

# Sustaining Development in a Thermodynamic Universe: Raging Against the Dying of the Light

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*Sustainable development often appears as a nirvana concept that means all things to all people. Nevertheless, there remains an idea that the concept's core revolves around ensuring humanity's survival. This text aims at bringing notions borrowed from physics into to the debate about sustainable development in order to clarify and further delineate the concept. It adopts an abstract and theoretical perspective to bridge the gap between legal scholarship and other scientific disciplines. Its main conclusions are twofold. Firstly, the laws of thermodynamics indicate that in order to maximise sustainability, development has to be minimized to the lowest possible level. Accordingly, the legal framework placing the most constraints on development is also the framework that most fosters sustainability. Secondly, there are critical thresholds where human development acquires emergent properties that make it unsustainable. Jurists are unable to locate these thresholds and define their exact nature based on methodologies that rely on natural sciences. However, the law might facilitate the materialization of these thresholds since legal provisions that protect the environment can identify or even produce emergent properties.*

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*L'idée du développement durable apparaît souvent comme un concept idéal dont chacun a sa propre définition. Néanmoins, il demeure que ce concept vise fondamentalement à assurer la survie de l'humanité. Dans ce texte, l'auteur cherche à intégrer au débat portant sur le développement durable des notions empruntées à la physique afin de préciser et de baliser ce concept. L'auteur adopte un point de vue abstrait et théorique afin de réconcilier les avis exposés par les chercheurs juridiques et dans les autres disciplines scientifiques. Sa conclusion principale comporte deux volets. Premièrement, les lois de la thermodynamique révèlent que, pour maximiser la durabilité, le développement doit être minimisé autant que possible. Ainsi, le cadre d'analyse juridique qui impose les plus grandes limites au développement est également le cadre d'analyse qui assure la durabilité. Deuxièmement, des seuils cruciaux s'appliquent lorsque le développement humain acquiert des caractéristiques émergentes le rendant durable. Les juristes n'arrivent pas à identifier ces seuils et définir leur nature exacte en utilisant des méthodologies se fondant sur les sciences naturelles. Par contre, le droit est susceptible de faciliter*

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*leur détermination puisque des dispositions statutaires visant à protéger l'environnement peuvent identifier voire produire des caractéristiques émergentes.*

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*« Que voulez-vous que je dise de moi? Je ne sais rien de moi! Je ne sais même pas la date de ma mort. »*  
Jorge Luis Borges

## I. INTRODUCTION

This short essay is closer to a thought experiment than to conventional legal doctrine. The original impetus to write it stems from my bafflement at the concept of sustainable development being used to promote projects that, to my eyes at least, epitomize unsustainability.

I have never been completely at ease with the concept because I instinctively found it fuzzy and somewhat contradictory. Still, the basic idea that human development should follow a path likely to make it perennial seems sensible to me.

In order to reconcile these conflicting feelings, I have tried to come up with a view on sustainable development that would make sense for myself. The attempt has taken me far from positive law onto the personal path that led me to the study of environmental law. It has required revisiting amorphous ideas that have been at the back of my mind for a long while, and articulating them as well as possible by reference to notions borrowed from diverse fields of research.

The result is a winding journey hopping from law to a wide array of other disciplines. I hope that the eclecticism of this perspective on sustainable development does not overly test the patience of readers. The risk is particularly significant given that my lack of knowledge in the domains I refer to prevents me from adequately buttressing the logical articulation of the argument: the reasoning is analogous rather than linear at crucial points in the text.

Despite these reservations, I believe that this text is relevant. Firstly, it brings into the debate about sustainable development ideas that I consider fundamental but insufficiently discussed in Canadian doctrine. It touches on notions such as ecological efficiency, ecosystem carrying capacity and limits to growth, among others. Yet another justification has appeared to my eyes while writing this text. In attempting to draw connections between law and other sciences at a very abstract level, some common patterns reoccurring across fields of research seem

to emerge and provide a unified perspective that shed light on specifically legal issues. To better highlight these patterns, the text starts from the familiar confines of legal jurisprudence to progress towards more exotic horizons. The blueprint for the overall argument may be summarised as follows:

1. The different theories that exist about what the law is rely on the axiomatic method.
2. The axiomatic method is unable to generate a coherent and self-referential logical system.
3. Logical systems based on the axiomatic method (including legal, philosophical, economical, and sociological attempts to accurately describe reality) are fundamentally incomplete.
4. The usefulness and validity of these logical systems depend on their open-ended, imperfect nature, and more precisely on the continuation of efforts to perfect them.
5. The continuation of efforts to improve and perfect logical systems depends on the survival of humanity.
6. To survive for the longest period possible, humanity must ensure that the global ecosystem supporting it remains viable and functional.
7. The laws of thermodynamics indicate that the more techno-economic human development is restrained and minimised, the longer the global ecosystem will remain viable and functional.
8. More precisely, human development would last longest if it did not cross thresholds after which it acquires emergent properties degrading the environment, and before which the human species remains indistinguishable from other species constituting the global ecosystem.
9. Accordingly, environmental law is more conducive to human survival and sustainable development the more it prevents the alteration of the environment and the global ecosystem. The legal definition of sustainable development should reflect this conclusion.

The argument that environmental law and the notion of sustainable development should integrate constraints revealed by the laws of thermodynamics stands alone (i.e. steps 6, 7 and 9 detailed above), without the need for considerations related to the nature of intellectual enquiry in general or legal jurisprudence more specifically. However, the broader perspective adopted in this text suggests that the continued, indefinite survival of humanity in the face of global environmental crisis is not only necessary in and of itself. The justification, usefulness and transient validity of attempts in many disciplines (including legal research) to explain reality, impart meaning and find truth, also depend on humanity's continuation. In return, the motivation for these scientific endeavors imbues humanity's survival with meaning.

Moreover, making parallels between the structure and functioning of systems (whether intellectual theories, logical systems, socio-economic systems or physical systems) hints that the identification of thresholds and boundaries

between systems and subsystems themselves or their surroundings constitutes a recurring issue across fields of research. Different disciplines may grapple with this issue from different approaches and through different labels—emergent properties in physics, ecosystem definitions and boundaries in biological sciences, and procedural versus substantive questions or jurisdictional versus preliminary questions in administrative law. In the context of sustainability, the superposition of different disciplines and approaches to tackle this issue may help define or pinpoint problematic thresholds and boundaries more precisely.

One last caveat: I do not claim to make grandiose discoveries or advance revolutionary ideas. Ultimately, this is really just an attempt to try and think a bit about the directions in which it might be possible to push environmental law beyond its traditional adherence to procedural and administrative norms towards a more substantive content without being hampered by the usual strictures of legal doctrine.

