ESSAYS ON SUSTAINABILITY

Thirteen Challenging Essays for Earthlings

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WHEELS AND WATER

One of the first things I saw on our first TV set in 1963 was a brand new car racing around a mountain meadow to show off how one could "See the U.S.A. in your Chevrolet." The car left highly visible tracks and I immediately wrote a letter to the General Motors Vice President in charge of advertising. I protested that this damaged the fragile mountain meadow environment and, more importantly, left viewers with the impression that it was OK to drive off the road in our treasured environments and, as a consequence, it established a disrespect for ecological resources in general. I got a quick response telling me "not to worry, Dr. Black. We got permission from the US Forest Service." I immediately fired off two letters to the Chief of the Forest Service and a response to the GM VP. No responses. I turned to other matters, but my files revealed a copy of a similar letter I mailed on May 22, 1985 (I never give up). It was addressed to the Editor of *Smithsonian Magazine* protesting it having accepted an ad for a vehicle plunging through a live stream. I got no response whatsoever.

Around the early 1990s, I discovered the Chevrolet correspondence and sent copies to then EPA Administrator Browner. No response. I have since written to my local newspaper in 2006 and submitted another protest on 12/21/07: I had noted a picture of a beautiful (and expensive) new Volvo plunging through a live stream in an article on the wonderful qualities of the new car. The text even bragged about driving the vehicle through the wilderness [sic!] in New York's Catskill Mountains, the major part of New York City's water supply. Another letter; again, no response. I am happy to point out that as of this date (9/18/08) I have seen no similar photo-ads in the local paper.

The impact of these irresponsible ads of course isn't just an environmental problem: speeding and recklessly-driven vehicles in the hands of young drivers are as deadly to them as their behavior is to our environment. An equally important aspect is that along with our current oil crisis, unless we launch a campaign with a full court press, there will be continued loss of lives along with despoliation of all our critically valuable natural resources and environments, especially biodiversity, and attendant disregard for those professionals and responsible citizens who join together to protect them for everyone's future benefits. The issue isn't "reducing our dependence on foreign oil." The issue is "eliminating our dependence on oil." It is linked with an underlying need to eliminate a major source of bad attitudes toward Earth's resources.

Unfortunately, the issue is intimately tied up with private rights and freedom. It confronts the self-proclaimed rights of citizens to drive anywhere they please: "I can do what damn well want to because it's a free country, isn't it?" "Nuts to you," says the new-car owner, "I earned the cost of my SUV with my brains and brawn. I can go anywhere I want." We have, indeed, lost the sense of mutual responsibility and community values. "I own the public lands" is a dangerous illusion. Shall individual freedoms not be constrained even if it means destroying our essential environmental life support systems?

I would like to start a national campaign with the goal of making our advertising – magazines, television, manufacturers' websites, and snail mail sales promotions – dealresponsibly with internal combustion engine vehicles of all types, venues, and sizes. It will take a major creative effort, for it involves change, and must produce environmentally positive results in individuals' behavior and expectations. We might start by reminding our fellow citizens that – as many Native Americans have long claimed – one cannot own the land; one owns the right to use it only by a piece of paper, and certainly not to destroy it.

WATER AND HUMANS ON PLANET EARTH

At present, we do not know ***how much*** of any of the essential life support systems on which humans depend for sustainable living conditions we need individually or collectively. We do know, however, that many of Earth's ecological niches (that does not imply "smallness") are changing dramatically, largely manifested in current observable changes in weather and climate. We have no idea as to whether there is a "tipping point," a level of some support system characteristic(s) sensitive to both dramatic change and our detriment. If such does not exist, then humankind need not be concerned over the immediate necessity to create and apply counteracting measures. However, if such *does* exist, humankind needs to pay attention. That may be a Good Idea in either case.

Much of Earth's ***biodiversity systems*** – the wide range of life species, biomes, ecological interrelationships, and the atmosphere's physical state, the temperature, humidity, gasses (e.g., oxygen, carbon dioxide, and nitrogen in the atmosphere) that support life – is in danger, marked by dramatic change. Note the melting of ***polar ice,*** widespread demise of ***ocean coral*** and ***phytoplankton, acidification*** of the oceans, melting of ***tundra***, and wild and changing ***weather*** conditions[1]. Add the concurrent ***endangerment of species*** that, while they have no immediately obvious relationship to ***our*** species' ability to survive, clearly represent warning signals. All involve changes in Earth's ***water resources***.

As the ubiquitous and fundamental environmental substance, water is basic to Earth's biodiversity support system. The many professionals engaged in water education, research, management, and policies need to communicate. All the physical evidence scientists can gather will probably be insufficient to convince enough people to support the massive effort of ***Mobilizing to Save Civilization***[2] much less those few who understand or think they understand the true importance of Earth's life support systems. It is clear to me that Brown's clearly articulated urgent steps to halt and remediate those systems are imperative. The daily-reported changes are alarming to many in the scientific community, flood, wind, and storm victims, and those who see non-scientific but nevertheless-related signals of pending disaster and beginning stress in the form of life-threatening conditions and personal loss.

The professions (including engineering, biological, hydrological, political and governmental strategy and policy, medical, and health communities, and especially legislators and elected leaders) are prone to "fix" problems as they arise or, more likely, it is financially or politically timely. In many cases, reaction to crises has been a successful approach. However many – myself included – believe that such will not suffice to "fix" pending problems of change in our vital biodiversity support systems. Those problems are rooted in our lack of understanding of: (1) *how much* of our support systems we need individually and collectively; (2) *where* the need is to maintain the complexity of environmental conditions necessary to human survival; and (3) *unintended consequences* of our historic "fix-it" approaches.

As sophisticated, experienced, and inveterate manipulators, managers, fixers, or tinkers, Earth's most endangered and invasive species, *Homo Sapiens,* needs to figure out how best to survive: ***now.*** Simply applying our modern technical skills and political infrastructure is and has usually proved to be the wrong approach. What we need to understand and evaluate is the basic ***functional*** nature, extent, and our dependence on Earth's vital biodiversity support system(s). To whatever extent we fail to achieve that knowledge, we will fail to provide the very support on which we depend and which is currently endangered. We have the ability to react to stress, to build, measure, analyze, and perhaps even to fix Earth's biomes. However, we do not know ***how much*** they are endangered much less how to fix the damage we don't always recognize. Physically correcting inadequacies, and enhancing what we ***see*** and can ***measure*** in biological, physical, and chemical terms cannot focus on the necessary solution to our crises. Control of Earth's intricate life system through complex, technologically-based programs, no matter how much money we throw at the problem is not a viable solution. What we desperately need is ***sound knowledge, shared, discussed, understood, and applied***.

