Carrying Capacity *and* Limiting Factors

NOT just water, resources, and food, but ALSO disease, WASTES, aggression, keystone species, competition, and sheer and ever-widening levels of damage and ERADICATION

including a critique of humankind's deeply-erroneous "vast open-space" suppositions

Carrying Capacity
and Limiting Factors

How many individuals can a particular ecosystem [or planet, for example], *indefinitely support over a long period of time without suffering severe or irreparable damage?* To scientists, the answer to such a question constitutes the system's carrying capacity. Since ecosystems are finite in their size and resources, each has an upper limit to the population that it can support while continuing to provide food, resources, accommodate wastes, resist damage, maintain, perpetuate, and repair itself, and also provide the assorted *ecological services* that allow a given population to exist

(such as, for example, each day's production and restoration of most of the molecular $\mathbf{O_2}$ that we and most other animals inhale every few seconds, and pollination, and helping produce rainfall by the process of transpiration).

In 1986 Garrett Hardin likened carrying capacity to an "engineer's…estimate of the carrying capacity of a bridge." To expand on his observation, suppose that we ask: Why do finite vehicles, such as aircraft and elevators, for example, have "carrying capacities" that constitute limits to the numbers of passengers that they can safely accommodate, and/or to the weight, damages, impacts, eradications, and wastes that they can safely accommodate? If one is about to board an elevator, for example, that can safely accommodate 18 passengers and 83, 247, or 978 passengers begin to squeeze aboard, it is easy to understand that the weight and stresses of excessive loading invite and virtually ensure failures in one or more components, triggering the collapse of the entire system and the destruction of both the vehicle itself and its passengers.

A quite similar unsettling scenario can be envisioned if one imagines boarding an airplane of finite size, only to notice that a line of more and more and more persons continue to endlessly board the aircraft in which we and our families are seated. A question that might be then be productively considered, perhaps, is the prospect of more and more and more persons endlessly boarding an elevator or aircraft of limited size – a scenario which, in real-world systems, virtually guarantees calamitous transgressions of one, multiple, or many limits, tipping points, and systems thresholds.

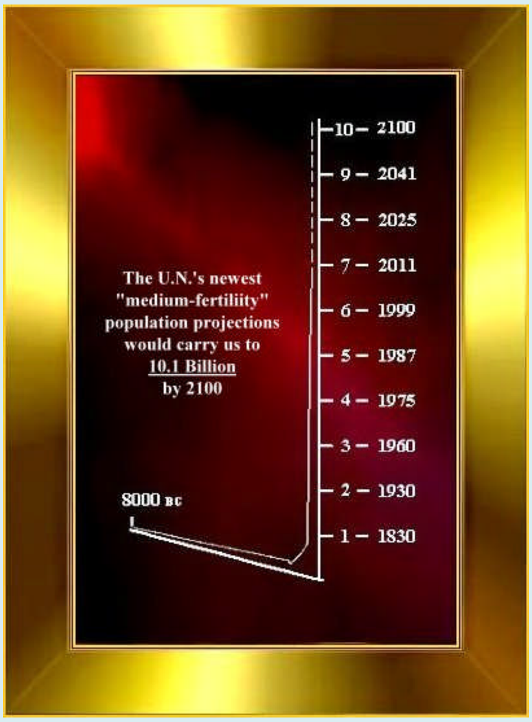
Therefore, when engineers or scientists warn of carrying capacities, overshoot, thresholds, tipping points and limits, which, if exceeded, invite potentially-calamitous systems-wide failures, we can appreciate the importance of serious attention to their warnings, concerns, and assessments.

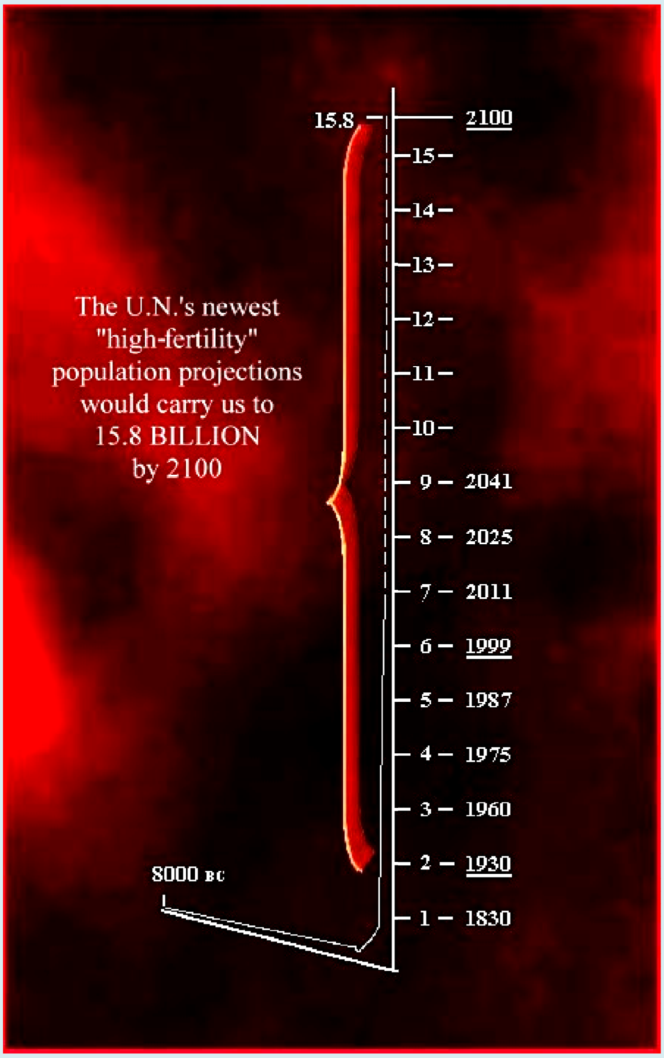
As a thought experiment, then, try to imagine a team of astronauts in a space vehicle if they were to cannibalize 95% of their guidance and propulsion systems, annihilate 93% of their heat shields, destroy 87% of their CO_2 scrubbers, degrade 77% of their computer codes, and eviscerate the other life-support systems of their spacecraft? Or, in a similar way, envision our planet as a global bus. If a bus has enough seats for fifty passengers, we would all agree that we could crowd a few extra persons on board in an emergency. But *how many* extras could the vehicle accommodate? What if 491 passengers climb aboard, or 937, or 7428?

To further extend these insights, suppose that the owner of a new and pristine automobile begins to systematically degrade its multiple operating systems, degrading 50% of its steering system, 75% of its tires, and then destroying its carburetor, most of its spark plugs, half of its axles and brake shoes, and 93% of its ignition and electrical systems, while simultaneously pouring ever more contaminants each day into its gasoline, oil, radiator, battery, transmission fluid, and brake fluid. And then suppose that this individual can't understand why his automobile, which "has always worked in the past," doesn't function anymore. Not so bright, is he?