## II. SEGUE

This section argues that different conceptions and theories about what the law is rely on a common methodology. The axiomatic method serves to support, articulate and validate the various strands of legal jurisprudence, irrespective of how divergent or contradictory they may be.<sup>1</sup> This is illustrated by showing methodological parallels between two theories that respectively fully embrace and totally reject the logical systematization entailed by the axiomatic method: formal positivism and critical pluralism.

I believe that, at some point, every jurist has felt the attraction of formal positivism towards sleek logical systems of principles and norms.

This might stem from the jurist's acquaintance with arguments in an abstract world where an opinion's validity depends on its rational coherence, and where revealing internal contradictions serves to refute alternate contentions, the irredeemable flaw of an imperfect logic condemning them as inferior.

Underlying such a perspective is a conception of the law as a finite set of axiomatic rules from which particularized norms are derived through a process of logical deduction to bridge the gaps between abstract generalizations and

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<sup>1</sup> According to Andrei Rodin, *Axiomatic Method and Category Theory*, Springer, 2014, at 15:

If we consider a particular theory more closely, we always see that a few distinguished propositions of the field of knowledge underlie the construction of the framework of concepts, and these propositions then suffice by themselves for the construction, in accordance with logical principles, of the entire framework. [ . . . ] These fundamental propositions can be regarded [...] as the axioms of the individual fields of knowledge: the progressive development of the individual field of knowledge then lies solely in the further logical construction of the already mentioned framework of concepts. This standpoint is especially predominant in pure mathematics. [...] Anything at all that can be the object of scientific thought becomes dependent on the axiomatic method, and thereby indirectly on mathematics.

Hilbert 1918, at 1108-1115.

reality in order to govern an infinite set of discrete situations. Here, the law purports to function as a self-contained system that achieves both consistency and completeness. Though supposedly formal and shorn of moral anchors that might introduce arbitrary biases in the law's mechanical operation, this perspective actually relies on rational coherence as its fundamental normative value in addition to other premises regarding what can be considered positive law.<sup>2</sup>

I am receptive to this conception of the law, perhaps because of my background as a practitioner. But I think its appeal is broader. The positivist temptation creeps up unexpectedly where it has been renounced or denounced or sidestepped altogether, in empirical or sociological strands of legal scholarship for example.<sup>3</sup> Casting aside the strictures of legal formalism is justified by a normative idea that brings better understanding of the legal phenomenon. Yet, for the concept of the law to retain a modicum of descriptive and explanatory value, there must still remain substantive propositions of law that are found to be true whatever perspective we adopt, and the truth of such legal propositions must rely on the existence of some standard external to positive law against which they may be evaluated.<sup>4</sup> Inevitably, the alternative external conception induces an analytical process that both reflects and develops basic normative tenets into an orderly structure describing the object of study through a more or less complex set of categorical abstractions that aim at internal coherence. Although apparently fostering diversity, this results in a proliferation of competing theories about what the law is that nevertheless respond to the same rational processes.<sup>5</sup>

This starting point is not a call for some preposterous reductionism that would crudely dismiss alternatives to traditional legal exegesis. It is only meant to convey the hegemonic tendency of positive logical reasoning.<sup>6</sup> It might be the

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<sup>2</sup> See Ernest Weinrib, "Legal Formalism: On the Immanent Rationality of Law" (1988) Vol 97 *Yale Law Journal* 949 (e.g. "Coherence is the criterion of truth", at 972).

<sup>3</sup> For example, realism is axiomatic in its approach—and thus conforms to the same systematic pattern as formalism. Justice Holmes acknowledges the axiomatic nature of his theory in Oliver Holmes, *Collected legal papers*, New York, Dover Publications, at 225-226: "The true science of the law. . . consists in the establishment of its postulates from within upon accurately measured social desires instead of traditions."

<sup>4</sup> See John Farago, "Intractable Cases: The Role of Uncertainty in the Concept of Law" (1980) Vol 55 *New York University Law Review* 195.

<sup>5</sup> Morris Cohen, "The place of logic in the law" (1916) 29:6 *Harvard Law Review* 622, 624-625:

We try to reduce the law to the smallest number of general principles from which all possible cases can be reached, just as we try to reduce our knowledge of nature to a deductive mathematical system. . . Law, of course, never succeeds in becoming a completely deductive system. It does not even succeed in becoming completely consistent. But the effort to assume the form of a deductive system underlies all constructive legal scholarship.

<sup>6</sup> Albert Camus, *Le mythe de Sisyphe*, (Paris: Gallimard, 1942) ("Quels que soient les jeux

pull of this dynamic of assimilation into the empire of reason that prompts the rejection of “traditional social-scientific legal pluralism” in favor of an authentic, *critical* legal pluralism.<sup>7</sup> To avoid the expansionary drive of logical reasoning that leans toward an inter-systemic consistency antithetical to true pluralism, the argument coalesces exclusively around the citizen-subject, who focuses on attaining self-understanding and acts as the irreducible generator of normativity.<sup>8</sup> Perfect incommensurability is barely averted by a reference to “meaning” which opens to discursive rationality, thus conceding to the syntax of symbolic logic.<sup>9</sup> In fact, Hart’s ultimate rule of recognition based on the empirical observation of human behavior to determine the boundaries of the law has only been displaced by a succinct premise according to which the law is fully justified by, and entirely reliant on, the existence of a subjective self.<sup>10</sup> The divergence masks a common pattern where uncertainties in the substance and the extent of foundational legal concepts are solved by an analytical process that integrate all answers into a coherent structure culminating in a keystone, value-laden principle.

In this context, positive logical reasoning under its various guises appears as the instrument enabling the formation of a common discursive project aimed at imparting shared meanings or values that is essentially monist in scope.<sup>11</sup> At this stage, the generality of the argument dissolves the boundaries of the law as a discipline and imposes considerations from other fields of knowledge.<sup>12</sup>

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de mots et les acrobaties de la logique, comprendre c’est avant tout unifier” [Whatever the plays on words and the logical acrobatics, understanding is unifying, first and foremost]).

<sup>7</sup> Martha-Marie Kleinahns & Roderick Macdonald, “What is a *Critical* Legal Pluralism?” (1997) Vol 12 *Canadian Journal of Law & Sociology* 25, at 37 (“because traditional social-scientific legal pluralism purports to be an empirically verifiable hypothesis of law, it remains a legal mythology that is as much a positivist image as the stigmatized image of legal centralism”).

<sup>8</sup> *Ibid.*

<sup>9</sup> Denying the possibility of inter-subjective meaning renders senseless the concept of the law: Matthias Klatt, *Making the Law Explicit: The Normativity of Legal Argumentation*, (Oxford: Hart Publishing, 2008), at 2 (“If propositions on meaning in general are not inter-subjectively valid, how could propositions on the meaning of a norm be so?”).

