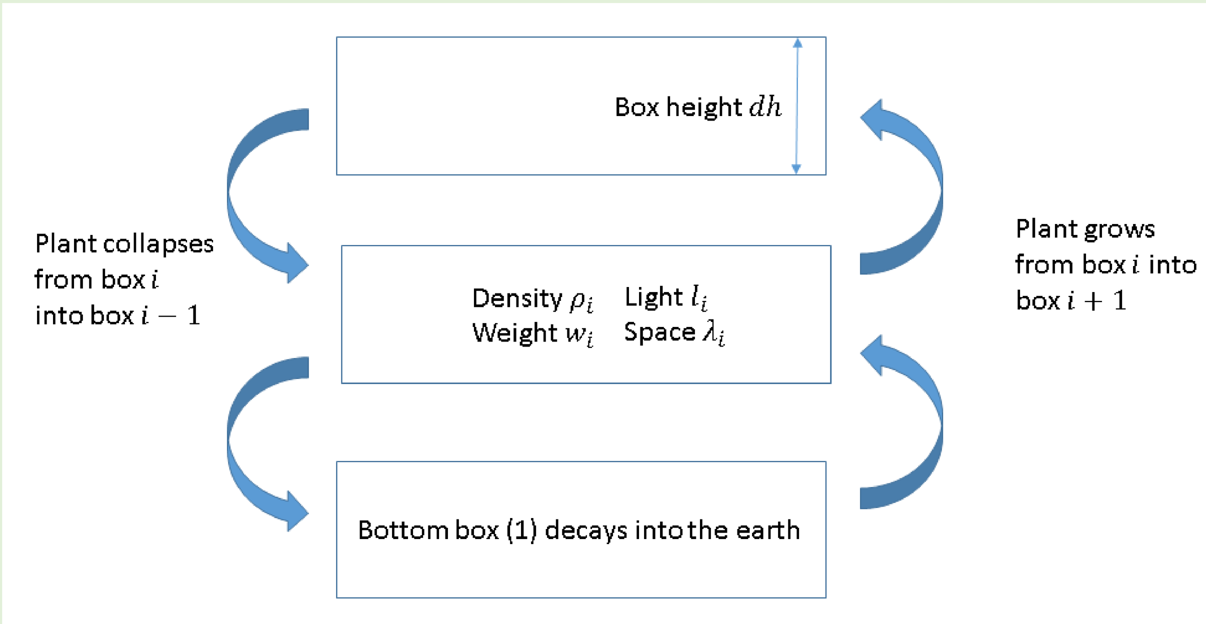


Experiment

Four *T. fluminensis* plants were grown in a glasshouse for around 9 months. After this time, the light intensity within these plants was measured at depths of 0, 10, 20, 30 and 40 cm. The dry weight of plant biomass in each of these layers was also measured.

Mathematical model

The plant is modelled as a series of vertically stacked "boxes", each of which has a different density of biomass and different light intensity:



rate of change of density = collapse from above − collapse to below + growth from below

$$\frac{d\rho_i}{dt} = \frac{\lambda_c}{\delta h}\left(\rho_{i+1} w_{i+1} f_i - \rho_i w_i f_{i-1}\right) + \frac{\lambda_g E_g}{\delta h}\rho_{i-1} L_{i-1} f_i$$

