Mitigation, Adaptation, and the Threat to Biodiversity

JAMES S. PATERSON,* MIGUEL B. ARAÚJO,† PAM M. BERRY,* JAKE M. PIPER,‡ AND MARK D. A. ROUNSEVELL§

*Environmental Change Institute, Oxford University Centre for the Environment, South Parks Road, Oxford, OX1 3QY, United Kingdom, email james.paterson@ouce.ox.ac.uk

†Department of Biodiversity and Evolutionary Biology, National Museum of Natural Sciences, CSIC, C/José Gutierrez Abascal 2, Madrid 28006, Spain

‡Department of Planning, Oxford Brookes University, Headington, Oxford OX3 0BP, United Kingdom

§Centre for the Study of Environmental Change and Sustainability (CECS), School of Geosciences, University of Edinburgh, Crew Building, King's Buildings Edinburgh EH9 3JN, United Kingdom

The recent Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (Parry et al. 2007) strongly supports the view that climate change is one of the main threats to life on Earth. Scientists have documented worldwide impacts of climate change on species and ecosystems around the world (Parmesan 2006) and even greater impacts are predicted in the future (Thomas et al. 2004; Thuiller et al. 2005; Araújo et al. 2006). The main response to global warming has been through mitigation in the form of renewable energies, energy-use efficiency, and carbon sequestration. Recently, the realization that mitigation may not arrest the effects of climate change has brought adaptation to the fore (Pielke et al. 2007) and, in some circumstances, the development of win–win strategies that integrate mitigation and adaptation (Klein et al. 2005).

Nevertheless, with the mounting recognition that mitigation and adaptation are vital for society (European Commission 2007b) comes a growing concern that biodiversity conservation will become an acceptable casualty in the fight against climate change. If the overriding priority is to preserve human welfare and prosperity at any cost, we foresee human actions compounding other threats to biodiversity. We argue that ultimately win–win–win goals should be sought, where mitigation and adaptation are considered on equal footing with biodiversity conservation. Opportunities for win–win–win solutions exist (Convention on Biological Diversity 2003), but they are not pursued in many current and planned strategies (Fig. 1).

Thus far, adaptation has occurred in limited ways (Adger et al. 2007), and as a result, the majority of conflicts with biodiversity conservation stem from mitigation schemes. Recently, the biodiversity implications of bioenergy crops have been discussed prominently (e.g., problems with species with invasive traits, the destruction of native habitats from displacement of food crops [Raghu et al. 2006; Scharlemann & Laurance 2008]), but the biodiversity impacts of wind power (habitat loss, mortality from collision [Drewitt & Langston 2006]), afforestation (compounding water shortages in drier regions [Farley et al. 2005]), and solar power (impact of large-scale units on habitats and water resources in sensitive areas [Tsoutsos et al. 2005]) have also been highlighted. One sector with a long history of ecosystem degradation is hydropower, but despite better knowledge of its impacts (World Commission on Dams 2000), hydro schemes are still touted as viable win–win solutions. Here we highlight 2 potential European developments in this sector that are attracting increasing criticism from environmentalists.

A major dam project, set to be built in the Sabor River valley in northeastern Portugal, has been mooted as a win–win development by the Portuguese government. The Sabor Valley, however, is also renowned for its local biodiversity with high levels of plant endemism, several endangered bird species, and richness in many other taxa. Furthermore, its biogeographical location and heterogeneous topography suggest it could play an important role as a biodiversity refuge under future climate change (Hampe & Petit 2005), as it has in the past (Lopez de Heredia et al. 2007). The ecological impacts of large dams are well documented (World Commission on Dams 2000) and, given the scale of the Sabor Valley, irreversible adverse change for Portuguese biodiversity appears to be a likely consequence. Although the Portuguese

Paper submitted February 5, 2008; revised manuscript accepted April 10, 2008.