<sup>10</sup> About the reliance of critical legal pluralism on the existence of the subjective self as the theory’s key postulate, see *ibid.*

<sup>11</sup> In general, see *ibid.* The terms of the debate on logical pluralism—the existence of pluralism in logics—are alien to me, which prevents me from validating my intuition of a logical monism. In particular, I am unable to identify a specific entry point into this debate for my opinion dovetailing with the Habermasian view that the elaboration of a dialogue creates a common, truth-generating reference to reality for its participants.

<sup>12</sup> See Robert Hockett, “Reflective Intensions: Two Foundational Decision-Points in Mathematics, Law, and Economics” (2008) Vol 29 *Cardozo Law Review* 1967.

### III. REGRESS

This section suggests that the methodology used in legal jurisprudence as well as in many other disciplines gives rise to incoherent or incomplete logical systems.<sup>13</sup>

The problem of the objective existence of the law alluded to above relates to the objectivity of a shared social reality, and thus touches on one of the most fundamental questions in general philosophy: is there an objective truth?

This ambitious question surpasses my limited capacities. In any case, the question falls outside the remit of this text. I raise it simply to situate my original impulse into intellectual enquiry, which initiated a quest to find a satisfactory definition for the notion of sustainable development. In fact, it is my inability to answer this question that led me to sustainable development, as will soon become apparent.

Looking for an absolute truth to ground the meaning of the world and myself in it, my candid personal search quickly floundered on paradoxes dating back to Antiquity. In particular, Aristotle's regress problem proved an obdurate stumbling block: whatever is known must be demonstrated; the premises of a demonstration must be known. Either the circular process engaged by these two propositions continues forever, creating an infinite regress of premises, or it stops at some point and the ultimate premises remain unfounded. In both cases, no certainty can be established.

Aristotelian logic has long been displaced by modern formal logic, but the problem of infinite regression still seems relevant. Firstly, that problem appears to reproduce the pattern outlined above with respect to legal jurisprudence, where adjudicating on what the law is inevitably requires introducing a second, supervening normative order—which would itself presumably require a tertiary system, and thus *ad infinitum* whatever approach is employed. Secondly, infinite regression has been an issue in domains far more systematically articulated than jurisprudence. In mathematics, logically incompatible statements cannot be simultaneously true. Demonstrating the validity of the axioms in Euclidian geometry, which was initially thought to describe objects in the world we experience, demands a proof of their consistency.<sup>14</sup> This proof can be established in Reimannian space or Hilbertian algebra. However, the validity of the respective axioms on which rely these two supervening systems remains questionable, and the demonstration is incomplete because it has not been shown that a pair of statements deduced from these axioms cannot be contradictory.<sup>15</sup>

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<sup>13</sup> The argument has been made or considered a number of times in legal doctrine: for example, see Mike Townsend, "Implications of Foundational Crises in Mathematics: A Case Study in Interdisciplinary Legal Research" (1996) 71 *Washington Law Review* 51; and Hillel Bavli, "Applying the Laws of Logic to the Logic of Law" (2006) 33 *Fordham Urban Law Journal* 937.

<sup>14</sup> For example, the following is an axiom in Euclidian geometry: "through a point outside a given line only one parallel to the line can be drawn".

The turn to mathematics is warranted here.<sup>16</sup> This discipline draws the conclusions logically implied by any given set of postulates, and the validity of a mathematical inference does not depend on the meaning associated with the terms contained in axioms.<sup>17</sup> What demonstrations may be made about the validity of sets of principles and their inter-relations in mathematics might very well hold true more generally. Particularly relevant is the finding by Russell of a contradiction within the framework of elementary logic used in the mathematical theory of classes adopted as the foundation for other branches of mathematics, including elementary arithmetic.<sup>18</sup> This raises the possibility that the axioms of all the systems composed of an infinite number of elements, i.e. whose validity cannot be assessed by exhaustive empirical observation, might be inconsistent.

An Austrian mathematician, Kurt G—del, makes a crucial contribution to this debate in the 1930s when he publishes his incompleteness theorems.<sup>19</sup> He demonstrates a fundamental limitation in the axiomatic method. One of his conclusions answers the question whether a given set of postulates serving as the foundation for a non-finite system can be internally consistent, so that no mutually contradictory statements may be deduced from the postulates. For a deductive system comprehensive enough to express a self-reflective statement logically derived from the system (e.g. a mathematical statement equivalent to “this arithmetical statement cannot be proved within the system of arithmetic”), it is either possible to prove both the statement’s truth and its falsity, or it is impossible to prove the statement relying exclusively on the system’s axioms. In other words, the system is necessarily either inconsistent or incomplete. If it is incomplete, the proof of some statements that can be derived from the original axioms of the system requires additional axioms exorbitant to the system, and we face the regress problem again.

#### IV. NIRVANA

This section argues that the incoherence or incompleteness of logical systems and theories does not invalidate them. Their value and interest rely in their

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<sup>15</sup> See Ernest Nagel & James Newman, *Gödel’s Proof*, (London: Taylor and Francis, 2003), on which the paragraphs above rely heavily for an overview of historical developments in mathematical logic.

<sup>16</sup> On parallels between legal and mathematic reasoning, see Steven Goldberg, “On Legal and Mathematical Reasoning” (1981) 22 *Jurimetrics Journal* 83.

<sup>17</sup> *Ibid*, at 11-12 (“the validity of mathematical demonstrations is grounded in the structure of statements, rather than in the nature of a particular subject matter”).

<sup>18</sup> See Alfred Whitehead and Bertrand Russell, *Principia Mathematica*, Vol I, 2d ed, Cambridge, Cambridge University Press, at 37-ff. The mathematical theory of classes deals with the properties and relations of collections of elements, whatever they may be (data, discrete situations, etc). Russell devised methods to bypass the antinomies he discovered, but the question remained whether these methods were sufficient to solve all forms of self-contradictory constructions.

<sup>19</sup> See in general Ernest Nagel and James Newman, *supra* note 14, and in particular at 85-ff.

endlessly perfectible nature. Their relevance is sustained by the perpetual renewal of attempts improve them. In this context, the indefinite survival of our species appears necessary.

