Next System Essay 2016

by

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Paradigm Tectonics: Embracing the Laws of the Natural World

There is only one system. Nature designed it. The "next system" is the current system, the prior system, the only system. It is our life-support system, a system unique in the known universe. It is the system that defines everything that humans are and are not able to do on Planet Earth.

This essay is concerned with breaking through the boundaries of the current dominant paradigm of global civilization and its view of "the system." After many decades, even centuries of effort,[1] it should be readily apparent that prevailing assumptions cannot save us from widespread environmental destruction; its poster child, global warming; and the passel of resultant adverse consequences listed in the guidelines for this essay.[2] When we solve our problems of living within the limits of the natural world, we solve many other problems as well. What is in question here is not the specifics of what we do or don't do, what is in question is *the context - the paradigm - that guides us.*

The next human system, therefore, is not properly expressed by a litany of actions, it's a set of guidelines that enables choices for peaceful and sustainable living on earth. We have an opportunity, even at this late date, to recreate a golden age.[3] The next system, therefore, represents a transformation of how we humans view our relationship with each other and with all other life on Planet Earth.

The elements of such a system are currently in existence and readily available everywhere, wherever there is a habitat that enables human groups to survive. These elements are inexpensive, low-tech, generally available locally, combine traditional and modern knowledge and skills, and, while there is always much to learn, are currently understood well enough to implement at appropriate and necessary scales (please see Appendix). Unfortunately, existing effective solutions and their implementation are invisible to a dominant culture obsessed with

[1] For overviews of the history of environmental destruction and its consequences, see, for example, Carolyn Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution*, Harper & Row, 1983. See also Jared Diamond, *Collapse: How Societies Choose to Fail or Succeed*, Viking, 2004. The word "Choose" in the title is questionable, since societal collapse is primarily a function of unknowingly violating laws of nature, not political "choice."

[2] Poverty, inequality, racism, climate change, environmental collapse, police brutality, mass incarceration, gender disparities, expropriation, corporate power, class divisions, unemployment, militarism and war. This list is, of course, incomplete, as humans are infinitely creative in creating problems.

[3] A "golden age" may be defined as a time of abundance, before exceeding eco-system carrying capacity. That is, when resources are consumed faster than they are regenerated, leading to scarcity and conflict among individuals, groups and societies and consequent ills such as those listed in footnote 2.

technophilia, centralized leadership and concentration of wealth. This is characteristic of complex societies throughout history, by no means peculiar to modern globalization.

What we do is an outcome of our prevailing paradigm. *The challenge is not what to do, it's how to think.*

Introduction

While struggling through years of activism, I searched for answers to our chronic problems living within the natural world. I pursued readings in archaeology, anthropology, and history as well as studies in biological sciences, and slowly arrived at some understandings of how the natural world works and our human place within it. I've been driven by wondering how I and so many others repeatedly engage in the same activist strategies over and over again, while the strange logic of large, complex societies continues to dominate. As corporate anthropologist Jane Anne Morris articulated so eloquently in "Help, I've Been Colonized . . . "

> Our campaigns follow the gambling addiction model. The last bet didn't pay off but the next one might if . . . if . . . if we just had a new, improved tripod, three more experts, more labor or church support, ten more elected officials on our side, a hundred more people at the demo, or a thousand more letters in the mail . . . Who are we kidding? We are just doing the "same old thing" over and over again and fooling ourselves that it might work next time.[4]

The "same old things" clearly are not working. Why?

The answers are complex and difficult - not because of inherent difficulty, but because the insinuations of culture are so deep and our assumptions so intractable. Consequently, even when something "revolutionary" comes along, from the Tea Party to Occupy Wall Street, erroneous and often invisible assumptions prevent our understanding of the natural forces at play, no matter our political stripe. To see more clearly we must look far beyond the boundaries of prevailing culture.

First Principles

1. *We are all creatures of the natural world, and are subject to its inviolable laws.* We cannot defy gravity; we cannot live longer than our maximum lifetimes; we cannot live without food, water or air; we cannot continue to exist collectively without reproducing. All of this should be readily obvious.

2. *Exponential growth is built into living creatures.*[5] That is, any population will expand at accelerating rates until it hits its limits to growth based on energy (food) availability and other limiting factors, at which point it will decline (temporarily or permanently). Depending on the rate

[4] Jane Anne Morris, "'Help! I've Been Colonized and I Can't Get Up . . . ' Take a Lawyer and an Expert to a Hearing and Call Me in a Decade," in *Defying Corporations, Defining Democracy*, Dean Ritz, ed., Apex Press, NY, 2001.
[5] For an excellent explanation of how exponential growth works in societies on the road to collapse, often in ways that are not obvious, see Albert Bartlett, "Forgotten Fundamentals of the Energy Crisis," http://www.npg.org/specialreports/bartlett_section2.htm, and his most entertaining video presentation, https://www.youtube.com/watch?v=e_VpyoAXpA8.

of expansion and the nature of the limits, the subsequent die-off may be partial or total for a given species in a given area.

Note: The endless growth that progressive activists often bemoan - and reasonably so - is *not* an unnatural function of misguided western consumerist civilization, it is a fundamental characteristic of life on earth. So too are the opposing factors that eventually reverse or stop growth in its tracks. Unlike gravity, however, unrestrained growth is a law amenable to human decisions, and not inevitable.

3. *Living creatures often exceed local carrying capacity and work to expand it.*[6] This pattern occurs in virtually all cultures and all environments throughout the world, as far back as we can see (since the end of the last ice age in some detail, thanks to archaeologists and anthropologists, et al.). We support ourselves, as hunter-gatherers, pastoralists or agriculturalists, by expanding food supply through expanding territory. Sometimes we can utilize more intensive food production technologies in a given area, but limitations are exceeded eventually.[7] And sometimes, due to such phenomena as geophysical forces and natural climate change, carrying capacity shrinks dramatically, occasionally rapidly.

4. *Expanding territory in response to population pressures eventually impinges on other groups who need to expand their territory for similar reasons.* Eventually and inevitably this leads to conflict and war. Wars are essentially fought over resources; however, given our deep innate penchant for metaphor, we are inordinately fond of misleadingly casting wars and inter-group conflict as driven by political, religious, amorous, economic, vengeful or other passions.

5. *Major biological adaptations that occur in an evolutionary timeframe - thousands of years - are functional in that evolutionary context. If the context changes too rapidly and drastically, those functional adaptations may become dysfunctional or even lethal.*[8]

For example: the human cerebral cortex is one of the more remarkable evolutionary developments in the history of life on earth (at least we and our cortexes would like to think so). Our cognitive and tool-making capacities have allowed us to become a dominant life form on earth and to survive in varied environments in ways no other living creature can (with the exception of the king of life forms, microbes, which will never be deposed). But many times throughout history our cortex has also led us to exploit our life support systems unto collapse (Easter Island is one well-known example, current anthropogenic climate-driven drought in the southwestern United States is another - the list is very long). Historically it has been local and regional collapse, now it is quite possibly global.

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[6] Carrying capacity is the ability of an ecosystem to continue supporting the demands made upon it by one or more life forms. Exceeding carrying capacity results in deterioration and eventual inability of the ecosystem to persist in its former state and support its historical biota.

[7] "Eventually" may be a decade or a millennium or more, a long time for humans but hardly a moment in the history of life on earth.

[8] See "Is Humanity Fatally Successful?", William E. Rees, Former Director, School of Community and Regional Planning, University of British Columbia, based on a lecture delivered by the author to The Vancouver Institute on March 15, 2003; *Journal of Business Administration and Policy Analysis*, Vol. 30-31, 2002-03. Online at http://steadystate.org/wp-content/uploads/Rees_HumanityFatallySuccessful.pdf. Rees and his graduate student Mathis Wackernagel were the inventors of the ecological footprint, a tool widely used to compare human demands on ecosystem resources across cultures and biomes.

The evolutionary processes that gave us cortical capacities did not readily grant us the ability to behave differently from the inclinations of our reptilian brain stem and the imprintings of culture, although certainly we may in theory.[9] In other words, one of the most stunning adaptations in the history of life may lead to extinction every bit as effectively as the Dodo bird's inability to adapt to human predators.[10]

Are there exceptions to be argued here and there? Of course. But they are relatively rare. The overall trajectory subsumes the exceptions in the sweep of the imperatives of life on Earth.

The implications of these fundamental principles are vitally important:

1. *Political metaphors, the revered currency of human societies, are misleading or irrelevant.* We spin tales because it is in our nature to pursue explanations, and the stories we tell are a vital evolutionary element in keeping us living together, and helping us to survive in our habitat, be it local, regional or global. But - and this is of key significance - our traditional stories stubbornly persist even when they outlive their usefulness as we exceed carrying capacity and have to fight for ever more limited resources. Divisions into left-right, radical-liberal-conservative, capitalist-socialist-anarchist, etc. are expressions of our varied creative reactions to biogeophysical reality, *but cannot result in changes in the way the natural world works.* No matter how strongly we may *believe* something, nature's course is unaffected.

