Why it takes all kinds:
Diversity mechanisms and patterns in ecological communities

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I certify that this thesis is the true and accurate version of the thesis approved by the examiners.

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Abstract

This work explores the effect of diversity of individuals on a community. The mechanisms generating diversity are explored, their effects on patterns of diversity are examined, and the impact of diversity on community properties (such as productivity and stability) is investigated. Three individual-based models are employed: 1) a mean-field differential equation model, 2) a simulation model of plant populations, and 3) a simulation model of interacting organisms.

The mean-field model is used to show that the traits of individuals in a community affect community diversity. The mathematical analysis, supported by numerical simulations, demonstrates that trade-offs between the individual traits are required for community diversity to exist. Moreover, the form of the trade-offs defines the equilibrium distribution of the population over the trait values. The nature of interactions among individuals (in particular, competition) determines the stability of the equilibrium state.

For a more realistic representation of the community, a more detailed and spatially explicit model of a community is defined. This model simulates each individual explicitly, with a fuller description of the physiological traits and interactions. The model is parameterised using experimental data from a grassland species *R. acetosa*. Diversity patterns in the modelled communities are of the same form as the patterns observed in biological communities. The mechanisms generating diversity patterns are examined. As in the mean-field model, analysis of the simulation model shows that a trade-off between physiological traits is responsible for generation of diversity in the simulation model also. Moreover, it affects the form of the diversity patterns. Community productivity results from the interplay of community diversity and environmental conditions.

To further explore the effect of individual interactions on community diversity and stability, a model of interacting organisms is developed. This model is a modification of the plant model, with the possibility of two-way mutualistic interactions between

organisms. The mutualistic interactions are found to increase community diversity in space and time and to promote community stability under environmental disturbance.

The impact of individual-scale processes on community-scale dynamics has recently been recognised as an important factor contributing to ecosystem dynamics. This work defines and explores some of the links between individual and community scales within ecological communities. In particular, it shows that individual traits in a community can affect community-scale properties such as diversity patterns and productivity, while individual interactions are important for community diversity and stability.

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