The integration of Human and Physical Geography revisited

Article *in* Canadian Geographer / Le Géographe canadien · September 2016

DOI: 10.1111/cag.12315

1 author:

Andrew S. Goudie
University of Oxford
405 PUBLICATIONS **13,392** CITATIONS

The Canadian Geographer
Le Géographe canadien
Canadian Association of Geographers
Association Canadienne des Géographes

The integration of Human and Physical Geography revisited

Andrew S. Goudie
School of Geography and the Environment, University of Oxford

Key Messages

- There are increasing signs of potential integration within Geography.
- A range of areas for collaboration exists between Human and Physical Geographers.
- Geography is not irredeemably divided.

Although there are still gulfs between Human and Physical Geographers, in the last three decades interest has burgeoned in a whole series of closely and inextricably related areas which lie at the interface between humans and their environment. These include inter alia seven closely interweaved themes: (1) the study of hazards and disasters and of resilience and vulnerability; (2) global changes and their causes, mitigation, and adaption; (3) Earth System Science; (4) human impacts; (5) the Anthropocene; (6) environmental history and environmental influences on human history and prehistory, including migration and settlement abandonment; and (7) the study and appreciation of landscape. These areas can act as foci for a more unified and valuable Geography.

Keywords: integration, Global Change, environment, human impact, Anthropocene

Un regard neuf sur l'intégration de la géographie humaine et physique

Bien qu'un fossé divise encore les spécialistes de la géographie humaine et physique, les trois dernières décennies témoignent d'un intérêt renouvelé pour un ensemble de domaines étroitement et intimement liés se situant à l'interface de l'être humain et de son milieu de vie. Ceux-ci s'articulent notamment autour de sept thématiques étroitement imbriquées : (1) l'étude des risques et des catastrophes ainsi que de la résilience et de la vulnérabilité; (2) les sources, l'atténuation et l'adaptation aux changements globaux; (3) les sciences du système terrestre; (4) les impacts d'origine anthropique; (5) l'anthropocène; (6) l'histoire de l'environnement et les influences de l'environnement sur l'histoire humaine et la préhistoire, y compris la migration et l'abandon des établissements humains; et (7) l'étude et la mise en valeur du paysage. Ces domaines peuvent constituer les fondements d'une vision plus cohérente et valorisante de la géographie.

Mots clés : intégration, changements globaux, milieu de vie, impact d'origine anthropique, anthropocène

Introduction

In 1986 I wrote a somewhat gloomy paper (Goudie 1986) on integration and the unity of Geography. I noted then that some reputable and rigorous geomorphologists (e.g., Worsley 1979) felt that their sub-discipline would be better located within the Geosciences, and that others felt that Physical Geography faced the dilemma that the physical environment was becoming less and less important as a control of the nature and pattern of human activity (e.g., Chorley 1971).

Correspondence to/Adresse de correspondance: Andrew S. Goudie, School of Geography, South Parks Road, Oxford, OX1 3QY, UK.
Email/Courriel: andrew.goudie@stx.ox.ac.uk

The Canadian Geographer / Le Géographe canadien 2017, 61(1): 19–27
DOI: 10.1111/cag.12315

Indeed, Geography remains a discipline with diverging or diverse components: most physical geographers do not publish in mainstream geographical journals; they obtain much of their funding from different and larger sources; in Britain some school syllabuses have in the past tended to offer sparse amounts of Physical Geography; some Geography departments have now split into two; much Human Geography is perceived as essentially a type of sociology; Physical Geography is generally quantitative whereas much Human Geography has become largely qualitative; the language used can be very different (Viles 2005); the separation between physical and human sides of the discipline began to grow "when human geography became increasingly disenchanted with quantitative, positivist methodologies during the 1970s" (Rhoads 2004, 749); and, say, a geomorphologist concerned with the reductionist study of the bedload transport in a flume has very little in common with a human geographer studying queer identities. Demeritt (2009, 5) discusses these problems and also notes that the heterogeneity of Geography means that the familiar human–physical divide is not the only one that needs bridging. He asserts that the discipline "is not divided between two opposing camps, with environmental research as the only link to the opposite shore, so much as it is an archipelago of specialisms, tied to each other and, just as crucially, to other places in myriad ways that the binary bridging metaphor does not capture."

In this new paper I reassess what I said three decades ago and adopt a more optimistic tone, for there has been a burgeoning of interest in a series of closely and inextricably related areas which lie at the interface between humans and their environment (traditionally perhaps *the* central focus of Geography) (see also, Goudie 1994), including *inter alia* (1) hazards and disasters and resilience and vulnerability; (2) global changes and their causes, mitigation, and adaption; (3) Earth System Science; (4) human impacts; (5) the Anthropocene; (6) environmental history and influences on human history and prehistory, including migration and settlement abandonment; and (7) the appreciation of landscape. These seven themes, which are a mix of thematic foci, methodological approaches, and putative new paradigms, offer a range of routes to and from Physical Geography.

