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Framing and Reframing Questions of Human–Environment Interactions

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Ways in which geographers have framed research on human–environment interactions have changed over time. This review emphasizes the limitations of previous ways of framing human–environment research and indicates new opportunities to be pursued by reframing the research questions. It begins with the research and influence of W. M. Davis and follows with research framed as environmental determinism, human ecology, natural hazards, human impacts on the environment, and sustainability. Studies of interactions between people and environments are central to geography, but such studies have dominantly been one-sided as a result of the type of relationship studied or the perspectives (physical or social) brought by the investigators. Awareness of the nature of nature and the dynamic, interactive behavior of biophysical and human systems has the potential to bring new perspectives to the traditional human–environment dichotomy. Because many of the world's important problems involve interactions between people and environments, geographers are encouraged to turn their attention to this core area of the discipline. Research opportunities include studies of the effects of environmental change on human populations, including the complex web of interactions and feedbacks involved; studies of how environmental services are valued and managed; and other studies that provide knowledge to support more sustainable human–environment interactions, especially in an urbanizing world. *Key Words: determinism, human–environment, human impact, nature–society dichotomy, sustainability.*

地理学家拟定的关于人类与环境相互作用的研究方式，已经随着时间的推移而改变。本评论强调以前所制定的人环研究方法的局限性，并表明可以通过重新定义研究问题，寻求新的机会。它由 W. M.戴维斯的研究和影响开始，然后评论环境决定论，人类生态环境，自然灾害，人类对环境的影响，以及可持续发展等研究。人与环境之间的相互作用的研究是地理研究的中心，但是这种作为关系类型的结果或研究者所持观点（自然或社会）的研究，具有明显的片面性。对自然性质以及生物物理和人类系统的动态的交互行为的认识，有可能给传统的人类与环境的二分法带来新的视角。由于世界上许多重要的问题，涉及人与环境之间的相互作用，我们鼓励地理学家把注意力转向本学科的这个核心区。研究的机会包括环境变化对人的影响，以及所涉及的复杂的交互和反馈网络；研究环境服务是如何被评价和管理的；和其它的，特别是在这个城市化的世界，可支持更持续的人环相互作用的研究。*关键词：确定性，人类与环境，人类的影响，自然—社会对立，可持续性。*

El modo como los geógrafos enmarcan la investigación sobre las interacciones hombre–medio ha cambiado a través del tiempo. La presente revisión del tema destaca las limitaciones de la manera como anteriormente se encuadraba este tipo de investigación, al tiempo que mediante una reformulación de las preguntas de investigación se indican nuevas oportunidades para ser exploradas. Todo comienza con los trabajos de investigación e influencia de W. M. Davis y sigue con las investigaciones fraguadas como determinismo ambiental, ecología humana, riesgos naturales, impactos humanos sobre el medio ambiente, y sostenibilidad. Los estudios sobre las interacciones de la gente con su entorno ocupan un lugar central en geografía, aunque tales estudios han sido predominantemente unilaterales como resultado del tipo de relaciones estudiadas o de las perspectivas (físicas o sociales) que han orientado a los investigadores. La conciencia sobre lo que es naturaleza y el comportamiento dinámico e interactivo de los sistemas biofísicos y humanos tienen el potencial de aportar nuevas perspectivas a la tradicional dicotomía hombre–medio ambiente. Debido a que muchos de los problemas importantes del mundo involucran las interacciones entre la gente y sus entornos, se estimula a los geógrafos para que dirijan su atención a esta área medular de su disciplina. Al respecto, las oportunidades de investigación incluyen estudios relacionados con los efectos del cambio ambiental

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sobre las poblaciones humanas, incluso la compleja red de interacciones y mecanismos de retroalimentación involucrados; estudios sobre cómo se evalúan y manejan los servicios ambientales; y otros estudios generadoras de conocimiento con el que se puedan respaldar las interacciones hombre–medio ambiente más sostenibles, especialmente en el mundo urbanizado. *Palabras clave: determinismo, hombre–medio, impacto humano, dicotomía naturaleza–sociedad, sostenibilidad.*

