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The “Anthropocene” in Global Change Science: Expertise, the Earth, and the Future of Humanity

NOEL CASTREE

The Anthropocene is currently a *buzzword*. The neologism now circulates far and wide – and not only in academia, from whence (to little initial fanfare) it originated nineteen years ago (Crutzen and Stoermer 2000). Soon it might become a *keyword*: that is, one of those terms that are absolutely central to the way we understand ourselves and the world in which we live. Its rapid rise to prominence since about 2010 is due to three things.

First, it signifies a striking and unprecedented development in the relationship between people and planet. For the first time, there is strong evidence to suggest that humans are changing the nature of *all* of the earth’s constituent spheres. It turns out that anthropogenic climate change, one of the defining problems of our time, is but one element of a much larger story. Second, the evidence for the Anthropocene’s onset has been presented by international groups of geoscientists. Though the cultural authority of science is not what it was twenty or thirty years ago, it remains sufficiently high that when numerous credentialized experts speak with one voice, people tend to listen (even if not everyone believes the messages being conveyed). Third, the credibility of these experts’ epochal claims has been enhanced by over three decades of prior research, media reporting, and political action relating to large-scale anthropogenic environmental changes – not only atmospheric warming, but also ozone layer thinning, ice sheet melting, deforestation, and overfishing (among others). These well-documented and widely publicized changes mean that when various geoscientists now declare the end of the Holocene – the 11,700-year period during which *Homo sapiens* have flourished – only a relative minority simply scoff in disbelief.

This chapter has two aims, one exegetical and the other evaluative. First, I detail the scientific origins and content of the “Anthropocene hypothesis.” I do so because the wider social credibility of the Anthropocene concept – today and in the future – rests almost entirely on the perceived quality of the underpinning science. Yet few people outside science have the time or inclination to read the scientific literature,

while digests of the research are frequently partial and journalistic (see Biermann and Lövbrand, Chapter 1). Anthropocene science has two arms, one stratigraphic and the other not.¹ What unites them, as we will see, is the claim that "planetary nature" is no longer natural (or, at least, is significantly less so than heretofore). Disagreements exist about the onset date, and precise magnitude of, this denaturalization of the earth. Nonetheless, the scientists involved place an analytical premium on revealing humanity's capacity to instigate more than incremental planetary change.

Though a number of summaries of the science now exist (e.g., Steffen et al. 2016), few, if any, approach it through the underpinning concept of nature and its epistemic framing.² More common is the practice of using the science to explore the ethical and management issues of life in a post-natural world (e.g., Maris 2015; Arias-Maldonado, Chapter 3). Yet, the mounting evidence for planetary change makes little sense without a set of prior assumptions about what is natural – in both a historical and an ontological sense – and what is artificial or modified. These assumptions, just as much as the scientific evidence that suggests their "material reality," deserve to be understood and scrutinized. The social efficacy of the assumptions will be central to determining whether "the Anthropocene" becomes, in future, a keyword animating the discourses of politics, business, and civil society. The assumptions have a particular relevance to environmental theory and politics because "nature" remains such a foundational concept for both. That is precisely why this book has been conceived and published.

I am an environmental social scientist with long-standing interests in geoscience and in how what we by convention call nature is represented in modern societies.³ I write as neither an uncritical believer in, nor a skeptic about, the science. I show how and why geoscientists in various disciplines have been speaking for the earth in the particular ways they have in recent years. As I will explain, the "onset" of the Anthropocene is not simply a scientific question: the science is inevitably freighted with extrascientific *baggage* rather than simply having extrascientific *implications*

¹ "Anthropocene science" is my term (though I discovered after writing this chapter that Christophe Bonneuil (2015) uses it too), while the term "global change science" is more conventional: it refers to any scientific attempt to understand the dynamics of global environmental change – primarily its biophysical elements, but also the "human drivers." It covers both stratigraphy and earth system science, more about which to follow. In this chapter, when I use the term "geoscience," I am referring to any and all areas of earth surface science (e.g., geomorphology) as they pertain to the study of humanly caused global change. While not all geoscientists study anthropogenic planetary change, a significant minority do just this.

² Though some have written about nature in the Anthropocene – Wapner (2014; see also chapter 11) and Hettinger (2014) are prime examples – few, if any, do so by examining how nature is referenced within Anthropocene science publications. An exception is the paper by Jeremy Baskin (2015) about what he calls "the ideology of the Anthropocene."

³ See, for instance, Castree (2014 and 2015a, b, and c). I am in good company: over the last two decades, Soper (1995), Cronon (1996), and Hull (2006) are among a number of authors who have written and edited insightful books about nature as both an idea and a realm of processes and entities independent of human conceptions, perceptions, and actions.

after the proverbial fact. This speaks to my second aim: to give readers the tools necessary to be neither passive recipients of geoscientific claims nor overzealous critics doubtful about these claims' robustness. Even if we were to query the science (on evidential or ontological grounds), we might still have very good reasons to take very seriously the normative implications of what people are currently doing to the planet. Likewise, even if we accept the assumptions, findings, and predictions of the science, its implications can only be understood in extrascientific contexts without which science loses all meaning and purpose. Either way, I will argue, a set of arguments about "nature" are in play that are irreducible to their scientific components yet which would lack public credibility without being advanced by geoscientists in the first instance.

The formal study of political reasoning, political institutions, public debate, and political decision-making is one of the many contexts in which geoscientific claims about the earth assume wider significance. Such study can help to shape the wider "Anthropo(s)cene" (Castree 2015a): that is, the plethora of discourses (and linked policy proposals along with technical interventions) about people–planet relationships inspired by the science of the Anthropocene. More specifically, it can help societies navigate between the now familiar – and paralyzing – alternatives of a "scientized politics" and a "politicized science." But that is only possible if we develop a reflexive relationship to Anthropocene science. This chapter seeks to foster such a relationship among its readers on the basis of a clear understanding of the science's cognitive *and* normative content.

Anthropocene Science

A Speculative Proposition: Can Humans Change Planetary History?

The Anthropocene means "the age of humans." It is an arresting word because it uses a suffix normally employed in nomenclature designed to describe extremely large-scale biophysical changes – ones that, in the earth's 4.5-billion-year history, have not involved humans at all. In the discipline of geology, technical terms such as Miocene and Pleistocene delineate specific phases of planetary change and stability caused by "endogenous" and "exogenous" natural forces. The asteroid impact believed to have caused the extinction of the dinosaurs is one such force. Consequently, when the Dutch chemist and Nobel Laureate Paul Crutzen objected to continued use of the term "the Holocene" – at an International Geosphere-Biosphere Programme meeting in February 2000 – he was being deliberately subversive and provocative. His subsequent short articles in the program's *Global Change Newsletter* (Crutzen and Stoermer 2000) and in *Nature* (Crutzen 2002) helped to disseminate the proposition that humans were significantly altering

not only the atmosphere but also – simultaneously – the cryosphere, lithosphere, hydrosphere, and biosphere.