The full ramifications of G—del’s theorems have taken some time to emerge, even within mathematics. I understood his conclusions to mean that finding an absolute and definitive standard on which to base a coherent and complete normative system would be impossible.<sup>20</sup>

The absence of a definite truth opens the door to postures such as radical relativism and skeptical postmodernism that deny any value to positive judgments, and in fact deny the very possibility of a rational and objective social reality shared between individuals.<sup>21</sup> The failure to understand the world and imbue it with cogent meaning leads some to conclude that human existence is absurd, an acknowledgement to which suicide is an appropriate answer.<sup>22</sup> The finitude of life renders it pointless in a boundless universe ultimately impervious to human reason and action. Even the utmost human creation fades away against that backdrop.<sup>23</sup>

In my opinion, this unduly tragic outlook appears misaligned with the lessons gleaned from our foray to the limits of reason. Firstly, death does indeed confine life to a bounded vector enabling limited possibilities for expression that reflect into a finite set of interpretations. Coherence may obtain from an existence subsumed to a definite number of elements encompassed in a finite set of observations.<sup>24</sup> However, such a truth would be static, fixed into a lifelessness entirely disconnected from its surroundings by self-referential perfection. In any case, adopting this perspective from a purely personal viewpoint is irrelevant inasmuch as it is spurious to conceive the individual in perfect isolation.<sup>25</sup> Life and meaning emerge in relation to community. To accept this implies a shift away from the individual that reframes the questions raised by mortality into a collective project. Secondly, death recedes to a mere possibility among myriad potentialities open to perpetuity in an infinite universe as soon as we adopt the

<sup>20</sup> On the possibility and the perils of transposing G—del’s conclusions in the legal discipline, see Mike Townsend, *supra* note 12, at 130-ff.

<sup>21</sup> See Richard Dworkin, “Objectivity and Truth: You’d Better Believe It” (1996) 25 *Philosophy & Public Affairs* 87.

<sup>22</sup> See Albert Camus, *supra* note 5. Camus himself favours another solution instead of suicide.

<sup>23</sup> André Malraux thought great works of art could convey a intersubjective meaning that transcends death and fends off absurdity: see Claude Pillet, *Le sens ou la mort: essai sur Le miroir des limbes d’André Malraux*, (Berne: Peter Lang, 2010).

<sup>24</sup> Perhaps this sheds a light on Romain Gary’s justification for his suicide: “Je me suis enfin exprimé entièrement” [At last, I expressed myself entirely].

<sup>25</sup> As this text, and many others, revisit Romain Gary’s suicide, *supra* note 23, his justification evolves through further interpretation. The meaning of his gesture is not fixed as long as it is still considered and discussed, raising the possibility of new perspectives the author himself had not thought of, including the potential demonstration that his work and his life were incomplete at the time of his suicide.

only alternate collective viewpoint, which is pinned to our species' existence. The possibility of limitless iterations and interpretations for the human condition ensures incompleteness, in turn endlessly renewing the relevance of attempts to impart evermore-ambitious meaning that would otherwise vanish into emptiness with the closure of our collective adventure. In this context, the indefinite survival of our species appears necessary.

As labored as they are, these personal considerations prompted my interest in environmental law. Faced with impending ecological apocalypse in the form of runaway global warming and mass extinction for biota, the survival of our species relies on the protection of the global ecosystem that allowed it to emerge and thrive.<sup>26</sup> This means curbing the ongoing damage human activities inflict on the environment.

## V. INCARNATION

This section argues that, in principle, sustainable development is the substantive notion most apt to address the issue of humanity's survival within the field of environmental law.

Environmental law fails its mission, as evidenced by the unabated destruction of nature.<sup>27</sup> In North America, it is a procedural domain often

<sup>26</sup> These days, the extent and severity of the environmental destruction goes without saying. However, Donella Meadows, Jrgen Randers & Dennis Meadows, *Limits to Growth: The 30-Year Update*, (London: Earthscan, 2004), is well worth a mention for a number of reasons: 1) the crucial role the original report of the "Club of Rome" played in the global rise of an environmental consciousness in the 1970s; 2) the clarity of its argument that humanity is destroying its life-support system and possibly committing suicide ("overshoot and collapse" in the business-as-usual scenario); and 3) the acuity of its predictions that still generally hold true more than 40 years later (on this specific point, see more recently Ugo Bardi, *The Limits to Growth Revisited*, (New York: Springer, 2011).

<sup>27</sup> Environmental law has emerged as a procedural strategy relying on administrative law to oppose natural resources development projects in the context of legislative frameworks authorizing environmental degradation. It can be argued that environmental law does not aim at environmental protection because it is a predominantly procedural domain. However, this would ignore the intent that initially motivated the procedural slant in environmental law, which can only exist autonomously from general administrative law if it integrates substantive values related to the protection of the environment. On these issues, see Dan Tarlock, "The Future of Environmental 'Rule of Law' Litigation" (2002) 19 *Pace Environmental Law Review* 575 ("Jurisprudentially, environmental law could be defined as the positive and common law that reflects environmentalism. [. . .] I define environmentalism as an emerging philosophy or value system which posits that we living humans should assume science-based ethical stewardship obligations to conserve natural systems for ourselves as well as for future generations" at 576 (references omitted)). Current trends in environmental alteration will possibly cause global ecosystem destruction so great that our world could shift to an entirely new, unrecognizable state: with respect to the sixth mass extinction in biota our planet has already entered, see Gerardo Ceballos et al, "Accelerated modern human-induced species losses: Entering the sixth mass extinction", (2015) 1:5 *Science Advances*; with respect to climate change, see James Hansen et al, "Target Atmospheric CO<sub>2</sub>: Where Should Humanity Aim" (2008) 2

devoid of substance, where permits to pollute, consume or harvest are granted as long as formal legal requirements are met and danger to human health is indirect enough to remain hidden. In other words, environmental law does not provide many notions that specifically address the issue of humanity's survival.

Among the few options, sustainable development appears to fit the bill most precisely.<sup>28</sup> In general, this concept is defined as a development that meets the needs of the present without compromising the ability of future generations to

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*The Open Atmospheric Science Journal* 217 (“Decreasing CO<sub>2</sub> was the main cause of a cooling trend that began 50 million years ago, the planet being nearly ice-free until CO<sub>2</sub> fell to 450 ± 100 ppm; barring prompt policy changes, that critical level will be passed, in the opposite direction, within decades. If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO<sub>2</sub> will need to be reduced from its current 385 ppm to at most 350 ppm, but likely less than that.”—to put these numbers in perspective, according to Arthur Meslen, “Carbon dioxide levels in atmosphere forecast to shatter milestone”, *The Guardian*, 13 June 2016, online: <[www.theguardian.com](http://www.theguardian.com)>, “Atmospheric concentrations of CO<sub>2</sub> will shatter the symbolic barrier of 400 parts per million (ppm) this year and will not fall below it our in our lifetimes”); with respect to areas of the globe becoming too hot to remain uninhabitable, see James Hansen and Makiko Sato, “Regional climate change and national responsibility” (2016) 11:3 *Environmental Research Letters*; and more generally on the sustainability of the Earth ecosystem being threatened, see Will Steffen et al, “Planetary boundaries: Guiding human development on a changing planet”, (2015) 374:6223 *Science* 736 (“There is an urgent need for a new paradigm that integrates the continued development of human societies and the maintenance of the Earth system (ES) in a resilient and accommodating state. The planetary boundary (PB) framework contributes to such a paradigm by providing a science-based analysis of the risk that human perturbations will destabilize the ES at the planetary scale. [. . .] The relatively stable, 11,700-year-long Holocene epoch is the only state of the ES that we know for certain can support contemporary human societies. There is increasing evidence that human activities are affecting ES functioning to a degree that threatens the resilience of the ES.”) In the context of the imminent destruction of the planetary ecosystem under the business-as-usual scenario, environmental law does indeed fail its mission—even if we accepted that environmental law slows down the degradation process despite the fact that most indicators actually show accelerating environmental degradation. For insights on the gap between the goals of environmental legislation and its actual implementation, see Nigel Bankes, Sharon Mascher & Martin Olszynski, “Can Environmental Laws Fulfill their Promises? Stories from Canada” (2014) 6 *Sustainability* 6024.