Many believe (know, panic) that the fundamental problem is an Earth-system-wide imbalance of human numbers in relation to those life-support systems. If so, humankind must determine how and to what extent we must control our numbers. If that indeed is true, we face our biggest challenge of all: ***how to humanely reduce and maintain Earth's human population within sustainable limits***.

[1] For example, now six years of tornado outbreaks in "Tornado Alley" in fall and winter instead of historical spring outbreaks: the basic *rules* don't change.

[2] Lester R. Brown, 2008 *Plan B 3.0, Mobilizing to Save Civilization*, Earth Policy Institute, 1350 CT Avenue, NW Suite 403, WDC 20036.

CLIMATE, WEATHER, GLOBAL WARMING

Climate, Weather, and Global Warming are three different but obviously connected characteristics of the atmosphere, the thin envelope of gases that enclose Earth. The three represent our environmental experience over days, years, and lifetimes. We have barely a century of reliable direct measurement records of temperature, rain and snowfall, humidity, wind speed and direction, and air pressure. (Scientists infer longer period information from tree rings, snow and trapped air bubbles in ice layers, and lake and ocean drilling cores.)

Climate is a long-term atmospheric condition defined as the sum of regional weather conditions (or average indicator values) over time. Humans' limited and recent (say, decades) of recorded experience with climate is that Syracuse, for example, has cold to frigid winters, relatively mild fall and spring, and warm summers. Within that noncommittal description, however, there is plenty of room for weather variation. Prolonged "deep freezes," blizzards, and "triple H" (hazy, hot, and humid) events are common. Typically, we don't get hurricanes and tornadoes. We can, of course, but our distance from and elevation above the oft-flooded coastal zone means that we are far from most hurricanes, and our varying elevation means that conditions necessary for tornado development are infrequent. Hurricane and tornado storm conditions often affect our weather. We do get (and have gotten) local storm events and snowmelt flooding.

Weather, on the other hand, is the local condition of the atmosphere for short periods, typically associated with high and low pressure systems that characteristically move from west to east at about weekly intervals, producing relatively short term changing – and often repetitive – conditions of temperature, precipitation, wind, and storminess. These systems and their specific conditions respond to unchanging rules about how Earth's rotation (Coriolis force), pressure, and temperature combine with gravity to form weather events. The emphasis is on "unchanging rules": they do not and will not change.

Global warming – one of the two principal types of climate change – is the relatively long-term planet-wide trend as increasing atmosphere and ocean temperatures readily exchange heat energy by direct contact, and by the evaporation and precipitation processes that take place between air and water. Warming of the atmosphere is necessary for the start of a new ice age or glacial period: as evaporation increases, white cloud cover reflects more solar energy to space shading Earth, setting up longer-term cooling favorable to build-up of glaciers and ice caps. Warming over the long haul is properly associated with the familiar "greenhouse effect," where short wave radiation from the Sun heats Earth's surface, thereby increasing the long wave radiation back toward space, energy trapped by the atmosphere. Excess warming may become a long-term characteristic of the atmosphere owing to extensive forest and grassland fires started by lightning in dry kindling that then release carbon and heat to the atmosphere in an incompletely understood positive feedback loop that may trigger major change. Current global warming is the consequence of the dramatic spurt in human population and energy use associated with the Industrial Revolution. Thus our present challenge: excess carbon dioxide (from burning fossil fuels and on which plants – but not animals – thrive), methane (from numbers of individuals and animal production), and water vapor (from increased temperature and consequent evaporation) are particularly effective in trapping the outward-bound long-wave radiation. Since more warm air flows from equatorial regions to the poles, more and more intense hurricanes are likely and during extended traditional "seasons." There still is cold air at the North Pole, and it will continue to flow south as it is displaced by the warm equatorial air producing conditions for violent storms such as tornados. I suspect that southeast Canada and northeast U.S. regions will tend to remain cooler as a consequence and perhaps not suffer as much extended heat waves as the Midwest and western U.S. regions.

The amount of carbon dioxide in the atmosphere is, to be straight forward about it, frightening. Its concentration has increased from the pre-Industrial Revolution steady level of about 270 parts per million to the current 370 parts per million, a *thirty-seven percent increase.* Methane – 23 times as potent a greenhouse gas as carbon dioxide – has increased over the same time period from 233 to 600 million metric tons/year, nearly *a three hundred percent increase*[3]. (Methane's life in the atmosphere, however, is much less than that of carbon dioxide.) Our immediate point of attack on this alarming condition should be to reduce consumption of fossil fuels to zero, immediately. However, atmospheric scientists tell us that even if that were to occur tomorrow, Earth's atmosphere would likely continue to warm for the next fifty to one hundred years. That could lead to a new ice age or eventually a carboniferous age[4], during which excess carbon is re-deposited – sequestered – in sediments respired by dead plants. Either would be a challenge to our ingenuity and survival, not to mention require considerable changes in our life styles. With the recent discovery of the existence of climate in Earth's oceans (also a global fluid, like the atmosphere) under the influence of the same environmental forces and characteristics, the limits of our environmental challenge will become more apparent.

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[3] Keppler, F., and R. Röckman, 2007 "Methane, Plants and Climate Change," *Scientific American* (296:2)53

[4] My understanding of that possibility, after talking with experts, is that it is unlikely, since such periods are associated with the precession of Earth's axis in its solar orbit cycles, and its angle of tilt relative to the Sun; the juxtaposition necessary for alignment enabling maximum solar energy arriving at Earth's land surfaces isn't due for several hundreds or thousands of years. However, …

A CATASTROPHIC LOSS OF SPECIES

Some of the news releases, articles, and summary quotations from deliberations of the International Panel on Climate Change (IPCC) are prepared to merge conflicting issues and concerns. They also keep the public (and governments) apprised of the likely course of events as the effects of excess carbon dioxide in our atmosphere from our Industrial Revolution fossil fuel power plants impact Earth's climate. These issues and concerns include informing the world of IPCC research and debate and how likely they are to be correct. Failure to react positively will result in dire consequences from continuation of our extravagant, wasteful, and damaging consumption of fossil fuels. What individuals, communities, states, and all Earth's humanoids might do to mitigate the adverse impacts of global warming come to light in discussion by the IPCC and the individuals and groups that consider the reports. Despite difficulties of composing, hearing, translating, and doing something about the IPCC's findings, it is imperative that the public have an understanding of what is really likely. In fact, Earth's myriad environments are seriously challenged. The purpose of this essay is to clarify potential impacts of global warming on us as individuals, communities, cultures, and a species.

