

The Juridical Dimensions of Earth System Governance: Initiating a Debate on Earth System Law

Louis J. Kotzé*

Rakhyun E. Kim**

Keywords

Earth system law; Earth system governance; Anthropocene; environmental law; legal science; Earth System Governance Project Science and Implementation Plan 2018

Abstract

While the focus of earth system governance is on the human-social aspects of Earth system changes, law has played a peripheral part in the earth system governance scientific agenda. Earth system governance perspectives have also not significantly infiltrated the juridical domain. In this paper we seek to initiate a debate on the juridical dimensions of earth system governance. We make out a case in support of developing a new overarching legal phenomenon that, more than environmental law (among others) comprehensively accommodates and encapsulates the juridical aspects of earth system governance, including a new accompanying research agenda. We call this new legal phenomenon 'earth system law'. Earth system law, as we aim to show, could introduce a new era in legal scholarship, while seeking to comprehensively respond to the regulatory challenges presented by a changing Earth system in the Anthropocene.

1. Introduction

Over the past decade, 'earth system governance' has matured into a full-fledged and autonomous research agenda, evidenced in particular by the establishment of this journal and the burgeoning earth system governance research community (Earth System Governance Project). The appeal of earth system governance lies in its innovative focus on a systems approach that embraces the complexities of global environmental change and sustainability science in the Anthropocene, while accommodating multiple scientific disciplines (notably social sciences and the humanities) at various spatial and temporal scales (e.g., Biermann 2014; Young 2017). To this end, earth system governance offers a common, inclusive and deliberative scientific platform for scholars to convene around a critical global sustainability challenge, that is, interrogating 'organised human responses to earth system transformation, in particular the

* Research Professor of Law, North-West University, South Africa; Marie Curie Research Fellow, University of Lincoln, United Kingdom; and co-scientific coordinator of the Task force on Earth System Law. Research for this paper was supported by the author's European Commission Marie Skłodowska Curie project titled: "Global Ecological Custodianship: Innovative International Environmental Law for the Anthropocene" (GLEC-LAW) under grant agreement No. 751782 and it was completed in December 2018. The authors acknowledge with gratitude the many views expressed on the conceptual development of earth system law during the annual meeting of the Task Force on Earth System Law in Utrecht, November 2018; some of which have shaped our thinking around this emerging concept.

** Assistant Professor of Global Environmental Governance, Utrecht University, The Netherlands; and co-scientific coordinator of the Task force on Earth System Law.

institutions and agents that cause global environmental change and the institutions, at all levels, that are created to steer human development in a way that secures a “safe” co-evolution with natural processes’ (Biermann 2007: 328).

While the focus of earth system governance is explicitly on the human-social aspects of Earth system changes, law has played a conspicuously peripheral part in the earth system governance scientific agenda. To date, earth system governance perspectives have also not significantly infiltrated the juridical domain, despite increasing calls for such a convergence (Kotzé 2018). We make this observation despite law’s critically central normative regulatory role in determining, directing and optimizing ‘organized human responses’ to an ever-changing Earth system. Even at a high strategic governance level, the United Nations General Assembly recently endorsed the view that a new regulatory approach is needed,

which draws upon the holistic scientific knowledge provided by Earth system science to evolve laws and policies that better manage human behaviour in light of the interconnections among people and nature. Both Earth system science and Earth system governance continually and mutually reinforce each other regarding a holistic vision for the planet. (UNGA 2014: Para 50)

While there is a clear link between earth system governance and the law, this link remains largely under-explored. We clearly observe what Galaz (2014) calls, an ‘Anthropocene Gap’ in relation to law and legal science’s role in earth system governance; a state of limbo of sorts where we are unable to dissect, understand and respond juridically to the major implications induced by transgressions into a human-dominated planet from an Earth system perspective. Consequent on this ‘gap’, it remains unclear how law could respond from a regulatory perspective to some of the key problem characteristics of earth system governance. These include, among others, the level of persistent uncertainty that characterizes anthropogenic Earth system transformation; the inter-generational dependencies created by Earth system transformation; the functional interdependence of Earth system elements such as climatic and aquatic systems; new and multiple forms and degrees of global spatial human and non-human interaction and interdependence; and the extraordinary degree of harm that is being done to the Earth system, including ways to address this harm and to adapt to it, while simultaneously creating options to increase resilience (Biermann 2007; see also Underdal 2010). Also, from a scientific perspective, the earth system governance research agenda still does not offer any explicit, systematized and comprehensive research agenda focusing exclusively and comprehensively on the juridical dimensions of earth system governance in the same way as it does for political science, for example.

This is of course not to suggest that law and juridical science have been completely stagnant, or ignorant of, or unresponsive to environmental change. Environmental law, to name but one example, has been the mainstay juridical strategy specifically designed to regulate human-environment relations and to protect the environment. It has grown impressively at least since the 1970s into a fully independent and mature sub-discipline of the law, while legal systems all over the world now include environmental protection provisions in some form or another (Tarlock 2009). But for the last 50 years, environmental law and its scholars have mostly been following an inward-looking norm development path and predominantly mono-disciplinary research agenda (Fisher et al 2009; Pedersen 2018). Some legal scholars are tentatively venturing into the uncharted juridical domain of earth system governance, while political science and governance scholars for their part, are increasingly focusing on the law (Ebbesson 2010; Kim and Bosselmann 2013; Kim and Mackey 2014; Lawrence 2014; Kotzé 2017; Kotzé and French 2018). But in the main, academic discussions about the role of law in relation to earth system governance have remained muted, with scholars resisting the urge to develop a collaborative juridical research agenda as part of the earth system governance network.

In response to this ‘Anthropocene Gap’, and as a first contribution to the work of the recently established Task Force on Earth System Law as part of the Earth System Governance Project (Task Force on Earth System Law 2018), the purpose of this paper is to initiate an academic debate on the *juridical dimensions* of earth system governance. We make out a case in support of developing a new overarching legal phenomenon that comprehensively accommodates and encapsulates all juridical aspects of earth system governance, including a new research agenda that is able to respond to the unique epistemic, ontological and normative characteristics, demands and nature of earth system governance in the Anthropocene. We call this new legal phenomenon and its accompanying research agenda ‘earth system law’. Earth system law, as we will show, could introduce a new era in legal scholarship, while seeking to comprehensively respond to the regulatory challenges presented by a changing Earth system as reflected by the Anthropocene’s global socio-ecological regulatory and associated normative and epistemic demands. To this end, we introduce earth system law as both a descriptive and prescriptive concept. We argue that in a descriptive sense, earth system law could more meaningfully embrace the juridical aspects of earth system governance while, conversely, earth system law could introduce earth system governance as a research and regulatory concern into the science of law. In a prescriptive sense, earth system law should be more closely aligned with the Anthropocene’s normative demands to the extent that it seeks to improve the ability of law to better respond to the deeply intertwined Earth system and its many complex socio-ecological challenges.

The discussion commences in Part 2 below by briefly introducing the Anthropocene as the broader context within which to contemplate the relevance and role of law in a radically altered human-dominated geological epoch. The central thrust of our argument is that law and legal science in their present guise have become unsuitable to ‘navigate the Anthropocene’ (Biermann et al 2012) and, therefore, we will need to critically revisit the place, role and purpose of law in modern society. For illustrative purposes, in Part 3, we reflect on the prevailing juridical response to global environmental change, focusing for the sake of brevity specifically on environmental law and its attendant scholarship. The discussion in this part will highlight some of the mounting regulatory and epistemic concerns surrounding environmental law in the Anthropocene; concerns which we believe could in time be more effectively addressed through the lens of earth system law. In Part 4, we describe for illustrative purposes what a conceptual progression from international environmental law to a planetary form of earth law might entail. We conclude the discussion in Part 5 with a brief elaboration of a proposed future research agenda that could contribute to establishing, clarifying, elaborating and further developing earth system law.

2. Law and the Anthropocene’s ‘brave new dystopian world’¹

Over the last two decades, earth system scientists have suggested that we might be entering the Anthropocene (Zalasiewicz et al 2017), a new geological epoch where humans have become a global geophysical force that dominate the great forces of nature (Crutzen 2002; Steffen et al 2007). While it remains debatable from a technical standpoint whether ‘humans have changed the Earth system sufficiently to produce a stratigraphic signature in sediments and ice that is distinct from that of the Holocene epoch’ (Waters et al 2016; but see Petit et al 1999),² it is now widely accepted that ‘climate events and associated suffering can no longer be cast as acts of God or nature. They are now at least partly linked to human agency and responsibility’

¹ An idea famously proposed in Aldous Huxley’s *Brave New World* (Chatto and Windus, 1932).

² We are still officially in the Holocene epoch (its third and most recent age was confirmed in 2018 as the Late Holocene Meghalayan Age) (International Commission on Stratigraphy 2018).

(Ribot 2016: 667; see also Intergovernmental Panel on Climate Change 2018). As a discursive category, the Anthropocene now occupies a central position in the human-environment relations discourse, and it has many scholarly manifestations or utilities. It could, for example, signify a complex time of accelerated anthropogenic change; it could be a narrative framing of contemporary life and futures; it could act as a lens through which to view multispecies worlds in formation; or a spatial and material manifestation of specific economic, scientific, and political practices (Moore 2015).

