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# Anthropocene and planetary boundaries

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## **The Anthropocene and planetary boundaries**

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### **Abstract**

‘The Anthropocene’ was scientific neologism in 2000 but is now something of a buzzword in the earth and environmental sciences, with the prospect of becoming part of the *lingua franca* of the social sciences and humanities too. It is closely related to the younger scientific neologism ‘planetary boundaries’. Both terms describe human impacts on the face of the earth that are wider and deeper than previously recognised. Both also have an epochal meaning, suggesting as they do the end of the Holocene epoch (the period of earth history during which *homo sapiens* have flourished). This article details the origins of the Anthropocene concept, and its collateral term planetary boundaries. It then discusses antecedent concepts that failed to catch-on in the world of science or the wider world. Contemporary attempts to formally designate the Anthropocene a new geological epoch are then considered. Despite being so-far inconclusive, these attempts have not prevented the Anthropocene being visible in the broader environmental sciences courtesy of the planetary boundaries hypothesis. The article considers how social scientists and humanities scholars are responding to the claim that humanity is leaving its ‘safe operating space’, concluding with a discussion of how the broader academic discussions of the Anthropocene are being registered in Geography. Though so far fairly marginal to debates about both ideas, geographers have a clear stake in determining their future significance for science and society.

### **Main text**

#### The Anthropocene concept: definition and origin

‘The Anthropocene’ denotes an epoch in which the collective impact of human activities is sufficient to significantly alter the conditions of life on planet Earth. The term is said to have been coined by American freshwater ecologist Eugene Stoermer in the mid-1980s. However, it was the Dutch Nobel Prize winning atmospheric chemist Paul J. Crutzen, of the Max Planck Institute for Chemistry, who did most to popularize the term among earth and environmental scientists. In 2000 he and Stoermer published a short article in the *Global Change Newsletter (GCN)* the ‘house publication’ of the International Geosphere-Biosphere Programme (IGBP). The IGBP was (and remains) one of several multi-country research programmes designed to study contemporary environmental change on a global scale by combining the expertises of multiple academic subjects, from climatology to oceanography to biogeography. In their article Crutzen and Stoermer suggested that the intentional activities of people, such as commercial farming, travelling by car and consuming imported foods, had unintentionally altered the ‘boundary conditions’ definitional of the Holocene. The latter is the period of earth surface

history beginning around 11700 years ago when the most recent ‘ice age’ ended. Research suggests that the various climatic zones and biomes emergent during the early Holocene remained fairly stable from thereon, so too average global atmospheric temperature. The most recent centuries of the Holocene have been those when the number of *homo sapiens* grew significantly and when large-scale migrations led to their dispersal away from centres of origin. Crutzen and Stoermer proposed that the cumulative environmental impact of people living in so-called ‘advanced’ societies is such that the Holocene might be at an end – if not at the time of writing then soon. Given how slow geological change normally is, at least when measured against an average human life-span, the suggestion that people are now equivalent to a ‘natural force’ (such as a large meteorite hitting Earth) was a startling one. It amounted to saying that Anthropogenic climate change, already a serious scientific and policy concern by 2000, was only the tip of the proverbial iceberg.

In 2002 Crutzen presented the Anthropocene hypothesis to the wider scientific community in a short essay published in the world’s leading science periodical *Nature* (Crutzen, 2002). Counter-intuitively titled ‘Geology of mankind’, the article pointed out that if current Western standards of living become globalised then people worldwide will take the Earth’s biophysical systems into *terra incognita*. This may, he argued, necessitate technical interventions of unprecedented scale and scope, such as “internationally accepted ... geo-engineering projects ... to ‘optimize’ climate” (*ibid.* 23). Similarly, Crutzen speculated, it may require substantial measures to engender “appropriate human behavior at all scales” (*ibid.*) so as to avoid harmful unintended impacts on fresh water resources, nitrogen cycles, oceanic currents and much else besides.