Consciously or unconsciously, we frame research questions within certain intellectual spaces. In designing research projects, we build on what has been done before and, in seeking support for research, strategically connect our ideas to "hot" topics of our times. The process of framing questions positions the research within a particular disciplinary context and establishes relationships with broader intellectual conversations. When a research framework is well established, it is recognized as a paradigm and part of "normal science" (Kuhn 1970). Even within a research paradigm, however, certain frameworks are more popular than others. Sherman (1996) referred to fashion in geomorphology, noting that, "Few of us would admit to being part of a disciplinary proletariat that is chained to an intellectual hegemony forged by a few academic power brokers more than a half century ago. But most of us are" (89).

Thus, on one hand, working within a given research framework is a desirable, focused way to promote the systematic extension of knowledge; on the other hand, it constrains the boundaries of investigation. From a practical standpoint, positioning an investigation within an existing framework helps justify the research and connects the researcher to others engaged in related efforts. From an intellectual standpoint, achieving objectivity requires consciousness of the broader ways in which these frameworks reflect values, social norms, and, perhaps, the disproportionate influence of a "fashion dude" (sensu Sherman 1996). Therefore, it is important to step back occasionally and reflect on the positions of our research frameworks in broader intellectual and social landscapes.

With hindsight, we can more clearly see the dominant ways in which geographers have framed research questions on human–environment interactions over the past century. Since the formation of the Association of American Geographers (AAG), new modes and tools of research and communication have been developed, and landscapes themselves have changed. Here, I revisit this core area of our discipline to explore (1) changes over time in the ways in which geographers have framed questions of human–environment interactions and (2) the contemporary status of and potential opportunities in this core area of geographical research.

Dominant Ways of Framing Human–Environment Research

Earth Science in Geography at the Founding of the AAG

The discipline of geography and the AAG have deep roots in physical geography. The appointment of William Morris Davis as an instructor of physical geography in the geology department of Harvard University in 1878 has been cited as the establishment of geography as a scientific subject in American universities (P. E. James and Martin 1981), although geography had been taught in American colleges and universities since the mid-seventeenth century. Davis, a founder of this Association, served as its first president in 1904 and as president in 1905 and 1909.

Davis was an influential personality and a prolific writer. A geomorphologist, he was publishing at a time when describing landforms and explaining their differences was mainstream science. New journals were established during the span of his career, including *Science* in 1883 and *National Geographic* in 1888. Davis's personal influence (read, "fashion dude") gave the Earth science tradition a central position in American geography. His writings framed research in geography as dominantly physical geography, with greater emphasis on the land surface than on the atmosphere and oceans (Leighly 1955). But Davis can also be credited with helping to expand the focus of academic geography in the United States, from a dominantly Earth science focus to a broader, nature–society focus (Leighly 1955). Davis's writings in the early 1900s expressed this broader view:

> Let it then be here agreed that the whole content of geography is the study of the relation of the earth and its inhabitants. We thus see two prime divisions of the subject. One includes the physical environment of life; the other all those responses which life has made to the environment. (Davis 1902, 240)

> Any statement is of geographical quality if it contains a reasonable relation between some inorganic control, and some fact concerning the existence of growth of behaviour or distribution of the earth's organic inhabitants, serving as a response; more briefly, some relation between an element of inorganic control and of organic response. (Davis 1909, 8)

These statements frame a worldview in which people respond to conditions presented by the physical environment. Davis outlined a two-part system in which inorganic factors are causal and organic factors are dependent. At that time, in the first years of the twentieth century, world population was less than 2 billion (United Nations 1999), the U.S. population was predominantly rural, and even the wealthy in the United States did not have the automobile, air travel, radio, television, or antibiotics. It is easy to imagine that the average American depended more directly on the natural environment in 1909 than is the case in the twenty-first century.