Thus, putting aside for a moment the empirical effort seeking to prove its existence, the Anthropocene has become interesting also for its epistemic and metaphorical potential. The Anthropocene's metaphorical function is important because 'metaphors deeply pervade all human cognition, scientific analysis included' (Rickards 2015: 281). They give new meaning to trite terms and ideas, and they have the ability to structure how we understand reality and how we respond to it. Metaphorically, the Anthropocene reveals that, while 'acts of God or nature' are seen to occur without volition, anthropogenic impacts in a human dominated time are 'the consequence, intended or otherwise, of decisions taken by human minds' (Hamilton 2013). Global environmental change is the direct result of *human agency* intended to reshape the Earth system:

Today, humans can no longer be conceived of as social actors operating exclusively within a social sphere of human-to-human engagements. We must now be conceived of as integral to earth systems. We act today ... as biophysical 'actants' who have, through our actions, significantly reshaped the earth. As geological agents, humans are slowly reconceiving themselves as biophysical beings interacting with other biophysical beings. (Shearing 2015: 257)

The image of 'humans as geological agents' highlights that we do not exist in a Cartesian-like 'social-only' domain that is separate from a natural world somehow removed from us; humans now impact 'natural' processes of which we are an intricate part. The Anthropocene's metaphor further draws attention to the fact that humanity's power to change the Earth system is undergirded by deliberate will that can be withheld as well as exercised (Hamilton 2013). There is accordingly a clear *social dimension* to Earth system change, both with respect to the power humans exert to change the Earth system, and with respect to the social institutions humans employ to live with these Earth system changes. The socially nested human power to change the Earth system and to respond to its changes is, therefore, a power that humans themselves seek to control with varying degrees of success through our social regulatory institutions such as religion, politics, economics and law.

Law, the focus of our present enquiry, is a critical element of the human-political-social system, and an important part of those social regulatory institutions that humans consciously design to establish and maintain a specific type of desired social order (Kotzé 2012; 2014); an order that is being destabilized by Earth system changes, as the impacts of climate change on societies across the globe clearly suggest. While admittedly simplistically considered, humans make laws to regulate society, human behaviour and human interactions inter se and between people and non-humans: '[L]aw is a tool that helps direct humans to behave in ways they otherwise would not, if left to their own devices. It works to modify aspects of the human environment in order to modify human behaviour' (Richardson 2011: 30). To this end, law aims to constrain free will of humans, and it sets governance outcomes to achieve while constituting, legitimizing and regulating governance processes and institutions. Law also attempts to ensure continuity in relation to specific forms of social organization, and it aims to establish order with a view to achieving justice (broadly conceived), while seeking to offer a sense of social stability, inclusion, participation, representation, accountability, resource allocation and distribution (e.g., Hart 2012).

When considered in the foregoing context, the juridical implications of the Anthropocene's imagery become apparent. No less because 'this new geological terminology casts no judgement on the desirability, or otherwise, of this new state of affairs, but it does invite profound normative questions' (Stephens 2017: 31). These questions will ask of us to consider how, and the extent to which, the Anthropocene is changing our perceptions of law as a regulatory institution, including our trite perceptions of law's content, purpose, objectives and design. They will also require of us to reflect on human agency and the role of law in governing human actions in the Anthropocene, including the impacts of these actions on the Earth system and the impacts of other Earth system processes on human existence. The Anthropocene, in this sense, allows for an opening up of hitherto prohibitive epistemic 'closures' in the law, of legal discourse more generally, and of the world order that the law operatively seeks to maintain, to a range of other understandings of, and cognitive frameworks for, global environmental change. It further reveals the context to contemplate possible ways to mediate this change through the law (Kotzé 2015).

As a result, the Anthropocene will ask of us to critically revisit the many trite assumptions we have internalized over the years in creating, interpreting, applying and reforming law as a key normative social institution. For example, the past and present transformation of the complex Earth system is arguably an irreversible process that would also significantly depend on innovative technological interventions to restore or even to substitute Earth system functions (e.g., National Geographic 2018). If we accept that once we have pushed the Earth system beyond its critical tipping points (Lenton et al 2008), backtracking to the Holocene becomes difficult, if not impossible. The regulation of technological interventions to enable new futures instead, might become a key focus of law, requiring law to also embrace a forward (instead of mostly backward)-looking perspective. In this way, law would continue to try and maintain the current Holocene-like state, which is the only state we know that is conducive to life (Rockström et al 2009), but law will also have to more comprehensively embrace new regulatory concerns in aiding humans to imagine multiple 'plausible and desirable futures' (Bai et al 2014).

In light of the Anthropocene's 'destabilizing' effect, characterized as such a destabilization is by many uncertainties and complexities, it seems appropriate to assume that law in its present guise might not be entirely appropriate any longer to enable plausible and desirable futures in the Anthropocene. Law, as we know it, might have become unable or even unsuitable as a regulatory institution to respond to Anthropocene exigencies, while our scientific methods and approaches through which we interrogate and critique law for the purpose of its further development and reform have equally become outdated and unable to relate and respond to other contemporary social science paradigms such as earth system governance. Such a realization highlights the critical need for a comprehensive re-interrogation of the nature, functions and objectives of the law and its science in the Anthropocene's 'brave new dystopian world'. We suggest below that such a comprehensive re-interrogation could be facilitated through the lens of earth system law.

3. Earth system law for the Anthropocene?

Although existing foundational assumptions in relation to law's nature, regulatory role and objectives are challenged in the Anthropocene, law will continue to play a critical regulatory role. Law will remain a useful and relevant social regulatory institution precisely also *because of* the deeply pervasive global socio-ecological crisis explicated by the Anthropocene, especially to the extent that law must respond to this crisis' unprecedented patterns of inter and intra-generational human and inter-species injustices, its profound levels of uncertainty and

social instability, its patterns of disorder that will most likely increase at all levels of social ordering, and regulate new technologies designed to survive amidst its socio-ecological crisis.

But while the continued relevance of law in the Anthropocene is apparent, a business-as-usual approach to law, legal regulation and juridical science will arguably not be tenable any longer. As we have showed immediately above, law and its accompanying science will need to change if it were to remain relevant in the Anthropocene, and if it were to maintain its position as an important regulatory instrument of choice to establish and maintain social order, predictability, legitimacy and stability while also pursuing justice. It is precisely these changes and reforms of, and improvements to law and its science in the context of the Anthropocene, that will arguably be the central concern of earth system law and its accompanying research agenda.

It is impossible within the limited scope of this paper to offer any comprehensive conceptual treatment of earth system law and the detailed content of its research agenda. What we aim to do in the remainder of this part is to foreshadow some of the key concerns with which earth system law might occupy itself. We distil these from an analysis of some of the principal concerns currently associated with environmental law.³ It would be these concerns, among many others that we do not identify or discuss here, that could possibly lie at the heart of earth system law and its research agenda.

3.1. Inability to achieve deep structural reforms

Environmental law emerged in the years following the Great Acceleration; a period in Earth's geological history that signalled a 'global-level, synchronous step change in human enterprise and the simultaneous human-driven change in many features of Earth System structure and functioning' (Gaffney and Steffen 2017: 57). But despite its relative maturity, environmental law remains a regulatory intervention at the periphery of the social regulatory system. It is essentially a collection of prohibitions with modest impacts on deeply intertwined socio-ecological relationships (Magalhães 2016). Environmental law has failed to keep humanity from crossing critical planetary boundaries that exemplify the Anthropocene's socio-ecological crisis in concrete terms (Rockström et al 2009; Steffen et al 2015). Chapron et al (2017) observe that:

effective environmental legislation must at a minimum act as legal boundaries that prevent human activities from reaching and breaching planetary boundaries, defined as the safe space for mankind to operate within. ... In other words, legal boundaries must translate the physical reality of a finite world into law and thereby delimit acceptable levels of human activity.

Because we have already purportedly crossed four of the nine planetary boundaries (climate change, biosphere integrity, biogeochemical flows, and land-system change) (Steffen et al 2015) environmental law, at least in these terms, has failed to meaningfully contribute to regulatory efforts that aim to keep humanity from reaching and breaching these boundaries.

In addition to concerns revolving on its ineffectiveness, and possibly also a reason for this ineffectiveness, there is a worrying lack of normative ambition at a time when precisely such ambition is critically required in the Anthropocene (Kotzé and French 2018). An example is the lacklustre draft Global Pact for the Environment of 2017; a newly proposed generic international instrument intended to be globally binding, through which states aim to consolidate all major principles of international environmental law in one document, whilst also developing progressively the law to provide a globally recognised right to live in an ecologically sound

³ For the sake of brevity, we only focus on environmental law, acknowledging, but not also discussing these for present purposes, that trade law, economic law, social security law and many other domains of law are equally implicated by the Anthropocene's socio-ecological crisis and in need of a comprehensive rethink.

environment (UNGA 2018). Yet, the Global Pact in its present draft form adds very little to the legal panoply of environmental norms, hard or soft: '[T]here is a legitimate question whether... [the draft Pact] would add value or might, in fact, end up simply creating legal confusion and negatively affecting existing legal regimes' (Biniaz 2017: 11). While it has some diplomatic and symbolic aspirations and relevance, the draft Global Pact, in its present draft form, does not constitute a firm foundation for inaugurating or embedding the type of paradigm-shifting global juridical regime that we critically need in the Anthropocene. It does not form the basis of *Lex Anthropocena* (Kotzé and French 2018; French and Kotzé 2019).

