Thresholds, Tipping Points, and Unintended Consequences

Imagine the first domino in a row of adjacent dominos being toppled, thereby causing all the others to fall in quick succession. In such an event, even an accidental instability imparted to a single domino can unexpectedly topple a far wider and interconnected system. We are living at a time when each of humanity's added billions is impacting one natural system after another, incrementally, and in most cases, repeatedly – again, and again, and again. And a disconcerting amount of accumulating evidence suggests that some of earth's most important dominos may already be toppling. In these excerpts from **Wecskaop** chapter thirteen we will consider thresholds, tipping points, and unintended consequences.

While an engineering firm may build a bridge to support a particular tonnage, if that threshold is breached, the integrity of the structure is compromised, leading to potential collapse or failure. In a similar way, elevators and aircraft have characteristic weight thresholds which, for safe operation, should not be transgressed.

Examples of known thresholds also occur in physical, chemical, biological, and environmental systems, along with a host of unanticipated thresholds and/or thresholds whose precise values have not yet been quantified. Such "thresholds" are *points that denote a limit or a boundary, whether known or unknown, that result in dramatic changes when transgressed*.

The boiling point of water is an example of such a boundary. If we imagine a pan of hot water at 211 ^{o}F under conditions of standard pressure, the system persists in its liquid state. If, however, we increase the temperature by just one added degree, the system is carried past a critical and, in this case, an unmarked tipping point, and transforms abruptly to a gaseous system of billowing steam (after Kluger, 2006).

As an example of thresholds in a biological system, pH buffers in our blood maintain blood pH at a mildly alkaline 7.4. Seemingly small transgressions, however, beyond 7.35 (lower threshold) and 7.45 (upper threshold), result in *acidosis* or *alkalosis* which are both potentially fatal.

As a third example, a nerve cell will not fire unless a critical number of neurotransmitters bind to its cell-surface receptors. Only if that threshold number of neurotransmitters is reached or exceeded, will the nerve cell "fire" and transmit a message onward. Each of these instances illustrates a threshold with critical implications for life-functions.

Many scientists worry that our population and our collective impacts may soon exceed one or more of earth's ecological thresholds, known or unknown,

or even that some such thresholds may have been exceeded already.

Elsewhere in Wecskaop we have already recounted two examples of reindeer herds that grew explosively, only to be followed in each case by a precipitous collapse in which more than 99% of the population died (see Scheffer, 1951; Klein, 1968; and Wecskaop chapters 4, 8 and 11). In each experiment, a mammalian population paid a calamitous price for exceeding an unmarked threshold that denoted the carrying capacity of its environment.

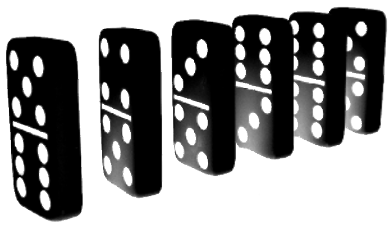
One wonders how many such experiments are required
before their clear implications become convincing.

Tipping Points

Natural systems also have *tipping points*. First imagine a laboratory balance or a schoolyard seesaw in a state of delicate balance. Small changes in position or small changes in mass at one end can destroy the equilibrium, shift the balance, and tip the system into an entirely new configuration.

Next imagine that a prevailing set of existing conditions in a system is increasingly destabilized by an accumulation of small changes until a critical threshold or tipping point is reached. At this point, a single increment of change triggers an abrupt and unexpected shift to vastly (or even catastrophically) different conditions.

Suppose, for example, that we introduce a small change with no apparent effect; followed by a second small increment of change; and then a third, a fourth, and then a fifth increment of change. At some point, such incremental changes, each seemingly small, have an additive or cumulative effect that abruptly *tips* the entire system, triggering a sudden shift from an initial condition of equilibrium or stasis to a radically different paradigm.