Human-environment relationships have become a central concern of society, of many disciplines, and of leading thinkers in Human Geography (e.g., Castree 2011; Tadaki et al. 2012). As a result, Geographers have been re-assessing how society and nature are related and are exploring the implications that this has for the discipline (Lorimer 2015). Cultural ecology—a field concerned with the interactions of cultural practices and environmental or biogeophysical change (Zimmerer 2007)—has arisen. As Lave et al. (2014, 1–2) have argued, "The belief that Physical and Human Geographers are joined by historical inertia rather than any potential or actual intellectual synergy remains common both inside and outside the discipline, and is important to refute." They argue that "there are great mutual benefits from active integration of physical and critical human geography, as demonstrated in the work of geographers who combine critical attention to relations of social power with deep knowledge of a particular field of biophysical science or technology in the service of social and environmental transformation." They term this integrative intellectual practice *critical physical geography (CPG)*. Its central precept is that "we cannot rely on explanations grounded in physical or critical human geography alone because socio-biophysical landscapes are as much the product of unequal power relations, histories of colonialism, and racial and gender disparities as they are of hydrology, ecology, and climate change" (Lave et al. 2014, 2). Debates are now emerging about the value and nature of CPG (see, for example, Tadaki et al. 2015). Other welcome debates have emerged between human and physical geographers with respect to ways of thinking about space and time (see Lane 2001; Massey 2001). It is also clear that the often-alleged decline in the numbers of Physical Geography papers in mainline geographical journals, such as the *Annals of the Association of American Geographers*, is spurious (Aspinall 2010). As Viles (2005) argued, it is by no means clear that Geography is "irredeemably divided."

Hazards and disasters

The study of hazards has become an increasingly important field in applied Geography (Montz and Tobin 2011) and there are many types of, for example, geomorphological hazards, which have implications for development (Brunsden et al. 1982) and for environmental management (Cooke and Doornkamp 1990), even in cities (Cooke 1984).

Pioneer studies by White (1974) showed the importance of human perception of hazards. Subsequently, attention has been directed towards how vulnerability to hazards is related to factors such as poverty and powerlessness (see Fuchs et al. 2011; Hewett 2014) and to consideration of resilience with respect to hazards like drought (Watts 2015). Concurrently, physical geographers have been concerned with the causes, frequency, magnitude, predictability, and possible future increases of hazardous events (e.g., Alcántara-Ayala and Goudie 2010; Smith 2013). Applied geomorphologists can contribute to reducing geomorphic hazards and mitigating human impacts on the landscape by mapping of hazard prone areas; constructing the history of occurrence of past hazardous events; establishing their frequency and magnitude; predicting the occurrence and location of future events; monitoring geomorphological change; and using knowledge of the dynamics of geomorphological processes to advise on appropriate mitigation strategies (Cooke 1992; Goudie 2001). Recent studies of hazards, which include a consideration of their human causes and implications, include ones on dust storms (Goudie and Middleton 2006), coasts (Viles and Spencer 2005), landslides (Glade et al. 2005), and salt weathering (Goudie and Viles 1997). One could also add here Medical Geography and Epidemiology, for the physical environment can have a major influence on the distribution and outbreak of some major diseases, including rift valley fever (Hightower et al. 2012) and human schistosomiasis (Brooker 2007). This is an area where hazardous events need to be considered (e.g., Goudie 2014; Kennedy et al. 2014), as well as future climate changes (Papworth et al. 2015).

Global Change

Wide use of the term *Global Change* emerged in the 1970s and referred principally, though by no means invariably, to changes in international social, economic, and political systems. It included such issues as nuclear proliferation, population growth, inflation, international insecurity, and decreases in the quality of life. However, since the early 1980s the concept has taken on a more geocentric meaning. This was seen in the establishment of the International Geosphere-Biosphere Programme "to describe and understand the interactive physical, chemical and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human activities" (CIESIN, n. d.). The term "global environmental change" has in many senses come to be used synonymously with the more geocentric use of "global change." Appreciation of the importance of Global Change issues for Geography was appreciated as early as 1992 by Cooke, and more recently by Castree (2015b).

Humans play a major role in Global Change, partly through modifying world climates, but also through land cover and land use changes (Slaymaker et al. 2009). These two tendencies are intimately related in that the latter are key feedbacks to climate change. Global warming is not the only major human driver of future geomorphological change. Also of immense, and often of more immediate importance, are other aspects of Global Change, particularly those brought about by modifications of land use and land cover (Pelletier et al. 2015). In spite of the increasing pace of industrialization and urbanization, it is ploughing and pastoralism which create many of our most serious environmental problems and most widespread landscape changes, as they have through much of the Holocene. Land cover modification may cause regional climate changes of comparable dimensions to those predicted to arise from global warming (Avila et al. 2012); changes in stream runoff and sediment loads caused by land cover change or dam construction may exceed those caused by future changes in rainfall (Ericson et al. 2006); loss of coastal wetlands due to direct human action may exceed those caused by sea-level rise (Nicholls et al. 1999); landslide activity may owe more to human activity than to climatic changes (Crozier 2010); and excessive groundwater exploitation in coastal areas may be a more potent cause of saltwater intrusion, and of possible increased amounts of salt weathering, than sea-level rise caused by global warming (Ferguson and Gleeson 2012).