Do we know anyone who seems to treat the only planetary life support machinery so far known to exist anywhere in the universe in a similar way?

The most important reason for understanding planetary carrying capacity, limits, systems thresholds, and tipping points is underscored by the two graphs below which depict humankind's global population history from circa 8000 BC to the present with projections to 2100. It should be especially disquieting to notice that BOTH graphs exhibit extreme and quite pronounced **J-curves**:





Above: U.N. **Medium-fertility** projections carry us to **TEN** billion by 2100.

Right: U.N. **High-fertility** projections carry us to almost **SIXTEEN** billion.

Unfortunately, the J-curve fission reactions at Hiroshima and Nagasaki at the close of World War II showed humankind quite powerfully that **J-curves** can flatten everything in every direction. It is quite dangerous that our own J-curves above are ***not*** localized events, but are global in scale. Secondly, since our planet's carrying capacity for a modern industrialized humanity is roughly two billion (or somewhat less), we are already in a state of massive OVERSHOOT.

In fact, our graphs (and the numerical skyrocketing that they depict) are so extreme as to surpass even the avalanche of growth that characterizes a typical "exponential" progression, so that some biologists have labeled such ultra forms of exponential patterns as hyper-exponential (e.g., Cohen, 1995).

Note that no amount of technology, innovation, or free-markets managed to save the passenger liner *Titanic* and its passengers from a 'Decider-in-Chief' who: (a) ignored six specific and repeated warnings and (b) who incorrectly assumed that his vessel was unsinkable.

As another thought experiment, envision a hospital that decides to treat the bodies of its patients in a similar manner by initiating policies intended to save a "representative sampling" of the cells, tissues, and organ systems of their patients? They argue that their innovative new policy, for reasons of economics and convenience, will make it far easier and less expensive to save or try to protect approximately 10% of bone, blood, muscle, heart, brain, endocrine, connective tissues, elbow joints, and some parts of the eyelids, bowels and kidneys of their patients. They point out that not only would such an approach save the hospital a lot of money and inconvenience, but that because it is so economically-compelling, it can help ensure that representative 10% samples of each patient's component parts can remain available for their families and their community. Clearly, saving tiny samples of each patient's component cells and tissues *offers no assurance whatsoever that the patient themselves as living and functioning entities will continue to survive*, so that the obvious flaw in the imagined policy is that it allocates zero thought or consideration to the implications for the survival of the complex equilibrial living entity itself and does *not even* contemplate the existence of such things as whole-systems and collapse outcomes.

How important is this? It is not an exact analogy, of course, but think of the moist tropical forests and the microscopic phytoplankton in the surface layers of the sea functioning as the "lungs of the world" because they provide us (each day) with most of the oxygen that we breathe. If we were to save 10% of a person's lung tissues and destroy the remaining 90%, could we reasonably expect the person to even survive, much less to continue to function normally?

Why then, should we suppose that earth's natural systems and environmental machinery are invulnerable? Is saving one lung and one kidney *enough*? One lung would amount to 50% and one kidney is 50%. Is that sufficient to maintain even a suboptimal level of physiological function? Or does a 50% loss of each system (*or even a* 3% *loss of each system*) constitute a new and highly precarious condition? Is it sufficient if we save some of the endocrine glands? If a person loses one lung *and* one kidney *and* half of their endocrine glands, what happens to their overall prognosis? It would appear that we need to save at least fifty percent of earth's natural and biospheric systems – *and to the extent that the above analogies hold that fifty percent may not be enough*.

Thus, humanity's currently-massive population size and growth, eradications, societal wastes, and population momentum confront earth's planetary life-support machinery (its carrying capacity for a modern industrialized humanity) with a crisis that is unfolding **RIGHT NOW** - at this very moment and in **THIS** decade, in the lifetimes of sons, daughters, or grandchildren, and of young people living today – and their generation has a right to know the demographic, carrying capacity, and population-environment data and implications set forth in this and related PowerPoints and PDFs.

So far, then, we have seen examples such as bridges, aircraft, and elevators that have **carrying capacities** which are finite limits to the sheer numbers, impacts, weight, damage, wastes, destruction, and/or eradications that such entities can safely accommodate without systems failures and/or whole-system calamities (such as an elevator with a capacity for 18 passengers as 38, 70, 788, or 3088 persons attempt to squeeze aboard as an invitation to systems-failures calamities for both the functioning vehicle and its occupants). Similarly, we envisioned an airplane able to safely accommodate 130 passengers as lines of 810 or 1678 or 2842 persons endlessly boarded one after another, permitting us to appreciate why **carrying capacity** warnings enunciated by scientists and engineers are not matters to be ignored or taken lightly as our rapidly and ever-increasing numbers OVERSHOOT the thresholds, limits, and impacts that our planet and its life-support machinery can sustainably accommodate.

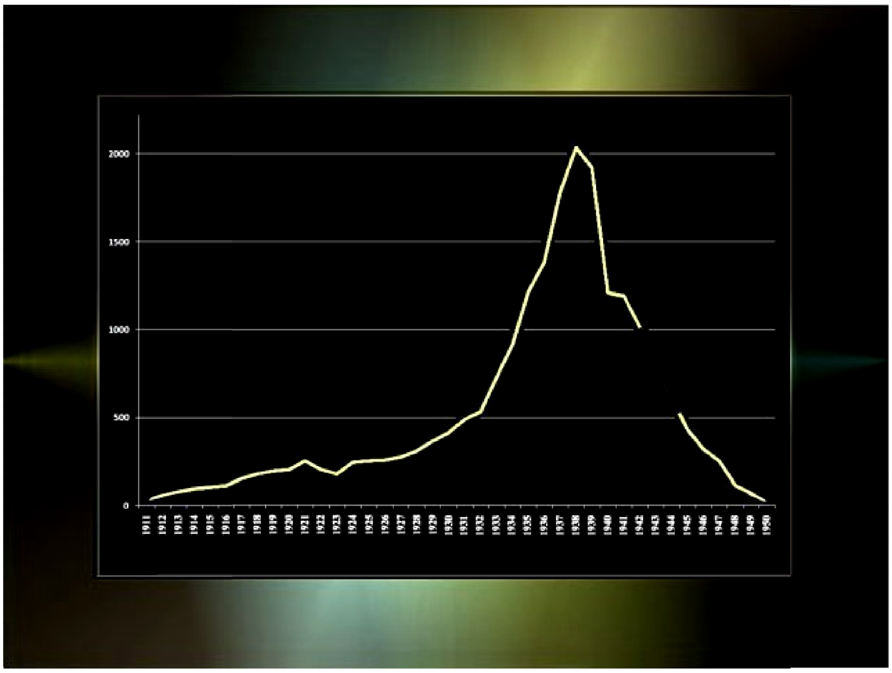
Only very foolish persons (or selfish economic interests perhaps)
would dare ignore such concepts, warnings, and data.

