SPECIAL ISSUE

Macroecological Tools for Global Change Research

The papers in this Special Issue arose from the international conference
Macroecological Tools for Global Change Research
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Conference venue: Potsdam Institute for Climate Impact Research (PIK) (photo: W. Cramer)

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SPECIAL ISSUE INTRODUCTION

Macroecology meets global change research

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Global change, including multiple human-induced changes to ecological systems, such as climate change, land use change, biological invasions, urbanization, nitrogen deposition, is one of the major threats to biological diversity world-wide (Sala *et al.*, 2000; World Resources Institute, 2005). In this context, biodiversity is not only threatened through the accelerated extinction of species but also through changes in community structure such as the abundance and distribution of species, which may lead to new assemblages on several spatial scales. Despite the global scale of the problem, most analyses on global change focus at a rather small spatial scale (Kerr *et al.*, 2007). In contrast, macroecological approaches, ideally suited to address large-scale patterns have less frequently been applied to global change problems. They are capable of analysing the statistical properties of large numbers of comparable ecological 'particles' (Brown, 1999) at any level of the hierarchy of biological organization, e.g. traits, species, etc., and over many spatial or temporal scales. The emerging properties of large numbers of comparable 'particles' can be uncovered only by broad-scale analysis, not by compiling detailed knowledge about all individual particles.

In 2004, institutes from three German Universities (Göttingen, Mainz, Marburg) and two research centres (the Potsdam Institute for Climate Impact Research – PIK and the Helmholtz Centre for Environmental Research – UFZ) joined their expertise in macroecology, global change research and experimental ecology by founding a 'Virtual Institute for Macroecology' with start-up funds from the Helmholtz Association of German Research Centres. The main aim of the Virtual Institute is to develop methods and concepts to assess changes in macroecological patterns under the conditions of global change. The participating institutes bring together expertise in different ecological fields, such as global change modelling, plant and animal ecology, biogeography, ecophysiology, management of large data sets, and advanced statistical analyses. In a novel approach, the Virtual Institute for Macroecology planned small-scale ecological, ecophysiological, or competition experiments to complement the large-scale analyses of extensive datasets, extending our analyses on functional traits and including evolutionary questions.

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Scientists in the Virtual Institute have contributed to deeper understanding of macroecological patterns and the effects of global change. For example, we have analysed the response of bird communities to climate change (Lemoine *et al.*, 2007a,b; Schaefer *et al.*, 2008), European distribution patterns of dragonflies (Hof *et al.*, 2006), spatial relationships between bird and plant diversity (Kissling *et al.* 2007), patterns of plant distributions and functional types (Kühn *et al.*, 2006; Kühn & Klotz, 2006) as well as plant phenology (Badeck *et al.*, 2004). Furthermore, we have developed new methods for spatial analyses of ecological data (Carl & Kühn, 2007; Carl & Kühn, 2008; Kissling & Carl, 2008).

In order to bridge the gap between global change research and macroecological concept development, the Virtual Institute for Macroecology organized an international conference on 'Macroecological Tools for Global Change Research' held on 21–23 August 2006 in Potsdam (Germany), bringing together more than 120 participants from more than 20 countries. The conference featured 19 invited talks from internationally renowned researchers and presentations of about 50 posters. The presentations ranged across a wide range of topics covering impacts of climate change on biodiversity and methods to analyse them, mathematical and mechanistic models of species richness and ranges sizes, the role of functional traits and ecophysiological properties in macroecological patterns, effects of biological invasions and the importance of considering phylogenetic relationships when analysing patterns under current and changing environmental conditions. This special issue presents selected contributions to the Potsdam Conference focusing on various aspects of global change and on the tools that can be used to analyse and predict the impacts of global change on biodiversity.

An important aspect of species patterns and their emergent properties in large-scale analyses is their evolutionary legacy. Therefore it is important to recognize evolutionary trajectories and phylogenetic relationships in analyses of the effects of global change. Diniz-Filho & Bini (2008) review recent analytical developments in phylogenetic comparative methods that can be used to understand the patterns of change of traits under environmental changes. They provide a novel interpretation linking the ecological and phylogenetic components of trait variation with the potential responses of species to global environmental changes. Recognizing phylogenetic relationships is also important in analysing biological invasions. When

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analysing phylogenetic patterns in biological invasions, results differ among various levels of spatial and biological scale as well as the groups of organisms under scrutiny (Procheş *et al.*, 2008). Another effect of biological invasions is the homogenization (or differentiation) of communities, i.e. communities tend to become more similar (or different) after being invaded. In Australian river basins, homogenization was observed in fish communities due to the widespread introduction of specific fish, while the north-eastern river basins were more differentiated due to sporadic introductions of alien fish (Olden *et al.*, 2008). In an analysis of the impact of climate change on the changes of community composition, Schaefer *et al.* (2008) show that under the assumption of usual climate change scenarios, species of migratory bird communities will rather adapt their migratory behaviour than be replaced by other species. Two papers of this special issue focus on specific patterns and hypotheses, using macroecological approaches. In a meta-analysis on global scale, Pärtel *et al.* (2008) showed that the frequently observed resource heterogeneity of soils under woody vegetation compared with grasslands is only typical for temperate regions. An analysis of resource allocation and ecological trade-offs showed the influence of propagule pressure on community composition using large species datasets (Boedeltje *et al.*, 2008).

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