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Learned Discourses: Timely Scientific Opinions

Timely Scientific Opinions

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In a Nutshell…

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INTEGRATED ENVIRONMENTAL ASSESSMENT AND MANAGEMENT DURING A PLANETARY STATE SHIFT

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At present, humanity has no organization charged with assessing the health and integrity of Earth's biosphere. Literature is beginning to appear on the possibility of a planetary state shift in Earth's biosphere (e.g., Barnosky et al. 2012). Five previous planetary shifts have occurred (five previous extinctions) when the biosphere collapsed and was replaced with a new biosphere. Not surprisingly, a major emphasis on the means (integrated environmental assessment and management) of forecasting such an event are not robust, because the early warning signs of planetary scale events are rarely studied. However, anthropogenic greenhouse gas emissions, exponential human population and economic growth (based on renewable and nonrenewable resources), plus excessive consumption of resources are clearly the primary causes of irreversible damage. Humanity has three options: 1) generate more hard scientific evidence on the way the universal laws of physics, chemistry, and biology work and develop a global lifestyle congruent with these laws; 2) deny reality (i.e., hard scientific evidence) and continue ''business as usual''—this option results in spending available resources and money on economic growth rather than on generating scientific evidence to forecast and prevent irreversible biospheric changes; 3) spend money on unproven, at the global scale, bioengineering projects to enable humanity to continue its present, consumptive, unsustainable lifestyle.

Staying within the limits dictated by universal laws (option 1) will require both scientific evidence and regulations, neither popular in the United States (or other nations) at this time. Above all, abiding by and understanding universal laws are essential and will require prompt and full admission when risks have been underestimated. Lord Nicholas Stern (Stewart and Elliott 2013) has set a magnificent example by stating: ''I got it wrong on climate change—it's far, far worse.'' Honest mistakes are inevitable when studies involve complex, interactive systems never before studied under present, severe stresses.

The quest for sustainable use of the planet is a noble venture because it envisions humanity living in balance with nature. However, a new word is emerging—*resilience*—that means adapting to an alien world quite different from the one in which *Homo sapiens* evolved. In a planetary state shift, the probability of returning to the predisturbance condition is remote. The human predicament has been summed up by Dilworth (2010): ''*Consequently, human civilization—primarily Western techno-industrial urban society—will self-destruct, producing massive environmental damage, social chaos and megadeath. We are entering a new dark age, with great dieback. The only question that remains is whether we will survive this dark age, and if so, for how much longer*.''

What should scientists and parents do when the worst case scenario looks so bleak? In my opinion, everything possible should be done to reduce the risks for posterity, even if only by a few percent. Determining which actions will result in reduced risk is essential. Lives of the present generation will benefit from working primarily for others, even though the present generation will probably never know if its efforts were successful.

Humanity will never survive a planetary state shift by substituting words for actions or by taking action without first stating goals and conditions and adhering to them. Noble statements of intent without numerical statement of goals and the specific conditions necessary to meet them give the illusion without the reality of accomplishment. Sustainable growth, really an oxymoron, was just such a diversion.

Sustainable use of planetary resources by large populations has only actually been achieved on a regional scale during the Edo period in Japan, but did not last for a millennium, even regionally. Sustainable use of the planet existed for humans when populations were small (packs and tribes) and spread thinly over the planet. ''*Why do we find 'traditional societies' so fascinating? Partly it's because of their human interest: the fascination of getting to know people who are so similar to us and understandable in some ways, and so unlike us and hard to understand in other ways*'' (Diamond 2012, p. 6). These societies of the genus *Homo* were resilient and lasted millions of years. Some examples still exist. A planetary state shift might result in a major reduction in human population size and initiate a return to traditional societies that were undoubtedly more resilient than humankind is today.

Only one of the three choices (option 1; increasing the amount of hard scientific evidence on the workings of the universal laws of physics, chemistry, and biology and developing a global lifestyle based on these laws) previously mentioned is likely to reduce risk for posterity substantially. Irreversible changes may occur swiftly, so time is short.

