Carrying Capacity -
Our Wickedest Problem

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Cover photo "Waves of Humanity: sprawling Mexico City,"
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Preface

Carrying capacity is the Earth's ability to support the aggregate effects of the human population indefinitely. It's simple-minded to ask "How many people can live on planet Earth?" The answer has dozens of interwoven variables, rendering this a "wicked problem" (a technical term). Questions about carrying capacity must at least ask "How many people, at what average level of consumption, with what attitude towards Nature," and the more serious systems thinkers need to add "and further allowing for [insert a couple of dozen additional variables here]." The human problem, the *problématique humaine*, as the Club of Rome termed it, is tangled beyond any hope of definitive answers, and perhaps beyond hope of solution. But if we don't try, we can be certain that the world itself will eventually tell us what our limits were. This fairly short work will attempt to identify a couple of dozen variables, threads, or dimensions to this tangle, as embedded within the greater ecosystem.

The word "overpopulation" seems at first glance like a plausible synonym for "carrying capacity overshoot." Both terms imply a still ill-defined number of people that this world can't support indefinitely. But the word also has weaknesses. It oversimplifies the larger human problem by constraining the issues to only one dimension, limiting its usefulness in both practice and argument. And it has a nasty habit of triggering irrational denial across the great mass of humanity. Those who dare to speak it might even be accused of colonialism, eugenicism, genocide, coercion, or racism. How is it racism to want to spare a billion or more Africans from an inevitable death by famine when the biosphere's bills at last come due? We are limited to a dialog with other rational people, and this is not a majority.

Often the subject will get quickly changed to "overconsumption," another huge piece of the human problem. Even here, though, this thread itself is seldom addressed in any comprehensive way. So we only get to talk about smaller slices, like poor food distribution patterns, income inequality, fresh water shortages, topsoil degradation, greenhouse gases, climate change, or meat and dairy diets. And then we are seen as traitors to corporate capitalism, which is the only way that business can be done now. For all the yakking that gets yakked about taking holistic approaches, nobody wants to hurt their heads with multi-dimensional, whole systems analysis. So we whack at one mole at a time, in a field of moles without end. And problems propagate faster than we can fell them.

Overpopulation and overconsumption are parts of a braid that can't be disentangled: changes in one part will affect the other, and in many cases they are meaningless when considered alone. Different parts of the world have different jobs to do on different parts of the problem. Clearly, Asia and Africa have different issues than Europe and North America. This can make it confusing to talk globally using global averages. It's important to note here that we're already far enough into overshoot that both strands will have to be dramatically reduced, whether by us or by a destabilized nature. But there's also a third strand in the braid that gets little mention: human exceptionalism. This is the belief that we are just too special, too infinitely sacred, for nature. Whether we think ourselves angels or spirits, walking around down here in meat puppets, or simply the crown of creation, entitled to divine rights, we are the center of the universe. We're entitled to claim life itself as a property right, to monetize the commons, to take whatever we need and want, ingrates with no care or duty to give anything back. It's our destiny to grow without limit, until everything not human enough gets pushed off the face of the world.

The simplest way to explain the need for multidimensional thinking is to ask whether you would measure the area of a rectangle or the volume of a box by looking only at its width. No. Without looking also at the height and depth, the effort is absurd. The limits on carrying capacity demand multidimensional analysis, not just a simplistic stab at what constitutes overpopulation.

This work will consider all three strands of this braid in its pathological aspects, which might be referred to collectively as human parasitism. And we will be scoping those couple of dozen other issues that system thinkers need to work with. The good news is that much of our human parasitism is cultural, and therefore learned. The bad news is that this species of ours has a major problem with unlearning, a process that might easily require generations that we no longer have.

1. Common Knowledge and Overshoot

The carrying capacity of Earth (or Terra, or Gaia) is nearly always cast in terms of human populations: “How many human beings can this world sustain indefinitely, assuming that our technology will solve most of our problems as necessities arise?” The science is lacking here for any hard and fast answers and we are thrown back on thought experiments. The calculations simply have too many variables, not least of which being average per capita consumption. It seems this uncertainty is often all that humans need to rationalize continuing business-as-usual, until more has been learned and knowledge grown perfect. Answers to the global question will vary widely. The majority seems to think our population can stabilize successfully somewhere around 10 billion, with plenty of others in the wider range from 5-20 billion. And we all get to keep our carnivorous dogs and cats. But a great many of these thinkers also think that the world was created in six days by a bronze-age tribal deity afflicted with clinical paranoia, with a talking snake for an arch-enemy, who wants us to be fruitful and multiply. Something other than a vote is needed here.

One of the most discouraging things about being in this field is having to continually observe the limitations of the human mind when facing complex and wicked problems, even in those who are relatively awakened and sincere. This is particularly prevalent with inabilities to think in systems. We isolate one or two aspects of the situation and declare these to be the problem, not those other issues. Linear thinking is especially common where appeals to the larger public are concerned. We wind up playing the whack-a-mole game instead of unplugging the machine. An equal difficulty concerns our limited time horizons. Politicians can't see past the next election or bribe, the CEOs, beyond the next quarterly report. Even when people are trying to peer into a future decades away, they tend to assume that other variables won’t vary. The UN keeps showing us continued population growth without a hint of societal and/or environmental collapse playing any role at all in crashing our numbers eventually. They limit their factors strictly to human reproductive choices, as though other serious consequences aren’t already entering the picture, and others winding up to take some big, involuntary bites out of our numbers. One-dimensionality doesn't give us helpful pictures and graphs, but more realistic projections, grounded in systems thinking, are harder to understand and they threaten to hurt human heads and human feelings. Mention of a need to reduce the human population hasn’t been seen in UN papers in decades, and family planning only gets mentioned in the context of reproductive rights. A fear of losing sponsors may be in play.

Even a good percentage of the so-called Greens consider the problem to be largely one of more equitable distribution of food, as though this were our only weak link, as though all an enlightened society needs to do is sit in the garden, in the rain and snow, without building materials or transportation, and eat homegrown vegetables. Diet, including high-quality protein and safe drinking water, is one of many real concerns. Others believe that once we get climate change under control, we’ll be sitting pretty. Others hold that the real problem is the inequality of accumulated wealth. It always seems to be one single problem that gets singled out of a vast, interconnected network of problems. Lately, the problem of population growth, if it gets mentioned at all, is discussed in terms of stabilization at some level higher than now, and rarely in terms of reduction. This is even in places where current overshoot is explicitly acknowledged. It’s as though nobody knows what overshoot means. Overshoot is always and by definition temporary. It necessarily corrects itself through population culls, increased predation, crashes, collapses, or diebacks. There are many further dimensions to the

question of carrying capacity that take us well beyond "how many humans can survive here?" We are hindered by our failure to look at the problems systemically, as a whole system, an almost unimaginably complex system.

It's asserted here that, even if we assume that Earth and its web of life is nothing more than a kit of raw materials with which to build a human civilization in order to maximize our numbers, and that any value nature may have must be cast in the economic terms of the environmental services it provides, it really takes an utterly delusional species, with no vision at all beyond a single generation, to fail to see that we are already well over the limit and into an ecocidal and self-destructive overshoot. Our thinking here is shortsighted, linear, and anthropocentric. The scientific question of our fitness to survive, suggested by Spencer and then Darwin, is one of adaptive fitness. Fitness has little to do with our strength, or might making right, or the victors writing the histories, and everything to do with how well we fit our niche and adapt to the ways it changes, or the ways we ourselves change it. In order to make this fit, we will need to comprehend the problems we face both in a lot more detail and in a more comprehensive way.

Environmental groups won't raise or entertain the overpopulation issue for fear of losing members. They may speak of overconsumption, though, as if these two could be disentangled. Neither the UN's 17 Global Goals for Sustainable Development nor the WWF's 2016 Living Planet Report mention overpopulation. Goal 3 of the latter mentions unmet needs for contraception, but this is only applied to the health of families. The humanists seldom want to face the subject at all, since this implies that the human species is something other than the center of both the world and the universe, or somehow lacks the genius to solve any problem it might choose to create. That hurts their feelings and makes them angry. They are also more than a little myopic when it comes to human migration, relative to both national and global issues. Economists tend to live in a world that has already overgrown its limits, a world that is fundamentally unsustainable to the extent that it demands continual growth within finite systems, many of which are already threatening immanent cascade failures. It's the economists and the economic players that wind up telling everyone else how life must be lived, and most people listen because their economic fears and insecurities can be played like musical instruments.

Across much of the population today, if family planning is even mentioned, it's only in the context of rights, women's education, autonomy, and dignity. Proposals to correct our problems are economic instead, Drawdown and Plan B, for example. But in an effort to circulate these ideas more widely, they must fail to mention overpopulation as a problem, and at most, they will mention stabilization, or a reduction in the rate of growth. Everybody is pussyfooting around the issues. But afraid to offend is afraid to inform, and this will only perpetuate our ignorance.

In deep time, all things need to end, or yield to some kind of succession. It's one thing to know intellectually that unsustainable behavior will lead, by definition, to the extinction of that behavior, and that the continued evolution of a sustainable civilization requires the failure of any unsustainable status quo. It's quite another thing to be here to watch that failure start to cascade in earnest. The scariest part is in the ecology of population dynamics: a species exceeding it's environment's carrying capacity must eventually undergo a population crash, which by definition means either a major dieback or cull, always to a level below carrying capacity. This in turn means a lot of people dying younger than they otherwise might and the suffering that goes along with that. This clearly won't be voluntary, given the moral conundrums, the intractability of our ignorance, and the time we have remaining, but eventually there

can be no alternative to morphing into a steady-state economy and a population with its consumptive lifestyles at or below this world's carrying capacity.

1a. Choosing a Team of Thinkers

We will usually begin to study a subject with our rough opinions and then be drawn to further research sources that tend to confirm and refine that. I can't honestly exempt myself. I had personally begun to suspect that we were in overshoot by the late 50s, while playing "duck and cover" to the sound of practice air raid sirens. But I did have some worthy criteria for further research on this topic, particularly recently. I noticed that a respectable number of thinkers were enumerating much larger sets of problems, and looking at their interactions with systems thinking and analysis. They weren't just naming a few select problems and treating them individually. I also noticed that their carrying capacity numbers were much lower than the 10 billion average, even below the 5 billion low end of the more common range. Today, the highest of this group is roughly 5 billion, supported by the Global Footprint Network (2018) with its Earth Overshoot Day. This is based on a calculation of Earth's biocapacity being sufficient for each and every one of us to appropriate about 1.8 global hectares per year. Yes, it's oversimplistic, and perhaps therefore popular. It's homocentric as well. Bioproductivity is seen as just that: nature is primarily for the servicing of a human need for nature with its ecosystem services. And it also neglects a few other large parts of the larger problem. Ecological footprint and biocapacity calculations leave little room for non-renewable capital depletion, degenerating lands, for nature itself, the wear and tear on civilization's infrastructure, and the waste of human efforts in political chaos. It's a snapshot, with no time horizons, no rainy day planning, and no buffers.

Gretchen Daily, with Anne and Paul Ehrlich, have proposed a considerably lower number of 1.5 to 2 billion, a number derived from a broader range of considerations and dimensions. Although based first on energy consumption, the Daily-Ehrlich numbers also speak to better distribution of resources to everyone, a basic floor of rights and human welfare, and the preservation of both biological and cultural diversity. Paul Ehrlich may more privately favor a more conservative one billion, the human population around the year 1804. At this point, all we can offer is prophesy. If or when we pass through our crash or dieback, the real number will be somewhere above the number we crash to. Spoiler alert: by the end of this book, I will be proposing two population levels: a maximum carrying capacity of 2 billion, which leaves a functioning, but severely degraded biosphere, with just enough left of nature to get by; and an optimum carrying capacity of one billion, in which there is opportunity for all life on Earth to thrive. The lower number also means that the world's poorest can still have food, shelter, some leisure, and an education, which drags the carrying capacity number down quite a bit from the numbers that people like to entertain. But to get to such a guess we will be looking at several dimensions that are currently being ignored or neglected in most of the current studies.

Aurelio Peccei referred to the aggregated cluster of our problems as the *problématique humaine*. The term human problematic was adopted as a central concept by the Club of Rome and then operated on with systems analysis. This specifically regards attempts to address single problems individually as being doomed to failure. The only hope is with a more global perspective, regarded with a much deeper sense of the long term. The authors of The First Global Revolution sought a comprehensive rally against the "problematic" as a new common enemy, to take the place of more parochial foes like nations, races, and religions, something to unite the human race. This global enemy may be referred to here as human parasitism, our pathological or dark side. Walt Kelly, or course, nailed it down best: "we have met the enemy, and he is us." In less militant terms, the first global revolution might also be recast as a new

Marshall Plan, a new New Deal, or a Moon Shot. All of these must launch pan-national efforts, including the more petulant nations and their corporate overlords.

We already have at our disposal a number of workable technologies and practices, together with the potential to develop new and truly sustainable technologies. Examples abound with simpler living,net zero architecture,renewable energy, improvements in efficiency, algal and cellulosic biofuels, material substitutions, regenerative agriculture, higher quality protein from the second trophic level and better management of the third, and the potential to develop a secular environmental ethic. But every one of these is moot in the long run as long as we remain in overshoot, except to the extent that we are developing prototypes for the survivors of our dieback.

You will generally find the ideas shared here to be in a camp with Lester R. Brown, Paul and Anne Ehrlich, John Holdren, Gretchen Daily, Dennis and Donella Meadows, Jorgen Randers, David Pimentel, Jared Diamond, Joseph A. Tainter, Nicholas Georgescu-Roegen, Herman Daly, Richard B. Norgaard, Jem Bendell, Philip Cafaro, Jacques Cousteau, E.F. Schumacher, Edward O. Wilson, and David Attenborough; some old timers and their admittedly imperfect prophesies like Thomas Malthus, Nikola Tesla, William Vogt, and Fairfield Osborn; newcomers Karin Kuhlemann and João L R Abegão; and even the pessimist Pentti Linkola. If we averaged their numbers, where they're offered, the recommendation for a maximum carrying capacity might be found somewhere between 2 and 3 billion. At least that's a fair intermediate goal for this present survey.

1b. The Wickedest Problems

Wicked problems are social or cultural conundrums that are extremely difficult or impossible to solve for multiple reasons: a hypercomplexity of interrelated subsystems or factors (often each in itself a problem), incomplete or contradictory knowledge, multidimensionality, changing conditions and requirements, large numbers of people and opinions involved, gridlock in the legislative and social orders, conflicting stake-holder agendas, indeterminate cascade effects and failures, excessive economic burdens or fundamental incompatibilities with economic systems themselves, and consequences unknown until attempts at correction are well underway. Multiple dimensions of a wicked problem need to be tackled at the same time, with unpredictable outcomes. According to Horst Rittel, they will have no definitive formulation, they bleed into one another, there is no idealized end state or stopping point, there can be improvement but not a final solution, they are unique and without templates, and they have multiple explanations. There are a number of smaller and separately nameable wicked problems involved in the issue of carrying capacity. Climate change is currently the most often cited, followed by the conservation of biodiversity. Overconsumption gets cited far more than overpopulation, although these are actually braided together with human exceptionalism into a single wicked problem refer to here as human parasitism. If there is a single umbrella name to cover them all, it may well be the Anthropocene, the period wherein human impacts on Terra ramped up most significantly, around 12 kya, which roughly coincides with the Holocene geological epoch, beginning with the last great glacial retreat. Ecocide of the biosphere and the Holocene Extinction are two of its faces. At a minimum, it's an existential threat to both human civilization and natural biodiversity, and without this infrastructure, the human population will have no alternative but to crash to a small fraction of its present size

One of the more significant difficulties here is that voluntary efforts to solve the problems are wholly inadequate, while coercive policy measures are wholly unacceptable. One seemingly positive factor is that a large number of the contributing dynamics are cultural in nature, or learned instead of natural. But opposing this is the human reluctance to learn alternative ways of being in this world. Most necessary tasks require cultural consensus and education, followed by changes in human behavior, a process that can take generations. But time for this is rapidly running out. And key elements of this change are militantly opposed by the fundamentalist religions. Pyramid scheme and Ponzi economists are fully embedded and entrenched, and more than a little reluctant to drop the pro-growth paradigm and surrender to steady-state economics. Effective scare tactics come easy: you will lose all that you have acquired. Those proposing to solve the problems are far too frequently the ones creating them. Corporations are drafting the bulk of the ‘solutions’ to the damage that the corporate ethic is doing. Even the global proposals like UN’s “2030 Agenda for Sustainable Development” appear to be written by the same forces that need to be dismantled, and soon. This amounts to a one-way, dead-end path dependency. From the Dark Mountain Manifesto, “Daily we hear, too, of the many ‘solutions’ to these problems: solutions which usually involve the necessity of urgent political agreement and a judicious application of human technological genius,” but “transformative change can expect opposition from those with interests vested in the status quo”

Humans are proud of their adaptive intelligence, but it’s by no means certain that they have enough of that stuff to get out of the present messes already made, let alone the new levels building. For one thing, humans keep fixating on ‘the most pressing crisis’ and fail to address the greater drivers of the multitude of crises. They also tend to not

get agitated until a problem has become a full-on crisis, when there's no time remaining for carefully planned responses. Further, you don't manage or micromanage a complex system from the top with the limited intelligence and understanding of politicians and their appointees. There you just get diminishing returns and compounded blunders. Long-term solutions require a long-term vision, and one that will not rely on hyperbolic discounting to calculate the future.

Corey Bradshaw and Barry W. Brook write "even if the human collective were to pull as hard as possible on the total fertility policy lever (via a range of economic, medical, and social interventions), the result would [still] be ineffective in mitigating the immediately looming global sustainability crises (including anthropogenic climate disruption), for which we need to have major solutions well under way by 2050 and essentially solved by 2100." They at least suggest that this voluntary approach might cut our numbers by a couple of billion. But even this is too little too late. Coercive measures are highly unlikely, and morally unacceptable. War, surprisingly, has never been enough to put more than a small dent in our growth. For the most part, then, the Reaper will simply be Consequences, no angry messiah, no holy-book prophesy, no planetary alignment or magical calendars, just the consequences of human ignorance and a refusal to adapt intelligently. It's unlikely that the problems will be solved by our growing up any time soon.

Potential efforts to merely reduce the population's rate of growth may not be entirely in vain. They will reduce total human suffering in the long run, and they may delay dieback. The four biggest contributions to such a reduction would remain women's education, family planning, meeting basic needs with the best available technology, and overriding religious dogma. But delaying dieback may be a bad thing for the world's biodiversity, since the longer it's delayed, the more long-term and permanent damage is being done. A human population crash, even if involuntary, might well be a boon to the future of Earth, including its human or post-human inhabitants. No well-known current projections include such mass-mortality events, except perhaps those of Donella Meadows and friends, which are again in need of an update. We haven't seen one of these population crashes on a truly global scale since Toba, 74 kya. The Black Death that ravaged Europe was significants in scale, but it did its ravaging mainly in Europe and the Mideast. You can see from this that any discussion that may approach the necessary scale of things is going to be seen as misanthropic. But at least it need not be racist or genocidal. This can be an equal opportunity holocaust, for all the pretty human colors, for rich and poor alike.

1c. Pessimists and Futurists

It seems that most of those who hold the Terran carrying capacity to be 5 billion humans or less still manage to hold forth some degree of optimism about the human future here, at least publicly. That may show a desire to encourage the broader public to a spirit of reform and not spread a gloom of despair. We are a plucky little band of Cassandras and Star Throwers, but many of us are still crying privately for all that's going to be be lost. At this point it still seems unlikely that our species will suffer a complete extinction, even in the thick of runaway climate change. That can't be worse than our designs to live on Mars. A collapse of civilization in the first round of a population crash is far more probable. But even the most pessimistic of us have to hold onto some shred of hope that something of culture might survive, perhaps a digital record of our several prototypes, experimental communities, inventions, solutions, and bright ideas might be cast into some form durable enough to last a couple of centuries. And there are seeds to plant now that might only grow later, when our species has learned some things the hard way.

Stable climate, biodiverse ecosystems,sufficient natural capital,reliably renewable resources, ample sinks for the reabsorption of our wastes, and a functional social order are all environmental systems that allow a temporary tolerance of capacity overshoot. This is ecosystem resilience. Pieces of these systems are already failing in spectacular ways, but the systems themselves are only beginning to fail in concert. When that happens in earnest, the synergy will become cascade failure. Not all parts of the globe will fail or succeed equally, even if we are all in this together. We are still concerned here with the whole of the Terran niche and average per capita impacts. I expect that significant population reduction will begin happening many decades within the frame of the 21st century, hitting hardest in Africa and Asia. Europe and North America will have a different set of problems, more closely related to large per-capita environmental footprints. But the line between those will be thick and fuzzy. Any significant measures that humans might take to address this will be emergency measures deployed in mid-crisis, not voluntary measures developed with long-range planning.

Donella Meadows writes that "our most important statements about the likelihood of collapse do not come from blind faith in the curves generated by World3. They result simply from understanding the dynamic patterns of behavior that are produced by three obvious, persistent, and common features of the global system: erodable limits, incessant pursuit of growth, and delays in society's responses to approaching limits." I will discuss these three later, in places within a different arrangement and set of categories. Certainly the system of economics we've set up will need to fail out of the way. Economics as usual is flat out opposed to the necessary solutions and is structurally incompatible with them. Economists can't even glance sideways at the problems without their heads exploding, being unable to face the idea that both population growth and growth in consumption must end, and soon.

I take a fairly dismal view of the near-term future of humankind, and that's based largely on some interdisciplinary understanding of the intractability of human ignorance, particularly in adults. I think we lack both the collective will and the adaptive intelligence to turn this juggernaut around. And I see us as having passed several important tipping points way back in the early 1970s, when the corporations got fuller control of our governments and we refused to learn lessons about perpetual war. Most of the people who are capable of getting motivated to work on this are already motivated. Most of the rest can't even see the real problems yet, or see only glimmers and slices, or can't imagine a role for themselves in any real solution. And of course, most of the people living in high fertility regions are too busy struggling to meet their

fundamental needs to look around at global issues, or care. The religious will be stubborn to the last, and many will continue to pray for the End of Days. We will eventually see the problems collectively, but not until we're trapped with no solutions. A dieback will be inevitable, this being the consequence of overshoot. This leaves us with the question of how much of civilization might survive. My guess is that our population will have crashed by at least a billion before the majority of humanity even admits to having population problem. And if you want to see how bad things can get while maintaining a high birth rate, just look at Sub-Saharan Africa. These people, and others in r-strategy populations, have nowhere to run, and will be the first to go, barring war between developed nations. By then, the developed nations will have too many problems of their own to lend any adequate aid.

I'm wrestling with any remaining optimism, but I can still be a futurist here and write for the survivors. We can hope there will be a Wayback Machine that's hardened against CMEs and EMPs. I'm not just writing this for the Cassandras, the Star Throwers, and the Deep Ecology choir. The main point of implementing practical solutions today will be to show the survivors that our proposals and prototypes might have worked, had cultural inertia and human ignorance not been so intractable. The steps being taken now will probably not be taken for nothing. Good ideas can survive dark ages, as the Epicureans and others have shown us. We don't know yet if the survivors of the coming bottleneck will be selected for any kind of ecological savvy. It could be some other, wrong kind of adaptive fitness, or perhaps a dystopian Road Warrior citizenry. The sustainable, off-grid ecovillage or intentional community, practicing peace and regenerative agriculture (like we should all be doing) might not be the fittest for survival if it can't defend itself against roving marauders and bandits, or seizure by despotic governments. Some solutions might need to hide themselves, like Asimov's Second Foundation.

I'm a pessimist, but I'm also a futurist. Even if we have no choice but to face a devastating population crash, we still can't give up. I don't expect humanity to find its way to any happy solution voluntarily, or as a result of far-thinking planning. We might assume a total collapse of the present global economy. Transition will be accomplished with much kicking and screaming. A steady-state economy ultimately means no usurious interest on loans, big profits on investments, or overly burdensome rents, stripping the economy of much of its current motivation. Many of today's truly promising solutions, including renewable energy, regenerative agriculture, desalination, *terra preta*, reforestation, substitutes for high-quality protein, simple living, cradle-to-cradle accounting,natural capitalism, localization, devolution of function, ecolonomics, drawdown, universal education for women, and experimental community will be necessary parts of any great big, beautiful tomorrow. All have important pieces to the puzzle. All will need to find their way into a comprehensive and integrated system, with a great deal of diverse expression. But such a system still will not function at current or projected population levels, not even if everybody goes vegan and stays at home. And it won't ever function without an end to perpetual war. Our experiments, and our written legacies, are the prototypes the survivors will need - a little something we can give to them besides a ruined world. Even at the most extreme, we can be leaving scrolls and artifacts for archaeologists digging through our ruins. Even if those archeologists have tails and huge, yellow teeth, life will go on.

We are likely faced now with helping to design what Rupert Read calls "successor civilization(s)." And in the transition to this, we can still do small scale experiments and prototype communities, as lifeboats, arks, wooden ships, seed cultures, as the first steps in our "transformational adaptation." We don't know what a collapse of the present civilization will entail, or what the selective pressures will select for. It's easy

to imagine Road Warrior or warlord scenarios, now constrained to a much-diminished environment and carrying capacity. Experiments kinder than that may need to be well-armed and defended. Jem Bendell, who is pessimistic about a survivable modification of the status quo, advocates instead for “deep adaptation”, fundamental adaptive alterations to the way humans do business here. Bendell sees three parts to our needed deep adaptation: “Resilience asks us ‘how do we keep what we really want to keep?’ Relinquishment asks us ‘what do we need to let go of in order to not make matters worse?’ Restoration asks us ‘what can we bring back to help us with the coming difficulties and tragedies?’” It may be that the most useful thinkers and designers of these “successor civilizations” will be our science fiction writers, at least those of us who haven’t surrendered wholly to dystopian visions.

In sum, my remaining hope lies with the survivors of a deep population crash somehow having been able to learn some hard lessons and adapt to a much-diminished world. Still, the intractability of human ignorance makes even our learning the hard way seem a bit doubtful to me. That not only needs culture - it needs the right culture, and generations of time. We have most of the pieces to the puzzle, we know how it could be done. Can pockets of us pull it off? Some of us are still obligated to try.This isn’t so much a book of practical solutions and the science behind them as it is about scoping or enumerating our many problems and their dimensions, filling in the inputs for the systems thinkers. We have been proceeding with far too narrow and piecemeal a view of these. Solutions, insofar as wicked problems allow, will evolve more slowly, out of improved understanding. Our biggest problem is a failure to comprehend the scope of the wicked Holocene problem in its many details. This is also about trying to personally apologize to future generations, and show that not all of us were thoughtless idiots and parasites.

2. Human Parasitism and Coevolution

Numerous writers have described the relationship between humankind and the planet's biosphere, with special regard to our unchecked population growth and our overconsumption of resources, as a pathological process analogous to malignant neoplasm, or cancer (Gregg, 1955; Eisley, 1961; Hern, 1990; and Forrester, 1991). Unlimited and poorly differentiated growth in a finite system certainly has this characteristic. It was Edward Abbey who wrote "Growth for the sake of growth is the ideology of the cancer cell." While such an analysis has a number of things to teach us about the dynamics of our predicament, the much simpler pathological model of parasitism will convey the same core message with greater simplicity and just as much mortal urgency. E. O. Wilson has characterized parasites as "predators that eat prey in units of less than one."

It hurts people's feelings to be called parasites. They don't like to hear that, or that there are too many of them, or that they're too greedy, or that they wrongly think they're the crown of creation and the center of the universe. They will call you a misanthrope. But they take and take from this world, and they give nothing back, and that's what a parasite does. In our species-wide narcissism, we frame nature as environmental services, frame time in human generations, and frame divinity in human form. Our insatiable appetite even leaves our own descendants out of the picture, and out of luck.

Human parasitism will be looked at here as a braid of overpopulation, overconsumption, and human exceptionalism. All three of these are driving our coming failure as a civilization. Although demographics characterized by high population, high consumption, and human arrogance will fail for different reasons, this braid can't really be disentangled. To say we can separate them is like saying it's not magnetism but electricity that makes the motor go around. We are so far into overshoot that solutions are required on all three strands of the braid. None of the three can be ignored. Another formula treats the first two as inseparable. This is described as I=PAT, from Paul Ehrlich and John Holdren. Total human Impacts are the result of population x affluence x technological interventions. Impacts can remain the same if population grows at the expense of affluence, or if the population falls within an increasingly affluent culture. Technological developments can make impacts better or worse, with the other two strands holding constant. Personally, I incorporate the T within the A, along with efforts at greater resource and capital efficiency, since the A is really all about our level of consumption, however it's modified. The parasitism braid is similar, but it functions as a combination of attitude and ideology, leading to behavior that diminishes the host being fed upon, the host that sustains us. Human exceptionalism is more than just a philosophical stance that underpins the other two. It's behavioral and it's expressed in ways other than overpopulation and overconsumption. Some might question whether this attitude is an actual cause, whether proximate or final, but we are speaking here of an engaged exceptionalism, not theoretical or ideological. It's behavior as if we were the crown of creation and the center of the universe. It's what allows us to claim nature as property, transforming life itself into environmental services dedicated to human ends, and a future that's somehow subject to our hyperbolic discounting. It lets us claim human rights without accepting corresponding human duties. We own the world. Overpopulating it and overconsuming its resources and capital is our right. To even ask that any population restrain itself is therefore misanthropic, coercive, and genocidal. This is pathological.

There are a number of human cultures still existing in this world that have long demonstrated a true sustainability, spanning millennia, and even tens of millennia. These are symbiotic cultures, distinct from the parasitic. We have destroyed most of them with our seductive new paradigm, or absorbed them, or tempted them into less sustainable lifestyles. The first order of business for the first wave of missionaries is to introduce the pleasure of consuming things never needed before, in exchange for a little labor. The religion comes later. The fact that these cultures have existed historically, and that some still do, tells us something important: parasitism is not a human universal. It's largely cultural, and not genetic except to the extent that it plays upon our inherited triggers. It must be learned, and so perhaps it can also be unlearned, were more humans able to unlearn. But in order for us to learn or unlearn something, the promise has to be as or more attractive to us that the other options before us. This will become a lot easier once we have more fully entered dystopia. Until then, denial can keep better alternatives from our view.

We coevolved with the Pleistocene epoch, which saw us change from *h. habilis* to *h. erectus*, into the present *h. ignoramus*. We did reasonably well here as symbiotes, all things considered. We thought we were doing even better in the Holocene, until we filled up the world and then some, and the real consequences of our overshoot began to show. People still don't grasp the seriousness of the word sustainable, or the correlate that an unsustainable behavior leads by definition to the extinction of that behavior. Most of us don't yet grasp that fitness means adaptive fitness, the ability to respond in viable ways to evolving environments. It really has little to do with 'might makes right.' We will either return voluntarily to sustainability, by way of adaptive fitness, or we will suffer population collapses or diebacks until we do. But we won't return to what we used to be. That great, empty world is gone now. The niche has changed. Some of us know more and better now. We have to invent new ways of being in this world. It will have to have things like medicine and dentistry, regenerative farming, electric cars and their roads, science and art, and computers with digital audio. These don't have to kill the world. But we can also keep or regain some of the lessons the old ways have taught us.

2a. Overpopulation and r-strategies

Thomas Malthus offered the following:"Famine seems to be the last, the most dreadful resource of nature. The power of population is so superior to the power in the earth to produce subsistence for man, that premature death must in some shape or other visit the human race. The vices of mankind are active and able ministers of depopulation. They are the precursors in the great army of destruction; and often finish the dreadful work themselves. But should they fail in this war of extermination, sickly seasons, epidemics, pestilence, and plague, advance in terrific array, and sweep off their thousands and ten thousands. Should success be still incomplete, gigantic inevitable famine stalks in the rear, and with one mighty blow levels the population with the food of the world. Must it not then be acknowledged by an attentive examiner of the histories of mankind, that in every age and in every state in which man has existed, or does now exist, that the increase of population is necessarily limited by the means of subsistence, that population does invariably increase when the means of subsistence increase."Some of the problems associated with human parasitism are more closely tied to overpopulation and others to consumption. Food production, biodiversity loss, water consumption, and land conversion tend to be functions of human populations, although the growing demands for meat and dairy diets, and pet foods, are more closely tied to levels of affluence.

However insightful he may have been, Malthus did get a couple of things wrong. But his prediction of where we are headed in the end isn't one of them. His biggest omission was a failure to predict the now ironically named 'green revolution' or 'third agricultural revolution,' the advent of modern industrial agriculture, with its massive inputs of fertilizers, biocides, high-yield seed varieties, and its mechanized farming aids. This has allowed the agricultural output per unit of land a temporary exponential growth that's been keeping pace with exponential population growth. This temporary failure has been enough for critics to get by with claims that his vision was just plain wrong. But his critics have failed to look at diminishing returns on the technological, resource, and the mineral inputs needed to temporarily boost the per capita productivity of land, and ultimately the decline of these inputs along with natural productivity. They have also failed to notice the over-appropriation of fresh water, particularly from in-stream river flows and fossil water aquifers. They have failed to notice the conversion of topsoil to sterile dirt, as well as losses from wind and water erosion. They have failed to grasp that carbonaceous life in the soil is the way nutrients are captured from weathering parent material, and that healthy, living soil is also our easiest means of carbon sequestration. In short, the agricultural revolution that has allowed food production to keep up with population growth is a loan drawn against natural resources and capital, but treated on the human books as income. We haven't planned on paying anything back. This is a very long way from sustainable.