#### The Anthropocene concept: current visibility and precursors

Since Crutzen’s *Nature* article, ‘the Anthropocene’ has attracted increasing attention across a range of earth and environmental science fields, including some branches of physical geography. The attention was by no means immediate. Even in 2006 Crutzen’s neologism rarely featured in peer reviewed scientific research papers. However, for various reasons to be explained below, it is now a fairly familiar term in the semantic landscape of several science subjects. Indeed, a new science journal, published by Elsevier, bears the name (see:

<http://www.journals.elsevier.com/anthropocene/>), as does the new interdisciplinary

*Anthropocene Review* (published by Sage). The Anthropocene even enjoys a degree of public and political visibility, albeit currently modest. For instance, *The Economist* magazine devoted a whole section of a late May 2011 issue to the subject, while two months earlier *National Geographic* magazine ran an article by American science writer Elizabeth Kolbert entitled ‘Enter the Anthropocene – Age of Man’. The year ended with *The New York Times* publishing an op-ed on the subject (Marris *et al.*, 2011). Meanwhile, science popularizer and environmentalist Mark Lynas used the idea of ‘planetary boundaries’ to structure his 2011 best-seller *The God Species: How the Planet Can Survive the Age of Humans*. This idea, as will explained below, is closely related to the Anthropocene concept and had already been highlighted in an April 2010 issue of *Scientific American* entitled ‘Managing Earth’s Future’. Two years later, scientists involved in the IGBP and other global environmental change research programmes organized the ‘Planet Under Pressure’ conference just prior to the United Nations Rio+20 ‘Earth Summit’. This conference, intended to capture the attention of politicians, opened with a time-lapse video of recent earth surface change entitled ‘Welcome to the Anthropocene’ (available at <http://vimeo.com/39048998> at the time of writing).

Though ‘the Anthropocene’ remains a novel term, its meaning is not entirely original. As British geologist Jan Zalasiewicz and colleagues noted, “The term Anthropocene is the latest iteration of a concept to signal the impact of collective human activity on biological, physical and chemical processes at and around the Earth’s surface” (Zalasiewicz *et al.*, 2011: 1037). For instance, eight years before Crutzen and Stoermer’s article in the *Global Change Newsletter*, *New York Times* environmental correspondent Andrew Revkin coined the term ‘Anthrocene’ to designate “... a geological epoch of our own making” (Revkin, 1992). Over a century earlier Italian geologist Antonio Stoppani (1873) had presciently talked of the ‘anthropozoic era’. Then, in the 1920s, the Russian geochemist and naturalist Vladimir Vernadsky was among the first to propose the idea of the ‘noosphere’. For him this was the realm of human imagination and desire, a constitutively social (even virtual) domain irreducible to humans’ biological capacities but with world-changing potential realizable through technology. Vernadsky had already argued that the biosphere was a force of nature akin to the movements of tectonic plates. Relatedly, his noosphere concept suggested that *homo sapiens* might rise above other species to exert a global influence. In the 1940s his ideas reached a wider English speaking science readership (see Vernadsky, 1945).

These and other predecessor terms did not catch-on in the scientific community (or wider world) in that way the Anthropocene seems to have done since 2000. What explains the difference? It no doubt helps that Crutzen is a highly visible and esteemed scientist in the broader earth and environmental science community. What’s more, he has been adept at developing relationships with notable members of this community who have a professional stake in examining the Anthropocene hypothesis more closely. Among them are the aforementioned Zalasiewicz and the Australian earth system scientist Will Steffen (about which more below). In addition, the fact that anthropogenic climate change is believed by most climate scientists to be real and significant is an important background consideration. If humans can accidentally alter the world’s climate then it is not so far-fetched to take seriously the suggestion that we are taking other biophysical systems away from their Holocene norms. Relatedly, environmental measurement and monitoring systems are far more numerous and granular than a generation ago, in part because of the impetus provided by the IBGP and related research programmes. This means that large claims about global environmental change are more readily testable than heretofore and easier to accept as working hypotheses that can be dis/confirmed in due course. Finally, and going back a little further in time, more than one generation of scientists, politicians, business people and members of the public are accustomed to ideas as intellectually and practically challenging as the Anthropocene. Even prior to anthropogenic climate change (once known more pointedly as ‘global warming’) becoming a key term in our societal lexicon, concepts like ‘natural limits to growth’, global ‘over-population’ and ‘nuclear winter’ were emanating from (parts of) the scientific community as far back as the mid-1960s. These concepts were taken seriously in the wider society, even if they fell out of use for various reasons. For older members of several non-academic communities (political, commercial etc.) the idea of the Anthropocene has thus not come out of the blue, but is only the latest – albeit most far-reaching – term used to describe human-environment relations on a global scale.

