EARTH'S LIFE-SUPPORTING BUFFERS

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Introduction

My concepts of environmental buffers has evolved since 1993[1]. This is not a typical research paper with testable hypothesis, data collection, analysis, rigorous evaluation and testing, proof of conclusions and a nice neat statistically convincing wind up. It resulted from reading, observation, contemplation, discussion, and more reading. I have presented several versions of the relationships between humans and resources as public discussions, seminars, classes, and professional conference sessions, keynote addresses, and three published journal articles. Some of what I have observed is from discussions with colleagues and students of all ages and specialties. It has been a fascinating journey; and it is not over. Join me in considering the details and implications of the title.

There appears to be a readily identified and rather simple, common, repetitive, and profoundly intriguing *pattern* describing the distribution of all natural resources and support systems throughout our many environments at all scales. The pattern's *asymmetry* appears to be a universal characteristic, with varying proportions that fulfill vital roles in the creation and maintenance of environmental conditions that sustain us. They demonstrate the magnitude, variation of scale, and the nature of the resource or system, evidence of pattern universality: the numbers may change, but the pattern does not[2].

Most already know one or more of the asymmetrically distributed resources or systems. This paper considers the major ones, and includes some readers may *not* know: it finds common threads, threats, challenges, and suggests a theory, not a law. The theory suggests a way out of what many find to be exciting yet often challenging and depressing implications. The discovery phase is not over, and it may never be. It just makes sense.

Buffers

Ours is a universe created in and sustained by violence. A buffer is a cushion against violence, the natural disturbances characteristic of Earth's catastrophes. A buffer may be a vast space, a force, or a material shield that absorbs shocks such as temperature, pressure, wind, lightning, noise, chemical reaction, disease and infections.[3] For this article, "buffer" includes natural resources and support systems, including biodiversity. A portion of the life form, or natural buffer that surrounds us renders most of the natural violent shocks harmless; in some cases, even life supporting, allowing such events to occur often without destruction of our ability to survive. Without such buffers, the initial shock or long-term impact to our physiology would likely kill us individually or collectively. The fact that it does not frequently do so speaks to the valued functions of such buffers and, of course, the resilience of life itself. However, some past catastrophes have required incredibly long periods before new life appeared and developed.

In our immense ecological spheres (water, energy, atmosphere, etc.) we may think we have no great influence on the distribution of the resource or support system's buffer function. Not true: for many, we *do* have significant impact. That is at the core of current environmental crises: impacts that *we* created and that *we* must fix. Often, the environmental alteration is not at all difficult to achieve, especially where unintended consequences affect niches we did not think we could affect[4]. Understanding them and accepting their role(s)

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[1] All references to previously published and more technical versions of this presentation, along with recommended readings conclude this paper.

[2] The concept of a universe-wide pattern is not new: the late Lyall Watson suggested some different ones in *The Dreams of Dragons* in 1992.

[3] Includes Hurricanes, tornadoes, tsunamis, earthquakes, space debris; and the newly-crowned alpha lion kills offspring of previous king.

[4] For example, the world's amazingly rapid – and so far effective – dealing with the ozone hole crisis two decades ago.

in our environments has been by assessing environmental impact.[5] Understanding our role in the management of environmental buffers, and in recognition of our ability to maintain or restore their natural function is essential. For some we need to do it before we stress critical buffers beyond their capacity to protect us. Thus, our most critical life-supporting system, the delicately small buffer of 0.038% of the atmosphere that is CO_2 is critical to life. Increasing the annual net flux by more than 50% each year has produced a documented and nearly *40% increase* in the atmosphere's CO_2 content. Whether such a change leads to continued global warming or to a new ice age remains to be seen: half a century ago it was speculated that the increased temperature would produce more evaporation, thus more clouds, thus reflecting more incoming radiation space, reducing Earth's temperature for an ice age to start.