Scientific thinking and public discourse of the late nineteenth and early twentieth centuries was profoundly affected by the concept of evolution. Publication of Charles Darwin's work on the origin of species (Darwin 1859 and subsequent editions) and the new paradigm of evolution influenced the development of theory not only in biology but also in geography. William Morris Davis is widely remembered for his cycle-of-erosion concept (Davis 1884). The cycle of erosion, describing the evolution of landforms from youth to maturity to old age, appealed to geomorphologists and educators for its simplicity and persisted in geographic and geologic education for well over half a century. In retrospect, we criticize the cycle of erosion for its lack of process-based explanation and inattention to climate (Beckinsale and Chorley 1991), but it persists, even today. Also prominent among geographers influenced by the concept of evolution were those who promoted the explanatory framework of environmental determinism.

Environmental Determinism

The focus on evolution led to the framing of human–environment questions in geography as environmental determinism. In this framework, the environment is the cause (independent variable) and the evolution of human and societal traits is the response (dependent variable; Figure 1A). Two influential North American geographers who promoted environmental determinism were Ellsworth Huntington and Ellen Churchill Semple. Both served as AAG president, Semple in 1921 and Huntington in 1923. Applications of environmental determinism were commonly framed with climate as the independent variable. Unfortunately, such applications were carried too far without objective, systematic inquiry. The following statements represent extreme examples:

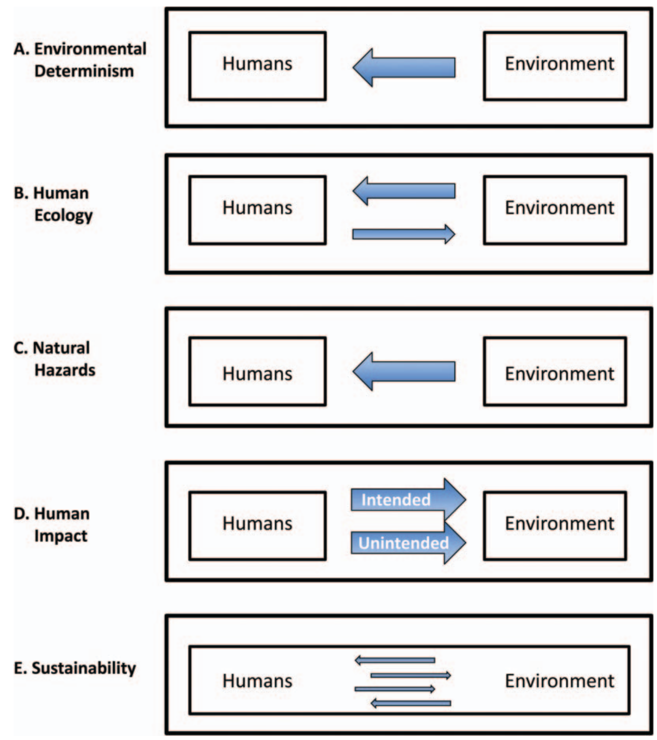

Figure 1. In each way of framing studies of human–environment interactions (A–E), the arrows represent the direction(s) of causation (from independent to dependent variable). (Color figure available online.)

> Transfer to the Tropics tends to relax the mental and moral fiber, induces indolence, self-indulgences, and various excesses. (Semple 1911, 626)

> Thus, if white colonization takes place on a large scale within the tropics, there is grave danger that the physically strong but mentally lethargic elements will be the ones to become the ancestors of the future population. (Huntington 1924, 70)

Looking back, we criticize environmental determinism for numerous reasons, not least for ways in which we now see that it promoted stereotypes, justified racism, and fostered imperialism (Peet 1985). Even in its heyday, however, environmental determinism was not espoused by all geographers, and the popularity of environmental determinism later became a source of embarrassment. Geography reacted strongly, turning almost completely away from studies of environmental influences on people and societies. The reaction was so strong that it essentially created a taboo for researchers interested in human–environment interactions and, in doing so, created a research gap that remains to this day. Another consequence of the outright rejection of environmental determinism was that physical geography became confused with determinism (Marcus 1979).