The state of the deteriorated Earth system is instead such that deep structural change in global governance is urgently required, both inside and outside the formal United Nations system (Biermann et al 2012). But environmental law at best only pursues incremental change in the formal public sphere which is insufficient to bring about socio-ecological change at the level and with the speed needed to respond to Earth system transformations. Consequently, environmental law now faces a challenge with respect to its practical effectiveness and, even more critically, with respect to its *raison de'être*:

In the human era many of the objects of traditional concern for international environmental law are being so radically disfigured or expunged that some environmental regimes are losing their power, significance and purpose. The Anthropocene threatens to wash away the relevance and influence of the discipline, with international environmental law becoming an international law curio, devoted to preserving a natural world that no longer exists, in a manner akin to the haunting inconsequence of the League of Nations as the world marched to war in 1939. (Stephens 2017: 48)

A key aspect of earth system law and its research agenda would therefore be to formulate ways in which law could become more effective and keep humanity from crossing planetary boundaries, while better achieving the type of deep structural changes, in and of society and its normative systems, that are necessary to navigate the Anthropocene.

3.2. State-centrism

The multilateral environmental law and governance domain remains predominantly state-centric, largely depending on the state as the central source of its legitimacy and authority. This is so despite the emergence of non-state entities and civil society movements as important actors in polycentric forms of bottom-up global environmental governance (Kotzé 2014). Non-state actors, for example, still do not play any meaningful role in the negotiation, enforcement and revision of multilateral environmental agreements. There are several reasons for the continued primacy of the state in this regard:

Firstly, states enjoy a comprehensive legitimacy as actors in public international law. Secondly, states still bear primary responsibility also as addressees of those norms and - insofar as the behaviour of private [non-state] actors is concerned - they remain the primary implementing agents of such rules. Thirdly, comprehensive democratic legitimacy and accountability can be best safeguarded within states. Thus, states legitimately are and remain the primary authors of international environmental law (Beyerlin and Marauhn 2011: 247).

A purely state-centric juridical paradigm, however, shuts out any meaningful involvement, incentivization and promotion of non-state actors in earth system governance at a time when such involvement is in fact critically required. Global environmental governance also remains decidedly undemocratic as a result of the exclusion of non-state actors in decision and rule-making. Considering recent developments in and the need for 'new environmental governance', which involves polycentric, bottom-up modes of governance through the involvement of non-state actors at all regulatory levels ranging from the local through to the global (Holley et al

2012), law's outdated assumptions with respect to the state's primacy in relation to legitimacy, democracy, participation and implementation are untenable. A key aspect of earth system law will therefore be to explore innovative ways in which law could elevate and more meaningfully facilitate the participation and influence of non-state actors in earth system governance, while it simultaneously explores ways in which to address the democracy deficit in global environmental governance.

3.3. Anthropocentrism

Reflecting on its ontological orientation, despite its rhetorical ambitions, the function of environmental law in broad terms has been to promote a shortermist, utilitarian, and neoliberal human growth agenda by protecting environmental resources for the socio-economic (and therefore *unsustainable*) development of some privileged humans of the present generation (Adelman, 2018). Environmental law is not predominantly concerned with advancing ecological sustainability well into the future, despite some encouraging but ultimately faltering normative attempts to do so during its early formative years (evidenced, for example, by the World Charter for Nature of 1982) (Kotzé 2018). Thus, environmental law has failed to ensure any meaningful degree of sustainability with respect to humanity's continuing dependence on and interaction with ecological processes (Mares 2010). To be sure, environmental law, especially in its liberal Western orientation, has been singularly successful in separating humans and 'nature'. The non-human world ('nature'), has been relegated to a mere regulatory object, there to satisfy the needs of environmental law's main referent, namely its human subject. Environmental law squarely rests on the assumption that 'the grand and the everyday events of human life take place against a backdrop of a blind and purposeless nature' (Hamilton 2013).

Yet, the Earth system does not only include 'natural' or ecological aspects such as climatic, oceanic and biodiversity systems. The Earth's is an adaptive and multifaceted system comprising human-social *and* ecological elements (Liu et al 2007; Phelan 2013). These elements are deeply intertwined. The stability of the ecological element is required for the human-social element to flourish, while the human-social element is determinative of the overall stability and integrity of the Earth system, including its ecological element. Environmental law in its present guise is unresponsive to such an integrated vision that more fully accommodates human-non-human relationships (Kotzé 2018). An important objective of earth system law and its research agenda would therefore be to explore ways in which to accommodate non-anthropocentric ontologies and ethical care, while at once critically reflecting on ways to prioritize protection of the non-human world in addition to human interests. In other words, earth system law will need to more fully embrace all present and future earth system constituents including humans and the non-human world.

3.4. Assumptions of Holocene stability

The body of environmental law that has developed domestically, regionally and internationally, squarely rests on assumptions of relative stability, harmony and continuity that prevailed in the Holocene epoch. In the Anthropocene, however, 'the pace and scale of Earth system change undermines many of the traditional, place-based concerns of environmental law which are becoming increasingly futile gestures in the face of global environmental transformation' (Stephens 2018a: 122). As a result, environmental law has fallen victim to a troubling regulatory concern, namely, that reactive approaches to complexity have generally proven to be ineffective. It remains unable to fully respond to a non-linear Earth system characterized by unpredictable, potentially catastrophic shifts at multiple scales ranging from the local to the global sphere (Nobre et al 2010).

Relatedly, despite its embracing the precautionary and preventive principles, environmental law mostly operates after the fact instead of attempting to foresee Earth system disruptions well in advance. To this end, environmental law has served humanity as ‘the passive inheritor of global environmental conditions set by forces beyond its control’, instead of enabling humanity to become ‘the trustee of planetary environmental stability’ (Stephens 2018b). A key premise of earth system law and its research agenda would thus be to discard any trite assumptions of Holocene stability, and instead depart from assumptions embracing complexity, instability and unpredictability, while it allows for forward-looking measures that also foresee harm instead of only addressing it in an *ex post facto* way.

3.5. Reductionism

It has been suggested that environmental law and its lawyers have been reluctant and ultimately unable to respond to deeply complex patterns of socio-ecological change and Earth system complexity, primarily because they have not fully embraced an Earth system perspective (Kotzé 2014; Kim and Mackey 2014). The Earth system perspective is emerging as an epistemological framework within which to organize transdisciplinary debates focused on understanding the complex, adaptive, erratic and globally intertwined Earth system and its myriad socio-ecological implications for the living order, and it is increasingly being employed to steer reform initiatives broadly focused on regulatory institutions. A systems approach has now become a fundamental concern and focus of various disciplines. For example, disciplines such as geoscience and political science have been actively embracing an Earth system perspective, notably since the turn of the millennium on the back of the Anthropocene trope and associated research agendas such as planetary boundaries and earth system governance (e.g., Biermann 2014; Nicholson and Jinnah 2016). But this is not yet true for environmental law. For law, the Earth system remains an ‘unidentified legal object’ (Aragão 2016: 93) and there is as of yet ‘nothing in the law responding to the Earth’s wholeness and complexity’ (Bosselmann 2016: 65). Environmental law’s normative and juridical science’s epistemic inability and associated failures to respond to the Earth system lie at several levels:

The focus of environmental law remains decidedly narrow and sectoral, while the discipline of environmental law has correspondingly not (yet) fully embraced an interdisciplinary research agenda (Bosselmann 2010; Pedersen 2018). Mostly as a result of its historical development trajectory, environmental law does not follow an all-encompassing, integrated and reflexive systems approach (Kim and Bosselmann 2013). Environmental law, and much of its attendant scholarship, therefore instead continue to view issues such as water, air and soil pollution, nature conservation and waste management as isolated, discrete issues that can be regulated by technocratic interventions based in and operationalized by sectoral and issue-specific laws (Fisher et al 2009); it remains ‘bound to defined places, spaces, habitats, ecosystems, species and objects’ (Stephens 2017: 51), which in turn runs the risk of resulting in regime deference, regime abdication and problem-shifting (Kim and van Asselt 2016). This is a classic ‘problem of fit’ between the global environmental governance architecture and the dynamic complexly adaptive and erratic Earth system (Young 2002). The body of international environmental law and its accompanying ‘institutional maze’ on the one hand and the functioning of the Earth system on the other are currently not aligned (Kim and Mackey 2014).

What would instead be required from an Earth system perspective is a fully functioning complex adaptive system of earth system law that adaptively manages other complexly adaptive natural and social systems (Ruhl 2012; Kim and Mackey 2014). Such an adaptive system-oriented body of law must simultaneously respect planetary-scale tipping points and pay due consideration to the dynamic interconnections of Earth system components, while embracing the complexity of interacting planetary boundaries and safeguarding the integrity of Earth’s life-

support systems. In other words, the ‘environmental’ aspects of law are but one consideration of a much more broadly conceived earth system, which means that ‘environmental’ law will instead have to accommodate a systems approach by orientating itself around the earth system as its principal object and determinant. The notion of earth system law fully embraces such a systems approach.

In summary and in light of the foregoing, earth system law is premised on the assumptions that: i) there is a need for a more pronounced role for law in earth system governance and earth system governance research; ii) law in its present guise has become unable to sufficiently and comprehensively respond to the unique epistemic, ontological and normative characteristics, demands and nature of earth system governance in the Anthropocene; and iii) there is a disconnect between law and earth system science. As a response, earth system law offers a new overarching legal phenomenon that comprehensively accommodates and encapsulates all juridical aspects of earth system governance, including a new research agenda that is nestled in the earth system governance science plan. We explore the concept of earth system law in greater detail below.

