Sustainability and Resilience

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Introduction

This article explores some of the main philosophical issues posed by the dominant ways in which current environmental discussions are structured. More specifically, the article examines the conceptual foundations and normative implications of notions of sustainability and resilience and traces the trajectory of their development against the backdrop of traditional ideals of natural conservation and the preservation of biodiversity.

Section "**Humanity's Relation to the Rest of Nature**" shows how notions of sustainability and resilience differ in their justification from ones proposed by moral theories and cultural traditions that view the intrinsic value of nature as an important rationale for moral responsibilities for the condition of the environment. The dominant global discourse among scientists and economists in particular emphasizes the unprecedented anthropogenic causes of global resource depletion and the severity of environmental degradation that limit future human activities, in tandem with an anthropocentric focus on their adverse consequences for human well-being.

Section "**Conservation Goals—The Preservation of What, for What?**" examines challenges to some traditional rationales for natural conservation and preservation of species. Arguments for halting species loss are driven increasingly by the emerging scientific understanding of the functional roles of key species within ecological systems, the global scale of the threat that loss of specific species might have, and the sense of urgency of those threats based on anthropocentric concerns. The shift in the character of these arguments mirrors the dominant patterns of argument in discussions about sustainability and resilience, where matters of systemic impact, global scale, and effect on human ends take center stage.

Section "**Sustainability: Of What, for What?**" examines conceptions of sustainability as they have evolved from the 1987 Brundtland Report, and most recently, the United Nations Sustainable Development Goals (SDGs). From the outset, the global conversation regarding sustainable economic development has been characterized by ambiguity in the understanding of what should be sustained and why, a lack of consensus on how priorities in the potential conflict between the goals of economic development and environmental protection should be set, and divergent moral responses to problems of intergenerational and international justice.

Section "**Resilience: Earth Systems and Environmental Services**" explains the rationale for a partial shift away from the focus on resource depletion to the more fundamental notion of decreased resilience of Earth systems. The central topic involves the threats to the sustainable provision of environmental services, and the conversations are often framed in terms of conceptions of planetary boundaries that define a safe operating space within which the planet remains in a Holocene-like state that can support life on Earth.

Section "**Sources of Environmental Crises: Modernism, Capitalism, and Globalization**" explores some of the sharpest normative fissures within the environmentalist community (broadly construed). Of particular interest are the diverse critics of modernity itself, globalization, dominant models of economic development, or contemporary modes of capitalist production, as well as debates prompted by a group of thinkers who describe themselves as ecomodernists.

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Humanity's Relation to the Rest of Nature

A diverse collection of contemporary authors, including scientists and security experts, economists and environmentalists, and political activists and policy analysts are generating new ways of thinking about humanity's relation to the rest of nature. In itself, the basic thrust of this kind of question is nothing new. These issues are familiar features of the earliest known religious and philosophical texts and staples of various literary genres that emerged more or less simultaneously in Europe and North America during periods of intense industrial development in the late 19th and early 20th centuries. However, the dominant terminology has changed dramatically since the late 1980s, and concepts of sustainability and resilience have been elevated to a central place within the global community of scientists and policy makers.

Anthropocentrism: The Intrinsic and Instrumental Value of Nature

Notions of sustainability and resilience embody a shift from a perspective that differs fundamentally from the normative assumptions that inform the activism of some members of an earlier generation of conservationists and figure centrally in the arguments developed within environmental ethics since its origin as a distinct field within philosophy in the 1970s.

Those activists and academics emphasize the intrinsic value of nature as the primary ground for norms of moral responsibility toward the rest of nature. The intrinsic value argument highlights reasons for caring about the existence of wild nature, preserving species diversity, and leaving substantial areas of the Earth largely beyond the reach and control of human beings (Brennan and Lo, 2016). The rationale is offered as an alternative to dominant justificatory appeals to the instrumental value that human beings obtain from preserving stocks of resources that advance well-being. It is an alternative also to theoretical approaches that emphasize the indirect benefit to humans derived from the knowledge that such areas exist or from the opportunity to experience first-hand pristine nature. Their critique of anthropocentric values as the sole, or primary ground for moral duties with regard to nature also opposes Kantian and virtue ethics approaches that justify a deeply respectful, even reverential posture toward rest of nature by appealing to the moral value that inheres in the dignity or character of human agents who adopt such a posture.

Contemporary philosophers have explored alternative ways of framing intrinsic value arguments, and as a result they have produced greater conceptual clarity and teased out the normative implications of each formulation. Nonetheless, the defense of nonanthropocentric values as the ground of moral obligation has proved challenging. Whatever prominence intrinsic value arguments retain in academic philosophy, or however much they figure in the motivations of some conservation activists, such arguments play only a marginal role in discussions of environmental issues within most scientific and policy circles.