We are experiencing major ecosystem changes. Temperature range, seasonal duration, the spread of the north and south limits of the equatorial Hadley cell influence and associated changes in plant and animal distribution will affect us all. The loss of *number* of species is not in the best interest of *homo sapiens*. And, one of our most important support systems is biodiversity, the wealth and variety of life that provides a cushion – a vital buffer – against the vagaries of disease, famine, fire, and competition for livable niches.

The IPCC recently identified rising temperatures with three possible extensions of the trend and their impacts on Earth. The optimistic forecast increase of 1.5°C for 2100 would mean up to "15% of global systems transformed." An intermediate 2.5°C rise would mean up to "20-30% of species committed to extinction." The pessimistic forecast is for a rise of about 3.5°C, would be a level at "which few ecosystems can adapt." Just below that level, there would be "extinctions of 15 to 40% of endemic species." "Endemic" is a synonym for "common." Humans are common.

Consider this challenging observation. "Humans are messing with climate and will, sooner or later, get burned if we keep it up." But just how urgent is this global warming alarm? IPCC wasn't at all clear on that, at least not in its summary reports. … Many scientists are more convinced than ever that immediate action is required. … What worries these researchers is the prospect that we have already started a slow-moving but relentless avalanche of change. And like an avalanche, it may gather irrepressible speed as it occurs. And, finally, the IPCC's occasional lack of clarity in their report implies uncertainty about "species."[5] Is that *numbers of species* or *number of members of a species*? The latter interpretation demands the attention of *Homo Sapiens.*

It is only logical to accept the prevailing view that we are part and parcel of Earth's ecosystems, whether mankind was inevitably or accidentally evolved or divinely created: what we see is what we've got. Mankind has varying degrees of cultural development, including a variety of religious beliefs, commitments to cultural values, government, art, leisure, literature, monuments, and all the learning and service industries that embody modern civilization. We humans played the major role in creating the current situation; we will most certainly endure or succumb to the consequences. In the oft-quoted and highly appropriate words of Pogo, "We have met the enemy and he is us." Nowhere are those words more suitable. Fitting every criterion, *Homo Sapiens* heads the list as the most invasive species of all Earth's life forms.

Pimentel *et al*'s (1999) estimate of the carrying capacity of our planet is 2.0 billion human beings, less than one third of Earth's current population of 6.8 billion[6]. If Earth's carrying capacity for humans shrinks to only 2 billion, then a 70% reduction in the number of individuals *within* our species will bring us into balance with our environment (see three paragraphs up). There is no doubt about there being losses of *members of species* as well as *numbers* of species.

What are we are going to do about the IPCC predictions? Two interacting problems loom: global warming and overpopulation, Will ecological principles prevail? "Lower" forms of animals often are more adaptable, less set in their ways than humans. We are habitually and culturally bound, thinking and acting as if we are detached from the concept of "species." We are not, of course. Higher species – intelligent and adaptable ones like *Homo Sapiens* – may be too set in their ways to adapt. Or not thinking! Many life forms that are environmentally dependent – e.g., Polar Bears, Pandas, etc. – may well become extinct species. But species come and go regularly: just not ours. So far. Our first and greatest challenge is determining what type, where, and how much biodiversity we need for sustainability. Ignorance and mismanagement of our diverse biomes is fraught with dangers, including potentially disastrous unintended consequences. Our second is determining how to assure our futures.

On a global scale, Lovelock's dynamic, organically behaving Earth is simply reacting to the *Homo Sapiens* global invasion in the only ways it can, with varying degrees of effectiveness and, from its standpoint, success.

Relentlessly.

[5] "How Urgent is Climate Change?" by Richard A. Kerr 11/23/07, *Science* 318(5854):1230.

[6] Pimental, D., O. Bailey, P. Kim, E. Mullaney, J. Calabrese, L. Walman, F. Nelson, and X. Yao, 1999. "Will humans force nature to control their numbers?" *Environment, Development, and Sustainability* 1(1):19-39)

THE NAKED TRUTH

Earth's most invasive species is *Homo Sapiens*. Until ***we*** figure out how to control ***our own species***, we will not have success with controlling others, which in most situations we have either set in motion or simply define as "invasive."

It is easier to be a critic than creative, so let me elaborate more constructively on this flip commentary which, I hope, as caught your attention. In truth, human faith, greed, ignorance, and stupidity may be central to our own species' demise.

At a recent (several years ago, in fact) meeting of the New York State Wetlands Forum, several speakers (as I recall) identified characteristics that contribute to the invasiveness of a lengthy list of animal and plant species, particularly in the state's waters. These attributes are as follows, in no special order and with some slight occasional degree of overlap:

1. Available/favorable ecological niches
2. Easy transport to available niches
3. Adaptable requirements for survival
4. Intra-species diversity to enable adapting
5. High reproduction rate (fecundity)
6. Freedom from predators, fungi, pathogens, insects
7. Species that is opportunistic
8. Species that is exploiting
9. Species that is aggressive

Since I am not an expert on (although I am a member of an) invasive species, I have not checked *Zebra Mussels* and *European Milfoil* (for example) to see which of these characteristics they possess, but it is clear that *Homo Sapiens* fits all nine of them.

Now you can look at my opening declaration and see that the emphasis really is that we need to understand what constitutes both invasive species *and the factors that make them invasive.* It might even be appropriate to describe them at this stage in the development of our civilization as "unintended consequences," though many of our invasive species were *intentionally* transported as "exotics[7]" from their original ecological niches to improve our environment or to show them off in parks, botanical gardens, or front yards. Probably a small percentage of what we classify as invasive species occurs naturally – that is, without a human hand – on Earth; I suspect that the majority of them spread because we *inadvertently* transport them ourselves, in ship ballast, attached to boat hulls, in or on our food, clothes, and bodies as we and products of our civilization travel around the globe. Furthermore, we delude ourselves with the term "invasive," depicting ourselves as *victims* when we are, in fact, the *perpetrators*.