That Malthus miscalculated his timeline, and failed to see a few variables, does nothing to refute the overall trend that has continued to develop at a somewhat slower rate. We're still moving in that direction. To say that Malthus is wrong because it hasn't happened yet is a specious argument. It's like saying "The gangrene is only in his toe, but I've heard that it progresses almost overnight. It has failed to reach his knee as soon as predicted and he's still alive now. Therefore, he is going to live forever." The predictions by Malthus, and then Ehrlich in 1968, were only a bit premature in the larger frame of things. As long as there is either growth or overshoot in a finite system, the predicted outcome still lies ahead. Furthermore, limitations on the availability of food aren't the only ones to which the Malthusian model applies. It can refer to any limiting necessary resource, especially the non-renewable natural capital in finite

systems. The bottom line is that without a birth-rate solution, there can only be an unavoidable death-rate solution, in war, famine, toxification, pestilence, habitat loss, and our hypertrophy into deadlier living environments and geohazardous regions.

In ecology we have r/K selection theory, developed by ecologists Robert MacArthur and E. O. Wilson. This describes a species' preference either for producing greater numbers of offspring with less individual parental care, or smaller numbers with greater parental investment. Humans who are doing well in their environments lean towards the K-strategy, with fewer offspring, and have been gradually moving further in this direction. Local populations tend to move in this direction following improvements in living circumstances, particularly with reduced infant and child mortality, the meeting of basic needs, more sociopolitical security, and improved education and career opportunities, especially for women. Women are offered alternatives to being mere baby-making machines and servants of the family. It should be noted more often that educating young women doesn't end with them making better informed decisions about family size. When they have children, they pass along the benefits of better understanding, and when they have fewer children, each child gets more of her attention. And childhood adversity is thereby reduced, with benefits that may last for generations. Smaller families are not diminished families.

The r-strategy gets diminished along with a reduced need for spare or replacement children. This tendency is described by Demographic Transition Theory or DTT, which explicitly refers to declining birth and death rates as populations transition from pre-industrial to industrialized economies through four or five distinct stages. This is not really a law, and the transitions aren't necessarily as automatic as the theory describes, but it does highlight a general trend. The most significant milestone in this transition occurs as a population's total fertility rate (TFR) falls below the replacement rate of 2.1-2.2 children per woman. This point looks like a positive step against the global population problem, but it isn't as positive when the increased per capita consumption that has triggered the change is accounted for. Once again, population and its consumption can't be disentangled, either in the parasitism formula or the I=PAT formula, and the accompanying increase in consumption can more than offset the decreased impacts of population reduction.

Growth-driven local and national economies, and their economists, already have issues with falling growth rates. But they pick up even more difficult challenges when fertility falls below replacement. Locally, this is where immigration might be reconsidered, but this doesn't solve any of our global population problems and it may well perpetuate local capacity and overshoot issues. At this point, the supporters of growth start to spend big on campaigns against too much family planning, and governments begin to encourage their citizens to make more babies. Here we see some fair arguments and some truly specious ones. The fact that we are already in a state of overshoot, with the prospective consequences of that, means that even the fair arguments merely describe conditions that we will have to find other ways around, and the sooner the better. There is a great deal of confusion between reductions in population growth rates, reductions in population growth, population stabilization, and population reduction. The last of these is the only survivable response to overshoot. The issue is overpopulation, and the subsequent collapse of support systems that collectively define what overshoot means. The good news about simply passing peak fertility rates would be better if we weren't already so far beyond carrying capacity. We need to understand more clearly that it isn't really a promise of success that half the world's population now lives in countries with fertility at replacement levels or below. Those people are also consuming much more per capita, and most still believe that humans are the center of the universe, and that money makes the world go around.

The greatest real challenge is referred to as youth and old-age dependency ratios. We get fewer younger people taking care of increasingly older elders, with their rapidly rising health care costs. We get fewer adults in the working class age group, so we have fewer workers paying into retirement, social security, and health care programs. These are funds which have long been borrowed against by nations with no ability or intention to repay them. They have been counting on a growing population. This makes them Pyramid and Ponzi schemes in effect, if not intent. This is especially terrifying to nations upside down in debt or already verging on bankruptcy. On a different scale and side of things, we should also be aware of a real 'only child' issue that also recommends we make village and community improvements, so that children can still grow up in age-diverse, extended family environments, such as those we are best adapted to. These give children younger ones to teach and older ones to learn from.

There are specious arguments claiming that more people means more bright leaders and brain power. There could be some benefit in number of patents, copyrights, and fortunate genetic mutations. But the best counter comes from Steven Jay Gould: "I am somehow less interested in the weight and convolutions of Einstein's brain than in the near certainty that people of equal talent have lived and died in cotton fields and sweatshops." A better grasp of childhood adversity and the horrors it inflicts on early cognitive development is the counterargument to make. Counterarguments that quality of life is more desirable than gross quantity are hard to make to the already-convinced.

It's argued that we need to keep growing because that's both human nature and the nature of economies. It's as good as a natural law. But sustainable population levels are wholly incompatible with a growth and Ponzi economy, which demands increasing downstream users to pay off the debts we're incurring today. Having to live within our means is, of course, out of the question, because we are far too special and deserving for that. Nations begin to scream in pain and fear as soon as their populations begin to decrease, but there is no other option that also includes survival. Most arguments fail to mention that it only gets worse with delays. We are hooked on delusional hyperbolic discounting. But we must lose the gangrenous toe, or else we lose the limb.

Other specious arguments include fundamentalist religious resistance to population management, along with outcries about reproductive rights violations,racism,and eugenic coercion, especially wherever attention gets trained on the more r-strategist, developing-nation populations. The new left, with its politically correct humanists and humanitarians, will tend to overreact at the merest hint of population control, even where it's called management, or non-coercive. Reactions to even the most incentivized and voluntary proposals for distributed contraception frequently mention the half-baked eugenics movements of the early twentieth century, culminating in Hitler's activities. Most will try to avoid the population question issue altogether. Of course this 'racist' point is idiotic. The PC people are now well into convincing even science writers to abandon the very word race, because it's caused trouble in the past. But whatever word you want to use to describe those dark-skinned people living all over Africa, those are the people who are going to suffer the worst as the population begins to crash. So who is it that's saying that trying to prevent this is racist, colonialist social engineering? Human parrots, that's who, who just aren't thinking things through. How is it racist to want to spare the Africans death by famine of hundreds of millions or even billions?Aside from famine, Jared Diamond cites five more interconnected causes of collapse, all seen at the end of prior civilizations and all related to overshoot: the non-sustainable exploitation of resources, climate changes, diminishing support from friendly societies, hostile neighbors, and inappropriate attitudes for change.

A typical boom-and-bust cycle is described in population dynamics 101. A population cannot survive in overshoot because it over-consumes both natural capital and renewable resources, and it fills the environment's capacity to absorb waste products. Eventually, it must undergo a necessary crash or dieback to below its environment's carrying capacity. Meanwhile, carrying capacity itself suffers some long-term damage from capital depletion, especially while in overshoot. Capital depletion is more characteristic of human societies, not those of the plants, fungi, and animals. Rebounding populations again exceed capacity and crash again in a dampening oscillation around a gradually diminishing carrying capacity, a limit that a reasoning species would stay comfortably below. The thing about population cycles is that eventually they will describe realities that are no longer optional or voluntary. Eventually, non-renewable capital runs out or down and substitutes for some can't be found. Sometimes the support systems for renewable resources are too badly compromised and themselves become non-renewable capital. Sometimes sustainable rates of renewal are exceeded in ways that their consequences can't be avoided. Eventually, unsustainable population levels have no alternative to a crash.

Until we reach a fully blown population crash, any coercive measures for population management will remain out of the question, for moral reasons and questions of human rights. Mass sterilization of the infirm, mentally feeble, or undesirably colored, just isn't going to catch fire again. Of course, if we were smart, we would stand clear of programs that have failed us in the past and learn from our mistakes. China has moved on from its one-child policy to its 'later, longer, fewer' approach. The best policy, of course, is in setting an attractive example, showing how a non-coercive management can lead to a better life. Many are looking to Botswana for such an example. People must be persuaded to produce fewer people, and the most persuasive agents are usually economic. Tax incentives might help, where governments aren't panicking over depopulation crises. For instance, a nation might offer only a single tax deduction for 'children,' regardless of whether a family has zero or three. Free contraception, freely distributed, would be a huge help if funding could be found, and this would take a huge bite out of the abortion problem.

2b. Overconsumption and Footprints

"Few educated people realize that the marvelous advances in technique made during recent decades are improvements in the pump, rather than the well." Aldo Leopold

Many people are already declaring the population problem solved because so many nations are achieving below-replacement total fertility rates (TFRs). As Adair Turner describes, "In all countries that have achieved middle-income status, and where women are well educated and have reproductive freedom, fertility rates are at or below replacement levels…. Rich, successful human societies choose fertility rates that imply gradual population decline." This also results in more people feeling entitled and over-consuming to fully obtain their due. Rises in per capita consumption will more than overcompensate for population-based reductions in the total human footprint. Over-population vs over-consumption balance remains a local affair. K-populations have concerns about footprint, demographic decline and immigration, while r-populations have concerns about the low value of human capital, poor standards of living, and inefficient environmental exploitation. Between these are the transitional populations, with their rising living standards amidst demographic decline, caught temporarily in what's called a demographic trap. K-populations might panic here and turn to pro-natalist programs, or as a last resort, immigration, to hold the population in growth mode, when they would be better advised to constrain any such efforts with negative population growth until reaching the local carrying capacity.

Most of the drive to accumulate stores of capital and resources appears to be cultural, since there are many cultures in which this is almost entirely absent. There may remain in us some evolved general adaptations to go the whole hog when encountering scarce necessities, notably dietary sugar and fat, which have led to notorious problems of restraint when these resources are no longer scarce. Evolutionary psychology may one day point to a stronger trend to hoarding goods among ancestral Europeans, who have long had better reasons than more southerly relatives to store supplies over long winters. But such a theory would need to account for the relative absence of same in the still more northerly, non-Caucasian tribes.

Knowledge of the workings of the human mind has perhaps contributed more than anything else to our present overconsumption, especially through the development of advertising and propaganda as sciences and technologies. Human needs are easily played to, and brand new human wants are too easily created. Self-image, self-worth, and the craving for belonging and social status are easily exploited, with devastating consequences to the environment. You can prove yourself to others only by consuming more conspicuously and out-competing them for the money to do so. Try to guess how much is spent on sexual conquest and arm candy and the chunk of GDP that represents. This drives much of the socioeconomic inequality and inequity at the root of many of our other problems. Governments will also play heavily on our fears and insecurities in order to metastasize in their powers, military and otherwise. Prohibition organizes crime, which then justifies more government. Growth becomes self-sustaining or automatic this way. We get ever-increasing socio-economic-political arrangements and machinations to service our growing aggregate consumption, until things grow too complex to manage.

We are most concerned here with global numbers, especially our average per-capita environmental footprints. Ecological footprint measures human demand on nature, in terms of quantity in natural capital, resources, and sink capacities. Average per capita footprint can then be measured against the environmental support system's natural capital and its biocapacity for sustained regeneration. Clearly, there are major differences and inequalities between cultures, and we've already pointed to strong

inverse correlations between fertility rates and consumption described by Demographic Transition Theory. That so many countries are now falling below replacement-level reproductive rates is often cited as a sure sign of our eventual coming around to sustainability. But when this is brought up for discussion, far too few will mention this in relation to the more-than-compensatory increase in affluence and environmental footprint. Further, these model countries are frequently panicking over the threat to their Ponzi economies and instituting programs to increase the birth rate again. Meanwhile they are also frightened of using immigration to make up the difference, for unrelated xenophobic reasons.

Herman Daly (1971), advocating steady-state economics, claimed "The stationary state would make fewer demands on our environmental resources, but much greater demands on our moral resources." The most needed of these moral resources is restraint, but this is best supported by other virtues like contentment, security, humility, greater concern for posterity, and gratitude for what we already have. Both contentment and security are much frowned upon by advertising, churches, and governments. It's the cultivation of discontent, envy, and insecurity that funds so much of these operations and drives the economy as a whole. Inflation of demand, planned obsolescence, perceived obsolescence, and conspicuous consumption are are all big parts of the toxic toolkit. Social insecurity over-consumes. That's why advertising cultivates it. The Communists are coming, too, so buy what you can while you can. Voluntary simplicity is almost seen as a form of treason. It costs your nation's economy life-giving jobs. Nobody is encouraged to investigate the line between real needs and wants. Much will be said later about the attainment of happiness (or better,*eudaemonia)*by way of consumer behavior, but the bottom line is that we can do a lot of decoupling of consumerism from quality of life using values that are far more easily satisfied than those which currently drive us. What does it take to resist the forces that drive us in directions not our own and not really to our benefit? Then the only remaining bogeyman is what to do with all that spare time and/or money.

More than a little disingenuously, supporters of the current market system tout their ideal as *laissez faire*, free-market economics. It's nothing of the sort. It's actually an economy run by corporate capitalists who draft and purchase their own legislation and manipulate the economy itself at will. Free market economics runs on the simple laws of supply and demand, not subsidies, sweetheart deals, and trade treaties to circumvent government oversight. Scarcity can't be concealed in a free market because it means something important. As some have claimed, the invisible hand has lately become the invisible foot, now tripping everyone up.

There is, however, an enormously important deficiency in true free-market economics that demands that it be supplemented by restraint on its actions that render it quite other than free. We need public intervention on behalf of public and common assets, capital, resources, and sinks. Noam Chomsky offers, "A basic principal of modern state capitalism is that costs and risks are socialized to the extent possible, while profit is privatized." If free-market economics is to work sustainably, it must be unfree to the extent that society at large, and the biosphere it exists within, can be otherwise burdened with costs and risks. External costs must somehow be incorporated into pricing. The easiest way to do this is for a government to tax what the public wants to have less of, and particularly, costs to the commons. If you want smaller families, you offer a single tax deduction for children, regardless of whether a family has zero or three. If you want better fuel economy, you build the socialized costs and risks of climate change and wars for oil into the price of vehicles and fuel. Use taxes are suited to this objective.

All real costs of consumer items should be made visible and even itemized for consumer information, even though the information won't always be used. This should include all of the embedded or embodied energy, water, and materials that go into production or manufacture. This might, for instance, highlight the big difference in footprint between feedlot beef and grass-fed and finished beef. Perhaps the price of gasoline in the US could reflect the cost of perpetual war in the Middle East. Informing the consumer is a vital step towards intelligent consumption. The consumers would less likely be blissfully unaware that their carnivorous dogs and cats have environmental footprints which can be similar to those of human beings in developing nations.

The careful use of Best Available Technology (BAT, and the T in I=PAT) can mitigate many of the impacts of high rates of consumption through better efficiency, life-cycle planning, sustainable or low-impact alternatives, and material substitutions. This is far more available in more affluent cultures, but at least this is where mitigation is needed the most. There is no way around the fact that, as people's income levels rise, they buy more consumer goods. They eat less grain-based food and more meat and dairy. The technologically better options aren't always available to low-income populations. You must buy the twenty-dollar boots instead of the forty-dollar brand that lasts ten times as long. And you can expect the charitable organizations to provide the cheap boots. There are also a number of systemic forces working against implementing BAT, self-reinforcing barriers to change. Among these are safety and building codes that are made to cover all worst-case scenarios and disallow special consideration for actual field conditions. Similarly, written laws and standards must be applied equally to all (for the sake of fairness), regardless of mitigating circumstances. We also have technological lock-in and path dependency that determine the components of inventive measures.

Since estimates of carrying capacity are so often driven by calculations of per capita footprint, these calculations should embrace more metrics, and more resources and capital, and also account for interrelated factors, potential for cascade failures, Liebig minimums, and peak production forecasts for finite resources. Most calculations, as with the Global Footprint Network, are based on oversimplifications that omit significant dimensions of the overall questions. Hopefully, most of the important ones will see some discussion in this book. There is a lot more to our overall impact that can't be surrounded with simple metrics like net primary production, or the output of greenhouse gases, or land used per capita.

2c. Human Exceptionalism and Humanism

"Then God said, 'Let us make mankind in our image, in our likeness, so that they may rule over the fish in the sea and the birds in the sky, over the livestock and all the wild animals, and over all the creatures that move along the ground.' So God created mankind in his own image, in the image of God he created them; male and female he created them. God blessed them and said to them, 'Be fruitful and increase in number; fill the earth and subdue it. Rule over the fish in the sea and the birds in the sky and over every living creature that moves on the ground.' Then God said, 'I give you every seed-bearing plant on the face of the whole earth and every tree that has fruit with seed in it. They will be yours for food.'" Gen 1:26-29 (NIV). God didn't make no junk, and we are his favorites, of all of creation. Many of us have evolved beyond this anthropocentric way of thinking, while many claim proudly, and perhaps correctly in a way, to have never evolved at all. While there is much that makes us special, there might yet be even more that makes us a huge mistake, and partly because we are capable of thinking like this. Survival of a species is not a right or entitlement, much less a function of unconditional cosmic love or divine favoritism. It's earned, with proof of adaptive fitness. We have long confused human dignity with unearned human divinity. Unlike God, evolution makes plenty of junk, and some of that is many of us.

"[The human] story has many variants, religious and secular, scientific, economic and mystic. But all tell of humanity's original transcendence of its animal beginnings, our growing mastery over a 'nature' to which we no longer belong, and the glorious future of plenty and prosperity which will follow when this mastery is complete. It is the story of human centrality, of a species destined to be lord of all it surveys, unconfined by the limits that apply to other, lesser creatures.... The last taboo is the myth of civilization. It is built upon the stories we have constructed about our genius, our indestructibility, our manifest destiny as a chosen species. It is where our vision and our self-belief intertwine with our reckless refusal to face the reality of our position on this Earth.... We intend to challenge the stories which underpin our civilization: the myth of progress, the myth of human centrality, and the myth of our separation from 'nature'. These myths are more dangerous for the fact that we have forgotten they are myths" (Dark Mountain Manifesto).

Human exceptionalism is not considered here as a philosophical problem but a behavioral one within a framework of cultural ideology. Like the first two cords in the braid, it might be amended with more enlightened culture. It comes with behavioral problems that are distinct from the other two cords, such as poaching, trophy hunting, and the multiple use mentality. It's the foundation of the environmental services model that represents the primary means of calculating our impacts and guiding the only implemented policies of restraint we've developed. It's our arrogation of a right to monetize the global commons. It's how we behave towards the world, right up to the bitter end, where our funerals are little more than a final insult to the biosphere as we refuse to return what was borrowed. We don't need to give anything back: that's just how special we are. The ever-cheerful Pentti Linkola offers, "On a global scale, the main problem is not the inflation of human life, but its ever-increasing, mindless over-valuation. Emphasis on the inalienable right to life of fetuses, premature infants and the brain-dead has become a kind of collective mental disease."

Not all of our problems are cultural. We do still have a pesky handful of inherited tendencies to overcome, at least when overcoming serves a greater good. Our inclination to perceive our own group as somehow qualitatively different from Theirs is a big one. A lot of our emotional responses to social situations are concerned with our place within the social hierarchy, and not with how equal we are to everyone else.

We come equipped with social and behavioral tendencies to sort experience into specific categories, archetypes as Jung intended the term, though much misunderstood by his readers. We allow ourselves to be overly influenced by others with prestige, charisma, physical beauty, and power. We also seem to make temporary (but still generational) epigenetic adaptations to certain environments, such as to the stresses of urban living.

One of the biggest problems we have is our arrogated ability to claim rights over and against nature, with nothing outside of ourselves to oppose us, other than the consequences of our actions, which may take a long time to appear. Even our things are given rights: capital has a right to replicate, governments to legislate, corporations to appropriate, all without the benefit of conscience or consciousness. These things have purposes of their own, but have little to do with processing the feedback a system needs for health and sustainability. They are all about growing ever larger. We lay these claims without the understanding that rights don't serve us well unless they come with corresponding duties, including and especially that our rights must end where those of others begin, even where the other may be unable to articulate such claims. We have human rights with no sense of human wrongs, at least with respect to nature. This denial of an opposing voice includes our own unborn and young descendants, as well as other life forms, whether sophont, sentient, or something 'less' or 'lower' than those.

The rights of reproduction are an important case. The UN asserts "the basic right of all couples and individuals to decide freely and responsibly the number, spacing and timing of their children and to have the information and means to do so, and the right to attain the highest standard of sexual and reproductive health. It also includes the right of all to make decisions concerning reproduction free of discrimination, coercion and violence as expressed in human rights documents. In the exercise of this right, they should take into account the needs of their living and future children and their responsibilities towards the community. The promotion of the responsible exercise of these rights for all people should be the fundamental basis for government and community-supported policies and programs in the area of reproductive health, including family planning" (UNFPA, 2014). There is no mention here of duty, or even a suggestion of a conscience or vision that goes beyond the family and present human population. There is no mention of any corresponding duty of restraint or a perspective on the species or the world as a whole. You will not find this in any UN documents.

All human life is thought sacred, usually infinitely so, and all other life is subordinated to our convenience and claims of necessity. The religious right, of course, may object to all forms of family planning. Many of its worst examples will even regard the offspring of rape and incest as god's will. How can there be too many of us when every human life is infinitely precious? Most aren't bright enough to see that free contraception is the best way we have to reduce abortion, but this is partly because they need the baby killing as the hottest button for their protests. Too much damage is also done by the social justice left, the humanists, and the politically correct, who may quickly regard any global push for population management and reduction as coercive policy, eugenics, racism, genocide, and colonialism. The media now fears any mention of population management for fear that these moronic buzzwords will get thrown at them. The biggest pushes still need to be made in economically poor, r-strategist populations, where the most likely alternative to sound population management will be famine, massive dieback, and other mass suffering, and likely at a time when the more developed nations will have too many problems of their own to provide any of the much-needed relief.

Rights to make or arrogate property claims against nature, whether to other life forms, natural capital, renewable resources, or environmental sinks, are a second major problem area, this one more concerned with overconsumption than overpopulation. The commons have no legal proxy to stand up for their protection, other than a few laws that have been grudgingly passed to silence protests. The human genome, biology itself, seeds, water, air, food species, the air waves and the media that use them are all being privatized and corporatized to some extent. Wilderness, public lands, and other natural areas are contained in shrinking reserves, and most of them still allow (or even encourage) multiple extractive and consumptive uses such as logging and mining. The commons may be monetized now, and they remain one vast waste receptacle. The US Forest Service actually calculates a monetary value for the extra floodwater that rushes over the ground of clearcut forests, ignoring its load of topsoil and soil nutrients. No corruption visible there. Heigham writes, "Over the last 40 years or so, neoliberalism has produced an expectation that certain members of global society can go wherever they like and buy whatever they want, a sort of detached mentality that rejects the previously perceived need for regulation and control in the national or community interest."

As our population has grown to the point of reaching and exceeding the world's physical and biological limits, we have found ourselves in need either of some form of ethic, or some form of rationalization, that can be used to inform legislative and policy choices. The commons are no longer unlimited sources and sinks, and this demands either a new kind of respect or a working substitute. Honestly facing the facts of human limitations, and the dangers of remaining ignorant, does not seem to be part of our natural skill set. In what may be deemed a wrong turn by succeeding generations, we have largely elected to use economic frames and rationalizations in the form of ecological economics. The natural world is valued in terms of the environmental services it provides to the human economy and the human civilization. Little more than lip service is given to the intrinsic worth of a thriving biosphere and the diversity of its inhabitants. The sad thing is that this is the most practical approach for now, even though it perpetuates economic paradigms that lie at the heart of our problems. We don't seem prepared to look at the ways of indigenous tribe that have managed millennia of coexistence with nature. We don't seem ready to prioritize our real needs over the new wants installed by advertising.

Human exceptionalism drives both growth and consumption, in addition to bringing its own set of problems along. It's our entitlement, as the crown of creation, to take what we want and do as we will. This leaves us without a requisite sense of duty to the whole, no moral accountability, no sense of obligation to pay any sort of rent for the privilege of being alive on this world. But we may still pay nature back for all those millennia of suffering it put us through. We will finally conquer nature. Exceptionalism is also very much alive in competition between individuals and local populations, such as nations, which in turn drives the socioeconomic inequity that also plagues us with social and political problems. Human ignorance is proving too intractable for this problem, and human intelligence too one-dimensional for the needed systems thinking. It's probably going to take some extremely unpleasant consequences to start bringing our numbers back down

The most useful opposite and antidote to our human exceptionalism is probably Deep Ecology. This is an acceptance of membership in the larger community of life on Earth. The humanist is ready to embrace the whole human species. This is a step in the right direction, and at least acknowledges a need to outgrow nationalism and patriotism, but it doesn't go nearly far enough. The Sioux phrase *mitakuye oyasin*, all my relations, acknowledges this larger kinship. But we also want to make a point of

including those less charismatic species, the vole and the housefly, and if we really know what's good for us, we will also embrace plant and microbial life as our kin. If we are to survive, it will become essential at some point to assert and enforce proxy rights on behalf of nature, a public trust doctrine, to secure the survival of future generations of other species as well as our own.

3. Environmental Services

It's with no small reluctance that this chapter carries this title, given the preceding complaints about human exceptionalism. Valuing the environment economically, or monetizing its services, currently represents the best chance for environmental policy reform, even where it has backing from those who are doing the environment the most damage. It also has the salubrious effect of alerting the otherwise unaware to just how valuable, and even precious, a healthy environment is. It helps some of us to better appreciate the world we live in, in the sense of increasing its perceived value. But we have failed so far to incorporate these quantified values, particularly of our negative impacts on the commons, into the pricing of goods, where these costs would work to drive demand downward. And policymakers still tend to be more often educated by bribes and other stimulus from the corporate world than by these assigned economic values.

As living beings, it's perhaps legitimate to think that we inherit the world we're born into. By virtue of having no choice in this, it would be hard to claim that we have no inherent right to make the most of life and take what we need to survive, even thrive, even without a corresponding sense of duty to not make a mess of things. And until we get our most basic needs met, it's pretty difficult to consider anything other than providing for our own self-ish needs. Social and political protest can emerge from states of impoverishment and deficiency, but protest over environmental damage will more often come from the better-fed and educated among us. This may in fact be the best argument for global socioeconomic equity and better education. Beyond a point, though, we get greedy. We arrogate rights to property in the common environment, we arrogate rights to far more than we need to thrive, and in ways which seriously compromise our ability to continue to thrive. We exterminate other life forms, both deliberately and collaterally. Perhaps a billion of the religious are actually praying for an End of Days. We act like we care little for the future of life on Earth, and we even apply our hyperbolic discounting to the value of our own descendants. We're even bad at being exceptionalists.

The phrase "tragedy of the commons" comes from Garrett Hardin (1968), who wrote, "Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit - in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own interest in a society that believes in the freedom of the commons." But the idea goes back at least to Aristotle: "What is common to the greatest number has the least care bestowed upon it." We need to learn how to embrace the commons as essential to our own well being in order to get past this. We need to get over ourselves for the perspective and overview needed to do this.

To properly study Aurelio Peccei's and the Club of Rome's *problématique humaine*, the full meta-system of predicaments and problems facing the world will require systems thinking and analysis from comprehensive points of view. But this still needs to have the parts identified, and these parts are best sorted into useful categories for clarity of analysis. This chapter and the next will attempt this. One popular way of sorting environmental services comes from the Millennium Ecosystem Assessment (See Bibliography). This offers four categories, but there is also much multiple occupancy of items. Some of these must be exploited with human technology supported by good social order. Shortages of some of these can lead to resource wars and other political destabilizations. The following isn't verbatim, since I've made bold to add a number of services and shift some into different categories:

* Provisioning Services: actual products, biochemicals, biofuels, fiber, firewood and cellulosic fuel, food, fresh water, genetic materials, geothermal heat, insolation (incoming solar radiation), lumber, medicine, nutrient uptake from weathering parent material, raw minerals and other raw materials, and volcanic ash.
* Regulating Services: air quality, atmospheric maintenance, biological pest control, detoxification, disease control, flood control, global heat redistribution, groundwater recharge, local weather and climate, soil fertility and regeneration, stormwater and meltwater runoff pacing, waste processing, water purification or quality, soil water retention, weather event moderation.
* Supporting Services: adaptive capacity and resilience, biodiversity maintenance, biogeochemical cycles, carbon sequestration, disease resistance, genetic resilience, hydrologic cycles, nutrient cycling, oxygen production, pollination, primary photosynthetic and biomass production, soil formation, speciation, and species habitat.
* Cultural Services: aesthetic inspiration, appreciation, biomimetic inspiration, cultural heritage sites, design inspiration, ecoliteracy, ecotoursim, educational value, elucidogens (entheogens), field trips, natural monuments, opportunities to practice stewardship, ornamental resources, recreation, reverence and gratitude, scientific discovery, sense of home and place, sophrosyne, and spiritual enrichment.

Having high-quality and timely information about the state or health of these services is vital, and yet there are special interests that will deliberately delay or distort this for short-term gain. The world itself is still large enough to conceal some of the damages being done, especially in conjunction with a willful blindness or denial in the majority of humanity. The environment still holds some buffering capacity. Overshoot of both component and system-wide limits can persist for some time. As is often the case, we may not awaken to these until we're already in mid-crisis.

Diminishing returns on the efforts to make use of these services, especially on those becoming increasingly scarce, is another neglected aspect. It's natural that we would till the most fertile soils, pluck the low-hanging fruit, and mine the richest veins before moving on to the harder extractions and exploitations. More work for the latter will also entail greater collateral damage to the environment. At some point we have to give up and find substitutes or change the way we live.

Liebig's law of the minimum asserts that growth is dictated not by total resources available, but by the scarcest resource as a limiting factor. The law has also been applied to biological populations and ecosystem models for factors such as sunlight or mineral nutrients. This becomes particularly vital with certain forms of non-renewable natural capital, and its importance will increase with the depth of our time horizons.

3a. Resources and Capital

Every year, humanity extracts or otherwise consumes nearly 100 billion tonnes of materials, including biomass,fossil fuels,metals, and other minerals. As these materials become more scarce, the cost of extraction rises. And sometimes this drives up costs and profits in ways that ramp up extraction efforts. For materials being seriously depleted, the only alternative is planned conservation and reuse. We have been doing ourselves and our science a great disservice by referring to all of these materials and environmental services as resources, or natural resources. The word resource itself means 'that which resurges.' A resource is either a reliable flow to which we might return for more, or else it rebounds or comes back if we appropriate a flow at too high a rate and later back off from that demand. The common phrase "non-renewable resource" is therefore an oxymoron. Non-renewables will be referred to here as natural capital instead, and only renewables will be regarded as resources. In this chapter, services will be parsed into renewable resources, non-renewable natural capital, and environmental sinks. The chapter will conclude with the various contexts for these, categories of land use and how lands are being converted from one use to another, more often than not, in or into degraded form.

We have also committed a still more heinous error of naming and thought, particularly in the recently conquered regions of the Western Hemisphere and Oceania. We have taken the natural capital of these stolen lands and regarded it as income, earned at the relatively minimal costs of extraction, and perhaps including the costs of exterminating the aboriginal populations. You just can't liquidate capital and call it income and then hope to survive as an economy forever. This sly bookkeeping catches up. It already seems to have caught up, from looking at national debts. And now we are so far in debt, as Daly puts it, we are "treating the Earth as if it were a business in liquidation." The US, especially, has treated its malappropriated resources and capital as income, with costs only seen in the costs of extraction. And even the costs of extraction have been heavily subsidized for the sake of economic growth. No services will be regarded here as income, not even sunlight. All have costs, and one of the great lessons we have yet to learn is that these costs should be borne by the harvesters, depleters, polluters, and ultimately, consumers. A tax on resources and capital at the point of use is perhaps the most rational. This might be done with a standard deduction for absolute necessities, so that only our excesses need pay for the excesses. We should also be taxing the things we want less of.

From the point of view of deep ecology, the words resource and capital should only be applied to those elements that a species with a conscience would need to lay claim to in order to survive, and thrive within reasonable limits. For many, like E.O. Wilson, that would be no more than half of those available, and further, with a deeper respect for the commons as possessing their own inherent value. But we have so far failed to develop that conscience, which appears to also require a certain standard of living and a carefully crafted education. In any case, we would do well to quit monetizing the global commons altogether, including the rain.

As with many dichotomies, the line between resource and capital is fat and fuzzy in places. Some will say that a supply is non-renewable if it takes more than a human lifetime to rebound. This would make the natural production of topsoil a non-renewable. And yet an unnatural production of topsoil, as with mycoremediation, accelerated seral succession, or regenerative agriculture, could return it to a renewable status. The atmosphere's capacity as a carbon sink would also be non-renewable capital by this measure. This could be made somewhat more renewable again with

large-scale carbon sequestration projects like reforestation, low and no-till farming,*terra preta*, and perhaps iron fertilization of marine algae.

On the other side, renewable resources must often be captured or collected using technologies that are heavily dependent on the use of non-renewable natural capital. Those magnificent offshore banks of windmills still need to be built of minerals mined from the earth. They need to be transported to the site using trucks, roads, ships, cranes, and fuel. They need to be maintained with replacement parts, along with environmental costs of maintaining a human workforce. And when their life is over, they will need to be fully replaced. The battery storage of renewably harvested electricity still wants minerals to make the batteries, and eventually to make the replacement batteries. The electric car isn't that much less costly to build or replace than a conventional car. Although both the automobile and steel industries have long been leaders in recycling, there are embedded resource and natural capital costs in that as well. Natural capital can only be thought a resource to the extent that it may be recyclable, and it can never be fully or perfectly so.

Environmental sinks, the ability of the environment to absorb wastes and recover from other impacts, comprise a third category of services. Until recently in our history, in our vast, empty world, this was never much more than a local problem. It hasn't been that long since cities in the industrialized nations quit dumping their sewage directly into rivers, and non-point-source pollution hasn't slowed down at all for agricultural runoff. Until recently, our impacts here weren't significant enough globally to do much lasting damage to the whole. At about the time we were approaching (what I regard as) our real carrying capacity, a fuller Earth, and some of our common limits, the industrial revolution gave us more significant and widespread air and water pollution. Within a couple of centuries, the population growth enabled by new industry necessitated the now ironically named "green revolution" of modernized agriculture and the quantity of our wastes exploded with our population. But now we had nowhere to put it that allowed us to just forget about it. We are only now being forced to redirect our wastes back into productive cycles. Simply sequestering our wastes is becoming untenable, although some of the places where we have done this might one day be regarded as mines by poorer generations of humans.