Imagine a row of dominos like those shown above. While the apparent stasis depicted in the illustration is real, it is also precarious. If a natural system displays a similar condition of apparent stasis, some economic interests ask us to assume that "business-as-usual" will govern that system, no matter what pressures to which it may be subjected. Yet, multiple systems may be more vulnerable to disruption than expected so that such assumptions that contemplate "business as usual" turn out to be not just unjustified, but dangerous.

In the dominos in our illustration, for example, inadvertently tipping one domino can trigger an essentially unstoppable succession of other events. In this manner, *exceeding a critical threshold* (whether it is known or not) *can act as a* **tipping point** *that results in the collapse of an existing paradigm*, resulting in an abrupt shift that may be irreversible, catastrophic, or both.

Researchers have recently identified assorted examples of natural regulatory dominos that if tipped, might produce paradigm shifts with global repercussions. These represent systems that, if destabilized beyond critical thresholds, might act as tipping points with feedbacks capable of irreversibly toppling other global processes. Suggested examples of such key regulatory systems have included (among others): Methane clathrates frozen in Arctic permafrost and deep sea sediments, the West Antarctic ice sheet, the Greenland ice sheet, the North Atlantic thermohaline current, the ozone layer, the Sahara desert, the Antarctic Circumpolar Current, ocean acidification, the east Asian monsoon, the temperature-sensitive El Nino/La Nina phenomenon, and the Amazon rainforest (e.g., Lenton, et al., 2008; IPCC, 2007; Schellnhuber, 2006, 2005, 2004; Doney, 2006; Whitty, 2006, etc.)

As an example, in 2005, researchers returning from western Siberia "found that an area of permafrost spanning a million square kilometers - the size of France and Germany combined - has started to melt for the first time since it formed 11,000 years ago at the end of the last ice age. The area, which covers the entire sub-Arctic region of western Siberia, is the world's largest frozen peat bog and scientists fear that as thawing occurs, it will release billions of tons of methane, a greenhouse gas twenty times more potent than carbon dioxide, into the atmosphere" (Pearce, 2005; Kirpotin and Marquand, 2005; IPCC, 2007).

The area, which has remained completely frozen for more than ten millennia, is now turning into "…a broken landscape of mud and lakes, some of which are more than a kilometer across." Kirpotin suspects that some unknown critical threshold has been crossed, triggering the melting. Estimating the melting to have begun in the past three or four years, Dr. Kirpotin termed the change an "ecological landslide that is probably irreversible" (Kirpotin and Marquand, 2005; Pearce, 2005).

This change may be of global significance because, according to some estimates, the west Siberia permafrost contains up to 700 billion additional tons of trapped methane gas (Pearce, 2005; Pielke, 2005; Sample, 2005). If, over the coming century, warming gradually releases just a portion of this to the atmosphere (e.g. 700 million tons a year), atmospheric concentrations could "effectively double," forcing climate scientists to revise their projections of global temperatures upwards (Sample, 2000). David Viner, a senior scientist at Great Britain's University of East Anglia points out that

> "this is a big deal because you can't
> put the permafrost back once it's gone."
>
> (As reported by Pearce, 2005)

He also warns that we can produce situations in which such processes can become unstoppable where "there are no brakes you can apply" (Pearce, 2005).

Self-fueling Feedbacks

If a system exceeds a critical threshold or passes a key tipping point, the event can also trigger a chain-reaction of **self-reinforcing feedbacks** (positive feedbacks) that act to *amplify or magnify* an existing trend or sequence. As one example, in 2005, scientists at Australia's Global Carbon Project identified "melting permafrost as a major source of feedbacks that could accelerate climate change." As project scientist Pep Canadell observes, melting permafrost could release "several hundred billion tons" of carbon into the atmosphere. (Pearce, 2005; Field and Canadell, 2005).