In a very broad sense, geography's affair with environmental determinism was an example of the scientific process. In a genuine search for explanation and theory, influenced by a tidal wave of Darwinism and the possibilities of explanations involving evolution, environmental determinists proposed explanations. In retrospect, the rise and fall of environmental determinism demonstrates the need not just for theory but for successful explanation to be supported by systematic investigation and robust evidence and, as much as possible, to be independent of prevailing ideologies. The process of science subjects explanations, even popular ones, to further testing and releases those that are not supported. The concept of environmental determinism, like the theory of continental drift, provided a stepping stone for the advancement of knowledge, even though it was subsequently rejected as new perspectives and new information emerged. Why did environmental determinism persist as long as it did? Its success has been linked to its support of prevailing national and cultural biases (Peet 1985) and to the prominence and authority of its champions.

More recent forays into big-picture views of the effects of environments on people have produced work considered "neo-environmental determinism" and criticized by academics for having many of the same problems as the old determinism. That the Pulitzer Prize–winning book *Guns, Germs, and Steel* (Diamond 1997) has been both widely popular and roundly criticized exemplifies widespread interest in unraveling and better understanding human–environment interactions and, at the same time, academic discomfort with generalizations that lack the support of rigorous, controlled studies (Sluyter 2003; Judkins, Smith, and Keys 2008). Neo-environmental determinism has also been criticized for portraying humans as passive beings, incapable of adapting to environmental change (Erickson 1999). Today's conditions of relatively rapid and widespread environmental change create an urgent need to better understand, from perspectives internal and external to existing cultures, the effects of these changes on individuals and societies and the nature and limits of human adaptation to environmental change. Researchers still face the challenges of recognizing their own perspectives while capturing the complexity of human–environment interactions in their work.

Human Ecology, Cultural Ecology, Political Ecology

Even as environmental determinism remained a popular way of framing geographic inquiry, it was actively opposed by other leading geographers, including Harlan Barrows and Carl Sauer. In his 1923 AAG presidential address, Barrows made a strong case for human ecology as the unifying framework of geography. In his view, the discipline of geography was moving toward a focus on the "mutual relations between man and his natural environment" (Barrows 1923, 3). Barrows promoted human ecology as a study of human adjustment to the environment, rather than as the study of environmental influence on humans or human impacts on the environment.

Sauer's geography emphasized cultural landscapes, created not by nature alone but by culture working with nature (Sauer 1925). He applied a fieldwork-based, inductive approach to the challenges of understanding landscapes and people in rural areas and concluded that, although the environment presents and constrains possibilities, it does not determine culture. Although his earlier work treated the natural landscape as a static background for cultural processes, he later wrote about human impacts on the natural environment, expressing concern for the sustainability of agriculture and silviculture (Sauer 1956).

In studies of human–environment interactions framed as human ecology, and later as cultural ecology and political ecology, causality flows both from the environment to humans and from humans to the environment (Figure 1B). Whereas the framework of cultural ecology encompasses the processes by which a society (typically a rural, agrarian society) adapts to the environment, the framework of political ecology has centered on the study of how political and economic structures can explain relationships between human–environment interaction and environmental (primarily land) degradation in the developing world (Bryant 1998).

In the history of the AAG, the development of these research perspectives led to the formation of the Cultural Ecology specialty group in 1980 and its extension in 2002 to become the Cultural and Political Geography specialty group. Framing geographic research around human response to the environment has broadened studies of human–environment interactions from simple cause-and-effect relationships to explorations of the complexity of interrelationships of people and societies to the natural environment. Work in this area, characteristically in the form of studies of small, rural places in developing countries (e.g., Chettri et al. 2002; Cupples 2004), has contributed to the development of a more dynamic view of human–environment interactions and to the recognition of the human role in constructing landscapes.

Natural Hazards

A rich framework for examining effects of natural conditions and processes on people and societies has been that of the study of natural hazards. Geographers have worked to better understand the physical events that become hazards (e.g., Caine 1980; Horn 1993; Mote et al. 1997; Liu and Fearn 2000; Changnon 2010; Matyas 2010; Strope and Budikova 2011) and to characterize and understand human vulnerabilities and responses to them (e.g., Burton, Kates, and White, 1978; Blaikie et al. 1994; Liverman 1994; Tobin 1999; Montz, Cross, and Cutter 2003; Cutter and Finch 2010). In this way of framing research questions, forces of nature are seen as independent agents acting on individuals, human societies, and landscapes (Figure 1C).