More generally, Adger et al. (2013) have pointed out that society's response to global climate change is mediated by culture, and they showed that climate change threatens cultural dimensions of lives and livelihoods that include the material and lived aspects of culture, identity, community cohesion, and sense of place. Equally important, they found that there are important cultural dimensions to how

societies respond, and attempt to mitigate and to adapt to climate-related risks. As the reports of the Intergovernmental Panel on Climatic Change (IPCC) have shown, impacts on society, adaptations, and mitigations are as central for consideration as the actual climatic changes themselves (see IPCC 2013, 2014). There is an enormous potential for human geographers to contribute to Global Change science as it enters a formative stage (O'Brien 2010) and to be involved with policy (Liverman 1999), but as Castree (2015a, 1) has pointed out "this potential will only be taken advantage of if certain human-environment geographers, unaccustomed to engaging the world of geoscience and environmental policy, change their *modus operandi*." Such advantage is already being taken, and as Castree (2015b) has pointed out, many geographers are already part of the multidisciplinary, international research networks that are trying to get global environmental change taken more seriously by politicians and others.

Earth System Science

Earth System Science, a modern manifestation of Global Change which concentrates on modelling, treats the Earth as an integrated system and seeks a deeper understanding of the physical, chemical, biological, and human interactions that determine the past, current, and future states of the Earth's lithosphere, hydrosphere (including the cryosphere), biosphere, and atmosphere. While it has its antecedents in the work of people like Humboldt (see Stott 2016), it came into prominence in the last two decades of the 20th century. It has emerged in response to (1) the realization that biogeochemical systems operate globally, and (2) an increasing appreciation that Earth is a single system. It includes societal dimensions and the recognition that humanity plays an ever-increasing role in Global Change. It represents humans as internal components of the Earth system, not just an external "forcing agent." The implications of this for Geography were expressed cogently and presciently by Slaymaker and Spencer (1998), while Pitman (2005) argued that geographers should contribute their synthesizing abilities to Earth System Science, as indeed they did to the landmark synthesis edited by Steffen et al. (2004). As Liverman and Cuesta (2008) have explained, human interactions with the Earth System are a crucial concern. Moreover, progress in this area will be magnified if greater integration occurs not only between physical and human geographers, but also among the major branches of Physical Geography itself (Malanson et al. 2014).

The human impact

While studies of Global Change and Earth System Science tend to focus on human influences at the planetary or continental scales, physical geographers have also written extensively in recent decades about the human impact on the environment at more local scales (e.g., Turner et al. 1990; Goudie 2013) and have built upon the magnificent legacy of Marsh (1864). Anthropogeomorphology, a term invented by Golomb and Eder (1964), has developed as a branch of geomorphology which describes the study of the human role in creating landforms and modifying the operation of geomorphological processes, and a recent study by Szabó et al. (2010) gives a flavour of this work. This is also an area for both geomorphologists and historical geographers to work on, and the regional study of Trimble (2012) on the history of soil erosion in the United States is an excellent exemplification of this type of work, in which he used archives to reconstruct landscape history in response to human agricultural activities. As Harden (2014) and Chin et al. (2014) have suggested, however, we need to move beyond unidirectional cause-and-effect (human impacts) and look at interactions and feedbacks, which, as noted above, is one of the characteristics of Earth System Science.

Anthropocene

Such is the importance of the human impact, that at the start of the millennium, Crutzen and colleagues (e.g., Crutzen 2002; Rockström et al. 2009) introduced the term *Anthropocene* as a name for a new epoch in Earth's history—an epoch when human activities have "become so profound and pervasive that they rival, or exceed the great forces of Nature in influencing the functioning of the Earth System" (Steffen 2010, 444). They suggested that in the last 300 years we have moved from the Holocene into the Anthropocene.

Great debates are, however, taking place about when the Anthropocene started, and this has involved

contributions from archaeologists and historical geographers. Early humans drove major environmental changes through such processes as the use of fire and the hunting of wild animals. Attention has been drawn to the deep history of widespread human impacts (Ruddiman et al. 2015).

