Tundra Light Extinction Model

Ruby An

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Introduction

The goals of this model are to (a) explain the coexistence of multiple species in tundra plant communities, and (b) make predictions about species' dynamics in a changing climate. Our approach is to build a simple model based on the physical constraints, resource availability, and demographic processes characteristic of plant species in tundra environments. We characterize equilibrium dynamics of the model, then test how environmental change (warming, longer growing seasons, higher nutrient availability) alters competitive outcomes.

Model Description

This model tracks the density of ramets (N_i number of individual ramets of species i in a given unit area) for species $i = 1, 2, ..., Q$) in continuous time. For ease of notation, we order species from tallest to shortest ramet height ($H_1 > H_2 > \cdots > H_j > H_i > \cdots > H_Q$).

Ramets reproduce once they have

Ramet Allometry

Ramets of each species have a specific height, crown area, and biomass. These quantities are related to each other through a series of allometric equations:

$$x = 10 \tag{1}$$
$$x = 20 \tag{2}$$
$$\tag{3}$$

Ramet Carbon Economy

Ramet Demography

Ramet Time to Reproduction

Light Environment and Competition Description

The first version of this model includes only competition for light, assuming light extinction following Beer's law.

Light requrirement at equlibrium

Light requirement for establishment

EQ density with light requirement as a continous trait

Simulations

Parameters

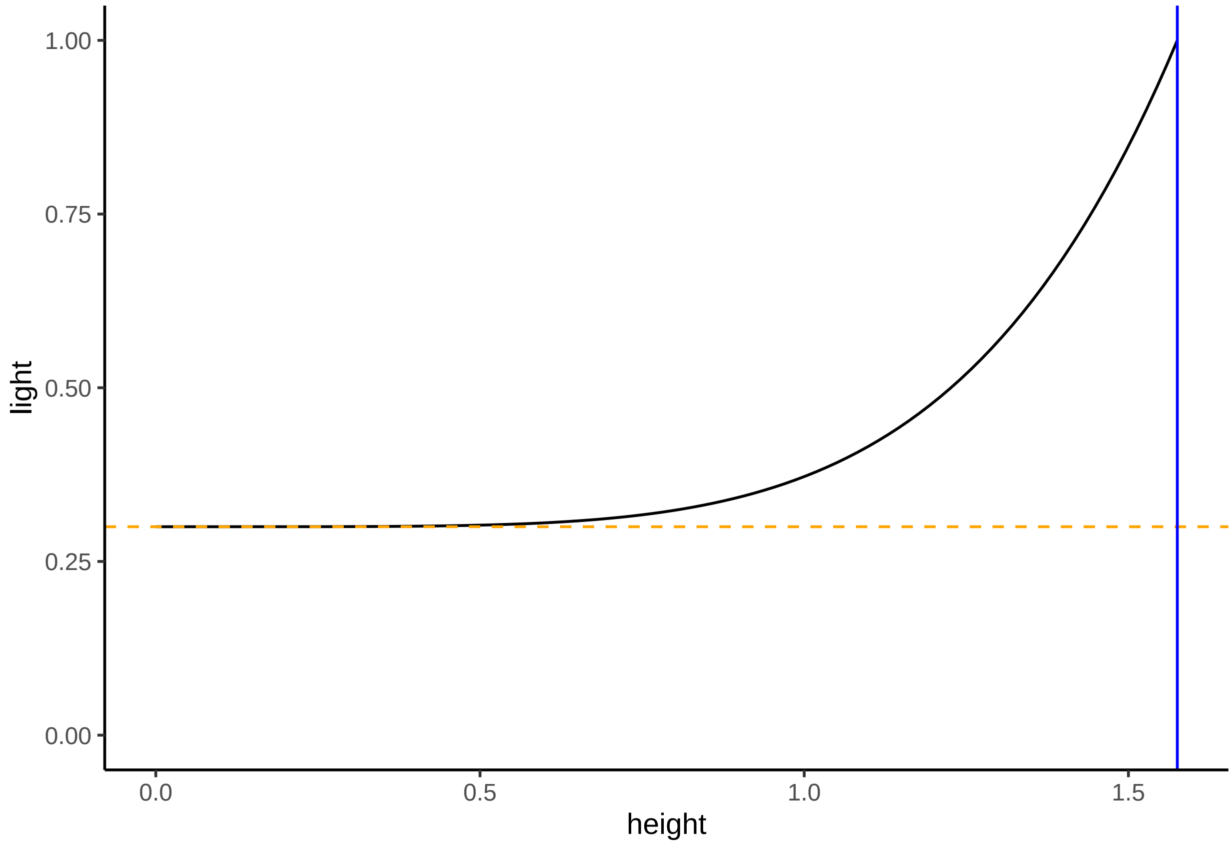
```
## <environment: R_GlobalEnv>
```

parameter	value	description	unit
a	2.0	rate of photosynthesis	NA
r_l	0.3	rate of respiration	NA
c_l	0.3	cost of construction	NA
b	0.5	biomass density	NA
k	0.2	light decay coefficient	NA
v	10.0	leaf area per ramet	NA
beta	5.0	height to mass power	NA
m	2.0	ramet mortality	NA

Light required for establishment

The biomass of a ramet increases in proportion to height to the 5th power. This means that the taller the species, the longer it will take a ramet to accumulate enough carbon to reproduce. We can plot the "light required for a species of height x" to invade from rare, e.g. lifetime reproductive success > 0 assuming no other ramets of the same species, as given below.

This means that the light must be AT LEAST this level in order for the ramet to invade.



Equilbrium Density impact on Light Level