Debates about sustainability and resilience in particular contain only isolated remarks about the importance of preserving wild nature or nonhuman species as something worth doing because of the inherent value of nature itself. When questions are raised about the sustainability of resources and the resilience of Earth systems the overwhelming emphasis is upon the magnitude of potential human impact on nature, but ultimately, the potentially catastrophic consequences affecting the future of human life itself and the quality of human life that will be possible.

This anthropocentric orientation, together with a companion emphasis on the anthropogenic causes of nature's destruction, is evident, for example, in the sustainability literature where references are made to material nature as stocks of resources necessary to support a certain quality of life for a rapidly growing population of human beings. Similarly, within the resilience literature the importance of maintaining Earth systems is framed in light of the essential role they perform in the provision of environmental services that ensure the persistence of a planet capable of supporting human life and the kinds of human endeavors that many have come to expect as the moral entitlement of our species. As discussed in the section "**Conservation Goals—The Preservation of What, for What?**," the dominance of this way of thinking about the relationship of humanity to nature is evident even in discussions of how to set priorities for preservation of biodiversity.

Two Natural Limits: Resource Depletion and Systemic Degradation

An implication of the current emphasis on nature as a source of resources and services is the identification of two highly significant natural limitations on human activity. There are natural limits on sustainable resource extraction and depletion undertaken for the sake of satisfaction of various human ends, and there are natural limits on the resilience of Earth systems and its ability to absorb and adapt to the systemic environmental degradation caused by human production and consumption.

Reflections on the increased salience of these natural limitations typically are informed by three additional normatively important assumptions.

First, there is a growing recognition of the systemic character of many environmental problems. Issues once viewed in isolation, such as species loss, are no longer assessed solely as a discrete environmental challenge but as components of a larger, more fundamentally troubling pattern of ecological dysfunction.

Second, there has been a fundamental shift in the way the scale of many environmental issues is conceptualized. Instead of highlighting the local or regional locus of environmental challenges, many of the most critical concerns now have to do with resources that are sustainable on a global scale, available for humanity as a whole, and the kinds of environmental degradation that is planetary in its impact. The relevant moral questions are less about what should be done here and now for the sake of one

adversely affected, geographically discrete community and more about what should be done everywhere and forever for the sake of humankind.

Third, there is greater awareness of questions pertaining to the human ends at stake and the morally appropriate response to the natural limitations of human activity in light of these ends. For example, the primary concern for sustainable resources, resilient environments, and biodiversity might be for the sake of the long-term prospects for the global expansion of economic development, meeting the needs of future generations, securing the well-being and human rights of the global poor, or serving some grander vision of the human project. The balance of arguments therefore often turns on judgments—explicit or implicit—of which of these human ends should be given the greatest normative weight.

In short, the dominant framework for public deliberation sees environmental problems as more salient to the extent that they constitute systemic ecological threats, and more pressing to the extent that they arise on a larger geographic scale, and meriting higher priority in proportion to the weight of the human ends at stake.

Conservation Goals—The Preservation of What, for What?

An instrumentalist approach that is systemic, global, and anthropocentric is relatively new, but there are many plausible reasons to care about the conservation of nature, and in particular the preservation of biodiversity. Traditional arguments assume that species diversity and the conservation of nature is in itself an important end, apart from any human end it might advance. For example, we might think that other things being equal, World A with more species diversity and more richly varied exemplars of abiotic nature is better than World B where there is less diversity. However, skeptics will ask, better for whom, and why? Would a world with more viruses, parasites, and bacteria be a better world, especially in light of the fact that it causes more diseases and suffering in humans and animals? Would a world containing more varied natural rock formations be better even if these abiotic features are so remote that few if any people will ever see them or the persistence of no life form depends on their existence?

Ideals of an Earth rich in variety, pristine and pure, often rest on an esthetically appealing conception of nature, whole and undiminished. Increased extinction rates for species might be a particular source of concern beyond esthetic reasons if the argument for preservation rests on the ancillary premise that there is a scientific fact of the matter about what constitutes a whole and undiminished natural world. However, a central tenet of evolutionary theory is that the natural world has never been and never will exist as a static, self-regulating state, forever reproducing itself. The natural history of the world is one in which species come into existence, die out, and others take its place. Nature is dynamic, its life forms are in constant flux, and it is an error to suppose that the one temporary ecological state, seemingly in balance, is the predetermined condition among all equilibrium points that is optimum and enduring (Powell, 2010).