### A new geological epoch?

At the time of writing discussion of the Anthropocene remains largely confined to academic circles, especially those that Crutzen and his coauthors move in. A minority of social scientists and humanities scholars are also beginning to consider the Anthropocene, including a small

number of human geographers whose arguments will be considered towards the end of this article. Only time will tell if the Anthropocene idea becomes truly prominent outside the world of universities. In the earth and environmental sciences, the debates have focused on issues of measurement and inception. The questions have been ‘What evidential markers can tell us whether or not the Anthropocene has begun and the Holocene ended?’ and ‘When, exactly, did the Anthropocene start?’. These questions have arisen because of Crutzen’s success in enrolling other scientists in testing his Anthropocene hypothesis. For instance, in late 2007 he co-published a paper with the above mentioned Will Steffen and American environmental historian John McNeill. Its dramatic and quizzical title was ‘The Anthropocene: are humans now overwhelming the great forces of nature?’ (Steffen *et al.*, 2007). The paper appeared in the peer review, multi-disciplinary science journal *Ambio*. More detailed in evidential and analytical terms than the earlier *GCN* and *Nature* articles, it was also more confident that the Holocene is a thing of the past.

However, none of the three authors was (or now is) a geologist. By contrast, Leicester University’s Jan Zalasiewicz was, in 2007, chair of the Stratigraphy Commission of The Geological Society (located in London). He noticed Crutzen and others’ use of the Anthropocene idea. He proposed to the other 20 Commission members that this idea should and could be tested using formal geological criteria for the identification of an epoch. The result was a coauthored article that appeared in *GSA Today*, the house periodical of the Geological Society of America (Zalasiewicz *et al.*, 2008). Entitled ‘Are we now living in the Anthropocene?’, it detailed the measures necessary to establish if and when the Holocene had ended. To quote from it at some length, “... Earth has endured changes sufficient to leave a global stratigraphic signature distinct from that of the Holocene or previous Pleistocene inter-glacial phases, encompassing novel biotic, sedimentary, and geochemical change. These changes, though likely only in their initial phases, are sufficiently distinct and robustly established for suggestions of a Holocene-Anthropocene boundary in the recent historical past to be geologically reasonable. The boundary may either be defined via a Global Stratigraphic Section and Point (‘golden spike’) locations or by adopting a numerical date” (*ibid.* 4). As a result of this paper and subsequent discussions among the academic networks of Commission members, the International Commission on Stratigraphy – which is ultimately responsible for identifying geological epochs – established an Anthropocene Working Group and made Zalasiewicz its chairman. At the same time Zalasiewicz and his Leicester colleague Mark Williams joined with Crutzen and Steffen to present the question of formally establishing the Anthropocene’s epochal status to non-geologists (Zalasiewicz *et al.* 2010a). A set of 2011 papers in the *Philosophical Transactions of the Royal Society A* were intended to do the same (Ellis, 2011; Steffen *et al.* 2011a; Zalasiewicz *et al.* 2011). As a consequence of these interventions, and various conference presentations by their authors, the broader environmental science community has been drawn into a geological discussion of epochal markers normally confined to earth science and normally focused on the deep past.

Which lithostratigraphic, biostratigraphic or chemostratigraphic indicators, if any, are considered sufficiently suggestive of a phase shift in earth surface conditions to serve an agreed criteria for the Holocene’s eclipse? There are several candidates, from lake sediments to greenhouse gas concentrations to artificial isotopes produced by nuclear weapons detonations. Clearly, because these markers all pertain to both recent and ongoing anthropogenic environmental change, establishing the Anthropocene’s epochal status in a way satisfactory to geologists requires environmental scientists from a range of disciplines (including physical geography) to

supply robust evidence of changes that might, thousands of years hence, be considered clear stratigraphic markers by future geologists. For instance, the British Society for Geomorphology has established a fixed term working group to advise the Society on whether and how contemporary landforms might comprise stratigraphic markers (see Brown *et al.* 2012). The complications involved in identifying and interpreting markers of any kind are manifold (Rull, 2013). First, which markers – one or several – should be taken as definitive of the Holocene's termination? Second, given that we may only be in the very early years of the Anthropocene, it is important that any one marker be resolved to geologically precise temporal scales, like a decade or a year. This is technically challenging in many cases. Third, because the ecological impacts of human activity have been and remain diachronous, significant environmental signatures evident in one part of the world (e.g. Western Europe) may not be replicated elsewhere until the last few years or next few decades. Finally, it is entirely possible that future environmental markers reflective of present day human activities will prove to be more compelling indicators of the Anthropocene's onset.