2. *We are every bit a part of the natural world as anything else, not separate in any way, technophiliac fantasies - and fossil fuels - notwithstanding.* We are therefore subject to the same rules and regulations as all other creatures, and the same consequences as well. Our technological developments, from arrowheads to nuclear power plants, are extensions of our evolutionary biology, and as such are entitled to the rubric "natural." They are our attempts to expand carrying capacity, as does any other living creature. The meme popular in some circles, "we civilized humans are alienated from nature," is only partially correct. We are using the natural world, albeit in exceptional and uniquely human ways, to pursue the imperative of all life forms: to be fruitful and multiply.

3. *All societies, large and small, eventually collapse, for many and varied proximate causes.* It's likely that few if any of them could have conceived of such a possibility until the very end was obvious, and for many not even then (surely there were always Cassandras who knew, but by definition no one paid them any notice). The overshoot-and-collapse script plays out as laws of nature dictate - *unless we become better at paying heed to natural laws*, as some smaller societies are sometimes able to do.

There are two general categories of decision and action before us:

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[9] "*Intuitions come first, strategic reasoning second"* (italics in original). From *The Righteous Mind: Why Good People Are Divided by Politics and Religion*, by Jonathan Haidt, Pantheon Books, 2012, p. xiv. "Wisdom" is an ever-elusive piece of our puzzle.

[10] The Dodo, prior to the appearance of humans, had had no predators on its isolated island of Mauritius east of Madagascar. It became extinct within 100 years after the arrival of humans and our animals. It wasn't that it was "dumb," any more than we are "dumb" in our eager pursuit of eco-collapse. It was simply that in terms of adaptation its circumstances changed drastically, it tasted too good (reportedly it didn't taste particularly good at all, but good enough); its world was turned upside-down, and from an evolutionary perspective it just couldn't figure us out in time. See http://en.wikipedia.org/wiki/Dodo.

- *Those within our control*, affairs of humans within the context of the current life support system. For example, significant changes in land management to capture atmospheric carbon, improve water cycles, mitigate floods and drought, as well as insulating our homes and altering transportation systems to save money and carbon emissions.

- *Those not in our control*, dependent on carrying capacity, related environmental parameters and the laws of geophysics, chemistry and biology. For example, we cannot successfully address climate change by pretending that we can bargain with nature with "offerings" such as more efficient vehicles or changing our diets. Our efforts have to focus on systemic remedies for anthropogenic life-support-system dysfunction.

While individually we make decisions that affect our own lives and the lives of those around us, we are also inevitably subject to what takes place in our society at large, both from biogeophysical events such as droughts and earthquakes and from socially-driven events such as war and economic cycles. We are all subservient to the course of our civilization, whose inherent but not inevitable outcome is a consequence of laws of nature. In the past such outcomes, overshoot and collapse, have been independent of human decisions[11] but it is possible that an understanding more in line with the laws of nature and characteristic of hunter-gatherer societies will lead to an outcome unique in the history of civilizations.

It reasonably follows that our activism efforts which are aimed at phenomena not under our control inevitably amount to naught. On a local level, of course we want to keep out the factory farms, the fracking, the nukes - and to a certain extent we can and should do that, if only for our local communities. The challenge is knowing where to focus our efforts. A closer examination of the laws of nature may help.

Therefore it's crucial to understand that it's not corporations or presidents or dictators or revolutionaries, or non-profits/NGOs, or war-mongering empires which are root causes. There is no one to blame here, as tempting and ingrained as blaming may be. It's simply (or not so simply) the result of exceeding carrying capacity, and our struggle to survive in the face of constant scarcity and competition for resources.

This explanation of corporate and empire behavior is not in the least intended as an excuse for destructive excesses, which we should continue to vigorously oppose and prevent. It is to point out that the only effective prevention of corporate and governmental harms is that which addresses the fundamental drivers of such behavior and the underlying dynamics of complex societies.

We civilized people don't want to address the limits imposed on us by natural phenomena because we imagine that we're in charge, and we thrive on enemies, especially during overshoot. But in nature - of which we are reluctantly a part - there are no enemies, no evil ones, only the way the world works, a way veiled by the melée of a complex society. Until we recognize nature's impartial and implacable rules, we will persist in our treasured mythologizing and afford ourselves not the slightest chance of changing our ways.

[11] See Joseph Tainter, *The Collapse of Complex Societies*, Cambridge University Press, 1988. Tainter is an important thinker here, as his work forms one of the pillars of my own.

The Laws of Nature: Love Them . . . Or Just Leave (Hint: Not Much of a Choice)

Laws of nature are laws, not of the justiciable variety where human argument is of concern, but of the physical variety, where human obedience in the broadest of terms involves little choice and dissent is not tolerated.

Nature is ultimately fair and egalitarian, but is concerned only with process. Unlike her creatures she is blissfully unconcerned with outcomes. If we want outcomes other than collapse, we have to learn to adhere to the rules.

How the laws work is a bit confounding with respect to human affairs because we simply don't live that long in an evolutionary context. Some of these laws are invisible until they manifest over the course of many generations. Great-great-great-grandparents may think they're getting away with it (although they may not yet have any idea what "it" is), but consequences are not shy when their time comes. Our current global warming dilemma is but one of many instances, though perhaps the most dire in collective human history.

Before I get to my particular list of the laws of nature, I'd like to present a few concepts that I think are helpful: life as a geological force, unthinkable thoughts, progress traps, technology as savior, and the phenomenon of collapse in human societies.

Life as a Geological Force[12]

Going back almost 4 billion years, a scant half-billion years since the formation of planet earth from cosmic dust, life began to appear. It persisted through eons of celestial, tectonic and climatic upheaval. Around a billion years later life found the driver's seat and has taken over the world ever since. In an anthropocentric culture that creates gods in its own image, we're not generally aware that millions of species of living things have molded this planet, turned it blue and green, and created most of its features, from an oxygen atmosphere to geological formations to proliferation of millions of other kinds of living things. Without life, earth would be just another rock whizzing through space, like Mars or Venus.

The power of life is especially important in discussions of and action on climate change, since mainstream climate science views living things as victims of global warming, not primary climate drivers. This is most unfortunate since our current obsession with greenhouse gases as a root cause of climate disruption has led us to a dead end. For even if we were to go to zero emissions immediately, due to positive feedback loops and a seriously degraded biosphere, climate chaos would likely continue to accelerate and rage out of control.[13,14] It is therefore not

[12] See Peter Westbroek, *Life as a Geological Force*, W.W. Norton, 1991. Westbroek's research is based on the groundbreaking work of Russian systems scientist and biogeophysicist, Vladimir Vernadsky (1863-1945). Vernadsky's work is relatively unknown in mainstream science, which is still fractured into narrow disciplines where systems thinking is more theoretical than operational reality. See Vernadsky's signal work, *The Biosphere*, in an excellent edition annotated by Mark McMennamin with a forward by Lynn Margulis, Copernicus/Springer-Verlag, 1998

[13] "A large fraction of anthropogenic climate change resulting from CO_2 emissions is irreversible on a multi-century to millennial time scale, *except in the case of a large net removal of CO_2 from the atmosphere over a sustained period* [emphasis added]," United Nations Intergovernmental Panel on Climate Change, 2013, http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf.

unreasonable to pursue the possibility that living things are able to remove the requisite carbon from the atmosphere and cool the biosphere, and in fact there is ample evidence that such is the case.[15]

Unthinkable Thoughts

Our difficulties in *addressing* system failures (such as those enumerated in the requirements for this essay) may well be a result of our inability to *think* about them. A paradigm shift may be necessary to break through brick walls of thought to reframe problems and see our way through to more functional solutions. In referring to the distortions of ecological thinking resulting from application of economic metaphors to living systems, anthropologist Tim Weiskel writes,

> . . . a very important way that economic metaphors constrain our thinking about the environment is by defining what Noam Chomsky has called the range of "thinkable thought." In democratically organized societies thought is not overtly censored. We are not forbidden to think about particular topics, but thought control manifests itself nonetheless in the far more subtle form of self-censorship. It is not what it is forbidden for us to think, but rather what it does not occur to us to think, that establishes the bounds of publicly acceptable thought in democratic society.
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> In this context, economic metaphors function to define the range of so-called "responsible" public thought. For instance, environmental goals which are widely acknowledged to be desirable and good but which are thought to be "expensive" are often characterized as "unrealistic." In this manner, a certain conception of "economic reality" is swiftly invoked to label specific kinds of thoughts or proposals about the environment as out-of-bounds ("unrealistic," "unreasonable," "irresponsible," "too idealistic," etc.) for public discussion. Whether or not the particular notion of "economic reality" involved corresponds to anything more than an extended fiction is never questioned because market metaphors have been accepted as the governing framework for responsible discourse.[16]

Thinking the unthinkable is an urgent necessity. We don't have the luxury of shifting paradigms one funeral at a time.[17]

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[14] "The growth rate of climate forcing due to human-caused greenhouse gases (GHGs) increased over 20% in the past decade mainly due to resurging growth of atmospheric CH_4 [methane], thus making it increasingly difficult to achieve targets such as limiting global warming to 1.5°C or reducing atmospheric CO2 below 350 ppm. *Such targets now require "negative emissions", i.e., extraction of CO2 from the atmosphere* [emphasis added]," James Hansen, http://www.columbia.edu/~jeh1/mailings/2016/20161004_BurdenCommunication.pdf.