Other feedbacks result when disappearing ice and snow expose dark-colored ground and ocean which are more likely to absorb solar heat than the snow and ice. Thus, if rising levels of CO_2 represent a first domino, then melting of polar snow and ice represent a second domino that changes earth's **albedo** (reflectivity). Instead of white snow and ice reflecting light energy back into space, dark polar waters and soils instead absorb that solar energy, causing further warming.

In this scenario, earth's thawing permafrost thus constitutes a third domino, which, when tipped, releases additional billions of tons of methane gas, which cause still more warming. And finally, the frozen muds of deep-sea sediments are estimated to hold still more gigatons of methane gas so that rising ocean temperatures might represent still another falling domino. *In a cascade of this sort, once atmospheric* CO_2 (the first domino) *reaches an unmarked, yet critical, threshold and starts melting earth's snow, ice, and permafrost, the other dominos might irreversibly follow*.

An ecosystem that crosses a critical threshold or tipping point may thus collapse or abruptly shift from one equilibrium condition to another with a sudden loss in biological productivity. Commenting on greenhouse gases, climate change models and IPCC projections, Dr. Bill Collins of Lawrence Berkeley National Laboratory has noted that "most of the data in the IPCC model related to China's economic activities… predates the last five years when China greatly intensified its already booming efforts…." As a result, nobody "…captured in their energy-economy models the acceleration of emissions from China in the last five years. That is what is so scary... What is happening now is worse than the worst-case projections that went into the IPCC model" (Collins, as reported by Friedman, 2008).

It seems possible [and may, in fact, be likely] that "global climate systems are booby-trapped with tipping points and feedback loops, thresholds past which the slow creep of environmental decay gives way to sudden and self-perpetuating collapse" (Kluger, 2006). As Kluger writes: "Pump enough CO_2 into the sky, and that last part per million of greenhouse gas behaves like the 212^{th} degree Fahrenheit that turns a pot of hot water into a plume of billowing steam. Melt enough Greenland ice, and you reach the point at which you're not simply dripping meltwater into the sea, but dumping whole glaciers" (ibid).

Thus, a **tipping point** is a condition or threshold where the additive or cumulative effects of individual changes act to "tip" a system from an existing condition of stasis or equilibrium to an alternate, new, or significantly different set of prevailing conditions. The result may occur as a relatively abrupt, unstoppable and/or irreversible paradigm shift (e.g., UN/Sigma Xi, 2007; Lenton, et al., 2008).

Thus, even though a system at equilibrium can frequently adjust to small changes and still maintain itself, <u>an accumulation of additive inputs, even if they are relatively small, can steadily nudge a system toward a tipping point</u> that abruptly triggers a new and potentially catastrophic or irreversible set of prevailing conditions. And, as Robert Pielke, Sr. observes, "a tipping point that results in serious, negative impacts on societal and environmental conditions could be catastrophic" (2005) . Thus, the likelihood of at least some self-fueling feedbacks means that various climatic and environmental systems

may be more vulnerable to a self-amplifying cascade
of unexpected shocks than we currently expect.

Unintended Consequences - 1

History shows us that even everyday human activities that we presume to be benign or that we intend to be beneficial, can often have *unanticipated* consequences with unexpectedly deleterious repercussions.

One of the simplest illustrations of **unintended consequences** can be seen in the story of the Stephen's Island wren, *Xenicus lyalli*. Stephen's Island is located off the coast of New Zealand and in 1894, its lighthouse keeper brought his pet cat to the island to keep him company. Upon arrival, the cat soon discovered a species of tiny bird previously unknown to science. Unfortunately, not only did the cat discover the world's only population of *Xenicus lyalli*, it also soon drove the species to extinction (Greenway, 1967; Anson, 1996). Thus, the initial arrival of an invasive species that survives and successfully propagates can act as a tipping point. In this case, the arrival of the lighthouse keeper's pet cat was *a threshold event that set in motion a quick set of unexpected outcomes*.