Natural Resources and Support System Pattern

These two different but similar categories constitute all or part of our many environments. The two are combined because they could, in most cases, be in either (human-defined) category. Thus, for us, water is both a natural resource and a support system. Water maintains planetary conditions on which we depend, provides direct services in the form of gaseous and nutrient exchange, temperature (energy) regulation, and lubrication. It is also the environmental vehicle of waste discharge and nutrient recycling without which we could not survive.[6]

Water conveys wastes from body cells, organs, bodies, communities, and all aquatic systems except the oceans, Earth's recycle bin. We would not exist without water's expansion as it freezes, enabling life's survival under winter's ice. High specific heat enables water to limit extremes of temperature and humidity and is the medium that transports the oxygen and carbon dioxide in our blood. We would not be here without the surrounding oceans that absorb shocks of space debris, atmospheric gases, solar energy, and, in addition, provide life forms – synthesizers – that, like those on land, are primary converters of solar energy to carbohydrates, food for simple life forms at the base of the food pyramid. Earth's food energy pyramid itself provides buffering for life forms occupying successive levels of Earth's ecosystems, also exhibiting the pattern.

We may start this examination of our many environments anywhere, but our planetary niche in the Milky Way Galaxy – the rock on which we stand and the star system in which we live – is as good a place to start as any.

Our Solar System[7]

99.9% of the mass of the Solar System is in our Sun.

- Of the remaining 0.1% that is planetary mass, 71% is in one planet, Jupiter.
- 99.7% is in the large outer planets (to which Pluto's zero mass doesn't contribute).
- A measly 0.23% is in our Earthly home.
- It is estimated that 30% of all the asteroid mass is in one asteroid.

For us, having Jupiter nearby is a buffer, or perhaps more correctly called a protector, big brother, or bodyguard. Most of the potential Earth-damaging space debris – asteroids, comets, meteors, and dust – is attracted by the mass of Jupiter and crash there instead of on Earth (Appenzeller, 2004). An exception occurred sixty five million years ago (and perhaps other times) when dinosaurs and most other life on this planet was exterminated by an asteroid impacting the Gulf of Mexico. Scale up, now, to the known universe.

[5] Formally started by the National Environmental Policy Act 42 USC 4321, 1970

[6] Although I didn't become aware of Lyall Watson's chapter "The Wonder of Water" until well after this paper was written, it is worth citing here, and joins the mid-century works by Guy Murchie and Davis and Day, all cited herein.

[7] Weast, 1977. *Handbook of Chemistry and Physics*.

The Universe

Dark matter (Trefil, J. 1993)[8] and dark energy (Rowan and Coontz, 2003**)** in our environments make up tiny percentages of the known or inferred total. Stars and their planetary systems, and galaxies follow the same pattern as that exhibited within our Solar System, although it is a bit more difficult to visualize (for me). All matter is made of atoms. The smallest atom – hydrogen – consists of one electron and one proton. The mass of the proton is approximately 2,000 times the mass of the electron: pattern! Surprise? No. Most of the atom is space, just like the Solar System. Is the distribution of *space* also asymmetrical? While interesting, this topic requires a wider and considerably lengthier treatment than is needed here. So, back to spaceship Earth and its life supporting oxygen dihydride.

Water

Water is a buffer in many ways. As a universal solvent, it can absorb chemicals and compounds, gasses, poisons, and waste products. As a vehicle of energy transformation with easy movement, it is involved in all chemical reactions that we know of in the universe.[9] Having established that one of the functions of water is acting as a buffer, here is the asymmetrical distribution for Earth as a whole. In addition to being one of our earliest examples of the lopsided or asymmetrical distribution of natural resources in our environment, the pattern is well known to all.

1. About 96.8 % of all the water on Earth is in the oceans, salty (from all the waste products and leached rock).
2. Of the remaining 3.2%, two thirds are (or were before the recent surge in melting) in ice.
3. That leaves less than 1% of Earth's water that is fresh. Of that:
   - 0.744% is in deep and shallow ground water, and another
   - 0.244% is in lakes that are not part of rivers:
     1. About 1/5th of all Earth's lake water is in one lake, Lake Baikal
     2. Another 1/5th is in the Great Lakes (one half of which is in one lake: Superior), and
     3. The tiny remainder (1-(0.744+0.244)) is in all Earth's other lakes.
     4. The final 0.12 % is in circulation throughout atmosphere, biota, soil, and land's drainage systems: our abundant supply of water as a natural resource.