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CAN A SPECIES RAPIDLY MOVING TOWARD A SELF-INFLICTED EXTINCTION BE CONSIDERED SUCCESSFUL?

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By failing to prepare, you are preparing to fail.
Benjamin Franklin

In science it often happens that scientists say, ''You know that's a really good argument: My position is mistaken'' and then they would actually change their minds and you never hear that old view from them again. They really do it. It doesn't happen as often as it should because scientists are human and change is sometimes painful. But it happens every day. I cannot recall the last time something like that happened in politics or religion.
Carl Sagan

Humanity's enduring idea has been that every human live a quality life. Civilization has talked about this concept but not taken any action to make it a reality. *Homo sapiens* is now at the crossroads of evolution—will it merely lose its ''dominance'' over nature?; will the present biosphere, which supports the species, collapse?; will the present global human civilization disappear as many previous civilizations have done?; will remnant *Homo sapiens* revert to being widely dispersed hunter-gatherers; or, will the species become extinct?

To avoid extinction, *Homo sapiens* must change its worldview to accept that both economic and population growth at the present rates are suicidal, as are all forms of growth on a finite planet. Lacking vision will result in a state of hopelessness and despair. A vision of sustainable use of the planet and intergenerational equity without actions is a waste of time because it is an exercise in futility. Exponential human population growth, coupled with per capita diminishing resources, has produced a widening chasm in wealth; consequently, resource acquisition is resulting in an increase in societal disequilibrium.

Such a disaster is a man-made event with varied synonyms—Armageddon, cataclysm, annihilation, holocaust—that indicate many cultures have given much attention to worst case scenarios. However, unreasoned optimism (e.g., the Titanic) can often result in worse consequences than worst case scenarios. Americans love unreasoned optimism, especially about distant (e.g., over 2 years) events such as the risks of climate change, overpopulation, food and water insecurity, rising sea levels, and other global crises. However, unreasoned optimism can have unintended consequences. The irony is that, if humanity (or just the optimists) waits to observe the consequences, the changes may be irreversible, the self-inflicted catastrophes may be serious, even fatal, and the changes may be abrupt. Ignoring scientific evidence, as humanity often does, is not a prudent way to prepare for irreversible, planetary state shifts. For example, television weathercasters have been ignoring climate change (Goodell 2012), which is a suicidal long-range strategy. The vulnerability of forests globally to drought is not getting the attention it deserves (Choat et al. 2012). Sea level rise is basically being ignored in management plans and, in some US states, laws are prohibiting the use of contemporary science in planning coastal development. Recently, a scientific ''. . . *team located suspected Pliocene beaches as low as 38 feet and as high as 111 feet above modern sea level. In similar work in Australia and on the East Coast of the United States, the researchers have found Pliocene beaches as low as 33 feet and as high as 295 feet above sea level*'' (Gillis 2013).

Humanity knows little about the critical, co-evolutionary relationship between *Homo sapiens* and Earth's biospheric life support system. Both climate change and hazardous substances affect the co-evolutionary relationship, such as that between pollinators and the plants they pollinate, including many plants important to agriculture. This ignorance could be fatal.

''*The situation* [the Biosphere's ability to support civilization] *is pretty much an endgame. Unless pressing issues of the biology of the planet and of climate change generated by greenhouse gas emissions are addressed with immediacy and at appropriate scale, the matters that occupy Davos* [Davos, Switzerland, host to the World Economic Forum (WEF), an annual meeting of global political and business elites] *discussions will be seen in retrospect as largely irrelevant*'' (Lovejoy 2013). Civilization is threatened ''. . . *with collapse by an array of environmental problems*'' (Ehrlich and Ehrlich 2013). Persuasive evidence indicates that ecosystems have state shifts; the biosphere is an interactive group of ecosystems, so a major biospheric state shift is probable. However, no robust evidence exists on either how many planetary ecosystems must have state shifts before the present biosphere is forced into a state shift or whether a biospheric state shift has one or more temporary stable-state phases during a collapse. Passing a tipping point usually results in a state shift (irreversible change). However, because, at present, tipping points can only be seen in retrospect, nurturing the present biosphere is a prudent management strategy.

