PREFACE

Editorial Commentary: Global Change in Multispecies Systems Part 2

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Volume 47 of Advances in Ecological Research is the second in a series of three that address a wide-ranging theme in contemporary ecology: global change in multispecies systems. In the previous volume, the ecological consequences of various environmental stressors were explored (Jacob and Woodward, 2012), including several of the different components of climate change (Ledger et al., 2012; Meerhoff et al., 2012; Mintenbeck et al., 2012), habitat loss and fragmentation (Hagen et al., 2012), land use (Mulder et al., 2012), and resource exploitation (Rossberg, 2012), and the consequences for biodiversity, ecosystem functioning and the provisioning of goods and services of value to human societies were considered. In this volume, different aspects of these themes are explored, while once again covering both the aquatic and the terrestrial realms. The topics addressed here include assessing consequences of global change in terrestrial food webs (Moya-Larano et al., 2012), in marine predator–prey relationships (Peck et al., 2012; Twomey et al., 2012) that can trigger whole-system regime shifts (Möllmann and Diekmann, 2012) as well as in freshwater (Jeppesen et al., 2012; O’Gorman et al., 2012) systems. New, multidisciplinary territory is explored by addressing how warming affects different spatiotemporal scales and organisational levels (O’Gorman et al., 2012), and how it might alter eco-evolutionary dynamics (Moya-Larano et al., 2012), as well as considering the prospects for bioremediation of eutrophication on a global scale (Jeppesen et al., 2012). The third thematic volume in this series will consider more ecosystem-level effects and methodological approaches, including analysing and visualisation responses of complex multispecies data, such as size-spectra, food webs and mutualistic networks: thus the three volumes in combination aim to provide a broad and deep coverage of global change in multispecies systems.

A range of different approaches are presented in this volume, reflecting the challenges associated with gauging the impacts of the drivers of global change,
including the use of space-for-time substitutions and times series data (Jeppesen et al., 2012; Möllmann and Diekmann, 2012; O’Gorman et al., 2012; Peck et al., 2012), direct field experimentation (O’Gorman et al., 2012; Twomey et al., 2012), and mathematical modelling and dynamical simulations in silico (Moya-Larano et al., 2012). A broad biogeographical span is covered, ranging from the poles to the tropics, and data are presented from studies conducted across many of the world’s continents and oceans (e.g. Jeppesen et al., 2012; Möllmann and Diekmann, 2012; Peck et al., 2012). This mirrors the range of approaches and global coverage employed in Volumes 46 and 48 (Jacob and Woodward, 2012; O’Gorman and Woodward, 2013), although different systems and questions are addressed here.

A brief overview of the key findings of the six papers is presented here, highlighting their connections to more general themes that developed from Volume 46 and some earlier papers. Taken together, Volumes 46 and 47 cover many of the world’s marine ecosystems and their likely responses to warming from large-scale survey data (e.g. Peck et al., 2012), which are complemented by more focused model-system approaches, such as that employed in the food web manipulation of Lough Hyne, one of the best-characterised marine food webs on the planet (Twomey et al., 2012). The Peck et al. (2012) paper presented here highlights how life-history traits and ontogeny within species populations can have far-reaching implications that ripple through entire food webs and across large spatial scales, as warming has the potential to alter source-sink dynamics and propagule dispersal across marine ecosystems. As highlighted in Volume 46 by Hagen et al. (2012), even such apparently very open systems have food webs that are structured in both time and space and are therefore vulnerable to fragmentation, especially in combination with other stressors, such as warming. Despite the potential for perturbations to marine food webs to be manifested on very large scales due, for instance, to altered source-sink dynamics as ocean currents change, the Twomey et al. (2012) paper revealed relatively weak effects of manipulating the biomass of a dominant predator in a local food web. This suggests that some apparently strong perturbations associated with global change might be well-buffered within particular systems, at least at a local scale, again highlighting the need to consider the spatiotemporal context of the system under study (O’Gorman et al., 2012). This latter finding is particularly important because there is still a bias in the literature for strong (negative) effects of predators to be published in preference to those that show weak or negligible effects, as suggested two decades ago by Paine (1992), even though such apparently underestimated interactions may be critical for food
web stability. This tendency to overlook weak effects of predators on the prey assemblage has almost certainly led to a skew in our perception of the stability, and maintenance of that stability, in food webs in general.