Three classical examples
Exceeding Carrying Capacity and Limits, Thresholds, and Tipping points:

In a classical real-world study of a "climb-and-collapse" population explosion that resulted in a nearly-annihilating 99%-plus die-off, V.B. Scheffer (1951) outlined the rise-and-fall of a reindeer herd on St. Paul Island, Alaska between 1911 and 1950. The island had no wolves, predators, or major competitors so that the reindeer population exhibited approximately 28 years of relatively unrestricted and unfettered growth. As the graph below shows quite dramatically, however, the herd's initial phase of growth, which was exponential, was followed by a massive and catastrophic die-off or collapse in which more than 99% of the herd died by the close of the study in 1950.

Underscoring quite powerfully that our discussions of carrying capacities, J-curves, limits, and massive real-world die-offs may be of profound survival importance for our own species.

The Rise and Fall of a Reindeer Herd
on St. Paul Island, Alaska

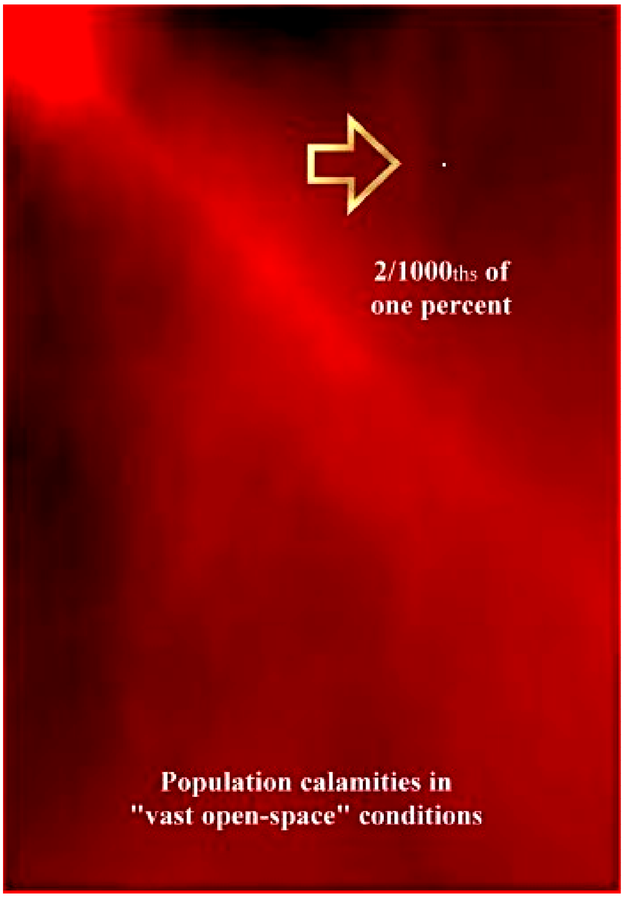


The 40 square-mile island had no wolves, predators, or major competitors for the reindeer in the study. Notice the rising trajectory of the J-curve produced as the population grew over the years. Secondly, however, notice the collapse underscored by the last data point in the graph which reflects a 99%-plus die-off *. Notice then, that in the absence of the usual predators and competitors that normally held their numbers in check, the population rocketed upward beyond the ecosystem's ability to sustain them.*

Thirdly, it should be both disquieting and quite provocative that at their peak numbers (1939) *the combined bodies of the entire herd physically-occupied roughly* 2/1000ths *of 1% of the area theoretically available to them as the collapse began, so that the die-off took place even as seemingly "vast amounts of open-space" appeared to remain theoretically available. (No data were able to be collected during* WW II.*)*

Graph is after Scheffer, V.B. 1951. *The rise and fall of a reindeer herd.* Scientific Monthly 73: 356-362.

This and similar patterns are also cited elsewhere in our "Wecskaop" collections (What Every Citizen Should Know About Our Planet).



It is important to recognize that when the reindeer population in the above study exceeded the carrying capacity of their environment, their peak numbers had already been reached and their collapse (that culminated in a nearly-annihilating 99%-plus die-off and mortalities) had already begun when the combined bodies of all the reindeer making up the entire herd, taken together, physically-occupied approximately

2/1000 ths of 1% (see image)

of the surroundings that visually-appeared to remain theoretically-available to them.

The image shown left depicts the approximate 'vast open-space' and '**too-late**' conditions the herd faced when it had already reached its peak numbers - when it was already too-late because they had already WAITED too-long.

In other words, in this classical example, the real-world population involved had already reached *and* breached its environment's carrying capacity at a time when its surroundings remained 99.998% unoccupied and in surroundings that appeared to remain ALMOST ENTIRELY EMPTY.

This above example is quite powerful because it underscores three core understandings relating to our topic of carrying capacities and limiting factors:

I. Humankind's apparently-instinctive suppositions that a population, including our own, must somehow be "safe" from overpopulation catastrophes and/or somehow distant from environmental limits as long as there are seemingly "vast amounts of open-space" in their surroundings

is a strikingly-dangerous misperception,....

for the die-off described by Scheffer took place even as "vast-amounts-of-open-space" appeared to remain seemingly-available

And in a follow-up study similar to Scheffer's, a second small reindeer population was introduced to another Alaskan island (St. Matthew Island) under much the same conditions. When the data and outcomes involving this second herd were reported (Klein, D.R., 1968), the results were similar – and equally shocking, for this second herd ***also*** grew exponentially, until ***it too*** underwent a 99%-plus die-off - *with an even more precipitous collapse* over the course of a single year.

II. The presence and activities of predators, pathogens, and competitors in an environment, individually or collectively, serve as classical regulatory or limiting factors that act to hold a population's numbers in check. And in a few paragraphs hence we will see classical examples of population explosions that result when such predators, pathogens, and/or competitors (sometimes referred to as "keystone" species) are removed from a system.

(Population explosions resulting from such removals are known as ECOLOGICAL RELEASE.)

III. Virtually identical 99.998% unoccupied (2/1000^{ths} of 1% occupied) images (as seen above) which powerfully depict "too-late" or "waited too long" conditions in TWO separate, quintessential and classical population-climb-and-collapse outcomes in the mammalian examples that we have cited, also turn out to describe catastrophic population-explosions of one-celled dinoflagellates (such as *Karenia brevis*) in marine environments that are known as RED-TIDES.

So now we have seen **THREE** classical, separate, independent, and quintessential **real-world** examples of calamitous population-environment thresholds and "too-late" conditions in environments that remain roughly **99.998%** *unoccupied* – and which visually appear to remain ALMOST ENTIRELY EMPTY.

We discuss these red-tide population-environment catastrophes
in a section of their own several paragraphs hence.