By virtue of some or all of these reasons, several environmental scientists doubt that the Holocene's end can (yet) be measured in stratigraphic terms. For instance, in a paper about anthropogenic soils as potential stratigraphic markers Gale and Hoare (2012) conclude that “ ... there are serious difficulties in using stratigraphic methods to define the base of the Anthropocene. In part this is associated with the worldwide diachroneity of human impact and the difficulty of establishing a single chronological datum for the epoch. Although several wide-ranging event markers exist (including bomb-produced isotopes), these fail to coincide with the worldwide initiation of [environment altering] human activity ...” (p. 1493). Given the several measurement issues itemized above, and given that the International Commission on Stratigraphy is very exacting about what constitutes a new geological time period, there is little chance that the Anthropocene will be declared a new epoch by geologists any time soon.

#### Beyond Geology: current debates in the environmental sciences

This has not deterred several researchers from searching for chronometric indicators of the Anthropocene's inception, regardless of their stratigraphic in/significance. In their 2007 *Ambio* paper, Steffen *et al.* divided the Anthropocene into 3 periods, beginning with 'The Industrial Era' (1800-1945), followed by 'The Great Acceleration' (1946-2015) and possibly followed by a period of 'Earth System Stewardship' (2016-) in which humans at last take collective responsibility for their huge global environmental footprint (see also Steffen *et al.*, 2011). However, without discounting the chronometric significance of 1800, American paleoclimatologist Bill Ruddiman and colleagues have suggested that a global anthropogenic environmental signal can be recorded hundreds of years earlier (see the debate organised Ruddiman, Crucifix and Oldfield [2011] in the pages of *The Holocene*). They propose that even as early as the Middle Ages (and perhaps centuries before that) collective human endeavor was able unintentionally to alter climatic conditions (see Ruddiman, 2013, for a review of the evidence in favour of 'the early Anthropocene hypothesis'). As with the discussion of stratigraphic markers it is unlikely consensus will be reached on a single year or decade when the Anthropocene can be said to have begun. Instead, environmental scientists may need to accept that different worldwide anthropogenic signals of varied magnitude appeared at different times over the last six centuries. In this light, the 'beginning' of the Anthropocene might be said to have been cumulative, unsynchronised and strung-out rather than punctual (see Lewin & Macklin, 2013).

In light of these debates about how to measure and date a crossing of the Holocene-Anthropocene boundary, it may be thought that Crutzen and Stoermer's hypothesis has reached an impasse a decade and a half after it was put forward. However, this is far from true. As paleoecologist Valenti Rull notes, "... it is not necessary to formally define the Anthropocene as an epoch to accept that human activities have significantly changed Earth system processes [and forms] during the last [few] ... centuries" (2013: 4). Geologists like Zalasiewicz and Mark Williams, and environmental scientists like Crutzen and Steffen, recognize this too. As they wrote in the journal *Environmental Science and Technology*, "... quite how and when the Anthropocene is formalized is of secondary importance; its real importance is in being a means to integrate a wide range of environmental indicators [and] to consider them within the context of the whole of [the] Earth [surface]" (Zalasiewicz *et al.* 2010b: 6008). Consequently, it is possible for the Anthropocene to remain an informal concept in geology even as it becomes a normal part of the vocabulary of many environmental scientists. Its facility for the latter is that it denotes biophysical changes that are profound relative to the *human*, rather than geological, past.

One notable example of this is the recent published work of Johan Rockstrom and colleagues – colleagues who include Crutzen and Steffen. In a 2009 paper in *Nature* (Rockstrom *et al.* 2009a) and a much longer essay published in the journal *Ecology and Society* (Rockstrom *et al.* 2009b), a large number of environmental scientists from across the disciplines have advanced the concept of 'planetary boundaries'. Aside from Crutzen and Steffen, high profile scientists both, these researchers include noted ecological economist Robert Constanza and the prominent climate scientist James Hansen. Rockstrom *et al.* argue that the environmental conditions of the Holocene are preferable to those of an unknown and potentially inhospitable Anthropocenic future. They identify nine global environment components constitutive of the earth system. These pertain to climate, ocean acidity, chemical balances, atmospheric aerosols, biodiversity, land use types, freshwater, nitrogen and phosphorous cycles, and stratospheric ozone density. For seven they specify a quantitative boundary, the crossing of which might take the system beyond Holocene norms (for the remaining two they are unable, as yet, to quantify the boundary). Together, the nine boundaries comprise what Rockstrom *et al.* call 'a safe operating space for humanity' (2009a: 472). Modern humans, they argue, have already transgressed several of these. Recognising that "Determining a safe distance involves normative judgements of how societies choose to deal with risk and uncertainty", they nonetheless commend their "... new approach to defining biophysical preconditions for human development" (*ibid.* 472, 474).

