Predicting species diversity in ecosystems

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Abstract

Species diversity is observed to follow similar patterns in many different types of ecosystem on many different length and time scales. Theorists have attempted to explain this with various models. There are two main approaches – neutral models, in which all species are competitively equal, and niche models in which species have varying amounts of competitive advantage. Here, a ’continuum’ models is presented in which the degree of competitive advantage can be varied with a single parameter σ.

***Keywords* — ecosystems, neutral models, niche models, population dynamics, theoretical ecology**

1 Motivation

A right-skewed lognormal distribution is often seen in abundance distributions of trophically similar species in the same habitat [1] and theoretical models have been constructed in an attempt to explain this. Traditionally ecologists used niche models, in which species are modelled with explicit differences and diversity arises because species find their individual niche. More recently, neutral models have been used in which all species are assumed to be competitively equal. The neutral model is described by the following equations, in which N_i is the size of species i and J is the total population. The probability of a species increasing or decreasing is equal, meaning population size is driven purely by stochastic effects.

$$P(N_i - 1|N_i) = \mu N_i \frac{J - N_i}{J(J-1)} \tag{1}$$

$$P(N_i + 1|N_i) = \mu N_i \frac{J - N_i}{J(J-1)} \tag{2}$$

$$P(N_i|N_i) = 1 - 2\mu N_i \frac{J - N_i}{J(J-1)} \tag{3}$$

This has been more successful at predicting the empirically observed distributions than pure niche models but it is still not perfect. More recently it has been hypothesised that most ecological communities are driven by both niche and neutral effects [3] and continuum models are used which use elements from both theories.

2 The model

The model presented here is a spacial continuum model. A habitat is modelled as a toroidal grid. Each gridsquare is described by an environmental parameter F between 0 and 1. Each gridsquare has a constant population of n individuals. Every species j has a preferred environmental parameter μ_j and if a species is on a square with an F close to its preference, it is given an advantage.

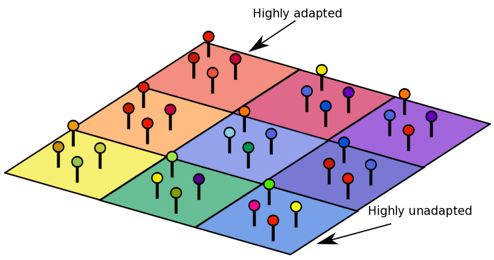

Figure 1: Species on the grid

On every timestep, an individual is removed from the grid and replaced with a replicate of a different species. The probability of each species being chosen is skewed by the following equation [2]:

$$p_j = e^{\frac{F-\mu_j)^2}{2\sigma^2}} \tag{4}$$

Thus, there is a single parameter σ which controls how neutrally the system behaves. A low value of σ will produce a nichelike system and a high value will produce a neutral system. We therefore have a system which can easily be controlled to produce neutral or niche effects.

3 Conclusion and further work

We have created a spacial continuum model and aim to compare the results obtained from the model with existing empirical data. We also aim to do experiments with spacially separated bacterial microcosms.

References

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