Resources can be said to have a natural yield, as sinks can be said to have natural rates of absorption. The economist Herman Daly suggests basic rules of thumb to define the limits of these. For renewable resources, the limit is the rate of regeneration or resurgence (perhaps with some seasonal dips or borrowings against highly predictable cycles). For natural capital, the limit is the rate at which renewable substitutions can be found or the capital can be recycled. Reaching the limits to natural capital can also be deferred a bit by improvements in technology, efficiency, and waste cycling. For environmental sinks, the limit is the rate of recycling, absorption, or detoxification.

To some extent, these services can be augmented beyond their natural rates, with the greatest limitations being on natural capital. Resource productivity is especially amenable to increase. For instance, nature isn't perfectly efficient in its net primary production, so that agricultural systems like Permaculture can increase a natural yield sustainably. But even this is provided that any requisite non-renewable minerals that are taken from the soil are somehow replenished eventually by composting, organic soils activity, or deep root structures uplifting minerals from weathering bedrock. The same goes for fresh water, which, with more careful planning, can be used several times before it disappears back into some stream. With regard to environmental sinks, we are only beginning to explore our better augmentation options, and we have some

good human-scale and low-tech options, as with reforestation, *terra preta*, and myco-remediation.

3b. Renewable Resources

Eventually, we will have to start regarding property rights as usufructs (use of the fruits), particularly with the commons. This a right to use the yield of a system without damage to the system producing the yield. This will, to some extent, permit borrowing yields against predictable seasonal fluctuations. The word sustainable means to uphold from below, meaning a due regard and respect for the systems supporting a yield. As long as we fail to see what this means, we will continue to be surprised when support systems collapse.

Once again, renewable resources are most often captured or collected using technologies that are heavily dependent on the use of non-renewable natural capital. The extraction, processing, and transportation of this capital can also inflict costly damage on the environment, even though this capital may lack other economic value. We cannot forget that renewables have embedded or embodied costs in minerals, energy, and water, most of which have external costs to the commons. Included here is the cost in human time, energy, and labor, and the environmental costs of supporting human lives during extended processes of exploitation.

Resources require income to the overall system. There are only a few of these: insolation (or incoming solar radiation, including wind and hydro), geothermal energy, chemosynthesis, meteoric dust, the recruitment of available minerals into soil from weathering of rock and microbial activities, and new deposits of volcanic ash. Water is distilled from the sea and land and pumped into the system by insolation. The atmosphere is refreshed by photosynthesis. Differentials in energy inputs and gains circulate climate and ocean currents. Numerous factors will contribute to rivers, groundwater recharge, and flowing freshwater aquifers, while fossil water aquifers are capital, not resources. These inputs all drive potential biocapacity and biomass, subject only to the ability of life to make use of them. When there is no income, there will be some depletion or degradation. Soil nutrient depletion can't be counteracted either completely or indefinitely with NPK fertilizer inputs. Other sources will eventually have to be found. Nitrogen compounds can be synthesized, but the phosphate rock and potash needed to make phosphorous and potassium available to crops are finite and alternatives aren't close to being cost effective yet. Peak phosphorous is coming soon, and this is a vital element for life.

Food production is generally regarded a renewable resource, and one that is subject to much improvement in yield. Thomas Malthus (1766-1834) is most often seen these days being scoffed at or derogated by overpopulation deniers for having erred in his general observation that exponential population growth will necessarily outpace the linear growth in food production, leading to a population collapse. Food production did go up in a non-linear way. Malthus' mistake was in not foreseeing this. The early Club of Rome made a similar miscalculation. But what their critics can't see yet is that food production didn't increase in any sustainable way. In effect, the green revolution in agriculture took out a huge loan and entered it into the books as income. It's now far too heavily dependent on new inputs from limited natural resources and finite, non-renewable natural capital. Agricultural outputs are now subject to overpopulation pressures on land use, pressures for higher trophic level protein, climate change, water shortages, fossil water aquifer depletion, topsoil loss, biocides, biodiversity loss, pollinator crashes, finite fertilizer inputs, and finite fossil-fuel-intensive mechanical inputs, among others. All are functions of both population and per-capita consumption levels. We are likely to soon find ourselves back to regarding food production as either linear or decreasing in both per capita and per hectare metrics, and shortly after that, in total. But that's probably after we pull out a couple more tricks we have up our sleeves.

The first trophic level, the food at the bottom of the food webs, relies most heavily on insolation and a handful of basic nutritional elements. The yield here is called NPP or net primary production, the usable chemical energy captured by plants in a system, less the energy spent in plant respiration. This energy budget determines the maximum total biomass of a system at all of the trophic levels. Level one consists of the autotrophs, using photosynthesis or chemosynthesis. On level two are the grazers, on level three, the carnivores. On level four are the consumers of carnivores, including detritivores and parasites. Trophic cascade failures can be upwards, as when a volcanic winter reduces plant life, or downwards, as when the wolves are removed from an ecosystem, allowing grazers to overconsume.

The renewability of resources is normally calculated in terms of flows or sustainable yields, over specified periods of time to allow for seasonal and other predictable fluctuations. This makes an unbiased calculation and representation of these flows a must. The exploitation of fisheries must allow for illegal fishing as well. Forest planners, often with educations supplied by the timber industry, use formulae for estimates of fiber productivity in board feet. These estimates may be derived with sound principles, but when it comes time to harvest the timber, the harvest figures can be tweaked and juggled to the harvester's advantage. I have seen an example with aspen OSB production from US Forest service lands, where logging trucks are weighed to determine initial volume, which is then adjusted by a factor of efficiency of use to get board feet. Aspen is said to weigh 62 pcf and be utilized at 25%. But in fact, aspen weighs about 40 pcf and is utilized at over 67%. Combining these two means that the loggers are harvesting more than four times the calculated sustainable yield. To add still more insult, a sustainable yield has come to be regarded as a sustained yield, "a non-diminishing flow of commodity outputs" rather than as a usufruct.

Occasionally, buffer limits are set on the exploitation of yields. In the case of minimum instream flows for aquatic ecosystems, the limits will be set over loud and well-financed protests, perhaps claiming that humans need the water more than the fish (where are your values, man?). Other limits will arise as overexploitation or overharvesting entail diminishing returns, or perhaps the diminishment defines what's meant by 'over.' We harvest until this becomes cost-ineffective. This can happen with wild medicinal plants,fish stocks,grazing pastures, game animals, forests, and water aquifers. With a resource, scarcity will generally be temporary, except when a species is harvested to extinction, or to below its genetic viability.

3c. Non-Renewable Natural Capital

The category of non-renewable capital includes energy minerals (fossil fuels like oil, natural gas, and coal; and uranium), higher grade mineral ores (phosphate rock, potash, antimony, indium, silver, copper, titanium, and tantalum are particularly important as peak production approaches), other metallic ores like bauxite, gemstones, rare earth minerals (the fifteen elemental lanthanides plus scandium and yttrium, in pockets concentrated enough to be mined economically), lithium (with its increasing importance in battery manufacture), fossil groundwater, and by some measures, renewable resources that take more than a human lifetime to recover. According to Global Resources Outlook, extraction has been tripling in the time it takes population to double. Biodiversity is be regarded as non-renewable, given the permanence of extinction, Jurassic Park scenarios excepted. Genetic engineering can be a little too blind to its consequences. Arable land, whether exhausted, deprived of aquifers, or overpaved, is non-renewable in the short run. Marginal land, to which we move after the best land has been exhausted, is even more non-renewable, especially where converted to desert. Construction materials (sand, gravel, brick clay, crushed rock aggregates) and industrial minerals (nonmetallic substances such as salt, limestone, silica, talc, and mica), while non-renewable, are generally in more plentiful supply, but it must not be forgotten that these must be mined from the earth or ocean, with inevitable collateral impacts and long-term damages from extraction. We also have underutilized materials like volcanic and fly ash that can be used as partial substitutes for cement.

The calculation of value of natural capital needs to include its value in the distant future (too often rounded too far down with hyperbolic discounting) along with the irreversibility of depletion. This is the worst place we can think of to deploy hyperbolic discounting to make our current myopic plans look better. Even where we are looking at peak production rates 50 years away, with 500 years to exhaustion, this is not sustainable, and to say that it is is merely myopic, a failure of long-term vision, perhaps with a blind faith in technology and human ingenuity. Oil production has already peaked, but we have substitutions already waiting in the wings. Peak phosphorous, on the other hand, is estimated at 2030, and its depletion within a century. This is vital to agriculture and fertilizer as we know it, yet it's is presently being lost in large quantities from erosion and runoff from agricultural lands, and into aquatic ecosystems, where it causes pollution problems.

There is no such thing as a sustainable rate of extraction and use of a finite stock of non-renewable 'resources.' The word 'reserves' should be used instead of supply or flow for non-renewables. If there is any yield at all, this must be interest on the investment of capital. Continued use will require either further exploration to expose currently unknown reserves or the development of substitutions. But substitutions are not always possible, as with the nutrient elements vital to plant, fungal, and animal life. Substitutions might also entail both known and unknown consequences or external costs. Outside of dropping unnecessary consumption of natural capital, finding easy substitutions, and decoupling, our main fallback is reuse or recycling, where waste management becomes the input for other production systems. Nature is our best guide here, and biomimicry is what we do when we get ideas there.

Many of the more finite materials are already approaching or surpassing peak production out of their known reserves. Donella Meadows describes an example of the gradual process: "Oil depletion will not appear as a complete stop, a sudden drying-up of the spigot. Rather, it will show up as lower and lower returns on investments in exploration, increasing concentration of the remaining reserves in a few nations, and

finally a peak and gradual decline in total world production." Exploitation or extraction of capital in a post-peak state nearly always involves diminishing returns and greater environmental damage in the process. Eventually there comes a point still short of complete exhaustion where further action is untenable. But up to this point, the nature of capitalism works against conservation of the reserves. Scarcity, even on its runup to peak exploitation, will drive the commodity prices and profits up, thereby accelerating exploitation. Once the easy pickings are picked and the low-hanging fruit plucked, further exploration entails higher energy costs and more environmental damage, like pollution and new inroads.

Given all of this, a system's carrying capacity must be thought to diminish over the long term from depletion of non-renewable and non-replaceable natural capital. It falls most quickly during overshoot. Limiting factors or Liebig minimums are the first necessary capital to be regarded as depleted. These are physical or chemical factors that will limit the existence, growth, abundance, or distribution of an an organism, a population, or an ecosystem. Nicholas Georgescu-Roegen" argues that economic scarcity is rooted in physical reality; that all natural [capital is] irreversibly degraded when put to use in economic activity; that the carrying capacity of earth - that is, earth's capacity to sustain human populations and consumption levels - is bound to decrease some time in the future as earth's finite stock of mineral resources is being extracted and put to use; and consequently, that the world economy as a whole is heading towards an inevitable future collapse, ultimately bringing about human extinction" (Wikipedia). Extended analogies to the 2nd law of thermodynamics have been used by Georgescu-Roegen and others to discuss the dissipation of limited natural capital like minerals, and also the costs of maintaining social order as a growing population's support system. But because these have not been prefaced as analogies, critics have been eager to dismiss such expository writing as invalid and unscientific argument (the 2nd Law being strictly about energy, as any fool knows) before strutting off smugly believing they've refuted all that's been said. So please note: I'm suggesting that there's a useful analogy here. Herman Daly uses this analogy as well, and comes to the depressing conclusion, as must we all if we're honest, that there is no winning a game against entropy. In the end, even the steady-state economy that remains our best option will one day run out of necessities. Hence the talk of mining the asteroids and the settling of other worlds. But as long as we can maintain an analog to climax ecosystems, where our living and dying are equals, we can still delay the inevitable long enough to have a civilization worthy of its name.

3d. Environmental Sinks

Waste materials released into the environment have only become a real problem since we filled up our empty world and exceeded our carrying capacity. Before this, we simply couldn't make enough of a mess, except locally. We crossed a line just a few decades into the Industrial Revolution. Urban sewage and air pollution were the first clear signs. Herman Daly states, "For a pollutant, the sustainable rate of emission can be no greater than the rate at which that pollutant can be recycled, absorbed, or rendered harmless in its sink." We can also add decomposed, detoxified, and sequestered to that. As the world got smaller, the specific industrial pollutants began to multiply. By the beginning of the 20th Century, the effects of fossil fuel use and mining, such as oil spills and tailings, were becoming clear to those with eyes to see. Lately, we've added substantially more groundwater pollution from activities like hydraulic fracking, which also releases a lot of methane. By mid-20th Century, we began to add the wastes from our so-called green revolution in industrial agriculture. Agricultural fertilizer run-off brings another set of problems as our additions to the nitrogen cycle and our added phosphorous flows enter marine ecosystems. This has created hundreds of aquatic dead zones, while much of this pollution is food in happier contexts. Better waste management could pull some load off the environment, as by harvesting algal blooms to make biofuels and fertilizer. Still, the runoff also carries sediment, pathogens, endocrine disruptors, biocides, heavy metals, and salts.Many of these biocides (herbicides, insecticides, and fungicides) are accumulating in agricultural soils, while the native biotic community in the soils is either gone now, or too compromised, or simply unable to break them down. Insecticide toxicity loading has become especially problematic in corn and soybean crops.

Shortly after mid-century would come nuclear waste, where decisions about the next hundred millennia are being made by politicians with less than two years of vision. The technology is improving here, as with fourth-generation fast neutron reactors. Used fuel from present reactors and large stocks of depleted uranium will get new life as fuels sources. It's also vital to find better ways to concentrate and sequester low-level wastes. Of course, as anyone who has been around for Chernobyl and Fukashima knows, Murphy's Law likes to play tricks on the nuclear industry. Medical wastes followed with the rise of wonder drugs, and now measurable quantities of prescription drugs are showing up in our water supplies. Lately, the one that seems to have snuck up on everyone is the proliferation of non-degradable plastic wastes, from our single-use, throwaway culture. The pieces just get smaller. Over 8 billion tonnes of plastic made from 1950 to 2020 (with 4 billion more by 2050) now exists either in landfills or as free-range pollution. The end state of our fabrics and clothing is becoming more problematic now, with ubiquitous microfibers entering the environment and food webs.

We're now releasing novel substances and entities into the environment, molecules that nature has never needed to deal with before. Man-made legacy contaminants such as PCBs, PFASs, and other persistent organic pollutants circulate more or less indefinitely through the biosphere. We can still use the words absorption and sink, but not conversion and detoxification. Life will have to adapt to what we've done here, even after we quit doing it.

Greenhouse gases are getting the most attention now, and threaten some the direst consequences, or rather, several of the direst cascades of consequences across numerous environmental sub-systems. Carbon dioxide remains the most threatening of these, followed by methane. The burning of fossil fuels are a huge problem by themselves, but by their contribution to total CO2 ppm, they are also helping creating dangerous positive feedback loops as rising temperatures acidify the oceans, crashing

marine photosynthesis, and melting the permafrost, releasing still more massive quantities of CO2 and CH4.The current melting rates of permafrost are showing previous estimates to have been far too conservative, in optimistic error by several decades. With this go the sequestration services locking up bad bugs or old diseases.We have hardly begun to see the effects of melting methane clathrates. While many of us have been assured that the Methane Dragon of clathrate release is still somewhere a century hence, the overly conservative predictive errors we've made so far should give us some pause. The worst part of the GHGs is the centuries that it will take for any system, natural or manmade, to absorb them, while we already see their runaway effects. The ocean has long served as a carbon sink, and today absorbs around 25% of fossil fuel CO2 production. But the default sink is the capacity or appetite of marine phytoplankton, algae, and other plant life, which is also diminishing as our output is increasing. The balance is absorbed in seawater, where it forms carbonic acid, a growing threat to most life, but most especially to the calcium carbonate used to build seashells and coral reefs.

The rapid expansion of industrial agriculture is deemed necessary to keep pace with the exploding human population, but the rapid conversion of lands to this use strips the soil of our most effective means of carbon sequestration. Regenerative agriculture, which combines such methods as low and no-till perennial crops, mycoremediation, biochar,*terra preta*, Permaculture, and Holistic Range Management, still offer much promise in reversing this trend, but even this won't carry our growing population, or even anything even close to our present numbers over the long term. On average, and at present, the agricultural impacts are more closely tied to our overpopulation than to our overconsumption, but this is changing rapidly as more of the global population shifts to a meat-and-dairy diet with the growing affluence of some populations. We are further compounding this problem by using arable land and fresh water to grow crops for CAFOs, and worse, for biofuels. Biofuels are a great idea, but we should be developing cellulosic and algal crops that don't consume as much water or soil. They have no good business to do on valuable farmlands.

Some of the environment's sink capacity occurs within the food web itself. The most familiar example is the upward migration of mercury pollution into living tissues at the higher trophic levels, rendering predators in particular the most unsafe meat to eat. This removes the consumption of invasive predator species like Burmese pythons and monitor lizards from the range of solutions to the invasive species problem.

Our recycling ethic remains poor enough still that great quantities of baled materials, representing our best efforts, are merely becoming sequestration efforts, only one step less problematic than landfills. However, at least these recycling storage facilities might one day be regarded as material mines by our resource-impoverished descendants. Too many of us still have the illusion that putting out most of their recycling once a week to the curb is doing their part to save the environment. There are a lot of Rs to the more comprehensive ethic we need, though their number and sequence keeps changing: Reduce, Replace, Reuse, Repair, Rebuild, Refurbish, Repurpose, Rot, Rotate, Recycle, Recover, Refuse, Remember, Reinvent, Restrict, Reject, Rethink, Remake, Resell, Re-gift, and Restore. Unfortunately, many of these Rs are still in conflict with civilization's larger economic goals of unlimited growth and consumption, the advertising that supports them, and the way that goods are packaged shipped around the world.

3e. Land Conversion

Lands and local niches tend to evolve naturally through successive stages, normally from bare minerals to climax ecosystems, constrained by available nutrients and evolving microclimates. Ecosystems do change naturally. Most of Canada was once under a mile-thick ice sheet, and Antarctica used to be tropical. The lifespan of niche evolution is called a sere, and the evolutionary process is called seral succession. Humans, and a few other animals, can interrupt this dramatically. Nobody comes close to doing it as ham-handedly as we do. The primary reason is our hypertrophy, or overgrowth. This is what's driving us to build on top of earthquake faults, onto the slopes of Vesuvius, and into flood zones. We need a revised set of Horsemen now, with Hypertrophy joining Famine, Pandemic, and War, to denote the most effective ways we have of 'involuntarily' reducing our own population. Our available per-capita land keeps shrinking, and our growing population, with its economic growth obsession, overconsumption, and bad attitude towards the biosphere, keeps demanding ever more *lebensraum*. Conversion often means degradation of the land from forced production of environmental services.

The conversion of land has its most serious impacts on the availability of fresh water, biodiversity loss, habitat loss, and climate change through loss of carbon sequestration. Too many of our industrial practices turn the soil to dirt and dust, and eventually to desert. Population growth, with its agricultural demands and other pressures for water, fibers, and fuels, is the primary driver of deforestation and other land use conversion. Such conversion "accounts for over 80% of biodiversity loss and 85% of water stress as forests and swamps are cleared for cropland that needs irrigation.... Three-quarters of all [usable] land has been turned into farm fields, covered by concrete, swallowed up by dam reservoirs or otherwise significantly altered" (Jonathan Watts). Little remains outside of Africa of the world's former tropical and temperate grasslands, now converted to agriculture and renamed bread baskets. These now become especially vulnerable to changes in temperature and precipitation. Aquifers are being overused to stabilize irrigation. New land conversion is currently worst in the tropics and subtropics, with the fastest encroachments being in areas of vital biodiversity hot spots. Three-quarters of freshwater rivers and lakes are now used for crop or livestock cultivation.

The most drastic of our activities here convert our natural and biodiverse ecosystems into monocultural agricultural crops. To the extent that we do this with industrial agriculture, we are also stripping the soil of mineral nutrients, exporting them in our crops, replacing only what we must with NPK fertilizer inputs. We use new biocides to remove insect populations, both noxious and beneficial, and the still poorly understood fungal soil networks. The soil eventually loses significant amounts of sequestered carbon in root structures both living and dead. The living root systems that once uplifted new mineral nutrients from weathering parent material below are gone. The sequestered carbon becomes atmospheric CO2 or CH4. Regular plowing deprives the soil of the structure it needs to store water, as well as to resist the wind and water erosion. Meanwhile, water is diverted from nearby aquatic ecosystems, often to levels well below recommended minimums, in order to supplement natural rainfall. Whether or not a parcel of land has already been converted to such a degraded state is irrelevant in the long term - it will always be moving in that direction unless we are practicing regenerative agriculture. In most cases, the arable land that's used up first will be the most fertile and cost-effective for production. It will be fairly flat, often bottom land that naturally received additional nutrients from flooding events, before the rivers were dammed. The land we move onto once this is degraded is usually upslope, poorer in

agricultural potential, more subject to degradation, less available for carbon sequestration, less cost-effective to farm, and requiring still more inputs from mechanization, infrastructure, irrigation facilities, biocides, and fertilizers. To make matters worse, we also incur these degradations to good arable land and nearby aquatic ecosystems to produce carbon-based biofuels and animal feed for CAFOs (concentrated animal feeding operations) with huge inefficiencies in the use of NPP (net primary production).

Biomes are communities of animals, fungi, and plants adapted to particular environments at particular stages of seral succession. Few are truly safe from our agricultural expansion, particularly as we move on from biomes we've already degraded as we accelerate expansion for meat and dairy production. Prairie and grasslands are early natural choices, even with their demands for additional water, which too often must come from non-renewable fossil water aquifers. Shrublands and savannah, even if unsuited for irrigation, can still be converted to rangeland, but these lands are normally grazed unsustainably for maximum temporary outputs. Rainforests seems to get raided next, even with relatively poor soils, because water is readily available until the larger biome is too compromised. Temperate and boreal forests would be more of a last resort for agricultural conversion, but they carry the added short-term profits from timber harvesting. Mangrove forests, sloughs, bogs, and other riparian systems are too often targeted. The classic Faustian bargain, and the basis of Faust's deathless fame, leads to the grand project of draining the swamp for *lebensraum* and great agricultural productivity to feed our growing numbers and make a handsome profit, "for by that means he will create a home for millions of happy and industrious burghers, to dwell not in secure idleness but in free activity."

While industrial agriculture has been the primary focus of land conversion efforts, it isn't the only one. We can convert just about any biome on Earth into a lifeless, open-pit mine. We have little use for desert, but we seem to be creating it as furiously as though it were a primary goal. Coastal ecosystems will soon be lost in larger quantities from rising sea levels. The only lands we're really gaining here are coming at some large costs to the climate from deglaciation and melting permafrost. Since both urbanization and our road thoroughfares have a natural affinity for flat and moderately-sloped land, much otherwise arable land is lost to overpaving and urban sprawl. Also lost there is the stormwater retention of overpaved soils.

Remediation has been half-hearted so far. The reforestation of our clearcut forests has been too much in name only, to satisfy requirements made prior to getting permits to cut, with too little regard for damage to soils systems and microclimatic effects. Of course, even failed attempts count on the books as reforested lands. Most true remediation will require fresh water that we are reluctant to spare, especially for damaged riparian systems. There is still a great deal of potential for remediation, using such practices as restorative agriculture, mycoremediation, accelerated seral succession, and the planting of pioneer species strategically as crops, but at the moment these seem only like luxuries, in a category with disintegrating infrastructure, on semi-permanent hold while we fund our perpetual wars. It's just something else we can leave for our kids to take care of.

4. Systems Under Siege

There are many dimensions to the carrying capacity problem that emerge directly out of human parasitism. While the problems aren't all sourced in environmental degradation, that will be the focus of the present chapter. It might be depressing, even read as a horror story, but we need to start facing the magnitude of the damage we've done and are doing, in comprehensive and detailed ways, not in oversimplified and one-dimensional sound bites. In Will Steffan's words, "human activity now rivals geological forces in influencing the trajectory of the Earth System." People will say, "We can't hurt Earth, only ourselves," but it isn't really Earth we're concerned with. That will in fact continue.It'sEarth's biosphere we worry about, and this is several orders of magnitude more vulnerable. This Earth System with its vulnerabilities is the focus here, while the vulnerability of the cultural system and the human social order, perhaps equally vital in even temporarily supporting our present population levels, will be charted in the next chapter.

Some environmental subsystems were seen briefly in the last section in the context of biomes. This chapter will look at six general sets of environmental problems and the subsystems within them. Although this is broken into six categories, there are numerous potential spillover effects, keystones, and tipping points that lead to further destabilizations and cascade failures that knit them all back together eventually. Some of the interrelationships here will be referred to or implied in passing, but not in any systematic way. There is no room here for a more comprehensive analysis, especially on two-dimensional screens and paper.

Herman Daly points out a habit we have, one left over from 19th century economic theory, and long before systems theory, of regarding resources as somehow fungible, disconnected, and interchangeable. We might assume that that resources, capital, sinks, human labor, social order, and technological inventiveness might all be substituted for one another, and with nearly infinite faith in human inventiveness. Now that we are closer to and beyond more of our limits, we can see stresses propagating through the webs that connect all of these.

Systems can be complex, integrating numerous subsystems which may or may not be critically intertied. When planetary thresholds, boundaries, or limits are transgressed, tipping points are reached and failures begin, first in subsystems, then propagating through the larger systems. Some subsystems may collapse in relative isolation. Some collapses share common causes or triggers, some have simple domino effects on others, and some will trigger wider cascade failures, often with unpredictable outcomes. Sometimes these are runaway positive feedback loops that expand until stopped by an external limit. Sometimes one or two stressed subsystems, still shy of their own tipping points, interact with others in ways that tip those systems into failure. Even though the interconnectivity of subsystems is a large part of system resilience, interconnections can also potentiate contagion, the propagation of problems into larger scales and greater complexity.

Here is one straightforward example of a domino cascade: Global warming melts the high country glaciers. The darker earth absorbs heat more quickly and stores it for winter. Snowmelt and spring runoff happen more quickly, leaving late summer streams over-appropriated and diminishing groundwater recharge. Farmers' wells, sunk into the free-flowing aquifers, now run dry in mid-season, so they turn to pumps sunk into fossil water aquifers, depleting these non-renewables that were best saved for sparing use during unavoidable emergencies. The diversion of late summer water from off-site diminishes the biomass at the source site, further harming water retention there.

A study by Juan Rocha (2018) refers to these failures or destabilizations as “regime shifts.” These are “large, persistent changes in the structure and function of social-ecological systems, with substantive impacts on the suite of ecosystem services provided by these systems.” He suggests that, of the 30 subsystems identified in his paper, only 19% were entirely isolated. Another 36% shared a common cause or driver, but were not likely to interact. The remaining 45% had the potential to create either a one-way domino effect or mutually reinforcing feedbacks. “Driver sharing is more common in aquatic systems, while hidden feedbacks are more commonly found in terrestrial and Earth systems tipping points.” The Rocha study is only a sampling, and it’s important to note that there are a lot more than 30 subsystems. But this does indicate that there is a lot more to be studied here, and it also suggests that understanding these compound and cascade effects may help us to better focus on the keystone corrective activities. We should start looking at these in more detail now. We are presently getting inferior, delayed, and deliberately distorted information about the long-term damage that’s being done to our environmental support systems. The most important decisions are being made by politicians and corporate entities, with hyperbolic discounting and too little regard for science and long-term consequences. Since effective system management will be a function of feedback, feedback delays, errors, and distortions are not our friends. We are only ensuring that we will be still further over our limits and deeper into our various crises before we even see them.

4a. Biodiversity and Habitat Protection

"The last word in ignorance is the man who says of an animal or plant, 'What good is it?' If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering" (Aldo Leopold, A Sand County Almanac).

Biodiversity is capital, not a renewable resource, even though there may come a time when genetic engineering or genomics will allow us to replace lost species, especially critical ones. Life has been adapting for as long as life has been. But today's rate of change in the environment is too challenging to the adaptive fitness of most of our species. Critical losses are happening both within species and on the whole. This describes a period known as punctuated evolution, where mass extinctions clear out entire niches by rendering them uninhabitable to most present occupants. The normal pace of change is called gradual evolution. In Donella Meadows words, the biotic gene pool is our library of life's "lessons in survival, resilience, evolution, and diversification strategies." It's far more fundamental to our continued existence than the Alexandria Library ever was, and its loss is even more heinous and criminal.

Biodiversity translates directly into an ecosystem's strength and ability to sustain impacts, like depth on a team roster, in providing alternative services to portions in failure, both resilience in recovering from impacts, and adaptive fitness in adjusting to rapidly changing environments. Monocultures and plantations are the opposite of rich, diverse ecosystems. We can have large increases in net primary production on converted land, but this comes at an enormous cost. These are the least resilient systems and the most in need or artificial defenses, supports, and inputs. Resilience has value for its own sake, and can be measured by a redundancy of entities performing similar functions, right down to intraspecies genetic variation. Losses here open the system to invasive species, pests, and rapidly evolving disease vectors. We make problems with monoculture even worse when we do it unnecessarily, as when biofuels such as corn ethanol, feed for CAFOs, and fibers for high-footprint fabrics compete for irrigated agricultural land.

Humans will tend to focus their protection efforts on individual species, and this usually means charismatic megafauna, or keystone and indicator species. Many care that the biomass of wild mammals has fallen by over 80%. It seems to confuse us when protection of the entire ecosystems that support them is recommended. This denies us desired ecosystem services. It makes the loggers want to hunt spotted owls. But the move from species conservation to a holistic approach to biodiversity preservation has to be made, even if it looks like we're wasting money on that stupid little vole, digging around the tree roots, connecting mycorrhizal communities, and allowing the trees to become a true forest. Still, it helps to name the species at risk. CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is the international agreement for the monitoring of threatened and endangered species of both wild plants and animals. Our global seed banks and captive breeding programs both seek valiantly to maintain global biodiversity and hold extinction at bay. More than a thousand participating botanical gardens, zoos and aquariums are also by far our richest source of data on known species, their needs and breeding habits, information desperately needed for species preservation. Threatened migratory species pose special problems, calling for distributed series of sanctuaries and protections.

Human civilization has become heavily dependent on some wild species of both animals and plants. The old red jungle fowl from Southeast Asia, who became the

chicken, is a great example. So is the honeybee. It's often wise to retain copies of the original species, from before we began our breeding programs (cisgenic GMOs). We are about to encounter some trouble with the familiar banana, since we no longer have versions that bear seeds, and diseases are spreading. But far more frightening than this is what could happen to our cultivated rubber trees if South American leaf blight (SALB, *ascomycete microcyclus ulei*) ever got loose globally. That means the loss of tires on motor vehicles, since no substitutes come close to having rubber's properties for this and numerous other applications. That's enough to crash civilization.

Microbial ecology is another weak point in our thinking. This is far too complex to be more than poorly understood. The microbial world was already billions of years in the making before complex life emerged. It's what allows complex life to emerge. Cells had a lot to learn before they could learn to specialize and play nicely together. In the soil, microbial losses are also losses of symbiotic relationships that create nutrients out of raw materials. Microbes are vital to carbon and nitrogen cycling. Soil is Earth's most valuable carbon sink. Fungi are every bit as important as bacteria. Theybreak down detritus back into useful nutrients.Symbiotic mycorrhizal relationships knit the living plant and soils community together into a whole. In the ocean, microbes, especially marine phytoplankton and algae, are another of the world's great carbon sinks, but rising ocean temperatures are compounding vulnerabilities. The complexity of genetic diversity in marine microbial communities is truly astounding. Craig Venter's boat, Sorcerer II, on a two-year voyage over 32,000 mid-latitude miles, collected millions of new genes and nearly 1000 genomes, and many of these may hold promise of unforeseen technologies, such as photosynthesizing gaseous hydrogen.

Injuries to biodiversity come from bottom-up trophic cascades (loss of primary producers), bycatch losses and wastage, forced species migration, hydrologic changes, land use conversion (for farming, ranching, logging, urbanization, and suburban development), microclimatic effects, pollution (air, land, water, and now ubiquitous plastics), seasonal timing changes, soil nutrient losses,desertification,stratospheric ozone depletion, local temperature changes, and top-down trophic cascades (the loss of apex predators). Land conversion as habitat loss poses perhaps the greatest threat to biodiversity, with agriculture being the greatest contributor to that. Conversion for production of animal feed hasn't yet exceeded conversion for cropland, but this is the most frightening trend. Conversion to crops for textiles still makes a little more sense than using irrigated crops with their soil nutrients for biofuels, but crops like cotton have enormous impacts and input costs. Trying to decrease deforestation for fuel wood and charcoal production should be more of a no-brainer by now, given more affordable, human-scale, solar cooking technology that's easily exported to the Third World. However, charcoal production still has a promising place in carbon sequestration with low-tech biochar and*terra preta*. Ironically, the only commonly seen positive land conversion for biodiversity happens when the degradation of arable cropland stops shy of desertification and the pioneer species take over to jump-start a new sere.

Habitat shrinkage and fragmentation can lead to genetic bottlenecks and inbreeding. Seed and nutrient dispersal is limited. Vagility, which measures the degree to which a plant or animal can migrate, circulate, or spread within its environment, is compromised. It should be noted, however,that some partial fragmentation can actually be used as a remedial tool to increase edge effect and biodiversity. But this is also used as an excuse for exploiters, like the timber industry, to deliberately fragment a habitat: "We're going to cut these patches of forest out in order to increase habitat diversity and edge effect." Such statements should be examined for sincerity.