Examples of Limits, Thresholds, and Limiting factors

Given humankind's growing and already-enormous worldwide population (together with our ever-widening consumption, wastes, destruction, impacts, and eradications) one of the most important questions in the history of our species is the prospect of breaching real-world environmental and biospheric limits, thresholds, and tipping points. Thousands of examples of such thresholds, limits, and tipping points (both known and unknown) exist in real-world natural and biospheric systems. As two quick examples: (1) One instance in a biological system can be seen in human blood which has buffers that maintain its pH at a mildly alkaline 7.4 level. Seemingly small transgressions, however, beyond pH 7.3 (lower limit) or 7.5 (upper limit) result in acidosis or alkalosis, both of which are potentially fatal. (2) In a physical system under conditions of standard pressure, a pan of boiling water at 211 degrees F persists in its liquid state. If, however, one

overshoots that threshold by just one added degree, the entire system abruptly transforms into a gaseous system of boiling steam (after Kluger, 2006).

Scientists recognize a variety of limiting factors that play a role in regulating the ultimate size of a population in a given environment. This article will enunciate six or seven as examples.

> Operating on instinct alone most of us can instantly identify finite supplies of critical resources such as food and water as factors that can limit the size of a population. But just because we instinctively think of such factors first, **does not mean** that they are the *first* or *only* factors that determine a system's carrying capacity, for in fact, **other** common but less-intuitive limiting factors exist that can induce disaster long before food and water and similar "running-out-of" suppositions become decisive.

Among these many other important *limiting factors*, we have mentioned several already, such as the reindeer herds that underwent population explosions when the absence of wolves, bears, and competing species allowed their numbers to grow far beyond the carrying capacities of their environments.

> It is also important to note as well that in the absence of pressures from competitors and bears and wolves, the two herds **did not** regulate their own numbers. Instead, *they continued to reproduce* at maximum and unsustainable rates until they OVERSHOT the carrying capacity of their environments - at which time their unsustainable bills came due and their devastating 99%-plus die-offs ensued.

When population explosions occur following removal of one or more key predators or competitors from a system, the phenomenon is known as ECOLOGICAL RELEASE. Thus, when ranchers removed coyotes from some areas of the American west, for example, the removals were followed by unexpected population explosions of jackrabbits. Why? Because the coyote populations were acting as a KEYSTONE SPECIES that helped keep jackrabbit numbers in check.

Other examples exist of keystone species, competitors, predators, and pathogens that can play important roles in regulating the size of a given population. One classical example described the role of a predatory sea star, *Pisaster*, in regulating the abundance of various prey species in rocky intertidal marine habitats (Paine, 1966; 1969). In a similar way, along the California coast, sea otters prey upon (and thereby regulate), sea urchin populations that would otherwise damage or decimate the state's famous offshore kelp beds. In the 1970s and 1980s, for example, assorted papers (e.g., Estes and Palmisano, 1974; Duggins, 1980) described an ecological release that began to damage some such kelp beds when bounty-hunting of sea otters caused their numbers to plummet. Because sea otters feed on sea urchins (spiny animals which look like tiny pin-cushions and that graze upon kelp), the reduced numbers of sea otters allowed sea urchin numbers to explode in a classical case of ecological release and begin to damage the kelp bed systems.

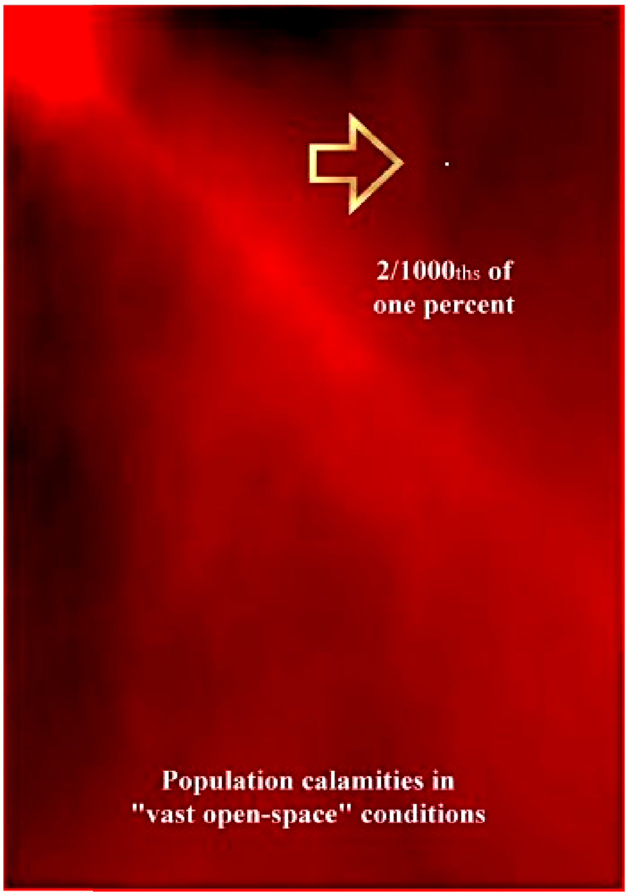
Competition pressures can also regulate population size. For instance, as populations become ever larger and increasingly crowded, increasing competition occurs between individuals within a species and between multiple species so that the presence of competitors acts as still another regulatory mechanism. As an example, among birds there may be competition for a limited number of nesting sites, while multiple populations of barnacles, sponges, and marine tunicates may compete for limited attachment sites on a pier-piling or offshore rocks.

As still another example, ever-larger and densely-crowded populations can constitute an invitation to sanitation problems and an increased likelihood of transmission of epidemic disease (e.g. Odum, 1959). Interestingly, crowding can even induce *internal limiting factors* such as hormonal, adrenal, and physiological stresses. Some studies of crowded populations, for example, have reported increases in aggression and infant mortality, as well as hormonal and physiological stress responses. Some early studies, for instance, found that crowded rabbit populations exhibit a shock disease...with enlarged adrenals, a breakdown in the adreno-pituitary system, and a wholesale die-off" (e.g., Christian, 1950, 1956; Christian and Davis, 1964; and Calhoun, 1962).

Still Another Limiting Factor -

A Limited Capacity to Accept Wastes

It is intuitively obvious to most of us that the carrying capacity of a particular environment can be limited by the amount of food and other resources that a population requires, or by other factors such as those we have already discussed. However, carrying capacities can also *be limited by the ability of an environment to accept and process the* WASTES *of a given population*. For example, in a population of yeast cells, Gause (1932) cited the effects of alcohol on new cells as the limiting factor, while, as Stiling noted in 2002, "It is interesting that in this situation population growth was limited by pollution of the environment by alcohol [and] not by limiting resources" prompting him to add that many people "think the same will be true of humans" (ibid).



As a particularly powerful and classical real-world model, the famous outbreaks of dinoflagellate **RED-TIDE** in marine environments constitute one of nature's quintessential examples of population explosions that can induce calamity (including, in this case, massive fish kills) by their release of wastes into their surroundings - *a characteristic that would seem worth noting, perhaps, since our own species appears to exhibit an extraordinarily-similar pattern of behavior.*

And the dinoflagellate populations manage to inflict their classical and quintessential population-environment disasters *even as their numbers physically-occupy* LESS THAN **2/1000**ths *of* **1%** of *seemingly "vast amounts of open-space" in surroundings* (see image) *that remain* 99.998% unoccupied - *and which visually-appear to remain* ALMOST ENTIRELY EMPTY.