Crutzen himself lacked the expertise to test his own (very grand) proposition. But he was vice-chair of the International Geosphere-Biosphere Programme, an international global change research program established in 1986. By 2000, the program had brought geoscientists across the disciplines – and nations – together over a period of years to work on a set of novel integrative research projects. The projects were innovative because the program's aim was uniquely ambitious. As its first executive director put it in the inaugural *Global Change Newsletter*:

The IGBP [International Geosphere-Biosphere Programme] objectives are to describe and understand the interactive physical, chemical, and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human action.

(Roswell 1989: 2)

In other words, the program was designed to produce new knowledge of the contemporary earth as a complex, integrated entity, with humans regarded as a significant component. Given this, Crutzen's neologism can be seen, with hindsight, as both a result of the program's first decade of scientific endeavor and an incitement for program participants to put empirical flesh on the conceptual bones of his epochal claim. In 2002, the International Geosphere-Biosphere Programme joined the three other international programs investigating global change – namely, the World Climate Research Programme, the International Human Dimensions Programme on Global Environmental Change, and *Diversitas* – in a so-called Earth System Science Partnership designed to produce greater integration between research projects on planetwide changes.⁴

In the years immediately after the term "the Anthropocene" was coined, leading scholars of the International Geosphere-Biosphere Programme provided a preliminary response to the question "Is the Holocene ending?" It took the form of a large synthesis published as a book in 2004 by American-Australian climate scientist Will Steffen and others, entitled *Global Change and the Earth System*. This 311-page volume linked evidence of environmental stability and change across all the earth's subsystems to the concept of a "natural" and "anthropogenically" altered earth system. As the book progressed, it contrasted a "human-

⁴ The World Climate Research Programme was created in 1980. It was followed by the International Human Dimensions Programme on Global Environmental Change (1990, relaunched in 1996) and *Diversitas* (launched in 1991 and focusing on global biodiversity and biogeography). The Earth System Science Partnership emerged from an open science conference in Amsterdam in 2001 where scientists in all four programs came together. The latter two, with the International Geosphere-Biosphere Programme, have been folded into the new Future Earth research program, which is in its early stages (see for more detail Beck, chapter 10), even though it takes forward a set of existing projects from the three previous programs as well as introducing some new ones.

dominated planet” with a “nature-dominated” one. In an often-cited passage, the authors concluded that

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.

(Steffen et al. 2004: 81)

Global Change and the Earth System was among the first attempts to offer a holistic conceptual and empirical understanding of the planet as a single system in which humans are shown to be a key global (as opposed to local or regional) influence. It was, in other words, an early example of what is today known as earth system science.⁵

So much for the scientific backstory. Over the last ten years, two intersecting areas of science have sought to ascertain the “reality” of the Holocene’s end. One emerged out of the International Geosphere-Biosphere Programme, and more broadly earth system science; the other from geology. Both fields of science have benefited enormously from the improved quality and quantity of earth surface data now available and the large improvements in computational modeling of earth surface dynamics (past, present, and predicted). Let us consider each in turn.

Testing the Proposition: Stratigraphic Research into a Holocene–Anthropocene Boundary

The Anthropocene concept refers to recent and ongoing changes to the earth’s outer layer. In the context of the planet’s 4.5-billion-year history, these changes are occurring in the blink of a proverbial eye. Yet, it is arguably no surprise that a number of geologists – whose concern is normally with “deep time” – have become key scholars in Anthropocene science since around 2005. I say this for two reasons. First, Crutzen’s use of the suffix “cene” in 2000, and its subsequent circulation in International Geosphere-Biosphere Programme

⁵ For some, earth system science is synonymous with “global change science” or else describes research informed by complex system thinking applied at a planetary scale. However, others take a less strict view, presenting earth system science (ESS) as any research into global environmental change that is pursued in a scientific fashion (Mooney et al. 2014). In this chapter I take the latter view, not least because not all members of the Anthropocene Working Group – to be discussed later – see themselves as earth system scientists. However, in a more strict sense ESS first flourished in the early 2000s. When Steffen et al.’s book was published, and during the years immediately after, a raft of texts appeared that sought to depict the Earth’s outer layer as an integrated, complex system. Some were by continental European authors, others by North American ones. See Butz (2004), Clark et al. (2004), Ehlers et al. (2006), Hergarten (2002), Kump et al. (2004), and Neugebauer and Simmer (2003). Over a decade on, a leading former International Geosphere-Biosphere Programme scientist, Kevin Noone, noted that “Earth system science has gone from being an oddball notion to becoming recognized as a paradigm necessary for us to make progress on the ‘wicked problems’ facing society today” (Liss et al., 2015: 10). For a full history of ESS in the strict sense of the term, see the PhD thesis published by O. Uhrqvist (2014).

networks, spoke directly to geologists' preoccupation with qualitative shifts in the earth's normally slow evolution. Second, though rapid in geological terms, the scale, scope, and magnitude of human-induced changes to the earth's constituent spheres may now be akin to a "great force of nature" (to use a term favored by Crutzen, Steffen, and other researchers from the International Geosphere-Biosphere Programme in many of their publications). In other words, though geologists normally study natural endogenous and exogenous drivers of planetary change, contemporary *Homo sapiens* might legitimately be considered a "geological actor" (as per *Global Change and the Earth System* and subsequent publications in this vein).

By 2005, the "Anthropocene" concept had been noticed by a British geologist at Leicester University, Jan Zalasiewicz. At that time, he was chair of the Stratigraphy Commission of the Geological Society in London. He proposed to the other twenty commission members that the Anthropocene proposition 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 whether 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 through a Global Stratigraphic Section and Point ("golden spike") location or by adopting a numerical date.

(Zalasiewicz et al. 2008: 4)

As a result of this paper and subsequent discussions among the academic networks of commission members, a subcommission of the International Commission on Stratigraphy – which is ultimately responsible for identifying geological epochs – established an Anthropocene Working Group in 2009. It appointed as chair Zalasiewicz, who was a member of the subcommission at that time. Since its formation, group members have worked tirelessly to assemble and assess evidence for possible stratigraphic markers of the Anthropocene's onset. In the context of geology as a discipline, their inquiries have been highly unusual for one obvious reason: most previous shifts in earth history have produced an enduring signal in rock layers, whereas human impacts on earth are so geologically recent that a globally synchronous signal likely to endure beyond this (or the next) century may not exist. Accordingly, not all group members are geologists or, more

specifically, stratigraphers (the membership can be found here: <http://quaternary.stratigraphy.org/workinggroups/anthropocene>).