Other major threats to diversity come from malpredation, the hunting of bush meat, overexploitation, overfishing, wildlife over-appropriation for the pet trade, poaching, sanctuary loss, and trophy hunting. Governmental predator extermination programs have downward trophic cascade effects throughout the food webs. Keystone species, the most integral and sensitive populations in a food web, can trigger food web disruptions from any trophic level. And paradoxically, gaining inclusion within a sanctuary, if primarily nominal and unsupervised, can lead to increased exploitation. Should the human population begin to crash, whether from collapse of natural systems or of supporting social order, pressures on wildlife, as both forage and game, will be amplified, and the mechanisms to control overexploitation will be severely compromised.

The life forms that aren't our friends are rapidly finding new ways around our cleverest wonder drugs, herbicides and pesticides. Adaptive pathogens and disease migration carry epidemiological risk for new disease and pest outbreaks, and this is supported by newly warming regions of the world. Introduced and invasive species are also not our friends, but our meddling is helping them propagate. Disease susceptibility from population stresses, as on diminished nutrient availability, contribute to the spread of parasitic pathogens.

Non-species-specific biocides are ecocidal. These are considered necessary for "green revolution" industrial monoculture, but they will both create and increase needs for biocidal pest management. The applications for integrated pest management require thought and work and are generally ignored in favor of genetic modification and transgenic (interspecies) modification. When these have done their work, the pesticide and herbicide residues often remain.

Our war on the insect world, particularly with insecticides, is already starting to show a frightening depth and array of unintended consequences, especially from the loss of pollinator species, and the loss of food sources for certain birds and other insectivores. Many of these populations will crash along with their food supply. It's not just about the honeybees. We lose beneficial insects, which also decompose detritus and manage other insect pests. We're even beginning to deprive ourselves of the growing promise of entomophagy, the use of insects as nutrient-rich food for ourselves. Integrated pest management takes more thought but less money and other resources. Some collateral casualties of this war include soil fungal networks, still poorly understood, but known to be critical to healthy soil, and the loss of other decomposers and detritivores that return nutrients to soil.

4b. Climate Change and Air Quality

Climate change has vast implications and repercussions in almost every other dimension of the human problem, but it's largely a media problem that it's held to be of greater importance than the underlying systemic factors that create it. Climate stability, within an historically normal range of variability, should be considered a non-renewable capital asset, especially since the predictability of climate that agriculture requires has always been marginal (as any farmer in debt will attest). Destabilization is as serious as variations in precipitation. Global warming can be considered irreversible on timescales from centuries to millennia. This is largely due to the ocean's capacity to absorb and hold heat. The specific heat (retention ability per unit of weight) of water is nearly five times that of stone. Climate change is largely the result of atmospheric greenhouse gases, or GHGs, principally carbon dioxide or CO2, nitrous oxide or N20, methane or CH4, and chlorofluorocarbons or CFCs. Per Cafaro, "Greenhouse gas emissions account for about three-quarters of anthropogenic climate forcing; the other quarter comes from deforestation and the conversion of wild lands to agriculture." The planet's several ecotones have evolved in reliance upon a particular and limited range of variations. When variation becomes excessive, selection pressures force plant and animals to adapt, die off, or migrate, at rates far faster than normal. Forced vegetation migration, to lands less well adapted would be analogous to a trail of tears for the plant kingdom, and at a time when our human population growth would demand an increase in plant productivity. Along with these migrations will come new microorganisms, diseases, and insect pests.

More sensitive still are our human agricultural adaptations, with their monocultural crops, in need of even more particular and predictable patterns of temperature and rainfall or irrigation. Elevated temperatures and unpredictable rainfall patterns give us both both overly dry and waterlogged soils. Steffen (2018) writes "agricultural systems are particularly vulnerable, because they are spatially organized around the relatively stable Holocene patterns of terrestrial primary productivity, which depend on a well-established and predictable spatial distribution of temperature and precipitation in relation to the location of fertile soils as well as on a particular atmospheric CO2 concentration." Human agriculture relies heavily on predictability for crop and market planning, so that simple climate irregularity can be just as disruptive to food security as steady change in one direction or another. Destabilization of important weather patterns like the South Asian Monsoon (SAM) could have devastating effects on large populations. Irrigation water is a big part of agricultural planning and it doesn't help that the systems supporting it are also beginning to fail on a number of fronts, to be discussed later. We are already seeing growing effects of this change as populations around the world become unable to raise their own food. Some of this is also from topsoil degradation.

We have stripped unthinkable quantities of carbon from the soil with our green revolution in industrial agriculture, as we've gradually 'busted the sod' and turned the soil into lifeless dirt, thereby hastening its erosion by water and wind. Increasing boreal, tropical, and subtropical deforestation has robbed the atmosphere of another huge carbon sink. Climatic stresses on the forests have left them more susceptible to disease, insect invasions, and CO2-releasing wildfires. On the whole, the increasing atmospheric CO2 concentration has been predicted to help the carbon sink of primary production, since this feeds the photosynthetic process. But there will come a point soon enough where both photosynthesis and plant fertility will be more seriously compromised by greater heat. Many of our crops may go through reduced yields if

temperatures exceed 32ºC during the flowering stage. Microbial respiration will increase in warming soils.More aerosols could add to precipitation.

Having said all the above, though, potential increase in cloud cover and associated albedo changes are still being debated. Potential levels of water vapor in the air over particular vegetated biomes are still being debated. Potential changes in photosynthesis still have unknowns. A hotter atmosphere will potentially hold more water vapor, increasing humidity, but the sudden cooling that produces rain may decrease. And that potential may not be realized due to other climatic factors, leading to deficits that affect a plant's water absorption. This could have significant negative effects on net primary production. Wenping Yuan sees a decline in atmospheric water vapor that's correlated with a vapor pressure deficit over vegetated areas, leading to an actual decline in plant growth over two recent decades, following a period of increase. Systems remain complicated, to the point of seeming whimsical, and destabilized systems will be even more so.

Rising sea levels are almost the least of the biosphere's worries, although the coastal riparian ecotones and reefs will be affected to more tragic degrees. Civilization will suffer the most here. More extreme weather events will bring killer droughts and heat waves, and new levels of cyclonic storms with their companion costs of disaster relief and recovery. Floods and cyclones release massive pollution into the environment, largely through river and marine pollution. Property and infrastructure lost in floods will have to get replaced, whether that's back in the same flood zone or somewhere more sensible. Environmental refugees need to be re-accommodated with new infrastructure as well, and we ought to consider that infrastructure replacement is costlier than original installation. Warmer oceans will find new things to do with new levels of heat. Heat is almost by definition the same as restlessness itself. A major disruption of the global oceanic thermohaline circulation (especially the Atlantic's AMOC) could disrupt the climate on a continental scale, with more extremes of temperature at both ends.

CO2 is primarily overproduced in the burning of fossil fuels, but the diminished reabsorption or sequestration from net losses of growing plant biomass is another major factor. Vast quantities of CO2 (and CH4) are now being released from organic decomposition in melting permafrost. It's argued that a global 'greening' of the planet has significantly slowed the rise of carbon dioxide in the atmosphere since the start of the century. Plants have (or had) been growing faster and larger due to higher CO2 levels in the air and warming temperatures that reduce the CO2 emitted by plants via respiration. (Bendell). But this only helps with a fraction of our problem, and it comes with other consequences. This includes a lowered nutritional value per pound of agricultural product, given that CO2 only affects carbohydrate production and not the balance of required nutrients, which become diluted. We think total global emissions remain above 10 billion tonnes of carbon per year (nearly 40 billion tonnes of CO2). But some vested interests are playing games with the estimates. The US military is the single largest institutional producer of GHGs (and consumer of liquid fossil fuels). This doesn't even count the GHGs produced by private military contractors or arms manufacture. But these figures have also been exempted from calculations of the US carbon footprints in international agreements such as the Kyoto Protocol and the Paris Accord (Belcher, 2019). Further, GHG emissions from melting permafrost may have been dangerously underestimated.

N2O in the atmosphere has now increased by nearly a third due to human activity, principally agriculture, fertilized soil activity (from NPK inputs), runoff and leaching, manure, and combustion of biomass, with some fossil fuel and industrial sources. N2O is a significant scavenger of atmospheric ozone, on a level comparable to CFCs.

Impacts are increasing from quantities added above natural baseline. It's contribution to climate warming is about a third that of CO2. Mitigation should focus on better and more efficient agricultural practices.

CH4 is primarily overproduced by biological decomposition, especially in melting permafrost, and this, too, is subject to diminished reabsorption or sequestration by dying soils. Compromised forest soils are a big factor. CH4, while found in smaller quantities than CO2, has roughly 25 times the global warming impact of CO2. Looming somewhat more distantly is the melting of methane clathrates or natural gas hydrates, massive quantities of CH4 trapped within the crystal structure of water ice in the cold oceans. Per Steffan again, "The ocean methane hydrate feedback, although not likely to lead to a significant release of carbon in the 21st century, is included [in this account] because on the longer term it is likely to be activated by a 2°C temperature rise, will lead to large releases of carbon, and is irreversible." In other words, this is a huge turbo boost to global warming waiting for us once the climate change starts to enter runaway mode. This runaway effect is thought to have played a significant role in the Permian mass extinction event, 250 mya. But the predictions for this tipping point may soon need revision in the wrong direction, given the overly-conservative trend of so many of our projections.

CFCs pose their most serious hazards in stratospheric ozone depletion and in their persistence as pollutants in the environment. Ozone depletion allows higher energy particles through the atmosphere, where ionizing radiation can damage tissues and mutate DNA. Gradual improvements in the ozone layer have resulted from international bans on their manufacture. These are now being replaced by hydrofluorocarbons and other chemicals. But N20 increases.

New ideas for sequestering atmospheric CO2 are being entertained with increasing frequency, but the higher tech solutions, like using large industrial plants to pump and store the gas underground, are still fairly ludicrous in their costs and impracticality. Passive sequestration has occurred in fossil fuels and carbon-rich mattes of deposits on the ocean floor. One of the more plausible mid-range technical solutions calls for fertilizing marine phytoplankton to photosynthesize more atmospheric CO2. Their little dead, carbon-rich bodies eventually fall to the ocean floor. Forests are among nature's primary means of actively sequestering carbon. Boreal, temperate, subtropical and tropical forests account around 60% of terrestrial sequestration. This is both in forest soils and in growing wood. Extensive reforestation remains the best remedial plan, and this could also be integrated with agroforestry to retain agricultural productivity (while diminishing monoculture). Changing the way we now do agriculture from high input industrial monoculture to regenerative agriculture will of course generate howls of protest from those who fail to realize that the green revolution is absolutely unsustainable at even current population levels. Promising experiments are now underway with low and no-till farming to retain soil carbon, as well as planting elemental carbon directly into the soil (biochar and *terra preta*). Holistic grazing is exploring the use of animals (which have co-evolved with plants) to restore soil root structure and water retention.

Outside of GHGs, air pollution has immediate consequences on the life forms that breathe it in, and that includes plant respiration. Pollution and land-use change that increases the release of dust and smoke adds to the atmospheric aerosol load. But we haven't yet reached the atmosphere's limits as a sink because particulates are redeposited, microorganisms are distributed, and the gasses are absorbed in atmospheric moisture and return by way of hydrologic cycles. This includes radioactive particles with long half-lives. The secondary pollutants, such as ground level ozone or smog, form in the atmosphere when primary pollutants interact.

Persistent organic pollutants resist environmental degradation and can accumulate in tissues in the food web, biomagnifying in the upper trophic levels. Whatever damage they do in circulation, the effects are temporary in the air and more persistent in the water and soil, and in living tissue. And air pollution still kills many millions of us directly every year, on its way back to field and stream.

Atmospheric warming melts glaciers, exposing darker earth. This diminishes the ability to reflect heat back into space, especially where glacier cover was once relatively permanent. The effect here is not insignificant, and may be as much as a quarter of our carbon emissions when all is done (Bendell). Furthermore, permanent ice sheets cap the organic decomposition of permafrost layers.

There will be high socioeconomic costs from climate change as well, ranging from the mass migration of climate refugees to the destruction brought on by increasingly violent weather events. Both of these demand both cleanup and the repair or provision of infrastructure.

Most recently, scientists in the climate field are discovering significant errors in projections and predictions of climate effects and their intensities. They are finding them to have been far too conservative in some frightening places. This may be from avoiding the appearance of being overly dramatic or alarmist, or simply from wanting consensus badly enough that they absorb the more conservative estimates into their numbers. We are now seeing consensus predictions made decades ago showing up as dangerously over-conservative, sometimes by one or two orders of magnitude. The rates of melting permafrost and glacial cover are two good examples, with levels of melt occurring many decades ahead of ‘schedule.’

4c. Oceans and Fisheries

One of water's more interesting properties is its ability to hold heat (at 1 cal/gm-degree Celsius). Soil, rock, and concrete will only hold about a fifth as much heat as this by weight. This is where the bulk of planetary warming is being stored, at roughly one yottajoule (10^24) for each degree Celsius. This gradual rise in water temperature is also having a few side effects. Warmer water holds less dissolved oxygen available to marine fauna. We're also risking increased bacterial respiration in the ocean, further compromising oxygen levels. With the addition of glacial and arctic/antarctic sea ice melt, the currently well-balanced thermohaline currents that distribute global ocean heat around the world are threatened with disruption, or even a shutdown, leading to more local extremes and more of the cyclonic weather events that this engenders. Changes in temperature, combined with increased ocean travel, are also resulting in changes to pristine ecosystems by exotic and invasive species.

The ocean also absorbs CO2, so far about 30 percent of what humankind has discharged. There it reacts with saltwater to form carbolic acid, acidifying the ocean, dropping pH from 8.2 to 8.1 since the pre-industrial era, and projected to fall to 7.8 by century's end. This in turn is eating away at the calcium carbonate structures that life forms such as mollusks, corals, and certain phytoplankton depend on for survival. Collapse of these populations threatens widespread disruption of marine food webs and bottom-up cascade failures, particularly as we advance towards pH 7.8. But coral reef death is happening much sooner.

Biochemical discharges from land-based agriculture are largely non-point-sourced and harder to redirect. These are loading the local lake and coastal ecosystems with excessive fertilizer, leading to algal blooms and subsequent eutrophication, often leaving only dead zones. This is especially problematic with the predominant NPK fertilizers phosphorous and reactive nitrogen. If this were a condition that isn't going away, the only useful countermeasure would be to harvest these blooms and render them into biofuels and fertilizer for return to the crops.

Organic pollutants, heavy metal compounds (especially mercury), and radioactive materials enter the food web, where they bioaccumulate and become concentrated in the tissues of the top predators, which are frequently also either dietary mainstays of human consumption or charismatic ocean life that most people would rather protect. We are only now beginning to see the effects of widespread plastics pollution on marine systems, and devastating effects on individual life forms, including cetaceans. Microplastics, the least amenable to cleanup, are becoming ubiquitous throughout the food web. Oil spills continue to wreak havoc, and every animal that gets cleaned up also means a bucket load of waste. We are experiencing a growing pollution load in the runoff from flooding and other extreme weather events, such as the contents of septic pits from hog farms and the industrial wastes so often found stored or staged near the sea.

Human overfishing has become increasingly ham-handed as we ramp up operations for economies of scale. Today's operations might drag the ocean floor, including coral reefs, or sweep the sea with miles-long nets, capturing and killing everything in their path, laying waste to unacceptable levels of indirect exploration or bycatch. But even despite rising efforts, marine catch has been falling. The growing industry of marine aquaculture is now showing us some of its unintended side effects, particularly with the susceptibility of monocultures to diseases that can then spread to native populations. The poaching of marine species for specious medicinal properties (like manta gill plates) or food fads (shark fin soup and totoaba bladders) is cutting deeply into important and protected populations. Some of the killing of top predators is

deliberate, even where it isn't sanctioned, as we see with the killing of sea lions to improve fish harvests. And some of the killing is incidental, as from sonar and mechanical noise pollution, which disrupts the cetacean sensorium, often with serious neurological damage, leading to mass beachings, and possibly even suicides.

Finally, our coastal land conversion is costing the biosphere many coastal defenses, like reefs, barrier islands, riparian areas, and mangrove forests, all important to extended marine ecosystems.

4d. Fresh Water and Aquifers

Much of the world is already in trouble with the timely availability of fresh water. Supply from rain and snow has been a relative constant historically. This comes to us from the clouds, more or less in distilled from, save for the particulates that rain and snow condense around. We can tweak the supply a little with cloud seeding technology. The primary variable here has been simple, routine variation from seasonal norms, but this is now also subject to more radical changes in the climate itself. It seems likely for now that global warming will largely magnify the existing contrast between the wet and dry regions and the seasons within them. The only place we are increasing water runoff is from development of impermeable surfaces like roofs and roads, or from damaged environments like logged or burned forests, accelerating discharges that carry added ingredients like wasted topsoil.

Storm runoff now carries more chemical pollution, from industry, roads and transportation, and agricultural fertilizers, and much of this pollution occurs in heavy pulses as weather events like storms and flooding grow more extreme. Eutrophication, especially from surcharges of phosphorous and reactive nitrogen kills aquatic ecosystems, or demands expensive mitigation. Mangrove forests, sloughs, bogs, and other riparian systems that perform water cleaning services (and carbon sequestration) are compromised by land conversion.

Riverine systems, in most areas, are already being overappropriated at levels well beyond what a dedicated aquatic biologist would recommend for optimum (or even minimum) instream flows, further compromising water quality downstream. This also deprives live aquifers of some of their needed groundwater recharge. Interbasin water transfers have substituted economics and politics for sound aquatic biology. Building more dams will also mean evaporative losses of roughly a tenth of each dam's capacity every year.

Free-flowing aquifers themselves are also becoming overappropriated, as well as being polluted from such operations as fracking, or leaching of such contaminants as nitrates. Dams are fragmenting aquatic habitat, as well as collecting unnatural levels of silt and sediments on both sides. Free-flowing aquifers are a resource, which will have maximum draws, and diminishing returns on technologies for extraction. Fossil water aquifers are another, more serious matter, although they remain out of sight and therefore largely out of mind. These are non-renewable banks of natural capital. If we're going to use these at all, their use should be limited to emergencies. Yet we pump them out as though they were bottomless, all the while thinking the green revolution in agriculture that does this is indefinitely sustainable.

The melting of alpine glaciers is beginning to effect quicker spring runoff and diminished late summer snowmelt and river flows [effect was the correct word]. This has big implications for any agriculture that demands irrigation water in late summer and early fall, when heat and evapotranspiration are also at their greatest.

We have just about ignored the water storage capacity of healthy, carbon-sequestering soils, especially those in the forests and grasslands that we are converting for industrial agriculture. This, combined with hotter and more poorly structured soils, actually increases the need for irrigation. The tropical drylands that support so many of us, especially in Africa, are growing hotter and drier.

Conservation efforts remain poor. There are places in the developed world where you can be fined for growing food instead of a lawn and ornamentals. This is somewhat self-correcting, however, as communities eventually pay for ignoring the hardships of drought and institute rationing and conservation rules. We wonder when Phoenix will drain its hundred-thousand-plus private swimming pools and quit wringing its hot little

hands over water issues. Coastal areas, at least those not compromised by rising sea levels, may at least see some benefits from increasingly affordable desalination projects. Energy efficiency is improving here, and moving towards solar. The technology is far from perfected, though, producing on average more brine in need of disposal than desalinated water, and this must broadly dispersed. Current technology also produces toxic chemicals, antiscalants, and antifoulants that need to be dealt with or resolved. Inland is another matter, where the best new lower-tech technologies seem to be wind traps.

Globally, water crises will continue to grow, or burgeon, as the stratification of power and wealth increase. Corporations like Nestle and Coca Cola will continue to privatize the fresh water commons until they are stopped by new laws.Since the price of idiot water in single-use plastic is higher than gasoline, and profit margins even higher, this will not be a voluntary humanitarian step. We are only beginning to see the water refugees crossing national borders. We can count on seeing some wars happening over this.

4e. Agriculture and Topsoil

The early development of agriculture enabled humankind through its first series of steps towards larger viable populations, as we moved from hunting and gathering, through pasturing, and into tillage or farming. Tillage then triggered the first urbanization and we were on our way, though that was often to war. But now, according to Lester R. Brown, "Today's 7.6bn and the 2bn more expected by 2050 must feed themselves from soils with, according to the UN, less than 60 more harvests to give, decimated fish stocks, a finite supply of fresh water facing even greater demands upon it and, most frighteningly, the risk of a collapse of insect pollinators and of millions of square miles of land made unproductive by climate change." It's unclear why most of the voices at the UN are calling for steps to accommodate higher human numbers instead of steps to reduce our numbers. This makes no sense at all, unless there is a great deal of peer pressure to avoid upsetting the global Ponzi economy and its wealthy supporters. Development must be sustained at any cost? That isn't what sustainable development means.

Instead of building soil, modern agricultural practices are slowly turning it all into lifeless dirt. But then we say these practices are necessary to feed the growing population, although some wonder where the water will come from. And the nutrients. The increased productivity has been real enough, but this is temporary, only to last a few decades. Unfortunately, most planning only looks a few years ahead, and the legislators see no further than the next election or campaign contribution. Our agricultural capability is now facing a decline after a long run of unsustainable growth. Both land per capita and unassisted land productivity are beginning to fall. Growth rates of agricultural production and crop yields have decelerated in recent years and will soon reverse. The fact that we could presently feed everybody on earth with present agricultural production, given better food distribution, is completely beside the point and dangerously myopic. This is a temporary state, gains bought on unsecured credit, to be repaid by impoverished future generations. Cisgenic GMOs, and especially high-yield crop strains, may be the most sustainable of our newer improvements to agriculture. But we can't forget that the nutrients (other than C, H, and O) have to come from somewhere. If not from the soil, then where? They won't come from the lifeless dirt we are turning the soil into. We also need to ask about the end states of our changes to the biogeochemical cycles of water, carbon, nitrogen, phosphorus, and potassium, among other nutrients.

Vast historical quantities and rates of manure and urine have gone missing from our lands. Wildlife once grazed what is now farmland and range, and eventually returned everything to the soil, including the decomposed dead. Today, this is often collected in CAFO lagoons instead, or as heavily regulated human sludge (now full of hormones, antibiotics, and cleaning materials) or as the plastic-bagged excrement of our dogs and cats, or in disposable diapers. Much of this is now rendered useless in landfills, but these are the molecules that we have consumed in our food, the products of our largest industry, and stripped from our topsoil. The world had far better uses for all of this stuff,including our corpses,to keep its biosphere going.

To give some scale to things, the USDA claims that, in the United States, "food production currently devours 50 percent of the surface area, 30 percent of all energy resources, and ingurgitates 80 percent of all freshwater" Abegão (2018). There really is only one way to answer the question "How will we feed our ever-growing numbers?" That is "Increasingly less well at first, and then, for many, with little to nothing at all, until our global numbers have fallen dramatically." The green revolution in industrial agriculture presents us with a grand illusion of progress and sustainability by showing

us many decades of progress in the quantities of its outputs. Aldo Leopold noted that we have simply made improvements to the pump, rather than to the well, which won't help us at all when the well starts to run dry. Too few of us are looking at the sustainability of the inputs that these outputs demand, or at the growing diminishing returns on their investment. We must begin with a harder look at these inputs.

Paul and Anne Ehrlich write, "Agriculture made civilization possible, and over the last 80 years or so, an industrial agricultural revolution has created a technology-dependent global food system. That system, humanity's single biggest industry, has generated miracles of food production. But it has also created serious long-run vulnerabilities, especially in its dependence on stable climates, crop monocultures, industrially produced fertilizers and pesticides, petroleum, antibiotic feed supplements and rapid, efficient transportation." The agricultural system is thus intricately interconnected with other, still more industrial drivers of carrying capacity. We use power to cook, freeze, and dry food, as well as ship it globally. We use enormous amounts of plastic and other packaging materials. Supermarket coolers and freezers are also part of the costs of feeding ourselves. Many of these costs exist either to accommodate a global shipping economy or because that's just how things got set up. It's efficient within its own reality, but relocalization and locavore diets are far more efficient in absolute terms and don't depend on a vulnerable global infrastructure. The global system currently does have the ability for now to avoid local food production shocks. Collapse of a fishery will increase demand for land-raised meat. Flooding or drought in one breadbasket may be offset by its opposite in another, and will simply alter global distribution patterns a little. But resilience will diminish along with food reserves, political and economic stability, and other buffers.

"Industrial agriculture displaces smallholder and indigenous farmers from their land. Smallholders make up a third of the world's population and half the world's poor; they nevertheless produce about 70% of its food on one quarter of its farmland, and that mostly without the ecological damages listed above" Weizsäcker (2018). The problem is that this is more labor intensive and this has to compete with the economies of scale boosted by the heavy subsidies of money and resources that big agriculture receives for its use of externalities. Trade regulations and treaties don't help at all. An ethic of food localization does, at least where it's rational. Shipping live chickens from America to China, only to import the processed chicken back to America in cans, only makes sense in a deeply confused and overly manipulated economic system.

The first large input to modern agriculture is the conversion of wildlands or wilderness to cultivation and grazing. Overpaving often happens on the most fertile land, since flat and bottom land is where silt and nutrients collect and water move or migrates most slowly. Ever more conversion is required both as the population grows and as our formerly fertile lands weaken in their productivity. We already have diminishing per capita arable land even without population increase, except to the extent that we are invading and occupying new ecosystems. We generally begin with the low-hanging fruit, the easiest conditions to exploit, and are (or soon will be) eventually forced to move on as more impoverished or problematic lands become relatively more attractive. This is the nature of diminishing returns. These newer lands are generally upslope, with poorer soils to begin with, even though though they might catch a little more rainfall, and erosion increases as we climb out of the bottom land.

Nicholas Georgescu-Roegen calls attention to the heavy mechanization and upscaling of modern agriculture, causing us to use the mineral and other non-renewable capital resources that we need to make the machinery, irrigation systems, fuel, biocides, and fertilizers as substitutes for human and animal labor and renewable sunlight. The costs are in fact a great deal higher than the old days, but the high costs are hidden in

subsidies for exploiting the commons. Modern food production would appear to be a lot less sustainable if all of the long-term damages to the commons, the hidden costs, environmental losses, and industry subsidies were to appear in our food prices.

Irakli Loladze speaks to the argument that CO2 is plant food, leading to greater product weight and volume. It is, at least until global warming gets worse, and barring other questions discussed in the last section, but this also compromises nutrient balance. Genetic modification made for harvest volume does the same thing. While it might be true that added atmospheric CO2 is contributing to plant growth or primary production, this is measured largely in cellulosic gross weight, or sugars. Crops are measured and sold by weight, not nutrient density, so we would now need to eat more food to get the same vitamins and minerals. This joins the GMO modifications being made for characteristics other than nutrition, like appearance, insect resistance, and transportability. Further, fertilizer inputs now consist disproportionately of nitrogen, phosphorous, and potassium. Peak phosphorous availability isn't far off, and effective depletion is seen within a century. Human activities now convert more nitrogen from the atmosphere into reactive forms than all of the Earth's terrestrial processes combined. Runoff gives us soil acidification and nitrate pollution in steams and groundwater. Other essential plant nutrients, like iron, zinc and iodine, don't increase in the same proportion, so that overall our food nutrient density is diminishing. Moist soils that have deep, complex, living root structures, healthy mycorrhizal relationships, microflora, and microfauna will literally pump vital mineral nutrients up from weathering parent material below. Living soil self-fertilizes to some extent. Industrial agriculture turns this living soil into sterile dirt, or quite a bit worse, into chemically contaminated dirt.

The weakened structure of the soil diminishes its capacity to hold water, increasing the inefficiency of irrigation, and also leads to the wind and water erosion that constitutes another big driver of topsoil loss. Soil salinization is an ancient and growing problem. Soil is also rendered more subject to mass wasting, especially through more frequent wildfires and storm runoff. All of this is in addition to decarbonizing one of the planet's greatest carbon sinks. The counterforce to all of this is regenerative agriculture, sets of practices which build living soil instead of depleting it. Soil is either not tilled or tilling is minimized, and perennial plants are preferred. Cover crops are important. A step more high tech than this is restorative agriculture, which can be used to repair damaged and polluted soils with mycoremediation and accelerated seral succession. Putting numbers to current losses, the UNCCD, in its Global Land Outlook (2107) claims that "Each year, we lose 15 billion trees and 24 billion tonnes of fertile soil."

Soil nutrient export from harvest and animal husbandry has always carried a necessity for refertilization. At the same time, the quality of manure from both human sewage systems and CAFOs has degenerated chemically with the addition of biological contaminants and medicines, and household cleaning products. This compromises nutrient recycling when it's improvement that we urgently need.

Insect populations are rapidly becoming a visible collateral casualty of our biocide use. This was discussed under Biodiversity. The consequences of this trophic-level disturbance of the food web are now being felt in bird, bat, and other insectivore populations, as well as in the efficiency of integrated pest management and the decomposition of detritus.

Agriculture has always been uncomfortably dependent on fairly predictable temperatures and rainfall, and an ability to irrigate. Large-scale, monocultural operations are now even more susceptible to climatic vagaries, at least regionally, such that geographic hedging and surpluses have become even more important. And yet,

global food surpluses are falling now, like our reserves in other areas. We are also running more serious pandemic risks by having fewer crop varieties. This narrowing of crop diversity is even supported politically, and sometimes enforced, by patent-holding crop developers.

Biofuel production on arable land, especially for corn ethanol, is one of our more myopic and boneheaded projects. Far kinder things might be said of dryland cellulosic biofuels, and algal biofuels made from agricultural wastes, if we had more vision and sense to invest in that. Both of those could give us a value in harvesting noxious and invasive weeds and algal blooms, instead of topsoil and water losses.

This section has concerned trophic level one and its ability to feed level two, the growing of the level one or autotrophic plants that feed the herbivores, such as irrigated crops, dryland crops, and agroforestry. We encounter yet another set of frightening problems when we step up to trophic level three with meat and dairy production, food for the carnivores.

4f. Grazing, Meat, and Dairy

On average, the calories and nutrients obtained from animal sources are around seven times as costly to the environment as those obtained from plants. These are basic trophic level conversion inefficiencies. In terms of quantities, our annual global consumption is now nearly 400 megatonnes of meat, including fish, and over 800 megatonnes of eggs and dairy. Many of us are still awaiting some more authentically tasty, plant-based meat and dairy substitutes for our high-quality protein. Many of us may even be looking forward to palatably textured vat-grown meat. And almost everybody wants those smug, proselytizing vegans and the nut jobs from PETA to shut up. In the meantime, however, per capita meat and dairy consumption is growing in non-linear ways with both the human population and the growing affluence of the developing world. Further, demand has been jacked up and suppliers over-encouraged by advertising, cheap irrigation water, subsidies on grain production, and below-cost grazing on public lands.

One might suppose that if we had a human population that was at or below the carrying capacity suggested by all other dimensions of the human problem, we would also have adequate room on this world for reasonable and wholesome amounts of meat and dairy in our diets. But at current levels of overshoot, diets at the third trophic level are among the major drivers of ecosystem collapse, with our rapid land conversion, deforestation, biodiversity loss, fresh water consumption, GHG production, and soil decarbonization leading the way. A global move towards more proportionately vegetarian diets, particularly in the developed world, would move us significantly further in the direction of sustainability, but the more fervent and fevered supporters of this must realize that this is only one of the issues to be addressed, and it’s far from being the only solution we need. The primary solution is to have fewer human beings trying to live here, but cutting back on our consumption isn't far behind Human numbers are climbing at about 1.2% a year, while livestock numbers are growing non-linearly at about 2.4%. This reflects an overall increase in prosperity in the developing world. We do want to decrease global poverty, but this will drive our carrying capacity numbers still further down.

Surprisingly to those who don’t think of such things, our dogs and cats are carnivores. Many of those who complain loudest about animal cruelty, while loving their pets, are having meat and dairy impacts here that are equivalent to the mostly-vegetarian third world humans. Big dogs are even more so. Plus there’s the cat litter, owner-packaged dog shit, and food packaging waste. There are devastating levels of house cat predation on wildlife, particularly songbirds. We really need to start incorporating all of the external costs into animal product pricing as well.

Concentrated animal feeding operations (CAFOs) are a large environmental problem in addition to their ethical and animal rights and cruelty issues. We've touched upon the great waste of using irrigated farmland to grow feed for CAFOs, at least where freer range operations are viable. These facilities output enormous quantities of waste, dozens of times the waste sent to wastewater treatment plants. On the positive side, most of this collected waste does find its way back to farmland as fertilizer, with plenty of nutrients like nitrogen and phosphorus. But it also carries heavy metals, methane, hydrogen sulfide, ammonia, and bacteria like salmonella, and these materials are also subject to catastrophic environmental releases from extreme weather events.

Modifying the extent of these problems, it should be noted that certain recently developed forms of animal husbandry, holistic grazing, and dairy production can in fact be beneficial and restorative to the environment.It’s also well-established that regenerative grazing can sequester significant and impressive amounts of carbon back

into the soil.These also avoid overgrazing our rangelands at unnatural levels and impact cycles. Jem Bendell writes, “Research into “management-intensive rotational grazing” practices (MIRG), also known as holistic grazing, show how a healthy grassland can store carbon. A 2014 study measured annual per hectare increases in soil carbon at 8 tons per year on farms converted to these practices (Machmuller et al, 2015). The world uses about 3.5 billion hectares of land for pasture and fodder crops. Using the 8 tons figure above, converting a tenth of that land to MIRG practices would sequester a quarter of present emissions. In addition, no-till methods of horticulture can sequester as much as two tons of carbon per hectare per year, so could also make significant contributions. It is clear, therefore, that our assessment of carbon budgets must focus as much on these agricultural systems as we do on emissions reductions.” (p. 10).