[15] Gathering the evidence in support of such assertions is challenging because it is scattered across many scientific disciplines, and much of it is from fields unrelated to climate science per se, such as botany, microbiology, mycology, hydrology, ecology and so forth. A new systems science is necessary for a more comprehensive understanding, and nature's timetable is unforgiving for creatures requiring a holocene climate. Biodiversity for a Livable Climate is currently collecting references in preparation for a detailed review of the literature pertaining to the biology of climate.

[16] Tim Weiskel, "Selling Pigeons in the Temple: The Danger of Market Metaphors in an Ecosystem," Harvard Seminar on Environmental Values, Harvard Divinity School, 6 July 1997, http://ecojustice.net/Coffin/ops-008.htm.

[17] Paraphrasing Max Planck, who said, "Science advances one funeral at a time," and "When you change the way you look at things, the things you look at change," https://www.goodreads.com/author/quotes/107032.Max_Planck.

Progress Traps

The concept of *progress traps* was introduced by archaeologist Ronald Wright in his brief, entertaining and compelling book, *A Short History of Progress*:

> Our practical faith in progress has ramified and hardened into an ideology - a secular religion which, like the religions that progress has challenged, is blind to certain flaws in its credentials. . . . The myth of progress has sometimes served us well - those of us seated at the best tables, anyway - and may continue to do so. . . . [But progress] has an internal logic that can lead beyond reason to catastrophe. A seductive trail of successes may end in a trap.
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> Take weapons, for example. Ever since the Chinese invented gunpowder, there has been great progress in the making of bangs: from the firecracker to the cannon, from the petard to the high explosive shell. And just when explosives were reaching a state of perfection, progress found the infinitely bigger bang in the atom. But when the bang we can make can blow up our world, we have made rather too much progress.[18]

What makes a "progress trap" a trap is how difficult it is to stop a progress cycle once it has begun. When we become more and more dependent on something, oil for instance, our ability to live without it shrinks. In the mid-nineteenth century, if we had turned off the spigot, life would have gone on, if in a slightly less merry way. Today, without oil for energy and synthetics, our economy and our food supply would fail dramatically. Notwithstanding the recent growth of alternative energy and the hopes of clean power advocates (of which I am one), we have no current means to stop using oil voluntarily without drastic social and humanitarian consequences. That is one stunning progress trap.

Progress traps are the end result of many things that seem like a good idea at the time. We are surrounded by them and their unintended consequences: from the short-term effects of using CFCs (chlorofluorocarbons) as coolants and solvents leading to the destruction of protective atmospheric ozone, to the long-term dilemma of agriculture, e.g., destruction of habitat, explosion of population, desertification of depleted soils, deforestation, effects on weather and climate and most obviously loss of food for an exponentially growing human population.

With a relatively narrow undertaking such as CFCs, the destructive chemicals may be replaced with less harmful ones, and the trap may at least be deferred (although we don't know what dangers lurk in the substitution: after all, it seems like a good idea at the time). A case such as agriculture, like oil, is much more difficult: Growing our own domesticated plants and animals offers tantalizing quantities of food. More food leads to a more a secure population which grows its numbers. As the population grows it's necessary to grow more food, in an escalating spiral that we can't escape without starvation and strife. We can postpone judgment day for a while, and pretend the progress is "forever," but it can't be. *Limits to growth are simply a built-in characteristic of the natural world.*

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[18] Ronald Wright, *A Short History of Progress*, Carroll & Graf, 2004, pp. 4-5. An excellent two-minute visual summary of progress traps may be seen in the opening credits of the 1973 movie, "Soylent Green," one of Hollywood's early forays into global warming and its consequences. Those credits may be seen at http://www.youtube.com/watch?v=AlVczvB4FQk

Technology Can't Save Us

There is no doubt that we humans have enjoyed the fruits of our technologies, everything from control over fire to lightspeed cyber-machines. Unfortunately, technologies also carry the inevitable burdens of unintended consequences, from minor to catastrophic. Sometimes undesirable outcomes are immediately obvious, as in lighting a match and burning down one's house. At other times it takes millennia for outcomes to reach our awareness, as in global climate disruption, which began with tilling of soils over ten thousand years ago and has accelerated with widespread use of fossil fuels since the industrial revolution.

Now there are all sorts of technologies proposed for solving the problems created by all sorts of other technologies. Notwithstanding our love affair with the technological, there is little if any evidence to indicate that the ultimate outcome of technology and its unintended consequences will be anything but destructive of life on earth, including human life. Again, this is amply illustrated by global warming.

It is possible that we begin to use technology effectively but minimally, guided by the workings of the natural world.[19] At this point in time, however, we are blinded by faith in high-tech solutions and find ourselves in hot technological pursuit of extinction.

Collapse in Human Societies

A paradigm-shifting book addressing how culture works in relation to the laws of nature was published in 1988. *The Collapse of Complex Societies,* written by archaeologist and anthropologist Joseph A. Tainter,[20] is a result of his dissatisfaction with prior explanations of historical collapse, the fall of Rome being the most famous example but only one among many. Whereas most explanations had been speculative, and no explanation could satisfactorily elucidate all or even most circumstances of societal collapse, Tainter felt that it was possible to develop a quantifiable approach that was consistent and covered all cases. And this he did.

Tainter defines *collapse* as a "rapid, significant loss of an established level of sociopolitical complexity."[21] His approach is both ingenious and fairly straightforward. His key concept, borrowed from economics, is called *marginal return*, which is simply how much more physical energy you can get out of a system for a given increase in energy you put in. For example, if you expend 1,000 calories growing food and get 10,000 calories worth of meals in return, your marginal return is 10 (10,000 ÷ 1,000). A reasonable investment. A marginal return of 10 represents a minimum stable and sustainable energy ratio for many living things in many circumstances.[22]

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[19] Returning to careful observation and imitation of nature in the search for solutions may help. Biomimicry, regenerative agricultural practices and locally-based architecture represent movements in that direction.

[20] Joseph Tainter, *The Collapse of Complex Societies*, Cambridge University Press, 1988.

[21] Tainter, p. 4.

[22] "Energy" is formally defined in physics as the ability to do work, i.e., make things move (from molecules to mountains). That is the strict sense in which Tainter uses it, and how I use it here. Although I do not discount the concepts of paranormal or "psychic" energy, or "energy" as used in casual conversation, I confine myself exclusively to the formal scientific meaning of the word. Virtually all energy used by life comes from the sun directly or indirectly (geothermal is one exception).

As individuals, species and ecosystems grow there must be some positive marginal return to continue and a large margin to thrive and overcome adversities in their existence:

> [I]ndeed some 99 plus percent of all species that have ever lived on the planet are no longer with us - their "technology" was not adequate, or adequately flexible, to supply sufficient net energy to balance gains against losses as their environment changed.[23]

Tainter's main point is that as societies grow more complex, marginal return decreases - slowly at first, more quickly as complexity becomes increasingly unmanageable. Societies almost always attempt to address such diminishing marginal return by instituting greater complexity (which looks like progress, and also may look like the only available choice), decreasing marginal return further in an accelerating feedback loop:

> After a certain point, increased investment in complexity fails to yield proportionately increasing returns. Marginal returns decline and marginal costs rise. Complexity as a strategy becomes increasingly costly, and yields decreasing marginal benefits.[24]

As marginal return approaches 1, that is, when the additional output of energy is equal to the additional input of energy (less formally stated as "Why bother?"), a society becomes increasingly unstable until it can no longer sustain itself. It doesn't generally disappear completely, but it breaks down into components that are less energetically expensive to maintain, e.g., from a centrally controlled nation-state to small independent regions or even villages.[25] There are many variations throughout history, which Tainter explores extensively, but the overall process is similar in all cases.

To illustrate decreasing marginal return and collapse of complex societies, I've created a simplified instance of a hypothetical post-ice-age society over its hundreds or, rarely, thousands of years of functional existence. It is an example of serial progress traps. Although details vary widely among societies, this story is representative, following a predictable pattern:

> A band of families wanders the land, having left a prior region for any of a number of reasons (e.g., excess population growth, climate change, depletion of local resources), and they come upon a beautiful fertile river valley uninhabited by other humans. They bring along a few domestic plants and animals to get started, and they settle down. Food is fairly easy to grow, the animals provide high-quality protein, hunting is plentiful, fresh water is nearby, so they are fruitful and multiply. And multiply.
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> In a few generations the soils so rich at the outset begin to tire from nutrient depletion. In addition, people overgrow the valley and move up the hillsides. Removing many more

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[23] Charles Hall, et al., "What is the Minimum EROI [Energy Return On Investment] that a Sustainable Society Must Have?", *Energies* 2009, 2, 25-47, http://www.mdpi.com/1996-1073/2/1/25/htm

[24] Tainter, p. 93.

[25] Our cultural meme of larger human-created entities being more efficient is the opposite of true. For example, we allow ourselves to think that large corporations are more efficient than small businesses because we don't do full-cost accounting, i.e., we don't take into account environmental and social costs that don't show up on ledger books. Such externalizing of costs is a very expensive and dangerous cultural conceit.

trees (in addition to those harvested over the years for shelter, boats and tools), results in soil erosion, interfering with the food supply.

Several of their members devise an innovative method of terracing to increase productivity of the hillside. A bureaucracy oversees these more complex agricultural arrangements. More specialized tools and experts are required for agriculture and other endeavors as well - pottery for transport and storage, advanced hunting implements, more efficient housing quarters; in addition, new religious specialists are needed to spend more and more time consulting with deities and spirits. All of these activities remove people - and their labor contributions - from the most basic of all activities, acquiring food.