Research questions framed in the domain of natural hazards have typically involved extreme, sudden-onset events, but emergent concepts of resilience, adaptation, and mitigation have also proven valuable in studies of gradual-onset hazards (e.g., drought, land degradation) and become central to discussions and predictions of human response to climate change (National Research Council [NRC] 2010a, 2010b). Studies of natural hazards have benefited from close communication between those who study the physical processes and those who study the human and social processes. Although not exclusive to geographers, such studies have created a shared workspace for integrating expertise and have provided a unifying research theme within the discipline. Social science aspects of the research of geographers on natural hazards have had broader application in understanding technologically caused emergencies and even the effects of terrorism (Cutter et al. 2003).

Human Impact on the Environment

In recent decades, a dominant way of framing research in physical geography has been to build knowledge of the processes through which human activities directly and indirectly change physical, biological, hydrological, and chemical attributes of environments. Such framing recognizes that human actions can change the biophysical environment and emphasizes the need to understand human impacts so that undesired anthropogenic changes can be reduced, stopped, or reversed. Framing research questions in the context of human impacts on the environment connects physical geographers and research that might have seemed to be "science for science's sake" to practical concerns of immediate interest to other researchers, funding agencies, and the public. Such concerns include environmental quality and human health, water supply and flooding, climate change, food security, and biodiversity.

Studies of human impacts on an environmental system require baseline knowledge of the behavior of the system prior to (or in the absence of) the impacts and sufficient understanding of system behavior to be able to predict the effects of different types and degrees of human intervention. Because environmental systems involve complex interactions and nonlinear relationships between factors, such studies present great challenges for physical geographers and other biophysical researchers. Framing research as the study of human impact on the environment provides clear, widely understandable justification for the research and, often, a sense of urgency, as future projections of human impacts point to serious crises and environmental restoration has become a multibillion-dollar industry.

The concept of human alteration of the environment is not new in North America. It was central to the writings of George Perkins Marsh ([1864] 1965) and others, as Americans became aware of the effects of forest harvesting on streams and rivers (Glenn 1911), the extent of soil erosion associated with agriculture (Bennett 1939), the effects of pesticide use on the food chain (Carson 1962), and other changes, both evident and subtle, associated with air and water pollution, unsustainable extraction of resources, and human modification of the land surface (Thomas et al. 1956; Turner et al. 1990; Vitousek et al. 1997; Goudie 2000; L. A. James 2011). Recently, Earth scientists have proposed naming the current geological epoch the "Anthropocene" in recognition of the dominant role of humans in landscape change (Steffen, Crutzen, and McNeill 2007; Zalasiewicz et al. 2008).

Consciousness of human impact on the environment extends beyond the discipline of geography, and it increased greatly in the latter half of the twentieth century. The first view of Earth from space in the 1960s was a stunning visualization of the finiteness of Earth and its resources. Since then, increases in mobility, satellite imagery, and the speed and reach of communication have made it evident that few places are uninhabited and fewer are unaffected by human activity. Systematic study using remote sensing has verified that landscapes of the United States are best defined by human activity (Cardille and Lambois 2010). We are aware of this, as we frequently have broad views of landscapes during air travel and on our computer screens. Our ability to monitor, measure, and analyze environmental change has rapidly increased, even as population and resource use have grown. The result is that, despite the inherent variability of environmental systems, we can no longer ignore the effects of human activity on our environments and are forced to recognize that Earth's surface is not a static stage, on which human dramas are enacted, but rather an organic system, vulnerable to perturbation by human actions. The same has proven true of the atmosphere (NRC 2001, 2010a, 2010b; Mastrandrea and Schneider 2010; Holtgrieve et al. 2011).

In the United States, growing awareness of environmental contamination and resource depletion led to the environmental movement of the 1960s and 1970s and to new governmental policies to protect the environment from unintended, undesired consequences of human activities. These included the National Environmental Protection Act (1969), the Clean Air Act (1970), the Clean Water Act (1972), and the Endangered Species Act (1973). Establishment of the U.S. Environmental Protection Agency (U.S. EPA) in 1970 demonstrated institutional recognition that the natural environment was vulnerable to change and that air, land, water, and biota needed the degree of protection afforded by federal authority.