At current population levels, not even these practices can be thought sustainable, but their growing practice is developing a new knowledge base for good regenerative methods, to become more useful once the population falls, and they can help minimize the damage done in the meantime. Even here, it might be plausibly argued that we need to retreat to less than half of the land we are currently using for meat and dairy production, to pull out of arable cropland for animal feed almost entirely, and scale way back on our use of CAFOs. Regenerative grazing might also be used on an interim basis prior to ceding repaired land back to wilderness, forest, and wetlands. Note that this ‘less-than-half’ figure assumes a much higher average level of global human prosperity than we now have, which is one of the oft-ignored dimensions of sustainability, to be discussed later. If we want more meat per capita, we can just have fewer capita. At the same time, we could use a better, more grateful ethic for our animal product consumption, targeting just a fraction, or at least less than half, of our current developed-world per capita consumption.

Pork production could be much more fully integrated with food waste and composting operations. This was, in fact, the main point behind the pig’s original domestication. These animals can absorb losses from mold, pests, or faulty climate control, supermarket surpluses,intentional food waste, and cooking misadventures, given timely local collection. Livestock can consume corn stalks, potato waste, and other inedibles. Poultry production could be better combined with integrated pest management, and ungulate grazing withdrawn more fully to grass fed and finished systems. We might not have to limit animal production to the natural environmental services they perform, but this would be a good baseline. The vegans seem to be unaware that there are coevolved relationships between ungulates, grasses, and forbs, and they do in fact serve some of each others needs. Agriculture which ignores this ignores some useful biomimetic opportunities, like the usefulness of manure and urine. Adam Sacks observes, “We are only beginning to understand the potential of intensive planned grazing with animals that break capped soil surfaces with their hooves, fertilize, moisturize and aerate the ground, and make earth hospitable to thousands of vital soil organisms. There is no climate-saving strategy that has anywhere near the potential of soils.” Such managed grazing can do more than natural grazing to sequester carbon and maintain living soil (Permaculture’s ‘obtain a yield’ principle), but it still has to respect and replenish nutrient export. We will also soon have more reasons at local scales to return to draft animals, for low-till plows and harvesting.

To those who offer output statistics for GHGs and other pollutants from animal husbandry, we need to start asking the question: “Before there were cattle, there were natural grazers and natural processes on the same land, and these had their own outputs of gasses and chemical compounds. Has anybody ever deducted this natural baseline from calculations of domesticated animal impacts?” In looking at natural baseline

impacts, we are also wise to compare these to the different species now used in animal husbandry. That would give us higher quality information. There is a broad scale of animal impacts here, with an order of magnitude in variation, from low impact, free-range poultry to high-impact CAFO beef and mutton. There are other impacts as well, which should be accounted and incorporated into pricing, to help drive down the demand, as for water demand, energy, transport, processing, and refrigeration. Still, no impacts are as great as ecosystem conversion, deforestation, and biodiversity loss. At the least, some of the killing and decarbonization of soil is very slowly becoming optional with regenerative agriculture.

It's a little misleading, and sometime intentionally deceptive, to compare or equate the land footprint of grazing to that of crops, since most grazing is done on non-arable or non-irrigated land. This land is largely unavailable for crops. But we often see these lumped together. Unirrigated rangeland can still leave significant impacts on wildlife populations, and we ought to stop trying justify predator control for ranching as good practice. Irrigated crops destined for feedlots are another matter, of course, and these impacts are enormous. Critics would do well to concentrate their efforts to change things here and then work on changing the standard practices elsewhere.

5. The Dimension of Social Order as Environmental Support

"Massive nonlinear events in the global environment give rise to massive nonlinear societal events" (Spratt & Dunlop).

We are new to issues with high and dense populations, having evolved to inhabit small tribes and villages until about 12 millennia back. We were generalists, like rats and raccoons. We continue to evolve, of course, and we appear to get some help adapting from epigenetics as well as adapting genes. Now at least the great mass of us are dependent on the evolved social order, vastly more complex, with a high-resolution fabric of specialized social functions and rules to maintain predictable behaviors. More recently still, both religion and politics have made much use of deities and other supernatural bogeymen to help manage overwhelming societal complexity, especially when populations rose above the hundreds of thousands. Some of these came to be supplanted with more secular ideologies, but even most of these had to appeal to a more primitive human nature, despite the illusion that we are rational beings.There is no way that we could maintain anything close to our present numbers without our cultural adaptations. But at present population levels, social order has grown more vulnerable in step with hypercomplexity and overspecialization, especially where it lacks redundancy and diversity of function. Individual autonomy, resilience, and adaptability are often excluded or prohibited to favor predictability and enforcement of the order. The acronym VUCA is used to denote an early threat of destabilization. Society grows Volatile, Uncertain, Complex, and Ambiguous, or changeable, unpredictable, perplexing, and multivalent. We add our reactions to this, like Toffler's "future shock." And increasing population may actually inhibit our cultural evolution because cultural mutations come from discrete individuals. A growing socioeconomic inequality can cheat us culturally by raising many of our young gifted in adverse childhood conditions.

Participatory democracy begins to fail us quickly as we grow beyond the village scale (128-150 people, or Dunbar's Number). We need representative democracy beyond this scale, but because we keep thinking in terms of real democracy, we just don't give enough care and attention to developing representative democracies that work in reality. We especially need better and quicker checks on abuses by representatives. The Romans had a "Council of Censors," answering to the people, which had the power to remove Senators from office for abuses of their trust. This is what James Madison meant by "The censorial power is in the people over government, not the government over the people." But what we have instead of this are career politicians with private agendas, and the great mass of people preoccupied with smaller things and lacking larger reference frames. This has been topped by a great dumbing down and de-skilling. When a social order like this crumbles, especially in the developed world, the efficiency with which we got our eggs is gone. Does the electric grid stay hot? Is water still on tap? What momentum carries? We've had enough regional wars and crises to see that humans generally get by, but this is usually with some outside help from the larger civilization. We have yet to see a truly global failure. The closest we've come may be the fall of Rome that gave us the dark Ages.

Civilization is a commons resource in both a real and a metaphorical sense. A humming social order is as vital to sustaining a large population as a bountiful land. Human beings are social and cultural animals. We learn from each other and we build on what we've learned over generations. We've been building since our ancestors were

hairier hominins, beginning with language, weapons, tools, and fire. To some extent, what we can build is a function of our population size. Cultural innovation appears to move slowly in small, isolated tribes, where we might be lucky to come up with a single new stone tool every thousand years. Our tribal culture and ecoliteracy play all-important roles here. Intertribal cultural diversity or fertility plays a big part in further cultural evolution, as the failure of maladaptive local cultures plays a part in cultural selection. But even smaller human social structures are not inherently stable. What stability they have must be maintained with permeable system boundaries to let new energy into the system, and by human decisions based on imperfect information and delayed feedback. Success demands an ability to do useful things with feedback, otherwise known as adaptive intelligence.

It seems obvious that our first big steps to enabling larger populations were the development of agriculture, early urbanization, and the specialization or organization of labor and other vital social functions. Around the dawn of agriculture, the human population was around 5 million. Social order gave us "the system" as our means to deal with entropy. The population began to explode only much later, first with the industrial revolution, and then with the revolution in industrial agriculture, but both of these systems are founded on non-renewable natural capital, and thus are unsustainable almost by definition. It does seem useful and even justifiable to have a billion or more of us around, to have the critical mass needed for much of our cultural creativity, and a working social system, organized and specialized, set up to exploit it. But it also seems that we've gone way too far and too far wrong in this.

We are progressing through never-before-seen population sizes and levels of cultural complexity, and complexity increases with population at an exponent greater than one. Complexity itself can destabilize order or incur unacceptable diminishing returns (Tainter). The overpopulated rats in John B. Calhoun's experiments still carry an ominous warning for us about the dangers of simple hypercomplexity in social interaction, even when all other problems of living are solved. This would also account for some of our rampant shallowness or superficiality. Toynbee notes that societies that develop expertise in problem solving become incapable of solving new problems by overdeveloping their structures for solving the old ones. Success can be maladaptive, leading to insoluble or wicked problems. Globalization is relatively new. But how well organized is this? Mesarovic distinguishes between undifferentiated growth and organic growth (growth with differentiation, or with a properly controlled balance of subsystems). The former simply follows the opportunistic growth patterns of parasitism and metastasis. We have never had this level of cultural inventiveness or technological savvy, but many of the problems we are now needing to address haven't been seen before (as if we could learn from history anyway). We have, to date, sustained or been able to tolerate our local failures, including those spanning whole continents, but this tolerance has relied on more global support and resilience. It's getting easier now to imagine Africa undergoing a devastating famine with the developed world being far too busy with its own problems to lend the needed aid.

Some might believe that the apex of social order is maximum top-down control, but this is the state of a system about to fail. The healthy social order exhibits maximum devolution, or subsidiary function. Here, no social task needs to be delegated to entities larger than necessary to do the job, while upper levels act primarily as information hubs, or otherwise doing no more than what they do best. Command-type, top-down control is unnecessary in many natural systems, hives being a well-known example of 'fast, cheap and out of control.' The more power that the upper levels exert, the greater the diminishing returns. Authoritarian efforts to force social cohesion amplify the strain. Bureaucratic or legislative gridlock grows, and those who find and legislate the

loopholes and ways around them become a political priesthood. Rigidification and harsh standardization of the social order is a bad sign, an overreaction to growing complexity. It's also incorrect to think that good social order also suggests full assimilation, homogeneity, or monoculture. Cultural diversity functions just fine at global scales. We want individual cultures, as with Richard Norgaard's patchwork coevolutionary quilt. We just need to find better ways to cope with our human "us v. them" dichotomizing, to learn to communicate, arbitrate, and cross-fertilize more effectively, and stop defining ourselves as not being what those other people are.

As a thought experiment, try imagining a global population anywhere close to the current 7.7 billion if we lacked any of the following global sub-systems of civilization, and try mentally to quantify the impact: Air travel (less vital, but contributing); Commerce; Consensual secular ethics (a minimal moral baseline that nations can agree upon); Defense (legitimate, as distinct from militarization for economic reasons); Disaster relief; Education; Electronic media and communication; Fossil fuels (or as replaceable by wind and solar); Fresh water infrastructure (where quality of life is important); Global food distribution; Global governance (with trade agreements and international policing); Industrial agriculture (replaceable with labor-intensive and regenerative practices); Internet (replaceable with snail mail and libraries); Irrigation and water impoundments; Legal institutions and standards of behavior; Manufacture; Medical services (or return to ethnobotany); Medical research; Mining; Peacekeeping forces; Political structure (more often than not more helpful than not); Power grids (replaceable with distributed generation and storage); Property boundaries (with security and enforcement); Roads; Sewage treatment (wherever quality of life is important); Shipping; Technological development; Transportation of goods; Urbanization support networks; and Vocational specialties. Might cities be the first to collapse? How many people do you think would remain?

We begin to see that the infrastructure we've built over many generations, and at great capital expense, temporarily supports our carrying capacity overshoot as much as a resource and capital-rich natural environment. But when the tipping points are reached and systems destabilize, cascade failure will strip away the surplus depth and resilience. The overshoot that was enabled before is left unsupported, leading to a crash in both population and per capita consumption (especially from war, famine, poverty, and disease) in addition to any crash resulting from environmental destabilization alone. The effects might even be comparable in scope. Recovery for any successor civilization, in addition to demanding generations of effort, and now-depleted resources and capital, would be heavily dependent on the conservation of cultural information, continuity in lessons learned, and any truly sustainable prototypes that were being developed prior to and during the crash.

Unfortunately, some of our more destructive cultural systems have learned to support themselves while resisting pressures to play more nicely with the biosphere. Extractive industry funds our environmental resource education. Corporations and their lobbyists purchase politicians on the cheap, deregulate themselves, and even draft whatever legislation they want to have passed. Economic exploitation of the poor does what it can to preserve job and mortgage insecurity, thus maintaining behavioral compliance. Privately-owned media regulate the flow of information to the public. Advertising creates an endless flow of new wants. Durable goods are made to be obsolete. Political party systems narrow the universe of public political discourse to limited false dichotomies. This translates directly into social factionalism and polarization, short-circuiting policy solutions, diplomacy, and compromise.

As a resource, good social order also relies on such intangible currencies as confidence, security, trust, empathy, and charity, all of which will allow us to make

reasoned predictions about the behavior of others and the outcomes of our dealings with them. Confidence underlies our monetary systems, which are no longer backed by anything more real than the public's belief that its nation will eventually be able to pay its debts. The irresponsible accumulation of debt, particularly in unnecessary endeavors like perpetual war, is undermining this confidence. Security is being undermined as the wealthy seek to maintain a level of financial insecurity in the poor, so they will do their jobs at minimum wage and not risk foreclosure or eviction with sassy protests. Insecurity isn't only the purview of terrorism: it's nurtured and cultivated as matter of course by businesses, governments, and religions, that these institutions might be seen to provide the wanted security. Trust is being undermined by parties seeking to keep races, classes, ethnicities, nationalities, and sexes in dynamic tension with each other, in order to feed on the social friction and heat. Charity, at least seen as a proportion of income, is a frequent casualty of socioeconomic stratification, as those taxed for wealth resent those in need of support. The concept of *noblesse oblige* seems all but lost now in all but the most natural aristocrats.

The people have long ago lost their individual sense of agency and sovereignty, and now accept both political impotence and anonymity. They have allowed their governments to claim a higher sovereignty than theirs, and have become convinced that governments and their constitutions are the sources of their rights. Despite the lip service, they think their vote means nothing, and that voting is limited to election day. Cultural inertia and path dependency don't help. People just believe when agencies like DARPA tell them what the future of war will be like, as though they had no power at all to change things. We are back to Margaret Mead's "small group of thoughtful, committed people" if we ever want to get anything done, even if we're running out of time. Hive mind is not a real mind, however much it might get things done, and it has no native conscience.

The close bonds formed in small communities, the tribe and village models of old, and the life to which we are best adapted genetically, continue to be lost or forgotten. We move into neighborhoods where we aren't allowed to choose our neighbors. Our jobs may demand that we change residence at least once or twice. Many of us are either moving up or moving to town or the city. Our exposure to life elsewhere in the world gives us a stronger sense of transiency, a sense that home is now only home for now. We lose our sense of place, our rootedness and belonging. We often lose our native language or forget our indigenous local knowledge, even as we substitute abstracts like patriotism and memberships. Lasting social bonds don't form nearly as well in these conditions. The population numbers at the community level of social organization (128-150, or Dunbar's number) also represent the highest numbers at which true participatory democracy functions, at which every member might feel that they can have a say. In many places, organizing communities of this size, and choosing their members, is now illegal. That sort of community is now a compound, or your gathering is a cult, a threat to the culture. Cultural resistance and nimby attitudes towards experimental lifestyles like ecovillages and intentional communities can discourage the widespread longing to recapture this lifestyle and its benefits. Losing this link, this scale of community, has been a disaster for our larger-scale sense of personal agency. And as we make a needed transition to having more one-child families, we are giving up something important: age diversity in childhood, as we enjoy with older and younger siblings. This is still important to childhood development, and this is challenging enough with our age-segregated public schooling. To compensate, the local community will become still more important.

Adaptive intelligence is measured against a changing niche. The idea that human civilization will need to adapt to deep and inevitable changes in the services that

civilization must provide is gaining some traction and is being called ‘deep adaptation.’ Jem Bendell writes, “We can conceive of resilience of human societies as the capacity to adapt to changing circumstances so as to survive with valued norms and behaviors. Given that analysts are concluding that a social collapse is inevitable, the question becomes: What are the valued norms and behaviors that human societies will wish to maintain as they seek to survive? That highlights how deep adaptation will involve more than ‘resilience.’ It brings us to a second area of this agenda, which I have named ‘relinquishment.’ It involves people and communities letting go of certain assets, behaviors and beliefs where retaining them could make matters worse. Examples include withdrawing from coastlines, shutting down vulnerable industrial facilities, or giving up expectations for certain types of consumption. The third area can be called ‘restoration.’ It involves people and communities rediscovering attitudes and approaches to life and organization that our hydrocarbon-fueled civilization eroded. Examples include re-wilding landscapes, so they provide more ecological benefits and require less management, changing diets back to match the seasons, rediscovering non-electronically powered forms of play, and increased community-level productivity and support.”

And yet, as Lester R. Brown notes, “there is not much evidence of societies mobilizing and making sacrifices to meet gradually worsening conditions that threaten real disaster for future generations.” We seem reluctant to even acknowledge a problem until it has overtaken us with multiple crises. This happens when you can’t see past the next quarterly report or election year. On relinquishment, Tainter argues that “investment in sociopolitical complexity as a problem-solving response reaches a point of diminishing marginal returns.” At this point, he recognizes collapse when a society involuntarily sheds a significant portion of its complexity. Back to earlier squares.

5a. Systems Infrastructure and Systems Failure

Complexity refers to the number, articulation, and functional specification of constituent parts. Complex systems, when healthy, don't always require a center that can fail to hold. Grassroots self-government, with devolution of function and invisible hands, can often manage the thing just fine with only a nominal queen at the center. A federation of states might do little more than coordinate local activities and only be a suzerain for common defense. The queen of a hive need not be fully informed. But health is easy to lose as systems age and their structures ossify, or as they close themselves off to new information and energy. Cultures are seen in failure fairly often, failing in forms like empires, nations, dynasties, and religions. The average lifespan of such entities is only a couple of centuries. So far, none of these failures have ended the world. We had the Muslims of southern Spain to keep the lights on through Europe's dark ages, with enough embers still burning to ignite the Renaissance. The Soviet Union fell and got invaded with economic support instead of enemy armies. We now face the new problem of having become too interconnected and interdependent, which at first blush seems like a good thing. But we haven't seen anything like a global collapse yet.

As cultural systems get more complex, they also grow more dependent on system integrity. The system components, even those "large and in charge," and too big to fail, become increasingly unable to mircomanage the details, even through well-specified chains of command. System integrity is largely a function of fresh information and energy inputs. Chaos is not shut out by closing the system off, by keeping it the same, or by "fixing" it. Further, the individuals trying to function within systems where they're denied both devolution of function and bottom up or grassroots organization necessarily lack the ultracomplex minds needed to solve the complex problems. They're forced instead into tackling one dimension of one problem at a time. The environmentalist trying to turn the culture away from ecocide is stuck in a game of Whack-a-Mole against one corporation or government agency after another. Meanwhile, the top-down decisions are either rooted in corruption or they consist in decision strategies that are formulated for worst-case scenarios and applied generally, regardless of mitigating circumstance, with huge inefficiencies in resource allocation. Situational ethics, a local first resort, gives way to the rule of law, which soon becomes the rule of lawyers.

When a system has grown unable to learn or adapt and begins to fail, its management becomes confused by complexity. Overspecialization doesn't fare well in system collapse. The individuals within it can no longer perform any but the most highly specialized functions. They are forced to re-skill as generalists to manage interconnected problems. Overgeneraliztion doesn't fare well either. The culture that has fully assimilated its subcultures has now lost all of its indigenous ecoliteracy and local-niche knowledge. Lack of vision, scale, or proportion becomes an even bigger issue. Those in power may still seem able to give their power base red herrings enough to keep them occupied, but their power base itself is doomed to the extent that its ignorance is encouraged. Desperately, the system will try to centralize control. In that scramble, those at the top forego all the advantages of system self-organization and devolution. Disorder slips into cascade failure of the integrated systems. And nobody knows how to fix it. As Juvenal remarked, "Already long ago, from when we sold our vote to no man, the People have abdicated our duties; for the People who once upon a time handed out military command, high civil office, legions, everything, now restrains itself and anxiously hopes for just two things: bread and circuses." Rome falls, but this, too, takes more than a day.

Analogies to the 2nd law of thermodynamics have been used historically to discuss the dissipation of limited natural capital like minerals. They can also be used to discuss the costs of maintaining our social order as a population support system. Once again, because some of these assertions have not been prefaced as analogies, critics have been eager to dismiss such expository writing as invalid and unscientific argument (the 2nd Law being strictly about energy) before strutting off smugly believing they've refuted all that's been said. There remains a useful analogy here. Social systems are hampered in their self-maintenance when system boundaries ossify, when energy inputs are restricted, when feedback loops are interrupted or deliberately distorted, and when top-down centralized management wrests control from devolved and grassroots functions. Self-maintenance might fall victim to poor prioritization of tasks: the population is all excited about the next phase of its perpetual war, but ignores its badly deteriorating infrastructure, rotten roads, and corroding bridges. This is the last thing a system wants to deal with when its sexier parts begin to fall apart.

Parkinson's law of triviality, also called bikeshedding, refers to giving a disproportionate weight to trivial considerations, rather than apportioning attention and effort according to an issue's real-world importance or value. A political board or deciding body may devote as much time to the color of a chair as it does to an annual budget. This may point to a failure to delegate, decentralize, or devolve authority to the appropriate level. It's busywork and fussing, instead of triage. Data is treated with too much equality. This is also plaguing our global information system, particularly in the news media and its manipulation of the public opinion with sensationalism, buzzwords, and sound bites. The new royal baby gets a hundred times the media coverage of an ecological disaster or a military screwup that kills thousands.

We shouldn't assume that "good" social order is needed to support a large or growing population, at least temporarily. We have only to look at Sub-Saharan Africa and Bangladesh to see that error. We shouldn't assume that human groups can't survive and grow powerful under despotic and otherwise toxic political and religious systems. Failing states might easily revert from K to r reproductive strategies. But good order does seem to be necessary for the support of a developing population, one with better hopes for a better future. Neither does the oppressiveness or topheaviness of the social order seem to be a short-term factor, since these can often thrive for decades, a generation, even if still short-term. We haven't seen more distant calamities avoided yet, like famine and disease, especially where an otherwise robust global civilization is no longer resilient enough to aid other populations in trouble. We have, however, seen calamities like Stalin's purges and Mao's Great Leap Forward, with their tens of millions of corpses apiece, and been unable to intervene. And the Americans themselves have committed similar atrocities against their own indigenous tribes and the slaves imported from Africa. It's now beginning to look like the developed world may soon be too busy with its own problems to help others in need. For our purposes here, we need to enumerate some of the functions of global civilization that might threaten a global population in overshoot, or one undergoing extreme changes in climate and the natural environment.

5b. Economic Order and Toxic Paradigms

It's interesting, in a scary way, how the worth of things in life comes to us already assigned by others. Worth is thought of as given or found, not made or taken. It's interesting, too, how the terms used in economics derive from things that should be more important than material gain. It's easy to find better uses for words like: appraisal, appreciation, appropriate, assessment, balance, charity, contribution, credit, economy, endowment, enrichment, enterprise, equity, fortune, indebtedness, inheritance, interest, legacy, leverage, liquidity, pledge, precious, premium, proceeds, purchase, realize, redeem, reserve, resource, reward, richness, right, security, solvency, speculate, treasure, trust, value, venture, and wealth. Sometimes the parts of speech can change: the words prize, trust, treasure, and value, for instance, work better as verbs, and more to our benefit. Every one of these words from economics refers to something we can get or do for free: they hold the keys to being rich, satisfied, and grateful, without spending much money, or working hard at anything besides our own attitudes. How did this get so twisted? A true economy should meet needs, not create them. Can't we take back our control of value and need? And isn't time worth more than money? Doesn't it make more sense to value all forms of capital, natural, biological, and human, with its components of time, labor, and leisure, with as much care as we value money?

The more we monetize the world, the more it seems like we have added to its value. Of course that's all within the fantasy world of our human exceptionalism. Perversely, though, there is much of real value that we have failed to monetize, like the housewife's housework and the chores of motherhood. Quality of life and ecosystem health have also escaped much due valuation. We also seem disproportionately drawn to the shiny things, while the less sexy necessities languish, roads and bridges deteriorate until they start eating cars and people. The slower development of human capital, like quality education, tends to drop lower on the list of priorities because returns aren't seen to be immediate.

Despite decades of growing opposition, GDP and GNP are still in use as primary measures of development, and even of national happiness. G stands for gross. It's all about quantity and nothing to do with quality. It includes prices we pay for all of the things we don't want. The broken window fallacy, an idea introduced by Frederic Bastiat in 1850, asserts that gross economic activity is wrongly seen as a better measure of prosperity than measures of net activity that subtract such things as damage repair, forgone opportunity costs, the health care costs of environmental damage, cancer cures necessitated by pollution, and inflated prices from long-term resource depletion. Perpetual war and toxic sludge are regarded economic goods. But these unintended negative consequences will affect the economy in ways that aren't seen or accounted. Weizsäcker writes of an alternative, the Genuine Progress Indicator (GPI), which "starts with personal consumption expenditures (a major component of GDP) but adjusts it using about 25 different components, including income distribution, loss of leisure time, costs of family breakdown, unemployment and other negative outcomes like crime and pollution; depletion of natural resources; as well as the numerous environmental costs of GDP growth, such as loss of wetlands, farmlands, forests and ozone, and long-term damage such as climate change. GPI also adds positive components left out of GDP, including the benefits of volunteering and household work."

Money began as pretty useful stuff. It simplified exchanges of goods and services. Supply and demand managed the pricing. You could store wealth without having it rot. You could secure it in mattresses and banks. You could accumulate some, to keep life

going over the rough patches and failed crops.You could take advantage of local fluctuations in product prices.Then we started to borrow at interest, with the usurers taking what rents they could, based on the expected usefulness of the money borrowed. Then it got too easy to live on credit. The primary use of credit now seems to be to live beyond our means, to get ahead of ourselves. Living within our means seems to have become an insult to our hopes and dreams. But we rarely catch up to our big appetites. Our habit is of course to give ourselves more credit than we deserve. As perpetual optimists, we discount the costs of our futures because tomorrow will be so much better, so much closer to living the dream. This, in its turn, leaves us insecure about our collateralized equity. We then need to behave ourselves, to toe whatever lines are drawn before us, so that we don't fall into bankruptcy and ruination, and lose all of the stuff we have worked so hard to purchase. Now we have moved from an empty world into a full one, to fight for what remains, but first come, first served is the first rule of order. We rarely think about how our discounted posterity will think about us. It's probably safe to assume that they won't be reviving ancestor worship.

Similarly to money, capitalism started out a lot more benign that it was to become. It was fair that your money did some of the work for you. It created some jobs for others. And some of that really did trickle down through your workers' pockets before it found its way back to your own. Labor eventually got a full complement of rights to organize, however tightfisted management and governments might be about that. Free-market,*laissez faire* economics and unregulated trade only brought a few problems to solve along with it. It did, however, lack any native means to incorporate external costs to the commons and unintended consequences into the price of goods and services. Too few governments figured out the wisdom in taxing only what they didn't want, to cover these costs, even though diminishing the things we don't want is the very purpose of government, at least from the people's side of things. Most of the voting population seems to believe that the economic system that this has evolved into is similar to free market capitalism, although some may suspect that the system is rigged and not free at all. In fact, it's largely owned by non-living corporations, which have somehow now gained a political sovereignty greater in many places than that of citizens, and without any need to demonstrate any conscience greater than a duty to shareholders to show profit. Gone are most restraints on rents and usury. Transnational corporations are now given more enforcement clout on trade than nations. These corporate "persons" now write much of the legislation that they want, and openly pay the legislators to pass it. Capital counts more than votes and it has unrestricted mobility through the deregulated banks. We have grossly confused *laissez faire*, free market economics with deregulated corporate capitalism and its wholly-owned legislatures rigging the system. The transition has been long in the making, but the strongest footholds were found in the early 70s (not in the Reagan era as many will claim). The signal flare in the US was the Powell Memorandum of 1971 but the movement soon went global.

Pyramid and Ponzi economics present their own set of problems, especially with regard to pressures for population and economic growth. These systems promise only failure when there are fewer payers on the next level down, the downstream generations, on what's supposed to look like a demographic pyramid. What was supposed to be a demographic dividend, with a large working-age group, becomes an aging deficit, a burden on the shrinking younger generations. Where will we get our armed forces (since we're just too stupid to swap war for diplomacy, or learn to depose our own tyrants)? Will we need to hire immigrants or ban condoms? Social Security in the US didn't have to look like it does, had the people the sense to push for population

stabilization. But it had to "borrow" the surplus, which is actually theft if you never really planned to pay it back. Not paying it back would have no impact on the budget.

Debts can be played with linguistically, too: you can convince people that these big promises are just "unfunded liabilities," kept in a separate column altogether. Bad bookkeeping, hidden subsidies, and twisted terms now run throughout this system of credit. Maybe we think we can print our way out of trouble, because it's all in our minds anyway. But other, harsher bills come due, with collectors who will take more than kneecaps. There really is only one final response to Ponzi schemes and their analogs: you have to amputate the gangrenous part, and the sooner the better. And then don't do that stupid thing ever again. Grade school arithmetic should tell us that we can't have unlimited growth on a limited world. The ecosystem that we need to live within is a steady state economy, but we don't want to learn this. Yes, it has income, like sunlight, but life stays on budget or else. The worst consequence of all this, as it now pertains to the human problem, is in the need for increasing generations of our younger descendants to pay our bills for us. Unthinking governments and economists with no time horizons lobby hard for the elimination of family planning efforts and even push incentives to breed beyond replacement levels. Failing this, they may next turn to deregulated immigration as a next resort. In short, our economic forces have gone to war against our adaptive intelligence.

Much of the developed world today is built up on entrenched economic strategies and their institutions. Since the bulk of this is now founded on the confidence that we can pay down our debts some day, the structure looks much like a house of cards, or an imposing murmuration of kited rubber checks. The economy is built on confidence in bubbles and the vapor that fills them, less hinged than ever to realities and consequences. Whatever you do, don't panic: that's like heresy or sacrilege. That puts cracks in the system. The "green" economists are working now to capture the prevailing system and train it to do more sustainable tasks. We can somehow turn this pro-growth corporate capitalist economy into a friend of the Earth without changing its fundamental dynamics in ways that make it unrecognizable. But sadly, that economy has to be changed by the people who are causing the problems, and the legislators they lobby. The corporate capitalists want to monetize even the commons, in order to regulate them. But this is different from seeing the intrinsic value of the commons, and the external costs of their destruction. The consensus seems to be that the system is too big to fail and too big to fight. Even the medium-sized portions of it, like a big bank or insurance company, must be protected from failure, at the public expense. It's like we never learned a single thing from the concept of natural selection. With our subsidies and tariffs, we stick out our "invisible foot" and trip the whole thing up.

The original free market economic system might have left us in much better shape, had we been able to deny rights to non-living entities, forbid the purchase of legislative votes, constrain the creation of artificial needs, and incorporate all long-term external costs into consumer pricing. We needed timely and accurate feedback for the system to work as it should. We could have used subsidies and tariffs for good. Now it may be that the whole system has to crash, with the loss of any wealth not bound to something real, plus the inflated wealth in whatever is, the vapor. This economic system has to die if civilization is to survive. At the very least, it will need to return to the simpler origins of economy, back when it used to mean thrift, and the conscientious allocation of resources. Growth and sustainability, or economic expansion and a steady state economy, are not reconcilable. This collapse might not be so bad if we did something to plan for it, and had some sound ideas for substitutes in mind. But this is not our way. Our vision seems to be one of hindsight, deployed only in mid-crisis. Even so, a collapsing economy will at least assist in reducing our numbers.

Under the current system, any supply will become more vulnerable as its limits are approached, whether this is a renewable resource or natural capital. Rising prices promise rising profits, prompting more extensive exploration and exploitation. Since the same is achievable with artificial scarcity, this occurs as well. Eventually, diminishing returns puts a stop to this, but only because lasting damage is done. This is another reason to internalize all real costs into the pricing of goods and service, even through trade agreements. Logically, this could be a source of government revenue, taxing what you don't want, and not taxing what you do. Environmental protections can be sources of revenue instead of barriers to trade. Starting economics over will mean learning to build wealth on capital collateral and specie instead of fiat, confidence, and indebtedness. It will mean forbidding ourselves to treat the extraction or exploitation of natural capital as any kind of income. It will mean internalizing all of our real costs, articulating embedded or embodied minerals, energy, labor, time, and water. It will mean reigning in the creation of artificial needs and wants, the cultivation of insecurity, and pressures for competitive conspicuous consumption from economic and political entities. It will mean weighing cradle-to-cradle costs and value, in a circular economy, with nearly complete recycling, reuse, and remanufacturing, justifying greater initial expense on more durable and maintenance-free systems, and turning our waste into resources. It will mean robustly progressive luxury taxes on excessive lifestyles, following a clear definition of excessive. It will mean revisioning development as something quite other than growth, such as improvement in the quality of life. A reboot that neglects these lessons will fail just like this last false start.

Economic growth must give way to a form of economic development that is qualitative instead of quantitative. The goal of severing the link between economic growth and its impacts is called "decoupling." This word is used freely to imply that growth can still be quantitative. But growth must give way to the more modest idea of development, and an implication that this also means degrowth. This begins with some redistribution of global wealth and resources, constraining the great excesses and eliminating both extreme and moderate poverty. Not only can't this be accomplished under our current numbers, it will necessitate a still deeper cut in what we think our sustainable numbers can be. This goes against the trend noted by Malthus, to wit,that mankind has a propensity to utilize his abundance for population growth rather than for maintaining a high standard of living.

5c. Inequalities of Opportunities, and Outcomes

"We cannot possibly expect to exclude riches and poverty from society, yet if we could find out a mode of government by which the numbers in the extreme regions would be lessened and the numbers in the middle regions increased, it would be undoubtedly our duty to adopt it" (Thomas Malthus).

We don't need to make all incomes equal, but we do want to generate a rising standard of living for the world's poorest and at least disincentivize the ridiculous excesses of the very rich. "Sustainable development requires the satisfaction of the basic needs of all, since endemic poverty can lead to ecological or other types of catastrophes" (Morandín-Ahuerma). Inequity, or socioeconomic stratification, has been a big part of our social organization since we were swinging through the trees. A great many of our evolved social heuristics concern our relative status in the troop or tribe, and very few have to do with how equal we are to everyone else. This is why it's so hard to put a few limits on the distance between the haves and have-nots, now that we so desperately need to do this. This stratification has done its part in collapsing a few civilizations before this one. Historically, this trend does not reverse of its own accord. It ends with revolution, collapse, or a failed revolution triggering collapse. This one is already either approaching or exceeding that extreme degree that helped trigger historical crashes.