Similarly, when explorers crossed the Indian Ocean in 1507, they happened upon three species of flightless birds known as Dodos living in the Mauritius Islands. As ships visited the islands over the next 100 years, they reprovisioned their supplies of food and water. First, of course, the flightless Dodos were easy to catch and their eggs were easy to collect. Secondly, rats unexpectedly swam from the ships to the islands and began to eat Dodo eggs. And finally, thinking of future voyages, the sailors released male and female pigs onto the islands. Unfortunately, it turned out that the pigs also ate, among other things, Dodo eggs. In hindsight, we may guess the consequences of all these events: The ultimate extinction of all three Dodo populations. Notice that this series of events *was initiated by the simple arrival of human beings which promptly set in motion a cascading series of unintended consequences*. Thus the simple arrival of an invasive species that survives and successfully propagates can act as a tipping point in which a threshold is breached that triggers an unexpected cascade of unintended outcomes.

Unintended Consequences – 2

Overharvesting and overexploitation of a biotic resource can also have unexpected and unintended consequences. Along the eastern seaboard of the United States, for instance, chronic overfishing has produced massive declines in the populations of large sharks that once dominated the top of the food chain. Since 1972, for example, serious declines range from "87% for sandbar sharks (*Carcharhinus plumbeus*); 93% for blacktip sharks *Carcharhinus limbatus*); up to 97% for tiger sharks (*Galeocerdo cuvier*) and 99% or more for bull (*C. leucas*), dusky (C. *obscurus*), and smooth hammerhead (*S. zygaena*) sharks (Myers, R.A., et al., 2007).

These sobering declines over a span of several decades both inform us of our own rapacious behavior as well as constituting a story in themselves. But these declines also had unintended consequences, for the sharp decline of large sharks at the top of the food chain unexpectedly **destroyed** a century-old *scallop* industry (ibid).

How could reduced numbers of *large* sharks bring about a population collapse among clam-like scallops? When populations of large shark species declined, the *smaller species* that were *preyed upon* by the large sharks (such as skates and rays and smaller sharks) suddenly increased in numbers in a classical example of ecological release. This increased the feeding pressures by the smaller species, resulting in a quick and unexpected reduction of scallops (ibid). Thus, human impacts <u>at one level of a food chain</u> unexpectedly triggered cascading changes in other parts of the system.

As another example, research in the 1960s documented dense populations of the white abalone *Haliotis sorenseni* on the sea floor off Catalina Island in California. A census of the population at that time documented approximately 16,000 to 82,000 individual abalone, or about 10,000 white abalone per hectare (see Malakoff, 1997).

By 1981, a survey of the seabed around Channel Islands National Park turned up only 21 individuals in the same area examined in the 1960s research. Worse still, a survey over a five year period found a total of just eight live white abalone in eight hectares of habitat.

Thus, the population of the species had collapsed from
about 10,000 *per hectare to just one individual per hectare*

while a more recent census of same area turned
up a total of <u>just three individuals</u> (ibid).

What had happened? When commercial harvesting of these abalone began in 1965, it was known that individual females of the species release approximately fifteen million eggs into the water each year. With a nearly astronomical reproductive capacity, the population was judged to be robust and reproductively well-buffered against overexploitation. Yet, in spite of minimum size regulations, within nine years the fishery had collapsed in a drastic and unanticipated decline.

As happens often with human activities, there were unexpected vulnerabilities that commercial harvesters and officialdom had not foreseen: *Unless males are present within one meter or so of the females, there are not enough sperm in close proximity to fertilize the seemingly astronomical fifteen million eggs*.

In other words, abalone must be close enough together for gametes released into the water column to find each other. Despite the large number of eggs produced yearly by each female, the reproductive strategy of this species is ***ineffective*** if individual animals are not close enough together. As park biologist Gary Davis observes, “It looks as if the last successful breeding season was in 1969, and those animals have been dying from natural causes ever since” (ibid).

