



UNIVERSITY
OF WOLLONGONG
AUSTRALIA

University of Wollongong
Research Online

Faculty of Social Sciences - Papers

Faculty of Social Sciences

2015

Changing the Anthropo(s)cene: geographers, global environmental change and the politics of knowledge

Noel Castree

University of Wollongong, ncastree@uow.edu.au

Publication Details

Castree, N. (2015). Changing the Anthropo(s)cene: geographers, global environmental change and the politics of knowledge. *Dialogues in Human Geography*, 5 (3), 301-316.

Research Online is the open access institutional repository for the University of Wollongong. For further information contact the UOW Library:
research-pubs@uow.edu.au

Changing the Anthro(s)cene: geographers, global environmental change and the politics of knowledge

Abstract

This article explores the relationships between geographers and the 'Anthropocene'. The latter comprises the networks, institutions and publications devoted to comprehending and responding to a fast-changing Earth departing from Holocene boundary conditions. The Anthropocene necessarily mediates peoples' understanding of what are said to be epochal alterations to our planetary home. It is currently dominated by geoscientists and certain environmental social scientists. Some geographers are among their number. Whilst these researchers are working hard to alert decision-makers and publics to the epic scale, scope and magnitude of 'the human impact', their work currently tends to screen out the insights of both critical social science and the environmental humanities. Both forms of inquiry are strongly represented in contemporary Anglophone Geography and have been central to human geography's 'environmental turn' this last 20 years. The article suggests reasons why many geographers who are not currently part of the Anthropocene might want to get their voices heard therein and thereby change the 'scene'. Global change research (and politics) is entering a formative moment, and it's important that a range of epistemic communities shape its content and tenor looking ahead. The stakes are high and place responsibilities on a wide range of environmental researchers and educators.

Keywords

change, cene, environmental, anthro, knowledge, global, changing, politics, geographers

Disciplines

Education | Social and Behavioral Sciences

Publication Details

Castree, N. (2015). Changing the Anthro(s)cene: geographers, global environmental change and the politics of knowledge. *Dialogues in Human Geography*, 5 (3), 301-316.

Changing the Anthro(s)cene: geographers, global environmental change and the politics of knowledge

Abstract: This paper explores the relationships between geographers and the 'Anthropocene'. The latter comprises the networks, institutions and publications devoted to comprehending and responding to a fast-changing Earth departing from Holocene boundary conditions. The Anthropocene necessarily mediates peoples' understanding of what are said to be epochal alterations to our planetary home. It is currently dominated by geoscientists and certain environmental social scientists. Some geographers are among their number. While these researchers are working hard to alert decision-makers and publics to the epic scale, scope and magnitude of 'the human impact', their work currently tends to screen-out the insights of both critical social science and the environmental humanities. Both forms of inquiry are strongly represented in contemporary Anglophone Geography, and have been central to human geography's 'environmental turn' this last 20 years. The paper suggests reasons why many geographers who are not currently part of the Anthropocene might want to get their voices heard therein and thereby change the 'scene'. Global change research (and politics) is entering a formative moment and it's important that a range of epistemic communities shape its content and tenor looking ahead. The stakes are high and place responsibilities on a wide range of environmental researchers and educators.

Keywords: geoscience, environmental social science, the environmental humanities, planetary management, epistemic communities, Geography

Changing the Anthro(s)cene: geographers, global environmental change and the politics of knowledge

The planet is now dominated by human activities. Human changes to the Earth System are multiple, complex, interacting, often exponential in rate and globally significant in magnitude. They affect every Earth System component – land, coastal zone, atmosphere and oceans ... Today, humankind has begun to match and even exceed some of the great forces of nature ... [T]he Earth System is now in a no analogue situation, best referred to as a new era in geological history, the Anthropocene. (*Global Change and the Earth System*, Steffen *et al.*, 2004: 81)

Introduction

Science continues to transform our world through its discoveries and devices. Evidence, concepts and inventions issuing from molecular biology, computer science, particle physics, toxicology and beyond alter our beliefs and practices continually. Since the early 1990s climate science has been a consistent focus of media attention, policy debate and public discourse – sometimes controversially so. But now its central insights into a changing atmospheric system are being folded into a much grander scientific conception of a world being irrevocably altered by humans. This conception has been advanced by international teams of geoscientists. By way of three big ideas – namely, ‘the Anthropocene’, ‘planetary boundaries’ and global ‘tipping points’ (see Crutzen & Stoermer, 2000, Rockström *et al.* 2009a & Barnosky *et al.*, 2012 respectively) – they suggest that humans are entering *terra incognita*. This much is clear from my epigram. It comes from a major work of synthesis completed under the auspices of the International Geosphere-Biosphere Program (IGBP). According to Will Steffen and his geoscience colleagues, humans are not only unintentionally altering the global atmosphere but all other planetary sub-systems too. We are now, they claim, geographers as never before: humans are (literally) writing themselves into Earth history in ways unimaginable even 50 years ago. Regardless of what we now do to reduce our biophysical impact, *homo sapiens* – most especially those in the West – have already altered the planet’s future through their past (post-1800) and present actions.¹

Unlike most developments in other areas of science, those relating to the Holocene’s proclaimed end are directly relevant to the research, teaching

¹Some, notably Bill Ruddiman, claim that humans’ global environmental signature begins much earlier – as far back as the Middle Ages.

and outreach conducted by professional geographers. Indeed, some geographers are members of the multidisciplinary geoscience teams advancing the three big ideas mentioned above (examples are Frank Oldfield in the UK and Billie Lee Turner II in the USA).² Meanwhile, given the profundity of these ideas, many other practitioners stand to be affected by the claim that humans are now a ‘runaway’ planetary force. After all, this claim speaks to an extraordinarily wide range of concepts, topics and questions spanning physical, environmental and human geography. These include, *inter alia*, the concepts of nature, scale, and space-time; topics like multilevel modelling of biophysical feedbacks and thresholds and the geographies of moral responsibility in an unequal world; and questions like how political leaders can cooperate to manage a borderless physical environment or how local socio-ecological innovations might inspire change elsewhere and be scaled-up. More fundamentally, an idea like the Anthropocene invites geographers to ask deep questions about their *modus operandi*, such as its semantic reach and significance (cognitively, morally and aesthetically). Are we content with the forms of knowledge we produce? Are we influencing the wider intellectual climate within and beyond universities to our own satisfaction? Is Geography, to put it bluntly, part of the ‘problem’ or contributory to the ‘solution’, depending on how we define these loaded terms?

A short essay like this one cannot possibly answer these meaty questions. However, it can – at the least – show why it’s necessary and timely to pose them. What’s more, it can describe some of the parameters that might help different geographers understand how the questions should ultimately be addressed. In what follows I try to realise these two aims. At base I’m interested in Geography’s relation to what we might call the ‘Anthroposcene’. This term directs us to the epistemic communities who are today speaking most audibly for Earth present and future, and who are espying *epochal* change on the horizon.³ It invites to us to consider whether we – and it’s essential to acknowledge the heterodox character of Geography’s practitioners here – want to alter the ‘scene’, whoever ‘we’ happen to be. As will become clear, my own view is that change is essential. The current Anthroposcene is far too

²By geographers I mean those who currently work in, or are professionally identified with, geography departments, schools or institutes in research-intensive universities.