Unfortunately, however, our own species **does not confine itself** to releasing only our biological, cellular, and metabolic wastes into our surroundings. Instead, we SUPPLEMENT our biological and cellular wastes, in a way that is utterly unprecedented in the history of life on earth, with billions of tons of societal and industrial wastes, so that we appear to be embarked upon a trajectory that is not only WORSE than that of red-tide dinoflagellates, but is multiple orders of magnitude worse at that – and unlike red-tides whose outbreaks are at least localized, our own outbreak is a global phenomenon with implications for the entirety of earth's biosphere.

Thus, on an increasingly-crowded fifty-passenger bus, that restroom at the back of the bus is easy to overlook until even minor crowding begins to take place. Even though the transmission, axles, seating, brakes, and engine might be stressed by ninety passengers, for example, those systems might manage to struggle onward under the load. That restroom, however, might not respond so well. Assuming a long trip, one can imagine overwhelming its capacity by the presence of as few as sixty or seventy passengers.

Upon reflection, we can see that this scenario might apply to earth, for if we assess the collective impacts that we have right now, with a population in excess of 7.2 billion, many of the stresses we see are the result of our societal and industrial wastes. Food and other resource shortages may be out there on the horizon as looming problems, *but earth's ability to accept, recycle, cleanse, and dissipate our avalanches of societal and industrial wastes* (such as CO_2) *appears to be stressed already.*

In their text BIOLOGY (1999), Campbell, Reece, and Mitchell expressed a similar caution: "It is... possible that our population will eventually be limited by the capacity of the environment to absorb the wastes and other insults imposed by humans." Joel Cohen has made a similar appraisal: "Today's rapid relative and absolute increase in population stretches the productive, absorptive, and recuperative capacities of the earth" (1995). Still others, such as Raven and Johnson (1999), remind us that "the world ecosystem is already under considerable stress."

Thus, if we rely on instinct alone and focus our attention exclusively on food supplies (which too many previous studies have done) (e.g., Revelle, 1976), we may distract our attention from other critically important aspects of our problem. In his book OVERSHOOT, William Catton wrote that: "...the capacity of the world's oceans, continents, and atmosphere to absorb the substances [*Homo sapiens*] must put somewhere in the process of living is limited. Even as a waste [pollution] disposal site, the world is finite" (1982).

Our point is this: Although it is quite appropriate to consider finite supplies of food, water, and critical resources as factors that limit a species to some ultimate population size, *we are guilty of error if we allow such topics to be our only focus of our concern.* On a passenger bus, for example, it is easy to recognize a finite supply of available seating as a limiting factor that affects the vehicle's ultimate capacity. But if we were to actually crowd additional passengers onto such a bus, while the seating might become more crowded and increasingly uncomfortable, the vehicle might still lumber forward, even with a load of ninety or more. But ever-increasing numbers of passengers, together with non-stop, accumulating, ever-widening, and ever-growing wastes, impacts, and eradications suggest that somewhere during the 30-40-50-60-70-80-or-90% **eradications** that present policies envision and may permit, one or more catastrophic thresholds or tipping points with global repercussions will almost certainly be crossed.

Thus, despite our seemingly-instinctive suppositions, an environment's sheer quantities of "open-space" rarely constitute biology's central limiting factors because ***other*** limiting factors come into play much sooner. As a result, even though our "vast-open-space" suppositions seem to constitute a natural "intuition," in reality they constitute an exceedingly-dangerous misperception that acts to blind us to the degree, extent, and proximity of the marching calamity that is underway.

A neglected limiting factor: Levels of sheer $\boxed{\text{eradication}}$ of physical, environmental, and biospheric systems

As populations become larger and/or more crowded, they commonly inflict damaging changes to their physical and environmental surroundings. *Each ecosystem has an ability to maintain itself and to resist or heal physical damage, but these capabilities have limits.* For example, when lakes and ponds undergo **eutrophication**,* they demonstrate damaging changes that are inflicted by the populations that they host.

* Eutrophication constitutes an over-fertilized condition resulting from animal wastes or fertilizer run-off, etc.

If plants and other autotrophs living in a lake or pond are nourished with abundant nutrients (e.g.-from animal wastes or fertilizers) they respond with a burst of exuberant growth. *The problem is, dissolved oxygen levels in the water are limited.* Each night at dusk, even though photosynthetic ***production*** of oxygen ceases, the crowded and over-abundant populations living in the pond continue ***consuming*** the limited supply of O_2 all night long.

In this case, heterotrophic microbes utilize the available "O_2 faster than it can be replenished," resulting in "complete depletion of O_2" (Prescott, 1999). When this happens, the pond or lake becomes ANOXIC (without oxygen), thereby suffocating essentially all aerobic populations in the pond, and a similar process produces anoxic "dead zones" in ocean habitats. In these events, then, we see calamitous changes that result from too many organisms drawing on a limited resource.*

* *Also notice that the problem here is **not** due to limited supplies of food and nutrients.*

Instead, in this instance, extra nutrients actually serve to fuel the growth that leads to depletion of the O_2 that ends in collapse.

Damage to the physical environment can also be inflicted by vertebrate animals like ourselves. We see, for example, that when elephants are confined to small areas, they destroy the very trees and vegetation needed for sustenance. In the same way, when predator populations were reduced near the Grand Canyon in the early 1900s, local deer populations exploded, and began to consume "...every leaf of available vegetation" (Odum, 1959). *Nearly everywhere we look and nearly everywhere we travel, we see evidence that our own species is inflicting physical and chemical damage to earth's ecosystems and to our biospheric, climatic, and biological environments.*

"Open-space": An extraordinarily-dangerous misperception

As noted earlier, when discussing or contemplating population limits, we are easily and too often tempted to imagine that a growing population may eventually "run out of space." The data sets that we offer next, however, argue quite powerfully that such perspectives can be extraordinarily dangerous. The term "space," for example, technically refers to a mathematical area or volume, so that the resulting problem then, is this: The term carrying capacity *does **not** refer to the sheer number of individuals whose bodies can physically-squeeze into a given area or volume.*

First, among mammals, the two real-world data sets mentioned on pages 6-7 involved reindeer herds on Alaskan islands (Scheffer, 1951; Klein, 1968) which each underwent a boom-and-bust population explosion that concluded, in each case, with a catastrophic 99%-plus die-off.. It is particularly worth noting that in each case the die-off both began (and proceeded to near annihilation) in seemingly "vast open-space conditions" when the *combined bodies of all the individuals* in each herd physically-occupied roughly **2/1000ths** *of* **1%** of the island area that visually-appeared to remain theoretically-available to them (see tiny white dot in image below).