This works well enough for a few more generations, the area is bountiful and despite the increased work required is able to sustain its inhabitants. But its growing complexity decreases marginal return per capita, and now requires more effort per person.

In order to enforce the food production requirements, a hierarchy evolves. The hierarchy has to be housed and fed - preferably in the style which they feel they deserve - despite not contributing to the community's food supply. The original settlement, where everyone knew everyone, is turning into a stratified and sometimes divided society.

The priests and priestesses - who with respect to food are a drain on the society's resources - inspire the growing populace to continue to work without complaint, invoking gods and goddesses to smile upon them and bestow rewards, often intangible but nonetheless effective. Marginal return, however, being immune to religious passions, grows shaky, diminishes as greater numbers of people rely on declining productivity.

All the valley, with its hillsides and hamlets, is now covered with people. The only thing to do is to look for new places to settle. They know from occasional encounters with strangers and from explorations of their own that suitable locations not too far away are already similarly settled by others. They have traded with them from time to time, but given their rate of growth trading is no longer enough. They must take what they need by force. Their oracle tells them that these other groups are barbarians by modern standards, and they are justified in taking whatever they want. But how?

After heated debates in secret council, they assemble their first army. Holy leaders beat the drums of war, and young men, with the support of their overburdened women, enthusiastically muster. They set off in search of certain victory.

The victory, however, has to be of significant proportions. This is because many workers formerly productive in the fields, in the dairies or on the hunt are now warriors, a further drain on the collective resources, requiring significantly more calories and physical support than they had required as working members of the community. Marginal return takes another plunge. It has to be counteracted with conquest and pillage (legal pillage, taken from barbarians, you will recall), lest people at home rebel under their yoke.

Many more generations pass, and the descendants of our peaceful wandering settlers meet with great success under their smiling deities. The population multiplies many

> times, they see victory after victory, their culture prevails over many lesser ones. Yet there are problems.
>
> Despite powerful rulers, mighty palaces, monuments and temples, sophisticated arts and sciences, an effective written script, abundant slave labor, and the largest military force in the known world, there is constant threat of rebellion and overthrow of the now bloated government. Even loyal citizens are not without complaint, and the empire - for that is what it has become - is spread far and wide, requiring increased force, burgeoning bureaucracy and heavy tax collection. All of this is aggravated by decreased productivity from exhausted soils, lowered resilience in the face of an occasionally adverse natural cycle (there used to be plenty of grain to survive floods and droughts) and too many mouths to feed.
>
> Finally, as fighting forces stretch far too thin, the glorious victories of the golden age turn into a series of humiliating defeats, abetted by defections and refusal of the populace to pay its high taxes and fight in seemingly pointless, endless wars. The centralized bureaucracy collapses and people in towns and villages have no choice but to rely on themselves and their neighbors to survive - that is, in those communities lucky enough to avoid slaughter by angry - and hungry - invading barbarians. The marginal return for the people who remain, beaten into the ground by complexity, would now have a chance to recover wherever the damage was less than prohibitive.

Chasing complexity often ends up in progress traps, and I'm sure you will find many elements of this story familiar; after all, we humans have been living some variation of it since the dawn of agriculture roughly 11,000 years ago. But it is different from the story of most of our 200,000 or so years on earth as distinct *homo sapiens*, when we relied on hunting, gathering and some horticulture for our subsistence. Our lives were very different then, but hardly the Hobbesian "nasty, brutish and short" of cultural myth. The shock and surprise over the research of anthropologist Marshall Sahlins's 1974 landmark work, *Stone Age Economics*, reverberates to this day:

> A good case can be made that hunters and gatherers work less than we do; and, rather than a continuous travail, the food quest is intermittent, leisure abundant, and there is a greater amount of sleep in the daytime per capita per year than in any other condition of society.[26]

In other words, as Sahlins writes, hunter-gatherers were the original "leisure societies." People were for the most part not in distress over food and water, and performed what we would call "work" for a few hours a day (they probably would have called it socializing while hunting, gathering plant foods, preparing meals - that is, if they bothered to call it anything at all). Like cats, they slept a lot during the day, as well as during nights uninterrupted by artificial lighting. Perhaps a lesson in how sleep-deprived we industrialized humans may be.

That there is ample time for leisure makes sense: a stable species will not likely continue to be stable with relentless stresses of change. There are certainly groups of people who undergo stressful environmental conditions regularly but have been able to adapt accordingly; that is one

[26] Marshall Sahlins, *Stone Age Economics*, Routledge, 2nd ed., 2004, p. 14.

reason that we have populated the earth so extensively. But for the most part rapid environmental change is not favorable to the survival of a given species (including us), and certainly not for a leisurely existence. In any case, human leisurely existence mostly ends with the advent of agriculture, which is highly labor intensive but very productive of food and population growth. Our modern enslavement to fossil fuels has afforded us a temporary reprieve, but at the stiff and wholly unanticipated price of a gargantuan progress trap.

This in brief is *our* story, the story of civilizations. It is the story of a social structure almost entirely dependent on the productivity of domesticated plants and animals. It is the story of our highly adaptable species taking full advantage of a benign albeit occasionally irascible geological period since the last ice age, a time when favorable climate and an abundance of resources provided us with the opportunity to discover many new abilities afforded us by our large brains and versatile hands, finally to appear as modern industry, science and technology. On many occasions and in many places across the globe, we turned wild earth into highly complex societies - all of them gone now, save today's exuberant Globalized Everywhere.[27]

It is essential to recognize that it was not simply human cleverness behind all of these remarkable civilizational developments. Rather, it was a bounteous life-support system and an abundance of available energy - i.e., a very high marginal return. It was during the current period known to paleontologists as the Holocene, our almost twelve millennia of relatively warm, moist, and stable climate, that civilizations appeared - before then we were all hunters and gatherers. The holocene climate is the one we have left behind in the twenty-first century.

Welcome to the Anthropocene.

The Inviolable Laws of Nature

> *The Four Laws of Ecology [Nature]*[28]
>
> 1. Everything comes from somewhere
> ("There's no such thing as a free lunch").
> 2. Everything has to go somewhere.
> 3. Everything is connected to everything else.
> 4. Nature knows best.

By laws of nature, I mean the way biology works for living creatures on this physical planet earth. For our purposes I informally define "law" as follows: behavior of objects or living creatures that is so consistent that it appears never to vary.[29]

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[27] "Exuberant" is the word that environmental sociologist William Catton uses in his landmark book, *Overshoot*, to describe "the lavish use of resources by members of a freely expanding population who are, at a given time, significantly fewer in number than the maximum permitted by the carrying capacity of their habitat" (p. 275). The age of ongoing global exuberance is now firmly in the past. That doesn't mean that we won't keep trying.

[28] Barry Commoner, *The Closing Circle*, Alfred A. Knopf, 1971, pp. 33-48.

[29] Never vary" could refer to an instantaneous awareness, such as falling off a cliff, or deferred awareness such as a warming world, which may play out over centuries or millennia. As previously noted, such a time frame may be invisible to us.

A law is very useful in predicting future events. Our reference law, gravity, provides ample instances of illustration and proof. Defining "law" is a human process, but clearly laws of nature operate whether we recognize them or not. And at some level we all understand these basic laws as they apply to our existence: after all, we live with them, we are in effect ruled by them, every moment of every day. Just as we are ruled by gravity. It's also worth noting that

> our use of fossil fuels has allowed us to absent ourselves from observation of the main laws that provide us our food and shelter. We have by some measures, 80 to 100 or more "energy slaves" working on our behalf day and night. Our modern "technology" is just a way of leveraging that consumption of fossil fuels. Without those fuels, [much] of our technology would be useless, and we would have to return to human and animal labor to provide our food and shelter. Then we would soon have a more intimate appreciation of those laws of nature.[30]

The laws of nature are automatic, roughly analogous to how our bodies take care of millions of basic and very complex biological processes without our awareness or attention. Thus we don't generally consider implications of these laws in any depth, in no small measure because today we think that we can control nature if/when we need to, so there's nothing to worry about.

Listed here are some of the pertinent laws of nature - laws not only in a scientific sense, which we understand reasonably well, but more importantly in a cultural sense. The laws confuse us because they challenge our prevailing idea that we can attempt to defy natural limits with impunity, even - or especially - when we know what the limits are. To examine laws of nature successfully, we have to struggle to put cultural assumptions aside, and stop seeing *only* what we already believe.

Examining Our Defiance of Limits

To support our exuberant anthropocentric worldview, we modern industrialized humans often take the position that we are exceptional; that we can violate strict earthly constraints without consequence; that our technology and intelligence take us, metaphorically at least, beyond the boundaries of physics, chemistry and biology; that we are entitled, even mandated, to be the stewards (conquerors) of nature. After all, our oligarchical deities told us that's what we could and should do - subject to our imperfect interpretation, of course.

We do indeed have many characteristics that set us apart from other species. Along with our opposable thumbs, complex language and abstraction, and life- and earth-changing technologies, our cerebro-cortical talents have blinded us to the fact that we are every bit as dependent on our life support systems as any living creature, large or small, that has ever scurried, swum, run, squiggled or squirmed over the past three-and-a-half or so billion years.