If one accepts Rockström's (2015) view that "The Anthropocene is up there with Copernicus's heliocentricity or Darwin's theory of evolution as one of the most profound shifts in worldview that has emerged from scientific endeavour," then it is important for geographical contributions to the Anthropocene to be more fully developed. Remarkably diverse contributions are being published in the two new journals, *The Anthropocene Review* and *Anthropocene.*

Geomorphologists (e.g., Goudie and Viles 2016) are contributing to the study of the Anthropocene, as are many human geographers (Castree 2014a, 2014b, 2014c) and biogeographers (e.g., Ellis 2011). Many of the land cover changes and associated shifts driven by altered global atmospheric and hydrologic processes are resulting in novel (no-analogue) vegetation and faunal types that have had no previous history on Earth (Young 2014). Wildlife in the Anthropocene has emerged as a major field of study for geographers (Lorimer 2015).

In addition, other novel ecosystems have also been created, including urban environments (Francis et al. 2012). As a consequence, urban ecology, a transdisciplinary enterprise that integrates ecological, geographical, planning, and social sciences (Wu 2014) has become a major research area. Urban areas are hubs for people, infrastructure, and commerce, requiring extensive resources and putting intense pressure on the environment. They account for about 60% of all residential water use, 75% of energy use, 80% of the wood used for industrial purposes, and 80% of human greenhouse gas emissions. As Haase et al. (2014, 414) remark, "Understanding how urban ecosystems work, how they change, and what limits their performance can add to the understanding of ecosystem change and governance in an ever more human-dominated world."

Environmental history and environmental influences on human history and prehistory

Environmental history is another burgeoning area which has spurred productive work involving historians, foresters, historical geographers, and geomorphologists. Notable as an exemplar is the study by A. T. Grove and Rackham (2003) on the ecological history of the Mediterranean lands, the studies by R. Grove et al. (1998) on environmentalism and the environmental history of the tropics, and the magisterial account of the history of world deforestation by Williams (2003). One of the reasons for the increased interest in this topic is that environmental scientists have developed increasingly precise and reliable dates, and have also developed techniques for high-resolution environmental reconstruction, both of which are required to relate environmental changes to events in human history and prehistory (Anderson et al. 2013).

As Offen (2014) has shown, historical geographers have recently developed a strong interest in climatic influences on human health, migration, the abandonment of settlements, and the like. A measure of environmental determinism, once espoused by people like Huntington, and so long the subject of scepticism and even hostility, has returned (Livingstone 2012), and has been expertly critiqued by Hulme (2011) who writes of "climate reductionism," a form of "neoenvironmental determinism," and is rightly cautious about some of its more extreme manifestations. One of the areas in which environmental influences have become significant is in the consideration of past, present, and future migrations, for, as Black et al. (2011) have pointed out, environmental influences need to be considered along with social, demographic, political, and economic drivers. Likewise, McLeman (2011) undertook a comprehensive survey of settlement abandonment, and examined a progression from vulnerability to population decline and abandonment.

Studies of geomorphology and the Quaternary have led to collaborations between geomorphologists and archaeologists, as demonstrated by Butzer and Hansen's (1968) work in Nubia, and the edited collection of Martini and Chesworth (2010). Relict landforms can prove to be the sites of former settlements; past climatic changes which have been revealed, for example by changes in lake levels, can help to explain periods of occupation and abandonment of settlements; and fluctuations in sea-level and humidity can help to control human migrations, as, for example, from Africa to Asia (Osborne et al. 2008). Sudden shifts in river courses, whatever their cause, may help to explain the changes in the

fortunes of the Indus Civilization (Madella and Fuller 2006) and in Mesopotamia (Morozova 2005).

Climate changes may also have impacted upon early human societies, with Pleistocene pluvials allowing human migrations across the Sahara (Drake et al. 2011) and "out of Africa." Even human evolution may have been related to the appearance of African savannahs (Cerling et al. 2011). There are many examples of the effects of climate change (e.g., the dry event 8200 years ago) on human societies during the Holocene (Staubwasser and Weiss 2006). Agricultural intensification and domestication in the Middle East may have been stimulated by episodes of increased aridity (Sherratt 1997) and there was an association in the mid-Holocene between desiccation and increasing social complexity in the central Sahara and Egypt (Brooks 2006). Conversely, the "Greening of the Sahara" in the moist early to mid-Holocene may have led to an explosion of activity by Neolithic peoples (Drake et al. 2011). The Little Ice Age also had implications for human societies in mountain regions, as beautifully illustrated by J. M. Grove (2013).

Landscape

Landscape has long been a central concern of a swathe of geographers. I concur with Wooldridge (1949, 14–15) who made this point:

> The world contains not only factories, farms, railway sidings, market places, etc., but the blue hills on the skyline, the winding valleys which traverse them, russet bracken covered slopes, and heather fells and the ever changing incident of long and varied coastlines.