³I don’t want to unpack the niceties of debate about the scientific validity of the Anthropocene concept, or of affiliated ideas like ‘planetary boundaries’ and global ‘tipping points’. Suffice to say the debates are ongoing, one being about when the Anthropocene began, another – related to this – about whether stratigraphic markers exist to determine a Holocene-Anthropocene boundary in Earth’s long history. On these specific issues see Lewis and Maslin (2015) and Zalasiewicz *et al.* (2015) respectively.

science-led. It is dominated by those who regard planetary change, and human responses to it, as amenable to analysis and influence absent any deep engagement with other forms of knowing and acting. While we should thank geoscientists for sounding the environmental alarm, other epistemic communities beyond a few social science fields (notably environmental economics) need to shape the discourse before it solidifies. The stakes are much too high for people not yet part of 'global change science' to watch from the sidelines.

I begin by characterising the current scene in two phases, before considering in three sections how geographers have so far been – and might in future be – scene-shapers. A word on terminology. In what follows I use the term 'geoscience' inclusively. It describes all those fields of Earth surface science (terrestrial, aquatic and atmospheric) that are currently contributing to what is known as 'global change science' (GCS). The latter is a multidisciplinary endeavour devoted to describing, explaining, predicting, communicating and (increasingly) changing patterns of anthropogenic environmental change at the planetary scale. In significant measure it has emerged from the four global environmental change research programmes created 25-30 years ago,⁴ along with related national level programmes (see Mooney *et al.*, 2013). These initiatives enabled a more global, integrated geoscience to crystallise,⁵ but GCS expands the remit previously assigned to the International Human Dimensions Program (alone and in occasional collaboration with other programmes). Accordingly, GCS is a label that applies across the distinction between environmental and social science. In aspiration, it encompasses the socio-economic, cultural and political aspects of environmental change not only its physical dimensions. While some geoscientists (like Carl Folke) have long sought to examine human and physical dimensions simultaneously, GCS is now more committed than ever before to understanding and helping to modify human actions *viz.* the environment.⁶ Currently, certain sorts of environmental

⁴The programmes are International Geosphere-Biosphere Program, launched in 1987, which followed the World Climate Research Program, created in 1980. They were followed by the International Human Dimensions Program (1990, re-launched in 1996) and Diversitas (launched in 1991 and focussing on global biodiversity and biogeography). An attempt to coordinate these have occurred under the Earth System Science Partnership for well over a decade.

⁵This is evidence in current climate models, the most ambitious of which include feedbacks and teleconnections between climate and multiple other aspects of the Earth system (see Dahan, 2010).

⁶Invoking Folke's work reminds us that there is no agreed sense of where, exactly, global change science begins and ends. For instance, some might argue that 'sustainability science' (initiated by geographer Robert Kates) and 'resilience science' of the kind Folke has sometimes been involved in should be included (see Mooney *et al.*, 2013).

social science are central to this endeavour (those that favour a quantitative-analytical approach and aspire to relative 'objectivity'). Along with geoscience, they are leading contributors to the current Anthropocene. This begs questions about whether and how 'non-science' approaches to people and environment could loom larger.

Speaking for an Earth transformed

The Earth as a totality cannot represent itself (at least according to conventional conceptions of being and knowledge); it must, therefore, be represented. Through their instruments, measurements, models, graphics and concepts geoscientists have set about trying to make visible the momentous biophysical changes resulting from modern humans' collective actions. Of course, geoscientists have long been spokespeople for an 'Earth in crisis' (think of Rachel Carson, Barry Commoner and Paul Ehrlich among others). What's different today is the sheer number of researchers observing and predicting a 'phase shift' in the planet's long history. Sverker Sorlin (2013: 20) calls them "concerned synthesists". This is an appropriate description for two reasons. First, they are connecting data and forecasts about Earth surface phenomena so that the bigger picture too often missed by specialist research is apparent. Second, so alarmed by this picture are many geoscientists that they feel compelled to communicate their findings beyond academic conferences and peer review journals. The fact that policies to address climate change have been so ineffective since the first United Nations (UN) Earth Summit has rendered the need for such communication more pressing.

The group of geoscientists responsible for the 'planetary boundaries' idea illustrate well this concerned synthesist role. Led initially by Johan Rockström of the Stockholm Resilience Centre, the group comprises senior geoscientists from different academic fields, including Will Steffen (of the Australian National University), Paul Crutzen (Nobel Laureate and co-creator of the Anthropocene concept), James Hansen (the leading American climate scientist and sometime activist) and German science advisor Hans Joachim Schellnhuber. It identifies nine global biophysical boundaries beyond which humans are said to leave the 'safe operating space' afforded by Holocene conditions (Rockström, J. *et al.* 2009a, 2009b; Steffen *et al.*, 2015a). It thereby brings data and predictions about multiple Earth surface systems under one conceptual umbrella. All this is made visible to us in the form of a diagram, now widely circulated, which views the Earth from afar overlaid with wedges

depicting in hot and cold colours how close to (or far beyond) the nine boundaries we currently are (Figure 1).