Some have suggested that other abalone populations are likely in deeper nearby waters. If this is so however, apparently no successful recruitment / recolonization has occurred in the protected, but depauperated, areas of the Channel Islands National Park. The main points we wish to make here are: (a) That even an apparently prolific species can have hidden or unexpected vulnerabilities that can lead to unintended consequences; (b) That transgressing certain thresholds, whether they are known or not, can lead to serious and unexpected repercussions; (c) That, as a matter of routine, human activities commonly have adverse and unanticipated outcomes, and, (d) There is no reason to assume that we and our leaders will not continue to make a host of simple and sometimes profound blunders in the future.

Unintended Consequences - 3

Industrial scale production and use of plastics began as a post World War II phenomenon. Early instances of unintended consequences were noticed when plastic sandwich bags began to kill sea turtles (who mistook them for jellyfish) while various birds and marine mammals were killed when they became entangled in monofilament fishing line or in six-pack rings.

Now, six and seven decades out, the cumulative effects and wider impacts of nonbiodegradable plastics are beginning to emerge. As an example: Each year 250 million pounds of tiny plastic pellets are manufactured for use in thousands of plastic products, amounting to 5.5 quadrillion pellets per year. There are 5,000 plants in India alone that manufacture such pellets which are then used, for example, as abrasives in beauty creams, body scrubs, and other cosmetics instead of the ground seeds or walnut shells that were once used. These tiny microspheres are also present in products used to blast paint from boats (Weisman, 2007; Thompson, 2005).

As a result, collectively speaking, we empty **billions** of pellets and microspheres down the drain each year. Upon reaching the ocean, the pellets are eaten by sea creatures who mistake them for food particles and fish eggs. As a result, the particles turn up in the transparent bodies of jelly-fishes and salps or in the intestines of barnacles and similar filter-feeders (ibid). Worse still, once taken up, the ingested plastics become increasingly *concentrated* with each step of the food chain so that a recent study of dead seabird carcasses (fulmars) showed that 95% of them had consumed an average of 44 pieces of plastic. Another study in 1998 found more plastic by weight than plank-ton at the ocean's surface. Meanwhile, ocean currents continue to transport tons of discarded six-pack rings, old flip-flops and plastic bottles to slow-swirling mid-ocean vortices where they ac-cumulate as Texas-sized refuse-dumps (ibid).*

*Some plastics also contain endocrine disrupters such as PCBs (polychlorinated biphenyls such as bisphenol A) and phthalates, some of which may be linked to reproductive abnormalities, chromosomal abnormalities, breast and prostate abnormalities, feminization of fishes, and effects on the development of a fetus.

Unintended Consequences - 4

It is not humanity's intention, of course, to cause any portions of the deep-sea to ever become anoxic or to impair or destroy microscopic **phytoplankton** in the sea and thereby weaken or topple virtually every marine food chain. Yet ocean acidification, pollution, and/or other damage that we have inflicted or continue to inflict could have serious unintended consequences. Not only do these tiny phytoplankton produce the greater portion of the oxygen that we breathe, but they also act as the ocean's "pastures" that sustain virtually all of the higher forms of life in the sea. In addition, they also play a critical role in removing CO_2 from the earth's atmosphere, thereby acting as a brake on global warming (e.g., Schellnhuber, 2004, 2005, 2006; Whitty, 2006).

There are thus an assortment of acidification, nutrient enrichment, and/or ozone depletion thresh-olds that we should not test and must not cross. For example, certain for-profit ocean fertilization schemes that are currently contemplated could conceivably cause development of calamitous deep sea anoxic conditions capable of triggering widespread, human-induced extinction events of nearly unimaginable proportions. And elsewhere, warming waters could potentially transgress an El Nino/La Nina tipping point, passing a critical threshold beyond which the El Nino phenomenon, with its floods in some regions and droughts in others, becomes more or less permanent (e.g., Lenton, et al., 2008; Whitty, 2006).