Studies of human impact on the environment have tended to focus on unintended consequences of human actions, such as alteration of air, water, and soil chemistry (Holtgrieve et al. 2011) changes in hydrological regimes (Chen et al. 2001) introduction of toxins (Robbins, Polderman, and Birkenholtz 2001), reduction in habitat for certain species (Malanson 2002); or changes in physical properties, such as surface albedo (Vitousek et al. 1997; Pielke et al. 2002). Row crop agriculture, for example, can have the unintended consequence of accelerating rates of soil erosion, which has the further undesirable effects of decreasing the productivity of the agricultural field, increasing the turbidity of nearby streams and rivers, and creating unwanted deposits of fine sediments in locations where they alter aquatic habitats, plug drainage systems, and fill reservoirs. The work of Hooke (1994, 2000) served as a wake-up call to the fact that much anthropogenic change is done deliberately, with purpose. Using data on housing starts, mining, and highway construction, he calculated that more Earth materials are now moved by people than by natural processes.

Human-impact research continues to identify gaps in knowledge of the past and pose new challenges in the important efforts to understand environmental and human–environmental systems well enough to model and predict them. It has also provided a good scientific basis from which to design ways to correct problems and "restore" more natural conditions. The human-impact framing also has limitations, however. It is based on a unidirectional relationship that separates humans from the environmental system (Figure 1D), as opposed to a multidirectional relationship that incorporates feedback, or a more holistic relationship that sees human beings as part of the environmental system (are we an invasive species?). And because researchers bring values, ranging from economic to religious, to their views of human–environment interactions, it is important to occasionally step back and examine the framework of human impacts on the environment from an even broader perspective.

Changing Concepts of Nature

The Nature–Society Dichotomy

Most ways in which geographers have framed research questions of human–environment interaction over the past century have reflected a philosophical view of humans as separate from nature. This dichotomy, exemplified in the boxes in Figure 1, has allowed us to simplify complex systems and investigate subsystems within them. Studies of human impacts on the environment have destabilized this view by showing that the environment changes as a result of human activity. In addition, contemporary thought about the social construction of nature reminds us that the contents of the "environment" boxes (Figure 1) might be interpreted differently by persons holding different political or philosophical perspectives (e.g., Demeritt 2002).

We now realize that human–environment relationships are complex and involve many types of feedbacks and interactions. We also realize that the dichotomous view, which puts environment in one box and humans in another, is just one of many ways of viewing relationships between people and nature. McKibben (1989) argued that we have reached the end of the notion that nature, as we have known it, is permanent and noted that the concept of the separation of human society from nature has been undermined by the effects of human activities, such as changes to atmospheric chemistry and climate, genetic engineering, and water management. That people now regulate and alter much of what was once considered "natural" breaks down the separation of humans from environments.

The Death of Stationarity

In the environmental sciences, the ability to predict future conditions has been based on knowledge of what has occurred in the past. With climate, for example, we refer to departures from the mean conditions as *anomalies*. Droughts and floods surprise us. Our systems of prediction, such as flood-frequency analysis, have been based on placing a given event in the context of the frequency and magnitude of past events, with the assumption that landscapes of today function the same way as landscapes of a century ago. Now, however, we are forced to recognize that such "stationarity" of environmental and atmospheric systems cannot be assumed (Milly et al. 2008). Urbanization changes the hydrology, vegetative composition, and heat exchange of an area; sediments fill river channels; groundwater pumping changes the discharge of rivers; exotic species and monocultures dominate much of the landscape; and climates are changing. Researchers and managers can no longer rely on relationships determined from the past to predict those of the future—present conditions are without a past analogue (International Council for Science 2010). This is particularly true for water management. Researchers obtaining and analyzing hydrologic data face challenges of developing new ways of analyzing data and exploring broader views of causal factors affecting water resources (Galloway 2011; Hirsch 2011).