DOI: 10.1111/j.1523-1739.2008.01042.x

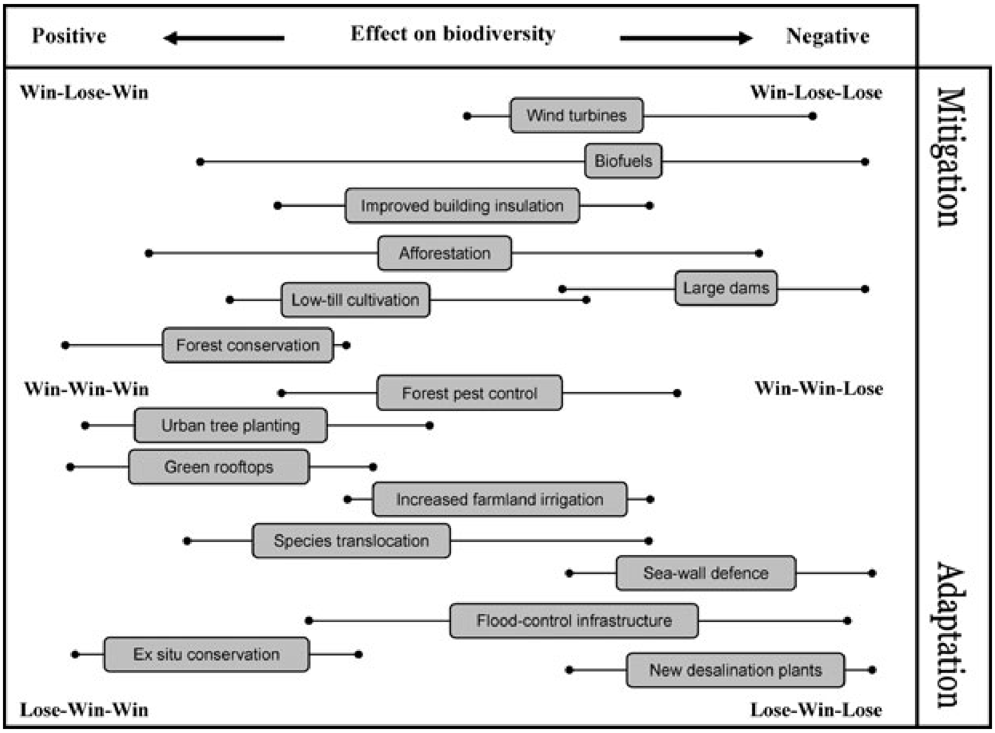

Figure 1. Known and potential relationships between mitigation and adaptation measures and their impacts on biodiversity. The position of the boxes on the biodiversity axis was determined from a literature review (available from J.S.P. upon request) of the biodiversity impacts of various mitigation and adaptation schemes and represents the typical outcome. The whiskers show the potential range of impacts. For example, not all afforestation projects are the same: monoculture plantations with high water demands could have detrimental effects, and encouraging natural regeneration around existing species-rich woodland could be beneficial. The win–lose trilogies are ordered mitigation, adaptation, biodiversity (e.g., lose–win–lose means a loss for mitigation, a win for adaptation, and a loss for biodiversity).

government carried out an environmental impact assessment that recognized the valley's unique biodiversity (European Commission 2007a), it nevertheless claims the energy and local development benefits outweigh the environmental consequences. However, the studies used to support the Sabor project did not evaluate the effects of future climate change. Tellingly, there is no mention of an assessment of the long-term viability of energy production (IPCC's scenarios suggest a 20% to 50% reduction of hydropower potential for the region by 2070 (Kundzewicz et al. 2007), let alone an appraisal of the effects of climate change on local biodiversity. This oversight is even apparent in the more recent announcement by the Portuguese government of plans for the construction of 10 more dams that would, under an unrealistic no-climate-change scenario, produce an additional 2000 MW by 2020 (Ministério do Ambiente do Ordenamento do Território e do Desenvolvimento Regional 2007).