It's truly strange, but we currently think and act as if many laws of nature don't exist. This is particularly true when nature clashes with the collective wishes of culture as we inadvertently stake our global survival on an economic system that *requires* impossible exponential growth.

[30] Philip Bogdonoff, personal correspondence.

Human population growth is also exponential; in fact, exponential population growth is innate in life forms until limits are encountered in the form of finite resources and space, competition, disease or changes in habitat:

> All species have an inherent capacity to expand into all the ecological space available to them. Unless there are other constraints on that expansion – negative feedback of one kind or another – all populations grow to the point that they destroy some critical resource and then they collapse. (This was Reverend Malthus' great insight about humans.)[31]

In our current globalized worldview, relentlessly growing wealth is not optional, it is required: without such growth, civilization - life as we know it - is threatened with collapse.

Yet, that exponential growth as a reality cannot *exist is currently invisible to us.* We take many extreme measures to maintain our denial, from censorship to extravagance to propaganda to economic and military conflict. But for the most part we simply assume that achieving the physically impossible is a normal part of everyday life. We don't yet notice that endless growth is impossible, because as far as we can see we're still growing, and so far so good.

Daniel Quinn, in his entertaining and culture-challenging novel *Ishmael*, relates a socratic dialogue about "Mother Culture" between a confused human who would like to save the world and a wise gorilla. In one illustrative anecdote, the gorilla tells the story of a man who thinks he can fly and "jumps out of a ninetieth-floor window on a bet. As he passes the tenth floor, he says to himself, 'Well, so far so good!'"[32]

The fact is that exponential growth can occur for only a limited period of time in our finite physical system - planet earth. We can see this in a wealth of examples of overshoot and collapse, non-human and human, all of which are predictable in occurrence if not in precise timeframe.[33]

Indicative that we're running out of much of what the earth provides, we currently have to go to great ends to obtain natural resources which in prior eras were far more readily and cheaply available. Examples of resources once thought to be renewable or inexhaustible include everything from coal and oil (which initially were closer to the surface) to forests, fisheries and aquifers (which were formerly abundant but now must be carefully conserved) to minerals such as copper, lead and silver, the mining of which is now far more expensive, difficult and toxic.

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[31] William A. Rees, "Is Humanity Fatally Successful?", Journal of Business Administration and Policy Analysis, Vol. 30-31, 2002-03, p. 72 (p. 6 of pdf file). Rees is co-developer of the widely used ecological footprint analysis. http://steadystate.org/wp-content/uploads/Rees_HumanityFatallySuccessful.pdf

[32] Daniel Quinn, *Ishmael*, Bantam Press, 1992, p. 106.

[33] Timeframes can be confusing when assessing predictions of signal events in the natural and human world. For example, Thomas Malthus in his classic book, *An Essay on the Principle of Population* (1798), postulated that population grows exponentially while food supply grows arithmetically, that is, far more slowly than population. In many quarters he is derided as a pessimist and dismissed as disproven by the course of events. But what Malthus was unable to anticipate was an *expansion* of carrying capacity afforded by growing empires; and more importantly a temporary widespread *evasion* of carrying capacity constraints resulting from emerging highly productive yet unsustainable agricultural practices. Thus, in judging Malthus's thesis, we must expand the time for it to play out. Now that the global human population is over seven billion and growing, we unfortunately have the opportunity to reconsider his assessments.

Increasingly precious resources such as energy, water and land would be better used for other purposes such as conserving biodiverse habitats on this planet where, as Commoner states, everything is connected to - and dependent on - everything else.

Limits to Growth: The 30-Year Update, is the third edition of the ground-breaking research published in 1972 by a group of young MIT scientists. It was an international bestseller at the time. The update confirms with today's hard data much of what was based on models back then, that the earth is running out of resources to support our current and future demands.[34] Low-hanging fruit is gone. Limits to growth. It's a law.[35]

Given that we live on a planet with finite resources, what are the implications?

To reiterate, our cultural imperative of endless growth is a primary obstacle to progress in addressing many current social and ecological urgencies, including climate change and its root causes. That the impossibility of endless growth even has to be argued is a strange artifact of culture and its power over our thinking. For it is trivial to show that when one empties a box, the box is empty; when agriculturalists replace trees with fields, there are no trees where they were before;[36] when an animal is slaughtered to extinction, it is forever removed from the web of life (and can no longer appear on the dinner plate).

The Laws of Nature: An Incomplete List

Laws of nature, like gravity and limits to growth, are writ in stone. They do not respond to human desire or will, to legislation or negotiation. We can dislike them, we can ignore them, we can deny them - and in fact we do all of those things, as it suits our purposes. We may use them to our advantage or disadvantage. But we cannot change them.

A reasonable reaction to some of the items on this list is "So what? It's obvious. Why bother?" My answer for the moment is that we are building a different way of looking at our proper place on this crowded planet. It's odd that while basic laws may be obvious, they often don't figure into our twenty-first century decisions. We act as if we're exempt from needing clean air and water, for example, or a hospitable climate. As you consider these laws, I ask you to imagine the consequences of attempting the impossible, that is, violating them.

1. Impossibilities are impossible.

Sometimes what's impossible isn't apparent for hundreds or thousands of years, and sometimes what is possible at a small scale is impossible at a larger scale. Since we often put little if any

[34] Donella Meadows, Jorgen Randers, Dennis Meadows, *Limits to Growth: The 30-Year Update*, Chelsea Green, 2004, pp. 105-6. Estimates of life expectancies of identified reserves of copper, lead and silver were 22, 17, and 15 years worth, respectively. There are far greater quantities in the earth's crust, but they are increasingly difficult and expensive to extract. There will always be more but it will grow prohibitively costly to extract them.
[35] See Herman E. Daly and Kenneth N. Townsend, "Sustainable Growth: An Impossibility Theorem," from *Valuing The Earth: Economics, Ecology, Ethics*, MIT Press, 1993, p. 267 ff. Available at http://dieoff.org/page37.htm.
[36] Trees may or may not regrow in a human timeframe, but in the present they are gone and unavailable for building, tools, firewood, holding soils together, sequestering carbon, cooling the habitat, releasing oxygen, and producing rainfall through evapotranspiration, among the many extraordinary and ecologically essential things that trees do.

effort into identifying what is impossible, we are at high risk of committing a great deal of time, effort and resources to accomplishing what *cannot* be accomplished. To what ends?

Examples of impossibilities include treating climate as a greenhouse gas equation; life in constant overshoot and societies built on such an endless growth economy; surviving destruction of the life-support system; peace during scarcity; and fully eliminating oligarchy, inequality and unfairness in a complex society.

It may give us a satisfying sense of power to imagine we can change things that we cannot, but it confounds our ability to tell the difference between situations where we can make decisions and what the actual choices are. Cultural lore addresses our confusion:

> God, grant me the serenity to accept the things I cannot change,
> Courage to change the things I can,
> And wisdom to know the difference.
>
> Reinhold Niebuhr, 1941

> For every ailment under the sun
> There is a remedy, or there is none;
> If there be one, try to find it;
> If there be none, never mind it.
>
> Mother Goose, 1695

"The difficult we do at once. The impossible takes a little longer."[37] This exuberant aphorism, sporadically posted around office and factory bulletin boards, included in popular songs and literature, represents the cultural heights of absurdity. Sometimes we live by impossibilities, even swear by (and at) them, as if they were, strangely enough, possible.

The impossible is impossible, not simply more difficult.

2. The life support system is everything to living creatures.

We need food and water. Without both, no life. Unless we can import them from elsewhere, we *always* leave habitats that don't provide them and try to find another place to live - or we die.

Ecosystems that are too damaged and exhausted or battered by forces such as flood and drought cannot adequately provide food and water. In the past there may have been other places on earth to seek out to support human life, but we're now living on a finite supply of resources borrowed from the future - and the future may be soon.

[37] Apparently from the Army Corps of Engineers, harking back to WW II, http://www.lrl.usace.army.mil/CT/.

3. Nature Never Fails

There is no success or failure in the natural world. Unlike its creatures, nature is all about process and entirely indifferent to outcomes. Species come and go,[38] climates heat and cool, continents shift and heave - it's all the same to what we call "nature." If the behavior of one species is the cause of extinction of one or millions of others, nature doesn't "care."

We want nature to care about us, she is, after all, our Mother. And it often appears that nature does care, providing food, water, shelter, and pleasure. Sometimes, like a stern Mother, she appears to punish us for known or unknown sins. But these appearances are deceiving, for Nature is the Great Experimenter, something always happens, but to Nature it doesn't matter what that something - or its consequences - may be.[39]

4. Endless growth is impossible in physical systems.

While discussed above it is worth mentioning here once again in order to place it in the list of laws. Planet Earth, as large as it is, is a finite source of physical things and cannot supply infinite necessities of life for any creature, including humans. Limits to growth are an integral, inseparable part of our life support system.

5. All living things have a life cycle.

We come into existence, we live, we die. And then we decompose, ashes to ashes, dust to dust. The cycle may take a few minutes or it may take thousands of years. It *always* works this way, whether you're a 30-minute mayfly or an eighty-thousand-year-old tree root system.[40]

6. Size matters.

The way things work on a small scale may be completely different, in process and effect, on a larger scale. Larger-scale activities are far more likely to be unsustainable for many reasons. A small monocrop in one's rose garden has very different environmental consequences from millions of industrial monocropped acres. Limited local use of local coal for heating or cooking has vastly different implications from global use of coal for manufacturing and its impacts throughout the supply chain.