We need to identify the causes of our pests' invasiveness, and to focus on the principal controlling factors that favor their invasiveness: ***us***. Put another way, it is irresponsible and probably quite unproductive to consider how to control invasive species in a context that ignores *our* role in *their* status as "invasive," and to focus instead on how we might control the factors that make plant and *other* animal species invasive. They are innocent. We are not.

[7] The tyranny of language: "exotics" is an O.K, welcome term; "invasive" is not.

ASYMMETRICAL RESOURCE DISTRIBUTION

In 1993 I wrote a paper entitled "Making Resource Use Personal and Accountable" in which I asked "How Much Resource do we Need?"[8] It discussed what today is often identified as our "environmental footprint." By 1995, it had evolved into my thinking about the overall distribution of our natural resources – and our support systems, which may be one and the same – resulting in a 1994 article "The Critical Role of 'Unused' Resources." That discourse focused on the concept of the asymmetrical distribution of our resource base, from atom[9] to cosmos, and identified the Resource Buffer Theory (RBT). This well-documented but unheralded pattern underlies the distribution of mass of the atom, Solar System and Universe; Earth's water resources, carbon, and energy distribution; biological reproduction, dark energy, and dark matter, and perhaps even time. It appears to be universal and is even replicated in human physiology and unknowingly in our culture.

I made use of an idea on how our environmental management might benefit from acknowledging this pattern and applying the understanding identified four hundred years ago by Sir Francis Bacon, who wrote "Nature, to be commanded, must be obeyed." A paper – and subsequent ones that refined the theory, its values, applications, and implications – appeared in various publications including a national symposium, and professional journals reaching different audiences. The topic has been presented at plenary sessions, seminars, classes, and talks with lay, student, and professional groups. Each of the incarnations identified even more observations about the world around us along with implications and potential for policy and management strategies and tactics. The RBT is the strategic underpinning needed for application of conservation measures to all our natural resources and support systems. Its concepts appear in articles and speeches by leading ecologists, geographers, and economists, all of whom envisage the dangers of our mismanagement of our environment by ignorance and sheer numbers of human beings. Since the RBT describes the way resources are distributed in our environment, that is the pattern we should use to assure sustainability. The many examples of skewed resource distribution need to be the subject of discussions across the disciplines, with an informed public, leaders, and responsive legislators.

An advanced civilization that had developed on Easter Island failed when the natural tree cover was lost for a variety of reasons.[10] The advanced state and lack of what we now know of that island nation's civilization was insufficient to protect the population from complete annihilation. One can be sure that it was not pleasant. Certainly, it appears that the residents of Easter Island unknowingly and, eventually, uncontrollably, destroyed their vital environmental buffer of tree cover, losing direct tree and wood-producing services, microclimate control, and protection against soil erosion. Had the society developed a balance of resource demand (numbers of residents) and availability (number of trees and, perhaps, forest acreage and/or protected soil for agricultural crops), it might have persevered. It is not difficult to translate Easter Island's development and fate from that of our inescapable island-in-space Earth and its many but limited resources. It is only a matter of scale. Of utmost importance is the care and maintenance of Earth's immense biodiversity upon which our very life depends[11].

Implications of the RBT – it *is* a theory, not a law – are of critical import to planning land use and development involving all our natural resources as our island in space approaches the numerical limits of our species. Specifically, the RBT states: *For every resource (support system) where a small proportion is essential to life processes of individuals, the greater proportion maintains sustainable environmental conditions necessary to the survival of the species.*

The RBT fits with the concept of Gaia, that Earth is – behaves like – an organic whole, creating conditions favorable to the life with positive feedback such that the environment is sustained in part by the life it creates. As the human population expands, it necessarily strains its resource and support systems bases. It will reach a point similar to that reached on Easter Island. But today's humans (hopefully) have the intelligence to understand the underlying ecology and our potential fate. To preclude the Easter Island experience on a planetary scale requires urgent understanding, education, cooperation, discipline, and leadership, as we may now be approaching a critical level between the quality of the human environment and our numbers.

Understanding the nature of the RBT is our first task. The second is guiding Earth's human support systems in a timely and ecologically sustainable manner. It will be necessary first to assess the demand each of us individually and all of us collectively place on Earth's vital resource buffers over which we have some control: forest, wetland, desert, tundra, prairie, open space, etc. Earth's oceans, estuaries, glaciers and continental ice provide vital life-support services to our well-being on the planet. Certainly, that is true of the atmosphere, yet we haven't quantified its support capacity either. Doing that may not be necessary, but it would be interesting (and perhaps helpful) to know it. Second, it will be necessary to determine how, when, and to what extent we will limit the number of our species. Along the way, we have some other challenges, as noted in these essays.

[8] Citations for all my publications (and recommended readings) are at www.watershedhydrology.com.

[9] The pattern is basic: a proton has two thousand times the mass of an electron.

[10] Cleveland, C. J., and R. B. K. Kaufman, 2008. *Environmental Science*, McGraw-Hill, New York, NY

[11] Wilson, E. O., 2001. "The Future of Life," National Council for Science and the Environment, Washington, DC.

STORMWATER AND GROUNDWATER RUNOFF

The differences between the two types (sources, if you will) of runoff – stormwater and groundwater – are critical to a variety of issues we currently face in our drastically human-altered environment. This is important because, although the natural distribution and occurrence of these two categories of runoff from rainfall, snowmelt, and storage is well known, the public at large is generally neither aware of important but subtle differences between them, nor of the potential for unintended consequences that disrupt our lives every day. Mostly, the differences are only used by professionals involved in water quality and quantity management, engineering, construction, land use planning, politics, and economics. They are either unable to help educate a public that is often not motivated, does not listen, or votes with pocket book and tax bills. The result is a chain of colossal errors in our environmental management.

For example, the June, 2008 flooding on the Cedar River (Iowa) and regional tributaries to the Mississippi River were natural events, undoubtedly worsened by increasing number and intensity of storms due to global warming, and yet within the range of historic events. Reliable sources assert that there are many reasons for the magnitude of the flooding from heavy, intense, and prolonged rainfall that was consistent with storms that would produce a 500-year flood. The terminology of the flood frequency concept is neither well understood by the public nor is it even well explained by professionals: thus, the "500-year flood" is actually a specific rate (discharge) of runoff one can expect to observe once in five hundred years in any long-term period of record. It is determined from historical data of streamflow at the point of reference, caused by rainfall (or snowmelt) on the watershed above and draining to that site. However, there is nothing in that statement that says a flow equal to *or greater than* the 500-year flood could not occur in two *consecutive* years. There is nothing, for that matter, that would prevent the five hundred year flood observed twice in the same year. Were that to occur however, it might signal a change in the flood precipitation and frequency *relationship* at that point on the river and, perhaps elsewhere as well. It is important to note too, in order to consider *all* flood events, the word "observed" should be followed by "or exceeded." That recognizes that in any given year there is *also* the chance of observing the 501-year flood, the 600-year flood, the 849-year flood, a one thousand-year flood. And so on.