The success of a species is based on its continued existence in a particular habitat or environment, which is accomplished either by the makeup of the species or its ability to adapt to environmental changes. Humankind has been changing its environment by ignoring the universal laws of physics, chemistry, and biology and has produced a habitat that is alien to the one of origin. Numerous self-inflicted changes are bringing the very existence of *Homo sapiens* into question. The answer is a balance between renewable resource regeneration and resource consumption so that civilization survives.

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SCIENTIFIC ASSESSMENT AND TRADITIONAL KNOWLEDGE: A MATCH NOT MADE IN HEAVEN

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During the consistent marathon of regulatory work, I attended a workshop, on behalf of the North Slave Métis Alliance (NSMA), for a water license renewal. The proponent had been navigating the regulatory process with the goal of receiving a water license renewal, something that is necessary for continued resource extraction. The license requires that the proponent provide rationale as to how traditional knowledge (TK) will be collected and incorporated into its annual reports and design. The proponent diligently discussed how they would ''include TK with scientific knowledge in the design and implementation.'' During the renewal, there was discourse surrounding how appropriate it was for TK to be integrated into the response framework.

In this Learned Discourse, I consider salient facets that I believe need to be addressed to facilitate the equitable transfer of knowledge and integration of TK into resource management with developments. This may not be a scientific issue, but it certainly is a process that involves many scientists in the North, and is therefore of relevance. I cannot offer a silver bullet of Truth for ameliorating the quandary of integrating scientific assessment and TK; however, I can introduce some concepts that may ease any scientist into working with TK holders. I will cover off three broad issues that researchers should be cognizant of: the present top-down methods of TK data collection; the understanding of differing knowledge bases; and, the practice of being reflexive.

First, a fact: scientific method (assessment) has become the hegemonic praxis of collecting, analyzing, and discussing data. It is through diffusionism (Blaut 1993) that scientific method and assessment developed into the primary means of understanding the world around us. Complementary, but not binary, there are other methods that are explored, such as TK. TK has largely been implemented into the regulatory process by means of policy. Developers seek to incorporate TK to fulfill regulatory regimes. It has largely been prescribed through a top-down approach, generally used by agencies and corporations with the power to regulate and legislate, such as the northern Canada Land and Water Boards (Ellis 2005). When implemented, the proponents will use terms such as community-based, or participatory; however, unless the Aboriginal groups are undertaking their own research, these terms are tokenism. The groups involved become nothing more than participants in a study, a one-day workshop, an engagement box that has been checked off, and a further regulatory hoop that has been cleared.

Second, I do not reject the existence of objective truth, nor should others reject the existence of subjective truth. Land use practices, cultural and historical beliefs, myths, and collective knowledge are often acknowledged, but perceived to be placed aside as they are deemed unquantifiable, thus anecdotal and nonreplicable. Situational knowledge is embedded in every language, culture, and tradition. Proponents weigh the evidence objectively, determine the varying knowledge bases as binaries, and display the results in a manner that is often not equitable for the impacted Aboriginal parties. The researchers involved have been educated in non-Aboriginal scientific methods and are seemingly unable to grasp or comprehend the statements and cultural messages being portrayed by the impacted groups. Remove the palimpsest of social constructions and situate the knowledge of the Aboriginal peoples within the broader context. Both parties must continue to distinguish between true knowledge and knowledge that has been distorted through a lifetime of Euro-Canadian science methods into knowledge systems of difference. This is where being reflective of your own epistemology is crucial for cooperation, collaboration, and acknowledgement.