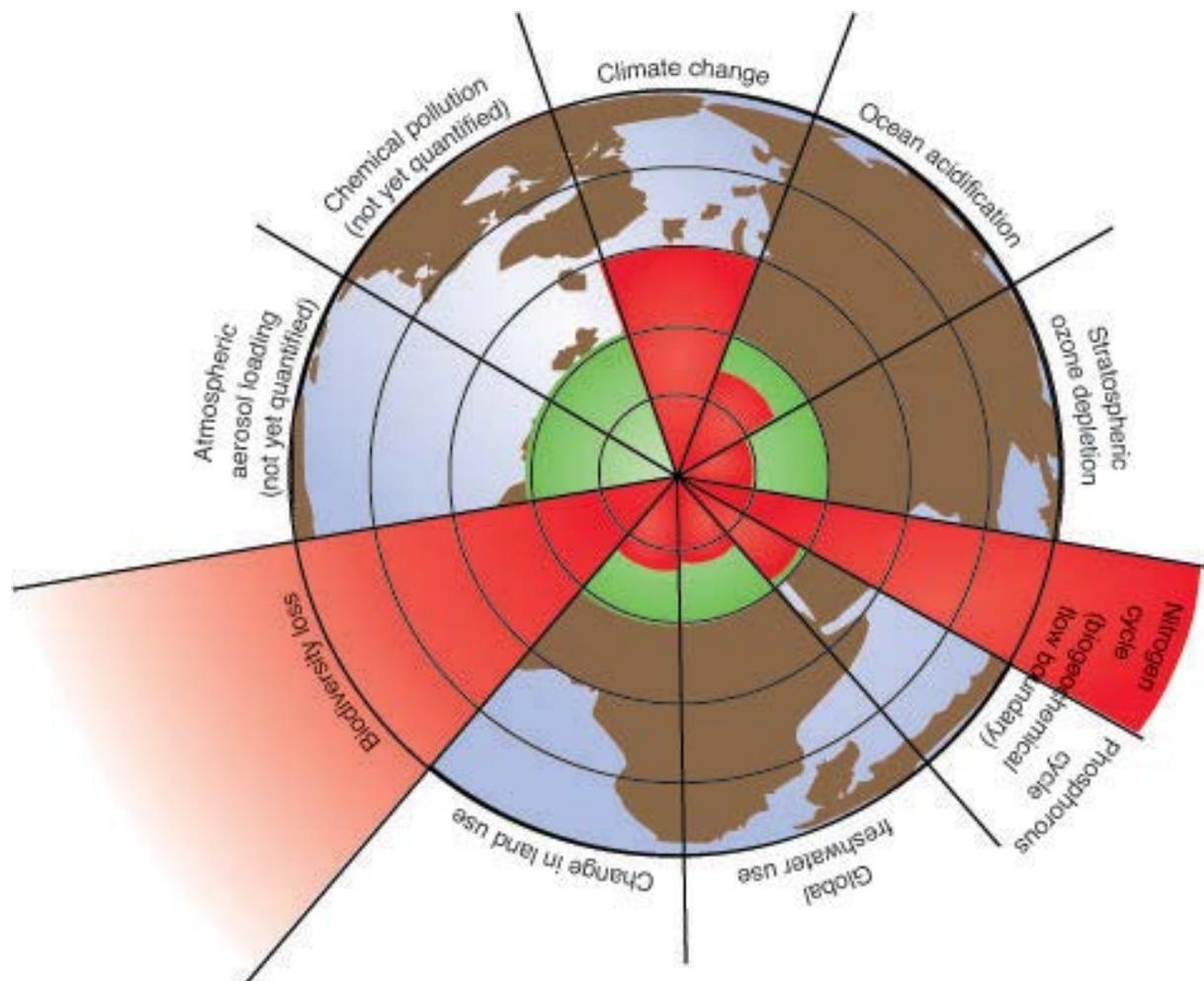


Figure 1: Humanity's causal relationship to planetary boundaries (reproduced with permission from Rockström *et al.* 2009a, design by Azote Images/Stockholm Resilience Centre).

Rockström *et al.*'s worries about boundary transgression are not only expressed in the charged metaphors they use to deliver their message. More than this, members of the group have deliberately inserted their scientific claims into world politics in a number of ways. For example, it was a key framing idea at the 2012 'Planet Under Pressure' conference held in London. This prominent event, organised by global change scientists, was designed to emphasise the gravity of humans' impact on Earth prior to the UN Rio+20 conference. More recently, attempts have been made to institute the concept at the highest political level through a revision of the UN's strategic goals for people and planet (see Griggs *et al.*, 2013). Most recently (at the time of

writing) the results of two newly published synthesis papers (Steffen *et al.* 2015a, 2015b) were presented at the 2015 Davos meeting of world political and economic leaders. Given this, in Naomi Klein's (2014) view, geoscientists – regardless of their personal political leanings – are *de facto* fifth columnists, challenging the prevailing socio-economic order from within. In years past, individual scientists have made loud claims about environmental degradation and resource scarcity. As Klein notes, what's striking today is that whole teams of respected researchers are joining the fray.

Besides making concerted efforts to represent Earth surface change in more forthright ways to non-academic audiences, many geoscientists and their allies are calling for two key alterations to GCS. The first arises from the recognition that if humans, in all their diversity, are now planetary actors, they need not only to acknowledge this fact but consider urgently what sorts of behavioural and technical responses are both feasible and desirable. Accordingly, we now hear arguments from geoscientists about the need to make the social sciences more central to global change research. It is not enough for scientists to present 'facts' about environmental change or offer technological 'solutions' absent a more textured understanding of the social fabric. This much has become obvious from the serial failures of greenhouse gas politics. Concerned geoscientists now recognise that only by understanding and altering peoples' values, perceptions, aspirations and practices can we stay within a 'safe operating space'. Short of a worldwide revolution, the only – unappealing – alternative appears to be science-led attempts to geoengineer our way out of a planetary crisis. To avoid this, a more moderate (and inclusive) way forward is being envisaged in which geoscientists and social scientists work in partnership. For instance, writing in *Science* Phillip Sharp and Alan Leshner – both senior figures in the American Association for the Advancement of Science (AAAS) – argue for “convergence science” (2014: 579). For them, this involves integration between basic and applied science, between STEM researchers⁷ and social researchers. Some current research into ecosystem services payments exemplifies such joined-up science: it aspires to a 'symmetrical' contribution from biologists, economists and others (see Naeem *et al.*, 2015)

Secondly, and related to this, several geoscientists argue for a new emphasis on 'actionable knowledge' and 'decision-relevant' science (e.g. DeFries *et al.*, 2013; Palmer, 2012). This is echoed in some high-level national

⁷STEM, as most readers will know, stands for science, technology, engineering and medicine.

programs for a new phase of GCS (notably, though by no means only, America's *Global Change Research Plan 2012-22*). This reflects a double recognition about GCS to-date. One is that much of it has involved fundamental research into biophysical processes, teleconnections and feedbacks. Until recently, applied research – including that 'human dimensions' – was not centre-stage (see Weaver *et al.*, 2014). The other is that international and national geoscience advisory bodies have rarely offered detailed insights into the means and ends of changing human behaviour. For instance, only in its most recent (fifth) assessment report has the Inter-governmental Panel on Climate Change (working group 3) ventured more confidently into the terrain of 'ought' as much as 'is'. This pushes against the norm of 'policy relevant but policy neutral' knowledge that's so far governed the Panel's conduct.

To summarise, geoscientists from across multiple disciplines are sounding ever louder warnings about the scale, scope and magnitude of the human impact on Earth. Alarmed by what's been called the 'sustainability gap' (Fischer *et al.*, 2007), these geoscientists now propose to make social science more central to their own endeavors, and to focus more on applied research that can help societies better mitigate and adapt to a transforming biogeosphere.

Speaking for and about humans transforming the Earth

To speak for the Earth as biophysical totality is an extraordinary act. In the largely secular West, science is perhaps the only institution that can credibly claim to describe, explain and predict phenomena encompassing every society and location on the planet. If geoscientists are right that we now inhabit a world indelibly altered by humans at all points of the compass then this opens the door for another extraordinary epistemological feat: speaking for *homo sapiens* as a whole. Though in its early stages, geoscientists' calls for social science to become more central to planetary management promises to enlarge the purchase of GCS. It implies that 'human dimensions' can (and should) be observed and altered not only *parallel to* but as *part of* ongoing attempts to represent Earth-wide biophysical changes.

This project has several aspects, and I cannot itemise all of them here. One is constructing theories and marshalling evidence that demonstrate convincingly the links between diverse human actions rooted in places and significant environmental changes (current and future) at larger spatio-temporal

scales (see, for instance, Palmer & Smith, 2014). Much of the research on land use and land cover change emerging out the IGBP and the International Human Dimensions Programme (IHDP) exemplifies this form of ‘coupled’ human-environment research. The next generation of such research promises to be ever more sophisticated and granular, based on more powerful computer models and a richer array of monitoring technologies. It represents humans as *internal* components of the Earth system not just an external ‘forcing agent’. A second aspect of this project is to better communicate to people – politicians, business leaders, and publics – the scale and scope of their environmental impacts. In other words, geoscientists and their social science fellow-travellers recognise that by better researching how communication ‘works’ lessons can be applied that make the message that humans pose a real danger to Earth’s life support systems stick (see, for example, Corner & Groves, 2014). As Nisbet (2009) argues, a key lesson is that different social groups require tailored messages; often these will need to be mediated by various non-science spokespersons trusted by different constituencies.