The group has broken new ground in trying to study a potential geological epoch that is still in formation: it is engaged in “real-time geology,” as it were. Only in thousands of years’ time might future geologists (if there are any) confirm that any markers the Anthropocene Working Group identifies as important today are, in fact, geologically significant: the markers are currently non-lithified. In 2015 and 2016, the group recommended that the period immediately after 1945 be considered the potential “base” of the Anthropocene (Zalasiewicz et al. 2015; Waters et al. 2016). During that period, it argues, there is clear evidence of new planetwide anthropogenic changes, such as the deposition of artificial radionuclides from testing weapons of mass destruction. This evidence, the group claims, indicates an alteration to the earth system when compared with Holocene norms.

At the time of writing, the group has not made a formal submission to the Subcommittee on Quaternary Stratigraphy. If and when it does, the subcommittee will assess the case and may reject it. If it accepts the plausibility of the case, it will make a positive recommendation to the International Commission on Stratigraphy, whose many members could decide to either endorse or reject the case for the Anthropocene. Currently, the prospects for endorsement look slim for several reasons. One is that the current chair of the International Commission on Stratigraphy, Stan Finney, has recently gone on record to question whether “the Anthropocene” can be a legitimate scientific concern for geologists (Finney and Edwards 2016). Another reason is that some senior Quaternary scientists have also doubted the wisdom of seeking to formalize the Anthropocene as a geological epoch (e.g., Gibbard and Walker 2013). The Anthropocene may be an idea before its geological time. In geographer Jamie Lorimer’s (2017: 5) felicitous words, “the ICS [International Commission on Stratigraphy] will be asked to pronounce with unaccustomed speed on a new epoch whose evidentiary base is alien to the epistemic conventions of stratigraphy.” Even so, the Anthropocene Working Group has now achieved sufficient scientific momentum and prominence that the possibility of the Holocene’s end is considered by some geologists to be a realistic one. As Jeremy Baskin (2015: 10) notes, “The conceptual horse has bolted and the ‘Anthropocene’ is being widely adopted” in Quaternary stratigraphy.

A New Earth System State?

Parallel to – and, as we shall see, sometimes as part of – the stratigraphic science pursued by the Anthropocene Working Group, several earth system scientists associated with the International Geosphere-Biosphere Programme and the Earth System Science Partnership have also concluded that the Anthropocene is

a scientifically credible concept. However, because they are not bound by the rigors of stratigraphy – with its exacting criteria for identifying a Global Stratotype Section and Point and a Global Standard Stratigraphic Age – these scientists have been more free to venture claims about qualitative changes to the earth system.

Since 2010, these claims have been expressed in a series of published articles about two phenomena: the so-called “Great Acceleration” and so-called “planetary boundaries.” In almost all cases, the Australian National University climate scientist Will Steffen has been a key author: he was the director of the International Geosphere-Biosphere Programme from 1998 to 2004 and lead author of *Global Change and the Earth System*. In their publications, Steffen and others use a battery of data about observed changes to both what they call “the human enterprise” and the earth’s component subsystems. The objective has been to “formalize” the Anthropocene in a sense akin to how the Neolithic and the Bronze Age have become recognized terms in archaeology and beyond. As scientists who are building the ship of earth system science as they sail, they are not beholden to their predecessors in the way the Anthropocene Working Group’s inquiries are beholden to the strictures of the International Commission on Stratigraphy.

A recent paper in *The Anthropocene Review* illustrates the way scientists from the International Geosphere-Biosphere Programme have tried to demonstrate earth system change “beyond the range of variability of the Holocene and driven by human activities” (Steffen et al. 2015a: 81). Using a wide variety of secondary data, the authors demonstrate a Great Acceleration after 1950 in terms of the size and rate of change to both “the human enterprise” and earth surface phenomena. Twelve indicators are used for the two interlinked “systems” (the human and the biophysical) – for instance, population growth and tropical forest clearance. These indicators are compared, where possible, with data for the Holocene period. The conclusion is that “only beyond the mid-20th century [is] . . . there clear evidence of fundamental shifts in the state and functioning of the Earth System” (Steffen et al. 2015a: 86). This, the authors argue, means that by virtue of their activities, contemporary humans must now be seen *as part of* the earth system, not an “external force” that merely “perturbs” it.

Another example of earth system scientists proclaiming the Holocene’s imminent eclipse is a 2015 paper on “planetary boundaries” (Steffen et al. 2015b). The concept was first coined in 2009 by Johan Rockström and colleagues, who used it to identify key global environment components constitutive of the earth system. Represented in a now familiar diagram (Figure 2.2), these planetary boundaries pertained to climate, ocean acidity, chemical balances, atmospheric aerosols, biodiversity, land use types, freshwater, nitrogen and phosphorus cycles, and stratospheric ozone density. For seven boundaries, Rockström and colleagues

specified a quantitative boundary, the crossing of which might take the system beyond Holocene norms (for the remaining two, they were unable, in 2009, to quantify the boundary).

Together, the nine boundaries comprise what Rockström and colleagues called “a safe operating space for humanity” (2009: 472). Modern humans, they argued, have already transgressed several of these. Recognizing that “[d]etermining a safe distance involves normative judgements of how societies choose to deal with risk and uncertainty,” they nonetheless commended their “new approach to defining biophysical preconditions for human development” (Rockström et al. 2009: 472 and 474). The more recent paper by Steffen and colleagues (2015b) highlights two especially critical boundaries, the transgression of which may be amplified through the seven others and thus take the earth system into a new post-Holocene state. Where “the Great Acceleration” paper, discussed earlier, details human activities, the planetary boundaries paper of Steffen and colleagues focuses solely on earth surface change using – again – secondary data in the context of expert judgements about how tolerant of change earth subsystems are likely to be.

To date, and unlike the response of some geologists to the Anthropocene Working Group’s endeavors, the Anthropocene claims of Steffen, Rockström, and other earth system scientists have not been met with sharp criticism in the wider sciences of the physical environment. In large part, we might surmise, this is because these researchers do not have to conform to preestablished criteria for what can evidence “epochal change.” Instead, they get to both create and apply evidential standards as to what counts as a phase shift in the earth system.

Stratigraphy Meets Earth System Science

Despite their slightly different emphases, what unites these various analyses is a set of earth system ideas used to interpret factual information about planetary change. These include the concepts of “earth system states” (or regimes), subsystems and complexity, force and response, negative and positive feedbacks, stability and transition, natural and human forces, and – reflecting wider developments in systems thinking since the 1970s – tipping points. With supporting evidence, these concepts are used to show that humans are now driving the earth system in a new direction without entirely being able to control the metaphorical vehicle.

