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A Call to Action for Conserving Biological Diversity in the Face of Climate Change

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The need to conserve biological diversity has never appeared greater, yet conservation professionals may feel overwhelmed by the new challenges imposed by climate change. Thousands of papers on the ecological impacts of climate change have created an overload of information, reflected in a recent spate of synthetic literature reviews (Felton et al. 2009; Heller & Zavaleta 2009; Lawler 2009; Mawdsley et al. 2009; six articles in *Environmental Management* 44[6] [2009]). The complexity and unpredictability of climate change are daunting, and this can make it difficult to decide if, how, and when to change tactics for conservation. Uncertainty and complexity could become a recipe for inaction, or merely a call for more research, modeling, and planning. Nevertheless, we believe the path forward for conservation is clear enough for steady progress, even if the route may shift a bit in response to further research and reassessment of priorities.

Staying the Course

Perhaps the clearest message that emerges from the literature on biological diversity and climate change is that traditional conservation strategies will remain effective. Consideration of climate change may lead to small shifts in how and when conservation interventions are applied, but will not undermine the foundations of our discipline. In particular, conservation biologists know that the ability of species to adapt to the novel stresses imposed by climate change will increase if existing stressors can be minimized (e.g., pollution, excessive exploitation, invasive non-native species). In other words, robust populations that are well distributed across a species' entire geographic range are most likely to persist as climate changes (Schwartz 2006).

Ecosystem degradation and conversion are the most fundamental stressors to biological diversity and thus the establishment of reserve networks remains an effective strategy for conservation. To be resilient to degradation, especially in the face of climate change, reserve systems should contain a representative array of environments with enough redundancy to account for unpredictable exigencies

such as local extirpations. Range shifts will lead to a continuously changing assemblage of species in any given reserve (Hunter et al. 1988; Hannah et al. 2007; Anderson & Ferree 2010; Beier & Brost 2010), but this does not obviate the validity of creating reserves. Ideally, reserves will be contiguous to facilitate species range shifts. Connectivity among populations or processes can also be maintained or restored by arranging reserves as stepping stones or connecting them with riparian zones and other features that are present across human-dominated landscapes (Opdam et al. 2006; Olson et al. 2009), even scattered trees (Manning et al. 2009).

A traditional but extreme approach to ensuring species persistence, *ex situ* conservation, may continue if zoos, aquaria, and botanical gardens serve as ultimate options for maintaining species that have no remaining habitat. Unfortunately, *ex situ* conservation is expensive and has an abysmal track record for restoring populations of species and their habitat after they are extinct in the wild.

Reassessing Priorities and Strategies

We can stay the course of traditional approaches to conservation with an emphasis on stress reduction and implementation of well-connected networks of reserves, but climate change will have such profound ecological, social, and economic consequences that our strategies will have to adapt to change and uncertainty rather than resisting it. For example, conservation attention may shift toward sedentary species with limited ranges and away from wider-ranging species that are disappearing from a particular nation or state as their range shifts (e.g., a species that is rare in the United States and retreating to its core range in Canada). Similarly, society may choose not to barricade coastal ecosystems facing inundation, but to facilitate a transition to estuarine then marine ecosystems.

Knowing when to stay the course and when to change in the face of uncertainty about climate change and its complex effects on species and ecosystem demands that conservation professionals finally become serious about implementing adaptive management. This is particularly true because,

despite our best efforts to model climate change and its effects on species and ecosystems, there will probably be substantial surprises to which appropriate responses are not immediately apparent.

New Opportunities

Literature reviews about biological diversity and climate change have generally ignored a major focus of climate-change policy—mitigation. Conservation professionals will generally support mitigation because it confronts root causes by, for example, reducing emissions of greenhouse gases, insulating buildings, improving vehicle efficiency, and developing renewable sources of energy. Mitigation also, however, offers major new opportunities for conservation professionals to contribute to mitigation efforts and inform climate-change policy. In particular, avoided deforestation (also known as reduced emissions from deforestation and degradation [REDD]; see the special issue of *International Forest Review* 10[3] [2008]) has substantial potential to simultaneously reduce global emissions and conserve biological diversity in forest ecosystems. Loss and degradation of forests is responsible for about 15% of the emissions of greenhouse gases; thus, curbing deforestation would reduce the input of atmospheric carbon and maintain ecosystems with a high concentration of native species (Canadell et al. 2007; van der Werf et al. 2009). Analogous scenarios for reducing emissions and conserving species could be developed in other contexts (e.g., substituting kangaroo harvesting for cattle grazing in Australia to reduce methane emissions from livestock) (Wilson & Edwards 2008).

Conservation professionals need to help evaluate whether carbon management schemes are likely to have unintended consequences. For example, increased production of biofuels requires conversion of extensive areas of native land cover (Koh & Gazhoul 2008; Robertson et al. 2008), 140,000 km² in the United States alone by 2030 according to one estimate (McDonald et al. 2009). Similar issues attend some other mitigation strategies, such as wind farms (Desholm 2009), hydroelectric dams

(McCartney 2009), nuclear power, solar energy, and fertilizing the ocean with iron (Buesseler et al. 2008). In some cases, it is feasible to minimize adverse effects. For example, wind farms can be located to avoid migration pathways of birds and bats, and some hydroelectric facilities produce power without damming rivers.

We believe conservation professionals should also seek opportunities to inform the public about situations in which conserving biological diversity enhances human welfare, especially in the context of climate change. The win–win scenario of avoided deforestation saving both carbon and biological diversity is one such story. Another example is conserving watersheds both to provide water for people and to maintain biological diversity.

Although climate change will pose some new threats and challenges, familiar and proven strategies for conservation will still be highly effective, and in many cases will be the best approach for avoiding the least desirable effects of climate change on species and ecosystems. Achieving ecological and social objectives despite the uncertainties of climate change will require adaptive management, but we know enough about the principal threats to biological diversity and about fundamental prescriptions for conservation to act now. Furthermore, there are new opportunities to develop desirable scenarios, such as avoided deforestation, and to demonstrate that sound conservation serves human welfare in many ways. The scope for acting to conserve biological diversity has never been greater.

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