Checking the news records, a remarkable yet unsurprising number of flood events take place in urban areas that include in their name "rapids," "river," "shores," "falls," "forks," "lakeview," and "creek," to mention a few. Our forbears selected those locations for communities based in large part on easy access, defense, commerce, and transportation, named them, and encouraged their growth. With twenty-twenty hindsight, their selection involved unknowing reckless infringement on the very feature that attracted settlement in the first place. Later, locally-oriented elected government representatives who, often with the chamber of commerce and/or their own businesses or close supporters at heart, created or manipulated zoning ordinances to promote development without regard for sound watershed management, a synonym for common sense.

We are in the way of the floods! Of course, periodic floods occur naturally without human interference, although they are especially enhanced by our interference with the relationship between groundwater and stormwater runoff behavior. Floods are natural characteristics of the river's hydrological environment, unique in their quantity and timing of runoff. The flow of *stormwater* in the stream is illustrated by a *storm hydrograph*, the timing of flow rate during and immediately after the storm that consists of surface and near-stream subsurface runoff, and by precipitation that falls directly into the stream channel. If storm water runoff has percolated to the ground water reservoir, some of the streamflow may also be groundwater runoff. The singular graph of *ground water* discharge, also known as *base flow*, displays variations within and making up of the *annual hydrograph* reflecting delayed time of runoff and usually less range in height than the storm hydrograph.

The characteristics of the watershed that affect the two types of runoff include the depth, type, and extent of soils and bedrock, the slope of the land, and where and how it is located. The latter interacts with latitude, determining how much solar energy (and atmospheric heat energy) is available to evaporate rain, snowpack, and soil storage capacity. In addition, there are the land use practices, planning, and economic developments that dramatically alter the land and water environment. For example, in the 2008 Iowa floods late spring rains reportedly delayed planting, so the soils were not protected from raindrop impacts, and in addition the sparse and underdeveloped young crops were not ready to transpire excess precipitation back to the atmosphere from the soil. In addition, several factors made the situation worse: (1) expanding urban areas are closer to the rivers. (2) Paving urban areas and transportation corridors have hastened runoff of potential rainfall and snowmelt that would otherwise infiltrate the soil and slow its delivery to streams as groundwater runoff. (3) Building levees higher encourages development in the flood plain itself and simultaneously reduces the storage of flood water in the natural flood plain. That raises water levels even more. Levees do not decrease floods: all they do is confine the flood flow between the levees instead of letting it spread out on the flood plain. All of these reduced the amount of available storage for runoff water. In addition, there has been historical reduction of wetlands and other riverine features that are essential to the function of the floodplain as a natural part of the river[12]. We know better. Inattention, stupidity, and greed are taking over[13]. Rebuilding after the last flood and even building in the flood plain to begin with are not Great Ideas.

In summary, floods are not *natural* disasters; they are one of several perfectly normal and environmentally functional hydrological features of river ecology. Floods become disasters when humans get in the way. The floodplain belongs to the river.

How can we clearly and effectively establish healthy relationships with our flood plains, especially the technical management details of the interactions between groundwater and stormwater runoff? It almost isn't really necessary. We *know* the differences. We *know* the causes of increased flooding. We *know* how to fix the problem. *Keep out of and ensure the natural functioning of our valuable and remarkable floodplain lands and wetlands.*

[12] Recent wetlands restoration has been part of the Corps of Engineers' overall Mississippi River management strategy, but is overwhelmed by historic and continuing abuses of the floodplain.

[13] Since Phase II nonpoint source pollution stormwater permits are concerned with *surface* runoff, near-stream subsurface storm runoff and channel interception are not directly addressed in the Phase II regulations. Consequently, the existence of a potentially important portion of stormwater runoff is not even acknowledged in flood plain management.

ECONOMY, ENERGY, ENVIRONMENT

Constant growth of our economy is both a financial benefit to our future and the source of civilization's major environmental challenge. The connection may do our civilization in unless we act to prevent it. Why?

First, we expect our economy to grow at the rate of about seven percent each year, meaning that our wealth doubles every ten years. The Federal Reserve regularly monitors and tweaks interest rates to assure smooth, controlled growth around that seven percent level. You can easily check that for yourself by examining the value of your house, your salary, the cost of your cars, or staples such as bread or milk over several decades. Consider the cost of gasoline. It was 25 cents per gallon in 1950. If it doubled every decade, it would be 50 cents in 1960, 1 dollar in 1970, 2 dollars in 1980, 4 dollars in 1990, and 8 dollars in 2000! That is what gas *did* cost in Europe. It has now reached *half* that in the United States, yet we complain bitterly about its recent rise toward that long overdue level. The anticipated cost of a gallon of gas would be $16 in 2010 having increased in value in accordance with our expected and otherwise comfortable seven percent controlled annual growth in wealth.

Second, the reason the cost of gasoline has not kept up with doubling every ten years, of course, is that the government subsidizes the oil industry justified on grounds that it needs support for expensive oil exploration and development. That may have sounded like a Good Idea one hundred or even fifty years ago: but not now, with 20/20 hindsight. Thirty years ago we discovered that we were diminishing the atmosphere's protective ozone layer, and fixed it. Today we are becoming aware of the consequences of human-caused global warming by atmospheric carbon dioxide loading from fossil fuel use. Temporarily cutting gas taxes might relieve minor local and short-term *economic* stress; but it does absolutely nothing to preserve the life-support *environmental* systems on this planet. These environments include the oceanic phytoplankton and coral reefs, rain forests, tundra, deserts, wetlands, ice caps, grasslands, and forests. Earth's wondrous water resource links all these systems, and us. Drilling for more oil in the nineteen million square mile Arctic National Wildlife Refuge would do more damage to the ability of a major natural area to provide us with those essential-to-life ecosystems. Earth's biodiversity is the ability of natural systems to absorb *within limits* the impacts of diseases, shortages, and other enhanced natural assaults. Further inroads on these areas may be committing planetary suicide, setting in motion disasters beyond our ability to control them. We are already in imminent danger of major changes to our civilized lives; next may be a series of uncontrollable changes to our sustainability. In sum, humankind is jointly mismanaging its economic and environmental resources with potentially disastrous results.