<sup>28</sup> Concepts aimed at ensuring the survival of both humanity and the global ecosystem abound: steady-state economics; degrowth; circular economy; deep ecology. . . However, none of these concepts have materialised in Canadian law, and they generally remain less defined and utilised than the concept of sustainable development. The notion of “ecological integrity” found in the *Canada National Parks Act*, SC 2000, c 32, s 2(1) has the potential to indirectly address the issue of humanity's perpetuation through the protection of the ecosystems that sustain our species. However, the implementation of the notion does not actually emphasise ecosystem integrity in national parks: Shaun Fluker, “Ecological Integrity in Canada's National Parks: The False Promise of Law” (2010) 29 *Windsor Review of Legal and Social Issues* 89. Moreover, the spatial application domain of the concept makes it unlikely that it could ensure a functioning environment to indefinitely sustain humanity.

meet their own needs.<sup>29</sup> Whatever “development” means, the idea of sustainability, and more specifically the emphasis on humanity’s perpetuation through future generations, seem promising. Still, the concept remains fuzzy enough to require clarification. A closer look at its legal manifestations provides additional guidance.<sup>30</sup>

While the federal law on sustainable development sticks to the accepted definition, it specifies that “sustainability” means “the capacity of a thing, action, activity, or process to be maintained indefinitely”.<sup>31</sup> However, the law qualifies these principles by saying that “sustainable development is based on an ecologically efficient use of natural, social and economic resources”.<sup>32</sup> Quite what is ecological efficiency remains open to question in Canadian law.<sup>33</sup> Biology tells us that it refers to the way energy from one trophic level—energy input (e.g. solar energy, food. . .) stored by organisms into carbon compounds to sustain life (e.g. glucose, adenosine triphosphate. . .)—is transferred to another trophic level.<sup>34</sup> Plainly stated, the ecological efficiency of a system increases when less energy is lost in processes between levels of the food web, from solar radiation to vegetal glucose, from herbivore muscle to predator fat. In any case, the actual application of federal law ignores this conception.<sup>35</sup> I have never heard of an authorisation process where the regulatory agency denied a permit to alter the

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<sup>29</sup> World Commission on Environment and Development, *Our Common Future*, published as an annex to General Assembly document A/42/427, *Development and International Co-operation: Environment*, 4 August 1987. For a review of the origins of the concept of sustainable development, see Kristin Bartenstein, “Les origines du concept de développement durable” (2005) 3 *Revue juridique de l’environnement* 289.

<sup>30</sup> For overviews of the legal manifestation of the concept of sustainable development in Canadian law, see Natasha Affolder, «The legal concept of sustainability», presented to the Symposium on Environment in the Courtroom: Key Environmental Concepts and the Unique Nature of Environmental Damage, March 23-24, 2012, University of Calgary; and Paule Halley & Pierre-Olivier Desmarchais, “Le développement durable, ses principes et leur intégration en droit canadien” (2012) 24:10 *JELP* 67. Given the aim of the present text to clarify the definition of the concept of sustainable development, the present section maps the semantic domain of the concept in Canadian law rather than to discuss its lack of operational or binding character.

<sup>31</sup> *Federal Sustainable Development Act*, S.C. 2008, c. 33 [FSDA], s. 2.

<sup>32</sup> *Ibid*, s 5.

<sup>33</sup> The preamble of the *Canadian Environmental Protection Act*, 1999, SC 1999, c 33, also mentions it without providing more details.

<sup>34</sup> See J.L. Chapman & Michael Reiss, *Ecology: principles and applications*, 2d ed, (Cambridge: Cambridge University Press, 1998), at 142-ff.

<sup>35</sup> For critical assessments of the FSDA’s substance and application, see Amissi Marinabona & Ivan Tchotourian, “Une évaluation critique de la première loi canadienne sur le développement durable” (2010-2012) Vol 42 *Ottawa Law Review* 33; Commissioner of the Environment and Sustainable Development, “Chapter 5—Departmental Progress in Implementing Sustainable Development Strategies”, in *Fall 2014 Report of the Commissioner of the Environment and Sustainable Development*, Ottawa, Office of the Auditor General of Canada, 2014, online: < <http://www.oag-bvg.gc.ca/> > .

environment because the way a project would transform energy from one form to another could result in the radiation loss of too much energy waste. A hypothetical example illustrates how revolutionary the application of ecological efficiency would be. In principle, it might mean the denial of a permit to build a new intensive commercial pig farm using cereals produced from surrounding fields in order to feed meat to a nearby city because this whole supply chain would deliver less edible calories to human consumers than feeding corn directly to the city inhabitants, all other energy inputs being equal.

At the provincial level, the law also refers to the standard definition for sustainable development, adding that it is “based on a long term approach”.<sup>36</sup> Sixteen guiding principles further flesh out this approach, ranging from “social equity and solidarity” to “economic efficiency” and “protection of cultural heritage”.<sup>37</sup> A number of these principles are related to environmental protection, but some have more specific relevance to the matter at hand. One of them indicates that human health and improved quality of life is an entitlement at the core of sustainable development. The principles of “respect for ecosystem support capacity” and “biodiversity preservation” read together state that human activities must ensure the “perenniality” of ecosystems and their components, which are essential to maintaining the quality of life of future generations.<sup>38</sup> These principles resonate with the necessity of humanity’s indefinite survival, but their effect is mostly declaratory and they remain bereft of substance in provincial law.<sup>39</sup> The precise meaning given by science to the notion of ecosystem carrying capacity—the number of individuals of a given species that a given habitat can support without being permanently damaged—is not tied to the human environmental footprint in Quebec law, although that notion is probably taken into account with respect to the most economically valuable wildlife species in establishing hunting and fishing quotas.<sup>40</sup>

## VI. EGRESS

This section argues that, in practice, the concept of sustainable development remains poorly defined and unable to guide socio-economic development towards a sustainable future.

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<sup>36</sup> *Sustainable Development Act*, CQLR c D-8.1.1, s 2 [SDA].