It is, perhaps, no surprise that scientists from the International Geosphere-Biosphere Programme such as Steffen have both informed the stratigraphic science summarized in the previous subsection and also drawn on it. As noted before, the unique remit of the Anthropocene Working Group has meant that its membership extends outside geology. Given their prominence within the International Geosphere-Biosphere Programme, both Steffen and Crutzen engaged with Jan Zalasiewicz early on, once

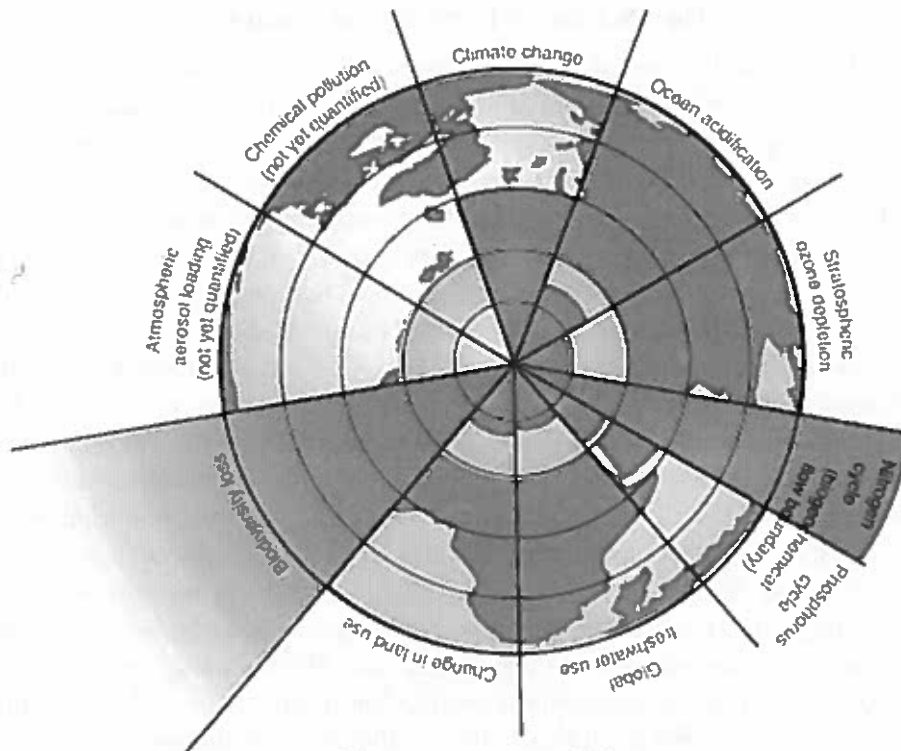


Figure 2.1 Humanity's proximity to planetary boundaries (reproduced with permission from Rockström et al. 2009, design by Azote Images/Stockholm Resilience Centre).

the Anthropocene Working Group was proposed in 2008. They came together in a short 2010 article on the Anthropocene (Zalasiewicz et al. 2010), in a special issue of the *Philosophical Transactions of the Royal Society A* (vol. 369, issue 1938, 2011), and – that same year – in a major article in the journal *Ambio* (Steffen et al. 2011). Since then they have collaborated routinely, not least because Steffen, Crutzen, and another former lead player of the International Geosphere-Biosphere Programme – James Syvitski – are all members of the Anthropocene Working Group.

One result in the string of publications authored by this group is that the term “the earth system” is used frequently when describing stratigraphic questions. Meanwhile, earth surface data assembled and evaluated by the Anthropocene Working Group has been used by Steffen and other earth system scientists in their recent papers on the Great Acceleration and planetary boundaries. A new article in the journal *Earth's Future* by the key scholars (Steffen et al. 2016) formally examines the character of, and relationship between, the two approaches to planetary change.

The "Nature" of Earth System Change

As we have seen, the aim of Anthropocene science, in its several forms, is to determine the magnitude and rate of anthropogenic change to the earth system. The overriding reason why the science has received so much recent attention outside scientific circles is because it takes seriously something scarcely thought possible even twenty years ago: namely, that *Homo sapiens* can now alter nature not only in a laboratory or on a farm or even at an ecosystem level but at a *planetary scale and irreversibly so*. As Crutzen and Christian Schwagerl put it, in a much-quoted statement, "It is no longer us against 'Nature'. Instead, it's we who decide what nature is and what it will be" (2011: np). When environmentalist Bill McKibben (1989) lamented "the end of nature" thirty years ago, some felt he was overstating the case. But today, with geoscientists in the vanguard, the profundity of this "fact" explains why a book like this one has been published.

Because they are well aware of the momentous extrascientific implications of their research, many Anthropocene scientists have become preoccupied with establishing the "correct" onset date of the Anthropocene. For my purposes, this is interesting not so much for the scientific questions at stake as for what it reveals about the underlying ontological assumptions in play. By rehearsing one part of the "timing debate," I will now make those assumptions manifest. As we shall see, this affects how nonscientists should judge the significance of Anthropocene science.

What Is in a Date?

A recent exchange in the pages of *The Anthropocene Review* reveals some very sharp scientific disagreements about when the Holocene (may have) ended. It involves the Australian economist, philosopher, and environmentalist Clive Hamilton – speaking for earth system science – and the British geographers Simon Lewis and Mark Maslin – writing with an eye on the requirements of the International Commission on Stratigraphy. The exchange was sparked by Maslin and Lewis's major paper published in *Nature*, entitled "Defining the Anthropocene" (2015). In the article, they consider the several possible onset dates of the Anthropocene proposed by the Anthropocene Working Group, earth system scientists, and others such as the historical climatologist Bill Ruddiman (who has talked of an "early Anthropocene" beginning in the early Middle Ages or before; e.g., Ruddiman 2013). In the piece, Lewis and Maslin carefully sift the evidence and conclude that only 1610 and 1964 could – according to Global Stratotype Section and Point criteria – count as inception dates. In the first of these two years, global carbon dioxide levels dropped significantly because of revegetation of the New World (linked with European colonialism and the trans-

Atlantic transfer of diseases). In the second, a peak global radionuclide signal was left by successive nuclear bomb detonations.