Still, it is not irrational to mourn the blight that devastated the American Chestnut trees, even though the best available evidence suggests that the overall forest health in the mid-Atlantic region of the United States was not thereby diminished. The same general point holds for the desire to preserve native plant species within a locality. There are very good reasons to worry about certain nonnative plants, like the ubiquitous kudzu (which initially conferred an ecological advantage in the prevention of erosion but soon began to choke the life out of every other living plant) but what counts as native and nonnative is not fixed. It is dependent on the choice of time frame. The natural state of all species involves the process of translocation and hybridization. Species once isolated in one geographic area disperse only to reappear or re-concentrate elsewhere, often in more hospitable ecological conditions. In addition, the ability of species to interbreed with closely related members of a genus and produce new hybrids is greater than once supposed.

The facts about the dynamic character of nature are crucially important for conservationists to consider. Its conservation efforts are motivated by a commitment to the value of biodiversity on Earth then the aim of preserving existing species and their current geographic distribution might be counterproductive. Biodiversity often depends on increased translocation of species and accelerated processes of hybridization. In short, whatever reasons local communities have for preserving an existing local ecological niche and the species found within it, it is not necessarily valuable for its contribution to the overall aim of preserving biodiversity on Earth.

The question then becomes, why care about biodiversity on a global scale? Conservationists often note with alarm the International Union for Conservation of Nature's Red List Index, which as of 2015 identifies over 23,000 species of plants, fungi, and animals that face a high probability of extinction. One answer given by some conservationists for adopting a global perspective is that the more fundamental environmental end is ecological system health. On this view, systemic concerns trump species-level concerns, global concerns trump local concerns, and arguments about the comparative importance of preserving particular species turn on the consideration on human priorities.

Biosphere Integrity: Genetic Diversity, Functional Biodiversity, and Bioabundance

A key reason that biodiversity matters on the instrumental view just described is that it is an important indicator of ecological health. Concern for biodiversity, measured by extinction rates, is part of a more general conception of ecological health known as biosphere integrity. Also, within this comprehensive approach genetic diversity is viewed as more fundamentally important for ecological health than preserving the number of existing species. The reason is that genetic diversity offers a kind of insurance policy against threats to all life forms and therefore plays a central role in maintaining the overall functioning of an ecological system.

Extinction rates, however, merely serve as a proxy for assessing the state of genetic diversity. In principle, more species might mean greater genetic diversity, but because so many species share the alleles from a common gene pool they might be genetically redundant. However, given the uncertainty in understanding the link between species diversity and genetic diversity a focus on preserving species diversity and attending to extinction rates might be the best practical strategy.

Another consideration is central to an instrumentalist approach to conservation. There are reasons to focus on the preservation of certain species rather than the absolute number of species. The underlying idea is that some species play a more fundamental role in preserving ecological functioning. This view is known as the keystone hypothesis. As we move upwards in scale to large regions, and even to the planetary scale, an overarching interest in preserving the proper functioning of whole ecological systems provides grounds for differentiating between the functionally valuable keystone species and species that are functionally marginal. So in addition to the goal of preserving mere numerical inventories of species (and perhaps better prospects for genetic diversity), the instrumentalist approach recognizes strong reasons to prioritize the preservation of functional diversity in deciding what to preserve.

In addition, another kind of loss that matters instrumentally for the sake of systemic functioning is bioabundance. Defaunation, or the loss of abundance of members of species, especially among the functionally important keystone species, is in itself a threat to overall ecological health. Preserving a few rare birds, for example, may have enormous esthetic value (and possibly instrumental value for ensuring genetic diversity), but their importance for the sake of overall ecological health depends on whether there are enough members of the species or their functional equivalents to perform their vital ecological function.

In short, the ideal of preserving any and all species, without differentiating the systemic functional role they play, especially at the planetary scale, or without attention to the degree to which species diversity is a useful marker for the more basic concern of preserving genetic diversity. The instrumental approach does not view the absolute numbers of species preserved as the decisive consideration in answering the big question for conservationists: what to preserve, and why? To the extent that systemic concerns about ecological health, and judgments about the importance of scale for biosphere integrity gain prominence in conservation thinking, there are prima facie reasons to prioritize preservation efforts on the basis of what sorts of biotic loss pose the greatest threat to the kind of environment that sustains human and other forms of life.

Sustainability: Of What, for What?

The origin of the global discussion of sustainability ideals is the 1987 Brundtland Report, popularly named for the chair of the World Commission on Environment and Development sponsored by the United Nations (WCED, 1987). The context in which the concept of sustainability entered the conversation was marked by the growing awareness of threats to the environment caused by the pursuit of economic development and accumulating evidence of its adverse impact on land, water, and nonrenewable resources. Sustainability as an environmental ideal poses a structurally similar question to the one that conservationists face: what should we seek to sustain, and for the sake of what ends?