This should cause us to reevaluate our own extraordinarily-dangerous and (seemingly-instinctive) suppositions that center on 'vast-amounts of open-space," for we have now seen THREE, separate independent, classical, and quintessential examples of ***real-world*** population-environment calamities in surroundings that visually appear to remain ALMOST ENTIRELY EMPTY - (except that our own outbreak is not a localized event, but instead constitutes a planet-wide phenomenon.)

Thus, the image shown here should be both worrying and disquieting - for, as both of our classical reindeer climb-and-collapse outcomes show, (including their catastrophic 99%-plus die-offs) together with the even worse dinoflagellate red-tides in marine systems, real-world population explosions both can (and do) transgress "**too-late**" thresholds in environments that remain **99.998**% **unoccupied**.

In other words, as underscored by the tiny white dot in the above image, the 99%-plus die-offs that we cite both began (***and*** proceeded to near-annihilation) in surroundings that remained 99.998% unoccupied and which visually-appeared to remain

ALMOST ENTIRELY EMPTY.

Next then, let us for imagine, as a thought experiment, that the population represented by the tiny white dot in the illustration happens to be a sentient species and that, *at the point in time depicted above* some members of its scientific community begin to issue warnings concerning carrying capacity, overpopulation, overshoot, and population limits, together with wastes and eradications in finite systems.

First, what is the likelihood that many members of the population will believe the assessments *when instinct seems to invite them* to imagine that any population calamity must surely not be catastrophically-critical when such vast "amounts of open-space" appear to remain theoretically-available in their surroundings?

In fact, however, as ALL THREE classical, separate, independent, and quintessential real-world climb-and-collapse calamities and die-offs that have been cited here show quite powerfully, if the scholars and leaders of such sentient populations were to WAIT until the conditions depicted in the image appear, they will have

already waited **TOO LONG**

for the image denotes, in a proportionally-correct way for all three examples, the moments in time when the populations have peaked and the onsets of collapse and die-offs ***have already begun.***

Thus the image depicts, in a proportionally-correct way, the roughly **2/1000**ths *of* **1%** climb-and-collapse die-offs (and/or even worse mass mortality outcomes) that we have seen in routine out-breaks of dinoflagellate red-tides in marine systems (which can include, for instance, fish-kills in the millions of tons),[1] as well as two separate, independent, and quintessential real-world climb-and-collapse population disasters seen in two classical studies of real-world reindeer herds on Alaskan islands in the Bering Sea.[2, 3] (For a synopsis from these reports, along with the supporting mathematics for the **2/1000**ths of **1%** figures we cite, see reference "4" below.)

1 - Bushaw-Newton, K.L. and Sellner, K.G. 1999. *Harmful Algal Blooms* IN: NOAA's State of the Coast Report, Silver Spring, Md. NOAA.
http://state-of-the coast.noaa.gov/bulletins/html/hab_14/hab.html
Also: http://oceanservice.noaa.gov/websites/retiredsites/sotc_pdf/hab.pdf

2 - Scheffer, V.B., 1951. *The rise and fall of a reindeer herd.* Scientific Monthly 73: 356-362

3 – Klein, D.R., 1968. *The Introduction, Increase, and Crash of Reindeer on St. Matthew Island.* Journal of Wildlife Management 32: 350-367.

4 - "Too-late" population conditions in environments that are 99.998% unoccupied: Three classical examples of calamitous population-environment thresholds in real-world systems. PDF, The Wecskaop Project PDF and Biospherics Literacy 101
http://www.scribd.com/doc/81278312/Population-Boundaries-Real-world-Collapses-and-Calamitous-Die-offs#fullscreen

Summary: "The Open-space" Delusion

We thus see that relying upon an unjustified "open-space" intuition as a criterion upon which to judge earth's planetary carrying capacity for an industrialized humanity constitutes ***an extra-ordinarily dangerous misperception.*** Beyond the data already cited, for instance, and the points already made, imagine a national park in Africa and its carrying capacity for lions. Although the enormous measured areas of a large reserve might allow us to physically squeeze hundreds of thousands or even millions of lions into such a park, to ***sustain*** even small numbers of lions, first there must be vast game herds with populations large enough to allow a *harvestable surplus* of zebra and wildebeest and similar grazers.

Secondly, these vast game herds, in turn, require *still greater expanses* of grasslands to sustain their grazing and seasonal migrations, together with adequate supplies of water. As a result, hundreds of square kilometers of "open-space" are required to support even a small population of lions. Thus, to erroneously imagine that millions of lions might occupy a reserve simply because its mathematical dimensions could physically accommodate their bodies constitutes a gross mis-representation of ecological, biological, and biospheric reality.

It is clear, of course, that attachment sites for marine invertebrates such as sponges and bryozoans might, in one sense, be considered "space-limited" resources. And, to establish nature reserves for conservation purposes, expansive quantities of "space" are essential if viable populations are to persist. Soule, for instance, observes that even the largest nature reserves and national parks today "...*are usually too small to contain viable populations of large carnivores*" (Soule, 1985; emphasis added). Consequently, the sheer physical dimensions (area or volume) of available space, while necessary, incorporates other more-immediate limiting factors that operate and exert their influences within that space sooner. We have already seen, for example, not just intuitively-obvious limiting factors such as supplies of food and water and resources, but also predation, disease, environmental damage, territorial disputes, waste accumulation, aggression, and competition between and within species, as well as cases of hormonal, physiological, and/or behavioral stress.

Hence, the sheer quantity of seemingly-available "space" is seldom biology's central limiting factor, which means that although the apparently "vast open spaces" of the American west or the Australian outback or the Mongolian steppes collectively contribute to biospheric equilibria, they do not connote "space" for billions and billions more humans. A growing yeast population, for instance, can poison its grape juice environment with ethanol even when the combined yeast cells themselves physically-occupy a volumetrically-insignificant portion of the bottle or vat in which they reside. Similarly, populations of dinoflagellate cells routinely poison hundreds of square kilometers of the sea even as the cells themselves occupy volumetrically insignificant portions of the "space" in which they live.

Likewise, the occupants of a eutrophic (over-fertilized) water body can induce lake-wide ANOXIC conditions (a lethal depletion of dissolved oxygen) even though the actual volume that is physically-occupied by their bodies and cells *constitutes an insignificant proportion of the total volume available*.

(See Biospherics Literacy 101 "Open-space" PowerPoints and PDFs for further elaboration on these "too late" topics.)

THREE CALAMITOUS POPULATION THRESHOLDS IN 'VAST OPEN-SPACE' CONDITIONS
http://www.scribd.com/fullscreen/81278312?access_key=key-r945rtq3hxbe7lnfn68

POPULATION CALAMITIES IN LARGELY "EMPTY" ENVIRONMENTS?
http://www.scribd.com/fullscreen/18695522?access_key=key-1w8nmjhkgenpvbghmsad

PPT 4 – RAZOR THIN FILMS - ATMOSPHERE AND SEAS
http://www.scribd.com/full/28709867?access_key=key-2nz7qoeakn2mqnl8h5o5

Shoulder to Shoulder? And "too late" conditions

One occasionally encounters blogs or talk show discussions in which a little mathematics is used to suggest that "all the people on our planet could stand shoulder to shoulder in an area the size of Minnesota." *While such statements may initially sound persuasive, notice that they are actually founded upon exactly the same fallacious* "available open space" *ideas that we have just been discussing*. Upon reflection, however, and as many of our PowerPoints and PDFs also show, such statements omit enough key considerations that they render themselves invalid.