Similarly, for Darby (1953) it was axiomatic that it was the purpose of Geography to explain the landscape and that an understanding of the landscape formed an indisputable part of geographical study. As Williams (1989, 92) pointed out, "He even went so far as to suggest that Historical Geography, the study of the formation of the human landscape, and geomorphology, the study of the tangible physical landscape, together constituted 'the foundations of geographical study'" (Williams 1989). Historical geographers and archaeologists (e.g., Wilkinson 2003) have been concerned with the evolution of the palimpsest of the land surface, while among other human geographers there is a long-standing tradition of trying to understand landscapes, not simply as concrete chunks of territory, but also as a rich cultural repertoire for representing land and our place within it, whether as "text, scenery, substantive polity or affective personal engagement" (Demeritt 2009, 6). Biogeographers share a similar interest in landscapes and their conservation, and geomorphologists also use the term landscape widely and are concerned with the identification, description, explanation, and conservation of superlative landforms (see Migoń 2010). Recently also there has been the development of what is termed "cultural geomorphology" (Gregory 2006) (see Goudie and Viles 2010, Chapter 8), which encompasses cultural reactions to and perceptions of landscape, including aesthetics (Goudie 2002), and how these should be considered by geomorphologists, especially in terms of improving environmental management. Geomorphologists, perhaps working within the guise of cultural geomorphology, can undoubtedly help boost the profile of geoconservation and collaborate with ecologists and heritage scientists to provide a more balanced approach to identifying and conserving landscapes of outstanding value at local, national, and global levels.

Conclusions

Since 1986, there has been a quickening of interest in a whole series of closely related areas which lie at the interface between humans and their environment. Human-environment relationships have become a central concern of many disciplines, and of leading thinkers in both Physical Geography and Human Geography. We can as a discipline, to use Stoddart's felicitous phrase from 1987, "claim the high ground" and aspire to follow in the footsteps of von Humboldt (Wulf 2015). Some of the publications cited in this paper indicate where that high ground is. Integration matters, because the issues at the interface of the two main branches of the discipline are so intrinsically important. Even though there is bound to be a great gulf between individual components of the discipline because of the sheer diversity of its subject matter, Geography is not irredeemably divided. However, interest in human/environment issues is not restricted to geographers, whether human or physical, so that in addition to working together with each other, geographers need

to reach out to other disciplines, to become involved directly with matters such as policy formulation, and to take part in major international programmes.

References

Adger, W. N., J. Barnett, K. Brown, N. Marshall, and K. O'Brien. 2013. Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change* 3(2): 112–117.

Alcántara-Ayala, I., and A. S. Goudie. 2010. *Geomorphological hazards and disaster prevention*. Cambridge, UK: Cambridge University Press.

Anderson, D., A. Goudie, and A. Parker. 2013. *Global environments through the Quaternary: Exploring environmental change*. Oxford: Oxford University Press.

Aspinall, R. 2010. A century of physical geography research in the Annals. *Annals of the Association of American Geographers* 100(5): 1049–1059.

Avila, F. B., A. J. Pitman, M. G. Donat, L.V. Alexander, and G. Abramowitz. 2012. Climate model simulated changes in temperature extremes due to land cover change. *Journal of Geophysical Research 117*. doi: 10.1029/2011JD016382.

Black, R., W. N. Adger, N. W. Arnell, S. Dercon, A. Geddes, and D. Thomas. 2011. The effect of environmental change on human migration. *Global Environmental Change* 21(1): S3–S11.

Brooker, S. 2007. Spatial epidemiology of human schistosomiasis in Africa: Risk models, transmission dynamics and control. *Transactions of the Royal Society of Tropical Medicine and Hygiene* 101(1): 1–8.

Brooks, N. 2006. Cultural responses to aridity in the Middle Holocene and increased social complexity. *Quaternary International* 151(1): 29–49.

Brunsden, D., J. C. Doornkamp, and D. K. C. Jones. 1982. *Urban geomorphology in drylands*. Oxford: Oxford University Press.

Butzer, K. W., and C. L. Hansen 1968. *Desert and river in Nubia: Geomorphology and prehistoric environments at the Aswan Reservoir*. Madison, WI: University of Wisconsin Press.

Castree, N. 2011. Nature and society. In *The SAGE handbook of geographical knowledge*, ed. J. A. Agnew and D. N. Livingstone. London: Sage, 287–299.

——. 2014a. The Anthropocene and geography I: The back story. *Geography Compass* 8(7): 436–449.

——. 2014b. Geography and the Anthropocene II: Current contributions. *Geography Compass* 8(7): 450–463.

——. 2014c. The Anthropocene and geography III: Future directions. *Geography Compass* 8(7): 464–476.

——. 2015a. Geography and global change science: Relationships necessary, absent, and possible. *Geographical Research* 53(1): 1–15.

——. 2015b. Changing the Anthropo(s)cene: Geographers, global environmental change and the politics of knowledge. *Dialogues in Human Geography* 5(3): 301–316.

Cerling, T. E., J. G. Wynn, S. A. Andanje, M. I. Bird, D. K. Korir, N. E. Levin, W. Mace, et al. 2011. Woody cover and hominin environments in the past 6 million years. *Nature* 476(7538): 51–56.