In one sense, the Commission's answer to the question of what should be sustained is obvious: the overarching aim is sustainable economic development. The most general and widely quoted definition of sustainable development also articulates an answer to the companion question regarding the underlying ends: "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, p. 45). The Brundtland definition of sustainability thus highlights normative concerns about intergenerational justice. Intergenerational justice arguably took top billing inasmuch as the Commission's charge was motivated by a growing awareness that rapid economic development, while vitally important for the sake of advancing the well-being of current generations, poses long-term threats of resource depletion and environmental degradation, which in turn, threaten the ability of future generations to experience the gains in material well-being that the global poor so desperately need.

However, the Brundtland definition did not settle decisively either the question of what should be sustained or why. The problem is that it gives co-equal attention to economic, social, and environmental sustainability, and in doing so it offers no clear guidance for how each aim should be weighted. On the one hand, it extolls the virtues of rapid economic development for the sake of poverty relief and the improvement of the global standard of living. To this end, it called for a 5–10 fold increase in economic growth. On the other hand, it highlighted the urgency of the growing problem of resource depletion and environmental degradation. Also, the concept of social sustainability is open to a wide range of interpretations, thereby complicating the problem of assigning weight to competing aims. The three pillars approach, as it is known, therefore did little to advance the resolution of the central tension between aims of economic development and environmental preservation that motivated the creation of the UN Commission.

Even the concept of environmental sustainability in the Report is open to multiple interpretations (Beckermann, 1994). Given that the need for setting limits on current resource extraction and depletion for the sake of preserving enough to meet the needs of future generations is the normative centerpiece of its definition it is unsurprising that the emphasis is on the sustainability of stocks of ecological capital. The notion of ecological capital is broad enough to encompass a wide range of resources essential to the well-being of future generations. It can be interpreted as including both nonrenewable natural capital (e.g., oil and minerals) and the kinds and quality of renewable resources (e.g., clean water and food sources) that are necessary to sustain a comparable standard of living or comparable set of opportunities for future generations.

However, if the ecological capital approach is taken to be the centerpiece of concern for environmental sustainability, then the paramount end of sustainability is the advancement of human well-being across the generations. If a standard of living is the ultimate end of sustainable development, then it is uncertain how much attention should be paid to sustaining resources of any specific kind. Beyond knowing that future generations will require food, water, energy, and other basic features of an environment that can support life and health, there is little basis for guidance in striking the balance between consumption that meets the needs of the current poor and investment in programs designed to meet the needs of future generations. Some resources needed now might be superseded by new technology, but it is highly speculative for societies to tailor current consumption patterns with the aim of leaving enough for the future.

Moreover, the stated ends of sustainable development are not limited to the concern for intergenerational justice that is highlighted in the Report's definition. In fact, a great deal of rhetorical emphasis is placed upon what the Commissioners took to be pressing problems of international justice. For example, the Report's discussion of the concept of human needs stresses the importance of changing current practices in order to give priority to meeting the essential needs of the world's poor. Of particular note is the fact that its assessment of the plight of the global poor is prefaced with the moral judgment that the industrial world has already used much of the planet's ecological capital and that the unequal appropriation of ecological capital is the planet's "main environmental problem" and its "main development problem" (WCED, 1987, Overview, paragraph 17).

While the emphasis on international justice in Brundtland is secondary to its discussion of intergenerational justice, the way it frames interstate issues points to how the Commissioners thought about the issue of scale. Clearly, it had in mind the importance of ensuring that all persons, now and in the future, have sufficient resources necessary to meet their essential needs. Sustainability was not cast as an aim of particular nations with respect to their own citizens, or as an aim of cities, private enterprises, or as a goal for communities to husband whatever resources they have at their disposal. Both the intergenerational and the international issues of justice point to concerns about maldistribution, rather than concerns about efficiency, or the need to make better use of the distributive shares of resources that states, communities, or private entities happen to have under their control.

Moreover, despite its obvious anthropocentric emphasis the Report contains some language suggestive of a somewhat wider rationale for their concern for environmental sustainability. Beyond leaving nature sufficiently intact in order to save enough resources for the sake of future human populations the Report recommends that a "first priority is to establish the problem of disappearing species and threatened ecosystems" (WCED, 1987, chapter 6, paragraph 57). A nonanthropocentric rationale for that priority is articulated in the observation that "the case for the conservation of nature should not rest only with development goals. It is part of our moral obligation to other living beings and future generations" (WCED, 1987, chapter 2, paragraph 55). The assumption seems to be that leaving room for the rest of nature also matters, although not as centrally as intergenerational and international justice concerns.