7. All life must reproduce.

Not all individuals or pairs of a given species must reproduce, but at least enough to maintain a minimal breeding population - which is likely, eventually, to fill its given habitat. When population is not balanced by limiting factors, e.g., predators, competitors or external natural cycles, it will

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[38] M.E.J. Newman and R.G. Palmer, "Models of Extinction: A Review," Santa Fe Institute, 1999, p. 3. That is, roughly 50 million current species compared to 400 billion over the history of planet earth. http://www.lassp.cornell.edu/newmme/science/ModelsOfExtinction.pdf.

[39] See John Kricher, *The Balance of Nature: Ecology's Enduring Myth,* Princeton University Press, 2009. Kricher maintains that attributing any goals to nature is indulging in the common scientific fallacy of teleology, projecting human aspirational dramas onto the indifferent natural world.

[40] "Pando," located in Fishlake National Forest in Colorado. It is also the heaviest known living organism, at 6,600 tons. http://en.wikipedia.org/wiki/Pando_(tree). Mayfly: http://victoryv.hubpages.com/hub/top-10-Short-life-Small-lifespan-animalsinsectsplants

eventually collide with maximum carrying capacity and damage its life-support system. Humans have frequently limited local population over the millennia by using contraception, abortion, infanticide and social taboos; ability to limit global population today is open to serious question.

From an evolutionary perspective, too little reproduction is a far more serious problem than too much. That it eventually doesn't always work out to the advantage of the species in question and others in the biosphere is secondary. But every species must try its best: enthusiastic reproduction is a survival mechanism built into the natural world. Life depends on it.

8. All living things must have energy and nutrients.

In order to survive and reproduce, life needs its basic building blocks and energy. Animals get energy and nutrients from food, and have built-in mechanisms, i.e., hunger, to make sure they do. Humans have many rules and rituals surrounding food, but we must be fed, peacefully if possible, violently if population pressure so dictates.[41] A corollary to this law is that acquiring food must take less energy than the food provides, i.e., high marginal return.

9. All living things must have water.

Biological processes cannot proceed without water. Since water evaporates, terrestrial life must do a balancing act between controlling water loss, using water to eliminate metabolic wastes, and acquiring fresh water. For humans, death is certain after a few days without water, depending on conditions such as heat, humidity and general health.

10. All living things must have means of, and space for, metabolic waste disposal.

After we extract energy and nutrients from food we have no use for what remains. At best it gets in the way, at worst it's toxic and interferes with processes that are necessary for life. We must get rid of waste and put it somewhere where it won't hurt us, either in its initial form or as it decomposes. A classic example of self-poisoning by its own waste is wine-making, as the alcohol produced by fermentation eventually poisons the yeast that produce it (if they don't run out of food - sugar - first). This illustrates how one creature's metabolic waste - wine - is another's feast, a cycle in the cycle of life.

11. Carrying capacity for any and all species is limited.

For any individual, the world is a very big place. Perhaps somewhat smaller in the last few hundred years but very big nonetheless. So our resources and dumping grounds may seem limitless.

That this is not the case is illustrated in an island ecosystem, where there are only so many fresh water supplies, so many animals, so many trees, and that using up any of these resources

[41] Two demographic factors are of interest, population density and population pressure. Density is the number of people per unit of area. Pressure is the level of demand on the ecosystem by those people. A less densely populated area, e.g., the United States (84 per square mile), may cause greater stress on the global ecosystem than a country such as India (954 per square mile), whose consumption is far less. http://www.infoplease.com/ipa/A0934666.html. Population pressure may be measured by ecological footprint; see http://www.footprintnetwork.org/en/index.php/GFN/.

will result in lowered carrying capacity. Scarcity of one species or essential element of a habitat will affect the abundance of all others because everything is connected to everything else.

The planet earth as a whole is an enormous island, and just like any island it has its limits.

12. Carrying capacity is variable over time.

Carrying capacity is affected by such factors as natural climate change, variations in weather patterns, volcanic activity, disease, invasion, or an abundance or scarcity of other species. Some changes in carrying capacity may be geophysical, but by and large changes in carrying capacity are under the influence of the living things in the environment. For example, carbon dioxide in the atmosphere is both biological and geophysical, as the vicissitudes of biology and changes in photosynthesis affect the relative quantities of atmospheric and soil carbon, while solar cycles affect climate independently.[42] Changes in carrying capacity significantly affect life in an ecosystem, human as well as other, and may occur quickly or slowly in human terms.

For example, European westward expansion across the Atlantic during the medieval warm period from 800 to 1300 CE led to the colonization of Greenland and Iceland for trading purposes. The global cooling at the beginning of the fourteenth century began rendering these difficult habitats entirely unlivable for the European population, and by the mid-fifteenth century the settlements were abandoned.[43] Carrying capacity had shriveled. The indigenous population remained there - they were at home, living in a different niche within ecosystem limits. But the mainstays of indigenous life were invisible and therefore unavailable to the Europeans, who had been set in the habits of their distant homeland.[44]

13. All living things affect carrying capacity.

Creatures interact in "attempts" to extend carrying capacity for their species and co-dependent species. This will have varying effects on other species, which are also engaged in extending carrying capacity on their own behalf. Beavers, for example, change a forest/stream habitat by building dams and creating a viable niche for themselves as well as many other species. In perhaps the most dramatic instance in earth's history, green plants turned a predominantly carbon-dioxide atmosphere into an oxygen atmosphere, radically changing life on earth for the last two billion years.[45]

Advantages to a population may also turn into the opposite as optimal levels are exceeded. Agriculture may trigger human population growth leading to destruction of woodlands to create more tillable fields. The result is loss of soil, nutrients, biodiversity and carrying capacity. After a period of abundance, dependent populations suffer crop failure and other unintended consequences of “progress.”

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[42] See, for example, http://www.ucsusa.org/global_warming/science_and_impacts/science/effect-of-sun-on-climate-faq.html#.WF1drR9ic8o.

[43] Brian Fagan, *The Great Warming*, Bloomsbury Press, 2008, pp. 103-5.

[44] For another example, see “Research Shows Rapid Pace Of Historic Desertification In Dead Sea Region,” http://thinkprogress.org/climate/2012/09/06/801961/research-shows-rapid-pace-of-historic-desertification-in-dead-sea-region/

[45] See https://en.wikipedia.org/wiki/Great_Oxygenation_Event

14. Overshoot will lead to die-off, followed by recovery or extinction, local or global.

Taking more from an ecosystem than it can provide over time is only a temporary solution to scarcity. Populations may face extinction depending on the extent of the damage, and the loss of a keystone species resulting from predation, disease, change in climate, or disruption in the food chain may cause collapse of an entire ecosystem.

15. Humans respond to limited carrying capacity just like any other creature.

In the aggregate we are no different from other living creatures. It may at times serve us well to act altruistically by sharing food and resources, but when scarcity predominates we protect what we need in order to survive, for the group that we call “ours.” In other words, scarcity or threat of scarcity generally evokes an aggressive survival response.

16. Humans are wired for language and social relationships.

In the unlikely case that someone were to survive alone from infancy, it would not be possible to proceed normally through life's developmental stages, including the learning of language. We require interactions with other people for brain function to grow normally. The minimum functional social unit seems to be the family and a single family, if it survives, becomes a much larger group over the course of only a few generations. The extended family creates complex kinship relationships, which are a key element in our social structures.

17. Humans will always create culture.

Culture represents our collective effort to thrive. The culture tells stories to bind individuals with the group for mutual survival. The stories teach the basics of social interactions, emotional health and how to navigate the physical world.

Due to many factors such as geophysical and ecosystem changes as well as interactions with other societies, a particular culture and its beliefs may outlive their survival value. They may nonetheless persist because collective memory tells us that it worked so well in the past. When a culture loses its survival value it may not be apparent for a long time. Neither would it be readily apparent what the next steps would be, as they are invisible from within the current culture. *Cultural response frequently lags beyond the point of no return, leaving inadequate time to adapt to whatever the new pressures may be.*

Again, the global culture of endless growth illustrates that although the alarms are sounding loud and clear, we don't seem to be able to heed them or even hear them - they are too alien to our dominant desires and beliefs.

18. Everything humans do qualifies as natural.

We are creatures of the natural world, it stands to reason that everything we do emerges from our inborn biological needs and abilities. That our capability for manipulating our world has grown immeasurably in the past several thousand years doesn't change that. While nuclear power plants, mechanized agriculture, sound-barrier-breaking flying machines, chemistry

previously unknown on earth, implausibly tall buildings, and so many other oddities we've created over the past several hundred years are products of an advanced civilization, the reasons we've made them and our inclinations to do so are as old as humanity.

Bemoaning how we've replaced the "natural" with the "unnatural" is therefore beside the point. We are doing our best to do what all living things do: expand the carrying capacity of our life support systems.