To show the fallacious nature of such comments, for instance, we might simply offer a modified version as follows: Suppose someone suggests that, mathematically speaking, we could physically squeeze all of earth's wildlife populations shoulder to shoulder into a geographic area "X" that is, for argument's sake, the size of Minnesota.

Imagine, then, squeezing every chimpanzee, elephant, buffalo, bird, mountain lion, squirrel, giraffe, orangutan, musk oxen, harbor seal, tarantula, manatee, cow, komodo dragon, tiger, whale, butterfly, parakeet, boa constrictor, ostrich, kangaroo, marlin, sailfish, sea urchin, jellyfish, and rhinoceros shoulder to shoulder into an area the size of Minnesota. Even if this could somehow be done in a grotesquely physical sense, it would be ridiculous to imagine it to have any relationship whatsoever with real-world systems.

First of all, such a scenario leaves no room for the woodlands and forests, or the waters, rivers, streams, grains, food, expansive grasslands, intertidal zones, and specialized habitat niches needed to support viable, self-sustaining, interacting, and self-perpetuating populations of such organisms. Secondly, the scenario shows a disingenuous or utterly uneducated view by those offering the supposition in that it omits any consideration or contemplation whatsoever of the environmental needs, demands, interactions, damage, destruction, eradications, and waste products that would accompany such an aggregation. And thirdly, the ensuing chaos and carnage resulting from movement, competition, aggression, predator-prey interactions, elimination of wastes, food and resource consumption, and habitat eradication would be unimaginable.

In the same way, assertions that imagine crowding all of humanity shoulder to shoulder into some imagined geographic area "Z" are just as fallacious. Why? Because they ask us to mistakenly *presume* that the physical "amount of space" constitutes the principle limiting factor affecting our species.

To achieve a more realistic appraisal of a carrying capacity, it would be more appropriate to ask how many people can live in Minnesota (or on our planet or any other locale) on a long-term basis (many generations) if they must rely solely on the resources and waste-cleansing capacity of that environment alone.

The Global Dashboard

A passenger bus, airplane, or space vehicle has warning lamps on its dashboard that light up to indicate trouble. On earth today, we already see a disconcerting number of warning lights beginning to light up the global dashboard. Examples of these include accelerating emissions of greenhouse gases, disappearing wilderness, massive deforestation in the tropics, melting permafrost, acid precipitation, collapsing fisheries, falling water tables, desertification, disappearing polar ice, ozone depletion, expanding dead zones in the seas, and an imminent mass extinction that may become the greatest biological disaster since the disappearance of the dinosaurs.

(e.g., IPCC, 2007; Begley, 2007, 2008; Ellis, 2003; Myers, 2007; Kerr, 2006; G.C.A., 2008; Buncombe, 2009; Pimm, 2001; and Johnson, 2007).

Our planet already began to show such signs of stress by 1987 with a world population of five billion, and these many signs of stress have grown even greater with the arrivals of our **sixth** billion in 1999 and our **seventh** billion in 2011 (and now we add approximately *seven million more* each and every month) (after PRB, 2012). Even if our population were to magically stabilize later today and were to not grow at all thereafter, *what will happen when that portion of humanity who are not yet industrialized attempt to emulate developed and industrialized standards of living?*

And what will happen as we add still more *impacts, eradications, damage, and wastes as we add billions numbers* 10, 11, 12, 13, 14, *and* 15**.**8 *over the next eight decades?*

How long can earth's biological, climatic, waste-cleansing, and environmental machinery survive the growing, accumulating, and ever-widening impacts of our explosively-growing numbers?

We don't know the exact answers to these questions yet, but children now living are likely to find out.

Other Passengers

We are not alone on our global vehicle, for other species occupy much of the available seating. Today, however, with billions of additional human passengers endlessly boarding, *these other species are being displaced at an unrelenting and accelerating rate*. By mid-century, for example, "...large species, and particularly large predators, will be by and large extremely scarce and some will have disappeared entirely" (Jenkins, 2003). Continuing, Jenkins adds: "almost all wild lands in the tropics will be impoverished in numbers and diversity of larger animal species" and concludes that continuing loss of forests in Indonesia, Madagascar, and the Philippines will "have a par-ticularly high impact on biodiversity" (ibid). Likewise, Pulitzer Prize winner Thomas Friedman cites a Conservation International estimate that a “forest area the size of three hundred soccer fields is cut down in Indonesia every hour” (Friedman, 2008).

In 2007, for instance, the United Nations Environmental Programme (UNEP) issued a biodiversity assessment (Last Stand of the Orangutan) including assessments of deforestation in Indonesia such as: "Given the rate of deforestation in the past five years…" [referring to 2002-2007], "and recent widespread investment in oil palm plantations and biodiesel refineries… new estimates suggest that 98% of the forest may be destroyed by 2022, the lowland forest much sooner."

Since the "late 1990s," they say, "the rate of deforestation and logging has increased," and "the rate and extent of illegal logging, may, if unchallenged, endanger the entire concept of protected areas worldwide." (Nellemann, et al. 2007; http://www.unep-wcmc.org/last-stand-orangutan_127.html)

Note that the above appraisals testify to two sobering and quite disturbing trends: (a) rather than being resolved, Indonesia's deforestation problems are unfolding even more quickly than previously anticipated, and (b) even national parks are not working.

On its page nine, the UNEP report offered still another disquieting assessment: "As a result of logging, infrastructure development, internal migration, and plantation development, Sumatra's forest area was reduced by **61%** between 1985 and 1997 (ibid; see also Bennett, E., et al., 1999).

Notice that at a reduction rate of 61% in twelve years, if actual hectares-removals remain unaddressed and are simply repeated, **the loss is so rapid as to be essentially unstoppable**.

One lesson here is that the informational lag-time alone *makes it virtually impossible for even politicians and citizens who are honest and concerned* (and powerful enough financially and politically) *to act or intervene* ***in time*** *to halt or prevent the obliteration.*

And it turns out that PALM OIL plays a leading role in the above deforestation, for, as the report observes, palm oil is "…already found in ***one in ten*** supermarket products, including margarine, baked goods, sweets, detergents, and lipstick" [not to mention its role as "the most productive source of diesel fuel"] (emphasis added).

(Nellemann, et al., 2007; and see also Bennett, E., et al., 1999).