Sustainable Development Goals

A recent United Nations Resolution endorsed 17 SDGs and 169 targets for their implementation (UN, 2015). The resolution was based upon a 2015 UN Commission report, *Transforming our World*: *The 2030 Agenda for Sustainable Development*. The Commission's Report and the Resolution identify the eradication of poverty as the greatest global challenge, and they describe that aim as an indispensable requirement for sustainable development. The relation might have been more plausibly stated the other way around in the way the issues of Brundtland are framed. One might think that sustainable development is valued as an indispensible requirement for poverty relief if the assumption is that the primary reason to care about sustainability is human well-being. That said, the link to Brundtland is memorialized in the Resolution's commitment to "achieving sustainable development in its three dimensions—economic, social, and environmental—in a balanced and integrated manner." However, the Resolution, including its preface, the overview of the purposes of the SDGs, and the specifications of the targets reflect several normatively significant departures from Brundtland.

First, Brundtland's admittedly modest nod to the importance of preserving biodiversity for the sake of nonhuman animals is absent in the SDGs. Instead of addressing the interests of nonhuman animals directly, the UN Resolution articulates a vision best described as a conception of a well-lived human life in relation to the rest of nature. It speaks of a world "in which humanity lives in harmony with nature and in which wildlife and other living species are protected." The linguistic shift from Brundtland is subtle and ambiguous, but it is notable that there is no straightforward reference to any nonanthropocentric grounds for preserving nature or leaving room for the rest of nature. The document adopts a decidedly instrumentalist, anthropocentric approach.

Second, while the commitment in the Brundtland definition's to meeting the essential needs of current and future generations is reaffirmed, the new Resolution does not highlight the existence of distributive considerations of intergenerational fairness. It speaks of human rights generally, but the importance of saving resources for future use is no longer the definitional centerpiece. The potential conflict of generational claims on resources is thus glossed over, and the task of securing human rights is cast largely in terms of a managerial approach, promoting "sustainable consumption and production, sustainably managing its natural resources."

Third, unlike Brundtland, neither the text of the UN resolution nor the report on which it is based, contain any mention of issues of fairness in historical patterns resource consumption at the global scale. There is no mention of past consumption and no mention of the growing global competition for scarce resources that potentially pits the essential needs of the global poor against the desire for resources that are used to sustain the lifestyles of the global affluent. Goal 10 does call for "reducing inequalities in income, as well as those based on sex, age, disability, race, class, ethnicity, religion, and opportunity—both within and among

countries." However, the primary mechanisms for the achievement of that goal are increased trade, a shift from agriculture to industrial production within less developed nations, and a more orderly system of worker migration and employment opportunity. Moreover, there is no mention of whether the current organization of the global order raises issues about the fair distribution of the environmental burdens of resource extraction and industrial production.

Fourth, the list of 17 goals and 169 targets reflects a decentralized perspective on achieving sustainability and a retreat from thinking about universal access to resources on a global scale. It notes at the outset that the primary responsibility for sustainable development and poverty relief rests with sovereign states, and that if the SDGs are to be achieved all nations will need to build them into their national policies and plans. While the Resolution discusses the SDGs with reference to the responsibilities of the developed nations (and the private sector), the emphasis is placed on strategic recommendations for international aid and public-private partnerships designed to facilitate the internal development objectives of less developed nations. Of special importance is the role that policies promoting international trading relationships can play in tandem with policies aimed at state capacity building. For example, state capacity for improvement of education, management of water resources, marine reserves, forests, and public health, sanitation, and energy delivery systems.

The upshot is that the evolution of the concept of sustainable development from Brundtland to the SDGs retains the three pillars approach, but the accent on economic sustainability is more pronounced. Unlike the original emphasis of Brundtland, sustainability in the SDGs looks more like a synonym for the aim of more efficient use of whatever resources states and localities happen to have than a prompt for reconsideration of more basic normative issues of fair distribution of resource access and the benefits and burdens of resource extraction and consumption. It is less explicitly concerned about fairness or distributive justice across generations and nations. While the Resolution adopts a comprehensive approach that recognizes the systemic interdependence of resources such as food, energy, and water, it nonetheless reflects a return to a scale of interest in sustainability that is less global and more localized within the boundaries of nation-states. It is focused on how less developed nations can more efficiently tackle their own problems of poverty relief through a mix of better resource management, more economically beneficial forms of foreign trade, and international aid directed toward state capacity building.

Resilience: Earth Systems and Environmental Services

The UN Resolution ratifying the SDGs prefaces its list of goals and targets with a sweeping statement of its "vision" of the world. While poverty relief and human rights take top billing, it does envision a "world where human habitats are safe, resilient, and sustainable" and it identifies existing patterns of production and consumption and the environmental degradation from development as the main threats. Resilience (like sustainability) is left undefined in the Resolution, and as a consequence a question that arises is, resilience of what, to what?