A third aspect is to identify general disincentives and carrots that can alter human values, perceptions and practices across international borders. Economics has been a privileged discipline here, not least because ‘the market’ is among the few – perhaps only – globally recognised and instituted mechanisms for coordinating and altering people’s practices. It is also a social science discipline closely connected to the agendas of political leaders and business professionals. Its concepts and arguments ‘compute’ with elites, even when innovative relative to the current political economy. In this light, it is no surprise that the Stern Review on the Economics of Climate Change garnered international attention when published in 2007. Similarly, recent international initiatives to ‘green’ modern society have often been economics-led, as with the roll-out of ‘ecosystem services’ policies and proposals to construct a new ‘green economy’. Though ecological economics is now, it seems, enjoying more high-level policy influence than heretofore, some believe this is being bought at the expense of retaining its ontological and normative differences from environmental economics (see the critique of Spash [2012], among others).

Fourth, other social scientists are focussing on the global governance arrangements that might support a ‘green transition’ economically and socially. These arrangements will need to be multi-level and transnational, and involve all the major economies at the least. They will also need to be perceived as legitimate by citizens and yet enable actions that might be hotly contested

politically looking ahead. This sort of research into political institution building is centred on political science and exemplified by the work of Frank Biermann, at Amsterdam University. He has led the Earth System Governance Project under the auspices of the IHDP.

Finally, complementing these sorts of global inquiries into how ‘human dimensions’ might be altered, are more local and regional attempts to speak for people as actors at once threatening (to Earth) and threatened (by a changing Earth). This sort of research, usually applied in character, employs a set of concepts that are now part of the *lingua franca* of GCS. These include resilience, adaptation, exposure and vulnerability. Under these umbrellas, teams of social and environmental scientists are seeking tailored understandings of specific localities with a view to implementing timely and appropriate ensembles of ‘hard’ and ‘soft’ measures. These include everything from early warning systems against biophysical threats amplified by anthropogenic environmental change to new infrastructural investments in places where money is scarce but community cohesion may be high. Examples of this sort of grounded socio-environmental research are easily found in the recent pages of *Nature Climate Change* and *Science* (e.g. Eisenack *et al.*, 2014; Aerts *et al.*, 2014). Attempts to badge various approaches in general terms – such as those by Moss *et al.* (2013) and Stern *et al.* (2013), advocates of ‘practice-relevant adaptation science’ and ‘climate vulnerability science’ respectively – suggest a desire to transfer lessons about inquiry and intervention internationally. A range of social science specialisms have been involved in this kind of research, including environmental planning and risk management.

There’s much more to be said about how various parts of social science are today articulating with claims and frames issuing from ‘concerned geoscientists’ alarmed about the human impact on Earth.⁸ However, this rapid survey offers some sense of how these parts are trying to make claims about – and therefore *on* – the many societies implicated in causing and addressing our proclaimed Anthropocenic condition. As we have seen, a range of broadly analytical-quantitative styles of environmental social science are prominent. They promise to grow their influence in the years ahead as more interdisciplinary, applied global change research becomes *de rigeur*. These styles are

⁸For instance, there’s ‘macro-level’ research into ‘socio-technical’ transitions of the sort pursued by Frank Geels at the University of Manchester. There’s also the behavioural psychology underpinning attempts to ‘nudge’ consumers, recently prominent in UK environmental policy.

generally compatible with the ontological and epistemological assumptions underpinning the work of many geoscientists. This much is evident in various collaborations to-date. For instance, Carl Folke has lent his name to key papers advancing the Anthropocene (Steffen *et al.*, 2011) and planetary boundaries (Rockström *et al.*, 2009) concepts. These papers are predominantly authored by geoscientists across the disciplines. Folke's interest in integrated socio-ecological systems analysis and ecological economics fits well with the quest for a holistic diagnosis of (and remedy for) Earth's current maladies.

Geography and global change science: actualities and probabilities

Research into global environmental change is entering a formative moment. The developments recounted in the previous two sections are feeding into, and will be shaped by, Future Earth (<http://www.icsu.org/future-earth>). This is the international successor to programmes like the IGBP and IHDP. It was launched at the UN Rio+20 Summit and is sponsored by the International Council for Science (ICSU), the International Social Science Council (ISSC) and Belmont Forum (a high-level group of global change research funders). Few, if any disciplines, contain the 'intellectual bandwidth' possessed by Geography when it comes to research into human-environment relations. How might geographers contribute to the sort of agendas Future Earth seeks to promote? Will they build on the research summarised above or find reasons and means to challenge it?

The first of these two scenarios is likely. Forty years ago, during the first great wave of global concern about 'the human impact', Anglophone Geography made little impact on wider research agendas, policies or public debates. Today, by contrast, many geographers are already part of the multidisciplinary, international research networks that are trying to get global environmental change taken more seriously by decision-makers and citizens. Their involvement takes many different forms. For instance, Eric Lambin, Diana Liverman and Tim Lenton were all co-authors of two papers that launched the planetary boundaries idea (Rockström *et al.*, 2009a, 2009b). Likewise, University of Maryland biogeographer Erle Ellis (e.g. 2011) has advanced the Anthropocene concept in prominent intellectual arenas. Meanwhile, Lambin and Billie Lee Turner II have long standing involvement in Land Change Science, fruit of IGBP and IHDP projects (see Turner, forthcoming). Then, various geographers (physical and environmental) have equally long-standing

involvement in IPCC working groups and report writing. Examples include Jon Barnett (University of Melbourne) and Neil Adger (University of Exeter). Recently, Liverman has joined Rockström in leading a 30-strong team to sketch-out the work program and governance structure for Future Earth (Future Earth Interim Secretariat, 2014). Finally, a number of physical geographers have recently been debating the different evidential markers that might help establish a Holocene-Anthropocene boundary (e.g. Brown *et al.*, 2012).

The efforts and involvements of these individuals scarcely exhaust those I could itemise if space permitted. They suggest that geographers' contributions to global change research are vigorous and wide ranging. At times they are also agenda-setting. Looking ahead, it is plain to see that certain geographers are well-set to furnish concepts, techniques and policy ideas relevant to the human aspects of global environmental change. As noted earlier, these aspects are far more central to Future Earth's agenda than they were to most of the programs that preceded it (excepting the IHDP). For instance, as adaptation to – rather than mitigation of – anthropogenic change becomes more important, several geographers will join other researchers in sharing lessons about 'successful adaptation' (see Moser & Boykoff, 2013). This kind of work emerges out of established traditions of natural hazard and disaster response research in Geography reaching back several decades. It fits well with Future Earth's aim of making human causes, effects and responses of/to environmental change a core objective.