Third, attempts to find methods of creating large amounts of cheap energy are having inevitable unintended consequences. They are *not* unexpected. Many have recently written that the rapidly increasing cost of food and oil is a direct consequence of shifting a major portion of corn production for food and fodder for ethanol fuel production, and that has resulted in dramatic increases in the price of grains as well as fuel. Those consequences are piggy-backed on other related problems: the interactions may be catastrophic. The next unpleasant consequence is widespread food shortage followed perhaps by attendant riots, combat, war, starvation, and predictably, failed states. All of these likely developments are intensified by the high cost of fuel to move meager surpluses to places of great need. That is happening now, confounded in large part by the intricacies of the relationship between oil used to produce, process, and ship grains and by the markets in which both products' prices are established or manipulated. To compound our problems, the potential shift to grain-based energy currently co-driving rising prices across the board fails to alleviate the dangerous production of carbon dioxide and global warming. Interestingly, and especially in the advanced economies, neither oil nor grain are allowed to respond to "free" economic markets. The problem is not our "dependence on foreign oil" but *dependence on oil and other fossil fuels*. Period. Both oil *and* grain are subsidized, trumping potentially more intelligent and sensitive controls. Combine these facts with the extraordinarily widespread land resource in the United States and a relatively dispersed population that has not planned for efficient, inexpensive transportation of personnel and economic goods – including grain and energy – and we have a recipe for disaster in an otherwise resource-rich country. For a timely example, consider the ongoing increases in fires, floods, and storms and the current state of the insurance industry.

Fourth, the overall planet's human population is growing at a faster and faster rate demanding both more food and energy with less and less arable land, and many other natural resources spread thin. Add first the devastating impacts of global warming in the form of increasing numbers of and more intense storms, wildfires, tornadoes, floods, and droughts. Second, add the misery to which we expose ourselves along with potential – and likely – widespread conflict and sustenance shortages of energy, water, space, and food, and we face colossal challenges.

One solution is more and better conservation, the shift of rates of *use* toward the future. Conservation is the cornerstone of sustainability. We need to pay for it now, not to rely on our descendants to pay for our wasteful ways, especially when we know better. Economy, energy, and environment are inexorably linked in our civilization's mindset. Until we figure out a way to husband Earth's resources, the wealth we enjoy now will always be at the expense of our children and grandchildren. Do you have any ideas on how to fix that? Where are our priorities? Do we want the relatively low cost of our rather luxurious lives to be borne by our descendants? Or are we willing to pay for our amenities and luxuries now instead of burdening our descendants with paying for our wasteful lifestyles? We must find ways to do it.

DRILL IN THE ANWR? NO WAY!

Impacts of climate change are appearing as substantial changes in Earth's biodiversity, consisting collectively of the polar ice caps and glaciers, tundra, rain forests, grasslands, forestlands, ocean phytoplankton, etc. Biodiversity is of vital importance because it provides fundamental support for all life forms, including us; it is our essential buffer against diseases, famine, competing species, adverse climatic conditions, and the rapid changes to which we must, but may not always be able to adjust. More and more it appears that we have exceeded and therefore strained our planet's capability to maintain that support, to tolerate change within our necessity for stable living conditions.

During the past three centuries of growth and maturation of the Industrial Revolution the climate has been quite affable, favorable to humankind's dramatic increase in numbers, to our waste and alteration of precious natural resources, and our throw-away life style. In the process we have unknowingly relied on Earth's ability to absorb changes that impact our very existence. First and foremost is the nearly 40 percent increase in atmospheric carbon dioxide that increases Earth's capacity to retain heat energy, evident in the dramatic increases in severity and occurrence of floods, tornadoes, hurricanes, drought, and fire. This increase in intensity and frequency of storms is a perfectly logical consequence of global warming. More heat in the atmosphere increases the opportunity for clashing air masses with greater differences in temperatures, pressures, and moisture content, three interacting factors of weather. Simply, there is now more energy in the atmosphere, so weather events become more frequent and more violent.

All the foregoing stress is of course, augmented by the exponential growth of the human population to 6.8 billion, straining our natural resource base to the point where the world's arable land is barely sufficient to provide food for all. Arable land, energy resources, and biodiversity are all severely strained by the dangerous impacts of burning fossil fuels.

It is extremely important, therefore, that we not further jeopardize the ability of Earth's biodiversity resource base (support systems) to even run the risk of destroying our ability to survive. Human sustainability is directly dependent upon reducing our dependence on *oil*, not reducing our dependence on *foreign* oil. Humankind cannot afford further assault on Earth's biodiversity. It is the principal reason for *not* drilling for oil in the 19 million acre Arctic National Wildlife Refuge or even along the continental shelves. Those biomes have more important things to do for all of us.

THE WONDER OF WATER

"What percentage of Earth is covered by water?" I ask my class at its first session. Answers are "sixty six," "seventy five," and other incorrect responses. "Sorry," I say. "The correct answer is one hundred percent." There are gasps or "Huh?" and, after the reason for that sinks in, the "of course, I knew that" responses. I urge them to listen more carefully, to recall what I had asked. I said "water" not "the oceans." Details are important. So is the difference between the two.

Earth's atmosphere blankets the planet with water vapor, clouds of droplets and, where one can see through a cloudless atmosphere at the poles, ice (at least up until now). Had humankind first seen our planet from space instead of from the land on which they walked, they would have called it "Water" not "Earth." That is a simple and perhaps unnecessary detail; but it is an important example of how we mis-view our home in this corner of the universe, in the vastness of space. It is exemplary of how we view, consider, understand, misunderstand, and most importantly, mismanage our environment. The bottom line is that such an ecological view of our aquatic habitat is of critical importance to our survival.

Water facilitates the exchange of life support gases O_2 and CO_2 between plants and animals. Water, of course, plays the essential role in enabling the blood to exchange oxygen and carbon dioxide in the lungs' air sacs. Big deal! Everyone knows that, it is just that we have forgotten it since our elementary school science class. But consider the numbers. Oxygen makes up about 21% of the atmosphere we inhale; CO_2 makes up a scant 0.03%. Yet that miniscule level of CO_2 dissolved in our blood (meaning in water, which makes up 90% of the blood) may act as a trigger (hiccups?) that alerts our nervous system when there is too much, meaning of course that the oxygen level is too low. Recall, too, that water is the vehicle of exchange of those two gaseous components of the atmosphere by plants, through the stomates, the small openings in the plant tissue, usually on the underside of leaves. And atmospheric water vapor content – as measured by relative humidity[14] – affects the opening and closing of the stomates' guard cells that control the plants' gaseous exchange: low relative humidity, the guard cells close conserving the plant's water supply. When the relative humidity is high, the stomata open, allowing the gaseous exchange upon which animals depend for oxygen and the input – sequestration – of carbon for plant growth.