4. A conceptual framework of earth system law

In the previous section, we have highlighted some of the major concerns associated with law in the Anthropocene. We specifically focused on environmental law for this purpose. While there may be many others, we believe these concerns offer examples of some of the core issues that could shape thinking around the conceptual contours, contents and objectives of earth system law and its research agenda. In this part, we provide for illustrative purposes the broad outlines of a possible conceptual framework of earth system law by focusing for brevity’s sake on international environmental law as an example.⁴ We aim to show how some of the core considerations of earth system law sketched above might set in motion the conceptual and regulatory changes required to eventually progress from ‘international environmental law’ to a form of ‘planetary earth law’. The framework presented below is merely illustrative, as it is based on just two of many, albeit core, considerations in the conceptual progression towards earth system law. These two axes include: (i) the regulatory object of law – ‘environmental’, ‘ecological’ and ‘earth’ – along the one axis; and (ii) the geographical or jurisdictional scope of law – ‘international’, ‘global/transnational’ and ‘planetary’ – along the other. This conceptual framework then identifies nine different stages in the progressive development from international environmental law at the one end of the spectrum, to a planetary vision of earth law, which could represent the broad outlines of earth system law at the other end of the spectrum (Table 1). We conceive of planetary systems-based earth law as a ‘mature’ form of earth system law, which is possibly more fit for purpose in the Anthropocene, more responsive to Earth system complexities, and better able to overcome some of the concerns associated with environmental law discussed in the previous part.

	Environmental law	Ecological law	Earth law
International law	Human-centred regulation of transboundary harm based on state sovereignty	Nature-centred environmental protection in a state-centric system	Earth-centred respect for the community of all life in a state-centric system

⁴ Importantly, it is not our contention to suggest that a mature form of earth system law could be realized through transformative changes in international environmental law only. The Anthropocene is a new ontological condition within which law now operates, and other aspects of law also now need to engage this new context. Other laws on trade, finance, health, labor, development, and human rights will need to undergo similar progressive developments to advance a new legal paradigm of earth system law.

Global or transnational law	Human-centred environmental protection through transnational legal processes involving state and non-state actors	Nature-centred environmental protection in a transnational setting involving state and non-state actors	Earth-centred sustainability governance in a transnational setting involving state and non-state actors
Planetary law	Human-centred recognition of environmental limits from a planetary perspective	Nature-centred environmental protection from a planetary perspective	Earth system-centred law for governance by and for all living beings from a planetary systems perspective

Table 1. A conceptual framework of earth system law along two selected dimensions for illustrative purposes. The framework identifies nine different developmental stages of earth system law ranging from *international environmental law* to *planetary earth law*.

4.1. Axis 1: The regulatory object of law

The first axis concerns the regulatory object of law. As discussed in the previous part, the current environmental law regime is generally perceived to be human-centred. It operates alongside and responds to a human timescale (corresponding to, for example, election intervals and human lifespans) and it aims to promote the dominant neoliberal growth paradigm benefiting the socio-economic development of the present generation (Adelman 2018). Environmental law often achieves these goals through, among others, protecting rights and interests of individuals to a clean environment, while the environment itself is reduced to an object of property.

As a counter reformative response, there have been several attempts to ‘ecologize’ environmental law by aligning it with principles, notions and objectives of ecological integrity, the interests of future generations, the intrinsic value of non-human beings, and the rights of nature, among others (Kotzé 2018). This alternative model is referred to as ecological law (Bosselmann and Taylor 2017). It is nature-centred and aligned with nature’s temporalities (Richardson 2017), notably through ecologically reflexive legal and political institutions (Dryzek 2014; Pickering 2017). Scholarly inquiry into ecological law has a relative long history, dating back at least to 1972 when a seminal paper was published by Christopher Stone on the question ‘should trees have legal standing?’ (Stone 1972). Various forms of ecological law have since emerged and have been practiced. One example is the wise use of wetlands, where the issue of the ‘ecological character’ of a wetland is a central concern (Bridgewater et al 2014). Another example is the legislative recognition of the rights of rivers in New Zealand in 2016 (Boyd 2017), and the rights of nature in Bolivia and Ecuador (Kotzé and Villavicencio Calzadilla 2017; Villavicencio Calzadilla and Kotzé 2018).

The focus on ecosystems as a key regulatory object of law implies that the law will have to operate on ecological timescales. In fact, environmental law can be too temporally one-dimensional. Mired in preoccupation with the present, environmental law has been unwilling to acknowledge past losses (Richardson 2017). But ecological law is different. By taking an eco-centric approach, ecological law aims to reach a particular moment in the past when there was little to no human interference. At the planetary scale, this would be the Holocene conditions, which are considered preferable and achievable by regulating human activities. Therefore, ecological law expresses, and endeavours not only to maintain but also to *restore*, the integrity of the Earth’s life-support systems (Bosselmann 2016; Telesetsky et al 2016).

Progressing from environmental and ecological law to an even more embracing notion of law’s regulatory object, more recently, scholars have suggested a new legal category, namely, earth law. The concept of earth law has not fully developed in the literature. We conceptualize earth law as founded on the recognition that, in the Anthropocene, the Earth is a human-dominated,

deeply intertwined, *social-ecological* system (Young and Steffen 2009). It is Earth-centred in the sense that it considers neither humanity nor nature as a central reference point, but rather the entire community of life as the central fulcrum around which it revolves. Earth law rejects Cartesian dualism between ecocentric and anthropocentric ethics, both categories of which might conflate or even become a myth in the Anthropocene (Levin 2014). Therefore, Earth law does not assume that the *integrity* of the Earth's ecosystem *in the Anthropocene* as desirable. Rather, it builds on the recognition that the yet unknown 'natural' state of the Earth system in the Anthropocene, that is, a new 'basin of attraction', is no longer necessarily tenable or conducive to the survival of life as we know it (Bridgewater et al 2014; see also Minter 2012). In the absence of a past reference, unlike ecological law, earth law is more future-oriented. Reflexivity will be a key tenet for earth law to remain relevant and effective in the Anthropocene (Dryzek 2014).

Furthermore, Earth-centrism implies that earth law would need to go beyond ecological timescales in order to align human affairs with Earth's geological timescales (Richardson 2017). Geological timescales correspond to major global biogeochemical cycles such as the carbon and water cycles. Earth law, for example, is not about addressing the problem of climate change through 'quick fixes' such as solar radiation management, but instead fully takes into account the lifetime of carbon dioxide in the atmosphere. According to earth system scientists, a unit of carbon dioxide emitted to the atmosphere will only be fully removed from the atmosphere and have no impact on the climate system when it has completely dissolved in the deep ocean, which takes thousands of years (Mackey et al 2013; see also Archer et al 2009). Earth law will similarly have to accommodate such a long-term perspective.

4.2. Axis 2: The geographical or jurisdictional scope of law

The second axis could be understood in terms of law's geographic or jurisdictional focus. As we move into the Anthropocene, not only is the established human-nature relationship being redefined, but also the myriad existing politico-juridico institutions and their conceptual and regulatory boundaries. Sovereignty is one such idea upon which international environmental law is fundamentally premised, but sovereignty has become singularly problematic in the present time of socio-ecological crisis. For example, multinational corporations and other private actors that are often causing the most significant Earth system harms and concomitant socio-ecological injustices are effectively hiding under the veil of sovereignty (Grear 2010), while states have largely been unable or unwilling to implement and enforce laws related to such corporations (Simons 2015). States as well are often more likely to protect their sovereign financial and political interests, instead of subjecting themselves to global environmental targets. The tenuous relationship that some states have with the global climate law regime is a case in point. Furthermore, while states themselves are hiding behind sovereignty in an effort to sidestep (what is perceived as) growth-inhibiting legal obligations, there is still a perception that binding top-down law is increasingly the preferred approach to regulation, while the role of (often far more progressive) soft laws and other quasi-legal instruments and initiatives are relegated to the sidelines.⁵

Responding to such limitations, global or transnational law has emerged as a non-state-centric system of law that does not solely depend on sovereignty or the state and its authority for its legitimacy (Jessup 1957; Teubner 1997; Wiener 2000; Backer 2012). Both state and non-state actors take part in transnational legal processes to make and obey law through processes of interaction, interpretation, and internalization (Koh 1996), while global law is also seen to have

⁵ See on the need for a more pluralist approach to law in the Anthropocene Gupta and Bavinck (2014).

some sort of universalized jurisdiction that is not necessarily subject to the territories of states (Weeramantry 2004).

Yet, international law and global (or transnational) law, less constrained by state borders and sovereignty as they are, still do not fully respond to a planetary perspective. Beyond these two categories of law exists what could be termed ‘planetary law’ or ‘planetary systems-based law’. This is a new paradigm of law that is informed by a planetary boundaries perspective that transcends geographic and jurisdictional boundaries. Planetary law acknowledges both the existence of an ecological ceiling and of a social foundation (Raworth 2017). This is to say planetary law is not simply about ‘planetary boundaries’ and making sure the integrity of the Earth’s ecosystem is maintained, but also about questions of justice and inequality relating to global patterns of consumption and production, resource allocation, benefit distribution, and so on. Therefore, the geography and jurisdictional boundaries of planetary law (if in fact there are any such boundaries) are informed by both natural and socio-economic processes that are already elaborated by earth system governance and earth system science (Schellnhuber 1999; Reid et al 2010).

4.3. Evidence of progression

While this process is far from complete, we believe it is already possible to observe at least some minimal evidence of progression from *international environmental law* to a more mature form of *earth law* (Table 1). For example, gradually progressing from the first building blocks of *international environmental law* that proclaimed the primacy of the state as the main actor in global environmental governance, non-state actors are increasingly becoming involved, despite law’s favouring of state actors. In parallel, norms emanating from non-traditional state-based sources are also infiltrating and expanding the corpus of international environmental law (Sand 1999; Yang 2009 and Percival 2009; Heyvaert and Ety 2012). Such developments beyond-the-state, as it were, are shaping an emerging body of *global environmental law*.