In the run-up to the UN adoption of the SDGs a number of scientists offered some suggestions about how to think of resilience and its relation to sustainability (Griggs et al., 2013). Their proposal advocates moving beyond the unranked three pillars approach of Brundtland by prioritizing some key environmental concerns. Specifically, they argue for the fundamental importance of maintaining the resilience of Earth systems that regulate the planet's ability to function within the boundaries that have characterized the 10,000 year Holocene period. Their proposal for revision of the Brundtland approach is motivated by a belief in the paramount need to safeguard the Earth's life-support systems, and moreover, by a belief that it is important to assign that goal top priority within a much shorter list of goals than the UN ultimately approved.

The reason for their proposal is that the stable functioning of Earth systems is a prerequisite for a thriving global society, and the seriousness of the threat is of such urgent moral salience that a lengthy list of worthwhile goals risks the loss of practical focus. Moreover, they argue that the UN's own headline goal of poverty reduction cannot be achieved by better management practices alone, or by a scale of response in which individual states are expected to act on their own within the parameters of the current global framework. In particular, without changes to the global "economic playing field any near-term advances in development will be lost as our planet ceases to function for the benefit of the global population."

The proposal to prioritize the environmental goal of preserving the stable functioning of Earth systems is grounded in recent theoretical work on the resilience of ecological systems (Brand and Jax, 2007), and more specifically the concept of planetary boundaries (Rockström et al., 2009).

Conceptions of Resilience

Resilience in the generic sense refers to the capacity of any complex system to absorb both internal and external disturbance and retain the same structure and function. Resilience thus understood is a capacity that is possessed by systems as diverse as ecosystems, social systems, or economic systems. For an understanding of how the term is used in the context of environmental sciences, the question then, becomes "resilience of what, to what?"

The resilience of any system, including an ecological system can be assessed on multiple scales. The health of an ecological system can be assessed on a scale as small as a shallow lake. With one nutrient load a lake might persist in a stable clear water state with aquatic plants, while under a different nutrient load it would persist in a turbid state without vegetation. In either case, the ecological state is resilient if within a defined set of chemical boundaries it can absorb disturbances in its nutrient balance without significant alteration of its structure and functioning. Ecological resilience is thus in this instance defined in purely descriptive

terms. The scientific task is to quantify the boundaries within which identifiable disturbances can exist without the system undergoing transformation to another state.

However, purely descriptive conceptions are of limited practical value. The relevant notion of ecological resilience employed for many research purposes is one that builds in some notion of the state that should be preserved. In the example of the shallow lake, the point of scientific interest lies in the preservation of a resilient clear water state. Accordingly, the task is to quantify the boundary conditions of nutrient loads that define the parameters of a safe operating space where the ecological system is strongly resistant to transformation to the turbid state.

Within environmental policy contexts planning agencies often speak of resilient socio-ecological systems, for example, the need for resilient coastal cities. The design of resilient coastal cities involves a variety of potential strategies that preserve the structure and function of these complex social systems. Typically, the aim is to provide protection from both the natural disturbances of regularly occurring extreme weather events and sea level rise associated with anthropogenic climate change. Resilience planning for cities not only involves engineering changes to the built environment (e.g., levies and sea walls) or retreat from building in low-lying areas, but implementation of emergency preparedness plans and creation of well-coordinated evacuation routes.

Ecological resilience, in contrast to extended definitions of resilience that include socio-ecological entities such as cities and economies, is applied to natural systems, including, of course, an accounting of the anthropogenic disturbances it can withstand. The concept of ecological resilience is exhibited not only in smaller scale contexts such as lakes, agricultural landscapes, and glaciers, but also at the scale of planetary systems. Resilient Earth systems are ones that can absorb internal and external disturbances and remain within a safe operating space. A safe operating space for the planet is the environmental envelope that is known to support human life and the kinds of human activities that allow contemporary human populations to thrive and flourish (Steffen et al., 2015). Resilient Earth systems, thus defined, build into its definition a conception of the ends sought to be achieved. It is from this defined end that scientists seek to quantify safe operating spaces for a number of Earth system processes that are essential to protect against transformation in order to ensure that the Earth does not veer away from the Holocene-like condition.

Planetary Boundaries

The application of the concept of ecological resilience to a planetary scale reflects an underlying concern that current patterns of human activity are creating an elevated risk of substantially altering nine crucial Earth system processes in ways that undermine the essential conditions that support life. The task of ensuring safe operating spaces for these nine processes begins with an effort to quantify planetary boundaries for each, within which there is a comfortable margin of operation—not a threshold that marks the tipping point of transition to another state—such that the functional conditions that have characterized the Holocene era are preserved.