Last, to be transparent, I am a non-Aboriginal employed by an Aboriginal organization. I acknowledge that I am an outsider. I note this facet of my position to address a bias that emerges when undertaking research with people: positionality. It is who you are; it is your heritage, your ethnicity, your sexuality, your religion, your education, your friends, and your family. It is every variable that sets you different or similar to others and it will inadvertently reflect within your research process, regardless of any perceived objective omniscient gaze (Haraway 1988). Acknowledging your positionality is part of being reflexive. Being reflexive of similarities, differences, and more importantly, power (relationships), can help facilitate an internal dialogue during the research process. Becoming more cognizant of your epistemology, ontology, and pedagogy, can facilitate deconstruction of researcher-participant relationships, some of which may be reciprocal, asymmetrical, or exploitative. By acknowledging your position within the research, you can adopt a stance of intimidation, ingratiation, self-promotion, or supplication, without removing your own history and/or context (England 1994).

In summary, the implementation of TK into resource management, when controlled or directed in a top-down manner, seems to have never left the stages of systemic tokenism. TK appears to be used only if it can be construed to fit into the specialized narrative of science frameworks (Simpson 2001), such as the weight of evidence, or if it can be quantified and placed in a data table or on a map. TK needs to be included as an independent line of evidence. It needs to be developed through a bottom-up approach. It needs equal weight within resource management. There needs to be further training within the proponent's contractors, the government, and the education system to address to all researchers, not just the touchy feely qualitative scientists, but the rigor and a priori folks as well. Being reflexive cannot hurt in the process of scientific assessment and TK.

All parties privy to resource development benefit from technical training in monitoring and scientific methods; however, the relationship is seemingly one-sided. The learning should be reciprocal. My final thought: impacted Aboriginal groups can host TK training for proponents, the developers, the scientists to come and learn about the land from their perspective. Why not spend a few weeks on the tundra? The training of knowledge cannot be a one-way flow of dialogue and information. This does not remove the power imbalance.

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USE OF UNBOUNDED TOXICITY ENDPOINTS IN ECOLOGICAL RISK ASSESSMENT

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The primary goal of most standard toxicity tests is to quantify the dose-response of the chemical stressor(s) of concern in relation to the toxicity endpoint of interest (e.g., LC50, NOAEC, where LC50 = lethal concentration to 50% of test organisms and NOAEC = no observed adverse effect concentration). In some cases, however, the desired point on the dose–response relationship is missed. For example, when mortality at the highest test concentration is below 50%, the resulting LC50 value usually cannot be determined with adequate certainty (the LC50 value is used here for illustrative purposes. This same concept applies to other benchmarks when point estimation requires extrapolation beyond the dose response curve). Often, these are reported as ''>LC50'' values and are referred to here as ''unbounded'' toxicity values. Similarly in hypothesis test designs, unbounded ''<NOAEC'' values are often reported when statistically significant adverse effects occur in all test concentrations relative to the control (i.e., when the LOAEC [lowest observed adverse effect concentration] is the lowest concentration tested). When no statistically significant effects occur at any test concentration, the resulting NOAEC is also unbounded because its relationship to the LOAEC is not known although, in practice, it often may not be distinguished from a NOAEC that is bounded by a LOAEC.

The question becomes whether (and if so, how) these unbounded toxicity endpoints should be used in ecological risk assessment. It is apparent that some risk assessors screen out such unbounded values from further consideration in risk estimation. However, I suggest that so long as the test is scientifically sound, such unbounded values can provide useful information in risk assessment.

A common practice in deterministic ecological risk assessment is the calculation of a hazard or risk quotient (HQ or RQ). In its simplest form, the RQ represents the estimated exposure concentration divided by concentration associated with the toxicity endpoint: RQ = Exposure/Toxicity.