Chin, A., J. L. Florsheim, E. Wohl, and B. D. Collins. 2014. Feedbacks in human–landscape systems. *Environmental Management* 53(1): 28–41.

Chorley, R. J. 1971. The role and relations of physical geography. *Progress in Geography* 3: 87–110.

CIESIN (Center for International Earth Science Information Network). n. d. *The International Geosphere–Biosphere Programme*. http://web.archive.org/web/19990117062310/http:/www.ciesin.org/TG/HDP/igbp.html.

Cooke, R. U. 1984. *Geomorphological hazards in Los Angeles*. London: Allen and Unwin.

——. 1992. Common ground, shared inheritance: Research imperatives for environmental geography. *Transactions of the Institute of British Geographers* 17(2): 131–151.

Cooke, R. U., and J. C. Doornkamp. 1990. *Geomorphology in environmental management. A new introduction*. Oxford: Oxford University Press.

Crozier, M. J. 2010. Deciphering the effect of climate change on landslide activity: A review. *Geomorphology* 124(3): 260–267.

Crutzen, P. J. 2002. Geology of mankind. *Nature* 415(6867): 23.

Darby, H. C. 1953. The relations of history and geography. *Transactions of the Institute of British Geographers* 19: 1–11.

Demeritt, D. 2009. From externality to inputs and interference: Framing environmental research in geography. *Transactions of the Institute of British Geographers* 34(1): 3–11.

Drake, N. A., R. M. Blench, S. Armitage, C.S. Bristow, and K. H. White. 2011. Ancient watercourses and biogeography of the Sahara explain the peopling of the desert. *Proceedings of the National Academy of Sciences* 108(2): 458–462.

Ellis, E. C. 2011. Anthropogenic transformation of the terrestrial biosphere. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences* 369(1938): 1010–1035.

Ericson, J. P., C. J. Vorosmarty, L. Dingham, L. G. Ward, and M. Meybeck. 2006. Effective sea-level rise and deltas: Causes of change and human dimension implications. *Global and Planetary Change* 50(1): 63–82.

Ferguson, G., and T. Gleeson. 2012. Vulnerability of coastal aquifers to groundwater use and climate change. *Nature Climate Change* 2(5): 342–345.

Francis, R. A., J. Lorimer and M. Raco. 2012. Urban ecosystems as 'natural' homes for biogeographical boundary crossings. *Transactions of the Institute of British Geographers* 37(2): 183–190.

Fuchs, S., C. Kuhlicke, and V. Meyer 2011. Editorial for the special issue: Vulnerability to natural hazards—The challenge of integration. *Natural Hazards* 58(2): 609–619.

Glade, T., M. G. Anderson, and M.J. Crozier, eds. 2005. *Landslide hazard and risk*. Chichester: Wiley.

Golomb, B., and H. M. Eder. 1964. Landforms made by man. *Landscape* 14: 4–7.

Goudie, A. S. 1986. The integration of human and physical geography. *Transactions of the Institute of British Geographers* 11(4): 454–458.

——. 1994. The nature of physical geography: A view from the drylands. *Geography* 79(3): 194–209.

——. 2001. Applied Geomorphology: An introduction. *Zeitschrift für Geomorphologie, Supplementband* 124: 101–110.

——. 2002. Aesthetics and relevance in geomorphological outreach. *Geomorphology* 47(2): 245–249.

——. 2013. *The human impact on the natural environment: Past, present, and future*. Chichester: John Wiley & Sons.

——. 2014. Desert dust and human health disorders. *Environment International* 63(1): 101–113.