In the United Kingdom another prospective large-scale hydropower project is causing similar concerns. The Severn estuary offers the largest tidal energy resource in the United Kingdom and the government is examining a number of tidal barrage schemes, the largest of which (a 16-km embankment from Cardiff in Wales to Weston in England) would potentially provide 4.4% of the United Kingdom's energy supply and flood prevention capabilities (the other win) (Sustainable Development Commission 2007). But like the Sabor Valley, the Severn Estuary has a remarkable variety of internationally important habitats and is particularly renowned for its assemblage of 65,000 estuarine birds (some 45,000 more than is required to become "internationally significant" under the EU Birds Directive). As well as some of the problems commonly associated with tidal barriers (turbines causing increased fish mortality and water quality issues), the creation of the large tidal barrage would reduce the tidal range by as much as 50%. Such a reduction would result in an irreversible loss of an estimated 14,400 ha of spring-tide intertidal habitats and would significantly affect salt marsh and several transitional habitats through less-frequent inundation (Sustainable Development Commission 2007).

In both examples governments are keen to see the projects implemented, not least because they will help in meeting carbon-reduction targets. The decisions to go ahead will hinge on whether they can circumvent the national and European conservation designations, which ultimately means that after an "appropriate assessment" is carried out, and if this is unfavourable, they will seek acceptance that there are "imperative reasons of overriding public interest" for the developments (European Commission 1992). The key is *public interest*, and the onus becomes to demonstrate that conserving biodiversity is in the public interest. But herein lies the problem: how can one convince decision makers that biodiversity is worth conserving? One approach is to adopt the ecosystem services paradigm (Millennium Ecosystem Assessment 2005). This concept employs a utilitarian valuation of all aspects of biodiversity and outlines the services or goods that are vital for human society. Although there has been little uptake of it in conservation planning and assessments thus far (Egoh et al. 2007), the use of such a concept has considerable utility for conserving biodiversity.

Examples of win–win–win schemes do exist, however, and there are viable opportunities to apply this approach (Convention on Biological Diversity 2003). Even the increasingly controversial bioenergy sector shows promise for producing low-input, high-biodiversity biomass on degraded soils (Tilman et al. 2006). Perhaps the best example can be seen in forest management, and in particular, the conservation of biodiversity-rich forests (Righelato & Spracklen 2007). The promotion of carbon trading to preserve old-growth tropical forests from deforestation activities would have significant positive effects for mitigation (reducing one of the largest emissions of carbon to the atmosphere each year), adaptation (e.g., reducing floods and erosion [Bradshaw et al. 2007]), and biodiversity (protecting some of the richest ecosystems on Earth [Laurance 2007]). Nevertheless, there are too many proposed schemes of other types (e.g., large dams) that could have detrimental effects on biodiversity. Until we recognize that conserving biodiversity is in the interest of local and global communities, the very schemes put in place to prolong our welfare and prosperity may, perversely, curtail them.

Acknowledgments

This work was supported by the European Union MACIS (Minimisation of and Adaptation to Climate change: Impacts on Biodiversity) project, contract number 044399.

Literature Cited

Adger, W. N., S. Agrawala, M. M. Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit, and K. Takahashi. 2007. Assessment of adaptation practices, options, constraints and capacity. Pages 717–743 in M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, editors. Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, United Kingdom.

Araújo, M. B., W. Thuiller, and R. G. Pearson. 2006. Climate warming and the decline of amphibians and reptiles in Europe. Journal of Biogeography **33:**1712–1728.

Bradshaw, C. J. A., N. S. Sodhi, K. S. H. Peh, and B. W. Brook. 2007. Global evidence that deforestation amplifies flood risk and severity in the developing world. Global Change Biology **13:**2379–2395.

Convention on Biological Diversity. 2003. Interlinkages between biological diversity and climate change. Advice on the integration of biodiversity considerations into the implementation of the United Nations Framework Convention on Climate Change and its Kyoto Protocol. Secretariat of the Convention on Biological Diversity, Montreal.

Drewitt, A. L., and R. H. W. Langston. 2006. Assessing the impacts of wind farms on birds. Ibis **148:**29–42.

Egoh, B., M. Rouget, B. Reyers, A. T. Knight, R. M. Cowling, A. S. van Jaarsveld, and A. Welz. 2007. Integrating ecosystem services into conservation assessments: a review. Ecological Economics **63:**714–721.