Water has numerous other unique characteristics (Davis and Day, 1961, Watson, 1987), too. But the pattern is virtually universal.

Energy

Imagine a sphere around the Sun 93 million miles in radius, the distance from our primary source of energy. Our seven thousand-mile diameter planet intercepts a piddling *one-billionth* of the Sun's output at that distance. Pattern.

On Earth itself, the classical relationship between calories at sequential biotic levels also illustrates the pattern (e.g., Odum 1989). Thus, (solar) photosynthesizers must produce 1,000 calories to provide 100 calories eaten by herbivores, that provide 10 calories to first level carnivores, that provide 1 calorie to second level carnivores, us. Pattern.

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[8] Initial announcement of the discovery of dark matter appeared as I first wrote about the Resource Buffer Theory (Severinghaus, 1994**)**.

[9] I am on record – unfortunately not in readily rectified recorded-on-CD form – as stating that "with the exception of nuclear reactions, water is present in all chemical reactions in the universe." Water is, in fact, also included in nuclear reactions. Mea culpa.

Biota

Most of us probably learned about this pattern in grade school science, although it is rarely identified as such a universal trait except perhaps in plant physiology courses. In its most simplistic and unadorned form, the pattern here is that it takes billions of pollen grains to fertilize thousands of seeds to yield hundreds of seedlings to produce tens of trees for one that survives to maturity, so as to have at least one offspring that produces billions of pollen grains, etc. Similarly, in animal species, large numbers of sperm are produced, each one of which has the potential to fertilize an egg where only one of each is necessary. Pattern.

The combination of animal and plant life into *biomes* is of particular import (University of California Museum of Paleontology, 2008). These geographical regions vary in size, but exhibit some stable geo-ecological niche or system, including rain forests, prairie, tundra, sea ice, ocean phytoplankton, and coral reefs. It is important to note that it matters not whether such a script for life – creation, development, and demise – is the consequence of intelligent design or evolutionary accident. It is the way things *are*. What we see is what we have; we had better learn how to manage what we have; and us. This is the only pattern we have to work with and live by.

Carbon

Back to Earth. Earth's Carbon distribution is extremely lopsided. 99.976% of all Earth's carbon is inorganic, leaving 0.004% organic[10], divided about equally between terrestrial and aquatic environments. An even smaller percentage is constantly undergoing change from one form to another, thus those numbers aren't as precise as they look, but it is so small that it doesn't change the basic pattern which, like water, continues: 99.88% of the organic carbon is in plants; 0.12% in animals. With a couple of simple arithmetic operations[11], it turns out that 4% of all the planet's animal carbon is in *Homo sapiens*. That fits the overall pattern somewhat, except that it is way too big when we remember that *Homo sapiens* are at the top of the food (energy) web. We could expect that half of Earth's animal carbon would be in the simplest form of life, microbes (e.g., Whitman, 1998) and half of the remainder would be in insects and so on up the trophic ladder. Note that no humans live in the oceans, so *Homo sapiens* actually make up *8%* of the organic carbon in terrestrial animals. *That does not fit the pattern.* And if the population doubles as often predicted, that figure balloons to 16% of all Earth's terrestrial organic carbon in one species, at the top of the food chain, and *that certainly* doesn't fit.

The carbon data clearly show that Earth's human population is excessive. Even if it were to level off at about 10 billion, it would incorporate 12% of all Earth's terrestrial organic carbon, enough to be considered as "out of line" by any ecologist with or without proof. I haven't applied these numbers to the figures presented last January in the *New York Times* OpEd page by Jared Diamond (1/2/08). He pointed out that if all the rest of the world's humans were brought up to the United States' standard of living – read "resource use" – that would be the equivalent of *72 billion* people on the planet, about *twelve times* our current numbers. I don't need to, and neither do you. Clearly, *Homo sapiens* have violated Earth's natural ecological characteristic, the pattern.