It has not been humanity's intention to melt Arctic sea ice or Greenland's ice sheets. It has not been our intention to melt the permafrost, change the earth's albedo (reflectivity), or to produce ice-free Arctic seas by the summer of 2050.* Nor was it ever our intent that thousands of Arctic lakes should disappear in the last thirty years or that the greenhouse gas methane should literally bubble out of melting Arctic peat bogs. Nor has it ever been our intention to increase the acidity of the ocean. Yet, all of these things have either already happened or are happening now or may occur sometime soon (for examples from the literature see Overpeck, et al., 2006; Lenton, et al., 2008; Otto-Bleisner, et al., 2006; Field and Canadell, 2005; Pearce, 2005; NCAR, 2006; Schelln-huber, 2006; Eilperin, 2006; Doney, 2006, and IPCC, 2007). As one example, records of past ice-sheet melting indicate that the rate of future melting and related sea-level rise could be faster than widely thought (Overpeck, et al., 2006). Recent studies, for example, have found accelerated rates of glacial retreat along the margins of both the Greenland and West Antarctic ice sheets (NCAR, 2006).

* The rate of Arctic melting unexpectedly accelerated in the summer of 2007 as summer ice volumes declined by 50% over 2004 totals and summer ocean temperatures were the "…highest seen in the Arctic in 77 years of record-keeping" (Borenstein, 2007). Only one year earlier, a model projecting ice-free Arctic seas as early as 2040 was greeted as an off-the-mark aberration. Yet, as this is written, the possibility of ice-free Arctic seas as early as the summer of 2020 or even 2012 have been suggested. Other researchers, however, contend that the 2007 summer data may simply be an anomalous blip within a longer-term trend. Still others, however, worry that the data may indicate that the climate has passed "an ominous tipping point" and that we may now be "entering a new regime" (ibid). (Consider, for example, that Greenland lost 12% more surface ice in the summer of 2007 than in its previous worst year ever and that the amount of sea ice floating in the Arctic Ocean was 23% below its previous record.) As one analyst noted, it's "even worse than…[our] models predicted" (ibid). Interestingly, Deutsche-Welle television aired a striking report (December, 2007) depicting a Russian scientist chopping a hole into the Siberian ice. Then, igniting a match above the opening, the geophysicist had to jump quickly aside to avoid a two-meter pillar of flaming methane gas erupting from the permafrost.

Further Examples

When the pesticide DDT was first developed, it seemed quite promising. For example, when sprayed on marshes, ponds, and wetlands, DDT killed mosquitoes, helping disrupt the spread of malaria. In addition, when sprayed on crops, DDT killed insects, raised agricultural yields, and helped feed a hungry world.

But DDT also had unintended consequences. When rain washed it into ponds, streams, and the sea, it was unexpectedly taken up by microscopic organisms, entering the base of the food chain where it was passed on to consumers, becoming increasingly **concentrated** with each step in the trophic pyramid. In effect, its concentration was magnified with each new level of consumers in a process known as **bioaccumulation** or biological magnification.

At the top of many food chains, birds were soon consuming high concentrations of DDT. And soon it turned out that: (a) DDT weakened eggshells, and (b) that DDT was also appearing in human breast milk and in Arctic mammals and birds far removed from any farms or fields. A biologist, Rachel Carson, wrote a famous book entitled SILENT SPRING describing the bioaccumu-lation of DDT and its implications. In birds, the weakened eggshells resulted in fewer young birds being hatched, even as the parents and the older birds continued to die as they grew older. In many places, bird populations (such as pelicans and bald eagles, for example) began to decline, raising the possibility of multiple extinctions and dozens of falling dominos.