The three marine papers presented here complement the Mintenbeck et al. (2012) study in Volume 46, but with a shift in focus from polar to temperate seas in this volume. Antarctic food webs, which are among the most complex trophic networks yet described (Jacob et al., 2011), may be especially vulnerable to widespread disruption and extensive rewiring in response to warming, as entire guilds of specialist cold-adapted species may be lost or replaced by polewards invasions of warm-water taxa with very different trophic roles (Mintenbeck et al., 2012). Jeppesen et al. (2012) also point out that the trophic ecology of freshwaters is not necessarily easily extrapolated across large latitudinal gradients and that our current assumptions and models, which have been developed largely in the temperate zone, might not apply in such a predictable manner in the tropics.

Staying within the aquatic realm, but moving inshore from the marine coastal waters of Twomey et al. (2012) into the headwaters of fresh waters, the paper by O’Gorman et al. (2012) in this volume represents a multilayered attempt to understanding the effects of an isolated component of climate change—environmental warming—in a “natural experiment” in Iceland. This paper combines experimental manipulations in the field and laboratory with extensive survey data across a broad natural thermal gradient that arises due to natural geothermal activity within a single mountain catchment. This model system is especially valuable because it avoids the common pitfalls of potential confounding effects of biogeographical constraints and other large-scale environmental gradients that typically bedevil space-for-time studies (e.g. where altitude or latitude are used as proxies for temperature change), as it is able to isolate the effects of temperature in a natural but spatially confined setting. This complements the paper by Ledger et al. (2012) in Volume 46, in which a different component of climate change—drought—was applied experimentally in a long-term stream mesocosm study. In both of these studies, the stressor led to marked changes in community structure and ecosystem processes, with large invertebrate predators being especially vulnerable to drought and warming, and more recent work has revealed that these stressors alter the size structure of the food webs in both study systems (Ledger et al., 2012; Woodward et al., 2012). One recurring theme that emerges from the O’Gorman et al. (2012) paper and other recent contributions is the strong interdependence between running waters and the surrounding terrestrial environment (e.g. Hladyz et al., 2011a,b), especially
in the form of food web subsidies to the former from the latter, revisiting the pioneering work of Hynes (1975) and others, but from a different perspective and in the new context of global change. These subsidies can enter the food web at different trophic levels, from the reliance on leaf litter as a major basal resource in wooded headwaters (Hladyz et al., 2011a,b) to extensive feeding of apex predators (brown trout) on terrestrial invertebrates (O’Gorman et al., 2012), and both partly decouple the dynamics within the food web across time and space (Hagen et al., 2012).

O’Gorman et al. (2012) Icelandic stream studies have also revealed some intriguing responses to environmental warming. Some of these are in line with current theoretical predictions, whereas others contradict the received wisdom. For instance, although there is some limited support for the commonly reported declines in body size with temperature (e.g. Daufresne et al., 2009), there are also examples of nonrelationships and even positive relationships. These apparent aberrations might, in fact, reveal cases where temperature-size rules may be reversed due to differential growth and development times or eco-evolutionary food web dynamics, as suggested by the Moya-Larano et al. (2012) paper that is also presented in this volume, and which complements the earlier work by Melian et al. (2011). These phenomena might explain the otherwise seemingly counterintuitive effect of increased abundance and body size of the apex predator in the Icelandic streams, brown trout, as temperature rises. It also appears that indirect effects that are akin to apparent competition may play a key role in these food webs: the supply of terrestrial insects may exacerbate the effects of the apex predators on the in-stream biota, again highlighting the potential critical importance of aquatic–terrestrial linkages (Hagen et al., 2012).