Thus, if our own species suffers because of our own actions or inactions (or our use of diesel fuel, margarine, and lipstick), that suffering will be self-inflicted. But what about all the other passengers aboard our global bus?

Do other species have a right to exist?
Is it our right to drive them to extinction?

Or does there exist a moral imperative to preserve our biotic inheritance and the fabric of life on earth?

At the edge of a forest, we see vines that compete with trees for sunlight. In the backyards of our homes, we see squirrels that compete with birds for birdseeds. In Africa, hyenas compete with lions for a carcass. And similar instances of competition exist throughout the natural world. Today, however, ***humans compete with wildlife for wilderness***. And in such a competition, wildlife and wilderness stand no chance.

Columbia's Jeffrey Sachs, for example, has likened (2008) today's industrialized fishing fleets to “hunter-gatherers with machine guns," noting that “the natural prey is simply no match for the incredible power and technology of modern fishing fleets, complete with fishnets that stretch for miles and satellite-based tracking of open-sea schools of fish.”

Note here that ‘technology’ does **NOT** serve to solve the problem, *but instead permits us* to make things worse *more quickly, extensively, and efficiently than ever.*

Today, a hungry, poor, and rapacious humanity – along with the economic engines of our wealthiest societies – lays waste to the natural world at a rate unparalleled in human history. Which, if any, species will survive the holocaust that is now underway? What portion of earth's biota will we drive to extinction in the years just ahead?

In closing

What happens when a population overshoots the carrying capacity of its environment? What evidence will we see when such overshoot has occurred or is occurring? Might humanity be in an overshoot mode already – ***right now?*** (Yes we are.) What happens to other species when they overshoot the carrying capacity of their environments? To what extent have our advances in medicine, life-extension, public health, and antibiotics suppressed the pathogenic microbes that constitute our chief predators from their role in regulating our populations? Is our species currently undergoing a population phenomenon known as ecological release? (Yes we are.) What price is to be paid if we continue on our present course?

How far can we push natural systems before they break? How many people can the earth support? At what standard of living? How many should it support? *Do other species have a right to exist* or should all of earth's resources be used to support humans alone? Do future generations have any rights to resources and raw materials? Or is it the right of generations now living to consume all such materials entirely and leave the poisonous wastes for someone else to clean up later? Do future generations have a right to inherit an intact planet with functioning ecosystems and the biodiversity that we inherited when we arrived? Or is it the right of those of us now living (or of our economic and corporate entities) to consume, pollute, and destroy to the maximum extent possible?

If endless lines of additional passengers were to endlessly board an airplane, an elevator, a space vehicle, or a passenger bus, how many such passengers could reasonably board without inducing whole-systems failures? Clearly, at some point, at least one or more, if not all, critical systems would fail. On a passenger bus, the engine would overheat, the tires would blow, the axles would break, the transmission would fail, or the engine would blow a gasket. In all likelihood, the first system to be affected by crowding would be the restroom at the back of the bus which would overflow as the amount of waste generated by the passengers overwhelmed its capacity to accommodate those wastes.

No rational astronauts, of course, would ever dream of eradicating or damaging the systems of the vehicle that sustains their lives in space, and the rest of us would never dream of inflicting such damage upon our automobiles. *Amazingly, however, we seem to suppose that we can systematically destroy, eradicate and dismantle the only planetary life-support machinery so far known to exist anywhere in the universe* and to presume that it will nevertheless continue to function as it has always done in the past.

Notice that the above has nothing to do with "*running-out-of* ” food or resources or anything else but instead counsels the urgency of caution when it comes to the degree of *sheer eradication,* *wastes, and physical damage* that we inflict upon the only planetary life-support systems so far known to exist anywhere in the universe.

A continuation of today's demographic tidal wave may constitute the greatest single risk that our species has ever undertaken.

Courtesy of The Wecskaop Project - Excerpted from
What Every Citizen Should Know About Our Planet
http://www.scribd.com/full/25205868?access_key=key-185oi1iak3v0apsejby0

Recommended and Freely-downloadable

Biospheric Literacy 101-Five PowerPoints / Five Days
http://www.scribd.com/collections/3705681/Biospherics-Literacy-101-Five-PowerPoints-Five-Days

Priority Population Collection for Academia and Policymakers
http://www.scribd.com/collections/3655003/Population-for-Academia-and-Policymakers

Librarians: A paperback edition of What Every Citizen Should Know About Our Planet is available from M. Arman Publishing, Fax: 386-951-1101

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Extracts and addenda from earlier versions of this document

A graph that traces our own population growth over the past ten millennia not only mimics the pattern seen in the climb-and-collapse of the two reindeer herds, but notice that our own pattern of growth is both ***more pronounced*** and ***far more extreme*** than that seen in the reindeer herds as they neared collapse.

Similarly, Sylvia Mader explains that today "two-thirds of the plant species, 90% of the nonhuman primates, 40% of birds of prey, and 90% of the insects live in the tropics" (Mader, 1996). Continuing, she points out that "every year humans destroy an area of forest equivalent to the size of Oklahoma. At this rate, these forests and the species they contain will disappear completely in just a few more decades" (ibid).

We hear similar concerns expressed by Raven, Evert, and Eichhorn: "As many as 40,000 species of tropical plants may be in danger of extinction in the wild within the next several decades" while "in temperate regions, about five percent of the native plant species are in current danger of extinction" (Raven, et al., 1986).

Columbia's Jeffrey Sachs (2008) has likened today's industrialized fishing fleets to "hunter-gatherers with machine guns," noting that "the natural prey is simply no match for the incredible power and technology of modern fishing fleets, complete with fishnets that stretch for miles and satellite-based tracking of open-sea schools of fish."

Note here that technology does not serve to solve the above problem, but instead permits us to make things worse more quickly, extensively, and efficiently than ever.

By 1995, in his book HOW MANY PEOPLE CAN THE EARTH SUPPORT?, Joel Cohen noted that we have moved into "...a poorly charted zone where limits...have been anticipated and may be encountered." More recently we see too many economists who are worried about their worldwide population-growth Ponzi scheme being threatened by recently slowing population growth in the world's richest and most technologically advanced countries, even as, on a worldwide basis, humankind's "…historically unprecedented population expansion in the poorest parts of the world continues largely unabated" and "as a consequence, nearly all future global growth will be concentrated in the developing countries, where four-fifths of the world's population lives" (Bongaarts, 2002).

The National Academy of Sciences should immediately empanel a team to evaluate such questions of overshoot, including the possibility, likelihood, and consequences, in the event that our present overshoot of earth's carrying capacity continues over the five, six, and seven decades just ahead.

And, in our opinion, the members of the panel should be well-represented by natural scientists specializing in biology, population biology, atmospheric science, zoology, botany, marine science, ecology, whole-systems ecology, bio-spherics, and chemistry –

as opposed to demographers, social scientists, political scientists, statisticians, and economists who, by training and expertise know little or nothing about the behaviors, intricacies, feedbacks, and thresholds of functioning natural systems.