Goudie, A. S., and N. J. Middleton. 2006. *Desert dust in the global system*. Heidelberg: Springer.
Goudie, A. S., and H. A. Viles 1997. *Salt weathering hazard*. Chichester: Wiley.
——. 2010. *Landscapes and geomorphology: A very short introduction*. Oxford: Oxford University Press.
——. 2016. *Geomorphology in the Anthropocene*. Cambridge and New York: Cambridge University Press.
Gregory, K. J. 2006. The human role in changing river channels. *Geomorphology* 79(3): 172–191.
Grove, A. T., and O. Rackham 2003. *The nature of Mediterranean Europe: An ecological history*. New Haven and London: Yale University Press.
Grove J. M. 2013. *The Little Ice Ages: Ancient and modern*. London: Routledge.
Grove, R. H., V. Damodaran, and S. Sangwan, eds. 1998. *Nature and the Orient*. Delhi: Oxford University Press.
Haase, D., N. Larondelle, E. Andersson, M. Artmann, S. Borgström, J. Breuste, E. Gomez-Baggethun, et al. 2014. A quantitative review of urban ecosystem service assessments: Concepts, models, and implementation. *Ambio* 43(4): 413–433.
Harden, C. P. 2014. The human-landscape system: Challenges for geomorphologists. *Physical Geography* 35(1): 76–89.
Hewitt, K. 2014. *Regions of risk: A geographical introduction to disasters*. London: Routledge.
Hightower, A., C. Kinkade, P. M. Nguku, A. Anyangu, D. Mutonga, J. Omolo, and R.F. Breiman. 2012. Relationship of climate, geography, and geology to the incidence of Rift Valley fever in Kenya during the 2006–2007 outbreak. *The American Journal of Tropical Medicine and Hygiene* 86(2): 373–380.
Hulme, M. 2011. Reducing the future to climate: A story of climate determinism and reductionism. *Osiris* 26(2): 245–266.
IPCC (Intergovernmental Panel on Climate Change). 2013. *Climate Change 2013: The physical science basis: Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley. Cambridge: Cambridge University Press.
——. 2014. *Climate Change 2014: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. C.B. Field, V. Barros, K. Mach, and M. Mastrandrea. Cambridge, UK: Cambridge University Press.
Kennedy, I. T., D. N. Petley, R. Williams, and V. Murray. 2014. A systematic review of the health impacts of mass earth movements (landslides). *PLoS Currents Disasters*. doi: 10.1371/currents.dis.1d49e84c8bbe678b0e70cf7fc35d0b77.
Lane, S. N. 2001. Constructive comments on D. Massey 'Space-time, "science" and the relationship between physical geography and human geography.' *Transactions of the Institute of British Geographers* 26(2): 243–256.
Lave, R., M. W. Wilson, E. S. Barron, C. Biermann, M. A. Carey, C. S. Duvall, and C. Van Dyke. 2014. Intervention: Critical physical geography. *The Canadian Geographer* 58(1): 1–10.
Liverman, D. M. 1999. Geography and the global environment. *Annals of the Association of American Geographers* 84(1): 107–120.
Liverman, D. M., and R. M. R. Cuesta. 2008. Human interactions with the Earth system: People and pixels revisited. *Earth Surface Processes and Landforms* 33(9): 1458–1471.
Livingstone, D. N. 2012. Changing climate, human evolution, and the revival of environmental determinism. *Bulletin of the History of Medicine* 86(4): 564–595.
Lorimer, J. 2015. *Wildlife in the Anthropocene: Conservation after nature*. Minneapolis, MN: Minnesota University Press.
Madella, M., and D. Q. Fuller. 2006. Palaeoecology and the Harappan Civilisation of South Asia: A reconsideration. *Quaternary Science Reviews* 25(11-12): 1283–1301.
Malanson, G. P., L. Scuderi, K. A. Moser, C. J. Willmott, L. M. Resler, T. A. Warner, and L. O. Mearns. 2014. The composite nature of physical geography. Moving from linkages to integration. *Progress in Physical Geography* 38(1): 3–18.
Marsh, G. P. 1864. *Man and nature*. New York, NY: Scribner.
Martini, I. P., and W. Chesworth, eds. 2010. *Landscapes and societies: Selected cases*. Dordrecht: Springer.
Massey, D. 2001. Talking of space-time. *Transactions of the Institute of British Geographers* 26(2): 257–261.
McLeman, R. A. 2011. Settlement abandonment in the context of global environmental change. *Global Environmental Change* 21(Suppl. 1): S108–S120.
Migoń, P., ed. 2010. *Geomorphological landscapes of the world*. Dordrecht: Springer
Montz, B. E., and G.A. Tobin. 2011. Natural hazards: An evolving tradition in applied geography. *Applied Geography* 31(1): 1–4.
Morozova, G. S. 2005. A review of Holocene avulsions of the Tigris and Euphrates rivers and possible effects on the evolutions of civilizations in Lower Mesopotamia. *Geoarchaeology* 20(4): 401–423.
Nicholls, R. J., F. M. J. Hoozemans, and M. Marchand. 1999. Increasing flood risk and wetland losses due to global sea level rise: Regional and global analyses. *Global Environmental Change* 9(Suppl. 1): S69–S87.
O'Brien, K. 2011. Responding to environmental change: A new age for human geography? *Progress in Human Geography* 35(4): 542–549.
Offen, K. 2014. Historical geography III: Climate matters. *Progress in Human Geography* 38(3): 476–489.
Osborne, A. H., D. Vance, E. J. Rohling, N. Barton, M. Rogerson, and N. Fello. 2008. A humid corridor across the Sahara for the migration of early modern humans out of Africa 120,000 years ago. *Proceedings of the National Academy of Sciences* 105(43): 16444–16447.
Papworth, A., M. Maslin, and S. Randalls. 2015. Is climate change the greatest threat to human health? *Geographical Journal* 181(4): 413–422.
Pelletier, J. D., A. B. Murray, J. L. Pierce, P. R. Bierman, D. D. Breshears, B. T. Crosby, M. Ellis, et al. 2015. Forecasting the response of Earth's surface to future climatic and land use changes: A review of methods and research needs. *Earths Future* 3(7): 220–251.
Pitman, A. J. 2005. On the role of geography in earth system science. *Geoforum* 36(2): 137–148.
Rhoads, B. L. 2004. Whither Physical Geography? *Annals of the Association of American Geographers* 94(4): 748–755.
Rockström, J. 2015. Environment. *The Observer*, 15th November, 2015, p. 35.
Rockström, J., W. L. Steffen, K. Noone, A. Persson, F. S. Chapin III, E. Lambin, T. M. Lenton, et al. 2009. Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society* 14(2): 32. http://www.ecologyandsociety.org/vol14/iss2/art32/.