European Commission. 1992. Council directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. European Commission Environment DG, Brussels. Available from http://ec.europa.eu/environment/nature/ legislation/habitatsdirective/index_en.htm (accessed December 2007).

European Commission. 2007a. European parliamentary questions 20 April 2007: answer given by Mr. Dimas on behalf of the Commission in response to written question (E-0533/07) by Carlos Coelho (PPE DE) to the Commission. Commission of the European Communities, Brussels.

European Commission. 2007b. Green paper from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions—Adapting to climate change in Europe—options for EU action. Commission of the European Communities, Brussels.

Farley, K. A., E. G. Jobbágy, and R. B. Jackson. 2005. Effects of afforestation on water yield: a global synthesis with implications for policy. Global Change Biology **11:**1565–1576.

Hampe, A., and R. J. Petit. 2005. Conserving biodiversity under climate change: the rear edge matters. Ecology Letters **8:**461–467.

Klein, R. J. T., E. L. F. Schipper, and S. Dessai. 2005. Integrating mitigation and adaptation into climate and development policy: three research questions. Environmental Science & Policy **8:**579–588.

Kundzewicz, Z. W., et al. 2007. Freshwater resources and their management. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, editors. Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom.

Laurance, W. F. 2007. A new initiative to use carbon trading for tropical forest conservation. Biotropica **39:**20–24.

Lopez de Heredia, U., J. S. Carrion, P. Jimenez, C. Collada, and L. Gil. 2007. Molecular and palaeoecological evidence for multiple glacial refugia for evergreen oaks on the Iberian Peninsula. Journal of Biogeography **34:**1505–1517.

Millennium Ecosystem Assessment. 2005. Ecosystems and human well-being: biodiversity synthesis. World Resources Institute, Washington, D.C.

Ministério do Ambiente do Ordenamento do Território e do Desenvolvimento Regional. 2007. Programa nacional de barragens com elevado potencial hidroeléctrico. Instituto da Água, Lisbon, Portugal. Available from http://www.inag.pt/inag2004/port/diversos/ temporario/seguranca/Seguranca.html (accessed December 2007).

Parmesan, C. 2006. Ecological and evolutionary responses to recent climate change. Annual Review of Ecology, Evolution, and Systematics **37:**637–669.

Parry, M. L., et al. 2007. Technical summary. Pages 23–78 in M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, and C. E. Hanson, editors. Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom.

Pielke, R., G. Prins, S. Rayner, and D. Sarewitz. 2007. Lifting the taboo on adaptation. Nature **445:**597–598.

Raghu, S., R. C. Anderson, C. C. Daehler, A. S. Davis, R. N. Wiedenmann, D. Simberloff, and R. N. Mack. 2006. Adding biofuels to the invasive species fire? Science **313:**1742–1742.

Righelato, R., and D. V. Spracklen. 2007. Carbon mitigation by biofuels or by saving and restoring forests? Science **317:**902.

Scharlemann, J. P. W., and W. F. Laurance. 2008. How green are biofuels? Science **319:**43–44.

Sustainable Development Commission. 2007. Turning the tide, tidal power in the U.K. Sustainable Development Commission, London.

Thomas, C. D., et al. 2004. Extinction risk from climate change. Nature **427:**145–148.

Thuiller, W., S. Lavorel, M. B. Araújo, M. T. Sykes, and I. C. Prentice. 2005. Climate change threats to plant diversity in Europe. Proceedings of the National Academy of Sciences of the United States of America **102:**8245–8250.

Tilman, D., J. Hill, and C. Lehman. 2006. Carbon-negative biofuels from low-input high-diversity grassland biomass. Science **314:**1598–1600.

Tsoutsos, T., N. Frantzeskaki, and V. Gekas. 2005. Environmental impacts from the solar energy technologies. Energy Policy **33:**289–296.

World Commission on Dams. 2000. Dams and development: a new framework for decision-making. World Commission on Dams, Cape Town, South Africa.