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Introduction. Global change and biodiversity: future challenges

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Introduction. Global change and biodiversity: future challenges

There can be few starker challenges for environmental change biologists than the need to see as many species as possible through the bottlenecks of the next two centuries. Increasingly, we will have to work in 'triage' mode—making tough decisions about the probability of species' survival, the effectiveness of habitat management and the allocation of scarce resources. At the same time, we may have to do this in the context of societies that are increasingly unstable, and institutions that are increasingly strained and powerless. So the kind of tools we need must be as robust, as well-founded and as easy to use as possible in a complex, fast-changing and difficult world. It is truly a 'grand challenge' for the field (Thuiller 2007).

There has seldom been such a need for good science, but so little time to fiddle with the details. Is the field of global change biology delivering this clear advice?

We like to think that it is, but frankly, the jury is still out on this point. Undeniably, the best global change science has done exactly that: delivered spatially explicit, scientifically rigorous, priority-based advice about species' vulnerability and adaptation options—although the latter remains an enormous gap. This science is based on empirical data, spatial and demographic models that are as rigorous as possible under imperfect circumstances. But we have an enormous global responsibility to keep this work flowing. As we pursue greater methodological refinement, greater rigour, more comprehensive datasets and additional robustness, we are also at risk of a tragic complacency—fiddling while Rome burns, building secure careers from the conceptual advancement of the field as if it is just another academic issue, and rushing to stake claims to abstruse intellectual territory. The best collaborative research in this field, such as some of the EU-funded research consortia, counters this tendency and applies the principles that numerous good brains are better than one or two, and that a common purpose, with clear goals, tight timetables and scientific productivity, allows us collaboratively to 'cut to the chase and deliver the goods'—as conservation managers have increasingly started to demand of us.

Several of the papers in this special issue of *Biology Letters* spring from these collaborative global change consortia, and others are based on independent integration of themes and methods. Rickebusch *et al.* (2008) is one such consortium output, from the FP6 MACIS European project (*M*inimization of and *A*daptation to *C*limate Change *I*mpacts on Biodiver*s*ity). It brings together key players from different fields in predictive global change science, who in the past seldom collaborated closely. The outcome is challenging, indeed a bit mind-blowing. MACIS is finding that usual proxies for precipitations and soil humidity could be misleading, as they do not account for the direct effect of CO_2 on vegetation—leading to more conservative projections of vegetation change under climate change scenarios. The paper by Keith *et al.* (2008) also stems partly from European collaborative grants (FP6 MACIS European project) and other sources (NERC, IUCN), which brought together population biologists and species' distribution modellers to propose an exciting new framework for estimating the influence of both climate and land use change on population dynamics. Other papers originating from collaborative global change consortia are Pompe *et al.* (2008), who evaluate the impact of climate change on German flora (FP6 ALARM European project), Ohlemüller *et al.* (2008), who conclude that rarer climates occurring in current centres of species rarity could shrink disproportionately under future climate change, thereby probably increasing many species' vulnerability (a direct output of the large European project ALARM), or Hannah *et al.*'s review of climate change adaptation for conservation in the Madagascar biodiversity hotspot.

Fortunately, although they are increasingly successful, large global change consortia are not the only ones producing robust and rigorous science. On the more conceptual side, Morin & Lechowicz (2008) discuss the latest developments in predictive modelling, community ecology and biogeography, and argue that a new understanding of relationships among the niche concept, species' diversity and community assembly should lead towards more rigorous models of global change effects on species' distribution and community diversity.

On the methods side, De Marco *et al.*'s paper (2008) demonstrates how useful spatial eigenvector decomposition can be in tackling the problems of spatial autocorrelation in species' distribution models. Altwegg *et al.* (2008) emphasize the value of occupancy models that use imperfect presence–absence data in projecting species' responses to global change, in a way that

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avoids confounding occurrence with detection probability. Finally, Broennimann & Guisan (2008) draw on their seminal paper published last year in *Ecology Letters* (Broennimann *et al.* 2007) to show how modelling potential invasion using species' distribution models is improved by incorporating data from both native and invaded ranges. This paper shows us that realized niches, while easily modelled, are not easy to project into the future or in space, since they do not represent the full environmental capabilities of species, which should be closer to the fundamental niche. It also demonstrates the danger of projecting potential distributions into the future or into space using very limited or inaccurate data.

Global change scientists seem to have been better at developing concepts, methods and simulations than at gathering real data on species' vulnerability. This is an uncomfortable truth for the field, especially for those of us trained as field biologists. Indeed, we see it as one of our primary challenges. But the fact remains that we are severely data limited in many areas, and face a global conservation crisis. Given the urgency with which we often need to operate, and the consequences of delay or inaction for biodiversity, is it not a better strategy to validate and calibrate models and concepts adequately to suit what our best judgement tells us are the conservation needs of the greatest number of species, and focus fieldwork on those species that may fall outside the curve? This dilemma is complex, and seldom comfortable to those involved in species-level conservation implementation. But we may have little choice, particularly in biodiverse regions of the Southern Hemisphere where datasets—both biodiversity and climate data—are particularly sparse. Rare exceptions are the fine-scale work done on the protea family of the South African fynbos, which Keith *et al.* (2008) use to demonstrate the integration of habitat suitability and demographic models, and the multiple species range datasets from Madagascar in the extensive work summarized by Hannah *et al.* (2008). Even rarer are detailed analyses of historical biogeographic and/or behavioural or physiological data, such as represented in the paper by Monahan & Hijmans (2008), or the use of historical data to help validate modelling approaches, such as the retrodiction discussed by Green *et al.* (2008).

Monahan & Hijman's paper shows how complex species' responses really can be. Declining populations of field sparrows *Spizella pusilla* expanded their winter range by over 200 km polewards at the time of increasing net primary productivity, arguably limited only by ecophysiological tolerance. The integration of many of these factors—behaviour, phenology, life history, physiology, demography and others—is essential for building a comprehensive picture of species' responses. Yet, we will probably be able to do this for only a tiny subset of species, even with vertebrates. The most detailed European and North American research on the climate change-induced phenology bottlenecks in species' life cycles (e.g. Both *et al.* 2006; Visser 2008) require detailed pedigrees derived from patient, long-term population studies, which are rarely possible in the world's Southern Hemisphere biodiversity hotspots (e.g. Simmons *et al.* 2004). The most insightful, ecologically surprising and desperately needed collaborative work of the future must bridge this capacity and data gap between hemispheres, and link the strong teams of the North with other regions of the world that are so little known in terms of species' vulnerability.

Without doubt, global change biologists now need to make explicit the implications of their science for improved conservation planning, policy, research and management. Conservation adaptation work is a broad, complex, interdisciplinary field. It is unfortunately treated significantly in this issue only by Hannah *et al.* for Madagascar. We urge scientists in this field to forge alliances with those at the coalface of conservation implementation, to flesh out robust principles and detailed recommendations based on global change biology for real-world conservation action, a process recently started at a workshop in southern Africa (Barnard *et al.* 2007). There is so little time to waste, and so much insight into smart conservation actions to be gained.

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