Rockstrom *et al.*'s planetary boundaries concept is a particular version of the Anthropocene idea in all but name. We might therefore call it a 'collateral concept'. It signifies environmental changes of the same scope and scale as the Anthropocene idea, but in a less politically neutral and more overtly normative way. This is not to suggest that Rockstrom, Crutzen Steffen, Constanza, Hansen and others are distorting science to serve political ends i.e. to recommend urgent action to stay within a 'safe operating space'. It is simply to say that, in their view, current evidence of human impact suggests that future environmental change may pose a serious threat to human development in many parts of the world. In part, this is because the concept of multiple planetary boundaries suggests the possibility of 'coupled effects', where crossing one threshold then triggers serious biophysical changes to some or all of the other eight components of the earth system.

Unlike the Anthropocene concept, the planetary boundaries idea has not – for obvious reasons – preoccupied geologists. It can be taken seriously without any need to satisfy formal

geological criteria for the Holocene's end. Yet, given its novelty, it has not yet received much serious scientific scrutiny outside the large network of authors represented in the *Nature* and *Ecology & Society* papers. It has, however, been noticed by the United Nations High Level Panel on Global Sustainability and by leading non-governmental organizations like Oxfam and the World Wildlife Fund. In large part this is because it featured prominently at the aforementioned Planet Under Pressure conference in London. However, members of the American environmental think-tank the Breakthrough Institute caution against its uncritical acceptance (Nordhaus, Shellenberger & Blomqvist, 2012). Though not practicing scientists, their evidence-based report arrived at two conclusions. The first is that six of the supposed planetary boundaries cannot be said to be global but only regional or local; the second is that there is no compelling evidence that transgressing these six 'non-threshold boundaries' would necessarily diminish human welfare. Nordhaus *et al.* point to the choices and ingenuity humans possess to both adapt to and change their surrounding environments. They argue that people can and must 'trade-off' between alternative goals and courses of action. In this light, they insist, "... attempts to depoliticize [trade-off decisions] ... with reference to scientific authority is dangerous, as it precludes democratic resolution of ... [public] debates, and limits, rather than expands, the range of available choices and opportunities" (*ibid.* 37). Somewhat differently, British environmental scientist Simon Lewis (2012) worries that a focus on nine boundaries could spread politicians' environmental policy focus too thin, distracting them from prioritizing key boundaries like the concentration of atmospheric greenhouse gases.

#### The Anthropocene and planetary boundaries as strategic tools for policy-relevant science

In scientific terms, it is unclear how the Anthropocene concept and the related planetary boundaries idea will fare in the years ahead. As we have seen, geologists remain open-minded yet uncertain about the former, while many environmental scientists struggle to agree on an inception date. Meanwhile the planetary boundaries idea is rather too new to have attracted sustained scientific scrutiny as yet. What is clear is that both are intended by their originators to be a scientific means to capture the worldwide attention of politicians, business people, third sector organizations, and publics. As Steffen *et al.* wrote in 2011, "The concept of the Anthropocene, as it becomes more well-known ..., could well drive a similar reaction to that which Darwin elicited [a hundred and fifty years ago]. There is one very significant difference, however ... Darwin's insights into our origins provoked outrage, anger and disbelief but did not threaten the material existence of society of the time. The ultimate drivers of the Anthropocene, on the other hand, if they continue unabated ..., may well threaten ... the future existence of *Homo sapiens*" (2011a: 862). Given that these authors have been directly involved in proposing it, the same can be said of the planetary boundaries idea too. Both are intended to provide "an independent measure ... of the scale and tempo of human-caused change ..." (Steffen *et al.* 2011b: 756-7). They deliberately beg large non-scientific questions about what humans want for the future and how they might go about realizing their goals practically in world of rapid biophysical change. Science can help address these questions, but only up to a point. Science is thus inserted into vital discussions about what some regard as the ultimate question, namely 'How should we live?'