As illustrated in Table 1, the use of unbounded LC50 or NOAEC values can provide meaningful information depending on their relationship to the exposure concentration and the magnitude of the RQ that is considered a concern. In scenario #1, the precise value of the RQ is not known, but the upper bound of the RQ can be determined (i.e., it is known that it is somewhere below 0.5). If an RQ of 1 or above represents a regulatory cutoff for a risk concern, then the unbounded toxicity value of >20 μg/L can provide useful information because it is known that the RQ of 1 is not exceeded. Similarly in scenario #2, the unbounded NOAEC of <5 μg/L can be used to establish the lower bound of the RQ (i.e., it is known that it is somewhere greater than 2). The degree to which the exposure concentration exceeds toxicity is not known, but it can be stated that exposure exceeds toxicity by greater than a factor of 2. In scenario #3, the upper bound of the RQ can be determined (<2) as in scenario #1. However, the resulting RQ does not provide useful information in relation to a hypothetical regulatory cutoff of 1.0 because the RQ cutoff of 1.0 may or may not be exceeded depending where the actual LC50 value lies.

Scenario	Exposure Concentration (μg/L)	Toxicity Value (type) (μg/L)	RQ
1.	10	>20 (LC50)	<0.5
2.	10	<5 (NOAEC)	>2
3.	10	>5 (LC50)	<2

The situation becomes substantially more problematic when unbounded toxicity values are considered for use in probabilistic-based effects assessment such as species sensitivity distributions (SSDs). Difficulties arise because assumptions regarding inclusion or exclusion of the unbounded toxicity values can affect the distribution shape and the predicted concentration associated with a given effect percentile (e.g., HC5 [5% percentile of the SSD]), as illustrated in Figure 1. In Figure 1, a data set of 20 species LC50 values is plotted of which 17 are bounded LC50 values (solid black diamonds) and the three least sensitive species are assumed to have unbounded (‘‘>’’) LC50 values (open black diamonds). These unbounded LC50 values are included in the SSD and plotted as if they were bounded (‘‘=’’) LC50 values based on the highest concentration tested. Of course, the resulting SSD would contain some bias because it is known that the actual LC50 values of the three least sensitive species is greater than that actually plotted (i.e., the upper tail should be shifted to the right, but how far is unknown). Notably, if such unbounded LC50 values were excluded from this SSD and the 17 remaining bounded LC50 values replotted, the mid to upper tail of the resulting SSD shifts even further to the left (solid circles) which appears to introduce even more bias compared with the former case. Lastly, the data points shown in open triangles illustrate the effect on the SSD if the actual LC50 values were each assumed to be 3× higher than the unbounded values.

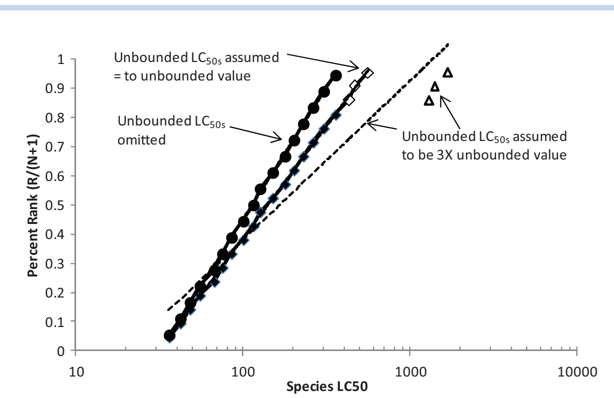

Figure 1. The effect of including and excluding unbounded toxicity values on the SSD.

The scenarios illustrated in Figure 1 may be somewhat extreme in terms of how the unbounded LC50 values are distributed just at the upper tail of the SSD; however, these scenarios are not unprecedented. If this were actually the case, the risk assessor should carefully review the study for quality and evaluate whether the species associated with the unbounded LC50 values may be responding with a different mode of action (MOA). This is particularly important for chemicals with highly specific MOA which may not be conserved across taxa. In such cases, SSDs may be constructed separately based on the actual or presumed MOA. In other cases where the unbounded toxicity values are more uniformly distributed among the bounded toxicity values, the impact of including or excluding unbounded values may be minimal. Although there probably is not a single approach for addressing the biases introduced by unbounded values in SSDs, it is recommended that whatever choice is made, the consequences of including or excluding the unbounded values be described in the risk assessment.