19. When, where and how we are born determine and limit our life possibilities.

Also known as luck, good or bad. Being born in a hut in Africa or in a penthouse in midtown Manhattan portend very different limitations, possibilities and futures. Similarly with many other characteristics: male or female, rich or poor, strong or disabled, ill or healthy, well-fed or barely subsisting, slave or free, during war or during peace, in a desert or a tropical rainforest or a modern city or on the tundra, in a powerful family or among the masses, surrounded by abundance or trapped by crowding and scarcity.

The prevalent myth that anyone's hard work and determination can conquer all obstacles to achieve the modern version of success serves many cultural purposes, but representing reality isn't one of them.

20. Humans can never adequately know unintended consequences.

Almost by definition, we can't consider unintended consequences because they are unseen, although we may glimpse but ignore them. Even if we do see them, however, we cannot grasp their full implications because the natural world is extremely complex and we have no way of clearly anticipating all or even most interconnected effects.

Another way of stating this is that we see progress traps only in retrospect. What we are able to reasonably assume, in theory, is that there will *always* be unintended consequences, and to proceed with caution.

One good example is the Green Revolution beginning in the 1960s.[46] A billion people may have been saved from starvation, but the technologies were often toxic, destructive of soils and the nutritional value of food, and generally unsustainable. In addition, increased food availability predictably led to growth of population. In other words, we expanded carrying capacity, postponed overshoot, and hit another limit to growth only to encounter what may be an even more intractable population problem (of which anthropogenic global warming may be an intractable unintended consequence). As a result of the Green Revolution, far more people may die than were saved by this instance of agricultural prosthetics. A cautionary tale.[47]

[46] See https://en.wikipedia.org/wiki/Green_Revolution. For an assessment of .

[47] The outcome of a local and sustainable revolution in agriculture would be very different. See See Nicholas Parrott & Terry Marsden, *The Real Green Revolution: Organic and Agroecological Farming in the South*, Greenpeace, 2002, http://www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/4526.pdf.

21. Humans do not learn from history.

This is clear from how repetitive the history of civilizations is. I am not referring to accumulated knowledge and technological advancement - we clearly learn from previous human observation and achievement. Nor am I referring to individuals or small groups - there are always those living on the far tails of the bell curve who are able to see things that others may not. Each generation does learn from previous generations and from the environment in patterned ways, and the patterns have some flexibility, e.g., different learning skills and talents, availability of opportunities, and varying cultural constraints.

Overall, however, we have not yet learned how to change a society's destiny. Our history itself is determined by laws of nature which we have so studiously ignored. Furthermore, the course of history is subject to forces outside of our control *whenever we grow exponentially*. We always push against those limits eventually, it's what living things do.

Thus, for example, we cannot prevent eventual conflict (although eventual may mean millennia), because when population pressures and limited resources press upon us, we take someone else's food (and territory, and shelter) if we want to eat and feed "our own" people. Nor can we help but exceed the capacity of productive agricultural land, since when we are well fed we grow our population and eventually we collide with physical limits of the land. Laws of nature leave us little overall choice in how to respond to scarcity and how to satisfy real or perceived needs, although details may vary with different cultures and technologies.

With regard to the rules of the natural realm, our feelings and thoughts about them are for all practical purposes irrelevant. The rules prevail, they are independent of us, not the other way around. That being said, *if* we understand and respect those rules we may discover and pursue better choices.

22. Humans are not exceptional as biological creatures in an ecosystem.

While we certainly have our exceptional qualities, we are firmly ensnared in natural cycles (e.g., energy, water, oxygen, carbon, nitrogen). We are subject to the same limitations as other animals. Those limitations never go away. Furthermore, we, like many species, carry the seeds of our own destruction in our limited ability to perceive and respond to dangerous signals from our life-support systems.

23. Complex societies develop only in favorable environmental circumstances.

Given that complexity is energetically costly, a complex society can only begin to evolve in circumstances of abundance; that is, where energy as food is readily available, as well as many other resources such as water, trees, metals, domesticable animals and crops. That usually means the full commitment to a progress trap.

Note that complex societies are a very recent human phenomenon:

> The citizens of modern complex societies usually do not realize that *we* are an anomaly of history. Throughout the nearly three million years that recognizable humans are known to have lived, the common political unit was the small, autonomous community

> acting independently, and largely self-sufficient. Robert Carneiro has estimated that 99.8 percent of human history has been dominated by these autonomous communities. It has only been within the last six thousand years that something unusual has emerged: the hierarchical, organized, interdependent states that are the major reference for our contemporary political experience. Complex societies, once established, tend to expand and dominate, so that today they control most of the earth's lands and people, and are perpetually vexed by those still beyond their reach. A dilemma arises from this: we today are familiar mainly with political forms that are an oddity of human history, we think of these as normal, and we view as alien the majority of the human experience. It is little surprise that collapse is viewed so fearfully.[48]

24. Roles in societies exist independently of those who fill them.

There is today, as in all civilizations, concern about who the rulers are and how they treat the masses (that is, us). But oligarchy is not specific individuals. It is a set of roles that develops in a society as it grows. We develop roles in the oligarchy, from laborer to mason to priestess and all in-between, as the needs arise. While we appear to select individuals for those roles, humans don't make decisions on *what* the roles are overall (although we may discover them as we go along). It's the requirements determined by the size and environmental conditions of a society that dictate the roles for us to fill.

We may bicker (or kill) incessantly over *who* fills what role, but the roles, like a vacuum, must be filled for the society to maintain itself. Furthermore, no matter who fills the role, the role itself shapes the behavior of those that fill it. Regardless of the intentions of any person who becomes king or president or chief, the demands of the role necessitate the nature of the relationships.

25. Marginal return is inversely related to sociopolitical complexity.

For many societal issues such as agriculture and resource production, information processing, scientific and technological advances, education, sociopolitical control, and overall economic productivity, the reasons for decrease in marginal return in a complex society are similar: (1) The least costly efforts are made first, so as efforts continue they become increasingly expensive; and (2) It takes greater effort (energy) to accomplish most tasks with a large complex group.

Furthermore, until complexity falls under its own weight, i.e., until marginal return plummets, the strong tendency is to continue to grow:

> . . . Once developed, complex social features are rarely dropped. Tax rates go up more often than they go down. Information processing needs tend to move in only one direction. Numbers of specialists ordinarily don't decline. Standing armies rarely get smaller. Welfare and legitimizing costs [that is, costs to prevent widespread dissatisfaction and rebellion among the population] are not likely to drop. . . . An ever increasing stock of monumental architecture [including infrastructure] requires

[48] Tainter, p. 24. The Carneiro reference is "Political Expansion as an Expression of the Principle of Competitive Exclusion." In *Origins of the State: the Anthropology of Political Evolution*, edited by Ronald Cohen and Elman R. Service, pp. 203-23, Institute for the Study of Human Issues, Philadelphia, 1978.

> maintenance. Compensation of elites rarely goes down. What this means is that when there is growth in complexity it tends to be exponential, always increasing by some fraction of an already inflated size.[49]

A small group will need to exert little energy to satisfy its needs to acquire abundant "low-hanging fruit" (or seeds, or game) with a relatively generous and more or less unvarying supply of food, i.e., a high marginal return. As the group grows and the easiest and closest supplies are depleted, it will need to work harder to satisfy its needs. It will have to search farther from home for new sources of plant foods and chase the faster antelope and more distant herds. Marginal return has begun its downward journey: more calories must be spent to pursue the same number of calories to take home.

In a complex society (or on the way to one) we need people to do many things other than produce food: build storage bins, count grains of wheat, protect the food supply, craft weapons so the protectors can protect, supervise everything, and so on as the number of roles increases. In hunter-gatherer societies distinct social roles may be no more than a few dozen; in modern European nations distinct social roles may approach one million.[50] The people in each of these roles must be fed.

All of the people in the society are expending energy to fulfill their roles, whether the roles number a hundred or a million, but a smaller and smaller proportion of the people are still producing food. The total calories expended by the population - that is, the combined work of food producers and non-producers - threaten to return fewer and fewer calories *per person* to the collective dinner table. To maintain adequate calories more producers and productivity must be found. Dinner gets more and more expensive. Fossil fuels have given us a big if temporary boost, but do not change the rules. Nor will alternative forms of energy, although they may seem to offer the glittering promises to be found in any instance of *deus ex machina*,[51] no matter how far-fetched.

To respond to decreased productivity societies naturally engage in attempts to increase food supply, which, when successful, results in increase in population, which once again necessitates new attempts to increase the food supply, and so on. In the past few thousand years, the Age of Civilizations, this has been our primary universal and perennial progress trap.

What is the Next System?