Cynics might argue that the multi-disciplinary science networks currently advancing the Anthropocene and planetary boundaries ideas are politically canny in their hunt for future science funding. Science is expensive to pursue and highly competitive between science subjects. It could be argued that the two concepts are eye-catching vehicles to persuade governments to

throw yet more money at global environmental change science in its various forms, keeping the likes of Crutzen, Steffen and Rockstrom gainfully employed for years to come. However, a different interpretation is equally, if not more, plausible. Scientists are not only scientists; they are also citizens, parents, members of local communities, and so on. This means they possess the same wider hopes for, and anxieties about, our future that other people possess. In many cases scientific insight can speak directly to these hopes and anxieties, without entirely dictating their content. This may explain a recent position piece published in the journal *BioScience* by – yet again – Paul Crutzen, writing with a combination of both environmental and social scientists. Entitled ‘Planetary opportunities: a social contract for global change science to contribute to a sustainable future’, it argues that societies now need ‘useable research’ from the science community that is ‘solutions orientated’ (DeFries *et al.* 2012). The paper is framed explicitly against the ‘reality’ of the Anthropocene and the nine Holocene ‘planetary boundaries’ defined by Rockstrom *et al.* It presents a vision of global change science at the service of societies worldwide, akin to what science policy analyst Michael Gibbons and coauthors famously called ‘Mode 2 research’ (Gibbons *et al.* 1994). Such research, these writers argued, does not satisfy merely academic curiosity but is, instead, geared to real world ‘contexts of application’ from the get-go. Understood in this light, the ideas advanced by Crutzen, Steffen, Rockstrom and allies are important not because they can ultimately be ‘tested’ empirically but because they can frame the future conduct of societally-relevant environmental science. The desire for relevance in parts of the environmental science community is currently very high. For instance, James Hansen has been a visible and vocal advocate of strong measures to mitigate future atmospheric warming. Meanwhile, British climate scientists Kevin Anderson and Alice Bows (2012) argue that too many scientists have been far too timid in emphasizing to politicians the severity of forthcoming environmental change.

#### The contribution of social science and the humanities

How have social scientists and humanities scholars interested in environmental change responded to the idea of the Anthropocene and its collateral concept of planetary boundaries? Some applied social scientists have used them as a (further) opportunity to argue for a new global governance architecture that can build on the not-entirely successful efforts of the United Nations to ensure coordinated and decisive transnational environmental management. Notable here is the work of Frank Biermann and colleagues on the so-called Earth System Governance Project which began in early 2009. The Project involves some 2000 social scientists worldwide. It is an outgrowth of the International Human Dimensions Programme on Global Environmental Change (IHDP), itself a product of the global environmental change research programmes established nearly three decades ago (such as the IGBP). The Project, which runs until 2018, aims to study and shape “... the interrelated and increasingly integrated system of formal and informal rules, rule-making systems, and actor-networks at all levels of human society (from local to global) that are set-up to steer societies towards preventing, mitigating, and adapting to global and local environmental change and, in particular, earth system transformation, within the normative context of sustainable development” (Biermann *et al.* 2009; see also Biermann *et al.* 2010). In this vision, social science arguably becomes the analytical and practical twin of Crutzen *et al.*’s environmental science. It seeks to create, monitor and suggest amendments to a new regulatory apparatus sufficient to govern “appropriate human behavior at all scales” as per Crutzen’s 2002 *Nature* paper.

For those persuaded of the scale and urgency of the environmental challenges encapsulated in the Anthropocene and planetary boundaries concepts, this kind of social science endeavour is both necessary and highly valuable. However, some social scientists have expressed concern. For instance, in a recent paper in the journal *Environmental Science & Policy* (Palsson *et al.*, 2013) a mix of anthropologists, historians and sociologists offer two criticisms of the style of ‘relevant’ Anthropocenic social science advocated by Biermann *et al.* First, they worry that seemingly ‘objective’ scientific concepts can be internalized unthinkingly by social scientists and then translated into action via policy makers. For instance, they point out that we should “view systematic boundaries as suitable constructs for a mechanistic worldview created by [scientists] ... for analytical purposes and projected onto reality, rather than an intrinsic property of the observed world” (*ibid.* 7). Second, they suggest that a rush to identify managerial ‘solutions’ to environmental problems identified by environmental scientists may overlook the need to explore the full range of possible societal causes of these problems, and the various ways they may be perceived and felt by diverse real-world actors. All solutions are, after all, relative to how one understands the underlying reasons productive of perceived problems. For instance, a Marxist might say that profit-hungry capitalist corporations are largely responsible for unchecked global environmental change; a neo-liberal economist might say that ‘missing markets’ are the problem; meanwhile, certain feminists might point to the deleterious effects of ‘masculine’ reason which treats the world as a set of objects and relations to be dissected, manipulated and exploited. In each case, the ‘social engineering’ required to respond to the challenges of the Anthropocene and remain within a ‘safe operating space’ would be very different than those likely to emerge from the Earth System Governance Project. And in each case we might be disposed to ask different questions about how ordinary people want significant environmental change to be tackled.