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RESPONSE TO ROARK ET AL. (2013) ‘‘INFLUENCE OF SUBSAMPLING AND MODELING ASSUMPTIONS ON THE USEPA FIELD-BASED BENCHMARK FOR CONDUCTIVITY’’

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In a prior Learned Discourse, Roark et al. (2013) attempted to cast doubt on a set of papers published in *Environmental Toxicology and Chemistry* (Cormier and Suter 2013; Cormier et al. 2013) and a USEPA (2011) report that used field data to derive a benchmark for conductivity in streams. They conclude, contrary to the findings of the journal’s reviewers and a review panel of the USEPA’s independent Science Advisory Board (SAB), ‘‘that 300 μS/cm has little relevance as an effect threshold for macroinvertebrates in these streams.’’ They base that conclusion on three findings that they claim show ‘‘biases that challenge the accuracy of the final benchmark.’’ We rebut their conclusions by responding to their three analyses.

First, Roark et al. contend that the benchmark is biased because we used the West Virginia Department of Environmental Protection's (WVDEP's) biological data which are based on a characterization of 200 ± 40 individuals per sample. Because Roark et al.'s simulations of smaller samples yielded slightly lower estimates of the benchmark (their Figure 1A), they concluded that the benchmark is biased. However, they do not recognize that their simulation of the effects of smaller counts does not demonstrate their hypothesized benefits of larger counts. Also, they do not acknowledge the studies done by WVDEP to determine the adequacy of a 200 count to characterize their samples. Most importantly, the benchmark value derived from the WVDEP data was validated using an independent data set from the State of Kentucky (USEPA 2011), which was comprised of a full count of the samples with as many as 6000 individuals per sample. The full counts yielded a slightly lower HC05 of 282 μS/cm, which is counter to the prediction by Roark et al.

Second, Roark et al. contend that the number of bins used to weight the data affects the results and contributes to the "bias." Roark et al. acknowledge that "weighting can be an appropriate method for accounting for uneven sampling…" Their objection seems to be that the number of bins is important and that we did not present our sensitivity analysis. However, an examination of their sensitivity analysis (their Figure 1B) shows the same result that we obtained; there is no bias in the result with the number of bins. There is only a flat line with a small random variance. Their figure also shows that the number of bins that we used (60) gives the same result as most other bin sizes and that result is the 300 μS/cm benchmark value.

Third, Roark et al. contend that our decision to require at least 25 occurrences of a genus to include it in the analysis also contributed to a "bias." However, examination of their Figure 1C supports our choice. Between 0 and 20 occurrences, there is a regular rise in the HC05 value (the potential benchmark) and a plateau between 20 and approximately 100 (we used 25 to be conservative). Between approximately 100 and 375 occurrences, the HC05 estimates rise and decline erratically. Finally, above 375, the HC05 estimates rise. This pattern is accounted for by three factors. First, if there are not enough occurrences of a genus, the level at which it is extirpated is likely to be underestimated. Second, as more occurrences are required, the number of genera in the species sensitivity distribution (SSD) decreases so that the estimate of the HC05 becomes less stable. Third, as more occurrences are required, the few remaining genera are generalists that tolerate a wide range of conditions including high conductivity. Those three phenomena each dominate a segment of the figure. Below 20 occurrences, the HC05 increases with the number of occurrences until there are enough points to estimate the extirpation level of each genus, at which point the relationship plateaus. As more occurrences are required, the number of genera in the SSD declines and the HC05 becomes unstable, rising and falling as genera are lost above or below the 5th centile. Finally, above 375 occurrences, only widespread, tolerant genera are included in the calculation.

In summary, the three analyses presented by Roark et al. do not demonstrate a bias in the USEPA's conductivity benchmark. Rather, they support our approach to balancing different sources of variability in the model. Their results are consistent with our own extensive sensitivity analyses in showing that varying these parameters within a reasonable range does not significantly change the benchmark value. None of their analyses provide a scientific basis for changing the method or the resulting conductivity benchmark.

Disclaimer—This document has been reviewed in accordance with USEPA policy and approved for publication. The views expressed are those of the authors and do not necessarily reflect the views of policies of the USEPA.

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