Preface

Ecological Networks: Simple Rules for Complex Systems in a Changing World?

This Thematic Volume of *Advances in Ecological Research* is dedicated to the study of ecological networks—the webs of antagonistic or mutualistic interactions that occur between individuals and, ultimately, also at the higher levels of biological organisation (e.g. among species populations or size-classes). Darwin first employed the metaphor of the '*entangled bank*' to describe a network of interacting species in the *Origin of Species* in 1859, and the first recognisable ball-and-stick diagram of a food web was described by Camerano (1880) a couple of decades later. Many of the eminent pioneering ecologists of their day also turned their attention to these systems, including Elton (1927), Lindeman (1942), MacArthur (1955), and Hutchinson (1959), who were among the first to suggest that complexity might confer stability on natural systems and that body size plays a key role in structuring communities and in determining the strength of interactions. These early ideas linking complexity to stability were subsequently challenged by the seminal modelling work of May (1972, 1973) and many others, who demonstrated mathematically that complexity should decrease stability. This raised the long-standing question as to what might be the '*devious strategies*' that allow the complex food webs we see in nature to persist. A new generation of food webs that were constructed with far greater sampling effort and better taxonomic resolution appeared from the 1990s onwards, in conjunction with new mathematical models that demonstrated how complex systems could be stable—for instance, if most links were weak (e.g. McCann, Hastings and Huxel, 1998). Since then, numerous studies have demonstrated, both empirically and theoretically, that the body-size of consumers and their resources is a key determinant of interaction strength, network structure and stability (e.g. Berlow *et al.*, 2009; Emmerson and Raffaelli, 2004).

In the last two decades, the study of ecological networks has undergone a dramatic renaissance, which has been manifested by the opening of new research vistas and an exponential rise in the number of publications (Ings *et al.*, 2009). The catalogue of high-quality data has now grown sufficiently for ecologists to be able to undertake meaningful meta-analysis and to search for macroecological patterns in network structure and dynamics across a wide range of systems, two areas that had, until recently, been hampered by limited or inconsistent data collection, as highlighted by the paper by Riede and co-authors in this Volume. In addition, the study of 'traditional' food webs and host–parasitoid networks has been complemented by the recent blossoming of research into mutualistic networks (e.g. plant–pollinator webs) and the attendant cross-fertilisation of ideas emerging from the study of networks in the social sciences, which are covered in Olesen *et al.*'s comprehensive review and synthesis paper. We are now edging closer to being able to make some (fairly) firm generalisations about network structure and dynamics, and to start to build predictive frameworks to anticipate how they might respond to natural and anthropogenic perturbations. One recurrent theme that has (re)emerged in recent years and that runs through much of this Volume and echoes the ideas of the early ecologists, particularly those of Elton and Hutchinson, is that body size plays a key role (e.g. Cohen *et al.*, 2003) and that its correlates (e.g. basal metabolic rate) have effects that can ramify through the food web.

The first paper in the Volume (Olesen *et al.*, 2010) provides an overview of the current and emerging perspectives in eight key areas of network research, including an in-depth consideration of the structuring of networks, and how this varies with both space and time. In the second paper, by Woodward *et al.* (2010), a new theoretical framework, based on first-principles related primarily to metabolic constraints and ecological stoichiometry, is suggested as a possible means of developing a more mechanistic understanding of network-level responses to climate change. The subsequent papers are based on detailed empirical data from a range of different systems, including marine, freshwater and terrestrial food webs. The first of these, by Riede *et al.* (2010), is a meta-analysis of network properties using a new, high-quality dataset, which reveals strong evidence of power-law scaling between network size and a range of food web parameters. The paper by McLaughlin *et al.* (2010) explores network properties and size-structuring within a highly resolved terrestrial above- and below-ground food web. The penultimate paper, by Layer *et al.* (2010) is a macroecological and modelling study of 20 stream food webs across a wide pH gradient, and is one of the first attempts to understand how structure and stability of networks is shaped by an environmental stressor. The final paper, by O'Gorman and Emmerson (2010), considers the role of body size within a benthic marine food web, and represents one of the first studies to characterise highly resolved networks within a replicated field experiment. In summary, the six papers that comprise this Volume cover a wide range of ecosystems (marine, freshwater and terrestrial), network types (food webs, mutualistic and host–parasitoid networks) and also combine theoretical and empirical approaches. Although the role of body size is addressed in each contribution, this does not in any way imply that it is the sole variable of interest or importance, but rather it represents a useful principal component that can capture much of the biologically relevant variation within a network. Examining the 'residuals about the line' can therefore provide invaluable additional information about a wide range of other important ecological properties and phenomena (e.g. idiosyncratic species traits, adaptive behaviour, and phylogenetic constraints) that would otherwise be masked. In many cases, and especially in aquatic systems, body size provides a relatively simple set of rules that can be used to help understand and (ultimately) predict the structure and dynamics of complex ecological networks and how they might respond to future change. This is a rather daunting, but also exciting, prospect for future ecological research, and the compilation of papers within this Volume represent a step towards this goal.

Guy Woodward