In his commentary "Getting the Anthropocene so wrong," Hamilton (2015) criticizes both scientists. For him, they mistake global signs of the human impact on earth for anthropogenic changes to the earth system. Though the latter were not at all evident in 1610, Hamilton argues, they were already occurring by 1964. Like various Anthropocene Working Group members (including Steffen and Crutzen), Hamilton dates the onset of the Anthropocene to 1945. In his view, Lewis and Maslin are blissfully unaware of the earth system concept and – as their 1610 date suggestion indicates to him – confuse *anthropogenic environmental change* with *humanly induced planetary change*. For Hamilton, the mere existence of a "global signal" is not at all the same as an anthropogenic global *impact*. In their response, Maslin and Lewis (2015) deny any ignorance of earth system thinking and point out that stratigraphic boundaries are usually markers of systemic change, not merely "disturbances" within system boundaries.

What is at stake in this dating dispute, beyond "interpreting the evidence correctly"? For the disputants, the answer is: a scientifically grounded capacity to identify which humans (when and where) are responsible for planetary change, with all this implies for how such change might be mitigated and managed (see Baskin, Chapter 8). For instance, choosing 1610 does not only reveal the global effects of early overseas trade and settlement, but implies – as Ruddiman's research does – that if humans were *already* global actors hundreds of years ago, then contemporary humans must be orders of magnitude *more* transformative of the earth system. By contrast, Hamilton regards selecting a pre-1945 date as not only scientifically wrong but politically problematic. For him, it is a "deflationary move" (Hamilton and Grinevald 2015: 60) in two senses: not only does it "gradualize" anthropogenic impacts on earth ("we've been doing this for centuries so present impacts are more of the same, just cumulatively bigger"); it also severely underplays "the suddenness, severity, duration and irreversibility" (Hamilton and Grinevald 2015: 66–67) of the biophysical changes occurring since 1945. In Hamilton's view, then, embracing the earth system approach directs us not to the last few hundred years – which has seen the passing of numerous forms of human society – but to the last few decades, when a small number of advanced capitalist societies have unwittingly altered planetary evolution.

I will not seek to adjudicate between the various scientists involved in the dating dispute.⁶ The key point is this: claims like Hamilton's, vouchsafed by earth system

⁶ Indeed, I will argue that the dating dispute is not only a "scientific question" and thus does not admit of a definitive scientific answer – this is because a set of assumptions about "significant change" are in play in any attempt to determine when the Anthropocene began, and these assumptions reflect social appraisals of how *much* change "matters."

science, rest on a set of judgements about when "unnatural history" begins which themselves rest upon beliefs about the nature of nature. It is to those beliefs that we now turn, since, without them, evidence of "planetary change" would quite literally be meaningless. Environmental change per se is not always considered a change to "nature," or if it is, then not always to the same degree or extent; yet the Anthropocene concept posits the emergence of a *post-natural globe* either in degree or in kind.

What Counts as "System Change"? When Does an Earth Epoch End?

The history of the earth is a history of perpetual change: the geological record tells us as much. At a planetary scale, nature – left to its own devices – has evolved the most intricate and complex processes and phenomena (including *Homo sapiens* as a species). If, as is clear from the two branches of Anthropocene science, the Anthropocene is understood to mark the end of earth's *natural* history, then what, exactly, has ended, and why does it matter? How much change is considered enough to make global nature into something qualitatively new or at least generative of novel societal impacts?

"Nature" has been a keyword in European societies and their former colonies for over two centuries (Williams 1976). In a semantic sense it is, we might say, a quintessentially *ontological* word: its many meanings tend to denote things believed to be real, regardless of human perceptions, opinions, or beliefs. It seems that "nature" has four principal meanings, all of which are quite venerable and familiar to people in Anglo-European societies (Castree 2014). These meanings frequently attach to "collateral words," such as biology, matter, "race," environment, and genes. First, "nature" denotes the *nonhuman world*, especially those parts untouched or barely affected by humans ("the natural environment"). Second, it signifies the *entire physical world*, including humans as biological entities and products of evolutionary history. Third, it means the *essential quality or defining property of something* (e.g., it is natural for birds to fly, fish to swim, and people to walk on two legs). This third meaning crosscuts the first two, bringing human and nonhuman nature into a single categorical space. Finally, it refers to the *power or force governing some or all living things* (such as gravity, the conservation of energy, the instructions contained in human DNA, or the Coriolis effect). As shorthand, we can (respectively) call these meanings "external nature," "universal nature," "intrinsic nature," and "superordinate nature" (see Figure 2.2). Their differences notwithstanding, a common semantic denominator is that nature is defined by the absence of human agency or by what remains (or endures) once human agents have altered natural processes and phenomena. In Jacques Pollini's (2013: 26, emphasis added) apt words, "Nature ... is

NATURE			
The nonhuman world of living and inanimate phenomena, be they 'pristine' or modified.	The physical world in its entirety, including human beings as both products of natural history and as biological organisms.	The defining features or distinguishing quality of living and inanimate phenomena, including human beings.	The power, force or organising principle animating living phenomena and operating in or on inanimate phenomena.
'EXTERNAL NATURE'	'UNIVERSAL NATURE'	'INTRINSIC NATURE'	'SUPERORDINATE NATURE'

Figure 2.2 The principal meanings of the word nature in contemporary Anglo-European societies (reproduced from Castree 2014).

considered as a world out there . . . that is not the outcome of human activities. *It's non-social by definition.*" Since the European Enlightenment, of course, science has been perceived as the window through which to view the true nature of nature. Today, many still consider it the epistemological means whereby nature's ontological actualities can be made manifest, from the molecular to the cosmic scale.

In this context, it seems clear that Anthropocene scientists interpret evidence of earth surface change as pointing to a new human–nature hybrid in all four senses. This follows from the encompassing character of the earth system concept and from the rigors of stratigraphic dating. It is what makes the Anthropocene proposition such an arresting one: nothing, it seems, is immune to human influence any more. The Holocene baseline is taken as a "natural" reference point against which to compare "epochal change." It is taken as the most recent period in earth history where natural processes, causes, effects, and feedbacks have together governed the character of the planet's constituent subsystems. Today, the earth system is seen to be (i) no longer external to human societies, (ii) universally affected by those societies (since no part of the system is now immune to influence), and (iii) moving towards a new operating state (thus losing many of the "intrinsic" properties characteristic of the last 11,700 years), and (iv) in that new state, its superordinate forces are being redirected by human actions, possibly crossing thresholds in the centuries immediately ahead. This means that, at the planetary scale, a new biophysical actor that is not "natural" – or not natural in the same sense as ocean currents and carbon cycles are – is now a *component* of the earth system rather than subsumed by it. In other words, the society–nature dualism – whose local transgression is so familiar to us (think of genetically modified organisms or artificial wetlands) – is now compromised "all the way out and up." This implies that a new hybrid world is coming into being (Arias-Maldonado, Chapter 3). Less dramatically, Anthropocene science tells us that, at the very least, the zone marked "nature" is rapidly shrinking at *all* spatiotemporal scales. In this more moderate view,

a powerful and lively nature endures but is having to adapt to escalating human impacts.