To the extent that these norms reflect ecological values, one could start inferring the emergence of *global ecological law*. An example is the Earth Charter of 2000, which is a civil society alternative to international and global environmental law with the concept of global ecological integrity at its core (Taylor 1998; Kim 2016). States are increasingly, albeit hesitantly, signalling some receptivity to ideas revolving on ecological integrity. This much is evident from the type of ecological language used in the World Charter for Nature (Kotzé 2018). The Charter was adopted with a majority vote by the United Nations General Assembly in 1982 (UNGA 1982) and it is an ‘avowedly ecological instrument, which emphasises the protection of nature as an end in itself’ (Sands and Peel 2012: 37). It is global instruments like these that suggest progression towards *international ecological law*, although it cannot be convincingly said that states are (yet) fully embracing ecological imperatives in any comprehensive or meaningful way.

There are also examples of states that now actively embrace the type of values associated with global ecological law against the backdrop of ‘radical’ normativity such as the ongoing United Nations General Assembly Harmony with Nature initiative (2009), and the Universal Declaration of Rights of Mother Earth of 2010. Bolivia and Ecuador are two examples of countries that openly endorse (at least on paper) the values of global ecological law through their embrace of the rights of nature paradigm in their legal systems (Kotzé and Villavicencio Calzadilla 2017; Villavicencio Calzadilla and Kotzé 2018), advancing in such an inter-state setting, what could be termed, *international earth law* between states. Here, states would assume the role of trustees of the Earth (Kim and Bosselmann 2015). When humanity as a whole, including non-state actors such as businesses and corporations, assume such an ecologically-oriented

responsibility of trustees globally, it would be possible to observe a progression towards *global earth law*.

But regardless of how ecological and normatively plural such a vision of state and non-state *global earth law* might be, it remains trapped in the Holocene worldview because it is not connected and responsive to planetary conditions and an Earth system perspective. As a response to these concerns, more recently, the notion of *planetary environmental law* has emerged to refer to ‘the set of legal strategies, rules and principles necessary to ensure our permanence in the safe operating space [of the planetary boundaries]’ (Aragão 2016; see also de Silva and de Veiga Junior 2011). Examples of key initiatives for building such a law include the Draft Declaration on Planetary Boundaries (Planetary Boundaries Initiative 2011; see also Kim and Bosselmann 2015) as well as calls for a ‘planetary boundaries treaty’ (Fernandez and Malwe 2018), a Law of the Atmosphere (Najam 2000; Sand and Wiener 2016), and a Law of the Biosphere (Robinson 2005).

While a primary purpose of planetary environmental law is to protect humanity from earth system transformations, *planetary ecological law* would aim to also serve and respect non-humans from a planetary perspective. To this end, planetary boundaries would need to be re-defined to provide a safe operating space not only for humanity, but for all life forms of the entire living order. Arguably, such an ecocentric discourse has not yet clearly emerged at the planetary level. In fact, the planetary boundaries framework can be criticized for being inherently anthropocentric. After all, the scientists selectively identified key Earth system processes and subjectively quantified boundary levels with *human development* in mind. The planetary boundaries are aimed at avoiding ‘unacceptable global environmental change’, which is defined ‘in relation to the risks humanity faces in the transition of the planet from the Holocene to the Anthropocene’ (Rockström et al 2009: 2).

The ‘strongest’ form of earth system law is *planetary earth law*, which is fully premised on and informed by the entire Earth as a social-ecological system (Young and Steffen 2009), with all living beings, both humans and non-humans, acting as responsible co-habitants of the planetary socio-ecological system. Spatially, jurisdictions founded on state sovereignty fall away to the extent that certain fundamental norms, such a planetary integrity or the rights of Mother Earth, become universal. Temporally, geological timescales, even longer than ecological timescales, come into play when making decisions affecting the Earth’s subsystems with long-term feedback loops such as climate change and ocean acidification.

A major insight from the foregoing discussion is that some of the conceptual processes related to earth system law have already been set in motion and some ideas associated with earth system law already exist. While these would require further development, there is accordingly already evidence of both the need for and movement towards designing a new legal paradigm that explicitly and comprehensively accommodates the juridical dimensions of earth system governance. Yet, these emerging concepts remain detached from one another and are arguably asking for a more deliberate conceptual consolidation and integration under a single overarching agenda. We suggest that earth system law could be such a consolidated conceptual and global research agenda.

5. Situating a research agenda within the earth system governance framework

The evolution from international environmental law to planetary earth law described above will probably be an incremental one, involving a series of transformations that must be guided by a suitable and representative research agenda. While its content still remains vaguely

defined (and thus also a matter for future research), we believe the concept of earth system law already invites researchers from all disciplines to engage in the debate to actively shape its architecture, objectives, content and broader research agenda. In this part, we offer some suggestions on those aspects that we believe could frame this research agenda.⁶

A useful point of departure for thinking about the broader contours of an earth system law research agenda is the recently updated research framework that forms the core of the new Science and Implementation Plan of the Earth System Governance Project (Earth System Governance Project 2018). The framework is useful for both introducing into the legal domain the type of questions and problems that earth system law scholars could address to improve the performance of earth system governance, as well as for introducing into the governance domain the type of questions and problems that earth system governance scholars could address to improve the effectiveness of legal systems. The juridical implications of the Science and Implementation Plan are evident from this plan’s contextual conditions including: transformations, inequality, Anthropocene and diversity. The new earth system governance Science and Implementation Plan also consists of five pairs of interconnected research lenses: architecture and agency, democracy and power, justice and allocation, anticipation and imagination, and adaptiveness and reflexivity. Law is an intricate part of all these contextual conditions and lenses and there is a strong case to be made out in support of reflecting on earth system governance’s juridical dimensions under the collective conceptual umbrella of earth system law. Importantly, the Science and Implementation Plan does not explicitly mention the term earth system law. But the earth system governance research agenda has several implications for and correlations with law, while law remains a central consideration in the type of questions that earth system governance researchers aim to investigate. There is, we believe, accordingly nothing in the new Science and Implementation Plan that militates against the adoption and elaboration of earth system law as the new ‘scientific home’, as it were, of the many and varied juridical aspects of earth system governance.

We offer in conclusion some suggestive research themes at the intersection of the Science and Implementation Plan’s research lenses and contextual conditions (Table 2). For example, at the intersection between the contextual condition of the Anthropocene and the research lens of architecture and agency, research topics could include ‘harnessing legal complexity’ (Ruhl et al 2017) in order to better address ‘globally networked risks’ (Galaz et al 2017) and optimize the overall performance of earth system law (Kim and Bosselmann 2013; Kim and Mackey 2014). The research lens of anticipation and imagination in the context of transformation would allow earth system law scholars to engage in making law more forward-looking for the purpose of facilitating anticipatory governance (Boyd et al 2015), as well as affording law a more prominent role in transformative environmental governance processes that aim to respond to, manage, and trigger regime shifts in social-ecological systems (Chaffin et al 2016). Other suggestive examples of earth system law research themes are briefly summarized in Table 2.

		Contextual Conditions			
		Anthropocene	Diversity	Inequality	Transformations
Research Lenses	Architecture and agency	Managing the fragmentation of laws for addressing networked risks	Implications of legal pluralism for environmental outcomes	Role of law in entrenching or disrupting patterns of inequality between agents	Pathways through which legal institutions guide, shape, or block transformations

⁶ For this purpose, we zoom out from international environmental law and draw examples from other bodies of law, including developments in and across these, which could inform and shape earth system law and its research agenda.

Democracy and power	Role of law in new forms of democratic practices in the Anthropocene	Law for mitigating the misuse of power that marginalizes minorities	Law for earth system democracy and for addressing unequal decision-making power	Role of law in ensuring democracy and participation in transformation processes
Justice and allocation	Law on allocation of resources and responsibilities where causality is complex	Harnessing plural laws to advance inter-generational and interspecies justice	Effectiveness of legal institutions to ensure everyone has equal access to justice	Role of law in addressing equity concerns in sustainability transformations
Adaptiveness and reflexivity	Reforming legal institutions to become more adaptive and reflexive to cope with uncertainty	Relationship between adaptiveness and diversity of legal institutions	Adapting legal institutions to address changing patterns of inequality	Balancing stability and flexibility of law for triggering and governing transformation
Anticipation and imagination	Role of law in the governance of anticipation that generate social imaginaries of the future	Law for ensuring that diversity is reflected in processes of anticipation and imagination	Law accounting for inequalities in and resulting from foresight processes	Designing future-oriented laws for governance of transformation

Table 2. Research framework for earth system law (based on Earth System Governance Project 2018). Some exemplar themes have been identified at the intersection between contextual conditions and research lenses.

Earth system law research could further be organized along three dimensions – analytical, normative, and prescriptive – that cut across the research lenses and contextual conditions elaborated above. These three dimensions are not intended to serve as mutually exclusive categories.

First, research could focus on analysing the status quo ante of the law and legal regulation. The analytical dimension of earth system law refers to understanding the science of law for understanding the structure, content, processes, and institutions of legal systems. The analysis should not be limited to doctrinal legal research but extend also to empirical studies of law or legal systems as an object of analysis. Research questions could include, for example: what are the implications of the Earth system perspective and what challenges does it pose for law and lawyers and hence for the development of earth system law; how do we translate the meme of the earth system perspective into law; what theoretical and methodological framework might inform earth system law; and what are the main challenges that the conditions of the Anthropocene pose to traditional law and law-making processes?