Notice the progression: Initially DDT was developed, widely used, and dispersed throughout the world where it underwent **biological magnification**. Only many years later did we learn about its wide dispersal, its effects on other species, and the effects of its bioaccumulation. As it turned out, the pesticide most notably affected reproduction in birds. The cautionary nature of this tale, however, is that *it could just as easily have affected human health,* so that in this case, our own species dodged the bullet simply by accident.

Other bioaccumulations are also known. In Japan, for example, mercury wastes emptied into the ocean at Minimata Bay were expected to be dispersed, with the supposition being, of course, that a little additional mercury in so large an ocean would be both harmless and little noticed. As it turned out, however, the mercury was taken up by marine microbes, and its concentration was magnified with each ascending step in the food chain. Shortly afterwards, cases of mercury poisoning, including neurological disorders, coma, and death, began occurring in fishing families whose livelihoods depended upon the bay. It was not the company's intention, of course, to produce "Minimata disease" among its neighbors, but the unintended consequences were deadly just the same.

Blunders and Good Intentions

Examples like these and others illustrate a routine characteristic of human activities: We know that as human beings we are fallible and that to be human is to blunder. We may accidentally forget that the car is low on gas, for example, or spill that can of paint onto the kitchen floor, or trip as we cross the stage during graduation. And, of course, as human beings, political leaders of every affiliation also commit blunders.

These considerations remind us that even our everyday activities that we hope to be beneficial or that we presume to be benign, can turn out to have unintended consequences with serious or even deadly repercussions. As a species, we are something like a bull in earth's planetary "china shop" of natural systems, accidentally knocking things over (crash!), breaking things (oops!), and stumbling from one blunder to another (auwe!). Unfortunately, much of the damage that we are causing, although unexpected and unintended, is potentially serious - and some of it may well be, like the melting of the permafrost, essentially irreversible. When one is driving too fast on an unknown and dangerous road, caution, wisdom, and quite possibly survival suggest **slowing down** and suppressing the urge to gamble everything for a few dollars more.

Accidents, Assumptions, and Ripples

By definition, most of our unintended consequences are entirely *accidental*. And although we might excuse ourselves in one way ("Well, who would have thought…"),

all of our excuses do nothing to mitigate
the effects of a calamitous blunder.

In Wecskaop's chapter five, for instance, we examine the phenomenon of **ecological release**. In one case, when humans killed too many of California's sea otters, the result was a population explosion of sea urchins, whose feeding, in turn, brought about wide destruction of offshore kelp beds and their biota. In a second example, when ranchers in Wyoming poisoned coyotes near their ranches, the result was a population explosion among jackrabbits. In each of these examples, an unanticipated population explosion with unforeseen impacts occurred as a result of human activities that were *presumed to be inconsequential, unimportant, or even benign*.

Other unintended consequences, of course, can arise from arrogance and/or from economic motives that place the welfare of a few individuals above the interests of everyone else and above the interests of our planet as a whole.

Finally, some unintended consequences arise from our natural, yet provincial, views of time and place. As individuals, our local sphere of awareness is generally limited to today or to this week (and to our own homes and neighborhoods). When we are infants, our sphere of awareness is confined entirely within a periphery of a one or two meters and a time span of right now. As we grow a little older, we become aware of a living room and a front yard and our perception of time broadens to include an hour from now or sometime yesterday. Over the years, of course, we continue to grow until gradually, our perceptions broaden to include our nations and our hometowns. And simultaneously, with education, our awareness of time may gradually expand to incorporate five years ago, the history of ancient Rome, and the dinosaurs of the Mesozoic.

In effect, <u>the demands of daily life have genetically and culturally programmed us</u> to deal mostly or entirely with "today" and to deal with near-term conditions and surroundings. In contrast, the earth as an entire entity, with its thousand-year, million-year, and billion-year spans of time, does not readily assert itself as a top priority in our everyday consciousness. As a result, our wider world with its changing albedo, melting permafrost, delayed feedbacks, and disappearing rainforests, seems fuzzier, less apparent, and less immediate.