Time

"Time is nature's way of keeping everything from happening at once." Googling this great quote leads to Woody Allen, but he may have gotten it from Albert Einstein. Which ever, it is both profound and humorous. The idea, however, that time also follows the buffer concept is sensible, but somewhat uncertain and more complex. There are many ways to look at time. One of them is that, as one ages, time *seems* to go by faster and faster. That could be because it *does*. Or that as we age, time speeds up, *appearing* to move fast

[10] That's life!

[11] Including about 14 kg of carbon per person

owing to our viewpoint[12], perhaps *ala* Einstein. But there remains the question of whether time can speed up or slow down at all[13], or even how to comprehend the April 2006 *Science News* release reporting that 80% of the known universe was determined to have become established in the first one trillionth of one trillionth of a second after the Big Bang. That discovery in and of itself certainly fits the model. Pattern.

The Resource Buffer Theory

Perception of commonality in our many environments suggests a theory, the *Resource Buffer Theory* that states: *For every resource [and 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.* (Black, 1995)

The statement is a theory; not a law. It can't be proven, but I am satisfied that we know full well that it is true and universal, both adequate and thorough in its ability to describe our internal and external environments. It seems to apply, too, to human habits and traditions of our ability to survive; our sustainability. It also supports the *Gaia* concept (Lovelock, 1988) that our Earth life system behaves much like an organism. If, indeed, the buffer concept theory accurately, reasonably, and satisfactorily describes the nature of nature, then it might be a good idea to celebrate and emulate its basic precept. In short, we could benefit from building the buffer concept into the policies and management of natural resources and support systems.

How do Humans Fit the Theory?

Baseball is just one man-made manifestation of the universal pattern observed for many environmental elements that ensure our sustainability. *Baseball?* Read on: natural manifestations first.

First, humans (like other animals) mimic the pattern in our internal biological nature. Thus, we can point to the number of cells in excess of the number necessary to get a job done. There are innumerable sperm to fertilize an egg; reserves of bone marrow (stored in well-protected bone vaults) to replenish blood and other bodily cells; brain cells for thinking (we reportedly use as little as 10%), etc. Our reserves and flexibility in the basic *internal* environment allows us to thrive anywhere enabling our invasiveness in *external* environments. Undoubtedly – and ironically – there are environmental buffers that shield us from the adverse impacts of failing to manage those and/or other buffers.

Invasiveness

If one examines the principal characteristics of invasiveness – normally applied to plants and lower level animals (in both cases, referred to as pests) – it turns out that human beings meet all of the nine (or so) criteria[14]. Clearly, humanoids are the most invasive of species. The lesson here is that it maybe futile to rant and rave about controlling invasive species (plants and lower life forms) when we do not control our own. It is presumptuous to attempt to control *them* without controlling ourselves, as difficult as that is sure to be. In addition, humans are the precipitating *cause* of most irksome invasive species anyhow. We might do a better job of controlling and preventing *them* if we knew how to and were responsible and effective in controlling *us* (Newbold, 2002; Vitousek, *et al.* 1997; Cohen, J., 1995). There are also several cultural examples of inadvertent human mimicry of the buffer concept. Intriguingly, our vast numbers are themselves a buffer that may absorb some of the less desirable results of overpopulation as in a feedback mechanism that might assure our sustainability. Or they might not.

[12] Grandparents know this: at age five, one year is 20 percent of your life; at age 50, one year is only 2 percent of your life. Clearly, time *appears* to go by faster as one ages.

[13] We erroneously believe – and in the process delude ourselves – that we can change time twice a year by setting clocks ahead and back an hour. It's just another illusion.

[14] The nine (distilled from several presentations about invasive species) are: (1) Available ecological niches or conditions; (2) Adaptable requirements for survival; (3) Intra-species diversity to enable adapting; (4) Easy transport to available niches; (5) High reproduction rate (fecundity); (6) Ability to change environment to meet needs; (7) Species is opportunistic; (8) Species is aggressive; and (9) Species exploits its environments.