Second, earth system law research could explore and address a set of normative considerations of earth system governance. To this end, research questions could include, for example: how can earth system law address socio-ecological injustices among and between species, geographical regions, countries and across generations; how can earth system law ensure a truly sustainable society without eroding natural, social and or economic capital; how can earth system law best steer and orchestrate the actions of multiple actors at different scales to respond to the Anthropocene; and how can sustainability best be reflected in the governing values that underpin the structures and processes of the Earth system?

Third, the analytical and normative dimensions lead to prescriptive questions about how to achieve a desirable future. Here, one could study the role of earth system law in the governance of societal transformations towards sustainability, and at the same time, the transformation of existing bodies of law (e.g., international environmental law) into an altogether more far-reaching and all-encompassing form of earth system law that would be required to facilitate

ambitious transformations. Key research questions could include, for example: which transformative pathways must earth system law develop when measured against insights from earth system science and earth system governance; to what extent could adaptive legal systems serve as a transformative concept for earth system law; how could we develop a participatory way to design earth system law; and what initiatives are required to embed earth system law in the emergent features of earth system governance?

6. Conclusion

Humans are causing massive disruptions to the Earth system in the Anthropocene. Law as a social regulatory institution has been complicit in creating the Anthropocene epoch and is unable in its present incarnation to create sustainable solutions to navigate the Anthropocene. Rethinking and reforming law and its role in Earth system governance will be instrumental in contributing to the regulatory response urgently required to enable humanity to mitigate the Anthropocene's impacts, to adapt to a drastically changed socio-ecological reality, and to increase resilience. As a response to this challenge we have proposed a new juridical phenomenon more responsive to the Anthropocene's normative, ethical and regulatory challenges; that is, earth system law. We used (international) environmental law as an example to illustrate that earth system law is better aligned with an Earth system approach and better fit for purpose in the Anthropocene.

Serving as earth system law's primary distinguishing feature, the Earth system (and everything that goes with that impulse), is the new all-encompassing focal point that must direct the orientation of juridical science and of all governance and normative-juridico efforts in the Anthropocene epoch. Building on the notion of earth system governance, earth system law reflects that law is a social regulatory institution, of arguably durable quality, that plays an increasingly important role in addressing pressing problems in the governance of the Earth system from the local through to the global level. To this end, earth system law captures incipient legal thought, science and practice that fundamentally challenge traditional perceptions of the trite role of law and law's many actors, processes and operative domains, including legal epistemologies and law's ontology, orientation, purpose and regulatory scope within the context of an unstable Earth system in the Anthropocene. Importantly, earth system law is not simply old wine in new bottles. We argue that earth system law has the potential to develop into an autonomous analytical and normative track of the larger earth system governance agenda, while at once conceptually offering a new term of art embracing all those contemporary juridical normative arrangements and interventions (the precise identification and description of which are still far from complete) that would be necessary to 'navigate the Anthropocene' (Biermann et al 2012).

The Earth System Governance Project's new Science and Implementation Plan offers a critical opportunity to (re)-imagine an altogether different legal paradigm for law, both in a descriptive and prescriptive sense, that is better aligned with and more responsive to the Earth system and its unique characteristics. Like earth system governance from which it takes its cue, the notion of earth system law is phenomenological or descriptive as it should reflect the changing legal dimensions of large-scale transformations, ranging from traditional environmental policy problems to the governance of earth system transformation. Earth system law is simultaneously reformative or prescriptive, in the sense that it should consist of radical and innovative legal approaches to proactively enable and govern human-dominated Earth-system transformations for sustainability. The process of gradually re-imagining law alongside the descriptive and prescriptive considerations that we have outlined above is an important and timely effort, we believe, that has considerable potential to feed into and strengthen the earth system governance

research agenda, while it opens up the epistemic closures of law to alternative understandings and potentialities of juridical governance in the Anthropocene.

Bibliography

S. Adelman, The Sustainable Development Goals, Anthropocentrism and neoliberalism, in: D. French, L. Kotzé, (Eds.), *Sustainable Development Global Goals: Law, Theory and Implementation*, Edward Elgar, Cheltenham, 2018, pp. 15-40.

K.-O. Apel, Globalization and the need for universal ethics, *Eur. J. Soc. Theory* 3 (2000) 137-155.

A. Aragão, Legal tools to operationalize Anthropocene environmental law, in: P. Magalhães, W. Steffen, K. Bosselmann, A. Aragão, V. Soromenho-Marques (Eds.), *The Safe Operating Space Treaty: A New Approach to Managing our Use of the Earth System*, Cambridge Scholars Publishing, Newcastle upon Tyne, 2016, pp. 83-103.

Archer, D., Eby, M., Brovkin, V., Ridgwell, A., Cao, L., Mikolajewicz, U., Caldeira, K., Matsumoto, K., Munhoven, G., Montenegro, A., Tokos, K., 2009. Atmospheric Lifetime of Fossil Fuel Carbon Dioxide. *Annual Review of Earth and Planetary Sciences* 37, 117–134.

L.C. Backer, The structural characteristics of global law for the 21st century: Fracture, fluidity, permeability, and polycentricity, *TiLR* 17 (2012) 177-199.

X. Bai, X., S. van der Leeuw, K. O'Brien, F. Berkhout, F. Biermann, E.S. Brondizio, C. Cudennec, J. Dearing, A. Duraiappah, M. Glaser, A. Revkin, W. Steffen, J. Syvitski, Plausible and desirable futures in the Anthropocene: A new research agenda, *Glob. Environ. Change* (2015) 1-12.

U. Beyerlin, T. Marauhn, *International Environmental Law*, Hart, London, 2011.

F. Biermann, 'Earth System Governance' as a crosscutting theme of global change research, *Glob. Environ. Change* 17 (2007) 326-337.

Biermann, F. 2012. Planetary Boundaries and Earth System Governance: Exploring the Links. *Ecological Economics* 81, 4–9.

F. Biermann, *Earth System Governance: World Politics in the Anthropocene*, MIT Press, Cambridge, 2014.

F. Biermann, K. Abbott, S. Andresen, K. Backstrand, S. Bernstein, M.M. Betsill, H. Bulkeley, B. Cashore, J. Clapp, C. Folke, A. Gupta, J. Gupta, P.M. Haas, A. Jordan, N. Kanie, T. Kluvankova-Oravska, L. Lebel, D. Liverman, J. Meadowcroft, R.B. Mitchell, P. Newell, L. Olsson, P. Pattberg, R. Sanchez-Rodriguez, H. Schroeder, A. Underdal, S.C. Vieira, C. Vogel, O.R. Young, A. Brock, R. Zondervan, *Navigating the Anthropocene: Improving Earth System Governance*, *Science*, 335 (2012) 1306-1307.

S. Biniat, 10 questions to ask about the proposed 'Global Pact for the Environment'. <http://columbiaclimatelaw.com/files/2017/08/Biniat-2017-08-Global-Pact-for-the-Environment.pdf>, 2017 (accessed 31 July 2018).

- D. Bodansky, L. Rajamani, *International Climate Law*, Oxford University Press, Oxford, 2017.
- E. Bodenheimer, The inherent conservatism of the legal profession, *Ind. L.J.* 23 (1948) 221-235.
- K. Bosselmann, Losing the forest for the trees: Environmental reductionism in the law, *Sustainability* 2 (2010) 2424-2448.
- K. Bosselmann, Shifting the legal paradigm: Earth-centered law and governance, in: P. Magalhães, W. Steffen, K. Bosselmann, A. Aragão, V. Soromenho-Marques (Eds.), *The Safe Operating Space Treaty: A New Approach to Managing our Use of the Earth System*, Cambridge Scholars Publishing, Newcastle upon Tyne, 2016, pp. 64-82.
- K. Bosselmann, P. Taylor (Eds.), *Ecological Approaches to Environmental Law*, Edward Elgar, Cheltenham, 2017.
- Boyd, D.R., 2017. *The Rights of Nature: A Legal Revolution That Could Save the World*. ECW Press.
- E. Boyd, B. Nykvist, S. Borgström, I.A. Stacewicz, Anticipatory Governance for Social-Ecological Resilience, *AMBIO: A Journal of the Human Environment* 44 (2015), 149–161.
- P. Bridgewater, R.E. Kim, K. Bosselmann, Ecological integrity: A relevant concept for international environmental law in the Anthropocene? *Yb. Int'l Env. L.* 25 (2014) 61-78.
- Earth System Governance Project: Science and Implementation Plan, Bonn, 2018.
- E. Burlison, D. Pei Wu, Non-state actor access and influence in international legal and policy negotiations, *Fordham Env'tl. L. Rev.* 21 (2010) 193-208.
- B.C. Chaffin, A.S. Garmestani, L.H. Gunderson, M.H. Benson, D.G. Angeler, C.A.T. Arnold, B. Cosens, R.K. Craig, J.B. Ruhl, C.R. Allen, Transformative Environmental Governance, *Annual Review of Environment and Resources* 41 (2016), 399–423.
- G. Chapron, Y. Epstein, A. Trouwborst, J.V. López-Bao, Bolster legal boundaries to stay within planetary boundaries, *Nat. Ecol. Evol.* 1 (2017) 1-5.
- S. Choudhry, Ackerman's higher lawmaking in comparative constitutional perspective: Constitutional moments as constitutional features?, *Icon* 6 (2008) 193-230.
- P.J. Crutzen, Geology of mankind, *Nature* 415 (2002) 23.
- I.R.V. da Silva, C.L. da Veiga Junior, Sustainability and Fraternity: A Few Proposals Based on a Planetary Environmental Law, *Veredas do Direito* 8 (2011) 25.
- J.S. Dryzek, Institutions for the Anthropocene: Governance in a changing earth system, *Br. J. Political Sci.* 46 (2014) 937-956.
- Earth System Governance Project, Home page. <https://www.earthsystemgovernance.org/>, 2018 (accessed 14 December 2018).
- Earth System Governance, Task Force on Earth System Law. <http://www.earthsystemgovernance.org/research/taskforce-on-earth-system-law/>, 2018 (accessed 14 December 2018).