Frames and Opportunities

A research frame defines an area of content and excludes others. Thus, examining the ways geographers have framed research questions in the area of human–environment relationships over the past century enables us to be more aware of the imprint of broader social and philosophical norms on the framing of research and more conscious of research frames. With hindsight, we can identify limitations in the ways geographers have framed research questions in studies of human–environment relationships. Identifying limitations does not necessarily imply a negative judgment of the value of the past research; rather, it allows us to identify opportunities to advance knowledge in new directions. Yesterday's limits are today's frontiers.

Looking back at the physiography and geomorphology-oriented research of physical geographers of the early twentieth century, we now see the need for more attention to ways in which human activities change the landscape. Conversely, with the pendulum swings of environmental determinism—from a position of great influence, to rejection, to afterlife as a geographical taboo—we now see that geographers turned too far away from considering ways in which people, cultures, and societies are, in fact, influenced by environmental factors. That slate is not completely blank: The tradition of Sauer integrated human responses to environmental conditions, if only at a local scale, and the subfield of natural hazards would not exist if people were not affected by environmental conditions. Research in cultural and political ecology increases our understanding of the ways people respond to and create environmental change on a local scale in rural landscapes; but, at a time when more than half of the global human population lives in urban areas, comparable attention should be given to urban and suburban environments. Fortunately, creative new research on urban areas has begun (e.g., Changnon 1992; Gober et al. 2010). Research on natural hazards has advanced our knowledge of how people understand, prepare for, and respond to extreme events and provided an important foundation for new work to address the challenges of climate change. Because natural hazards research has focused on the catastrophic, it leaves, at its frontier, the need for further study of human–environment interactions under conditions of gradual change.

For the most part, physical geographers have maintained the nature–society dichotomy and focused attention primarily on human impacts to natural systems. Recent research undertaken to distinguish human impacts on the environment from changes resulting from the variability of complex natural systems pushes researchers to consider humans, individuals, and societies as tightly linked to, not separate from, environmental systems (e.g., Ellis and Haff 2009). Moreover, better understanding anthropogenic impacts on environments has led us to recognize that biophysical knowledge alone is insufficient for fixing environmental problems. To reduce or reverse those impacts will require far more than good engineering and the application of scientifically derived knowledge. For example, as we work to understand, prepare for, and modify the effects of climate change, we find our understanding of atmospheric chemistry and atmospheric processes and our ability to monitor and detect change to be relatively well developed, whereas the ability to explain and anticipate the processes that lead to actions (or inactions) by individuals and societies remains less developed (O'Brien and Leichenko 2000; Smit et al. 2000; Dow, Kasperson, and Bohn 2006; NRC 2010a, 2010b).

Ways in which geographers frame human–environment research questions have changed as the magnitude of anthropogenic change, access to information, and perceptions of human–environment relationships have changed. Human impacts on the environment have become more intensive and extensive with population growth, economic development, and increases in mobility. In the absence of dematerialization or increased efficiencies, the increased per capita use of resources that has accompanied economic development would make current practices even less sustainable in the long term (Waggoner and Ausubel 2002). At the same time, greater mobility and the rapid transmission of information (and misinformation) have the potential to make more people aware of the extent to which humanity affects Earth's environments.

Concern for the sustainability of resources and societies has renewed interest in framing research questions around sustainability. Framing questions in terms of sustainability presents exciting new prospects for understanding human activity as part of the Earth system, rather than as separate actors on Earth (Figure 1E). At present, the term *sustainability* is popular in academia, in government agencies (e.g., U.S. EPA 2011), and in the corporate world, where it is equated with corporate responsibility (e.g., Coca Cola 2011). The current concept of environmental sustainability follows from the popular term *sustainable development* of the 1980s and 1990s. Wilbanks (1994), while noting the oxymoronic nature of the phrase, eloquently encouraged geographers to rise to the moral and scholarly challenges and opportunities afforded by its popularity. That challenge remains before us.