Of course, those worried about Geography's standing in the academic division of labour (and its perceived public value) might hope for something more than the scenario just sketched. After all, recent developments in GCS speak to Geography's historical origins as a 'bridging subject' that reaches the parts other subjects (supposedly) cannot. In this light, some might argue that it's not enough for various different geographers to make diverse contributions to initiatives like Future Earth. They might hope that teams of geographers take the *lead* on the kind of stakeholder-relevant 'convergence science' that the AAAS's Sharp and Leshner argue for. Otherwise, they might claim, Geography will miss a golden opportunity to showcase its integrative credentials as a discipline that marries environmental and social science perspectives. As several presidential addresses published in the *Annals of the Association of American Geographers* argue (e.g. Skole, 2004; Harden, 2012), Geography should be at the heart of what Robert Kates (2011) calls 'sustainability science'

for the 21st century. Such centrality would reprise, in a contemporary form, the high ambitions some of Geography's founders (like Halford Mackinder) had for the discipline. It would (further) challenge the long-standing divide between much of physical and human geography.

However things eventually play-out, there is a strong possibility that numerous geographers will – at the least – help to make research into escalating global environmental change less geoscience dominated and more responsive to the demands of real-world decision-making. To my mind, these efforts are likely to centre on areas summarised at the end of section two. Research into socio-environmental adaptation, vulnerability, resilience, hazards and risk plays to the current strengths of many environmental geographers. It is typically field-work based, multi-method, context-sensitive and operationalised in both rural and urban settings. It is also typically alive to complexity of the problems being addressed.

Geography and global change science: an alternative scenario

Let me now turn to a different scenario. I regard this as preferable, if far less likely. Whether it should be complimentary or alternative to the scenario just sketched I leave readers to judge. We can approach this second scenario by identifying two kinds of research into 'human dimensions' that have so far been rather marginal in the evolution of GCS.

The first is critical inquiry into anthropogenic environmental change. Such inquiry is reflexive about the suppositions used to define how people cause, are affected by and should respond to such change. It emphasises the role of researchers as active participants in determining how real world 'problems' and 'solutions' are understood by decision-makers and others. In Geography (and Anthropology), critical socio-environmental research has pedigree in the form of political ecology (among other approaches). Political ecology, in its various permutations, offers expanded and overtly normative analytical frames when compared to those employed in the sort of 'coupled' human-environment research I mentioned earlier. An excellent recent example is Jesse Ribot's paper 'Cause and response: vulnerability and climate in the Anthropocene' (2014), published in *The Journal of Peasant Studies*. Ribot anatomises "policy-oriented and scholarly publications on climate-related vulnerability and adaptation" (p. 3). He is highly critical of them because they treat as givens human 'factors' that are contingent, symptomatic of socio-

economic causes, problematic and potentially changeable. As he puts it, these publications “seek to identify *who* is vulnerable rather than *why*, indicators rather than explanation, fixes rather than causes – as if [root socio-economic] causes were not part of redressing vulnerability and its production” (*ibid.*). Anyone who knows something of political ecology’s history will realise that Ribot is reprising an old critique of ‘technocratic-managerial’ research (first ventured by Ken Hewitt, Michael Watts and others 30 years ago). However, that this critique is still relevant tells us something about how little mainstream human-environment inquiry has moved forward during this period.

Such inquiry too often brackets key questions of power, social inequality and environmental injustice as it searches for ostensibly ‘accurate’ understandings and ‘workable’ interventions. Geoscientists, along with environmental social scientists of all stripes, need to recognise that their own practices cannot ultimately duck these questions. For instance, even computer models of the global atmosphere reflect and affect their wider political-economic environment and are far from value-neutral (Demeritt, 2001). ‘Policy relevant’ science is thus always already political and was ever so (Charlesworth & Okereke, 2010), blurring the hoary is-ought distinction characteristic of post-Enlightenment reason. Critical scholars in Geography and other disciplines have done much to reveal the ‘extra-scientific’ work that science, in its various manifestations, performs (e.g. Biermann & Mansfield, 2014). In their long-run contributions to GCS, some (e.g. Diana Liverman) have sought to act on this insight. But recent calls for change in GCS networks suggest the challenges it poses to ‘scientific’ inquiry are not being taken on board by enough practitioners.

A second form of socio-environmental inquiry so far little evident in GCS is captured in the label ‘environmental humanities’.⁹ As I interpret it, such inquiry has two principal aims. One is to faithfully represent, and compare, the full range of human life-ways on Earth, including the beliefs, customs and practices characteristic of different societies past and present. The other is to variously challenge or advocate for certain of these life-ways. This latter involves exploring deep questions about the nature and limits of ‘the human’, including questions of liberty, duty, responsibility, faith, care, affect, cruelty, hope, solidarity, wisdom and more besides.

⁹For which there is now a journal of that name: <http://environmentalhumanities.org/>. Beyond this a large number of environmental humanities conferences, seminar series and collaborations are being established in a number of universities, as a Google search rapidly reveals.

In Geography, such questions were first broached in the early 1970s, and two recent volumes on the 'geohumanities' (Daniels *et al.*, 2011; Dear *et al.*, 2011) suggest they are still a vital pre-occupation in the discipline. Indeed, many human geographers regard the enormity of humans' impact on Earth as an imperative to explore these questions anew. Consider Nigel Clark's recent book *Inhuman Nature: Sociable Life on a Dynamic Planet* (2011). Clark focuses on those 'natural forces' that continue to disrupt social reproduction – for instance, floods, earthquakes and wildfires. He criticises the sort of 'calculative reason' that constantly attempts to predict, respond to and compensate for such forces – through scientific models, insurance policies or international aid. Such reasoning, he argues, closes-off more profound understandings of sociality, community and solidarity based on a shared sense of corporeal vulnerability to an Earth that's both bountiful and dangerous. For him, such reason threatens to lock-us into a rather anaemic conception of our place on Earth and our relations to diverse human others near and far. Relatedly, some who explore historical geographies of knowledge are adept at illuminating how previous epistemic nodes and networks – ones born of things like the Cold War, state militarism or neoliberal politics – leave traces in the sort of present day reasoning someone like Clark challenges (e.g. Masco, 2010; Lave, 2014). Looking ahead, one can easily imagine research into the 'social life' of concepts like the Anthropocene and planetary boundaries as they are infused with specific meanings, and exert a certain influence, within and beyond universities. Likewise, it is not hard to foresee insightful research into continuities and changes in how 'expertise' is employed as GSC assumes more political and economic influence in the years to come.

It is well worth considering what the wider landscape of global change research would look like if richly infused with both critical and geohumanistic work on human-environment relationships (though it could, of course, issue from without academic Geography as much from within). The research would certainly push beyond the analytical confines of contemporary geoscience and those fields and styles of social science currently framing our understanding of 'human dimensions'. I say confines because, not to put too fine a point on it, they work with the grain of the current socio-ecological order (Newell, 2011). A different sort of research would situate all 'facts' about, predictions of and proposed responses to global environmental change in different normative contexts. These contexts would reflect different conceptions of the moral and aesthetic goals of human lives. They would be underpinned by varied

understandings of what currently stymies peoples' capacity to realise these goals – economically, culturally and politically. The research would eschew the idea that 'evidence-based' solutions to the challenges of anthropogenic change can be proposed absent deep discussion of values and preferred ends. It would not in any way be 'anti-science'; instead, it would acknowledge science's inevitable implication in fostering certain environment-society interactions (and not others – see Lövbrand *et al.*, 2009). In short, the research would be diverse, overtly political, and thereby alive to the profundity of our planetary condition (see Castree *et al.*, 2014).