- J. Ebbesson, The rule of law in governance of complex socio-ecological changes, *Glob. Environ. Change* 20 (2010) 414-422.
- E. Fernández Fernández, C Malwé, The emergence of the ‘planetary boundaries’ concept in international environmental law: A proposal for a framework convention, *RECIEL* (2018) 1-19.
- E. Fisher, B. Lange, E. Scotford, C Carlarne, Maturity and methodology: Starting a debate about environmental law scholarship, *JEL* 21 (2009) 213-250.
- D. French, L. Kotzé, ‘Towards a Global Pact for the Environment’: International environmental law's factual, technical and (unmentionable) normative gaps, *RECIEL* (2019) 1-8
- O. Gaffney, W. Steffen, The Anthropocene Equation, *The Anthropocene Review* 4 (2017) 53-61.
- V. Galaz, *Global Environmental Governance, Technology and Politics*, Edward Elgar, Cheltenham, 2014.
- V. Galaz, J. Tallberg, A. Boin, C. Ituarte Lima, E. Hey, P. Olsson, F. Westley, Global governance dimensions of globally networked risks: The state of the art in social science research, *RHCPP* 8 (2017) 4-27.
- A. Grear, *Redirecting Human Rights: Facing the Challenge of Corporate Legal Humanity*, Palgrave Macmillan, Basingstoke, 2010.
- J. Gupta, M. Bavinck, Towards an elaborated theory of legal pluralism and aquatic resources, *Curr. Opin. Env. Sust.* 11 (2014) 86-93.
- C. Hamilton, Human destiny in the Anthropocene: A speech to the conference ‘Thinking the Anthropocene; Sciences Po, Paris, 15 November 2013’. <http://www.institutmomentum.org/wp-content/uploads/2014/04/Human-Destiny-in-the-Anthropocene.pdf>, 2014 (accessed 14 December 2018).
- H.L.A. Hart, *The Concept of Law*, third ed., Oxford University Press, Oxford, 2012.
- E. Hey, International law and the Anthropocene, *ESIL Reflections* 5 (2016) 1-7.
- V. Heyvaert, T. Ety, Introducing transnational environmental law, *TEL* 1 (2012) 1-11.
- R.J. Hobbs, S. Arico, J. Aronson, J.S. Baron, P. Bridgewater, V.A. Cramer, P.R. Epstein, J.J. Ewel, C.A. Klink, A.E. Lugo, D. Norton, D. Ojima, D.M. Richardson, E.W. Sanderson, F. Valladares, M. Vila, R. Zamora, M. Zobel, Novel ecosystems: Theoretical and management aspects of the new ecological world order, *Glob. Ecol. Biogeogr.* 15 (2006) 1-7.
- C. Holley, N. Gunningham, C. Shearing, *The New Environmental Governance*, Routledge, Abingdon, 2012.
- Intergovernmental Panel on Climate Change, *Global warming of 1.5 Degrees Celsius: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate*

poverty. https://www.ipcc.ch/site/assets/uploads/sites/2/2018/07/SR15_SPM_High_Res.pdf, 2018 (accessed 14 December 2018).

International Commission on Stratigraphy, Collapse of civilizations worldwide defines youngest unit of the geologic time scale. <http://www.stratigraphy.org/index.php/ics-news-and-meetings/119-collapse-of-civilizations-worldwide-defines-youngest-unit-of-the-geologic-time-scale,2018> (accessed 31 July 2018).

P.C. Jessup, *Transnational Law*, Yale University Press, New Haven, 1956.

H. Jonas, *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*, University of Chicago Press, Chicago, 1985.

R.E. Kim, Transnational sustainability law: Whither international environmental law? *Env't'l Pol'y & L.* 46 (2016) 405-408.

R.E. Kim, K. Bosselmann, International environmental law in the Anthropocene: Towards a purposive system of multilateral environmental agreements, *TEL* 2 (2013) 285-309.

R.E. Kim, K. Bosselmann, Operationalizing sustainable development: Ecological integrity as a *grundnorm* of international law, *RECIEL* 24 (2015) 194-208.

R.E. Kim, B. Mackey, International environmental law as a complex adaptive system, *Int. Environ. Agreem.-P.* 14 (2014) 5-24.

R.E. Kim, H. van Asselt, Global governance: Problem shifting in the Anthropocene and the limits of international law, in: E. Morgera, K. Kulovesi (Eds.), *Research Handbook on International Law and Natural Resources*, Edward Elgar, Cheltenham, 2016, pp. 473-495.

H.H. Koh, Transnational legal process, *Neb. L. Rev.* 75 (1996) 181-207.

L. Kotzé, *Global Environmental Governance: Law and Regulation for the 21st Century*, Edward Elgar, Cheltenham, 2012.

L. Kotzé, Rethinking global environmental law and governance in the Anthropocene, *JENRL* 32 (2014) 121-156.

L. Kotzé, The Anthropocene's global environmental constitutional moment, *Yb. Int'l Env. L.* 25 (2015) 24-60.

L. Kotzé (Ed.), *Environmental Law and Governance for the Anthropocene*, Hart, Oxford, 2017.

L. Kotzé, Reflections on the future of environmental scholarship and methodology in the Anthropocene, in: O. Pedersen (Ed.), *Perspectives on Environmental Law Scholarship*, Cambridge University Press, Cambridge, 2018, pp. 140-161.

L. Kotzé, A global environmental constitution for the Anthropocene?, *TEL* 7 (2018) 1-28.

L. Kotzé, D. French, A critique of the Global Pact for the Environment: A stillborn initiative or the foundation for *Lex Anthropocena*?, *Int. Environ. Agreem.-P.* 18 (2018) 811-838.

L. Kotzé, P. Villavicencio Calzadilla, Somewhere between rhetoric and reality: Environmental Constitutionalism and the rights of nature in Ecuador, *TEL* 6 (2017) 401-433.

- P. Lawrence, *Justice for Future Generations: Climate Change and International Law*, Edward Elgar, Cheltenham, 2014.
- T.M. Lenton, H. Held, E. Kriegler, J.W. Hall, W. Lucht, S. Rahmstorf, H.-J. Schellnhuber, Tipping elements in the Earth's climate system, *PNAS* 105 (2008) 1786-1793.
- P.S. Levin, New conservation for the Anthropocene ocean, *Conservation Letters* 7 (2014) 339-340.
- J. Liu, T. Dietz, S.R. Carpenter, M. Alberti, C. Folke, E. Moran, A.N. Pell, P. Deadman, T. Kratz, J. Lubchenco, E. Ostrom, Z. Ouyang, W. Provencher, C.L. Redman, S.H. Schneider, W.W. Taylor, Complexity of coupled human and natural systems, *Science* 317 (2007) 1513-1516.
- Mackey, B., Prentice, I.C., Steffen, W., House, J.I., Lindenmayer, D., Keith, H., Berry, S., 2013. Untangling the Confusion around Land Carbon Science and Climate Change Mitigation Policy. *Nature Climate Change* 3, 552–557.
- P. Magalhães, A new object of law: Attempt for a legal construction, in: P. Magalhães, W. Steffen, K. Bosselmann, A. Aragão, V. Soromenho-Marques (Eds.), *The Safe Operating Space Treaty: A New Approach to Managing our Use of the Earth System*, Cambridge Scholars Publishing, Newcastle upon Tyne, 2016, pp. 131-171.
- D. Mares, Criminalizing ecological harm: Crimes against carrying capacity and the criminalization of eco-sinners, *Crit. Criminol.* 18 (2010) 279-293.
- B.A. Minter, Geoengineering and ecological ethics in the Anthropocene, *BioScience* 62 (2012) 857-858.
- A. Moore, The Anthropocene: A critical exploration, *Environment and Society: Advances in Research* 6 (2015) 1-3.
- A. Najam, Future directions: The case for a 'Law of the Atmosphere', *Atmos. Environ.* 34 (2000) 4047-4049.
- National Geographic, <https://www.nationalgeographic.com/environment/2018/11/great-barrier-reef-restoration-transplanting-corals/> (accessed 17 December 2018).
- S. Nicholson, S. Jinnah (Eds.), *New Earth Politics: Essays from the Anthropocene*, MIT Press, Cambridge, 2016.
- C. Nobre, G.P. Brasseur, M.A. Shapiro, M. Lahsen, G. Brunet, A.J. Busalacchi, K. Hibbard, S. Seitzinger, K. Noone, J.P. Ometto, Addressing the complexity of the Earth System, *BAMS* (Oct 2010) 1389-1396.
- O. Pedersen (Ed.), *Perspectives on Environmental Law Scholarship*, Cambridge University Press, Cambridge, 2018.
- J.R. Petit, J. Jouzel, D. Raynaud, N.I. Barkov, J.-M. Barnola, I. Basile, M. Bender, J. Chappelaz, M. Davis, G. Delaygue, M. Delmotte, V.M. Kotlyakov, M. Legrand, V.Y. Lipenkov, C. Lorius, L. Pepin, C. Ritz, E. Saltzman, M. Stievenard, Climate and atmospheric history of the past 420,000 years from the Vostok Ice Core, Antarctica, *Nature* 399 (1999) 429-436.