Whereas research framed as the study of human impacts on the environment defines environmental problems, highlights needs for change, and adds to knowledge of how environmental systems operate, research framed to advance sustainability must also seek to understand the wide range of factors affecting human actions, integrate human–environment feedback, and identify and test practices expected to lead to a more sustainable future for life on Earth. For geographers, sustainability research invites integration of all types of geographic expertise. It needs the knowledge provided by those who study human impacts and human adjustments and offers a wide research frame that encompasses interdisciplinary efforts, outreach to stakeholders and practitioners, and research that once would have been considered "applied." To be effective, it will need to incorporate feedback in the human–environment system, as achieving sustainable human–environment interactions will require cultural, economic, philosophical, and engineering change.

Marcus (1979, 527) observed that "many of humankind's greatest problems—for example, environmental degradation, overpopulation, resource shortages or maldistributions, failures of urbanization—sit squarely in the geographer's realm" and called on physical and human geographers to "see geography's man-land theme achieve fruition." Geographers have followed his advice, but geography, as a discipline, has not built a strong reputation as the go-to discipline in these areas. A recent report, *Understanding the Changing Planet: Strategic Directions for the Geographical Sciences* (NRC 2010d), shows tremendous opportunity in a series of "Big Problems" that are central to geography and of great importance to society. More than half of those questions are in the human–environment area. We are well aware that these problems are not unique to geography (Kates 1987); thus, we face the challenge of finding our voices as leaders and key contributors to these issues, while continuing to advance our own discipline.

Calls for our collective expertise are coming from many directions. The need to incorporate human activity into studies of landscape systems was a finding by Earth scientists in the NRC (2010c) report *Landscapes on the Edge* and has been made a call to action by the international scientific community (Lambin et al. 2001; Reid et al. 2010). Ecologists have recognized the need to incorporate social science into their work (Mascia et al. 2003; Redman, Grove, and Kuby 2004; Lowe, Whitman, and Phillipson 2009). Similar needs have been expressed internationally. The Millennium Ecosystem Assessment (2005) called for better understanding of feedback between social and biophysical systems in the context of maintaining biodiversity and ecosystem services. In 2011, the United Nations Environment Programme was asked to consider a new assessment body, like the International Panel on Climate Change, to track causes and consequences of anthropogenic ecosystem change (Perrings et al. 2011).

The need to understand, predict, and respond to climate change creates considerable opportunity for research on human–environment interactions. Although we know that human activities affect the climate system, we get into a complicated muddle when we consider mitigating those impacts or restoring the climate system to some previous state. One of the positive outcomes of debates about what to do about climate change is that they compel us to think deeply about relationships between humans and the rest of our planet.

As the need for human–environment research grows, the opportunity costs to geography of not bringing our intellectual resources to bear are great. Fortunately, opportunities to publicly collaborate and lead studies of human–environment interactions are also great. Three examples merit mention here. First is the need to study the effects of environmental change on people, including the complex web of interactions and feedback involved. This will require breaking old taboos; developing new ways of thinking; more fully integrating the physical, human, and GIScience capabilities of geography; collaborating with researchers from other disciplines who are already at work in this area; and disseminating good science beyond the academy (Judkins, Smith, and Keys 2008). Second is the need to examine, at all scales, the values associated with, or attributed to, environmental services (e.g., Costanza et al. 1997; Muradian et al. 2010). This carries opportunities to study indirect as well as direct effects of human action and environmental change and to consider and reconsider the nature of values and the role of humans, local or distant, in managing the environment. Third is the need to advance research that promotes sustainable futures for an urbanizing world.

In the centennial issue of this journal, Zimmerer (2010, Figure 3) included a diagram that mapped nature–society publications over time. Interestingly, the center of the diagram is lighter than surrounding areas. The shading in Zimmerer's diagram fits my perception of the current configuration of activity in the discipline of geography as being stronger toward the periphery than in the center. If geography is a disciplinary doughnut, with important gaps at the center of its intellectual space, then we have a research frontier right at our core. This internal frontier offers new opportunities to integrate our full range of expertise as geographers, from the natural science perspectives of physical geography to the carefully nuanced understandings of those working with people and institutions, to fill critically important research gaps, identified not only by ourselves but also by others.

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