<sup>37</sup> *Ibid*, at s. 6.

<sup>38</sup> *Ibid*, at ss. 6(l) & 6(m).

<sup>39</sup> For a highly critical assessment of the SDA’s application, see Commissaire au développement durable, “Chapitre 2—Application de la *Loi sur le développement durable*: 2013”, in Vérificateur général du Québec, *Rapport à l’Assemblée nationale pour l’année 2014-2015*, online: <<http://www.vgq.gouv.qc.ca>> .

<sup>40</sup> With respect to carrying capacity, see Eugene Odum, *Ecology and Our Endangered Life Support Systems*, (Sunderland: Sinauer Associates, 1989). For insights on the decision process with respect to hunting quotas for cariboo, see *M.P. c. Ministère du Développement durable, de l’Environnement et de la Lutte contre les changements climatiques*, 2015 QCCA 154.

This quick overview confirms that sustainable development aims at ensuring a human development indefinite in time through environmental protection as well as the limitation of humanity's ecological footprint. Sustainable development seems central to humanity's survival in the Anthropocene.

Worrying ambiguities remain, however. The concept is still confused. Sustainable development has been extensively studied in many disciplines, and the effort has generated over 200 definitions.<sup>41</sup> Yet, its elusiveness persists, perhaps because of this multiplicity. Sustainable development has been labeled an umbrella concept, and in fact might be a nirvana concept referring to everything and anything depending on the perspective, seemingly immune to antinomies.<sup>42</sup> It can be indiscriminately invoked to justify an open-pit mine within the limits of a municipal territory where part of the population opposes the project, or to justify going ahead with some projects that rank among the biggest point-sources emitters of greenhouse gases.<sup>43</sup>

Sustainable development appears compatible with projects that epitomize unsustainability. This paradox might stem in part from the concept's indeterminate substance in law combined to its lack of binding effects. The two legislations on sustainable development examined above impose reporting and accountability requirements—in other words, these legislations are not

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<sup>41</sup> Sara Parkin, "Sustainable development: the concept and the practical challenge" (2000) Vol 138, No 6 *Proceedings of the ICE—Civil Engineering* 3.

<sup>42</sup> UNECE, "Sustainable development—concept and action", online: <<http://www.unece.org>> ("One of the most striking characteristics of the term 'sustainable development' is that it can mean all things to all people"). See Jaye Ellis, "Sustainable Development as a Legal Principle: A Rhetorical Analysis", in Helene Ruiz Fabri, Riidiger Wolfram & Jana Gogolin, eds, *Selected Proceedings of the European Society of International Law*, Vol 2, (Oxford: Hart, 2010), 641, for a substantial discussion that mentions, interestingly in the context, the "unboundedness of human activity, each action setting into motion a chain of events that can neither be predicted nor controlled" by reference to Hannah Arendt, *The Human Condition*, 2d ed, (Chicago: University of Chicago Press, 1998), a book concerned with immortality. The following definition aptly illustrates sustainable development's reach as a nirvana concept: according to Encyclopedia of Life Support Systems, *Conceptual Framework*, (Oxford: EOLSS Publishers, 1998), it is "the wise use of resources through critical attention to policy, social, economic, technological, and ecological management of natural and human engineered capital so as to promote innovations that assure a higher degree of human needs fulfillment, or life support, across all regions of the world, while at the same time ensuring intergenerational equity". In short, sustainable development is anything and everything that is good. Nevertheless, it is sustainable development's open-ended nature that makes it particularly relevant across disciplines, as Ellis points out.

<sup>43</sup> The examples provided refer to actual projects in Quebec. With respect to the open-pit mine, see Alexandre Shields, "Le Gouvernement dit oui à Mine Arnaud—Le gouvernement investit 120 millions dans le projet qui déchire Sept-Îles", *Le Devoir*, 17 March 2015, online: <<http://www.ledevoir.com>>; with respect to the biggest point-source GHG emitting project in Quebec, see Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques, *Communiqué de presse—Cimentrie de Port-Daniel: le ministre Heurtel fait le point*, 18 juillet 2014, online: <<http://www.mddelcc.gouv.qc.ca/>>.

intended to directly constrain development. Other disciplines attempt to articulate sustainable development into an effectively applicable principle, generating unwieldy sets of extensive guidelines and indicators, to no avail.<sup>44</sup> Environmental degradation continues apace, and the concept is now effectively coopted by the dominant techno-industrial development paradigm to the point where sustained economic growth is touted as the indicator of sustainable development.<sup>45</sup> This raises the question:

“whether a civilization can afford to surrender itself *entirely* to the maelstrom of the driving force of just one of its subsystems—namely the pull of a dynamic, or, as we would say today, recursively closed, economic system which can only function and remain stable by taking all relevant information, translating it into, and processing it in, the language of economic value.”<sup>46</sup>

For all the rhetoric it has generated without curbing the business-as-usual scenario, sustainable development’s failure as a fundamental guiding principle seems complete. Yet, there is a sense that the ideas to which it refers could still yield a foundational principle able to structure human undertakings meaningfully. At this point, presenting the socio-economic aspects of human civilisation as a well organised, quasi-mechanical system is intentional. It recalls the biological and physical concepts comprising sustainable development—such as ecological efficiency, energy conservation and carrying capacity —, and asks whether it is possible to augment indefinitely or simply maintain a system’s functioning and structure.

## VII. STILLNESS

This section argues that the laws of thermodynamics provide essential substantive principles that must be integrated into the definition of sustainable development to foster actual sustainability. Accordingly, environmental law is more conducive to human survival and sustainable development the more it prevents the alteration of the environment and the global ecosystem.

Our society depends on sophisticated means of production, advanced technological equipment and processes, intricate supply chains spanning the

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<sup>44</sup> See Hartmut Bossel, *Indicators for Sustainable Development: Theory, Method, Applications*, (Winnipeg: International Institute for Sustainable Development, 1999).

<sup>45</sup> See Sharachandra Lélé, “Sustainable Development: A Critical Review” (1991) Vol 19, No 6 *World Development* 607; David Pearce and Giles Atkinson, “Capital theory and the measurement of sustainable development: an indicator of ‘weak’ sustainability” (1993) Vol 8 *Ecological Economics* 103; Herman Daly, “Towards Some Operational Principles of Sustainable Development” (1990) Vol 2 *Ecological Economics* 1. Micheal Redclift, “Sustainable Development (1987-2005)—An Oxymoron Comes of Age” (2007) Vol 25 *Horizontes Antropológicos* 65, unpack some of the ethical and distributional issues raised by the idea of development.