As mentioned in the opening paragraph there is only one system, Nature's System. What must come next within that system is a change in the way we humans relate to the natural world. A wide range of system failures may be addressed with a deeper understanding of the laws of nature, including:

- *Mainstream climate science and activism:* Current efforts have emphasized greenhouse gases as a driver (rather than sign or marker) of global warming, and have erroneously

[49] Tainter, p. 116. For details of how marginal return is affected in different societal endeavors, see his Chapter 4, "Understanding collapse: the marginal productivity of sociopolitical change," pp. 91-126.
[50] Tainter, p. 23.
[51] Latin for "god by machine," representing our undying hopes for rescue by technology, or by any unexpected and improbable intervention.

ignored the root causes: *widespread destruction of biodiversity and the biosphere*. Yes, carbon dioxide and other heat-trapping gases are a problem, possibly a lethal one, but the solution is a broad systemic one, not resolved by the simplistic equation of CO_2 = global warming.[52]

- *War and conflict:* The modern peace movement has been understandably focused on philosophy, principles, diplomacy, and persuasion. Yet war and conflict are inevitable when essentials are scarce, in perception or reality. Reframing the conversation to embrace fundamental forces of nature could begin to support eco-restoration as the primary foundation of peace, and redirect many current peace activities to restoring the land.
- *Feeding the world*: It may be possible, not with inefficient, destructive and unnecessary industrial agricultural practices,[53] but with traditional approaches adapted to local environments combined with growing knowledge of regenerative land management. Any efforts must be deemed suitable and adopted by local communities in their own interest, unpressured by vested interests.
- *Money-based economics*: Until we can eat coin, paper, and now digital pulses through cyberspace, the only real value on earth is the bounty of lands, lakes, rivers and seas. Only when our means of exchange reflect our life support systems we will be able to maintain a stable economy.
- *Democracy*: This is a theoretical form of governance in which people affected by decisions have a meaningful role in making them. As animals having evolved in small groups as hunter-gatherers, humans tend to be intensely loyal to our group of origin, on whom we traditionally depend for all of our life support. Each group member has to collaborate for the group to survive and we are able to have close relationships with only a small number of people. We do not scale up well.

  As societies grow people stratify into new smaller groups. Some groups become more powerful for a variety of reasons, e.g., resource access, kinship advantages and personalities. Stratification leads to oligarchy, inequities and unfairness, as some acquire more advantageous circumstances than others. We have all experienced this on a small scale in workplaces, activism, and social groups. We must of course strive for fairness and justice and the ideals of direct democracy help us move in that direction, as we work toward optimal social conditions where we work and relate at our best. These conditions are primarily small-scale and local, and based on a realistic understanding of our limits: what we cannot do (the impossible), and perhaps more importantly, what we can do but should not.

Additional system failures are those listed in the essay specifications: poverty, inequality, racism, climate change, environmental collapse, police brutality, mass incarceration, gender disparities, expropriation, corporate power, class divisions, unemployment, militarism and war.

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[52] See my short essay, “Real Climate Reality,” December 7, 2016, http://bio4climate.org/2016/12/14/real-climate-reality/.

[53] According to Via Campesina, https://viacampesina.org/en/index.php/organisation-mainmenu-44, a grassroots organization representing 200 million farmers, women and small farms grow 70% of the food on earth. In addition, there are roughly 12 billion acres of formerly productive land that have been desertified due to human mismanagement since the beginning of agriculture. We know how to restore that land to health, low-tech, without synthetic inputs, at little cost. See also FAO, “Meeting the food security challenge through organic agriculture,” 2007, http://www.fao.org/newsroom/en/news/2007/1000550/index.html.

Of key importance is that these are not isolated failures. They are each and every one a facet of collective modern human inability and/or unwillingness to look beyond prevailing assumptions and to understand the laws of nature that define and drive us. At this point in history, we have the opportunity and the potential to reframe these failures and successfully address them by incorporating laws of the natural world into our assessments and prescriptions.

Given the trajectory of global ecological destruction, *we don't have much time to move into this new paradigm*. Clearly none of these failures will be remedied easily, even as we begin to understand nature's underpinnings of our behavior. No Next System will come without substantial effort. But to the extent that we can address root causes, it will be that much easier.

The Next System Awaits

We already have many existing elements for human systems that benefit people and the broadly biodiverse species that make up the web of life.[54] The year 2016 has brought a dramatic transformation in the discussion of how the world works. The transformation is still quiet, but there's a building crescendo of awareness of the core centrality of a healthy, unpolluted biological world for our survival. There is growing activism for continued existence for all forms of life. It's part of a phenomenon, well-described by Paul Hawken in his 2008 book, *Blessed Unrest*, where small local upwellings of restoration and social innovation are beginning to coalesce into a force for global change.[55] Blessed unrest gains momentum as such efforts multiply across the world, from urban to rural, among wealthy and poor.

The Next System will acknowledge the need for many diverse systems that will vary according to habitat, climate, and culture and will of necessity be small, local, regenerative, egalitarian, equitable, employing minimal technology with modest environmental demands in balance with rates of resource replenishment and waste cycling.[56] With knowledge of the many flavors of governance worldwide and an understanding of the dynamics of groups that create governing styles (small remains beautiful and most sustainable) we have a rich menu to choose from. With numerous available low-tech and environmentally friendly approaches to food production, there are ample choices to maximize planetary short- and long-term productivity.

With all of the potential on this remarkable planet, maybe, just maybe, all species - including *homo sapiens* - will survive, even thrive.

APPENDIX

Detailed descriptions of Next System specifics are beyond the scope of this particular essay. However, many Next Systems have been proposed and developed over the human millennia,

[54] See Fritjof Capra, *The Web of Life*, for an excellent exposition of the many facets of life, the original worldwide web.
[55] Paul Hawken, *Blessed Unrest: How the Largest Social Movement in History Is Restoring Grace, Justice, and Beauty to the World*, Penguin Books, 2008.
[56] Given the laws of nature I've outlined, the future of cities and suburbs, with their intensive demands on surrounding productive lands, is, in my opinion, in doubt. This is also true for alternative energy production for which raw material, storage and distribution costs are ongoing challenges, along with future maintenance costs that are chronically underestimated - not to mention assumptions about the persistence of key technologies over time. Finally, given the virtual inevitability of some level of climate crisis, while a level of international assistance will be helpful in many instances the more we can rely on readily available resources near home the better off we'll be.

encompassing every societal configuration from hunter-gatherer through today's global civilization. In addition to what we already know we still have much to learn about ourselves and our history, and as we learn about forgotten systems they become available for our use. Rediscovery of the past offers many "new" solutions, as does changing the paradigm through which we view the panorama of human experience, which is what I have attempted here.

Most urgent and fundamental for life on earth is a functioning life-support system with healthy soils, waters, and abundant biodiversity from all kingdoms of life, with photosynthesizing microbes and plants at the core. Eco-restoration has many benefits, including addressing global warming, food abundance, droughts, floods, local economics, environmental justice, as well as the failures noted in the Next System essay specifications.

There are many effective approaches to restoring ecosystems. Examples are familiar to many readers of this essay, and include such approaches as permaculture,[57] biochar,[58] holistic planned grazing,[59] bio-intensive farming,[60] reforestation,[61] living shorelines,[62] coral reef restoration,[63] mangrove restoration,[64] food forests replacing dead-end lawns[65] and other unproductive, resource-draining misuses of land everywhere, the new water paradigm for managing water cycles,[66] and even doing everything all at once.[67] Additional resources are on the Biodiversity for a Livable Climate website[68] and facebook pages.[69] The variety and proliferation of possibilities are cause for much hope.

We have what we need in order to do what has to be done. Now let us find the will to do it.

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[57] There is now extensive practice and literature in permaculture. See, for example, http://www.rodalesorganiclife.com/garden/permaculture-101 and http://www.permaculture.org/.

[58] See the International Biochar Initiative, http://www.biochar-international.org/. There is an excellent introductory text by Paul Taylor, Hugh McLaughlin and Tim Flannery, *The Biochar Revolution: Transforming Agriculture & Environment*, Global Publishing Group, 2010. Also note development of local-scale technology for turning sewage into biochar, addressing both sanitation and carbon sequestration issues, http://www.climatefoundation.org/awards/gates-foundation, and https://www.youtube.com/watch?v=ZUS085zKD_c.

[59] Allan Savory, with sixty years of rangeland research and practice, has inspired transformation of land management and regenerative practice on millions of acres of grasslands around the world. See http://savory.global/ and https://holisticmanagement.org/. See "Soil Carbon Cowboys" for an excellent short video introduction to holistic planned grazing, https://vimeo.com/80518559.

[60] Examples of low-tech, sustainable biointensive farming around the world are at http://www.growbiointensive.org/

[61] See, for example, the Willi Smits reforestation project in Borneo, https://www.thesolutionsjournal.com/article/redd-and-smits-model-reforestation/.

[62] Living shorelines are promoted by Pew Charitable Trust, http://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2016/05/living-shorelines-a-key-line-of-defense and more recently by the Army Corps of Engineers, http://www.pewtrusts.org/en/research-and-analysis/analysis/2016/06/01/army-corps-of-engineers-releases-living-shoreline-permit

[63] The Biorock process enables coral reef restoration by extracting minerals from seawater *in situ*. See http://www.biorock.org/content/biorock-process.

[64] Mangroves are a keystone system for the biodiversity and integrity of coastal ecosystems. See the Mangrove Action Project, http://mangroveactionproject.org/

[65] For an excellent example of turning barren suburban land into a food forest, see Eric Toensmeier and Jonathan Bates, *Paradise Lot*, Chelsea Green, 2013.

[66] Michal Kravcik, *Water for the Recovery of the Climate - A New Water Paradigm*, 2007 http://www.waterparadigm.org/download/Water_for_the_Recovery_of_the_Climate_A_New_Water_Paradigm.pdf

[67] One Community Global: http://www.onecommunityglobal.org/true-community/

[68] Biodiversity for a Livable Climate Resources page: https://bio4climate.org/resources/resources/

[69] Biodiversity for a Livable Climate Facebook page: https://www.facebook.com/bio4climate