Of course, the scientists in question do not systematically distinguish the four meanings of nature in their various observations about earth past, earth present, and possible earth futures. This is because, as noted, the quintet is contained within the concept of the (pre-humanly altered) earth system, while specific meanings are manifest when Anthropocene scientists use the words nature, environment, earth, planet, and so on in their published papers. The "end of global nature" is thus reported in the research literature without recourse to mentioning each dimension of nature separately. Some quick examples will have to suffice to illustrate this. Steffen and colleagues (2016: 324) recently suggested that "the Earth may be approaching a third fundamental stage of evolution because of a wide range of human pressures." A year earlier, Steffen and colleagues (2015) asserted that "there is clear evidence for fundamental shifts in . . . the Earth System . . . driven by human activity and not by natural variability" (2015a: 13). Finally, in one of several recent papers, the Anthropocene Working Group concludes that "human changes [to earth] . . . are so extensive that it is reasonable to suggest that the biosphere has made one of the greatest transitions in the history of life" (Williams et al. 2016: 49). In all three cases, the status of nature as external, as a totality beyond the realm of human influence, as possessed of intrinsic qualities, and as a superordinate power is clearly called into question by the force of human intervention.

All this implies a new ontological monism, albeit one characterized by complexity and differentiation, not simplicity or harmony. The momentous nature of this insight into a "new reality" – what Valenti Rull (2016) calls "the humanized Earth System" – animates the dating dispute recounted above. Likewise, the Anthropocene Working Group recommendation is an attempt to "officially" demonstrate to nonscientists that the new "unnatural" epoch has begun. Meanwhile, the planetary boundaries concept, with its notion of a "safe operating space" for humanity, is an attempt to quantify how far towards "points of no return" the earth system is currently being pushed compared with the last 11,700 years.

In all cases, ontological claims about *qualitative change* are posited. These claims are presented in a realist mode as representing objectively occurring alterations: "the *concept* of nature is now outdated because, *in reality*, nature is increasingly a thing of the past—at all points of the compass!" The changes will be ongoing, and possibly both large and abrupt if boundaries are transgressed and tipping points are overshot. No wonder Anthropocene science is so attention grabbing for those outside science, like most readers of this volume. It raises very large questions about human agency and human responsibility, as well as about the autonomy, agency, and value of the nonhuman (see Arias-Maldonado, Chapter 3; Baskin, Chapter 8; Wapner, Chapter 11). It also raises organizational,

technical, distributional, and temporal questions about whether, and how, societies can cope with, and consciously influence, future global environmental change. The questions are begged, because science retains considerable legitimacy as a "truth-seeking" enterprise perceived to be freer from bias and error than most other human endeavors.

Post-natural "Realities": How Should Green Theory and Politics Respond to the Anthropocene?

I have summarized Anthropocene science and shown how it pivots on historical and ontological claims about the end of nature. In this final section of the chapter, I consider how nonscientists might want to respond to the science and its significant implications for present-day humanity.

To speak for the earth in its totality is an extraordinary act of epistemological representation. In the early twenty-first century, it comes with a huge burden of responsibility: "speaking out" about the state of the planet is not something many geoscientists are accustomed to, since it involves normative judgements about risk and harm. Anthropocene scientists, as we have seen, are adducing as much evidence as they can to make visible earth system changes that are utterly imperceptible to the naked eye or to most people "on the ground." To adapt Karl Marx's famous saying, "The earth system cannot represent itself: it must be represented!" Anthropocene scientists are representing in good faith: there is no reason to believe otherwise, even though some geoscientists worry that the science is led too much by barely concealed political values (see, for instance, Finney and Edwards 2016). The scientists observe, they measure, they compare past and present, and they make plausible predictions about earth system futures. They are metaphorical canaries alerting the rest of us to changes that, in their view, are worthy of very serious attention – be we academic researchers, political decision-makers, business executives, religious leaders, or ordinary citizens. Should we trust Anthropocene scientists, wait for more of a scientific consensus, or take an altogether different stance? Specifically, what should "people like us" – that is, social scientists and humanists – do with the insights provided by Anthropocene science?

The Anthropocene in Social Science and Humanities Scholarship

In recent years, a small but increasingly visible group of social scientists and humanists (including myself; e.g., Castree 2017a and b) have paid close attention to the implications of Anthropocene science for people. We can learn some useful things by attending to the manner of their responses – though I do not have the space here to offer more than a brief sketch. Note that I do not consider the research

of the relative minority of practitioners who actively collaborate with geoscientists in interdisciplinary global change research (e.g., within the various Future Earth projects; see Beck, Chapter 10).

A number of commentators in the "people disciplines" have sought to rethink their philosophical, analytical, and methodological "common sense" by virtue of the "force" of scientific insight. Dipesh Chakrabarty is perhaps the best-known example of this. He traces the implications of the science for his own field of professional endeavor. Chakrabarty (2009: 200) "assumes the science to be right in its broad outlines" and proceeds to argue that academic history will and should experience irrevocable change when the "environmental crisis" is fully acknowledged by practitioners. For instance, one of his four Anthropocene-inspired theses is that it is increasingly implausible to bracket out biophysical phenomena in the stories historians tell about humankind. The history of people and planet are now coterminous. Relatedly, Tim Clark's book *Ecocriticism on the Edge* (2015) explores the impacts on disciplinary norms of Anthropocene science. Ecocriticism involves interpreting creative works (e.g., novels) that call into question or valorize certain human perceptions and uses of the nonhuman world (see also Nikoleris, Stripple, and Tenngart, Chapter 5). Clark argues that the Holocene's eclipse disrupts the normative reference points of the field. This is because ecocritics can no longer presume that what appears environmentally progressive at one spatiotemporal scale will not have regressive impacts at other scales – such are the complex, ramified teleconnections of an earth system undergoing anthropogenic forcing.

In contrast to the likes of Chakrabarty and Clark, who attend to the "geologization of social thought" (Clark and Gunaratnam 2016: 1), others have used the existing resources of social science and the humanities to reflect critically on how Anthropocene science presents so-called "human dimensions." For instance, Marxist environmental historian Jason Moore (2015) unpacks the "human enterprise" category widely used in the literature from earth system science and the International Geosphere-Biosphere Programme. He endeavors to "socialize the geological" (Moore 2015) by showing how capitalist societies – with their specific ensemble of class relations, technologies, valuation processes, and growth logics – have changed earth history, thereby offering a worked-up explanation for the so-called Great Acceleration. He is one of several critics to take issue with the generalized "anthropos" apparently signified by the Anthropocene concept (see also Baskin, Chapter 8). The sort of detailed explanation he offers is missing in Anthropocene science – though, as noted earlier in the discussion of the dating debate, Anthropocene scientists seem well aware of the different ways the "human enterprise" can be narrated. Relatedly, a thorough exploration of the normative implications of the science for humans is also missing in the scientific literature.