<sup>46</sup> Jürgen Habermas, “What Does Socialism Mean Today? The Rectifying Revolution and the Need for New Thinking on the Left”, (1990) Vol 183 *New Left Review* I.

globe, and extensive consumption of high-density energy resources. These technical and economical bases impose an orderly pattern to social interactions, structuring them and their subjects into a dynamic system that can be conceived as a functioning unit.<sup>47</sup>

Obviously, the comparison between that system and a simple mechanistic model, such as a car engine, can only take us so far given the immeasurable gap in complexity between both. Yet, the analogy is much more direct than initially appears. Both simple and complex systems rely entirely on energy inputs to sustain their functioning. Both can be described by the ordering of their various components into a characteristic structure that defines systemic boundaries and identity. This structure represents the material aggregation of past energy expenditures. Order or structure is the physical manifestation of energy in stable if transient form. The parallel thus refers to a single currency that enables comparisons across vastly different scales. It even encompasses the biological realm, where a species appears as a self-replicating unit whose unique identity is expressed through the particular physical structure it adopts to process energy and various materials in order to sustain itself.<sup>48</sup> In this perspective, humanity is just the first amongst equals, our technology the industrial extension of our metabolism.

Focusing on energy as well as dynamic self-sustaining structures leads us to physics, which has identified inescapable laws that govern thermodynamic systems.<sup>49</sup> Only two of these laws need be mentioned for my purposes. The first law, called the law of conservation of energy, states that energy cannot be created or destroyed; it can only flow across space or change from one form to another. This law means that the total energy of an isolated system does not change but remains constant. Since it applies to closed systems, this law does not describe either human civilization as a system or the entire planetary ecosystem because

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<sup>47</sup> Michael Huesemann, "The limits of technological solutions to sustainable development" (2003) Vol 5 *Clean Technologies and Environmental Policy* 21, at 28: "the human-generated 'order' is generally related to the many physical artefacts and activities that are considered signs of civilization such as the endless array of consumer goods and services. In practice, a wide range of mining, manufacturing, transportation, and communication technologies are employed to create this highly ordered human environment." In general, see Yaneer Bar-Yam, *Dynamics of Complex Systems*, (Reading: Addison-Westly, 1997), as well as Harry Soodak & Arthur Iberall, "Thermodynamics and Complex systems", in Eugene Yate, ed., *Self-Organizing Systems: The Emergence of Order*, (Boston: Springer, 1988), at 459.

<sup>48</sup> See E.D. Schneider & J.J. Kay, "Life as a Manifestation of the Second Law of Thermodynamics" (1994) Vol 19, No 6-8 *Mathematical and Computer Modelling* 25.

<sup>49</sup> For major works on this perspective see Nicholas Georgescu-Roegen, *The Entropy Law and the Economic Process*, (Cambridge: Harvard University Press, 1971); and Herman Daly, *Beyond Growth: The Economics of Sustainable Development*, (Boston: Boston Beacon Press, 1996). For an accessible primer see Andrew Simms, Victoria Johnson & Peter Chowla, *Growth isn't possible*, (London: New Economics Foundation, 2010). For a reader to dig further, see Herman Daly, *Ecological Economics and Sustainable Development, Selected Essays*, (Cheltenham: Edward Elgar, 2007).

they both function in open environments with external energy inputs, whether fossil fuel and harvested food calories for the former or solar radiation for the latter. However, this law indicates that, on the long term, solar energy input and its various derivatives such as the hydrologic cycle and vegetal glucose or its fossilized hydrocarbon by-products, constitute the ultimate limit to humanity's energy supply once geothermal energy is fully exploited.<sup>50</sup> After the glut of fossil fuels is spent, the orthodox paradigm of indefinite socio-economic growth thus faces some clear physical limits because the energy flow into the Earth system is more or less constant.

What the second law of thermodynamics tells us is even more interesting, but it first requires expanding on the notion of system already referred to above.<sup>51</sup> Physical objects, including living organisms, can be thought of as discrete structures differentiated and distinguishable from their surroundings by their persistence in time, however small the period for which they last. These structures are open to interactions with other systems and with the by-products of systems around them. A living organism processes food for energy and absorbs nutrients to replenish the constituent parts of its internal bio-mechanisms. Even a rock absorbs and radiates heat from the sun while rainwater erodes it. Because of these interactions, such persistent open structures are considered systems in dynamic equilibrium. If the dynamic equilibrium loses its balance beyond a point, the structure degrades and ultimately disintegrates. If the rock cannot radiate the heat it continuously absorbs, it shatters or melts, while the organism dies and decomposes without energy input.

These considerations point to a number of significant elements. Firstly, the concept of system encompasses different nested scales, from more or less independent subsystems at macroscopic level like the planets in the solar system, to more closely integrated components at microscopic level like mitochondria, the little sub-cellular power plants providing energy to most living organisms. Secondly, the open nature of systems places the emphasis on their structure, the way matter is ordered within them, rather than on the systems' components which can often themselves be replaced while the system persists. Thirdly, system openness implies inter-systemic interactions embodied by energy flows or transfers of some kind, be it physical, chemical or magnetic. Fourthly, energy must be spent to indefinitely maintain the ordered structure of a system in dynamic equilibrium, which is obvious with respect to both inert objects and living organisms at smaller scales but remains true at larger cosmological scales. Fifthly, the energy to maintain an open system must ultimately come from an extraneous source, as required by the first law of thermodynamics. Finally, the energy source itself can be conceived as a particular ordering of matter resulting

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<sup>50</sup> Some other energy sources must be taken into account. For example, atomic energy could still play a significant role, especially if fusion becomes viable further to technical advances resulting from research such as the Iter project in Europe.

<sup>51</sup> On that notion in general, see Donella Meadows, *Thinking in Systems—A Primer*, (London: EarthScan, 2009) (“System structure is the source of system behavior”, at 188).

from the work of another system, whether it be an atom, a molecule, meat, petrol, sunlight, water impounded by a dam or gravity.

These elements provide a better understanding of the ramifications of the second law of thermodynamics. This law states that interactions between systems through the transfer or transformation of energy is never perfectly efficient; some wasted energy always escapes into the surrounding environment in unusable form never to be recovered. As a result, the overall quality of the available energy stock within a closed dynamic system to power and maintain subsystems always decreases. In other words, the overall disorder, also called entropy, always increases. In addition, the more work is performed—i.e. the more energy is spent—to locally maintain or increase order in subsystems, the higher entropy's overall rate of increase is within the entire system, and the faster the system reaches a state where all the energy left is unusable waste.

In summary, the laws of thermodynamics indicate that maximizing humanity's life span depends on minimizing development to the lowest possible level.<sup>52</sup> The resources and energy consumption required for economic growth implies increasing the scope of, and the order within, the socio-economic system. It also means increasing disorder outside that system by accelerating the transformation of useful energy into useless waste, thereby reaching more quickly the point where the global ecosystem becomes unable to sustain our species.