Underpinning Palsson *et al.*’s arguments is a clear recognition that the social sciences and humanities produce value-laden concepts, proposals and evidence. They cannot pretend to exist ‘above the fray’ and need to be explicit about the normative judgments written-into both their analyses and proposals for alternative courses of human action. This is for the obvious reason that all values are debatable and require reasoned discussion in order to be accepted as the proper basis for social conduct and environmental husbandry. Palsson *et al.* are among a number of scholars calling both for more diverse and more radical conceptions of how to respond to the challenges of our Anthropocenic times. This presents a real opportunity for social scientists and humanists to demonstrate their societal relevance, but in ways that are not narrowly instrumental or unthinkingly reproductive of the political-economic and cultural status quo. Several science policy makers are keen to maximize this opportunity. For instance, The European Union ‘RESCUE’ foresight project (Responding to Environmental and Social Challenges for our Unstable Earth) created a working group focused on ‘revolutionary education and capacity building’. Relatedly, in key American science funding bodies (notably the National Science Foundation) ‘transformative research’ is now seemingly *de rigeur*, and is conceived in wider terms than simply ‘transformative technologies’ (like nanotechnology).

Aside from its several applied subject areas (like social work), the social sciences have long been productive of radical thought (often in a highly utopian register). This is equally true of the humanities, as they have typically been unencumbered by concerns about ‘policy relevance’ or ‘stakeholder needs’. This does not render them mere ivory tower pursuits, but ensures they have the freedom to stretch the boundaries of what’s thinkable and considered to be possible. Moreover, whereas social science is not terribly visible outside universities, humanistic endeavors certainly are among sections of the wider society (think of literature and poetry, for

instance). During the period when the Anthropocene and planetary boundaries concepts have entered scientific discourse the so-called ‘environmental humanities’ have risen to prominence within (and indeed beyond) the academy. In the broadest sense this involves non-academics and has proceeded in three connected ways. First, many professional writers in the West have been publishing works of autobiography, ‘faction’, literary fiction and poetry that focus on a ‘rediscovery’ of the non-human and an exploration of the role of ‘nature’ can and should play in our everyday lives. In Britain the writings of Robert Macfarlane (author of *The Wild Places*, 2007) about the relationship of people and land are emblematic of a wider fascination with the affective significance of the material world. Second, in a range of humanities fields – most notably literary criticism – newer (like Macfarlane’s) and older (like Thoreau’s) attempts to rethink human-environment relations have produced a new body of humanistic analysis called ‘ecocriticism’ (see Garrard, 2013). This seeks to shine light on the content, tropes and aims used by nature writers, photographers and film makers in their attempts to have people reconsider the ways they (de)value the non-human. Finally, the environmental humanities have, *sui generis*, been productive of radical new conceptions of how to apprehend and register the significance of the non-human. Literary critic Tim Morton’s work is a good example (e.g. Morton, 2010), attempting as it does to entirely eliminate the nature-society dichotomy that has for so long structured how most Westerners conceive of reality.

#### Geographers and the Anthropocene

How have these wider currents of thinking with and beyond environmental science influenced the discipline of Geography and vice versa? Thus far, few geographers have either been involved in originating the two concepts being discussed here (University of Arizona’s Diana Liverman and University of Maryland’s Erle Ellis are exceptions) or in responding to them/fleshing-out their possible significance. Given their encompassing meaning and implications, one might expect the Anthropocene and planetary boundaries ideas to engender renewed consideration of how physical and human geographers can better work together to study and improve the world. This has not happened yet but is very likely to in the near future. In the meantime it is human geographers of various stripes who have so far paid the ideas most attention (or rather the first idea, since planetary boundaries have scarcely attracted geographers’ attention as yet). Since human geography has both social scientific and humanistic elements, it is no surprise that the geographers in question have offered diverse reflections on what the Anthropocene signifies for Geography and/or society (see, for example, the 2014 ‘Forum’ organized by Johnson and Morehouse in the journal *Progress in Human Geography*).

In the first place, some have used the Anthropocene as an occasion to pronounce the ‘death’ of Nature, a category that has long vouchsafed physical geography’s identity and which remains a touchstone for public pronouncements about the need to mitigate or adapt to global environmental change. According to Jamie Lorimer (2012), the worldwide ontological mixing of human forces with non-humans definitive of the Anthropocene has profound intellectual and normative implications. For him it is creating ‘emergent geographies’ that are spatially and temporally varied, often surprising; the implication is that we can no longer talk about a singular, asocial Nature to justify various management/conservation/remediation/preservation/restoration measures (be they large or small). He commends an “experimental ethos” (*ibid.* 600) that is open minded and reflective, challenging us to make considered, revisable decisions about how we and non-humans might live together in a thoroughly syncretic world whose vitality we have big role in determining. Though Lorimer does not come out and say it, his approach to responding to the

Anthropocene is almost the opposite of Biermann *et al.*'s vision of rule-bound institutions for 'earth system governance'. His arguments are offered more in the spirit of different places and countries sharing experience and practice in the face of geographically variegated forms of future biophysical change (see also Lorimer & Driessen, 2013).