Throughout history, stratification for any reason has been confused with questions of merit and demerit. Sometimes this is seen as one's class of breeding instead of an accident of birth, and sometimes it's past-life karma standing in for retributive justice. Such rules or laws of merit always flatter the well-to-do and ease their conscience some. In too many cases, aristocracy is confused with meritocracy. The have-nots have rarely stood a chance to truly rise high in the order, although there are enough exceptions to warrant more study than this is given. However, when low socioeconomic status means levels of childhood adversity known to harm cognitive and neurological development, it becomes what should be regarded as criminal abuse or neglect on the part of the society.

Equality of rights and opportunities is something quite a bit different from equality of outcomes. This means that everybody has a chance to test or prove themselves, regardless of any economic, racial, or ethnic handicaps of birth. Who should win at life becomes a question of talent and character, and not the accumulations of one's parents. Character both is and should be destiny, or at least humanity benefits greatly when this is the case. An equitable society need not be the same as an egalitarian one. If you want something, you should be able to work for it. When you're made to work unreasonably long and hard hours, sometimes able to go nowhere, there is a real problem. And when what you want is unreasonably more than any person should need to live a good life, you also have a problem. As to outcomes, there is much to be said against everybody being either considered or made equal. An absolute equality is neither real nor desirable, but we might work to constrain the gaps to within an order of magnitude and use progressive taxation to more fully mitigate the external environmental costs of luxury and excess. There's also a somewhat separate issue, only part moral, that looks at defining an economic floor, a basic level of needs satisfaction, rights, and opportunities, to which every human being ought to be entitled, a fair start instead of a handicap. As used here, this isn't the same as a "universal basic income," since labor or training would be a prerequisite. This is the subject of Chapter 9, The Dimension of Living Standards and Development, and is only touched upon here.

Globally, the greatest inequities of income and material well-being are little more than accidents in the geography or demography of birth. These accidents are also the

bars on the juvenile cognitive playpens of racism, caste, class, sexism, patriotism, and the one true religion. We do not earn or deserve these titles, until we show too little character to question them. But we also need an education to question them properly, and not a limited education designed to prepare a working class for servitude. With these walls we build between us, we neglect and oppose our own human resources and capital. We are only making diminished use of our labor, hours, skills, and cultural knowledge. This is the real argument for more equity in the distribution of well-being: we do grievous harm to our own collective potential.

Racial inequity is most problematic when it carries an entrenched exploiter-exploited relationship, where wages can be depressed below subsistence levels to feed the ridiculously rich at the top. Class or caste of birth will usually drive both exposure to childhood adversity and a chance for a quality education, although paradoxically, conditions of low birth may also be more stimulus rich, more social, age diverse, and multilingual. The ripples from misogyny extend even further, as women raise the children they send into the world. The global suppression and control of women is among the most horrifying of all the dark deeds we do. Aside from the obvious, like honor killings, genital mutilation, rape, and sex trafficking, denying women freedom of movement, a good education, and reproductive rights adds a huge burden to our world's carrying capacity. The big losers are the children, who become tomorrow's adults, carrying with them the long-term effects of their childhood adversity, poor nutrition, poor hygiene and sanitation, and poor education. And there is almost nowhere for the illiterate and innumerate to go.

Currently, our high levels of socioeconomic stratification are linked closely to our overconsumption of renewable resources and natural capital, and the environmental effects are highly disproportionate, even where demographic transition shows the well-to-do having smaller families. Again, the strands of overpopulation and overconsumption cannot be teased apart, and all of the strands of that braid need to be addressed at the same time, and rendered less damaging, until we fall below carrying capacity again. The surplus of wealth in the hands of the few is probably enough today that distributing this fairly, or at least equitably, across the global population might alleviate much of our social stress. But this is only myopic thinking. We would still be in extreme overshoot. The hungry would be fed for a while, but the resources and capital would be consumed. A truly visionary solution to spreading the wealth would have to also combine such pieces as family planning, real education, training in regenerative agriculture, and cultural support for simple living.

In terms of justifying destratification, it's important to start remembering what's at stake here: the future of human civilization and much of the future of the natural world. The moral issues of human rights and fairness might even be regarded a lesser issue relative to the fate of the world at large. Heavy costs need to be imposed on extravagant, conspicuous, and unnecessary impacts, reflecting the real external costs of luxury and abundance to the commons. This cannot continue to be subsidized. We will need to decide soon on any ethical limits set over and above real costs. We need a consensual, secular ethic that will append our rights with a corresponding set of duties.

So far, the redistribution of income has only been a local solution, at most continent-wide. And it hasn't always been a roaring success. Still, the stock or standard solution to reducing the extremity of stratification will be some form of progressive taxation. There are basic tax exemptions for those barely squeaking by, although there are enough taxes embedded in even the most basic goods and services, amounting to several slices of each loaf of bread, enough perhaps to cover a poor person's minimal impacts. As we rise in multiples of what resources we truly need, the burden grows progressively heavier. With a better system than this, we might calculate footprint

rather than income, so that it's more truly our excesses that we are paying so dearly for. With a more perfect system, however, prices would reflect total impacts, and use taxes would take us most of the way to our goals. Use taxes are preeminently fair, but they could entail rebates, a standard deduction, for our necessary expenses in meting the most basic needs. What is taken off the top should be spent in ways to help those on the bottom to better meet their needs. This, of course, will cause resentment enough to warrant that those receiving assistance at least perform fair due diligence in working for their aid, or getting vocational training. There is no need to hand people a living where they can get fair recompense for honest work. Heavier costs can be imposed on unreasonably extravagant and conspicuous impacts, reflecting the real external costs of luxury and abundance to both the social fabric and the biosphere. This can't continue to be subsidized. And we will need to decide on more absolute ethical limits over and above real costs.

We treat economics like a game, with affluence as winning, and poverty as losing. And yet in sports we have rules against cheating. The main point of playing on a level field is to show us who really has the merit, who deserves to win. It's unsportsmanlike, and usually illegal, to violate this. We would be well-served with a similar set of rules for our livelihoods, a bill of duties to accompany our bill of rights.

5d. Political Insecurity, Migrants and Refugees

Social order is a true environmental support system, allowing significantly larger human populations. As already suggested, this order can be less than ideal, even despotic, and continue in this way for a couple of decades until it necessarily self-destructs. Also, a deteriorating social order can trigger a reversion to r-strategy reproduction (having more spare babies). While still allowing human population growth, neither of these contribute much to human development, so larger populations lead lower quality lives. Eventually this harms the environment, because it's lived in with greater ignorance, which in turn will lead to depopulation. Our concern here, though, is with the effects of political destabilization and collapse. What happens when global diplomacy, commerce, and infrastructure start to break down?

Steven Pinker's work on *The Better Angels of Our Nature* tracks a long-term decline in violence as human and global society self-organizes or knits itself together. He also shows how the media helps keep us be blind to this by focusing on the bad news. Things have indeed been getting better in terms of per capita violence. But this is a look back, not much of a look into the future, and it doesn't account for destabilization and collapse of the organization that allows us to parasitize the world. His optimism won't allow him to see this coming. In fact, very few of our optimists, who've remained confident in our short-term planning, our band-aid solutions, and our technological wizardry, will ever see this coming.

The wars we have seen to date still haven't done has much as disease in keeping our numbers in check. All of the fallen soldiers of the 20th century combined, and added to triple that number in war's civilian casualties, barely made up for two years of late-century population growth. Perpetual war has added much to human misery, and taken much from our development, but it still hasn't done enough to convince a blind majority that it's too idiotic an endeavor to be worth pursuing. The environmental footprints of rebuilding infrastructure after our wars are expected to keep growing, but this still isn't waking us up. Overall, the human "us-versus-them"mentality is still a big contributor to weakened human development. Nationalism still has more weight in our decisions than our growing interdependence. And so much of this us-them nonsense is founded on evolved neurological substrata. Any solutions will require a much better understanding of who and what we are as primates. And that will be over the objections of most of the world's"great"religions, especially the Abrahamic. Our 14,000-plus nuclear warheads (as of mid-2018) still retain some significant potential for more rapid depopulation, and we still have fools standing guard at those buttons with launch codes. A whole generation of frightened children playing duck-and-cover through grade school, to the tune of practice air-raid sirens, still lacked the will to stop this insanity. We are not a wise species.

The need to maintain the infrastructure in good working order is too soon forgotten by the shortsighted civilizations. It's just not as sexy as the next shiny thing. Hyperbolic discounting has them looking the wrong way through the futurescope. "That will take care of itself when the time comes. We'll fix that bridge when we get to it, but right now we need this war." By the time things start to fall apart, capital and resources are too compromised to fix anything. Maybe the most important part of our overall infrastructure is the system we use to educate our children, to provide them with any skills they might need, and ourselves with human capital. This is suffering as much disrepair as our corroding bridges and utility infrastructure. Should the economy crash, the neglect of basic infrastructure maintenance could be our first great regret, since this provides an important resilience buffer. We don't want rebuilding what we

never should have lost to be among our highest priorities, especially with compromised resources and capital.

Issues of migration (globally) and immigration (locally and nationally) are confused somewhat when we fail to articulate the different varieties or drivers. These differences call for different responses. Sometimes these are divided into two categories, as push and pull migration, clarifying whether those on the move are driven or drawn to new locations. Those who are driven or pushed from their homes are refugees, those who are drawn are simply migrants wanting to be immigrants.

The primary drivers of refugees are political conflict, political repression, corruption, gang activity, racial intolerance, gender abuse, ethnic intolerance, religious extremism, grinding or extreme poverty,water shortages, drought, famine, and other anthropogenic environmental degradations. The Geneva Convention (1951)is somewhat more limited, but more official in terms of obtaining entry visas: a refugee is a person who, "owing to well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable or, owing to such fear, is unwilling to avail himself of the protection of that country; or who, not having a nationality and being outside the country of his former habitual residence as a result of such events, is unable or, owing to such fear, is unwilling to return to it." These may be regarded as asylum seekers. Fear must be well-founded: you will be executed, imprisoned, raped, or beaten nearly to death. Today there are over 12 million refugees, and already they are dying in real numbers for a lack of welcome in new homes, or they are stuck in limbo for years in camps, in adequate tents if they're lucky. It's safe to say that this is only the beginning.

The US and its European allies create a special class of refugee, fleeing from military interventions, escalations of armaments, regime changes, and drug war activities, notably in the Mideast (especially after 1918) and Central and South America (especially after 1954). Refugee problems are exacerbated by nations like the US destabilizing other governments and feeding organized crime with draconian drug laws that drive the black market and build the drug cartels. And it's a clear indictment of their lack of collective cognitive and emotional maturity that they are unable to own their role in the creation of this class of refugees. In a just world, this would strip these nations of any prerogative to turn these displaced people away at their borders.

The primary migratory draws are family ties, economic opportunities, educational opportunities, and religious freedom. Movement for reasons of economic displacement, as by land conversion, mining and timber production, or even by gentrification and prosperity, might be in a middle zone between migrants and refugees. Family ties are often already provided for in constitutional and legislative provisions for chain migrations and "anchor babies." Beyond these, we have broader discretion. Here, even the globally awakened, who already know that we are all one species sharing his world, may have to allow that local populations and nations should have some prerogative and say over who enters their society, and accordingly set immigration standards. [We should never say that this is a sovereign nation's right, because a nation is a non-living corporation, authorized by its sovereign individuals, and nations have delegated powers, not rights]. Surely it's good to have free peoples moving freely around. But there are serious constraints that we need to start facing. Where we have migrants simply seeking better lives, it becomes a lot more morally acceptable to demand they submit to or comply with national standards. We ought to remember that migration will demand economic and physical infrastructure. Immigration is a sensitive subject, for liberals and conservatives alike, although for different reasons. The liberals and the Greens don't look closely enough at the carrying capacity impacts. Immigration standards may be seen as racist or xenophobic. Conservatives, despite any

racism or xenophobia, may want to open up to selected classes of migrants or immigrants to compensate for demographic decline, while making use of unused infrastructure and abandoned housing. They may have to overcome their diversity, multiculturalism, melting pot, and assimilation issues. The economists who are so easily frightened by threats to the Ponzi economy may want to fling open gates wider than they should be flung, at least after failing to encourage declining populations to step up the breeding efforts.

Some confusion arises when we don't distinguish between the global and local points of view. We must come to understand that it does the future world no good at all to let the exploding populations in one part of the world simply move freely to other parts that have now achieved declining fertility rates. We really need to practice some tough love here, so that burgeoning populations eventually learn to accept responsibility for same. We have some options here that aren't really coercive, like tying international aid to provision of family planning programs. The religious fanatics will resist that, though. We could do more to help improve living standards in places that produce these migrants, starting with schools and skills. For any nation in local carrying capacity overshoot (nearly all of them), immigration could still be welcome, but should to be managed to maintain a net rate of population reduction. The UK's Green Party declares, somewhat myopically, "richer regions and communities do not have the right to use migration controls to protect their privileges from others." Despite any moral issues we might have with rights of first possession, this show a nearly complete obliviousness to carrying capacity issues, which in turn shows an ignorance of ecological issues, and so-called Greens should be ashamed of themselves for this. Recall that this work regards Humanism as something of a problem, especially where it drifts recklessly into human exceptionalism. There is much more to this world than our cosmopolitan human brotherhood, and much of it is in trouble.

So far, failed states have largely remained local events, with their warlords, gang battles, and conscripted child soldiers. But the numbers of political refugees aren't going away, or shrinking any time soon. If these people ever find a home outside of the tent encampments, their resettlement is going to require infrastructure and housing, and all of the capital and resource costs that go along with that. They won't need any less food, and of course they will need paying jobs. That's while all for their former infrastructure settles into ruin, and their former investments in capital and resources vanish, or all of that just gets bombed into ever-smaller bits, because transnational corporations need to sell more bombers and bombs. The social order that was barely able to maintain civility between rival ethnic, racial, and religious populations seldom needs to be weakened by much for the open conflicts to commence, and amidst a social collapse there may be no greater forces at hand to pacify them.

We don't know yet how displacement for political reasons will compare with displacement for environmental reasons. But that race is underway now. There will be both skirmishes and larger scale wars over resources like habitable climate, water, and arable land. It doesn't seem to be commonly grasped that China's greatest rivers have their headwaters in Tibet and its glaciers. We'll just put that out there and let the reader ponder the real motives for that conquest. Nations rendered agriculturally diminished by climate change will be pressed to do something about about finding better homes in greener valleys. We're running pretty low on greener valleys. We're running low on any color *lebensraum*, except the lands we've ruined or turned into desert. Populations facing widespread death by famine will first have to beg for relief from the rest of the world, but once failing agricultural production threatens hunger in the rest of the world, that relief won't be so forthcoming. They won't have the energy to march on their neighbors, so there may be no resource wars there. But prior to that, there could be a

lot of climate refugees looking for somewhere to go. An increase in natural weather disasters will have a similar effect. Yet even all of this suffering won't prevent refugees from having sex in their refugee tents, without the benefits of contraception, something to reassert their humanity and make some of the pain go away for a while. Ultimately we will likely see a lot of poleward migration, onto poorer soils, but following better climate. What percentage of the human population will one day be on the move like this is anybody's guess.

6. The Dimension of Sustainability and Honest Accounting

The human exceptionalism strand of our human parasitism has us lying to ourselves a great deal about the meaning of the word sustainable. We do have a semi-official, stock definition of sustainable development as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." (Bruntland UN Commission Report on Environment and Development, 1987). This also calls it "a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs [note that] and aspirations." And a few years later, "Caring for the Earth: A Strategy for Sustainable Living" (International Union for Conservation of Nature and Natural Resources, 1991), defined sustainable development as "improving the quality of human life while living within the carrying capacity of supporting ecosystems." We should note that the term "sustainable development" is also known as "weak sustainability" because it considers economic growth to be indispensable. Strong sustainability would have to be explicitly qualitative as well, and not threaten to exceed planetary limits. We have more definitions, but none really show much care or direct concern for the quality of life of other species, or maintenance of their populations. Most conceptions will still tend to confuse our development with extended growth in finite systems. Most still consider the system of human economics as running parallel to the natural ecosystem, and somewhat independent, rather than as a vulnerable subsystem.

It may be generally recognized that the word sustainable means "for a long time," but how good is our vision into deep time? "Indefinite" means smaller things to smaller minds. We will tend to look at things small-mindedly and shortsightedly, in ways that serve our immediate goals, in ways that flatter us for our accomplishments and overlook our shortcomings. But this word is used here more honestly, not in the greenwashing sense that humans are currently using to mass-market green products. It's not a weasel word or a marketing buzzword. Sustainable activity has indefinite longevity. The behavior can be sustained indefinitely, for millennia if necessary, while an unsustainable activity simply can't be continued long-term, period, and so must eventually end. The success of any non-sustainable program or script is necessarily temporary, as unsustainable behavior must by definition extinguish itself. However, the time frames that frame the unsustainable behavior can extend beyond any perceived horizons, so that fatal consequences can remain unseen by the near- and shortsighted. Perhaps most of our present human behavior is unsustainable, at least at our current population levels and the intensity of our consumptive activities. A sustainable activity must necessarily respect the conditions and supporting systems that sustain it. Sustain is not the same word as continue. The wino will continue to drink his gallon of wine a day; our government will continue to bankrupt our grandchildren. Neither of these can be kept up forever. Accounts must come due. Hitting bottom and a need for complete reorganization is the consequence.

Etymologically, the word sustain means to hold up from below, to provide a basis, ground, or the necessary preconditions. The extinction of a behavior, or a life form, thus defines the boundaries of the sustainable. This means that if an activity is relying on non-renewable natural capital, then all of this finite capital must eventually be recycled, or replaced with sustainable substitutes, not merely a token percentage of them to make our guilt go away. Or we must find a way to live without it. We must put

it out of our minds that industries hungrily extracting natural capital are sources of new wealth or income. In current use, the term is a rubber check. Economists still speak of the need for sustained growth in finite contexts. Corporate public relations will even speak of sustainable petrochemistry. Congress, with industry encouragement, turned the phrase "sustainable yield" into "sustained yield," thus making it easy for the US Forest Service (with its timber-industry educations) to reinterpret this phrase as "a non-diminishing flow of commodity outputs."

Our habit of using this word so loosely is also tied to our habits of cooking our books and making our grand plans and ideas look pretty in order to sell them. Visionaries, progressives, and greens alike may pat themselves on their backs for doing the "sustainable behavior" that's in fact little more than 20% less unsustainable. This often applies to so-called "green" building materials, which might represent only enough of a reduction in embedded or embodied elements to ease a shallow conscience. An electric automobile has a mining and manufacturing footprint that isn't that different from an IC auto. Honest life-cycle cost accounting will examine all of the embodied water, energy, and materials in the manufacture, operation, maintenance, and replacement of new green technologies, as well as convert natural capital waste streams into new inputs. Mining must be done to build and ultimately replace windmills. When we deceive ourselves about this, we are raising the bar just high enough to trip over. Sustainable limits are what ultimately drive long-term carrying capacity. It's important to understand that this still-indeterminate number, however it's measured and whatever its value may be, is continually decreasing over time, especially during times spent in overshoot, due to the consumption of irreplaceable natural capital. This was pointed out in detail by both Nicholas Georgescu-Roegen and Herman Daly. There is one important distinction between human population dynamics and those of plants, fungi, and animals: the latter don't really consume natural capital. They use resources, a usufruct.

We can too easily ruin something wonderful forever out of our misplaced devotion to short-term ephemera, like nations and dynasties. There is a "seven generations" social and environmental ethic, said to come from the founding law of the Iroquois federation. This states "The Lords of the Confederacy of the Five Nations shall be mentors of the people for all time. The thickness of their skin shall be seven spans." Nietzsche also spoke of time as a skin when looking ahead in time: "Live unknowing of that which your age deems most important. Lay between yourself and today at least the skin of three centuries" (The Joyful Wisdom). Oren Lyons, Chief of the Onondaga Nation, writes in American Indian Environments: "We are looking ahead, as is one of the first mandates given us as chiefs, to make sure and to make every decision that we make relate to the welfare and well-being of the seventh generation to come. ... What about the seventh generation? Where are you taking them? What will they have?" This is without question a far better approach to the issue of true long-term sustainability than the modern abuse of the term. At least it has a 140-year reach. While this idea has plenty of merit, the order of magnitude is no longer sufficient to envision all of the long-term consequences of our misbehavior. Extinction is forever, and warrants a longer, even more serious look. It's serious like a heart attack or your house on fire. To sustain means to uphold from below, to maintain the ground we stand on, the same system that permits our emergence as a species. This view will require either deeper time horizons or else enough of a population crash to get this lesson across and leave us humbled out of our exceptionalism.

Both the United States and the industrial revolution have already managed to survive for more than seven generations, while seven more generations of "more" is looking extremely unlikely. Seven generations may be a good first look, test, or stretch, but I

would submit that sustainable should not refer to less than a ten-thousand year time horizon. We will also need to outgrow our cognitive playpens of patriotism and nationalism, to start regarding ourselves as Terrans. Then, if we still need to identify a group that is “not us“ in order to cohere socially, we might turn our dissatisfactions on those among us who are killing our grandchildren’s world. Personally, I’ve settled on a ten-millennia frame of reference for four reasons: 1) It’s close to the age of civilization as we know it, and so it calls into question the manner in which we feed, clothe, shelter, breed, govern, and even bury ourselves. 2) It’s the average age of a sere, the average span of the progress of an ecological niche from lifeless mineral to climax ecosystem, during which the physical niche itself adapts to the life that inhabits it. 3) It’s roughly the average half-life of our toxic waste, or perhaps an average recovery period for our biosphere, time needed to rebuild the topsoil and recharge the great aquifers. And 4) It’s the period during which, under the relatively benign stewardship of Native Americans, more than half of the species of North American megafauna went extinct.

We have a few perceptual and measurement problems when we try to look at big pictures, even aside from those of time horizons, frames, and scales. Discounting the future is a big one. We're so used to second-comings and other apocalypses never coming true that real disasters usually take us by surprise. Our management efforts begin in mid-crisis instead of before the beginning. We tend to ignore the out-of-sight-out-of-mind externalities. We will look at hydrocarbons as a vastly more efficient energy source because we aren’t looking at the long-term consequences of their use. But at the same time, the costs of renewable energy are huge, and not merely in the transition into them where petroleum is used to manufacture and transport windmills. With some technologies, renewables might be less efficient by an order of magnitude. Batteries, which require eventual replacement, have enormous environmental footprints. Restraint, economy, and efficiency, or “negawatts,” to use Amory Lovins’ useful term, have by far the biggest energy payoff. When change starts to accelerate in earnest, we may turn to a shifting or sliding baseline that moves forward in time past many previous changes. This may diminish our perception of how much has really changed. It requires culture and a learning curve to keep all of these subtleties in mind as we’re consuming this world. This is another reason why use taxes on commodities can incorporate external costs in proportion to their use, will pay these costs as we go, and will keep these real costs in front of us, that we might more intelligently decide if we really want to pay them. Standard deductions or rebates can always be used to proportionately reward conservative use and efficiency.

Trying out and combining different perspectives, and moving frames of reference around to get more complete pictures, are not cognitive skills that the majority of us are notable for. But we need to add at least a couple more than we are collectively using. We need start doing more honest accounting than what we’re used to performing, with true life-cycle costs and cradle-to-cradle planning, a closer examination of total embodied resources and capital throughout the life-cycles of everything we use. Management of this will be easier and more self-governing when actual costs are reflected in consumer pricing, instead of being actively subsidized by our corrupt, corporation-run governments, as most are now. Subsidies still must be paid, by the taxpayers, by the commons, or by future generations. They should directly burden the consumer instead. Scarcity is valuable information and shouldn’t be hidden from view or removed from prices paid. The politicians who are currently championing free markets have no clue what free markets are: they have this completely confused with deregulated corporate capitalism. But free markets, reflecting true supply and demand, can only move us halfway in the right direction. We also need to internalize

all of the environmental and other external costs to the commons into commodity pricing. And even then, we still need find ways to prevent the rising of prices due to scarcity from leading to the accelerated exploitation of diminished capital and resources flows. The word resource needs rethinking in popular dialog, as the prefix ”re-” suggests that this is a source that we can keep coming back to, and thus should apply only to true renewables used at safe levels.

7. The Dimension of Remediation and Restoration

Time horizons are the most neglected factor in our planning calculations. We fail to divine the accumulation of long-term impacts and depletions out of some bottomless optimism about our adaptive intelligence. We'll burn those bridges when we cross them. We won't appreciate something important until it's going, going, or gone. But many of the lands or environments that we've damaged or destroyed still lend themselves to programs of remediation and restoration. Little of the long-term damages that we have already inflicted are truly permanent in deep time, except for irreversible extinctions. Earth and life itself will survive us, with temporarily diminished biodiversity and some unpleasant climate extremes. What's a million years, give or take, to life itself? Considering how much of this world we have ruined in ways that will take far more than a human lifetime to repair, we need to consider restoration of these damaged lands as an important factor in recovering some of Earth's carrying capacity. Or else we need to start writing this out of any calculations we do based on historical production, yields, or outputs. A third program, one of restitution, action by way of apology, is more of a moral or ethical issue, which will be discussed later in Chapter 11, The Dimension of Wilderness and Deep Ecology. It's still too much to ask of a species with so little conscience to make restitution out of love or regret, although a minority of our individuals are now ready to do this.

Earth's carrying capacity itself is suffering some long-term impairment with any human technological presence consuming natural capital. Ultimately, the inputs to the global ecosystem are few: insolation (incoming solar radiation, including wind and hydro), tidal energy, geothermal energy, chemosynthesis, meteoric dust, the recruitment of available minerals into soil from weathering of bedrock and microbial activities, and new deposits of volcanic ash. Seral succession will build habitable niches and topsoil only at geological speeds. The great fossil water aquifers are not going to replenish themselves as long as our demands exceed their small trickle of resupply. Losses of biodiversity through irreversible extinction are permanent, although adaptive successors will eventually fill all the surviving niches. The deserts we've made will take thousands of years to come back to life, after the climate is finished running amok with the added heat we're trapping.

When our wild animal populations crash, whether from overpopulation, over-grazing, overpredation, diseases related to overstress, or extremes of climate variation, recovery of the niche is often fairly quick, but only due to these populations being reduced to below the carrying capacity. Eventually, populations re-stabilize, with numbers usually oscillating first above, then below capacity, but at a lower capacity until any long-term damage has been repaired by seral succession. This is where humankind is now headed, to a diminished capacity and a population crash to some level below that. We are, however, doing much additional damage by consuming non-renewable natural capital and spreading persistent poisons and pollution. The animals don't do either of these.

To avoid an involuntary dieback, we would need to conduct what amounts to a controlled population implosion. Our best alternative is not a deceleration of growth, but a rapid population decline to below carrying capacity. This is almost certainly out of our reach morally and ethically, and perhaps even culturally, so we will most likely be incurring more long-term damages while we wait for a destabilized nature to help crash our numbers for us. Population decline seems to be occurring as a matter of course in local populations, but this tends to be a developed-world phenomenon that

also requires a higher standard of living, hence a larger per capita ecological footprint, and good education, particularly for women. If we cannot manage to attain dramatic population reductions prior to reaching first-world levels of development, it will need to be done nature's way, and every number in a population crash will mean real people dying younger than they would in a better world, the suffering and premature death of living individuals. Undoing some of the damage we've done is both a present employment opportunity and a way to ease suffering down the road.

We have only recently begun to think about reducing pollution. Most of this thinking has arisen in the last 60 years. And we have to do battle here with powerful economic interests that want to keep on introducing new and often unvetted chemistry into the environment. Plastics pollution, with its long-term persistence in the food chain in its microplastic form, has only recently got our attention, and this is rapidly becoming an overwhelming problem, particularly for marine life. Nuclear pollution, most obviously from Chernobyl and Fukushima, has us questioning the renewed push for nuclear energy, which of late has even come from the greens, and people who can pronounce the word nuclear. Landfills remain an issue, and to a lesser extent, enormous yards of backlogged baled recyclables, although ironically, these may be viewed by our descendants as some of the more valuable mines we've left behind. Being able to make better use of our waste will require better planning in what goes into it and how it's to be used later. If we're going to make better use of humanure and other sludge, we will want to take better control of what chemistry we flush down our drains. All waste should be regarded as some kind of food, just like in climax ecosystems, if we want honest sustainability. We should also start seeing our nitrogen, phosphorous, and potassium agricultural runoff as food for other processes, like food for algae, to be rendered into biofuels and re-fertilizer. One of the lessons that government-mandated reclamation has failed to learn is the wisdom of doing triage in allocating resources to repair. Repairs are ordered with no regard to relative hazards or cost-benefit studies. It would be wiser to have a large reclamation fund to be apportioned according to effectiveness, assuming of course that we won't be fixing all of the messes we've made.

Repairing the damage we've done still seems to be a step too farsighted for us, particularly as our immediate troubles grow more pressing. It's the same problem we have with aging infrastructure: it just isn't shiny enough. It redirects valuable resources and capital. If these are wanted elsewhere on some more immediate or urgent task, you already know what job is going to get hyperbolically discounted. We are even too busy to redirect our valuable waste and pollution streams where this could save money. But such expenditures do restore some of the world's carrying capacity. You would think that allowing more living beings to live here would change things. It renders our otherwise unusable environments productive again, without having to wait for glacially slow processes like seral succession, moving things from a category of depleted natural capital to renewable resource. It's unlikely, however, that we will one day be pouring fresh water down into depleted fossil water aquifers. It's also unlikely that we will be manufacturing depleted strategic mineral stocks out of more plentiful atomic elements. Will we still be able to reach the asteroids to mine those, or will civilization have fallen too far?

Reforestation, or even new enforestation, provides a dramatic example of remediation that's realizable within a decade or two. A number of dedicated souls have enacted Jean Giono's *The Man Who Planted Trees* in real life. Search for Jadav Payeng, Abdul Kareem, Bhausaheb Santuji Thorat, the Dandakaranya Movement, and the Green Belt Movement. These show that just one or two dedicated people with plenty of free time can create an entire ecosystem by working with natural processes. See also

documentation of the Gaviotas project in Columbia and the Instituto Terra of Lélia and Sebastião Salgado. Agroforestry is another example of managed reforestation that adds biodiversity and reduces erosion. These projects are all distinguishable from the stock replanting procedures of the timber industry and their government assistants, where the preference is to clearcut parcels (called intensive even aged management) and replant monocultural tree crops in the damaged soil structure. This is not true reforestation, which restores a more complete forest ecosystem.

Not all reclamation is as easily done as holistic silvaculture, although low and no-till farming, especially with perennials and cover crops, is still pretty straightforward. Biochar and *terra preta* introduce elemental carbon directly into the soil, restoring or enhancing many of its original properties. Other low tech systems are coming into their own, although some require significant consideration and planning, and more human labor. Regenerative agriculture can turn dying, degenerating, and eroding soil around and back into dynamic productivity. Soil nutrient preservation and restoration are keys. Permaculture may be the best known regenerative system for farming, although it also knits farming into animal husbandry, energy, and other living systems in general. Holistic ranching does something similar for grazing, by restoring patterns of activity that mimic the original conditions under which animals and plants coevolved and came to need each other. Both of these latter systems also sequester large quantities of carbon in the soil, retain more water, and bring dead dirt back to life.

Restoration ecology is the broad science of restoring damaged ecosystems. Soil contamination is one of the most problematic aspects of this and can be an expensive cleanup operation, even for the relatively benign salinization. Remediation has to be tailored to the condition itself. Some forms can be treated with oxygen or heat. Bioremediation uses living entities. Microbes might be used to digest or convert a pollutant into something less harmful. Phytoremediation uses absorption of troublesome materials by plants, and mycoremediation by fungus. Groundwater may be extracted and processed. Surfactant leaching will carry dissolved contaminants further underground and eventually into groundwater, whether deconstructed or not. But often all we can do is cap pollutants in place, or excavate ruined soil and store it in isolation. It's always easier to not stain a carpet than to get the stain out again, but we're only beginning to think that far ahead. Groundwater remediation might be the most problematic. It doesn't do much to clean groundwater itself, but some microorganisms will treat it *in situ*. Most recovery is done between the ground and a new end use with such methods as chemical precipitation, membrane separation, and ion exchange. Damaged land and soil might be restored with accelerated seral succession, beginning with pioneer species and replacing these with successors as soon as soils build. This can move far more quickly than natural succession if done with soil nutrition and structure in mind. Other remedial efforts employ more macro concepts of ecology, like habitat defragmentation, population dynamics, and ecological engineering.

8. The Dimension of Contingency and Surplus

Contingency is another dimension that's often forgotten as we pick up the pace of our development and growth. This is the backup plan, our disaster readiness, emergency supplies, stocks, stores, spares, safety nets, buffers, rainy day funds, and reserves. It's the substance of our resilience. We seem to assume that our evolving technology, combined with our human ingenuity and the inventiveness of Mother Necessity will cover all of this for us, so we continue to discount the future instead of allowing safety margins. From time to time, our world is hit with abnormal and extreme events, new diseases, long periods of drought or ice, large objects arriving from space, solar storms, earthquakes and tsunamis, hurricanes and floods, big volcanoes and super-volcanoes. We know with some certainty that another coronal mass ejection (CME) on the level of the 1859 Carrington Event is on its way, and probably a lot sooner than any asteroid strike or another Toba. Events on this level or greater happen every couple of centuries on average. The grid isn't fused against such an assault, even though we know that one of these could shut civilization down for a decade or two. These *force majeure* events, which now include our own wars and other moronic pursuits, demand that a surplus of our resources and capital be set aside for emergency use only. Even the Bible shows this much wisdom, in Joseph's plan for Pharaoh to set aside a large, seven-year store of grain (Gen 41).