ρ_i = biomass density in box i

w_i = dry weight of plant above box i

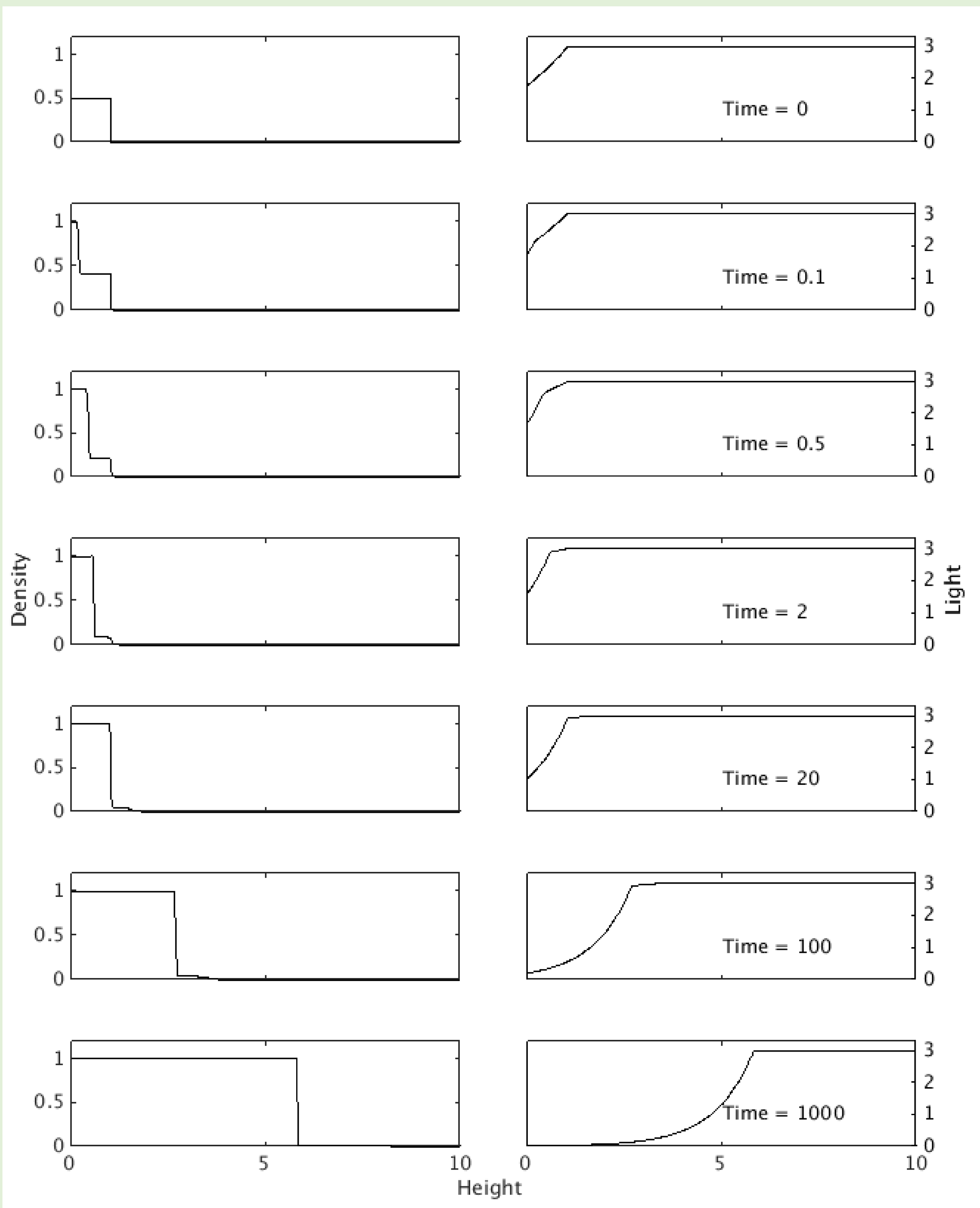
$f_i = 1 - \frac{\rho_i}{\rho_{max}}$ = available space in box i