The planetary boundaries for the nine critically important processes include metrics of stratospheric ozone depletion, ocean acidification, atmospheric aerosol loading, the amount, distribution and balance of energy at the Earth's surface that regulates climate, biosphere integrity (discussed in the section "**Conservation Goals—The Preservation of What, for What?**"), freshwater use, land-system change, biogeochemical flows (e.g., nitrogen and phosphorus flows), and novel entities.

Recent estimates conclude that four of the nine critical Earth systems exceed the planetary boundaries that have been established for each (Steffen et al., 2015). These include the climate system, biosphere integrity, biogeochemical flows, and land-system change. Transgressions of planetary boundaries for two of these systems—the climate system and biosphere integrity—are particularly worrisome for two reasons. First, large changes in either, on their own, are sufficient to cause serious adverse effect on human well-being. Second, because they are highly integrated with other systems they have the potential to alter these other systems in ways that predispose them to boundary transgression. For these reasons, recent research has resulted in the identification of these two systems as core planetary boundaries. They are considered core boundaries in the sense that preserving a safe operating space for each is assigned the highest priority.

Unquantifiable Risks

The planetary boundary approach not only seeks to identify the critical planetary systems but to quantify the boundary conditions that constitute a safe operating space for each. However, the task of quantification is complicated by various factors that have considerable normative significance. Two factors are particularly noteworthy.

First, for some crucial Earth systems there are no quantifiable boundaries of safe operating space. This is the problem that complicates the task of understanding the tolerable effects of novel entities. Novel entities are new substances or new forms of existing substances that have the potential for unwanted geophysical or biological effect on the functioning of the planet and ultimately, on human health. The identification of novel entities as a special concern arises in response to the fact that there are now approximately 100,000 such substances in global commerce, which were introduced into the Earth systems mostly since the end of World War II. These substances are in addition to other novel entities such as nanomaterials, plastic polymers, and engineered organisms. The chemical intensification of the planet is included as a crucial concern in the planetary boundary approach because of the potential for these entities to persist in the environment, their wide distribution on a global scale, and their demonstrated potential to effect the functioning of other Earth systems.

The normative upshot is that the theoretical possibility of threats to resilience of Earth systems from chemical intensification is treated as sufficient reason for a precautionary approach. Just how that prescription for precaution should be translated into science policy and industrial practices remain uncertain and deeply contested (Powell, 2010). Nonetheless, novel entities earn a place in the approach because of their systemic effects and interactions, global scale of diffusion, and magnitude of potential harm to people and the planet.

Geographic Decoupling of Cause and Effect

Second, quantification is complicated by the fact that planetary boundaries are highly sensitive to transgression as a consequence of regional scale activities. For example, changes in land use (e.g., forest to cropland) can influence climate far beyond the region in which land-system change occurred. Similarly, changes in regional biogeochemical flows—for example, changes in the phosphorus and nitrogen flows due to agriculture intensification—can alter the balance of flows globally, which already exceed a key planetary boundary set for biogeochemical processes. The scientific uncertainty lies in the difficulty of quantifying these interactive effects.

The normative upshot of such interaction is the creation of environmental problems characterized by adverse effects that occur far from the site of their causal origins. The decoupling of the geographic sites of cause and effect is normatively problematic for several reasons. It poses a challenge for the hope that self-interest will serve as an effective motivational impetus for remedy and prevention of the harm caused by human activities. The geographic decoupling also poses a challenge to effective governance. The political challenge in less complex, less interdependent societies was to deal with environmental impacts that were largely local and transitory. Now there is a serious mismatch between the systemic character and planetary scale of environmental problems and the local scale and fragmented character of problem solving capacity that is distributed among separate sovereign political entities. Climate change is one such example, but the planetary boundaries approach, with its recognition of how regional and planetary effects interact reveal a richer array of environmental problems in which locus of cause and effect are decoupled in normatively significant ways.

Sources of Environmental Crises: Modernism, Capitalism, and Globalization

The root causes and potential remedies of the extraordinary anthropogenic impact on the rest of nature are matters of intense disagreement. The depletion of both renewable and nonrenewal resources and the environmental degradation produced by patterns of production is sometimes traced to the technology, social ethos, and institutions that characterize modernity. Colonialism dating from the 16th century, made possible by ocean travel, changed the scale of human activity and its impact. The industrial revolution since the 18th century expanded the technological repertoire of human societies, and with it the range of distantly available resources required to support human societies. The emergence of global markets in the 19th century expanded the geographic scope of resource extraction, and the parallel ascension of global capitalism led to the proliferation of products that often improve human well-being, but always reconfigure human appetites for consumer goods.