Accordingly, some moral and ethical philosophers are trying to fill the gaps (e.g., Alberts 2012), while others (e.g., Biermann 2014 and 2018) attend to the governance implications of a world of almost 200 nation-states undergoing biophysical change.

Finally, some social scientists and humanists have focused less on the "missing (or misrepresented) human dimensions" of the Anthropocene proposition and more on the science itself. This focus arises from over forty years of historical, cultural, and political-economic research into science as a "socially constituted" enterprise, much of it contained in the field of Science and Technology Studies. Two illustrative examples will have to suffice here. Writing in the journal *Environmental Humanities*, Eileen Crist (2013) sees the science behind the Anthropocene proposition as suffused with contestable value judgements that scientists are trying to naturalize (wittingly or otherwise). For instance, Steffen and colleagues (2011) have talked several times about the need for planetary stewardship, an "ought" that for them flows from the "fact" of humans' planetary impact. However, for Crist (2013: 133), they thereby "veer away from environmentalism's dark idiom of destruction, depredation, rape, loss, devastation . . . and so forth into [a] . . . tame vocabulary that humans are changing [the earth]." From Crist's overtly ecocentric perspective, this bespeaks a short-circuiting of the is-ought link so as to narrow normative reasoning and human response. For instance, several geoscientists, including Crutzen, have made the case for large-scale geoengineering technologies as an emergency response to a "runaway" Anthropocene.

Writing in a less politically pointed way than Crist, Ola Uhrqvist and Eva Löfbrand (2014: 342) explore the role of earth system science and the International Geosphere-Biosphere Programme in planetary "governmentality." Following Michel Foucault, they examine "how thought produces [a] . . . governed reality and thereby directs the ways we act upon it." They treat systems thinking as one way of "framing" reality, and trace the evolution in earth system science from thinking that invites integrated "earth system management" to more complex thinking that, today, points towards a more distributed, differentiated and less orchestrated human response to a possible regime shift in the earth system. For them, this shift comports with an "adaptive" approach to planetary management that moves beyond the "systems engineer" approach. Like Crist, therefore, they challenge the neutrality of the concepts and metaphors favored by some Anthropocene scientists. Unlike Crist, though, they do not pass judgement on the cognitive or normative adequacy of the "frame," simply noting its contingency and historicity.

In sum, to date, social scientists and humanists have engaged Anthropocene science in three ways. Yet, despite the apparent differences involved, it seems to me that the examples above have an important thing in common: namely, they all at

some level accept the epochal claims of Anthropocene science and so endorse its fundamental insight. Even Crist, who is highly critical of the terminology used by Anthropocene scientists, does not demur to the essential claim that we are entering a new geological epoch. Likewise, in their recent attempt to showcase different "narratives" about the human causes and consequences of the Anthropocene, Bonneuil and Fressoz (2015: xi) leave the kernel of the science intact: "The Anthropocene label," they write, "is an essential tool for understanding what is happening to us." Only by accepting the geoscientists' claims emanating from stratigraphy and the earth system approach does the two authors' attempt to offer different causal and normative accounts have purpose and punch. The same is true of Hamilton and colleagues' (2015) *The Anthropocene and the Global Environmental Crisis*, which showcases social science and humanities responses to the Holocene's end. "The Anthropocene," the three editors declare, "forces us to reconsider it all" (Hamilton et al. 2015: 11).

The Anthropocene in Green Political Thinking and Practice

In this light, and relating all this to the concerns of this book, how should those who analyze green political theory and environmental politics react to Anthropocene science? Is it advisable to follow the lead of Chakrabarty, Hamilton, and others? Are the fundamental categories organizing the study of contemporary politics to be rethought in light of Anthropocene science? Who, now, is a political actor, who (or what) has civil rights, and who (or what) deserves representation in the political sphere? It may seem necessary to rethink the political in light of these Anthropocene-induced questions. Not only do we social scientists and humanists lack the expertise to assess the *quality* of the science, but the stakes in *ignoring* the science are extremely high: after all, if the scientists are right, then Naomi Klein's (2014) judgement about climate change is amplified by orders of magnitude, since the Anthropocene will "change everything" within a century. Intelligent, innovative analysis and prescription about political values, political reason, and political institutions in our post-Holocene world are thus, in this context, essential to shaping our collective future in ways that are both just and feasible. It is the sort of work undertaken in this book by Manuel Arias-Maldonado (Chapter 3), Anne Fremaux and John Barry (Chapter 9), and Paul Wapner (Chapter 11), among others. Moreover, the sort of impulses contained in Jason Moore and Eileen Crist's work suggests there is plenty of room for intellectual maneuver relative to the insights Anthropocene science provides: as these authors demonstrate, and as many a philosopher has shown before them, a "fact" never determines either the reasons for its existing (the causal "back story") or its normative implications (the possible or desirable future responses to it by people). In this scenario, green analysts should

press ahead vigorously with "Anthropocene scholarship, activism, and policy work," since the worst that could happen is a premature pronouncement of the Holocene's end, even as – short of a worldwide anti-capitalist revolution – its termination is surely only a matter of time.

A different option is to proceed more cautiously and await greater scientific consensus. Rather than treat the Anthropocene as a virtual "fact," more patience may be advisable. The International Commission on Stratigraphy may need ten years or more to receive and assess a formal submission from the Anthropocene Working Group. Meanwhile, earth system science might benefit from the sort of external validation that climate change science has received from scientists who are not climate experts – such as Richard Muller at the University of California, Berkeley.⁷ As Oldfield and Steffen (2014) argue, this validation will have to reckon with the challenge of verifying knowledge about a hypercomplex open system that even the best computational models cannot properly simulate. Without more time to develop and to be scrutinized, both the stratigraphic and earth system branches of Anthropocene science may be subject to the sort of politically led skepticism that so damaged the public reception of climate science through the early 2000s. In this second scenario, green analysts would avoid accusations of uncritical reliance on scientific expertise and, by extension, of trying to "scientize" the green arguments and proposals they wish to advance for altogether other reasons (such as a love of the nonhuman world).