> Lesson One: water is ubiquitous, an essential vehicle and governor of our micro- and macro-environments in many ways with which we are familiar, as well as a threat to life itself in all its forms. Water is essential to life processes including gases nutrients, waste products, and materiel, involving intricate plant and animal physiological processes in addition to the distribution of energy.
>
> Lesson Two, water and carbon dioxide are yet two more examples of the Resource Buffer Theory's[15] asymmetrical distribution in that they make up extremely small percentages of the atmosphere, yet play critical roles in life processes. The pattern prevails and, maybe more importantly, is itself a universal characteristic of life and our many environments, linking life's forms in viable and sustainable niches and processes.

You and I – in fact, we *all* – might need to ask at this point (noting that water operates as a life regulator and ingredient at a great variety of scales) *how* does water support our sustaining micro- and macro-environments? It surely does, behaving as a variable feedback mechanism in global warming, atmospheric and ocean climate constituent and control, flushing and supplier of nutrients, life's essential gases, and temperature regulation. And, perhaps, hiccups.

Thus, it is logical that, on a larger scale, water plays similarly essential and significant roles as regulator and material in our internal and external environments: plants, atmosphere, and animals. Its collective unique properties, including existence at Earth's normal temperatures as a liquid, solid, or gas, high specific heat, existence everywhere, and its many life-supporting functions constitute the web of life. How does global warming fit in? Simply as human interference with the atmosphere's CO_2 content, intimately associated with water and the intricately interrelated life processes. On the other hand, it is not simple. The web of life is about much more than humankind's biological composition and operation. It is about how we relate to and survive in our watery world.

It is all part of the wonder of water[16].

[14] The amount of water vapor as a percent of the amount of water vapor that the air could hold at that temperature and pressure.

[15] See essay number 6.

[16] For a more comprehensive view of the "celebration of the wonder of water," see the wide range of free two-minute essays at public radio (www.prx.org and a listing of all titles at my website http://www.watershedhydrology.com/html/WaterDrops.html.

BUFERING SANDS OF TIME

Humans live within the rather narrow range of Earth's upper lithosphere (terrasphere) and lower atmosphere with a variety of special life support systems linked by water and life. Humans, along with all other life forms, provide the means of transfer of energy, gases, and matter – mostly dissolved in water – between those two spheres. What is there that we might learn from our natural environment thus defined about how the violent energy of weather, ocean waves, earthquake, and tidal wave resist yet allow change?

The hydrological regime – that is, the relatively small zone within which humans live – is remarkable in that it is structurally governed by a relatively simple concept, articulated it in a number of classical maxims, proverbs, sayings, axioms, or simply truisms. "There is strength in numbers;" "Don't put all your eggs in one basket;" "Many hands make light work;" and others. Detailed consideration of such articulations, along with that wonderful phrase "the pulse of the planet" may hold a greater collective truth.

Nature – the sum of the substance and interactions between and among our multiple environments – is governed by incredible and perhaps unfathomable numbers of repetitions (in time[17]) and replications (in space[18]) because that is the only way conditions for life can exist, be created, or evolve (take your pick). Consider why the relentless energy of waves crashing on the beach does not greatly change its form much from day to day. That massive amount of energy – a force against which we cannot stand (we cannot even stand against a waist-high flowing current of more than about four feet per second) – is dissipated by the billions and billions of grains of sand. Each responds to the wave-crashing energy individually and interactively with other sand grains, perhaps just as the incredible numbers of stars – and comets, asteroids, and dark matter – absorb, rearrange, and maintain the energy of the universe. **Paradox: the result is an overall stability based on continual change.** The same concept applies on dry land where there are similarly billions and billions of soil particles, plus organic material absorbing the rain's impact. Wind, rain, burrowing animals and insects, growing vegetation, and the mind-boggling power in the expansion of water as it freezes maintain the myriads of channels for the movement of water that would otherwise erode the soil as it moves from atmosphere to terrasphere. Yet another example is of the size of Coast Redwoods' needles: they are quite small in diameter, an observation evaluated by the Aeronautical Icing Research Laboratory as being the most efficient in removing moisture from fog-laden air that daily bathes the trees. It seems reasonable that that small diameter played a similar role in the 1962 Columbus Day storm that battered the coast of northern California, Oregon, and Washington blowing down thousands of trees, but not Redwoods[19]: were the large numbers of minute needles able to – similarly to sand particles – able to dissipate the massive wind energy?

There is a danger in acknowledging such a simple idea as a panacea. But there is also danger in not doing so. That, of course, is that attempts to overpower natural processes usually won't work. I recall one example from the 1960s: in order to preserve and render reliable a stable channel entering California's Humboldt Bay, the Corps of Engineers emplaced about twelve multi-ton chunks of concrete designed to mark and stabilize it. A tidal wave removed (or buried?) them all in a few minutes without a trace. The beach along the spits of land that separate the bay from the ocean, however, absorbed the energy without what you and I would call major change. Sea walls are vulnerable; sand particles are not.[20]

Beaches adjust as each particle of sand moves back and forth multiple times in response to tidal wave and normal, everyday waves generated by normal temperature- and pressure-induced winds. Ignoring this fundamental and universal phenomenon signals a failure to understand, celebrate, and preserve the endlessly multiple channels for rainfall and snowmelt to enter the soil, and for wave energy and ice to provide multiple channels for energy dissipation. It is, perhaps along with time itself, our ultimate buffer against the forces – the energy – of nature, of the universe.

The apparent success of humans to overpower and control the environment is a myth, a myopic illusion of apparent mastery of our surroundings and faith. Nature will out, and unless we take into account in policies, planning, design, construction, and management details the collective intelligence of all the poetic maxims people have *individually and collectively* [sic!] created, we cannot escape – nor should we *try* to escape – the natural forces or our oversimplified understanding of the universe. Think about it! It is even apparent in the word itself: universe.

[17] For example, the beating heart, breathing, seasons, ocean waves, orbital periodicity, orbital motion of the atom, Solar System, and the Universe….

