

## Interdisciplinary Climate Change Collaborations Are Essential for Early-Career Scientists

Climate change research is an interdisciplinary field, and understanding its social, political, and environmental implications requires integration across fields of research where different tools may be used to address common concerns [Baerwald, 2010]. One of the many advantages of interdisciplinary approaches is that they open communication between complementary fields, filling knowledge gaps and facilitating progression within both individual fields and the broader field of climate change research [Ludwig et al., 2011].

However, despite the clear benefit of interdisciplinary approaches [e.g., Williams et al., 2008], collaborations among scientists from the natural and social sciences are still relatively uncommon [Ceballos et al., 2010]. Current academic training promotes specialization, which may hinder our ability to parse interactions between different scales of organization, limiting our ability to extrapolate to the multiple levels of organization critical for climate change research.

A useful but underutilized solution to tackle this obstacle is to facilitate collaboration among scientists with different specializations [Root and Schneider, 2006]. This is particularly important for early-career scientists, for whom integration across subfields may influence the focus of research programs as they become established and will encourage a tradition of broad-scale interactions.

Early-career researchers, particularly graduate students and postdoctoral research associates, should be encouraged to participate in interdisciplinary conversations for three main reasons. First, technological advances require greater cross-discipline understanding. For example, in biology, to apply genomic tools within a climate change context, one may need to integrate expertise in genomics with knowledge of ecological processes occurring at the level of populations, communities, and landscapes. Second, current graduate students and postdoctoral researchers are disproportionately responsible for moving the field of climate change research forward as they establish new research programs and directions. If scientists become habituated to considering approaches from different disciplines early in their careers, such approaches will become more common later in their careers. Finally, the effect of climate change

is global, suggesting that this research will benefit from international collaborations lending a global perspective.

One practical way to facilitate interdisciplinary research is to offer international courses or convene working groups or research networks for young researchers who share a common interest in climate change research but have different backgrounds. While this suggestion may not be novel, we feel that its relevance is not emphasized within the current academic curriculum.

We recently participated in one such course entitled “Ecological Consequences of Climate Change: Integrating Research Approaches” offered by the Estación Biológica de Doñana (Consejo Superior de Investigaciones Científicas), Spain. This course brought together 15 advanced graduate students and postdoctoral research associates, representing 8 countries, with a variety of research interests in climate change. The course provided the opportunity to discuss experimental and modeling approaches to climate change research in the absence of field-specific constraints. Although this course focused on integrating climate change research approaches across the subfield of ecology, it does represent a model to build upon. More well-known examples of interdisciplinary courses and research centers that facilitate synergy among researchers with different backgrounds include the U.S.’s National Center for Ecological Analysis and Synthesis (NCEAS), National Evolutionary Synthesis Center (NESCent), and Santa Fe Institute, along with the European SIZEMIC research network. These institutions provide a platform to develop cross-disciplinary approaches to climate change research.

Courses like the recent one in Spain, along with centers for collaboration through established institutes, provide great utility and should not be as scarce as they are currently. There is clearly a need to broaden the scope of interdisciplinary climate change research and integrate natural sciences into the applied social and economic sciences. As an early-career scientist, specialization can be necessary to become an expert in a discipline, but the full value of specialization manifests when experts from different

disciplines coalesce to enhance the gaps in each other’s knowledge. For example, ecologists have been grappling with understanding broad-scale vegetation responses to climate change using experimental methods that generally capture small-scale biotic interactions. Recently, however, ecological investigations have integrated remote sensing techniques that facilitate more accurate and extensive documentation of biome-wide vegetation responses to environmental changes [e.g., La Puma et al., 2007], leading to improved forecasts of the ecosystem-level consequences of climate change. Without collaboration between the ecological and remote sensing community, this bird’s-eye view of ecological changes could not have been produced.

Another important area of social and economic interest that can benefit from experience among complementary fields is sustainable development and conservation strategies under a climate change regime. For example, a study conducted in the Middle East territories combined knowledge of ecological processes involved in the water cycle with geomorphological, hydrological, and climatological expertise to propose optimal water management strategies [Tielbörger et al., 2010]. Concurrently, collaboration between social scientists and economists identified the role of local cultural activities in maintaining the natural water resources [Fleischer and Sternberg, 2006; Tielbörger et al., 2010].