Wealth

Perhaps one of the most intriguing observations of human civilization is the distribution of wealth. If one lists individuals' income in the United States, sorted by amount of wealth and then calculates the percentage of total wealth in each quintile, the astonishing results are in the displayed tabulation (cited in Gilbert, 2001). It is also getting worse, that is, the disparity between rich and poor grows (Gilbert, 2001; Erhenreich, 2008).

The fact that the pattern shows here, and that I obviously like how the buffer concept describes our natural universe, does not mean that I like this particular embodiment. It does illustrate quite clearly however that the buffer concept is a legitimate pattern that pervades many, if not all, aspects of our existence, not just our natural environment.

Distribution of Personal Wealth in the United States

Quintile	% of total
Richest	49.3
2nd Richest	23.0
Middle	15.0
2nd poorest	9.0
Poorest	3.7

Source: U. S. Census Bureau Data, September 26, 2000

Where we live

Just a few years ago it was reported that half the world's population lived in cities and, not long thereafter, that half the world's population lived in cities of a million or more. What causes that? Is that another example of the buffer concept? Humans band together because we are gregarious, thriving on mental challenges and friendship, sharing valued experiences, thoughts, beliefs, and material comforts best provided by joint efforts. We also band together for protection, especially in reaction to other communities (as we call them) that have different cultural characteristics than ours and with which there is conflict[15]. Some individuals, of course, are hermits, and I do not know how to explain that within the confines of the buffer concept, unless one considers the truism: "it takes all kinds." Exactly! Even if there are only a few of them! In spite of this centralization, humans tend to associate and spread out for a variety of reasons, not all of them ecologically-based (cf. e.g. Graham, 2004).

Organizations

Many organizations exhibit the buffer concept's pattern. The typical committee has a single leader, several officers, and many members to buffer the ideas of the organization, formulate a policy, to take action, and, hopefully, a large number to support the organization's mission. The same applies to leadership positions, for example, life boats (Fagan, 2004), which also applies to those who believe most strongly in the organization's principles. And, where member financial contributions are necessary, the number of individuals giving large amounts is generally few; and *vice versa*.

Baseball

Baseball? Yes, we even emulate the buffer concept in our national game. How many outfielders and infielders does it take to catch a fly ball? One. How many *are* there? *Seven*, plus two more – the pitcher and the catcher – for a total of

[15] So do other higher members of the animal kingdom, such as the Great Apes. Other animal species, such as ants, coalesce in social structure.

nine in case the ball strays or, in response to the talents of the batter, goes to a remote part of the field where no one is located or can get to it for a catch. The list goes on and on.

Dreamland

Somehow, we believe we have control over Earth's environment when the energy that drives it comes from a ninety three million miles distant source over which we have absolutely no control. Once it is here, however, it is easy to mismanage by failing to understand the delicate buffers that enable Earth's life. For example, even though carbon dioxide (CO_2) makes up a scant 0.037% of the atmosphere, this potent greenhouse gas, trapping the long-wave energy emanating from the land surfaces, has been increased *by our action* nearly 40% since the beginning of the Industrial Revolution. The warmer air, especially at the Equator, generates hurricanes that naturally move energy poleward, displacing cold polar air, and melting the ice caps, sea ice, glaciers, and tundra.[16] That increases the absorption of the incoming short wave radiation and warms the northern ocean waters directly, too. Just because the atmosphere is a huge system doesn't mean we can't affect it. We can and do. We also affect CO_2 absorption by the oceans, darkening them. That means that they, too, absorb more short wave energy[17] and can dissolve more carbon dioxide, acidifying them as well. Perhaps the atmospheric and oceanic consequences will balance – or reinforce – on another: perhaps not. We do not know. Humans modify – intensify – the ubiquitous pattern, tweaking it here and there, with massive unintended consequences way beyond our control. We could ease such impacts of "advanced," modern-luxury society by application of the buffer concept to our life-sustaining environments. To some extent, we do that now.