Worse still, in the absence of education and curiosity, the perceptions of time and space that comprise the universe and our planet, its history, and its biological machinery may never develop at all. As one recent observer notes, our "local sphere of awareness blinds us to the global ripples" that we cause (Western, 2001). To expand upon Western's observation, if our individual impacts can be pictured as ripples, *then our collective impacts are more like tsunamis*, that wash as waves of destruction across our planet with each of our added billions. Even when we have the luxury of time to contemplate tomorrow, we typically do so

while taking the continued functioning of nature,
natural systems, and natural processes
entirely for granted

by imagining or supposing that they constitute a kind of ongoing constant. Yet, given our numbers today and a technological leverage that amplifies our impacts, many scientists now voice concerns again and again about "the integrity of the biosphere's environmental services that we still take for granted" (Woodruff, 2001). Some recent papers conclude, for example, that around the world today, "every major planetary process, whether in the biosphere, lithosphere, hydrosphere, or atmosphere, is already altered or dominated by human activity" (Western, 2001). Thus, our world population today (billions), along with our needs, our wastes, and our powerful technologies are already impacting multiple natural systems <u>that too many vested interests complacently and erroneously presume to be invulnerable</u>.

If We Put Our Minds to the Task

Imagine the first domino in a row of adjacent dominos being toppled, thereby causing all the others to fall in quick succession. In such an instance, even an accidental instability imparted to a single domino can unexpectedly topple a far wider and interconnected system. We are living at a time when each of humanity's collective billions exerts a host of fierce and unrelenting impacts on one natural system after another, sometimes incrementally, and in most cases, repeatedly – again, and again, and again. And a disconcerting amount of recent evidence suggests that some of earth's most important dominos may already be toppling.

We didn't *intend* to drive the Stephen's Island wren to extinction, we did it by accident. Nor has it ever been our *intention* to melt the earth's permafrost or damage the ozone layer or to change the earth's albedo. Instead, these have been the *unexpected* and *unintended* results of often routine activities that we undertake as a species.

The reasons these things are happening now and not at some other time in history are: (a) There are so many of us – billions and more billions of us invading and inhabiting every corner of the biosphere, and (b) although as a species we are inventive, we are also brash and lack the understanding, humility, and foresight to completely anticipate where our collective actions and decisions are likely to take us. As a species, it seems, our minds are geared to help us survive this day, today, right now, with too little thought or respect for the years and decades that constitute tomorrow.

We have been reminded that "there is a line between a can-do optimism and a keen awareness that the hour is late and the scale of the problems practically overwhelming" (Friedman, 2008). We must not feel completely helpless, however. As one writer has noted, for example, the dramatic changes that the United States was able to accomplish in the twelve months following Pearl Harbor show us that in times of emergency, our societies are capable of rapid transformations - if we put our minds to the task (Whitty, 2006).

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

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Sources and Cited References

(pending)

Anson, 2009. What Every Citizen Should Know About Our Planet. M. Arman Publishing.
Anson, 1996. Marine Biology and Ocean Science. Balaena Books.
Borenstein, 2007.
Collins, as cited by Friedman, 2008.
Deutsche-Welle television, December, 2007
Doney, 2006;
Field and Canadell, 2005.
Friedman, 2008.
Greenway, J.C., 1967. Extinct and Vanishing Birds of the World. Dover, NY.
IPCC, 2007;
Klein, 1968
Kirpotin and Marquand, 2005.
Kluger, 2006.
Lenton, et al., 2008;
Malakoff, 1997.
Myers, R.A., et al., 2007.
Pearce, 2005;
Pielke, 2005;
Sample, 2005.
Scheffer, 1951;
Schellnhuber, 2006, 2005, 2004;
Thompson, 2005.
UN/Sigma Xi, 2007.
Viner, D. as cited by ....
Weisman, 2007;
Western, 2001.
Whitty, 2006.
Woodruff, 2001