The above example represents efforts to bridge Earth and environmental science with social science. However, even though assessments on the far-reaching implications of climate change on ecosystem balance, as well as on society, have been anticipated over the past 2 decades [Gucinski et al., 1990; Millennium Ecosystem Assessment, 2005], effective collaborations between social disciplines and climate change research are not yet common. Climate change research needs to bridge the gap between disciplines, both within and outside of Earth science, and apply research approaches that incorporate linkages among disciplines.

Yet such collaborations have eluded the community. For this reason, incorporating these linkages at early stages in an academic career is necessary to move the newest generation of the scientific community toward establishing collaborations by rote. Such interdisciplinary opportunities, established through international courses or working groups, have the potential to influence the trajectory of climate change research as students complete graduate training and initiate their own research programs.

Thus, scientific institutions should be encouraged to develop and secure funding for such interdisciplinary programs and should strongly encourage participation of

young researchers during early academic career stages. Only then will research adequately capture complex responses to climate change and encourage social and political change [e.g., Zavaleta et al., 2008].

### References

- Baerwald, T. (2010), Prospects for geography as an interdisciplinary discipline, *Ann. Assoc. Am. Geogr.*, 100, 493–501.
- Ceballos, G., A. Garcia, and P. R. Ehrlich (2010), The sixth extinction crisis loss of animal populations and species, *J. Cosmol.*, 8, 1821–1831.
- Fleischer, A., and M. Sternberg (2006), The economic impact of global climate change on Mediterranean rangeland ecosystems: A space-for-time approach, *Ecol. Econ.*, 59, 287–295.
- Gucinski, H., R. T. Lackey, and B. C. Spence (1990), Global climate change—Policy implications for fisheries, *Fisheries*, 15, 33–38.
- La Puma, I. P., T. E. Phillippi, and S. F. Oberbauer (2007), Relating NDVI to ecosystem CO<sub>2</sub> exchange patterns in response to season length and soil warming manipulations in arctic Alaska, *Remote Sens. Environ.*, 109, 225–236.
- Ludwig, R., R. Roson, C. Zografos, and G. Kallis (2011), Towards an inter-disciplinary research agenda on climate change, water and security in southern Europe and neighboring countries, *Environ. Sci. Policy*, 14, 794–803.
- Millennium Ecosystem Assessment (2005), Ecosystems and human wellbeing: Biodiversity synthesis, report, World Resour. Inst., Washington, D. C.
- Root, T. L., and S. H. Schneider (2006), Conservation and climate change: The challenges ahead, *Conserv. Biol.*, 20, 706–708.
- Tielbörger, K., A. Fleischer, L. Menzel, J. Metz, and M. Sternberg (2010), The aesthetics of water and land: A promising concept for managing scarce water resources under climate change, *Philos. Trans. R. Soc. A*, 368, 5323–5337.
- Williams, S. E., L. P. Shoo, J. L. Isaac, A. A. Hoffmann, and G. Langham (2008), Towards an integrated framework for assessing the vulnerability of species to climate change, *PLoS Biol.*, 6, e325.
- Zavaleta, E. D., C. Miller, N. Salafsky, E. Fleishman, M. Webster, B. Gold, D. Hulsey, M. Rowen, G. Taylor, and J. Vanderryn (2008), Enhancing the engagement of U.S. private foundations with conservation science, *Conserv. Biol.*, 22, 1477–1484.
- ELISE S. GORNISH, Florida State University, Tallahassee; E-mail: egornish@bio.fsu.edu; JILL A. HAMILTON, University of Alberta, Edmonton, Canada; ALBERT BARBERÁN, Centre d’Estudis Avançats de Blanes, Blanes, Spain; BLAS M. BENITO, University of Granada, Granada, Spain; AMREI BINZER, Georg-August University, Göttingen, Germany; JULIE E. DEMEESTER, Paris, France; ROBERT GRUWEZ, Ghent University, Ghent, Belgium; BRUNO MOREIRA, Centre for Functional Ecology, Coimbra, Portugal; SHIRIN TAHERI, Museo Nacional de Ciencias Naturales, Madrid, Spain; SARA TOMIOLO, University of Tuebingen, Tuebingen, Germany; CATARINA VINAGRE, Faculdade de Ciências da Universidade de Lisboa, Lisbon, Portugal; PAULINE VUARIN, Muséum National d’Histoire Naturelle, Paris, France; and JENNIFER WEAVER, University of Toronto, Toronto, Canada