- L. Phelan, A. Henderson-Sellers, R. Taplin, The political economy of addressing the climate crisis in the Earth System: Undermining perverse resilience, *New Political Econ.* 18 (2013) 198-226.
- J. Pickering, Ecological reflexivity: Characterising an elusive virtue for governance in the Anthropocene, *Environ. Polit.* (2018) 1-22.
- K. Raworth, *Doughnut Economics: Seven Ways to Think Like a 21st-century Economist*, Chelsea Green, London, 2017.
- W.V. Reid, D. Chen, L. Goldfarb, H. Hackmann, Y.T. Lee, K. Mokhele, E. Ostrom, K. Raivio, J. Rockström, H.J. Schellnhuber, A. Whyte, Earth System science for global sustainability: Grand challenges, *Science* 12 (2010) 916-917.
- J. Ribot, Cause and response: Vulnerability and climate in the Anthropocene, *J. Peasant Stud.* 41 (2014) 667-705.
- B.J. Richardson, A damp squib: Environmental law from a human evolutionary perspective, *Osgoode Hall Law School Comparative Research in Law and Political Economy: Research Paper Series*, Research Paper No. 08/2011. <https://digitalcommons.osgoode.yorku.ca/clpe/46>, 2011 (accessed 14 December 2018).
- B.J. Richardson, Doing time: The temporalities of environmental law, in: L. Kotzé (Ed.), *Environmental Law and Governance for the Anthropocene*, Hart, Oxford, 2017, pp. 55-74.
- L. Rickards, Metaphor and the Anthropocene: Presenting humans as a geological force, *Geogr. Res.* 53 (2015) 280-287.
- N. Robinson, Fundamental principles of law for the Anthropocene?, *Env'tl Pol'y & L.* 44 (2014) 13-27.
- J. Rockström, W. Steffen, K. Noone, Å. Persson, F.S. Chapin, III, E. Lambin, T.M. Lenton, M. Scheffer, C. Folke, H. Schellnhuber, B. Nykvist, C.A. de Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sörlin, P.K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R.W. Corell, V.J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, J. Foley, Planetary boundaries: Exploring the safe operating space for humanity, *Ecol. Soc.* 14 (2009) 32.
- J. B. Ruhl, D.M. Katz, M.J. Bommarito, 2017. Harnessing Legal Complexity, *Science* 355 (2017) 1377-1378.
- P.H. Sand, *Transnational Environmental Law: Lessons in Global Change*, Kluwer Law International, The Hague, 1999.
- P.H. Sand, J.B. Wiener, Towards a new international law of the atmosphere, *Goettingen J. Int. L.* 7 (2016) 195-223.
- P. Sands, J. Peel, *Principles of International Environmental Law*, 3rd ed, Cambridge University Press, Cambridge, 2012.
- H.-J. Schellnhuber, 'Earth System' analysis and the Second Copernican Revolution, *Nature* 402 (1999) C19-C23.

J. Schneider, *World Public Order of the Environment: Towards an International Ecological Law and Organization*, University of Toronto Press, Toronto, 1979.

C. Shearing, *Criminology and the Anthropocene*, *Criminol. Crim. Justice* 15 (2015) 255-269.

P. Simons, *Selectivity in law-making: Regulating extraterritorial environmental harm and human rights violations by transnational extractive corporations*, in: A. Grear, L. Kotzé (Eds.), *Research Handbook on Human Rights and the Environment*, Edward Elgar, Cheltenham, 2015, pp. 473-507.

W. Steffen, P.J. Crutzen, J.R. McNeill, *The Anthropocene: Are humans now overwhelming the great forces of nature?*, *AMBIO* 36 (2007) 614-621.

W. Steffen, K. Richardson, J. Rockström, S.E. Cornell, I. Fetzer, E.M. Bennett, R. Biggs, S.R. Carpenter, W. de Vries, C.A. de Wit, C. Folke, D. Gerten, J. Heinke, G.M. Mace, L.M. Persson, V. Ramanathan, B. Reyers, S. Sörlin, *Planetary boundaries: Guiding human development on a changing planet*, *Science* 347 (2015) 736-746.

T. Stephens, *Reimagining international environmental law in the Anthropocene*, in: L. Kotzé (Ed.), *Environmental Law and Governance for the Anthropocene*, Hart, Oxford, 2017, pp. 31-54.

T. Stephens, *What is the point of international environmental law scholarship in the Anthropocene?*, in: O. Pedersen (Ed.), *Perspectives on Environmental Law Scholarship*, Cambridge University Press, Cambridge, 2018, pp. 121-139.

T. Stephens, *The Antarctic Treaty System and the Anthropocene*, University of Sydney Law School Legal Studies Research Paper Series No. 18/22 of April 2018. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3165816, 2018 (accessed 14 December 2018).

Stockholm Declaration on the Human Environment of 1972

Stone, C.D., 1972. *Should Trees Have Standing? – Toward Legal Rights for Natural Objects*. *South California Law Review* 45, 450–501.

D. Tarlock, *History of environmental law*, in: D. Tarlock, J. Dernbach (Eds.), *Environmental Laws and Their Enforcement: Volume I*, EOLSS Publishers-UNESCO, Oxford, 2009, pp. 42-65.

P. Taylor, *An Ecological Approach to International Law: Responding to the Challenges of Climate Change*, Routledge, Abingdon, 2008.

Telesetsky, A., Cliquet, A. and Akhtar-Khavari, A., 2016. *Ecological restoration in international environmental law*. Routledge.

G. Teubner, *Global Law without a State*, Ashgate, Aldershot, 1997.

A. Underdal, *Complexity and challenges of long-term environmental governance*, *Glob. Environ. Change* 20 (2010) 386-393.

UNGA, *World Charter for Nature*, Resolution A/RES/37/7, adopted 28 October 1982.

UNGA, *Harmony with Nature*, Resolution A/RES/64/196, adopted 21 December 2009.

UNGA, The Future we Want, Resolution A/RES/66/288, adopted 27 July 2012.

UNGA, Harmony with Nature, Resolution A/69/322, adopted 18 August 2014.

UNGA, Towards a Global Pact for the Environment, Resolution A/RES/72/277, adopted 10 May 2018.

Universal Declaration of Rights of Mother Earth adopted by the World People's Conference on Climate Change and the Rights of Mother Earth on 22 April 2010

D. Vidas, O.K. Fauchald, Ø. Jensen, M.W. Tvedt, International law for the Anthropocene? Shifting perspectives in regulation of the oceans, environment and genetic resources, *Anthropocene* 9 (2015) 1-13.

D. Vidas, J. Zalasiewicz, M. Williams, What is the Anthropocene - and why is it relevant for international law? *Yb. Int'l Env. L.* 25 (2016) 3-23.

P. Villavicencio Calzadilla, L. Kotzé, Living in harmony with nature? A critical appraisal of the rights of Mother Earth in Bolivia, *TEL* 7 (2018) 397-424.

C.N. Waters, J. Zalasiewicz, C. Summerhayes, A.D. Barnosky, C. Poirier, A. Gałuszka, A. Cearreta, M. Edgeworth, E.C. Ellis, M. Ellis, C. Jeandel, R. Leinfelder, J.R. McNeill, D.D. Richter, W. Steffen, J. Syvitski, D. Vidas, M. Wagnreich, M. Williams, A. Zhisheng, J. Grinevald, E. Odada, N. Oreskes, A.P. Wolfe, The Anthropocene is functionally and stratigraphically distinct from the Holocene, *Science* 351 (2016) aad2622- 1 - aad2622-10.

C.G. Weeramantry, *Universalising International Law*, Martinus Nijhoff, Leiden, 2004.

J.B. Wiener, Something borrowed for something blue: Legal transplants and the evolution of global environmental law, *Ecology L. Q.* 27 (2001) 1295-1371.

T. Yang, R.V. Percival, The emergence of global environmental law, *Ecology L. Q.* 36 (2009) 615-664.

O.R. Young, *The Institutional Dimensions of Environmental Change: Fit, Interplay, and Scale*, MIT Press, Cambridge, 2002.

O.R. Young, O.R., *Governing Complex Systems: Social Capital for the Anthropocene*, MIT Press, Cambridge, 2017.

O.R. Young, W. Steffen, The Earth System: Sustaining planetary life-support systems in: F.S. Chapin, F.S., III, G.P. Kofinas, C. Folke (Eds.), *Principles of Ecosystem Stewardship: Resilience-Based Natural Resource Management in a Changing World*, Springer, Berlin, 2009, pp. 295-318.

J. Zalasiewicz, C.N. Waters, C.P. Summerhayes, A.P. Wolfe, A.D. Barnosky, A. Cearreta, P. Crutzen, E. Ellis, I.J. Fairchild, A. Gałuszka, P. Haff, I. Hajdas, M.J. Head, J.A. Ivar do Sul, C. Jeandel, R. Leinfelder, J.R. McNeill, C. Neal, E. Odada, N. Oreskes, W. Steffen, J. Syvitski, D. Vidas, M. Wagnreich, M. Williams, The Working Group on the Anthropocene: Summary of evidence and interim recommendations, *Anthropocene* 19 (2017) 55-60.