Redundancy

Humans already provide a wide variety of examples of redundant safety measures, for example, for individuals to avoid vehicular injury and death in modern transportation technology. They range from education to laws, speed bumps, rumble strips, governors and cruise control, police, fines and/or loss of license or freedom for violations of speeding laws, and as a last resort, air bags. Thus, redundancy itself is the buffer concept applied to transportation, housing and manufacturing building safety, food, environmental, and material threats to health, and beyond. It is about time to be concerned about recognizing the verity of the buffer concept to ensure our more comprehensive collective environmental safety, our sustainability.

How Might we make Productive use of this Theory?

When one adds in the present threats[18] of climate change, global warming, our abuse of natural resources, destruction of important carbon sinks such as oceans and rainforests, and the loss of tundra and sea ice in the north Atlantic, we face apparently insurmountable challenges to our survival, to our sustainability. Recognizing that, it is not difficult to get depressed. In fact, many of the authors who have recently written about the resources mess we're in have also noted – as have I – that we have become depressed, in large part because the challenges we face seem overwhelming. But the one thing that all people have in common is hope. I hope we can mend our ways, understand Earth's ecosystems – especially the importance of biodiversity – and find new technologies and processes that will aid us in thriving on our four billion year-old space ship. And we must.

A Way Out

We may turn to the nearly 400-year old words of Sir Francis Bacon (1620) who penned "Nature to be commanded must be obeyed."[19] This insightful and succinct concept suggests an agenda. We would be well off to determine the

[16] Here the reflectivity of the surface, known as albedo, decreases, increasing absorption of short wave radiation, and this feedback makes the ice melt even faster.

[17] Another way to look at this is that the oceans naturally adjust to be a *sink* for carbon dioxide.

[18] Brown, 2008; Diamond, 2005; Flannery, 2005; Hardin, 1968; Heinberg, 2005; Lynas, 2003, Orr, 2004; Pimental, *et al*, 1999; Postel, 1999; Roberts, 2004; Speth, 2004; Taylor, 1999; Wilson, 1993; Murphy, 2007, and others.

[19] My silviculture instructor, Stephen H. Spurr told our 1954 class that if we wanted to manage the forest, we needed to know and understand how trees grow as individuals and in stands. To emphasize the point, he cited Bacon's words. I have kept them as a guide ever since, but it was not until forty years later that I saw a new way to apply the concept to this theory and sustainability. The quotation has slightly different wording in *The Forest and the Sea* (Bates, 1960), but is essentially the same message. Bates, by the way, was also a wonderful instructor and his paraphrased message, too, is still with me: had we first seen our planetary home from space, we would have called it "Water" not "Earth."

limits and quantity of our great buffers – perhaps best as biomes – so that we might evaluate how much of each we need for survival as individuals and in existing traditional, optimum, or ideal living groups or communities. The amount would likely vary for different internal and external living arrangements, as well as for different habitats (e.g., climate, seasonal regime, distance from ocean, etc.)

Then we must determine where such support system or resource is best located (preserved or managed), and how many humans it will support, as well as how distant it can be. For example, it should not be difficult to determine (or estimate) the annual output of oxygen by trees and how much each of us takes in. And we should remember, too, that (a) humans and animals also breathe in oxygen so that probably several could share a tree, and (b) deciduous trees don't count since they don't emit oxygen in winter and most of the fall and spring seasons; evergreens are OK. Thus, it is likely that a full-grown spruce tree could probably supply several human beings as well as domestic and wild animals with oxygen for a year, but I surely do not know the numbers. Great research project! Even more important, and most likely quite difficult to evaluate, is the areal extent of patches of *biodiversity* each of us need to survive. Biodiversity (National Commission, 2004) is, probably, our most important buffered resource or support system. Biodiversity provides resilience against disease and all manner of human needs. We have, for example, tremendous colonies of bacteria in our gut. How do they get there? What are the conditions necessary for their survival? How can we maintain them? How are they re-established after we have taken an anti-bacterial drug for treatment of disease? Pose – and answer – those same questions for the domesticated and wild animals on which we partly depend for sustenance. Many of the currently threatened species will take with them into oblivion precious chemical secrets that might help our sustainability (Chivian, 2008). True, this is not a very concise project description, but it certainly is a big one, and might be a Good Idea, as well as interesting to determine at least how many people the Earth's oxygen-producing vegetation could support.[20] And determining our biodiversity resources and needs as individuals and communities is not far behind, although undoubtedly a lot more challenging research project that would allow us to state with some degree of confidence that we need *x* hectares of rainforest for each *x* thousand people within *x* kilometers of our abodes. This is not just a fanciful research challenge. It is a necessity, unless we want to experiment via trial and error (which would not be pleasant), to determine how much area of prairie, desert, rainforest, tundra, sea ice, etc. we need for sustainability.