[18] For example, grains of sand, soil particles, seeds (and eggs and sperm), cells of life, genes, chromosomes….

[19] There is reference to some Coast Redwoods being blown down in local newspapers, but it did not appear to be widespread.

[20] While it is true that massive sea or flood walls, piers, and other structures may provide the hydraulic and hydrological controls we seek, eventually they will fail. I believe we would do well to heed the message of the RBT (Essay 6) along with experience in trying to control nature's forces.

ECOLOGY AND CIVILZATION IN A WATERY WORLD

Our **universe** was created by forces we may never need to understand much less agree upon. Nevertheless, some things are evident.

Earth consists of minerals, gases, water, and life forms.

Earth's solid, gaseous, and liquid **geosphere** orbits our Sun maintaining temperatures at which solid, liquid, and gaseous water can co-exist.

Earth's **atmosphere** contains gases, including water vapor.

Earth's **biosphere** – organic compounds containing carbon, hydrogen, oxygen and nitrogen – sustains local and global ecological conditions through gaseous and liquid water reactions. Gaseous exchange at air-water interfaces occurs by plants breathing in carbon dioxide and exhaling oxygen, the reverse of animals. Liquid water also moves nutrients, wastes, and energy. Continually adapting life forms create environmental conditions beneficial to life, and *vice versa*.

Earth's **Hydrosphere** connects those three spheres in the water or hydrological cycle, our understanding of the movement and storage of water on the planet. Water is an essential substance of and for life, the vehicle of gaseous and aqueous exchange of nutrients, cell and organ substance, and waste products, and is a classical example of the Resource Buffer Theory. It is also the major player in the energy balance of the planet (and universe?) interacting with sand and soil, as well as an energy storehouse itself. It is of vital importance to our understanding of the terrasphere's beaches and soils, two segments we heedlessly alter to our detriment.

There is a common asymmetrical **pattern**[21] to the distribution of (probably) everything in the universe – water, mass, space, time, dark matter, and energy – all derived from the distribution of mass in the simplest atom's proton and electron.

Nothing I have examined contradicts this pattern. It is universally characteristic of our earthly support systems: the natural resources and the support systems on which we depend, especially Earth's biodiversity, carbon, and water.

We **violate** the pattern in our *numbers* where, according to the pattern and at the top of the food chain, we should occupy an infinitesimally small percentage of Earth's organic carbon. We unintentionally **emulate** the pattern in our *culture.*

Of utmost importance to Earth's highest organism is how its most successful and invasive species – ***homo sapiens*** – can maintain Earth's ecological balances that have persisted over the eons, resulting in customs, rules, regulations, and laws enabling and constraining human behavior toward our planet's resources and each other, what we call "civilization."

Civilization is humankind's probably futile attempt to achieve immortality while greedily demanding seven percent annual inflation and controlling the violent male orgasm, both of which exhibit the pattern.

[21] The asymmetric distribution of water: 97% is in the oceans, salty; 2 of the remaining 3% that is fresh water is (or was before serious global warming in ice). Of the remaining 1%, three quarters is in deep and shallow groundwater, and nearly one quarter in lakes, leaving less than one percent of all Earth's water to be in circulation between atmosphere, biosphere, soil, and us. See essay #6.

WITH A BANG, NOT A WHIMPER

(Musings on T. S. Eliot's *The Hollow Men* (1925) and global warming)

Our universe began in violence. For four billion years or more (for humankind an almost unimaginable length of time) violence has been the basis for building and re-ordering processes of our universe. Galaxies, stars, comets, and asteroids move at incomprehensible speeds over incomprehensible distances for incomprehensible periods of time, slamming into one another, pulling out or enhancing a neighbor's substance, exterminating existing conditions and substance, even spreading life's beginnings. So vast is our universe that that violence can continue without our being adversely affected by it (so far). And conditions on our tiny ball of rock, water, and gas adjusted until a relative long (for us) two hundred year period enabled – and/or drove – human civilization's industrial revolution and *Homo Sapiens*' incredible invasiveness.

Violence is – was then, is now, and probably will always be – in our blood, our psyche. It is pervasive to most of our evolved or god-given physiology, intelligence, invention, civilization. It probably will always be so, assuming that we do not destroy our life support systems and thus ourselves. Well we might. We may have already unknowingly started to do so. By upsetting the delicate balance of significant portions of Earth's atmospheric gases we apparently have set in motion a chain of events that could allow our corner of the universe to let violence reign, embodied in a host of unintended consequences of which we are just now becoming aware, perhaps too late for countering, and threatening our future.

Taming energy so that it is readily available – as well as desirable – for every human comfort was accomplished during our incredibly short (in the history of Earth) three-hundred-year Industrial Revolution. Altering that balance sufficiently and without the understanding or imagination to realize our folly, has restored a rising and surely unacceptable measure of violence to Earth's global ecosystems. The solar energy soaked up by plants and stored over the millennia as fossil fuels has been and continues to be rapidly released as carbon dioxide (up nearly forty percent) and methane (up nearly three hundred percent) since the seventeenth century. They must be newly accommodated in Earth's global and local ecosystems.

Three hundred years ago, Earth had a relatively nice balance: ice at the poles, and a regular flow of incoming solar energy at the equator. Short wave incoming solar radiation dissipated in Earth's spheres, and most of it returned to space as long wave radiation[22]. Warm air energy moved poleward aloft, and heavier cold air flowed southward near the surface, creating storms, circulating gases, minerals, nutrients, waste products, and water. Energy, which can be neither created nor destroyed, was simultaneously distributed; the excess stored in fossilized rock. Normal, well-understood physical laws resulted in now predictable weather patterns, slowly, gently dissipating that energy around the globe.

Where can the excess energy trapped in our natural greenhouse go now? More and stronger hurricanes will move it poleward, there displacing colder air and dissipating energy along the way producing even more violent storms caused by greater temperature gradients. There are even more violent and more frequent storms – violence if you will – over longer periods with still longer hurricane and tornado seasons. We can expect it to get worse: it is probably beyond our – but not Earth's – control.

No, humans are unlikely to achieve or boast the power to completely change, control, and/or eliminate Earth's ecosystem to the point of our extinction. But we are inadvertently working on it as unintended consequences. For us, certainly as individuals, if not for all, our world of human beings will likely end with a bang, *not* a whimper.

Unless we act. ….

[22] See Essay 3 for discussion of greenhouse effect.