Mike Hulme (2014a) gestures to this in a recent essay on how virtue can loom larger in contemporary debates about 'the future we want' (to quote the title of the UN declaration issuing from the 2012 Rio+20 summit). Hulme, a recent returnee to Geography,¹⁰ challenges the presumption that there is a single (changing) Earth reality, for this invites ontological monism and dreams of 'total analysis' (as if the world is a gigantic jigsaw and experts can assemble all the 'correct' pieces given time). He further argues that *episteme* and *techné* cannot trump *phronesis*, even as the latter inevitably needs the other two. For me, this conjures a vision of global change researchers across the disciplines enriching – with diligence and urgency – the 'conversation of humankind' that has barely begun in the public domain, government or the commercial arena. In human geography the philosophical basis for alternative conceptions of the means and ends of GCS already exist, albeit with little reference to GCS so far. I am referring here to notions like assemblage, hybridity and post-humanism, all fertile entry points for conceiving of different style of 'joined-up, actionable' research.

Of course, arguments like these are hard to make in existing networks and institutions of GSC. Symptomatic is a recent article by a team of anthropologists trying to showcase their subject's value to global change scientists (Barnes *et al.*, 2013). The authors, in my view, pull their punches. Perhaps worried about its invisibility in places like the IPCC, they present anthropology as a 'social science' whose largely qualitative renderings of cultural specificity can 'broaden the knowledge base' about environmental change. In their account, it seems, there's no room for the innovative work of a person like Tim Ingold (author of *Being Alive* [2011], among other germinal writings). They scarcely broach the challenge posed by some anthropologists

¹⁰He is now in geography at King's College, London, after 30 years in environmental science at the University of East Anglia.

to the very worldviews underpinning GSC as an enterprise that currently ‘couples’ geoscience with the ‘people disciplines’ in very particular ways.

However, there are encouraging signs that Future Earth might drive a wedge into existing mindsets and create space for more robust contributions from critical social scientists and eco-humanists. I say this because, aside from geoscientists, its new science committee comprises two anthropologists (Melissa Leach & Eduardo Brondizio), a feminist ecological economist (Bina Agarwal) and a philosopher (Armin Grunwald). Such figures have not, by and large, been party to GCS to date. Interestingly, Future Earth’s interim director was not a geoscientist (it’s Frans Berkhout, a colleague of Hulme’s). Moreover, one of its three overarching themes is ‘Transformations towards sustainability’. This suggests an appetite for far-reaching analysis of, and change to, socio-environmental relations at a range of scales. Indeed, Susanne Moser – another member of the science committee – has recently insisted in a manifesto published in *Nature Climate Change* that we “reframe environmental change as quintessentially social” (Hackmann *et al.*, 2014: 655). This decision to foreground ‘the social heart’ of planetary change, she and co-authors continue, will “shape ... what we perceive and everything we might do” (*ibid.*).

In Geography and a few other disciplines, such openings and arguments speak to a range of researchers who have not so far participated in the networks and institutions of global change research. I am one of them. If such researchers could make their voices heard in these networks and institutions the discourse about future Earth would, I believe, be significantly more inclusive and richer. At present, however, few of them (us) are stepping outside established tramlines. As I explain in the next, and final, section of this essay it’s time to lay some new tracks. Fortunately, potential allies exist in Geography who are already involved in global change research. An example is Katrina Brown (University of Exeter), whose critical inquiries into adaptation foreground key issues of power, in/capacity and poverty in affected communities (e.g. Brown, 2011).¹¹

Geography and global change science: towards new relationships

¹¹There are also collective attempts to foster exchange between different society-environment approaches. For example, see Brannstrom & Vadjunec (2013) *Land Change Science, Political Ecology and Sustainability: Synergies and Divergences*.

Karen O'Brien (University of Oslo) has recently urged human geographers who research environmental issues to contribute more than heretofore to the wider world of global change research. She cuts an interesting figure. She has past IPCC involvement and is presently the one geographer (by both training and institutional title) on the Future Earth science committee. From her 'insider' position she argues for wider engagement among social researchers and humanists focussed on the theme of 'transformation' (O'Brien, 2011; 2012; 2013). Her involvement in a European Science Foundation co-funded project – Responding to Environmental and Social Challenges for our Unstable Earth (O'Brien *et al.*, 2013) – has raised pointed questions about the difference between 'shallow' and 'deep' change to our socio-environmental order. With Heide Hackmann (of the ISSC¹²), Susanne Moser¹³ and Berkhout she has advocated for more heterodox social science and humanities input in a recent high-level report (ISSC/UNESCO, 2013). Like her, I believe there is need and opportunity for a broader range of geographers to help inject new thinking into global change research, policy and practice. In considering how we might proceed, it is useful to critically engage two of O'Brien's most striking propositions.

The first is that "... human geography [is] complicit in the perpetuation of paradigms that contribute to continued global environmental change ..." (2013: 593). At first reading this seems like an odd claim. After all, people like her, Katrina Brown, and others are *challenging* global change scientists to reframe key topics like socio-ecological adaptation. Moreover, human geography's far-reaching 'environmental turn' this last 20 years has yielded rich and innovative scholarship that has important things to say about humanity's 'no analogue' condition. One example is Clark's work, mentioned earlier. Another is that of Marxist Erik Swyngedouw (my Manchester University colleague). He's authored a string of hard-hitting papers about how climate science and climate policy are together 'post-political' (e.g. Swyngedouw, 2010). These papers argue that, in the guise of responding urgently to the 'threat' of a warmer world, science and policy together actually help to *prevent* the sort of radical change many people desperately want to see happen. His argument might equally apply to the recent geoscience claims about the Anthropocene, planetary boundaries and tipping points. However, O'Brien's point, as I understand it, is that work like Clark and Swyngedouw's (indeed my

¹²Though soon to be executive director of the International Science Council.

¹³Moser is also a Future Earth science committee member.

own) is not currently making a difference where it might otherwise count. In other words, by not actively engaging geoscientists and ‘mainstream’ environmental social scientists, many human geographers are watching from the sidelines. This may insure them against being co-opted into techno-managerial agendas. But it also, in effect, perpetuates those agendas by refusing to engage the epistemic communities who promote them in universities and beyond. The result is that sustainability transitions are more likely to eventuate rather than more far-reaching *transformations* (cf. Pelling, 2011).

