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EDITORIAL

The Future of Human–Landscape Interactions: Drawing on the Past, Anticipating the Future

Anne Chin · Kathleen A. Galvin · Andrea K. Gerlak · Carol P. Harden · Ellen Wohl

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Without question, humanity is at a crossroad amidst rapid environmental changes. Some of these changes are natural, such as climate variability, but human-induced alterations on Earth have accelerated in recent decades, reaching a scale and intensity like never before. Virtually no place on Earth remains untouched by human activity. With a growing human population expected to exceed 10 billion people in coming decades (United Nations 2010), human interactions with Earth will likely continue to accelerate. A formal proposal to name a new timeframe within the Geological Time Scale, the "Anthropocene" (Crutzen and Stoermer 2000), is in development for consideration by the International Commission on Stratigraphy (Zalasiewicz et al. 2011). This proposed geologic timeframe recognizes the undeniable role of human activity in affecting Earth's functioning, and is now widely debated among academic scientists, practitioners, and the public alike (e.g., Balter 2013).

In light of increasing recognition of human interactions with Earth, this special feature explores new scientific questions and frameworks for tackling research frontiers for understanding human–landscape systems. These questions and frameworks derive from multidisciplinary perspectives, developing from discussions among 50 physical, social, and biological scientists gathered in a 3-day workshop sponsored by the U.S. National Science Foundation (NSF), held at the University of Oregon, USA (Chin et al. 2010). The workshop responded to a need to catalyze new research paradigms about the future of Earth's surface in light of increasing human interactions. Outlined in recent reports to NSF's Geosciences Directorate (NSF 2009; NRC 2010), these paradigms require development of new theories and predictive capacity for integrated human–landscape systems. In particular, the report by the U.S. National Research Council, *Landscapes on the Edge: New Horizons for Research on Earth's Surface* (NRC 2010) identified a Grand Challenge in: "How will Earth's surface evolve in the "Anthropocene"? In highlighting the need to account explicitly for human–process interactions in understanding the change on Earth's surface, the report recommended creation of new collaborations across the geosciences, biological sciences, social sciences and engineering, in addition to development of new conceptual frameworks and methods. Team-based interdisciplinary studies of Earth's surface processes were also a primary recommendation in NRC's 2011 report, New Research Opportunities in the Earth Sciences, specifying development of models of the active role of humans in landscape change.

The papers in this feature contribute to a view of human–landscape systems in which advances in a range of disciplinary sciences feed into an integrated core (Fig. 1; Harden et al. 2014, this issue). These disciplines span the social, biological, and geological sciences and include anthropology, archeology, atmospheric science, ecology, economics, geography, geomorphology, political science, and sociology. Harden et al. provide an overview of the science of human–landscape systems as explored in the 2010 Oregon workshop. Key questions are identified within contributing disciplines, leading to a discussion of

A. Chin (✉)
University of Colorado Denver, Denver, CO, USA
e-mail: anne.chin@ucdenver.edu

K. A. Galvin · E. Wohl
Colorado State University, Fort Collins, CO, USA

A. K. Gerlak
University of Arizona, Tucson, AZ, USA

C. P. Harden
University of Tennessee, Knoxville, TN, USA

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challenges and opportunities for an integrated science at this juncture. Wohl et al. (2014) explore the composition of the integrated core science (center of "flower" schematic in Fig. 1; Harden et al. 2014, this issue) by identifying themes common among the physical, biological, and social sciences feeding into it, as represented in the disciplines of geomorphology, ecology, and environmental governance. These themes include feedbacks, thresholds or tipping points, space and time scales, and connectivity, providing promising areas for interdisciplinary research. Example applications of the Interactive, Integrative, and Iterative Framework for Human Landscape Change illustrate how the framework allows conceptualization of contemporary human–landscape interactions as well as longer-term evolution of the Earth system under human intervention.

The next set of papers develops some of the disciplinary research questions that feed into the integrated core science (petals of the "flower" schematic in Fig. 1; Harden et al. 2014, this issue). In reviewing the state of knowledge, these papers draw upon the rich histories within the disciplinary sciences that have brought us to this juncture, and discuss the new interdisciplinary directions with potential for meeting the challenges of the future. Thus, Chin et al. (2014) discuss feedbacks in coupled human–landscape systems and identify key questions and challenges for geomorphologists. Perdinan and Winkler (2014) focus on climate assessments for addressing the impacts, vulnerability, and adaptive capacities of human–landscapes to climate change. Peterson et al. (2014) outline how economic processes are intertwined with landscape change, reviewing the state of the science while describing key questions about the economics of landscape change. Similarly, Gerlak (2014) discusses how research in environmental policy and governance has contributed to the integrative themes of thresholds and tipping points, spatial scales and boundaries, feedback loops, and time scales and time lags. Promising research questions are identified for advancing interdisciplinary research for human–landscape systems.

The last three papers discuss methodological issues including ongoing challenges and emergent opportunities for integrating human and bio-physical components of landscape systems. Kondolf and Podolak (2014) explore spatial and temporal scales and show the vast range of scales encountered in linking human and bio-physical landscapes, where mis-matches in scales could potentially result in unsustainable land-use practices. Lach (2014) addresses one of the most challenging aspects of studying human–landscape systems, whereby scholars using quantitative and qualitative methods must reconcile these different approaches for effective interdisciplinary research. Because those who use qualitative methods are primarily a subset of social scientists, difficulties may arise when collaborating with natural and social scientists rooted in quantitative research. After reviewing the philosophical underpinnings of qualitative and quantitative approaches in research, Lach suggests that a pragmatic, realist approach may allow natural and social scientists to work together productively. Finally, Zvoleff and An (2014) bring attention to a set of emergent tools with potential to integrate data obtained from a broad range of sources. These tools include data fusion, simulation modeling, and participatory approaches. The relative strengths of each tool are outlined, providing guidance for future researchers.

This special feature would not have been possible without the lively and productive contributions from the diverse participants of the Oregon workshop. We would like to thank all of these individuals, as well as the authors who subsequently developed some of the ideas discussed at the workshop into papers. We would also like to thank the National Science Foundation (Geomorphology and Land Use Dynamics Program and Geography and Spatial Sciences Program) for sponsoring the workshop and a subsequent meeting in which the organizers synthesized the discussions and outcomes. The University of Oregon and University of Colorado Denver provided additional financial and logistical support which is gratefully acknowledged. Finally, we thank the many reviewers of the papers in this issue for their efforts in evaluating and improving the manuscripts. The authors hope that the ideas and examples in this set of papers will stimulate new collaborations across disciplines and generate novel efforts to link research on human and landscape systems. The time has come to break old barriers and take our science to new heights.

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