Taken together, the papers presented in this volume span the hierarchy of ecological organisation, from genes and individuals to populations, communities and ecosystems, highlighting the need for interdisciplinary science if we are to grapple with the full ramifications of global change. The O’Gorman et al. (2012) paper, for example, spans multiple levels of biological organisation, from individuals to entire ecosystems, and uses a range of different perspectives in attempts to understand the dynamics of the systems exposed to warming. The individual-based empirical data presented by O’Gorman et al. (2012), for instance, map onto the organisational levels investigated by Moya-Larano et al. (2012) and the earlier individual-based food webs considered by Melian et al. (2011), Gilljam et al. (2011) and Woodward et al. (2010), whereas the population, community and size-spectra approaches connect with the dynamical modelling approaches used by Rossberg (2012) in Volume 46.
In addition to the principal focus on climate change, several other major global stressors are also considered in this volume, including the effects of eutrophication and the prospects for biomanipulation and restoration in both temperate and tropical lake ecosystems (Jeppesen et al., 2012). There is a well-established body of theory behind the practice of biomanipulation in shallow lakes, based on trophic cascades within food webs and the ecosystem-level regime shifts that can arise from them. However, these ideas were developed in the temperate zone, and their relevance in the tropics, and hence the prospects for applying a standardised global approach to restoration, remain largely unknown. The Jeppesen et al. (2012) paper is one of the first to explore these issues, and there are clear suggestions that tropical systems may behave in some fundamentally different ways from their temperate counterparts. A clear message that emerges from this new synthesis is that a far better understanding of these systems, and if and how trophic cascades might be manipulated as a restoration tool, requires considerable new research effort, as a simple “one-size-fits-all” approach is evidently not appropriate. The Jeppesen et al. (2012) study also highlights the potential risks associated with current bias towards studies conducted in mid-to-high latitudes: far less is understood about how the drivers of global change might reshape the ecology of the tropics, a worrying gap in our knowledge that needs to be addressed urgently.

Although much of the research into the drivers of global change has, largely due to logistic constraints, focused on single stressors, as in many of the papers in Volumes 46 and 47, it is clear that we need to move beyond this simplistic view and start to deal with the reality that multiple stressors are operating in most ecosystems and that many of these may be acting synergistically. Several of the papers in this and the preceding volume have touched on this point. For instance, eutrophication, which has been arguably the dominant ecological problem in lakes for many decades, clearly now needs to be considered in a multistressor context, especially as it will increasingly be accompanied with climate change and associated problems arising from overabstraction, drought and warming (Woodward et al., 2011). As Meerhoff et al. (2012) demonstrated in the previous volume, the effects of warming are also not necessarily identical in temperate and tropical systems, and potential synergies between these two major global stressors could give rise to complex and seemingly unpredictable responses at local or regional scales (Friberg et al., 2011; Jeppesen et al., 2012).

In terms of responses to perturbations, regime shifts resulting from biotic or abiotic drivers operating through the food web appear several times in this and the preceding volume, particularly in marine (Mintenbeck et al., 2012;
Möllmann and Diekmann, 2012) and freshwater (Jeppesen et al., 2012) systems. Here, Möllmann and Diekmann (2012) discuss how climate change and overfishing could combine to trigger dramatic rearrangements of food web structure and altered dynamics over large scales. They also consider how eutrophication and invasive species can add to the overall stressor load, with the potential for synergistic effects to be manifested, which may be difficult to reverse if alternative stable states develop. However, we should be wary of extrapolating to generalisations too early: there appears to be a wide range of responses to the perturbations associated with global change, from relatively weak responses (Twomey et al., 2012) and some strong effects embedded within certain chains in the food web but which fall short of the classic trophic cascade (O’Gorman et al., 2012) to large-scale, dramatic regime shifts into new stable equilibria (Jeppesen et al., 2012). A major challenge now is to understand what makes certain systems especially vulnerable to particular stressors and over what range of spatiotemporal scales these relationships operate.

In summary, the six papers in this volume, especially when placed in the context of the preceding and subsequent volumes, represent a broad, but also often highly detailed, coverage of some of the global stressors currently in operation as well as those that are emerging on the horizon. Even so, we are still only in the embryonic stages of understanding how our natural systems are likely to change as we move deeper into the Anthropocene, and clearly much remains to be done.

REFERENCES