This brings me to a second striking proposition ventured by O’Brien. She espies a ‘new age for human geography’ in which practitioners as varied as Clark and Swyngedouw help to alter global change research (O’Brien, 2011). But for this to eventuate, she argues that environmentally-minded human geographers need to question the unexamined assumptions that hold many of them at a distance from things like Future Earth (O’Brien, 2013). For instance, one assumption might be that it’s just too hard for ‘someone like me’ to publish in a journal like *Ambio*, *Proceedings of the National Academy of Sciences* or *BioScience*. This is the same as assuming that researchers who normally publish in those journals are not interested in the sorts of arguments I might want to make. Another assumption might be that people like me are having a meaningful, though ‘indirect’, impact by educating the next generation of thought-leaders in academia and elsewhere. Yet another is that we usefully influence our ‘mainstream’ colleagues at general conferences and in our coffee room conversations. O’Brien argues that such assumptions immunise us against taking the risk of fostering new habits. For her, they threaten to become excuses that justify inertia. In a sort of collective, academic version of individual psychoanalysis, she calls for our disabling assumptions to be confronted.

Though she does not fully acknowledge the institutional procedures and norms that bind so many of us into particular habits of mind and action, there is something empowering about O’Brien’s call for rigorous self-scrutiny. In Geography, and other disciplines, radical social science and humanistic inquiry have for too long – though with some notable exceptions – been estranged from STEM subjects (Kagan, 2009). Geography remains virtually unique in its intellectual breadth. In recent years, the juxtaposition of seemingly incommensurable approaches has led to some novel intra-disciplinary experiments (for instance, see Lane *et al.*, 2011). It has also inspired recent calls to reconfigure wide areas of geographical research (e.g. Tadaki *et al.* [2014] on ‘critical physical geography’; Lane [2014] on ‘socio-hydrology’). Such

experiments and calls remind us – and this is surely O’Brien’s key point – that, however regulated academic life may now be, we still possess plenty of freedom to alter our *modus operandi*. By changing ourselves we can change global change research, with all that implies looking ahead: this is O’Brien’s ultimately optimistic message.

Is she naïve? Perhaps. But let us take inspiration from legal studies and the impact some of its practitioners have had on legal professionals and global institutions like the World Trade Organisation. In a recent study, political scientist Jean-Frédéric Morin (2014) shows how an international network of left-leaning scholar-activists have meaningfully shaped wider discourses about the merits of intellectual property (IP). By organising to get their critical voices heard in intergovernmental organisations, the national media and NGO networks, these legal academics have, Morin shows, weakened the hegemony of Anglophone IP frameworks. They have challenged the previous dominance of intellectual property lawyers in setting legal agendas in this domain. His research inspires me to ask what global change research – and associated policies – might look like if new voices joined the fray with real intent.

Conclusion

This short paper has covered a lot of ground. I am acutely aware of the simplifications and short-cuts involved in trying to survey so much intellectual territory.¹⁴ However, I hope there are grains of truth in the many claims I have made. This a time of change and challenge in the world of GCS. Many environmental and social scientists who inhabit that world are trying hard to get decision-makers and publics to come to terms with the enormity of Earth-surface change. This is all to the good. Even so, I have argued that the ‘Anthropocene’ is currently too science-led. Recent proposals to ‘geoengineer’ the global atmosphere are symptomatic of the undue dominance of certain epistemic communities in debates about humanity’s planetary future (Hulme, 2014b). We need a wider range of voices to speak-up with authority (and passion) about the sort of Earth we wish our descendants to inhabit. At base, geoscience concepts like a ‘safe operating space’ are an incitement to ask

¹⁴For instance, as they evolve fields like ‘global change science’ and ‘sustainability science’ will, in the hands of certain practitioners, bleed into the critical environmental social sciences and the environmental humanities. For sustainability science there are strong hints of this in Miller’s (2015) new book. So the ‘geoscience’, ‘mainstream social science’, ‘critical social science’ and ‘humanities’ distinctions I make cannot be overdrawn in practice, however useful they are as heuristics. Then, if one looks at international nature conservation it’s clear that, for some years, critical social science and humanities scholars have been trying to shape both thought and policy. In Geography a distinguished example is Bill Adams (Cambridge University), whose writings are alive to many of the concerns I am articulating in this paper.

deep questions that admit of plural answers rather than clever ‘solutions’ – questions such as ‘how should we live?’ and ‘what is it to be human?’.

As O’Brien argues, a wider range of geographers (especially human geographers) could play a formative part in changing the Anthropocene. The global financial crisis of 2007-8 showed us the acute dangers of letting certain forms of knowledge (in this case issuing from economics and business schools) achieve worldwide hegemony. Given its rich and plural interrogations of human-environment relations, Geography has an opportunity to help ensure that science-led ideas of ‘planetary management’ do not foreclose on democratic, probing explorations of the future we want. As historian Felipe Fernández-Armesto sagely notes, real change arises from wider and deeper exchange: “The more exchange, the more change. Inter[-group] ... contacts do not just re-shake the kaleidoscope of the world; they also multiply the crystals it contains” (in Radcliffe *et al.*, 2010: 111). Geographers’ intra- and extra-disciplinary engagements could and should serve to diversify and connect windows of opportunity and possibility on our ‘human planet’. There’s genuine capacity for them to alter the intellectual (and policy) climate by creating some productive turbulence in the values, goals, evidence, plans and technologies thought most salient to life in a post-Holocene world.

Acknowledgements: I’m indebted to my three referees, two of whom provided especially rich suggestions for improvement. Parts of this paper were presented to audiences at the universities of Melbourne, Auckland and Manchester. In each case, several comments and questions I received proved to be formative. Finally, Lauren Rickards and Deirdre Wilcock have been very helpful conversants about the issues discussed in this paper.

References

- Aerts, J. C. J. H. *et al.* (2014) ‘Evaluating flood resilience strategies for coastal megacities’, *Science* 344, 2nd May: 473-5.
- Barnes, J. *et al.* (2013) ‘Contribution of anthropology to the study of climate change’, *Nature Climate Change* 3, June: 541-44.
- Barnosky, A. *et al.* (2012) ‘Approaching a state shift in Earth’s biosphere’, *Nature* 486: 52-8.
- Biermann, C. and Mansfield, B. (2014) ‘Biodiversity, purity, and death: conservation biology as biopolitics’, *Environment and Planning D* 32, 2: 257-73.
- Brannstrom, C. & Vadjunec, J. (eds) (2013) *Land Change Science, Political Ecology, and Sustainability: Synergies and Divergences* (New York: Routledge).
- Brown, A. G. *et al.* (2012) ‘The Anthropocene: is there a geomorphological case?’, *Earth Surface Processes and Landforms* 38, 3: 431-4.