What can we do?

So, now, the questions come up: what should we do about it? At a theoretical level, we obviously need to understand, celebrate, and emulate the pattern in strategies (policies) and tactics (management practices) of our natural resources and support systems. That, of course, is assuming that you buy all this stuff. So assume that we agree to the challenges that are to be considered in light of the discovery of the universality of buffers as an ecological foundation of our internal and external environments. To what extent do you "buy" this view of our environments? Do you think it as important as I do? Do you consider it as something to be discussed more? How might we integrate the concepts into professional conference material? Who should do it? Take the lead? Are the challenges so large that we cannot do the calculations? Is that a wise copout? How might we organize to do it?

Other questions include, how and to what extent do we spread the word about this "discovery"? What do elementary, secondary, and advanced degree teachers need to know? What do they need to present to their students? Since not all of this information is "pretty," what does one explain to a third grader? Or to the future members of a profession that involves natural sciences and/or human-made technology? This is indeed Technology and Knowledge in the interest of Society.

What do I think? If I did not think we could understand how our many environments work and that we collectively could find ways to preserve asymmetry of natural resources and support systems into our management strategies and tactics, I wouldn't waste my time on this article[21]. To the contrary, I believe that we not only *can* do it, but that we *must* do it. In order to bring that about, the message must get out. That in itself is no small challenge. Thus, I make an effort to get this message across to as many folks as possible. I hope you do too.

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[20] I suspect that – according to the *RBT* – the number of trees far exceeds our minimum needs, that it too is buffered. But *proximity* to living centers and their demands on the oxygen-supplying support system might still be important.

[21] I know it can be done, as I have done so on three major resource management projects: The Coast Redwoods National and State Park, the Mohawk Valley Flood Plain Consultant Report, and the Highlands Project in southern New York and Northern New Jersey for which I was an advisor (Black 2005).

Conclusion

The widespread *Resource Buffer Theory* pattern is clearly characteristic of our universal life support systems and natural resources[22]. Regardless of where, when, or how you believe it appeared, Earth's life is characterized by and depends upon relatively miniscule and incredibly delicate *buffers* of mass, space, time, energy, carbon dioxide, water, and persistence of vital buffers of terrestrial and aquatic biodiversity. I believe that it is in humankind's best interest to assure continued existence of the natural buffering, flexibility, and resilience of those systems to maintain the environments that sustain us. To do otherwise is reckless, irresponsible, and not in the long-term interest of life on Earth.

If you have time to read only one of the following, read Lester Brown's *Plan B 3.0:* every word.

Acknowledgments

There are too many to name here. Many are cited above and I am indebted to all. There is also is also a host of contemporary colleagues and friends and family members (also friends!) who have listened to or read all or part of my drafts, and responded with good humor to what probably seems like endless questions, including: "is this true"? "How does this sound"? "Should this be first or later"? "Does this read OK"? And so forth. Without their innumerable contributions, I am not sure I could have put all this together; and maybe I haven't yet. Any misstatements of fact or other errors are, of course, mine.

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[22] Either way, it is a clear message to us that we must stop burning fossil fuel, not because of our dependence on foreign oil (as important as that might be), but because of our dependence on the atmosphere!

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