In this context, the more economic development is refused or denied, the more sustainable development is. The most sustainable development pathway would see humanity turn its back to technology and return to the Stone Age. This radical scenario is both unfeasible and ludicrous, but the considerations suggesting it are unavoidable. They indicate that the legal framework placing the most constraints on development is also the framework that most fosters sustainability.<sup>53</sup>

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<sup>52</sup> According to Nicholas Georgescu-Roegen, *supra* note 46 at 21:

the maximum of life quantity requires the minimum rate of natural resources depletion. By using these resources too quickly, man throws away that part of solar energy that will still be reaching the earth for a long time after he has departed. And everything man has done during the last two hundred years or so puts him in the position of a fantastic spendthrift. There can be no doubt about it: any use of the natural resources for the satisfaction of non vital needs means a smaller quantity of life in the future. If we understand well the problem, the best use of our iron resources is to produce plows or harrows as they are needed, not Rolls Royces, not even agricultural tractors.

<sup>53</sup> Another way of expressing this is that the most sustainable development is the development that leaves most room for nature: David Pearce, "Economics, Equity and Sustainable Development" (1988) *Futures* 598 ("Natural capital augmentation then becomes the only route to sustainability", at 602).

## VIII. EMERGENCE

This section argues that human development would last longest if it did not cross thresholds after which it acquires emergent properties degrading the environment, and before which the human species remains indistinguishable from other species constituting the global ecosystem. The superposition of different disciplines and approaches to tackle this issue may help define or pinpoint problematic thresholds and boundaries more precisely.

Apart from this very simple idea, the perspective adopted in this text might yield another insight relevant for jurists working on sustainable development. Humanity can be considered as a specific subsystem within the planetary ecosystem only after a certain threshold of techno-economic development is crossed. Before that threshold, humanity is indistinguishable from any other species forming, and contributing to the functioning of, the global ecosystem provided that it remains within the environment's natural carrying capacity.<sup>54</sup> For example, excretion from a small nomadic tribe constitutes fertilization integrated into ecosystemic processes, while sewer effluent from a city of ten million inhabitants constitutes pollution that might permanently degrade the environment. A critical threshold is passed somewhere in the continuum between these two extremes.

The notion of critical threshold can be understood through the concept of emergence.<sup>55</sup> Again, reference to physics is helpful to illustrate this concept. One hydrogen atom is composed of a few elementary particles and has specific physical and chemical properties. Taken together, a few thousand hydrogen atoms still have the same properties as a single atom. However, the continued addition of atoms confers new properties to that accretion of matter: at some point, it becomes big enough to acquire a gravitational mass; later still, it becomes dense enough to trigger the thermonuclear reactions that take place within stars; ultimately, it becomes a black hole from which not even light can escape. At each of these stages, a threshold is crossed where the system acquires an emergent property in addition to the properties of its constituent parts; the system becomes more than the sum of its parts. Such emergent properties can be found everywhere: something as trivial as the transition from solid to liquid water at zero Celsius is an emergent phenomenon.

Emergence is not only common in physics but also in many other disciplines, including biological science where defining and delimiting ecosystems require the

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<sup>54</sup> See William Rees, "Revisiting Carrying Capacity: Area-Based Indicators of Sustainability" (1996) Vol 17, No 3 *Population and Environment: A Journal of Interdisciplinary Studies* 195.

<sup>55</sup> See Gregoire Nicolis & Ilya Prigogine, *Self-Organization in Non-Equilibrium Systems*, (New York: Wiley, 1977); Stuart Kauffman, *The Origins of Order: Self Organization and Selection in Evolution*, (Oxford: Oxford University Press, 1993). See Ashley Fulmer and Cheri Ostroff, "Convergence and emergence in organizations: An integrative framework and review" (2015) *Journal of Organisational Behaviour* [in advance on print] for a social-science perspective on the phenomenon.

identification of emergent properties. To some extent, the concept of emergence is problematic. Better knowledge about the constituent parts of a system might explain emergent properties. In that sense, the concept of emergence could be tautological. Yet, it remains useful given the impossibility of perfect knowledge. Emergence helps identify the critical thresholds in human development that should not be crossed for development to remain sustainable.

Moreover, the combination of different disciplines and approaches to tackle issues related to emergent properties may help define or pinpoint problematic thresholds and boundaries more precisely. For example, jurists are unable to scientifically locate thresholds in environmental degradation and define their exact nature with respect to ecosystem function and structure. This requires an approach based on biological sciences, among others. However, the law might facilitate the materialization of these thresholds.<sup>56</sup> The law relies on language, and the mechanisms of symbolic abstractions that they use to describe reality identify and create emergent processes and properties.<sup>57</sup> The 2000 European Water Framework Directive provides a good example of the legal discipline working together with natural science in the context of sustainability thresholds.<sup>58</sup> The Water Framework Directive relies on a classification of different ecological statuses from bad to pristine in order to characterise existing aquatic ecosystems through series of detailed indicators relating to biological, chemical and hydro-morphological elements. The Directive imposes the

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<sup>56</sup> A typical legal tool to materialise a threshold in environmental law is volume control: see Nigel Haigh, «'Volume control' is a tool for contributing to the achievement of sustainable development», (2015) 33:4 *Journal of Energy & Natural Resources Law* 405.

<sup>57</sup> By way of illustration, the *Environment Quality Act*, CQLR c Q-2, s 22, identifies the inflexion point where an emergent property appears: “No one may erect or alter a structure [ . . .or] carry on an activity [ . . .] if it seems likely that this will result in [ . . .] a change in the quality of the environment. . .” As long as a projected activity seems unlikely to change the quality of the environment, the activity is excluded from the regime’s scope. However, as soon as the activity seems likely to change the quality of the environment, the administrative authority in charge can use its discretionary power to block the activity. Thus, section 22 traces a line, or threshold, on a continuous spectrum of activities that range from entirely innocuous to highly destructive for the environment. Once the activity passes the legal threshold determined by s 22, it acquires emergent legal properties that require the promoter of the activity to submit to a complex administrative process designed to maintain environmental degradation to an acceptable level. Yet, whether an activity passes s 22’s threshold is entirely defined by the operation of legal mechanisms because the application of the notions in this provision ultimately depend on traditional rules of statutory interpretation by the courts. In other words, the existence and operation of the emergent property materialised by s 22 rely entirely on the law. For a study of that provision that focuses specifically on the legal thresholds triggering its application, see Hugo Tremblay, “Le pouvoir de déterminer le domaine de l’article 22 de la *Loi sur la qualité de l’environnement*” (2014) Vol 55 *Cahiers de droit* 713.

<sup>58</sup> See *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy* [2000] OJ L327 1.

obligation to improve an aquatic ecosystem's ecological status, that is to cross thresholds defined in conjunction by science and the law.