Lorimer's arguments are a challenge for environmentally-minded human geographers to embrace what Morton has called 'ecology without nature' (Morton, 2007). They build on over a decade of research into so-called 'more than human geography' pioneered by the likes of British geographer Sarah Whatmore (2002). In a similar spirit, but with a much keener eye on new ideas that key societal decision-makers might take seriously, Karen O'Brien (2013) has challenged geographers like Lorimer to produce 'transformative research' of the kind commended by Palsson *et al.*—indeed she was a member of the RESCUE foresight project mentioned above (see O'Brien *et al.* 2013). In her view, human (and, by implication, physical) geographers need to unpick the deep and unexamined assumptions they hold about ontology, epistemology, method and practice. Only then, in her view, can they offer non-academic stakeholders the eye-opening ideas needed to inspire societies to travel down genuinely new roads as they face environmentally dynamic and possibly threatening futures.

In this light, ideas about the Anthropocene advanced by some more philosophically-minded human geographers may appear either too radical or else too abstract to be useful as part of the 'axial revolution' O'Brien wishes to see within and without Geography. For instance, Kathryn Yusoff (2013) regards the Anthropocene as an occasion to discuss not the ascendancy of humanity over other life forms but the very meaning of the 'anthropos'. Yet her arguments are complex, subtle and rarefied: it is hard to imagine them being understood and acted on by many of her fellow geographers, let alone people outside the academy. By contrast, political geographer Simon Dalby (2013) points to the emergent discourses outside academia that may soon be using the 'fact' of the Anthropocene to justify questionable national security and surveillance policies. Pointing to leading governmental, quasi-governmental and non-governmental actors, like O'Brien he asks what alternative, motivational concepts and aims might be offered to them by geographers and others in the name of a more social democratic, just Anthropocenic future.

For still other human geographers the likes of Lorimer, O'Brien and Dalby might be regarded as too fixated on engaging (and trying to change the thinking of) mainstream societal actors, like national government ministers and departments. The writing duo J-K Gibson-Graham (2009, writing with Roelvink) argue that human geographers and other social researchers should both study, and actively engage with, everyday communities who want to create truly alternative ways of living. For them the onset of the Anthropocene can and should give such communities further impetus to inspire researchers and various social actors to develop real options outside mainstream thinking. For a Marxist geographer like Jason Moore (2013), however, Gibson-Graham's arguments may appear to risk ignoring the enduring power of capitalist political economy to limit such options, even as it tries to 'green' itself in order to avoid dangerous environmental change. Yet for Gibson-Graham a geographically differentiated grassroots politics lacking worldwide coordination is at least as viable a way to address the challenges of the Anthropocene as the sort of necessary, but current unviable, global anti-capitalist politics that Marxists call for.

## Conclusion

In sum, the Anthropocene – and its collateral term planetary boundaries – are arresting terms designed to characterize the human impact on the non-human world. It is too soon to say if they will significantly influence the terms of public debate about humanity's future on Earth. However, they are gaining a degree of traction in Anglophone academia, and beginning to frame discussions of human-environment relations in Geography. Given their enormous implications, the key question about the two terms looking ahead is this: who will speak in their name, what claims will they make, whose claims will prevail, and what practical measures will follow from those claims? Like other interested analysts, Geographers stand to be participants in the future discursive contests that will determine the exact answer to this important question. Though scientists can be credited with inventing and disseminating the two terms discussed in this article, it would be unfortunate if their ideas dominated future debates. By combining scientific, social scientific and humanistic ideas about Earth future in a single disciplinary space, professional geographers and their students may together present the mixture of data and ideas needed to think creatively about a world to come (see Hulme, 2008, for a similar argument in relation to anthropogenic climate change).

**SEE ALSO:** Climate change, concept of; Earth System Science; Environmental futures; Environmental science and society; Holocene; hybridity; Nature; Wicked problems.

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**Key Words:** Earth Observation; human-environment interaction; interdisciplinary research; nature; society; sustainable development; uncertainty; wicked problems.