- Brown, K. (2011) 'Sustainable adaptation: An oxymoron?', *Climate and Development* 3, 1: 21-31.
- Castree, N. et al. (2014) 'Changing the intellectual climate', *Nature Climate Change* 4, September: 763-8.
- Charlesworth, M. & Okereke, C. (2010) 'Policy responses to rapid climate change: an epistemological critique of dominant approaches', *Global Environmental Change* 20, 2: 121-9.
- Clark, N. (2011) *Inhuman Nature* (London: Sage).
- Corner, A. & Groves, C. (2014) 'Breaking the climate change communication deadlock', *Nature Climate Change* 4, September: 743-45.
- Crutzen, P. J. & Stoermer, E. F. (2000) 'The Anthropocene', *Global Change Newsletter* 41: 17-18.
- Dahan, A. (2010) 'Putting the Earth System in a numerical box?', *Studies in History and Philosophy of Modern Physics* 41, 2 : 282-92.
- Daniels, S. et al. (eds) (2011) *Envisioning Landscapes, Making Worlds: Geography and the Humanities* (New York: Routledge).
- Dear, M. et al. (eds) (2011) *GeoHumanities: Art, History, Text at the Edge of Place* (New York: Routledge).
- DeFries, Ruth et al. (2013) 'Planetary opportunities', *BioScience* 62, 6: 603-606.
- Demeritt, D. (2001) *Annals of the Association of American Geographers*
- Eisenack, K. et al. (2014) 'Explaining and overcoming barriers to climate change adaptation', *Nature Climate Change* 4, October: 867-72.
- Ellis, E. (2011) 'Anthropogenic transformation of the terrestrial biosphere', *Philosophical Transactions of the Royal Society A* 369: 1010-35.
- Fischer, J. et al. (2007) 'Mind the sustainability gap', *TRENDS in Ecology & Evolution* 22, 12: 621-4.
- Future Earth Interim Secretariat (2014) *Future Earth initial design report* (International Council for Science: Paris).
- Griggs, D. et al. (2013) 'Sustainable development goals for people and planet', *Nature* 495: 305-7.
- Hackmann, H. et al. (2014) 'The social heart of global environmental change', *Nature Climate Change* 4, August: 653-55.
- Harden, C. (2012) 'Framing and reframing questions of human-environment interactions', *Annals of the Association of American Geographers* 102, 4: 737-47.
- Hulme, M. (2014a) 'Climate change and virtue: an apologetic', *Humanities* 3: 299-312.
- Hulme, M. (2014b) *Can Science Fix the Climate?* (Cambridge: Polity).
- Ingold, T. (2011) *Being Alive: Essays on Movement, Knowledge and Description* (Routledge, London).
- ISSC/UNESCO (2013) *World Social Science Report 2013: Changing Global Environments* (ISSC & UNESCO: Paris).

- Kagan, J. (2009) *The Three Cultures* (New York: Cambridge University Press).
- Kates, R. (2011) 'What kind of a science is sustainability science?', *PNAS* 108, 49: 19449-50.
- Klein, N. (2014) *This Changes Everything* (New York: Simon & Schuster).
- Lane, S. et al., (2011) 'Doing flood risk science differently', *Transactions of the Institute of British Geographers* 36, 1: 15-36.
- Lane, S. (2014) 'Acting, predicting and intervening in a socio-hydrological world', *Hydrology & Earth System Sciences* 18: 927-52.
- Lave, R. (2014) *Fields and streams* (Athens: University of Georgia Press).
- Lewis, S. & Maslin, M. (2015) 'Defining the Anthropocene', *Nature* 519, 12th March: 171-9.
- Lövbrand, E. et al., (2009) 'Earth System governmentality', *Global Environmental Change* 19, 1: 7-13.
- Masco, J. (2010) 'Bad weather: on planetary crisis', *Social Studies of Science* 40, 1: 7-40.
- Miller, T. (2015) *Reconstructing Sustainability Science* (London: Earthscan).
- Morin, J-F. (2014) 'Paradigm shift in the global IP regime: the agency of academics', *Review of International Political Economy* 21, 2: 275-309.
- Mooney, H. A. et al. (2013) 'Evolution of natural and social science interactions in global change research programs', *PNAS* 110, S1: 3665-3672.
- Moser, S. & Boykoff, M. (eds) (2013) *Successful Adaptation to Climate Change* (New York: Routledge).
- Moss, R. H. et al. (2013) 'Hell and high water', *Science* 342, 8th November: 696-98.
- Naeem, S. et al. (2015) 'Getting the science right when paying for nature's services', *Science* 347, 6227: 1206-7
- Newell, P. (2011) 'The elephant in the room', *Global Environmental Change* 21, 1: 4-6.
- Nisbet, M. C. (2009) 'Communicating climate change', *Environment* 51, 2: 14-23.
- O'Brien, K. (2011) 'Responding to environmental change: A new age for human geography?', *Progress in Human Geography* 35, 4: 542-9.
- O'Brien, K. (2012) 'Global environmental change II: From adaptation to deliberate transformation', *Progress in Human Geography* 36, 5: 667-76.
- O'Brien, K. (2013) 'Global environmental change III: closing the gap between knowledge and action', *Progress in Human Geography* 37, 4: 587-96.
- O'Brien, K. et al. (2013) 'You say you want a revolution? Transforming education and capacity building in response to global change', *Environmental Science and Policy* 28, 1: 48-59.
- Palmer, M. (2012) 'Socio-environmental sustainability and actionable science', *BioScience* 62,1: 5-6.
- Palmer, P. & Smith, M. (2014) 'Model human adaptation to climate change', *Nature* 512, 28th August: 365-6.

- Pelling, M. (2011) *Adaptation to Climate Change: From Resilience to Transformation* (London: Routledge).
- Radcliffe, S. et al. (2010) 'Environmentalist thinking and/in Geography', *Progress in Human Geography* 34, 1: 98-116.
- Ribot, J. (2014) 'Cause and response: vulnerability and climate in the Anthropocene', *The Journal of Peasant Studies* DOI: 10.1080/03066150.2014.894911
- Rockström, J. et al. (2009a) 'A safe operating space for humanity', *Nature* 461, 24th September: 472-5.
- Rockström, J. et al. (2009b) 'Planetary boundaries: exploring the safe operating space for humanity', *Ecology & Society* 14, 2: 1-24.
- Steffen, W. et al. (2004) *Global Change and the Earth System* (Berlin: Springer).
- Steffen, W. (2011) 'The Anthropocene: from global change to planetary stewardship', *Ambio* 40: 739-61.
- Steffen, W. et al. (2015a) 'Planetary boundaries: guiding human development on a changing planet', *Science* 347, 6223: 736-46.
- Steffen, W. et al. (2015b) 'The trajectory of the Anthropocene: The Great Acceleration', *The Anthropocene Review* 3: 1-18.
- Skole, D. (2004) 'Geography as a great intellectual melting pot and the preeminent interdisciplinary environmental discipline', *Annals of the Association of American Geographers* 94, 4: 739-743.
- Spash, C. (2012) 'New foundations for ecological economics', *Ecological Economics* 77, 1: 36-47
- Stern, P. C. et al. (2013) 'Managing risk with climate vulnerability science', *Nature Climate Change* 3, July: 607-9.
- Swyngedouw, E. (2010) 'Apocalypse forever? Post-political populism and the spectre of climate change', *Theory Culture & Society* 27, 2-3: 213-232.
- Tadaki, M. et al. (2014) 'Cultivating critical practices in physical geography', *The Geographical Journal* doi:10.1111/geoj.12082
- Turner, B. L. (2015) 'Land change science', in D. Richardson et al. (eds) *International Encyclopedia of Geography* (Malden and Oxford: Wiley Blackwell).
- Weaver, C. P. et al. (2014) 'From global change science to action with social sciences', *Nature Climate Change* 4, August 656-9.
- Zalasiewicz, J. et al. (2015) 'When did the Anthropocene begin?' *Quaternary International*, in press DOI:10.1016/j.quaint.2014.11.045