Though rather different, these two scenarios possess a shared characteristic: they would hold green analysts at a distance from Anthropocene science. In the first case, uncritical reliance on expertise prevails, while in the second scenario, critical practices within science are relied upon to eventually yield robust claims about socio-natural reality. Both differ from a third scenario, one that returns me to this chapter's focus on how "the end of nature" is a predicate for Anthropocene science. In this scenario, some green analysts would follow the lead of the likes of Crist, Uhrqvist, and Lövbrand but go somewhat further. As we saw above, these authors effectively place the core insight of Anthropocene science "off limits," focusing on the language and framing used to convey the insight. Despite their "social constructionist" sensibilities, these authors ultimately default to an old-fashioned realism wherein evidence, models, and expert judgement decide upon the fundamental "reality" of our post-natural globe. In my third scenario, by contrast, green analysts would attend to the *contestable social judgements made in the very heart of Anthropocene science*.

⁷ Muller and team at Berkeley reanalyzed data used by climate experts to offer an independent assessment of the Intergovernmental Panel on Climate Change's claim that global warming is almost certainly the result of human influence. The so-called Berkeley Earth Surface Temperature Project concluded in 2012 and endorsed the conclusions of the Intergovernmental Panel on Climate Change.

As hinted at earlier in this chapter, some of these judgements pertain to what we call "nature" both historically and ontologically. One judgement is that there really is – or was – a realm of (global) "nature" separate from "society." Anthropologists, among others, have shown that this is a culturally specific belief that pretends that science is "the culture of no culture," able to give us an unmediated perspective on the real (Descola 2013). Another set of judgements pertains to when, exactly, nature is natural no more (or notably less so): at what point does a change to "nature" become qualitative change? What quality of change counts as epochal and worthy of attention? What anticipated *future* biophysical changes should scientists reasonably enjoin us to care about *today*? Here, Raymond Williams' (1980) famous observation about references to nature remains relevant. In his historical analysis of nature in Anglo-European social discourse, Williams showed that, in important respects, people are usually talking about themselves when they discuss rivers, rocks, or the climate. Even in the laboratories, computer models, and published papers of scientists, evidence of biophysical change makes little sense without a set of prior judgements about when quantitative additions or removals become qualitative alterations. These judgements turn "matters of fact" into "facts that matter." In Bruno Latour's (2004) terms, they subsequently become a "matter of concern" not because "reality" *forces* such concern upon us all equally but because a set of spokespeople for "the real" give some of us reasons to care. In both areas of Anthropocene science, it seems to me, the notion of a "new" earth system has value content at its core rather than being only a scientific notion with detachable value content (Ellis and Trachtenberg 2013: 123).

All this may sound perilously close to the sort of "strong social constructionism" that led to the so-called "science wars" in the United States during the 1990s, triggered by Alan Sokal's (1996) hoax in the journal *Social Text*.⁸ It may also appear to make green analysts de facto Anthropocene skeptics by "de-objectifying" claims about a post-Holocene transition.⁹ However, far from "relativizing" Anthropocene science, green analysts would here make explicit, and assess the merits of, the judgements made by scientists about when the earth is natural no more. These judgements cannot be secured by recourse to "objective truths," but they can be appraised in a reasoned way. This much has already become evident in the fields of conservation and restoration biology, where "objectively" existing "natural baselines" have proved elusive. This would contribute to a more mature understanding of what Anthropocene science – like all science – has to offer

⁸ Sokal famously published a paper analyzing one area of esoteric science as if he were a knowledgeable sociologist of science – his analysis was, deliberately, nonsense, yet it still got published! Sokal then went on to reveal his true identity, and his hoax called into question the credibility of the "social constructionist" approach to science that was, by the 1990s, a growth area in social science.

⁹ Clive Hamilton, for instance, as an environmentalist and spokesperson for earth system science, would doubtless be alarmed at any whiff of constructivism or relativism when it comes to Anthropocene science.

nonscientists in all walks of life. By highlighting the social dimensions of geoscience, in its stratigraphic or earth system forms, green analysts – in this third scenario – would help navigate between attempts to scientize politics (and policy) and attempts to politicize science for nonscientific reasons while refusing to properly debate those reasons. To borrow Roger Pielke's (2007) useful terminology, they would avoid the antinomies of "hurricane politics" (where an "is" gets used to justify one all-encompassing "ought") and "abortion politics" (where science becomes the servant of incommensurable ethico-political agendas, often producing gridlock). They would also offer those pursuing scenario one a stronger basis on which to trust Anthropocene science.¹⁰

To summarize, it is likely that green political thinking will undergo a fundamental rethink in light of the colossal ontological implications of Anthropocene science. In the years ahead, existing ideas about political actors, political subjects, political institutions, and so on will be challenged because "the Anthropocene" resets the compass for any attempt to understand "the political," be it in descriptive-explanatory or normative terms. For some, the challenge is even more important if some societal actors try – as they assuredly will – to depoliticize the Anthropocene by advocating "post-political" arrangements, such as a new expert-led global governance body designed to "manage" the earth system (Fremaux and Barry, Chapter 9). However, it will be important for political theorists to scrutinize Anthropocene science "all the way down" when vouchsafing their own arguments. That will require a confident, knowledgeable approach to the science that many green political theorists currently lack.

Conclusion

This chapter has sought to instill a reflexive attitude towards Anthropocene science. Despite nearly forty years of scholarship in science and technology studies, the social science and humanities reaction to the science so far has, I have shown, been either uncritical or else critical within certain parameters that insulate the science from further scrutiny. By exploring three future scenarios for how green analysts might respond to the science, I have cautioned against leaving the Anthropocene proposition "to the experts" even as I have resisted arguing that the Holocene's proclaimed end is merely a "social construction" fabricated by a cadre of geoscientists. Value judgements about nature – about how much of it is gone, how much of it is left, which parts to protect, and which technologies to use to ensure a "good Anthropocene" – are not only anterior to Anthropocene science. Though such

¹⁰ And here I make critical mention of the Breakthrough Institute's "ecomodernist manifesto" (2015), which seeks to "objectify" its fundamental premise of a "post-natural world." Go to: <http://thebreakthrough.org/index.php/voices/michael-shellenberger-and-ted-nordhaus/an>

anterior considerations matter – as current debates about the propriety of “geoengineering” demonstrate – they do not exhaust the value dimension of Anthropocene science. Green analysts, like others in the social sciences and humanities, can help demystify the stubborn myth of scientific “objectivity” and so foster a mature debate about what grounds scientific statements about “an earth in crisis.” What is needed is constructively critical engagement with Anthropocene science (Lövbrand et al. 2015), not undue deference or mere indifference to its messages. Such engagement can help “coproduce” science and politics in ways consistent with democratic debate and choice (see Beck, Chapter 10).

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