We can build surpluses from an environment at rates that are faster than nature alone can provide. Given the inefficiencies of natural systems, natural levels of replacement or resurgence can be altered and yields increased, even at sustainable levels, above natural baseline. This is an important principle in Permaculture, where it's known as "obtaining a yield." A system will have a sustainable yield that is a function of its energy and nutrient income and storage, minus system losses and waste. This should be the basis of yield computations, not wishes for what it might be. With this knowledge, we can increase yield over natural systems production, but realistic resource budgets must still be respected, proven processes considered, and all natural capital losses must be accounted. Non-renewables aren't replaced. With our "green revolution" in industrial agriculture, we haven't done anything close to this. Instead, we've added non-renewable inputs and subtracted non-renewable biodiversity. In effect, the yield that's been obtained here is the equivalent of embezzlement, while the books only seem to look good to those without eyes to see, or time horizons beyond a couple of years. If we are to dip into extreme solutions at all to get our added yield, it should almost certainly be done in emergencies only.

Most of us know by now that civilizations come and go. One of the things that sends them packing is the occasional hundred-year drought. Another is the exploitation of one-hundred percent of their occupied niche, with nothing lying fallow or given any chance to recover. And raiding adjacent niches isn't always an option in a filled-up world, or when it is, this leads to war and then to accelerated collapse. In other words, it's frequently unwise for us to occupy the whole of a niche, and wiser in the long term to under-develop. This is never our first option, which is usually to occupy fully and overrun. Had we the wisdom, we would allow a significant amount our forested, arable and grazeable lands, in any normal year, to lie fallow, or else managed by natural and biomemetic processes, with a chance to recover some natural health. Wisdom will often look just like restraint. *Lebensraum*, room for living, can use some recycling as well. Such an ethic, however, would require some time for most cultures to absorb it, and this would require underdevelopment to develop its own kind of attractiveness. Too few seem to see the benefit now.

An as-yet unnamed horseman of our coming apocalypse is overextension, hypertrophy, our crowding into the flood and tidal zones, onto the slopes of Vesuvius, on top of the earthquake faults, and into our armed neighbor's yard. Ecological spacing was the last good excuse we had for war, but we lost it when we outgrew our tribes. Our default response to a new opportunity is to exploit it, to a new space, to expand into it, to a population void, to populate it. When hazardous terrain is all the remains, that's just where we have to go next. Restraint hasn't been much of a strong suit for humanity, except to the long-standing populations of indigenous peoples, with cultures and lifestyles of proven sustainability. Sadly, too many of these have fallen prey to the seductive flash of our missionary and colonial cultures. Such conversion is fully intended by the exploiters. When they didn't want to be assimilated right away, we simply fenced them away on reserves or exterminated them.

Having enough set aside for the future, for contingencies and emergencies, is key to good stewardship, while it's our own insecurity that overproduces, over-plants, overgrazes, and generally overconsumes. Security is the steward: it has something worth protecting or securing. Hyperextension and security are fundamentally incompatible. The bubbles pop and populations crash. While there's no real need to paralyze our civilization with excessive precautionary principles, we nonetheless have been cashing in the benefits of doubt when we should be accepting more burdens of proof. It's no matter of prophesy that big challenges are coming. Magical calendars or planetary alignments won't be the cause: it's simply statistics and human stupidity.

One means of preparation that we are increasingly forgetting is keeping our civilization's infrastructure in current repair and working order. We don't seem to be smart enough to spend money on this instead of war, even though it creates even more jobs for the economy and does good instead of damage. The arrival of an emergency is not the best time to start thinking about this. Starting a crisis with a failing infrastructure is the opposite of a head start. You want your infrastructure to hold throughout your crisis, instead of falling apart and multiplying your miseries.

9. The Dimension of Living Standards and Development

Malthus noted that mankind has a propensity to utilize his abundance for population growth rather than for maintaining a high standard of living. This became known as the Malthusian trap. At its conclusion, populations have a tendency to grow until the lower class suffers hardship and want, and incurs a greater susceptibility to famine and disease. This is called the Malthusian catastrophe. We can escape the trap by re-prioritizing a healthier relationship between population and living standards, but it's a cultural push. Better living is in fact a part of the solution to our population problem, but at the same time, it drives the numbers for both optimum and maximum carrying capacity significantly downward. Conspicuous consumption does nobody any good. We don't really need equality here, and equalitarianism even less. But we do have good uses for socioeconomic equity for healthy social function. We should be using an economic inequality index as one of the metrics of national wealth and quality of life.

The justice of a higher quality of life for the world's poor is an important limiting dimension to Earth's carrying capacity. Our focus is more often on the overconsumers, not on those who really need to consume more. Naturally, this can't be achieved at current population levels and reproductive rates, so moral questions still loom over it all. What we need to come to grips with, and ultimately establish, is an acceptable minimum standard of living, or economic floor, that allows self-actualization to any human being who cares to seek it. This means that the poorest among us should be not be impeded in meeting all of the basic human needs, impeded by interference and surcharge from their governments, or by repression and exploitation from economic or corporate entities. This isn't the same as a right to be handed the basic requirements of life with no personal effort. Some degree of work ought to be both expected and demanded where assistance is needed in reaching this floor, at least with modestly paid vocational training or public service, if not adequately paid, gainful employment. Yes, from each according to their ability. There must one day be a right to achieve this standard or floor within an amount of time that still leaves hours for family, leisure, recreation, travel, and education, because these too are among our real human needs. Meeting this condition would elevate the global per-capita ecological footprint to a level well beyond the current global average and mean, although this is still below the per-capita footprint of several of the developed nations. A closely related problem is the greater longevity that we are giving ourselves, which also increases our footprints. This has several implications, shifting us towards needing more elder care, and social security that's less of a Ponzi scheme and less reliant on a growing population. We will also have higher infant and child survival rates. Both of these improvements are challenging consequences of greater well being and will drive capacity still further downward.

Despite its habitual association with low resource use, there is nothing at all environmentally friendly about poverty. Severe impacts from impoverished peoples in overshoot include the high toll on forests from firewood gathering, on wildlife bushmeat and local rivers from food gathering, on biodiversity from poaching and the pet trade, on soils from poor farming practices, on water quality from poor sanitation, and on consumption from the simple lack of affordability of more durable goods. At still larger, village scales, outside pressures for land conversion, especially mining and forestry, wreak havoc on local environments, while providing only minimal or sub-minimal subsistence income, far out of proportion to local losses, but desperately needed for basic survival. Childhood adversity does long-term neurological damage to

children with malnutrition, poor health, impaired cognitive development, and poor education, and all that unfolds into environments of crime and social mistrust. The rights of children to have a fulfilled and happy life seldom enters the ethical debate. Donella Meadows writes, “To reach sustainability, humanity must increase the consumption levels of the world’s poor, while at the same time reducing humanity’s total ecological footprint. There must be technological advance, and personal change, and longer planning horizons.” Even from a selfish, homocentric point of view, by raising new generations of diminished human beings, we are depriving ourselves of vast stores of human resources and resourcefulness.

The UN 2030 Agenda avows (rhetorically at least) “ending poverty in all its forms everywhere.” This might be accomplished very temporarily if all wealth on Earth could be evenly redistributed. Beyond that, somebody isn’t thinking straight, knows nothing of human nature, and can’t do math. Ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture would all be temporary achievements at best at our current and projected population levels, given the resource and capital depletion involved. We would still be in dangerous overshoot. Though well fed on fish for a day, we still wouldn’t know how to fish, or run a sustainable fish farm. Sustainable agriculture, or much better, restorative and regenerative agriculture, is still a must for any viable long-term scenario. Ensuring availability and sustainable management of water and sanitation for all is also a physical impossibility at current and projected population levels, especially given the already current climatic changes. Somebody isn’t watching the water tables dropping, or watching the industrial waste polluting the groundwater. Family planning only gets two hurried mentions from the UN in passing, contraception and birth rates get none, and the word population appears a few times only in the demographic sense. One may suspect that the UN document was written by the very same people who are causing the problems. Karin Kuhlemann offers, “the question is not whether we are living well, but whether we are living within our means.” The answer to this should be an input in estimating our sustainable numbers, but it’s currently one of our last and least considerations.

There are two further questions here, the first being: “What does it take to meet our basic needs?” Life itself needs sufficient space, water, food, and sunlight. For humans, we add supplemental heat, shelter, clothing, sanitation, medical care, exploitable resources, education, and social organization. And in a still better world, we could also add autonomy, security, community, leisure, and discretionary income. The current UN definition of absolute poverty needs to be raised from the current $1.25 a day for 1.3 billion people. The bar needs to be set a lot higher than this. In the US, the generally accepted response is the called the poverty line. This is the cumulative average cost of a specified basket of goods and services. As of this writing, the average global per capita income is $10,298, but the median is only $3700. This contrast illuminates the enormous and growing imbalance in per-capita global wealth. That’s a thought problem you may wish to ponder. The US poverty line (in 2018) was $12,060, which represents the 82nd percentile globally. Depending on the cost of living within individual cultures, the suggested economic floor might be set somewhere between the global median and the US line, an order of magnitude above the UN standard for absolute poverty, maybe averaging somewhere around $5500 per year. This would represent an enormous increase in the human footprint on Terra.

Up to any true poverty line, people on average must remain preoccupied with meeting the needs over which they have little control, while beyond this, discretionary expenditures of both hours and money will bring a degree of liberty and happiness back into life. We will also tend to see declines in reproductive rates with both development and prosperity. This allows us to raise our young with greater care, with

greater attention to our hierarchy of needs, such as described by Maslow. With regard to our wicked problem here, what too few of us see are the lasting effects of childhood adversity, the deprivation of basic needs early in life, concurrent with the most foundational layers of neurological development. We would benefit greatly if we were to take a deeper and broader look at this, and demand good primary education (especially compensatory improvements for girls), and even start looking at fundamentalist religious indoctrination as a form of child abuse. Every nation should have its own ability to manufacture condoms or birth control pills and devices, and enough education to know how and why to use them. Children are resilient, but there are real limits to how much of self-actualization six-year-old coal miners or war and climate refugees can recover, especially if these conditions persist for years. Gandhi wrote "To a hungry man a piece of bread is the face of God." We develop into higher beings by satisfying our lower needs and moving on. We humans only think ourselves "all that" because we can't see past our own deficiencies. We need to become less self-important, but how do we do that if basic needs can't met? We will remain the center of the universe until we have a chance to get over ourselves, at least for a glimpse of a larger world than that of our hungers and immediate needs.

The second question is: "Within these parameters for a basic standard of living, what more can be done to minimize humanity's ecological footprint?" Provided that we can learn to need less, which seems to be easier said than done, we can revisit the whole notion of economy that's been so deviously twisted of late. At bottom, we can learn a degree of control over our own power to assign value to this or that. We can, for instance, learn to value time above money. If we have no choice but to work a forty-hour week, but we only really need the income from twenty-four, wisdom suggests that this be fairly rigorously applied to investing now in working less later, instead of being resigned to spending it all now when it only appears to have more value. We would need to learn to stop discounting the future. Voluntary simplicity and poverty are two very different states of being, even though they may be funded by identical incomes. For the good of the world, lifestyle enhancement must be accompanied by per-capita footprint management. The footprint at the poverty line can vary dramatically with the use of resources and the recycling of natural capital. Being able to afford durable products might warrant some public financing, even at modest interest. It's better to buy the thirty-dollar boots than six pairs of the ten-dollar brand. Ted Trainer advocates for a package that embraces "simpler lifestyles, devolution to fairly self-sufficient and cooperative local economies, while maintaining global exposure and interconnectivity." And reinvigorating at least some portion of our ancient community, village, or tribal lifestyles would return us to a stronger sense of participatory democracy and personal agency, thereby raising us to a stronger sense of responsibility for the world around us.

We need to be much clearer in distinguishing growth from development. We see a beginning of this in metrics of assessment moving slowly from GDP to HDI. Development should be defined in terms of optimization, where it can as easily be understood in terms of degrowth, or the shedding of clutter and waste. Growth is specifically quantitative, development is qualitative, with special emphasis on quality. Some development costs nothing at all: you can get it with a library card. Sustainable development is only possible in finite systems because it can include degrowth, otherwise it's oxymoronic, with the emphasis on moronic. We substitute optima for maxima as system goals, and optimize for net benefit instead of gross. To grow up or mature is to lose the growth paradigm for one of health. Real development might include lower productivity, or a reduction in the hours a day needed to meet real needs. Voluntary simplicity means a healthier work-life balance, solvency, and self-

sufficiency. It doesn't need to be monastic or ascetic. We needn't spin our own yarn. We needn't be Luddites. There's plenty of room in such a lifestyle for some tourism, digital music, and a little fine dining.

Technological development in the developing world can bypass many of the less efficient intermediate steps that the pioneers in the developed world had to take. We can distribute solar ovens to villagers, and light mud huts with solar panels, and serve some villages potable water with high-tech filtration and wind traps. We can share information technologies in village centers and libraries. We can introduce them to Permaculture and other forms of regenerative agriculture. Development of new generations of environmentally sustainable, human-scale technology should transferred as quickly as possible to the developing nations, so they can leapfrog some of the consumptive and polluting 20th century technologies. Many of the things we've been learning are transmissible.

The change to subsistence economics will of course have huge impacts on unearned income and speculation, the rewards expected from these, and thus the motivation to invest. This will eventually clarify a big difference between corporate capitalism and free market economics. Beyond optima, there are usually diminishing returns on the way to maxima. In the growth economy, it's been most of the people and the health of the world that got diminished. We want the best bang for the buck, not the biggest boom. Studies have been done that correlate increases in our incomes to self-rated happiness (how much happiness does more money bring). The curve looks like you might expect: having more money to spend does a lot at low income, and very little as we move from millionaire to billionaire. Unsurprisingly, at least to those who pay attention, the best bang for your buck is had around the poverty line, when real needs can be met and spending becomes truly discretionary. These facts have to be hidden, made to disappear by advertising and other economic interests. You need to make more and spend more, because that's what makes the world turn. You need to live at least a little beyond your means. You need to feel at least a little anxious and insecure, so that you will accept reassuring advice from your betters.

Housing, and rent in particular, remains the biggest economic floor issue, and this will require some form of major government intervention to address. But government should absolutely Not be the provider of housing: this has always been a really bad idea. It should exercise its power to get out of the way. It can do this with full tax exemptions for a minimal level of housing needs, something like 25 square meters per person. It can allow specific code exemptions and a freer use of alternative building materials. It can prohibit NIMBY zoning that pushes the working class out of the communities in which they must work. It can provide low interest financing until these minimum conditions are paid off. Ownership opportunities would be a huge step off of the endless treadmill. But GDP would fall with freedom from rents.

One of the more positive and promising steps that this civilization is taking now is towards free online education at all grade levels. Unfortunately, accreditation for the self-taught still lags well behind, although programs like G.E.D. and CLEP are showing rays of hope. There ought to come a time when any autodidact could challenge any higher education course of instruction, or any full academic degree, including those of guild monopolies like medicine, law, engineering, and architecture. And this should be with credit that's widely respected. The subject of education might seem out of place here to some, but it isn't. Education of women in the third world, for example, might do more than any other factor in curbing our population problem, and those women will teach their children with the extra one-on-one time they have. Then family planners can deal with issues of contraception, abortifacients, abortion, grinding poverty, and infanticide in their proper order of preference. The introduction of a core

critical-thinking or cognitive hygiene curriculum early in elementary school could go a long way towards neutralizing the ideological ignorance and short-sightedness that prevents us from even looking at our problems. We have to see what's coming before we can see our need for restraint. Better educated people make better democracies, while ignorant populations will only give us the democracies that are failing us now. What if we had a population intelligent enough to reject any national economy that demanded perpetual war? What if any child on Earth could get a quality education and a degree in a thatched-roof village library, for free?

10. The Dimension of Human Ingenuity and Due Precaution

Humans are somewhat more fortunate than the animals we're driving to extinction, in that we can respond with cultural adaptations and innovations a loft faster than the natural biosphere can respond with genetic and epigenetic adaptations. But given the time frame that we've cornered ourselves with, and the general intractability of human ignorance and belief systems, we can still ask whether even culture may be too slow. What would it take to rally us? The various media are saturated with one-dimensional solutions, banners under which to march forth. This will save us, no, that will save us. Bioenergy with carbon capture and storage (BECCS) is a geoenginering proposal that's often touted as a major strategy to combat climate change. Of course the large external costs aren't often mentioned, and the technology hasn't been scaled up. Regenerative agriculture is promoted as the solution, but while this will be absolutely necessary as a component of any larger solution, but we aren't going to fix anything long term without a deep population reduction, along with a few dozen other coordinated efforts. This one is ironic, too, because regenerative agriculture is all about thinking holistically, thinking in systems, not just in one-dimensional threads. You have to ask: Why does everyone think that their favorite piece of the puzzle is the only important piece? Yes, we need human-scale technology and relocalization. We need to be saying "that, too," more often, and less of "that, instead."

When we aren't looking to mythical deities, offering thoughts and prayers, we will often look to human ingenuity and technological advance as our savior. The cavalry is always just over the hill. Or we will combine the two in some fantastic *deus ex machina*. But technological optimism may not be serving us as well as we think. Our progress is also a history of unintended consequences, and techno-fixes that often require dedicated fixes of their own. Our greatest inventions have nearly all come with mixed blessings. Mass electronic communication has given us networking and online education, but it has also made possible the frighteningly effective mass brainwashing in advertising, politics and religion. We can plainly see the blind faith in typical comments like this, from Mashable: "As it turned out, though, Malthus and his successors hadn't reckoned with human ingenuity. Every time we think we've hit a wall in terms of food production, we come up with new technology and new efficiencies – just as we did in the so-called Green Revolution of intensive agriculture in the 1960s and 1970 that put paid to the 'population bomb' problem." There is a delusion here that's probably much more dangerous than Malthus's miscalculation: the belief that any or all of these improvements are sustainable for more than a couple of decades.

The Cornucopians are heeded far more enthusiastically today than the Cassandras. We try to be plucky about what we have coming our way. Ruin this world? No problem. We'll move to Mars first, mine the asteroids, and then move on to the stars. Faster-than-light travel can't be more than a couple of discoveries away. This used-up world cannot have been our destiny: we're just too special for that. Despite whatever tendencies we have to cultural inertia and conservatism, we are also known to be overly enthusiastic in embracing the new and the modern, often just for its own sake, with little to no regard for consequences. There's an assumption that "what can be done should be done." Rebecca West wrote, "If the whole human race lay in one grave, the epitaph on its headstone might well be: It seemed a good idea at the time."

It's true that we will likely invent our way out of some unknown number of problems, and even avoid some serious tipping points at the eleventh hour, just prior to subsystem

failure. Nonetheless, we have to survey how well this has worked for us in the past, with a special eye to both real life-cycle costs and discouraging surprises. New products are often touted for their benefits while their salesmen pitch nothing about their impacts, and many impacts are new or still unknown. They may be billed as the greenest thing in all of history, while providing only a 10% improvement over the old ways. Huge windmills and electric vehicles must still have their component materials mined from the earth, must still be manufactured at substantial energy and water costs, must still be delivered along maintained roads using fuel, and must be repaired and eventually replaced. Some pollution of the commons will almost certainly occur. Paying interest on their financing requires extra work, also done at real cost to the environment. Honest efficiency calculations are needed to expose all of the real costs, but our honesty is getting rarer. In sum, the techno-fix dimension of the carrying capacity problem might not have anything close to the sustainability value that we have hoped for. On the whole, our march of progress hasn't really solved many of our problems without incurring costs of similar weight. Some of this is acceptable, such as advances in medicine increasing our costs in elder care. But look at the minuscule net energy gain in producing corn ethanol, which also costs the commons in topsoil losses and water consumption. Many of our gains might just be a wash or worse, especially the way humans like to do accounting. Technology is the T in the often seen I=PAT formula. Environmental Impacts = Population x Affluence x Technology. However, it's often mistakenly assumed that more advanced technology translates into a reduced impact, or that people living in poverty have next to no environmental impact or will remain poor for ever. As far as the T is concerned, we may even want to leave this techno-fix dimension out of our calculations entirely, or else turn any hopes for net gains in carrying capacity into a much-needed contingency line, tuition for the school of hard knocks.

Precautionary principles are one way to implement some conservatism, particularly at governmental and regulatory levels. We want to use a healthy skepticism. In effect, this strips the benefits of doubt from new proposals, products, patents, or designs. Where extensive knowledge or testing is lacking and consequences of implementation are in any way suspect, the burden of proof falls on the proposer. There is often an assumption of responsibility to protect the public from harm, even where such interference is all that incurs such liability. This has been growing progressively less cautious in some important areas, as corporations pay their legislatures to deregulate them. Permissible amounts of incidental death and injury have also become more accepted, as long as the statistically acceptable cost-benefit analyses have been performed. Precautionary principles can also be counterproductive. We adopt codes and set standards for general application, but in part because we are under "the rule of law," wanting to be fair to everybody, too few exceptions are made for special or mitigating circumstances. Laws of general application often result in extreme design overkill in specifics, and an associated waste of resources. It still makes sense to use reasonable precaution. As a wise sorcerer said long ago, "Don't conjure what you can't banish."

As a counterweight to overdone precautionary principles, transhumanist thinker Max More has proposed a Proactionary Principle: "People's freedom to innovate technologically is highly valuable, even critical, to humanity. This implies several imperatives when restrictive measures are proposed: Assess risks and opportunities according to available science, not popular perception. Account for both the costs of the restrictions themselves, and those of the opportunities foregone. Favor [those] measures that are proportionate to the probability and magnitude of impacts, and that have a high expectation value. Protect people's freedom to experiment, innovate, and

progress.” There are, of course, edges and lines not to be crossed, often predicted by science fiction writers, that might warrant a still closer look, like grey-goo scenarios from runaway nanite replicators, or their green-goo counterparts in hyperadaptive artificial microorganisms. But we can certainly use a better balance than we now have between precaution and proaction, and this will work in both directions if our thinking improves. Daniel C. Wahl asks, "Why not limit the scale of implementation of any innovation to local and regional levels until proof of its positive impact is unequivocally demonstrated?”

When the risks we are facing are large and complex, and might threaten our whole world and our future, we would be well advised to take some much bigger steps back from our blind faith in the techno-fix. Karin Kuhlemann, writes of these as global catastrophic risks (GCRs): “There is great appeal in the proposition that a (cost-free) technological solution may be just around the corner. It plays right into our cognitive biases. We do not want to bear any costs to mitigate GCRs generally, let alone the embarrassing overpopulation or the kill-joy climate change GCRs. We think we will be richer in future than now, we do not much care for future or geographically distant people, and we are optimistic about our own chances. But the option of foregoing mitigation in hopes of a technological solution amounts to simply embracing the GCR and doing nothing. It is unclear that a technological solution is realistic; technological advances to date have greatly increased (rather than done anything to reduce) per capita consumption, while automation breakthroughs may lead to catastrophic unemployment. And whether it is realistic or not, a technological solution is not real. We do not yet have effective technological solutions in place for any unsexy risk. Until such time as a technological solution actually exists and actually solves the problem, we simply have no grounds for assuming that it will exist and that it will solve it. It would be unconscionable to rely on a non-existing solution to a global catastrophic risk we contribute to, and which is disproportionately likely to impact people much more vulnerable than ourselves - children, the young and poor, and those not yet born.”

Some of the more frightening nominees for prospective global solutions involve geoengineering proposals. Part of the frightfulness lies in the fact that we have come to this, and another part from knowing there are people with influence who think such things. The overwhelming costs or impracticalities in most proposals are often a big source of relief. We have too much carbon in the air because we have taken too much out of the ground. So we need giant industrial plants and big machines to put the carbon back, because letting green plants and their roots do this for us just makes too much sense? Why we can’t address problems by treating their causes and sources directly is often a puzzle that draws us deep into human psychology, and particularly that of denial. Karin Kuhlemann asks why we can’t just pull on the levers that connect directly to the problem at hand. Is it because we can’t work directly with who and what we are because we don’t know who and what we are? So we use Rube Goldberg contraptions, and roundabout approaches to sneak up on ourselves. Ultimately, we are the puppeteers, and not the puppets, but that thought is just too frightening to face. We still have nuclear, biological, and chemical weapons. And we aren’t offended or outraged at all when DARPA proudly tells us what the future of war will be like. Somewhere we got this really bad idea that the individual is only sovereign when convenient, but somehow not accountable in any way for the actions of the whole. That’s how stupid we are as a species. The sense of fate and helplessness is only overcome by a few. For these, the solutions still involve simply getting rid of a problem by dismantling its causes and support systems. Geoengineering solutions to climate change are getting increasing attention, where our money would be far more effectively spent funding contraception and education.

Decoupling refers to some change or switch in technology that uses less material or energy per unit of output. It's the T in I=PAT that most often works. There's almost always some extent to which we can decouple our development, prosperity, or well-being from our environmental footprint. For instance, we might take some waste stream and find a way to use it as a resource, or as food for another process. Decoupling may also consist of substitutions. The switch from a manufacturing to an information or service economy decouples a population from some of its reliance on material extraction. We might find processes that cost us more in some ways, such as more human labor, as in moving from mechanized, high-input agriculture to Dacha or Permaculture gardening. But what we save there is non-renewable natural capital, the most valuable stuff we have. One sense of decoupling might even regard wisdom as a way to decouple our lifestyles from things we don't need to be doing at all. There is also relative decoupling, getting more work done with less damage, or simply increasing our efficiency in resource and capital use. Appropriate technology might be the best input term for further research. The term comes from Ernst Schumacher and means "small-scale, decentralized, labor-intensive, energy-efficient, environmentally sound, and locally autonomous" applications of knowledge. Information isn't impact free, but we have to think of digital audio as sustainable or civilization has produced too little of value.

It sometimes happens that some new labor or time-saving invention is so exciting that entire lifestyles grow up around it, increasing costs in both labor and time. Frequently, technological progress increases resource efficiency in ways that drive up demand and lead to increases in overall use. Sometimes converting to a friendlier product will alleviate some of the guilt that went along with the old product's usage, so we use more of it. You trade your 14 mpg Bronco for a 40 mpg Civic and your conscience feels so good about that that you now drive five times as far. This is known as Jevons Paradox, or a rebound effect. Aside from turning our interest and investments away from a particular product, deciding that we didn't need it so urgently after all, maybe the next best technologies to work on increase efficiency, develop negawatts, and learn to consume wastes as food for other processes.

Most dangerous of all our techno-fixes may be a technological solution that alleviates only the symptoms of a problem, while masking the underlying causes, giving only the appearance of a real or long-term solution. Industrial agriculture is perhaps the most dangerous of these because people invariably focus on the fact that increasingly more mouths get fed now, while ignoring the unsustainable costs of increasing non-renewable natural capital inputs, especially fossil water, soil health, soil carbon sequestration, and global biodiversity. Solutions have accelerated long term losses in both soil quality and quantity, increasing dependence on inputs even further. The apparent progress has "animated the conviction that human numbers are not constricted by environmental forces but can elude limits through technological and agronomic modernization" (Abegão 2018).

11. The Dimension of Wilderness and Deep Ecology

Integrity is wholeness, the greatest beauty is
Organic wholeness, the wholeness of life and things,
the divine beauty of the universe.
Love that, not man apart from that,
or else you will share man's pitiful confusions,
or drown in despair when his days darken. Robinson Jeffers

Even a rigorous ecologist or systems theorist might still see a scientifically acceptable underpinning to "the interconnectedness of it all": of us all, of all our relations, including the microbes and detritivores. For most of humanity, however, the dimension of wilderness and deep ecology breaks us into a new realm altogether, one of purely subjective opinion, or at best, one of morals, ethics, character, and conscience. We may have deep feelings about it, and we might even weep for various reasons, happy or sad. But it can't and should not be quantified? Daniel Wahl writes, "The aesthetics of complex dynamic systems are rooted in valuing diversity, interconnectedness, and cooperative exchanges or symbiosis as the basis for the dynamic stability of the system." We who possess what Schweitzer called "reverence for life" have to ask why so many others don't, and others don't seem to. And how in the hell could anyone but a psychopath kill a giraffe for fun or sport? Idiots. Others may note that the intensity of reverence for life increases with some practices of "breaking open the head," with mindfulness training, shamanic experience, or mind-altering sacraments. Sometimes it might just be Scouting, getting us out of the city and into the woods. Sometimes it might be a fortunately-timed class or family outing to a zoo, aquarium, natural history museum, or observatory. Whatever the introduction to this sense of sacred connectedness, it comes with a horror when next we look around and see the crimes humanity is committing against nature and future generations, the suppression of our equal rights and opportunities, the damage done by shortsighted greed, and the unimaginable stupidity of war (which includes signing on as a soldier).

A deep respect for the more than 3.5 billion years of "life's struggle for existence" becomes reverence for many of us, and is often accompanied by gratitude to be a part of it all, even when we still need to struggle. We also pick up a corresponding sense of duty. What is it that keeps our fellows away from this, and what is it that helps us to arrive in this state? Many, of course, would call it a religious experience or epiphany. Religion may at least call verbal attention to our interconnectedness, and perhaps call for compassion, but there is very little evidence that it pays more than lip service, while it also interposes an ideological dogma that more closely favors human exceptionalism. States like awe, reverence, gratitude, and appreciation of the sacred are in no way limited to religious or even spiritual experience. Maslow would be quick to point out that most of us, especially the very poor, are still stuck trying to satisfy deficiency needs, which keeps our heads down and our minds in less than exalted states. We may need better exposure to higher and alternative states. Many are simply deprived of close experiences with nature.

It might come as something of a shock to realize that humanism and socialism don't help us much here at all. The fantastic bubble of our great civilization, with the beliefs that keep it inflated, reinforces the illusion of our separateness, and our specialness. Pro-human identities may give only lip service to a larger, but somehow still separate environment. Humans are most sacred of all, and then come the charismatic species

that we find ourselves attracted to, even if they don't get to go to Heaven. The left and the politically progressive political wings won't have any necessary commitment to the life beyond the human sphere. Platforms may mention the need for a healthy environment and resource conservation, but this still largely comes down to a recognition of environmental services, things supporting the human cause or project. It's frightening that such advanced cultures as Norway, Denmark, Iceland, and Japan can still be involved in such an evil perversion as whaling. But it does illustrate that neither their humanism nor 'the right amount' of socialism will be much of a help with our human exceptionalism problem. We have to get over ourselves. "Man is something to be surpassed." as Nietzsche's Zarathustra proclaimed.

Deep ecology is a world view that lends itself to at least some degree of scientific systemization. It argues for the inherent worth or value of all kinds of living beings, without regard to the environmental services they perform for humankind. All organisms are part of a larger fabric of interdependence, mutualism, and synergy. Without this greater fabric, without being part of it, we are either lessened or nothing at all. The inability to see ourselves as part of a greater whole allows us to incur massive unpaid environmental debts. Although the philosophy (if you will) of Deep Ecology is central to the beliefs of many indigenous cultures, cultures that have stood the tests of millennia, it is nonetheless a cultural teaching, and not inherent in humankind's biological nature. We only seem to have a default kind of goodness that doesn't want to wantonly do damage. Deep ecology requires learning to restrain ourselves collectively on a permanent and voluntary basis for the benefit of the world around us and our own future generations. To get there from where we are will demand a pretty full transformation of our cultural values to justify a much more minimalist footprint to our ravenous appetites. More than anything else, we will need to lose our appetite for things that can't be replaced or recovered. James Lovelock's Gaia hypothesis might play a part in this, if we think of Gaia as a complex, self-regulating, adaptive system and not as the conscious, self-directed entity it's sometimes mistakenly thought to refer to.

There are issues with degrowth (in both population and consumption) that will be painful. We will be reminded that climax ecosystems are steady states, with as much biomass dying as living. Some periods and aspects of negative population and market growth will feel like a recession or depression, or an uncomfortable rebalancing of age demographics, but important others might seem like a dividend, with more good stuff per-capita to go around. Per-capita land or *lebensraum* will grow. If we shrunk to two billion, we could give E.O. Wilson his whole Half-Earth in full and still double the per-capita turf that we now occupy. And the progress from A to B will include many of the subjective characteristics of growth. We could return half of the land we've deforested or otherwise appropriated for agricultural use and let it self-replenish with wild flora and fauna, with enough arable land remaining for regenerative agriculture and holistic grazing, to return carbon and nutrients to the soil that feeds us. We could decouple from unsustainable mechanical and chemical inputs. Even where we aren't measuring environmental services, humankind would be well-served by such an approach, and we'd get to have some real living and thriving descendants, instead of imaginary ones.

For most of our long prehistory, the world was relatively empty of us. Even much more recently, the loss of wilderness was a great thing to the pioneers. There were swamps to drain and savages to conquer or enslave. We didn't really have the necessity to outgrow all this until we outgrew the world and found walls, staked claims and property boundaries, and limits at every turn. Suddenly, finding the intrinsic value in nature, ecosystems, and non-human life has acquired new value in the slowly-growing recognition that this is a *sine qua non* of our survival. The conscience needed isn't

native or well-supported by most cultures, so we do have a steep learning curve ahead of us. Somewhere we need to find a moral center or a secular environmental ethic to which the religious folk can also subscribe. But we may have to write off the billion or more who are actually praying for an end to this world. Those minds were long gone before Sunday school graduation. But we could still eventually surpass them in numbers.

The soundest place to begin an ethic is with the Golden Rule, which began with the Confucian "What about 'fairness? What you don't like done to yourself, don't do to others" (Analects 15:24). We would only need to add that "others" referred to other living beings, not just the most sentient. We could then add on Aldo Leopold's Land Ethic: "A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise." Mihaly Csikszentmihalyi offers, "When the values that support a moral stance are parochial, it is impossible to reach universal agreement on what is good or bad. The only value that all human beings can readily share is the continuation of life on Earth." Maybe we could just make a better effort to leave this world a better place than it would have been without us. Given the amount of damage that today's human life does to this world, that's not an easy goal. Perhaps then we could constrain the whole concept of property right to that of a usufruct, a legal term defined as: "the right to enjoy the use and advantages of another's property short of the destruction or waste of its substance." The word "another" here would refer equally to the global commons. This leaves us with the question of how far we might monetize the remaining portion of nature, how much we might appraise ecosystem services at all. Is a consensual conscience enough to place a limit on how much we can regard life and its necessities as resources and stocks at all? Should we not limit potential property at least to that which is necessary for survival and our qualitative human development within the world's carrying capacity, and exempt the whole of the global commons from consideration as property? You must know that corporations are out there right now trying to monetize the atmosphere. Others have already done it with our streams and aquifers.