The post war period from 1945 to the present marks a particularly important turning point. In this period known as the Great Acceleration the world's population doubled and the global economy grew by more than 15-fold. Both trends intensified the pressure on the global environment and precipitated global conversations about the sustainability of resource use and the resilience of the Earth in the face of environment degradation.

Demographic Decoupling of Benefit and Burden

The Great Acceleration brought about other important changes that are normatively important. The decoupling of the site of origin of environmental harm from the site of its impact was one such change, but it has been accompanied by another form of decoupling. The locus of resource extraction and industrial production, where much environmental damage and resource depletion occurs, is increasingly concentrated in regions of the world that are home to many of the global poor, while the site of most consumption is home to most of the global affluent. The distribution of the benefits of modern technology is therefore decoupled from the distribution of its environmental burdens (Wiedemann et al., 2015).

The distributive implications of both decouplings raise issues of justice that often are not highlighted by discussions of the impact of human activity on the rest of nature. Too often the impact of interaction between the global poor and the global affluent is not registered in many discussions of human activity in the age of the Anthropocene. The Resolution that created the SDGs is one prominent example of this omission.

However, not all discussions of globalization and its adverse impact on the environment ignore the decoupling of benefits and burdens of production and consumption or the decoupling of locus of cause and effect (Wackernagel and Silverstein, 2000). A familiar theme in environmental politics is the role of current forms of capitalist organization, with its built-in incentives for firms to search the world for natural resources and new labor pools, to extract resources and produce consumer goods as cheaply as possible, and externalize social costs, especially the burdens of environmental degradation. For some observers, the proximate cause of both resource depletion and environmental degradation resides in the systemic nature of how capitalist economic systems operate.

By contrast, an alternative diagnostic approach argues that the state of current environmental crises is a systemic problem, but one that transcends any specific form of economic organization (Alperovitz, 1995). On this view, the pro-growth ethos of modern societies is not strictly an artifact of the current global capitalism, but an inherent feature of the institutional architecture and power relationships found in many socio-ecological systems. Both socialist governments and traditional autocracies mirror the internal dynamics of modern capitalism in key respects. They perpetuate and magnify materialist aspirations among the social and economic elites, generate hierarchies of consumption and envy, and offload the environmental burdens of production and extraction on future generations and the most vulnerable, least powerful of their contemporaries.

Ecomodernism

All of the efforts to diagnose the main causes of the environmentally self-destructive path of humanity are met by counterarguments from a more optimistic view known as ecomodernism, or alternatively, as ecopragmatism. The position is developed in detail in *An Ecomodernist Manifesto* (Asafu-Adjaye et al., 2015). Ecomodernists call for two different forms of decoupling. If the problem (as they put it) is leaving room for the preservation of nature, they argue that societies need to decouple consumption from the drawdown of natural resources and decouple the footprint of human societies from much of the Earth's surface by concentrating populations in urban centers. The ideal of living in harmony with nature—if that means living in close proximity to and exercising responsible stewardship of its resource bounty—should be replaced with an aim for humanity to liberate itself from dependence on nature. The ecomodernist hope is that the price of well-being, defined as a high material standard of living, need not be the sacrifice of the rest of nature, and that with appropriate technological fixes, the global poor can be liberated from both material poverty and the misery of dangerous and grueling work that currently sustains the lifestyles of the global affluent.

An important part of the ecomodernist argument is that there is no viable alternative. Human societies, they argue, will not be willing to accept the return to a romanticized, preindustrial existence. Optimism regarding the prospects for finding new technologies to cure the problems created by old technologies is thus seen as an attitudinal imperative if environmental crisis and the associated problems of intergenerational and interstate justice are to have any serious chance of resolution.

The ecomodernist prescription is open to various counterarguments. It places too much faith in the technological approach that led to the current crises and valorizes a lifestyle of material consumption that should be rejected for other reasons. It offers false hope to those who bear the greatest burdens of supporting lifestyles that are unsustainable on a planet made less resilient as a result. Until the realization of the ecomodernist's utopian vision, the calculus of environmental triage will continue to result in sacrifice zones, located wherever the poor and the powerless are clustered. Moreover, the critics argue that the ecomodernist proposal for living apart from and beyond dependency on the rest of nature is not a prospect that most of humankind is likely to find attractive or feasible.

One thing that transcends the divide between most ecomodernists and most of the critics who are less optimistic about the consequences of business as usual is the recognition that many of our challenges are systemic in origin and effect, arise on a global scale, and put into contention a range of competing human ends.

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