Ruddiman, W. F., E. C. Ellis, J. O. Kaplan, and D. Q. Fuller. 2015. Defining the epoch we live in. *Science* 348(6230): 38–39.
Sherratt, A. 1997. Climatic cycles and behavioural revolutions: The emergence of modern humans and the beginning of farming. *Antiquity* 71(272): 271–287.
Slaymaker, O., and T. Spencer. 1998. *Physical Geography and global environmental change*. Harlow, UK: Longman.
Slaymaker, O., T. Spencer, and C. Embleton-Hamann, eds. 2009. *Geomorphology and global environmental change*. Cambridge: Cambridge University Press.
Smith, K. 2013. *Environmental hazards: Assessing risk and reducing disaster*. London: Routledge.
Staubwasser, M., and H. Weiss. 2006. Holocene climate and cultural evolution in late prehistoric–early historic West Asia. *Quaternary Research* 66(3): 372–387.
Steffen, W. 2010. Observed trends in Earth System behaviour. *Interdisciplinary Reviews, Climate Change* 1(3): 428–449.
Steffen, W., A. Sanderson, P. D. Tyson, J. Jäger, P. A. Matson, B. Moore III, F. Oldfield, et al. 2004. *Global change and the Earth System*. Berlin: Springer.
Stoddart, D. R. 1987. To claim the high ground: Geography for the end of the century. *Transactions of the Institute of British Geographers* 12(3): 327–336.
Stott, P. 2016. Physical geographies: Past, present, and future. *Progress in Physical Geography* 40(1): 3–6.
Szabó, J., L. David, and D. Lóczy, eds. 2010. *Anthropogenic geomorphology*. Dordrecht: Springer.
Tadaki, M., G. Brierley, M. Dickson, R. Le Heron, and J. Salmond. 2015. Cultivating critical practices in physical geography. *Geographical Journal* 181(2): 160–171.
Tadaki, M., J. Salmond, R. Le Heron, and G. Brierley. 2012. Nature, culture, and the work of physical geography. *Transactions of the Institute of British Geographers* 37(4): 547–562.
Trimble, S. W. 2012. *Historical agriculture and soil erosion in the Upper Mississippi Valley Hill Country*. Boca Raton, FL: CRC Press.
Turner II, B. L., W. C. Clark, R. W. Kates, J. F. Richards, J. T. Matthews, and W. B. Meyer, eds. 1990. *The Earth as transformed by human Action: Global and regional changes in the biosphere over the past 300 years*. Cambridge: Cambridge University Press.
Viles, H. 2005. A divided discipline. In *Questioning geography: Fundamental debates*, ed. N. Castree, A. Rogers, and D. Sherman. Oxford: Wiley-Blackwell, 26–38.
Viles, H., and T. Spencer. 2005. *Coastal problems: Geomorphology, ecology and society at the coast*. London: Edward Arnold.
Watts, M. 2015. Adapting to the Anthropocene: Some reflections on development and climate in the West African Sahel. *Geographical Research* 53(3): 288–297.
White, G. F. 1974. *Natural hazards, local, national, global*. Oxford: Oxford University Press.
Wilkinson, T. J. 2003. *Archaeological landscapes of the Near East*. Tucson, AZ: University of Arizona Press.
Williams, M. 1989. Historical geography and the concept of landscape. *Journal of Historical Geography* 15: 92–104.
——. 2003. *Deforesting the earth: From prehistory to global crisis*. Chicago, IL: University of Chicago Press.
Wooldridge, S. W. 1949. On taking the "Ge-" out of Geography. *Geography* 34(1): 9–18.
Worsley, P. 1979. Whither geomorphology? *Area* 11(2): 97–101.
Wu, J. 2014. Urban ecology and sustainability: The state-of-the-science and future directions. *Landscape and Urban Planning* 125: 209–221.
Wulf, A. 2015. *The invention of nature*. London: John Murray.
Young, K.R., 2014. Biogeography of the Anthropocene: Novel species assemblages. *Progress in Physical Geography* 38(5): 664–663.
Zimmerer, K. S. 2007. Cultural ecology (and political ecology) in the 'environmental borderlands': Exploring the expanded connectivities within geography. *Progress in Human Geography* 31(2): 227–244.