For all of its many flaws, one truly great concept came out of aristocracy: *noblesse oblige*, or noble obligation. Where we've been well-endowed by the world, there is a corresponding duty to give something back, and with some gratitude, particularly where we are blessed with leisure. Thomas Jefferson claimed that aristocracy as it's commonly known wasn't at all necessary to the sense of *noblesse oblige*, and that there was in fact a "natural aristocracy," of talent and virtuous character, that held that ethic just as a matter of course. Mohammad Ali claimed "Service to others is the rent you pay for your room here on Earth." And Dave Foreman, of Earth First! infamy, has advocated a similar ethic for the sake of the biosphere that gives us life and so much more. Pay your rent. Try to make your life a demonstration that you know life itself to be more important than you are. Try to leave the world a better place than you found it. To take and take and give nothing back is the very definition of parasitism. Meanwhile, the great majority of humankind seems to believe that being born is all we require to have earned or be granted the full complement of human rights and privileges, indeed, all that we need to have our full measure of worth and full justification for self-esteem. We're entitled by birthright to all we can take, subject only to our own human laws. The biggest and hardest part of taking little and giving much back is to set a lifestyle example that will inspire others to do the same. A particular challenge is making simple living look more attractive than opulence with all of its toys. We also need to find ways to help people who are still living in parochial but sustainable cultures to see past the seductiveness of our impressive growth, while still encouraging their cultural

development. It's the cargo that turns the indigenous village into the cargo cult. That comes even before the missionaries roll up their sleeves.

It might seem kind of silly to grant rights to non-living entities, like rivers, or Mother Earth, or to animals who can't speak up, especially to do so with flowery prose. This might be taking things out of bounds rationally, but some alternatives with similar effect do exist, and rights must be somehow asserted. The more honest approach, since sovereign individuals, and not appointed instruments, are the source of all rights, would be to claim proxy rights for such entities and assume the legal responsibility for defending them. Since we write the constitutions, duties can be legally held to be as sacred as rights. The reality of our need to reintegrate with nature, or suffer devastating losses to the species, should also warrant keeping the rights of future human generations within the scope of a broader declaration. As sovereign peoples, we can still secure proxy rights on behalf of these entities and declare a corresponding and inalienable duty for ourselves as stewards of this trust. This is often found in common law as a Public Trust Doctrine, but where it isn't enshrined in the highest laws of a land, it really lacks the teeth to take any necessary bites out of bad actors, particularly multinational corporate ones protected by such things as trade agreements. There is also something fundamentally wrong with any conception of rights that doesn't acknowledge reciprocal duty. Of course the obvious is often implied: our rights end where others begin. But here we may need to make this explicit and make "others" refer to all living beings and the systems that sustain them.

12. The Dimension of Human Ignorance and Misinformation

Honest ignorance, or simply innocence, may be the least of our problems, especially when we can get to the innocent during cognitively formative years, with or around parental consent. As proposed in the beginning, our human parasitism is, at least to a large extent, cultural, and therefore learned. Policy intervention is vastly more effective in the young. If you're trying to do good, then you want to start with the kids and have a generation or two worth of patience. But our parasitism is also culturally viral, by design. It sells itself to the innocent and unsuspecting. Wisdom will sometimes need to get more assertive to counteract this, but this comes at the risk of the backfire effect, where those infected with misinformation will double down and defend an error with renewed vigor. Willful ignorance, or *amathia* in Greek, is a much more intractable problem. And between this and innocence is a complicated array of levels of unknowing, such processes as defective cognitive heuristics, emotional overreactions, cognitive biases, coping strategies, psychological defense mechanisms, and logical fallacies. It's frightening to know how much we need to wade through to get even a small group of people to awaken to the seriousness of our global problems in even a small portion of its detail. We are like winos, doing suicide at the cowardly pace. But where can sobriety come from in a hive mind without any real agency? Our denial can look at life in sub-Saharan Africa and take no action, and still see no population problem. Denial won't make these problem go away, any more than it does for the drunkard or the junkie. It only raises the long-term costs and makes the problem harder to end. Do we merit being stripped of the *sapiens* in our name? I would switch that for *ignoramus*. "Man is something to be surpassed."

For some of us there is the question of how much patience we can afford. How can we assert that the globe and its commons now need to have some equivalent to rights that are superior to those of nations, states, corporations, and religious ideologies. We also need to own a duty to stand proxy in defense of these claims. We should already be at the same level of urgent care that we might see in a global war or an alien invasion. But even the most progressive elements of the status quo are only pushing for a gradual greening of the status quo. The governments "suffering" from declining birth rates are actively campaigning for increased birth rates. The economists are digging in to defend the Ponzi economies. We are out of time for the gentlest solutions, while denial runs too deep for anything more than dismissal of any problem at all. We know that monoculture is nowhere close to an answer, but the Bible still calls it a sin to plant two different crops in the same field (Lev19:19).

The human problem, or the Club of Rome's *problématique humaine*, has powerful supporters, and deep pockets full of encouragement. Our common troubles serve the short-term agendas of a heinously wealthy minority. The forces arrayed against system correction are social, economic, political, and religious, and they are well-entrenched in the institutions there. Sometimes it seems like the rebels are stuck wearing loincloths, only setting examples of questionable impressiveness, and using our words like Cassandra tried to do. The people we need to turn around with these words are the voters and the consumers. The people actively working against global health are as much of a minority as those working for it. It's the vast murmurations of humanity between them, being swept along, directed and manipulated more that a little too effectively through the media, that we still need to persuade to a more sustainable path. It's hard to change things with no movement there, and the mob isn't known for its genius. The worst and most frustrating effect of willful ignorance is that it delays

system feedback, our perception of and response to genuine crises that are headed our way or already upon us.

In grade school, my generation spent hours under our desks playing "duck and cover" to the sound of practice air-raid sirens, imagining our little bodies instantly fried in a nuclear blast, wondering why the grownups were so stupid and never grew up. It was about this time many more of us started thinking there were already too many people. By the early 70s we were sure the boomer generation was waking up, and at last ready to put a stop to this unimaginable idiocy. We got excited by Malthus and the Club of Rome around this time as well, and that pique left us too. Most of us just twitched a bit and went back to sleepwalking, collecting our paychecks, and borrowing more money, while the threats got worse. There are other realistic threats we ignore today, too, like a Carrington-level CME, and we do nothing to fuse the power grid against it. That requires a present investment against a hyperbolically discounted threat. But the threat is twenty years without a power grid, without civilization as we know it. What happened to all those great lessons we were supposed to have learned? Now we are told that degrowth is bad, a threat to all we have built. Our workforce will be smaller, our militaries weaker, our populations older and overburdening the young. Governments are now campaigning for larger families. Try to spare the poor people of the world from inevitable famine and the other faces of megadeath and you're a just racist and a heretic to capitalism. You can't deny them their god-given reproductive rights to famine and social collapse. Our lifesaving proposals are recast as coercive policies denying the human right to bear and raise children. And the humanist left wing gets as irrationally hysterical about this as the right. We do go mad in herds. And the people just vote the way they're told to vote, by whoever can afford the most effective media.

Cultural inertia at the global level is a juggernaut, "mercilessly destructive and unstoppable." Much of this is sourced in path dependency, the cultural equivalent of the individual's apperceptive mass, the inertia that keeps us moving in our old directions. Culture is an edifice, built gradually over long stretches of time. The older layers become foundational and the newer layers are adapted to functioning with them. It's hard to just jump in and move fundamental values around without shaking up the entire system. Systems adapt to preserving themselves, to conserving their order, and the more a shakeup reverberates throughout a whole system, the more it's regarded a threat and dealt with accordingly. Consequently, more believable promises of improvement need to reverberate through a system as completely as anxiety, and a little ahead of it. Otherwise, the system will remain conservative. As Toynbee observed, societies that develop great expertise in problem solving will become incapable of solving new problems by overdeveloping their structures for solving old ones. The introduction of new strategies for new problems has to be done more effectively than simply floating the newest proposals. This is best done with prototypes and examples wherever a culture hasn't prohibited these outright, out of anxiety. You need to be sure that your experimental ecovillage is seen that way, and not as some Satanic coven and cult compound, if you can even get the permits to start one. Most institutions will resist or fight others that threaten in any way to replace them.

For systems to run well, accurate real-time feedback is a must. But in the current system, the manipulation of information has become both an art and a science. Data can be delayed, distorted, reframed, censored, filtered, inverted, and discounted by anyone with control of the media. The media has largely fallen into the hands of transnational corporations, both in their ownership and indirectly through their advertisers. It's pretty safe to claim that transparency in matters of global importance is now a thing of the past, except in private publication. The discrepancies between what

people are told and what is really happening don't often become clear until lies can no longer explain global events, or a major crisis wakes people up to the fact they've been lied to. Sometimes this comes too late and a whole sub-system of the global order collapses. We are just too plucky in our sense that necessity will provide a timely solution in proportion to the urgency, so we can let things grow more urgent in order to make our responses more efficient. This error also demands a sense of being "too big to fail," like Rome had. We may yet learn the hard way how big a dieback it will take to finally set us in motion.

Human beings have important psychological needs for a sense of who they are and why they must do what they do. They want a sense that what they believe is correct, so they look to ideological consensus in the social order. They also want a strong sense of which groups they belong to and where they stand in the social order. Being without these can be loaded with anxiety, and once they get hold of something that finally comforts them, it can be nearly impossible to loosen that grip of theirs. But since the birth of advertising and propaganda, identity, belief, and belonging have become extremely effective tools in social and economic engineering and control, particularly useful to those who can afford to employ them and buy the media time to deliver them. Misinformation will get all the rich sponsors and is freely seeded. But if you want to read that new scientific paper on childhood adversity, you will have to go through a paywall.

The manipulation of personal fear and insecurity across whole populations, particularly at the levels of nationalism or patriotism and religious fervor, is one of the more frightening things we do. We do get strength in numbers, but often at great cost to intelligence. It used to be that social insecurity was the big factor. You wanted to be part of the group that got the social rewards, or if you couldn't belong, you could serve them and get some of that trickle down. But more recently, economic insecurity drives much of social control and engineering. Fundamental to this effect is getting the people to get ahead of themselves, living beyond their means and in debt, so that even a month or two without income can be catastrophic. This will keep the working class obedient and following the advice of their betters. This can be used to kill labor unions. Public education gets dumbed down to prepare the lower classes for servitude.

The points of view that we see things from can be altered either by our own choice or managed by others. Most of us can be maneuvered into a single point of view and cemented in place in that one true perspective. Then we will see just what we are intended to see, and mind what our minds are narrowed to mind. But some of us are able to see things from multiple perspectives at the same time, which gives us an added sense of depth. We can respond to situations in varying ways, and can choose different emotional responses to them. Do we need to be taught how to do this?

Besides changing point of view, we are also able to switch our frames of reference around, to see things in different lighting, metrics, scales, and contexts. The process is called reframing, and there are a few ways of doing it. A small frame of reference can leave us small-minded. Marketing ploys using terms like green and sustainable can shrink a comparison frame down to yesterday's product versus today's, so that a 10% improvement is all the difference in the world. Spatial reframing can get us thinking outside the box, too, without even changing the metaphor. That's often where the real options are, the substitute resources and materials, the decouplings, the divestments, the changes of plans, and escapes from diminishing returns. But we need to inhabit a larger world and that can lead to anxiety and too much of freedom.

We can manage what ingredients will go into a discussion. Control of the universe of discourse may not entirely censor things from a conversation, but it certainly helps us to misdirect and refocus. The WWF Living Planet Report between 2008 to 2016

dropped their old conclusion "with the world already in ecological overshoot, continued growth in population and per person footprint is clearly not a sustainable path" (2008, p. 26). The use of the word overshoot drops from 35 to 4 times. We have to wonder what pressure they were under to do this. The problem got a lot worse, not better, in those eight years. Was it a major donor to the cause? Somewhat earlier, a discouraged Peter Scott, a WWF founder, said "I have often thought that at the end of the day, we would have saved more wildlife if we had spent all WWF's money on buying condoms." How could they have fallen that far from the cause when we're all supposed to be advancing? Noam Chomsky wrote, "The smart way to keep people passive and obedient is to strictly limit the spectrum of acceptable opinion, but allow very lively debate within that spectrum – even encourage the more critical and dissident views. That gives people the sense that there's free thinking going on, while all the time the presuppositions of the system are being reinforced by the limits put on the range of the debate." We need to take better charge of the terms under discussion and the scope of what's being debated.

Our limited time horizons may be one of our weakest features as a culture. Temporal reframing usually calls for expanded or deeper time horizons, as with the "seven generations" principle. It puts life's evolutionary "struggle for existence" into billions of years of context, and it makes creationists' heads explode with rage. Perhaps springboarding off a Greek proverb, Rabindranath Tagore wrote, "The one who plants trees, knowing that he will never sit in their shade, has at least started to understand the meaning of life." Now our boards of directors can't seem to see past the next quarterly report, and our politicians, the next election. Yet these are the people we trust to sequester nuclear waste with a hundred millennia half-life. We might build dams with fifty years of vision, but fail to figure damage from both silt and no silt, or the cost of removing the dam in year 53. Waste and pollution must be held at or below reabsorption rates, but how can you measure rates if you have no sense of time? The right questions aren't being asked. Both Gandhi and Bucky Fuller are often quoted about Earth having plenty for everyone, pending certain social or economic adjustments. These are still quoted today, although the population has tripled since those words were spoken and the error has become more obvious. Are the elites as oblivious as they seem to the trajectory they are on? Wouldn't they otherwise have to see that they have even more to lose than the poor when it all comes crashing down? They are, after all, more invested in bubbles than in bunkers. We need adaptive intelligence to keep up with a changing niche, meaning that we need to look ahead farther to notice the direction that the changes are taking. We need it to understand irreversible environmental changes. This gives us what Jared Diamond calls "the courage to practice long-term thinking, and to make bold, courageous, anticipatory decisions at a time when problems have become perceptible but before they have reached crisis proportions."

As you may have noticed, the human problem is complicated enough to be called a wicked problem, and in all probability, too complex to ever fully solve. Karin Kuhlemann has drawn a connection between wicked problems and "unsexy" global catastrophic risks, notable for their multi-dimensionality, interdisciplinary demands, resistance to predictive analysis, politicization, and gradual or "boiling frog" development: "There are too many moving parts and feedback loops, complex patterns of cause and effect that impose a high cognitive cost onto anyone attempting to engage with these problems." Yet we have to appeal to vastly simpler intellects, who might equate holistic thinking with "feeling instead of thinking," instead of intelligent systems analysis. The big, multi-dimensional problem invariably gets broken up in such minds into small, bite-sized, one-dimensional chunks, and dealt with one bit at a

time. Even lay greens or environmentalists will largely neglect the big picture and longer time horizons, and only concentrate on a single cause or effect. Whack-a-Mole, the arcade game in which players strike toy popup moles with mallets, provides a wonderful analogy to non-comprehensive, piecemeal solutions that result only in temporary gains. The struggle never ends, and the r-strategist moles like it that way. They have plenty to spare.

The United Nations' population projections offer us a very clear example of one-dimensional thinking. These are based solely on human reproductive choices, taking no account of any coming collapses in the environmental and socioeconomic support systems that enable temporary population overshoot. We could be well into an involuntary dieback by 2100, beginning in the r-strategy populations that have nowhere to run. And some of that killing will be done by more clear and present dangers sneaking up too quickly, like "where'd all the water go?" We can't count on the larger global population to start thinking multi-dimensionally. The problems are far too complex for the average mind. We get highly fragmented pictures of our multi-dimensional problems. People will focus all their attention or effort onto one little sliver of a problem and eventually come to see that investment as the primary key to salvation. Going vegan is the solution to all of our ills. Some other common examples are the redistribution of wealth, or better distribution of food, or solar energy. We seem stuck with having to train one army on problem one and another on problem two. But somebody has to be at the center of things, in possession of the Map to the whole human problem, with the promising intervention points highlighted, or a lot of effort is going to be wasted, and maybe much of it counterproductive. We we need reliable clearinghouses for comprehensive information.

Scientists, who tend to be specialists, don't provide any sort of guarantee that their projections will be multi-dimensional and comprehensive, or will involve any sort of systems thinking. They are more likely to see little more than their own narrow area of interest and neglect what those other scientists in those other fields are doing. Consequently, it can be hard to take scientific reports seriously, but credibility will improve with consensus across a wider variety of disciplines. We ought to consider as well that even pessimists will try to sound more optimistic than they are, in order to convince others that we still have hope and time. We see a lot of Titanic deck chair rearrangements in the scientific and academic journals, but we ought to be paying attention as well to the interdisciplinarians, who may be a little too far out ahead of the hard science and evidence, and who are still unable to provide anything close to precise numbers. This may not be such a good reason to ignore them.

A wicked problem is overwhelming by definition. There is an emotional reaction to this, often characterized by denial, or paralysis, to avoid cognitive dissonance. A solution which demands that a large population change its path dependency, values, and behavior has to work around such a reaction. Look at green parties and the larger environmental groups. Most won't even dare mention a population problem, and not just for fear of losing members and new recruits. The problems are too complex for most human minds, and way too much for committees to handle. Pieces to the needed work are in fact getting done, but the work is still getting done only in pieces, and the less glamorous and obvious pieces are getting neglected to the detriment of the needed systems thinking. Weizsäcker laments "Examples of ecological good news are restricted to local successes concerning pollution control or species protection, but offer no relief for looming global disasters."

It becomes more than a matter of picking our battles better. The fight for survival is on several fronts. Those directing the effort need to keep the larger picture in mind, understanding both the system and its many pieces, and tasking individual talents to

individual problems. The objectives need to be coordinated instead of fragmented. Joseph Tainter uses agricultural pest control as an example of the problem: “As the spraying of pesticides exacted higher costs and yielded fewer benefits, integrated pest management was developed. This system relies on biological knowledge to reduce the need for chemicals, and employs monitoring of pest populations, use of biological controls, judicious application of chemicals, and careful selection of crop types and planting dates (Norgaard 1994). It is an approach that requires both esoteric research by scientists and careful monitoring by farmers. Integrated pest management violates the principle of complexity aversion, which may partly explain why it is not more widely used.” The only advantage the problem solvers have over the troublemakers is that the latter are also unable to see the big picture, and often far too myopic to see past the next quarterly earnings report or doomsday prophesy. Wicked men, with schemes and plans but no vision, at least have weak spots to exploit.

13. Carrying Capacity, from Maximum Down to Optimum

A distinction needs to be drawn here between maximum and optimum carrying capacity. Both must absolutely be understood as sustainable in the very long-term. Both should count the number of people able to live healthy, good, educated, and meaningful lives, and not the number of people who could survive here in poverty, ignorance, and squalor, or doing nothing more than tending their gardens and eating vegetables. Carrying capacity is vastly more complicated than simply dividing current population by someone's calculation of the number of Earths we would need to support it, especially when these calculations omit a significant number of impacts and variables. This is the basis of the Earth Overshoot Day calculations, which at least acknowledges that we are already in significant unsustainable overshoot at present population levels. By far the most grievous omission in most numbers is an allowance for permitting the non-human life on Earth to truly thrive. But there are others, discussed below.

The largest portions of the difference between our maximum and optimum capacities, as seen here, can be found in three of the dimensions discussed above: 1) The Dimension of Contingency and Surplus means not consuming everything that we are able to consume, but learning to defer gratification and allow the resilience in our existential buffers to replenish. 2) The Dimension of Living Standards and Development means raising all of our survivors out of actual poverty, so that they can meet a fuller spectrum of human needs, and particularly throughout childhood and without regard to gender. And 3) The Dimension of Wilderness and Deep Ecology means outgrowing our human exceptionalism, along with our cognitive playpens of nationalism, patriotism, and religious affiliation, and even outgrowing our humanism, to become not just cosmopolitans but true Terrans, living symbiotically with all our relations. Yes, we can live here at our maximum capacity, but this is not living as well. We would have just enough of nature left to get by.

It's becoming increasingly obvious that we humans aren't going to attain to much of this voluntarily. Even decades down the road from here, there might still be a majority who deny that we even have a population problem, who deny that we are parasites, and hundreds of millions who do little more than pray that the Lord return and save us by ending it all, by closing up His shop of horrors on Earth following our liquidation sale. Our capacity for denial is as intractable as our parasitism. Still, by definition, unsustainable behavior leads necessarily to the extinction of that behavior. So where does this thought experiment leave us, if all of these carrying capacity dimensions are given due attention? It's a SWAG, or "Scientific Wild-Ass Guess" at this point. But let's try. You had your spoiler alert.

Gretchen Daly and the Ehrlichs (1992-1994) haven't really distinguished maximum from optimum, but focus discussion on an optimum. "An optimum population size should be small enough to guarantee the minimal physical ingredients of a decent life to everyone." They have cautioned that "human population sizes have never, and will never, automatically equilibrate at some level," and that realistically, "a global optimum should be determined with humanity's characteristic selfishness and myopia in mind." They have also acknowledged the need for "viable populations in geographically dispersed parts of the world to preserve and foster cultural diversity," and the need to "provide a critical mass in each of a variety of densely populated areas where intellectual, artistic, and technological creativity would be stimulated." They further note (*nota bene*) that "an optimum population size would also be small enough

to ensure the preservation of biodiversity. This criterion is motivated by both selfish and ethical considerations. Humanity derives many important direct benefits from other species, including aesthetic and recreational pleasure, many pharmaceuticals, and the very basis and security of agricultural production. Furthermore, the human enterprise is supported in myriad ways by the free services provided by healthy natural ecosystems, each of which has elements of biodiversity as key working parts." and "Morally, as the dominant species on the planet, we feel homo sapiens should foster the continued existence of its only known living companions in the universe."

Reaching for a number, they write "At the upper end, the present [written in 1994] population of 5.5 billion, with its resource consumption patterns and technologies, has clearly exceeded the capacity of Earth to sustain it. This is evident in the continuous depletion and dispersion of a one-time inheritance of essential, nonsubstitutable resources that now maintains the human enterprise … On the population side, it is clear that avoiding collapse would be a lot easier if humanity could entrain a gradual population decline toward an optimal number. Our group's analysis of what that optimum population size might be like comes up with 1.5 to 2 billion, less than one third of what it is today. We attempted to find a number that would maximize human options – enough people to have large, exciting cities and still maintain substantial tracts of wilderness for the enjoyment of outdoors enthusiasts and hermits."

The 1.5 to 2 billion number from Daily and the Ehrlichs was simplistic in its derivation, using a very limited set of dimensions, especially using energy. I can't really agree with this method, suspecting that this was more of a later rationalization to support an intuited number. But this number, given the fuller scope of limiting dimensions that we've looked at here, intuits pretty well for me too. 2 billion was our number in 1927. From a socioeconomic and political perspective, it makes sense that we were at least approaching a maximum carrying capacity by WWI, perhaps over it when the stock market crashed in 1929, and well into overshoot by the start of WWII. And around this time, many more of us were beginning to notice the environmental damage we were doing and take major steps into conservation efforts. We can take factors included in the higher 2 billion "optimum" number, and add to this all of their remaining undiscussed problems seen in the "Systems under Siege" surveyed in Chapter 4, and our challenges with the "Social Order as Environmental Support" surveyed in Chapter 5, then control these with "honest accounting," and relegate "human ingenuity" to a contingency line. With such a thought experiment, it seems as though their 2 billion number would serve us a bit better as a maximum carrying capacity. Remember that part of our honest accounting must include any irreversible consumption of our non-renewable natural capital.

A long-term optimum carrying capacity will be significantly lower than the maximum. Daily and the Ehrlichs claimed that "an optimum size is a function of the desired quality of life and the resultant per-capita impacts of attaining that lifestyle on the planet's life support systems." This qualitative phrase "desired quality" gives us reason to set some even higher standards. This number is of course a utopian ideal. There is a larger set of socioeconomic limits to be determined here. These would even have to accommodate some inequity, managed by progressive taxation, possibly to within an order of magnitude in wherewithal, and scaled either according to effort or merit. A progressive taxation should be directly applied to the mitigation of human impacts, and people should all pay their proportionate per capita share (including those who take only the minimum share). The concept of an economic floor was described in Chapter 9. This is almost certainly a much higher standard of living than that attainable by 2 billion. There would still be be a degree of variety in per-capita income and impacts associated with a necessary degree of cultural diversity around the globe.

Different cultures meet human needs in different ways. We are still only looking at global averages. But the exploiter-exploited model would be long gone. An optimum would need to preserve personal freedom and sovereignty, and realistic opportunities for self-actualization. Aside from varying outcomes, securing equal rights and opportunities would be a must. Pay for full-time work would have to allow each person to escape real poverty. But this will also maintain a vastly better degree of socioeconomic stability.

Optimum capacity should allow for the "Remediation and Restoration" surveyed in Chapter 7 as well as the "Contingency and Surplus" surveyed in Chapter 8. But most importantly, and most controversially, our allowances for wilderness and deep ecology would have to go far beyond any commonly held idea of environmental services, at least wherever humankind wasn't using these for its real necessities, including all of the global commons that we share with the biosphere. Optimum would have to take steps that are well beyond the simple survival of the biosphere demanded by the maximum, and leave an environment that was fully biodiverse and in robust good health once again. Even the resources and capital being used by humanity to meet its own needs would have to be regarded as a usufruct. Given all of this, it seems fairly safe to suggest that this utopian combination would draw optimum human numbers down to around 1 billion, roughly our population in 1804. That just doesn't seem like too much of a setback in exchange for the world we could have in return, but we might need to become a lot more sapient to get there. In either case, maximum or optimum, the only way out of our present mess runs straight through significant depopulation and consumptive degrowth. In the big picture and deep time, there is no downside to that. We need to have fewer children, live simpler lives, and really see that there's more to this world than its human infestation.

Time, of course, will tell us what these two numbers were or should have been. But it will make big difference whether we can manage our population descent before we really start a dieback or crash. Without better population management, which now means nothing less than significant reduction, we may never have the leisure to govern by vision instead of by crisis. Much of the smoothness of our civilization's operations relies not on our best and brightest minds, but on hive mind, which in turn requires either things to run smoothly on their own, or to maintain a systemic resilience that we are seriously compromising on multiple fronts by flirting with more than a dozen tipping points at once. A serious breakdown of order now will force a very large number of specialists to learn general skills in too much of a hurry. Our hive mind could suffer a widespread dementia. The grocery stores will run out of milk and eggs. The costs of overpopulation will not just be our nations. It could be civilization, and with it, the means to come up with our magical techno-fixes and fly off to mine the asteroids.

Further Reading

Abegão, João Luís Ramalho. Human Overpopulation Atlas, Vol. 1. Master's Thesis, Universidade do Porto, 2018.

Abegão, João Luís Ramalho. "Where the Angels Fear to Tread: Immigration, Population and the Identity Question." *Overpopulation Atlas (*June 2019) 20 pp.

Belcher, Oliver, et al. "Hidden carbon costs of the 'everywhere war': Logistics, geopolitical ecology, and the carbon boot- print of the US military." Wiley Online Library (May, 2019) 16 pp.

Bendell, Jem. "Deep Adaptation: A Map for Navigating Climate Tragedy." *IFLAS Occasional Paper 2* (2018) 36 pp.

Bourcke, Michael, et al. "Accounting for demand and supply of the biosphere's regenerative capacity: The National Footprint Accounts' underlying methodology and framework." *Ecological Indicators* 24 (2013) pp. 518–533.

Bradshaw, Corey J. A., and Barry W. Brook. "Human population reduction is not a quick fix for environmental problems." *PNAS* 111-46 (2014) 16610-16615.

Bradshaw, Corey J. A., and Enrico Di Minin. "Socio-economic predictors of environmental performance among African nations." *Scientific Reports*(2019) 13 pp.

Cafaro, Philip. "Climate Ethics and Population Policy." *WIREs Climate Change* 3 (2102) 45-61.

Cavicchioli, Ricardo, et al. "Scientists' warning to humanity: microorganisms and climate change." *Nature Reviews* (June, 2019) 18 pp.

Coole, Diana. "Too many bodies? The return and disavowal of the population question." *Environmental Politics* 1-21 (2012) 21 pp.

Daly, Herman E. Beyond Growth: The Economics of Sustainable Development. Beacon Press, 1997.

DiBartolomeis, Michael. "An assessment of acute insecticide toxicity loading (AITL) of chemical pesticides used on agricultural land in the United States." *Plos One* (Aug, 2019) 27pp.

Ehrlich, Paul R. and Anne H. Ehrlich. "The Population Bomb Revisited." *The Electronic Journal of Sustainable Development* 1-3 (2009) 9 pp.

Ehrlich, Paul R. and Anne H. Ehrlich. "Can a collapse of global civilization be avoided?" *Proceedings of the Royal Society* (2012) 9 pp.

Ewing, Brad, et al. Ecological Footprint Atlas 2010. Global Footprint Network (2010) 113 pp.

Green New Deal. Full text of House Resolution 109, 2019. 7 pp.

Hawken, Paul, Amory Lovins, and Hunter Lovins. Natural Capitalism: Creating the Next Industrial Revolution. US Green Building Council, 2000. 416 pp.

Heigham, Steve. "Cultural evolution and neoliberalism." The Ecologist.org (June, 2019. 6 pp.

IPBES. "Media Release: Nature's Dangerous Decline 'Unprecedented'; Species Extinction Rates 'Accelerating'," *IPBES* (2019) 11 pp. Read Draft Chapters.

Kingsnorth, Paul and Dougald Hine. Uncivilization: The Dark Mountain Manifesto. Dark Mountain Project (2009) 68 pp.

Kuhlemann, Karin. "Any size population will do?: The fallacy of aiming for stabilization of human numbers." *The Ecological Citizen* 1-2 (2018) pp. 181–9.

Kuhlemann, Karin. "Complexity, creeping normalcy, and conceit: sexy and unsexy catastrophic risks." *Emerald Publishing, Ltd*. (2018) 18 pp.

Levin, Kelly, et al. "Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change." *Policy Sciences* 45-2 (2012) pp 123–152.

Loladze, Iraki. "Hidden shift of the ionome of plants exposed to elevated CO2 depletes minerals at the base of human nutrition." *eLife* 3 (2014) 11 pp. See also

Malthus, Thomas. "An Essay on the Principle of Population, as it Affects the Future Improvement of Society." London, 1798. 134 pp.

Meadows, Donella, Jorgen Randers, and Dennis Meadows. Limits to Growth: The 30-Year Update. Earthscan (2004) 363 pp.

Meadows, Donella H. Thinking in Systems: A Primer. Sustainability Institute (2008) 235 pp.

Mesarovic, Mihajlo D. and Eduard Pestel. Mankind at the Turning Point: The Second Report to the Club of Rome. E.P. Dutton, 1974.

Millennium Ecosystem Assessment

Morandín-Ahuerma, Indra, et al. "Socio–Ecosystemic Sustainability." Sustainability 11 (2019) 26 pp.

Motesharrei, Safa, et al. "Human and nature dynamics (HANDY): Modeling inequality and use of resources in the collapse or sustainability of societies." *Ecological Economics* 101 (2014) pp. 90-102.

Nooten, George A. "Sustainable Development and Nonrenewable Resources- A Multilateral Perspective." *Open-File Report* (2002) 6 pp.

Norgaard, Richard B. Development Betrayed: The End of Progress and a Coevolutionary Revisioning of the Future. Routledge, 1994.

Ranganathan, Janet, et al. "How to Sustainably Feed 10 Billion People by 2050, in 21 Charts." *World Resources Institute*, July, 2019. 14 pp. A good example of dreaming instead of thinking: to simply say "increase fish supply" does nothing to increase fish supply, especially while the food chain is failing.

Ripple, et al. "World Scientists' Warning to Humanity: A Second Notice." *Bioscience* 67-12 (2017) 1026-1028.

Rocha, Juan C., et al. "Cascading Regime Shifts Within and Across Scales." Preprint of text in *Science* 362-6421 (2018) pp. 1379-1383. See links at Watts.

Spratt, David and Ian Dunlop. "Existential climate-related security risk: a Scenario Approach." *Breakthrough* policy paper (May, 2019) 11 pp.

The Royal Society. People and the Planet. The Royal Society Science Policy Centre, 2012. 134 pp. Summary and Recommendations.

Steffen, Will, et al. “Trajectories of the Earth System in the Anthropocene.” *PNAS* 15-33 (2018) pp. 8252–8259.

Tainter, Joseph A. “Complexity, Problem Solving, and Sustainable Societies.” From *Getting Down to Earth: Practical Applications of Ecological Economics*, Island Press, 1996.

Trainer, Ted. “A Limits to Growth Critique of the Radical Left.” *Simplicity Institute Report* 14b, (2014) 27pp.

United Nations. “Transforming Our World: The 2030 Agenda for Sustainable Development.” (2015) 41 pp. This is a another delusional document, not recommended for its wisdom, but it’s eye-opening.

Watson, Robert, ed. Environment and Development Challenges: The Imperative to Act. Collected contributions from Blue Planet Laureates. University of Tokyo Press, 2016.

Watts, Jonathan. “Risks of 'domino effect' of tipping points greater than thought, study says.” *Guardian*, Dec 20, 2018. The referenced paper is behind the *Science* journal paywall, but the angels at Sci-Hub directed me here, where this and a few more related articles are freely available.

Weizsäcker, Ernst Ulrich von and Anders Wijkman. Come On! : Capitalism, Short-termism, Population and the Destruction of the Planet. Springer, 2018.