L_i = light intensity in box i

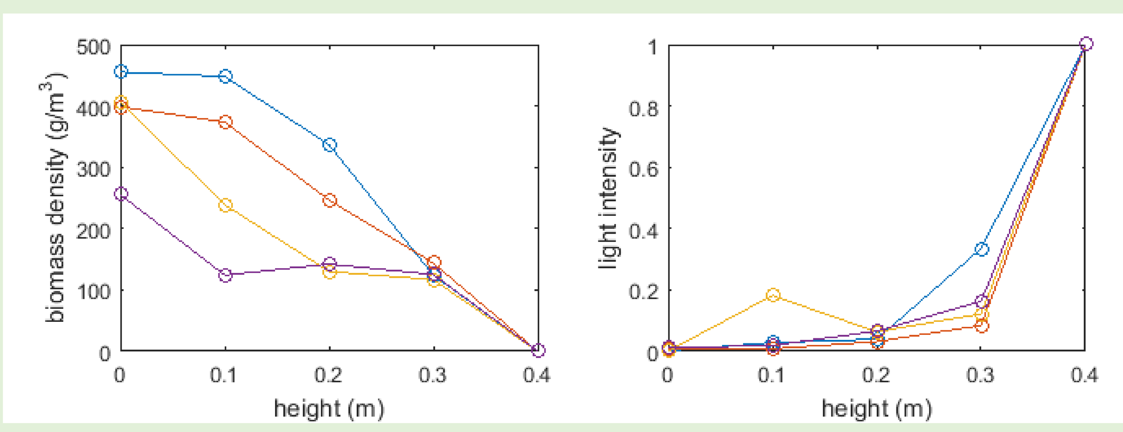
E_g = photosynthetic energy available for growth

Results

Model results

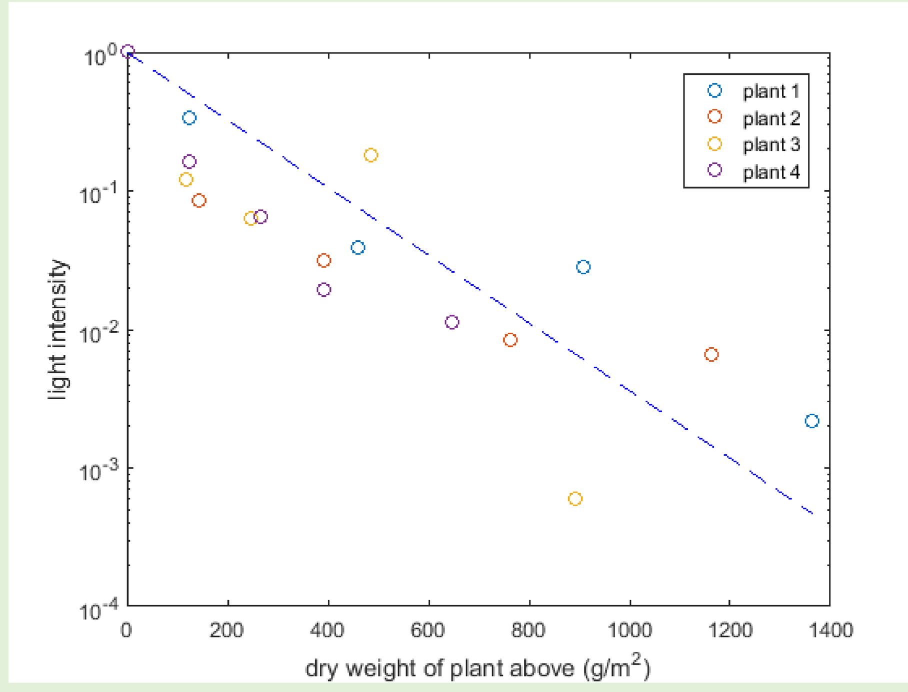


Experimental results



Light intensity data

Light intensity decreased with depth due to self-shading and had an approximately exponential decay with the total dry weight of plant above



A log-linear relationship was fitted (dashed blue line):

$$L = e^{-cw}$$

where

L = light intensity (relative to ambient)
w = dry weight of plant above
c = decay rate

A value of $c = -0.00562\ m^2/g$ was estimated from the experimental data

Conclusions

- Collapse of the plant means that the lower part of the mat quickly reaches maximal density
- The dense mat grows upwards but the plant maintains a less dense layer in the upper part of the mat
- As time goes by, the upper layers gets taller but less dense
- The mat eventually reaches steady state due to a balance between energy gained from photosynthesis and energy lost to maintenance and decay
- The light intensity profile reaches almost zero light at ground level
- Model results agree qualitatively with experimental density profiles
- The model will be used to estimate the effects of control strategies, e.g. shading, tip removal

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