

Integrating Information from Different Levels of Biological Organization - What Then ?



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Abstract : Global ecological problems as well as regional problems require information from a variety of levels of biological organization from single species to ecosystems. Both scientists and decision makers benefit from synthesis of this information, especially when coupled with chemical/physical information. Synthesized information is also more easily communicated to the general public, especially if the minutiae so fascinating to specialists are avoided. However, neither integration nor synthesis should be an afterthought, but should be incorporated into the original project design. A continual flow of information should be maintained during the data gathering stage so that midcourse corrections can be made when significant interactions are discovered. However, if the scientific information conflicts with political ideology, it should not be rejected.

Key words : Synthesizing information, Global data management, Information flow, Data connections, Levels of biological organization, Global commons.

Education is the ability to perceive the hidden connections between phenomena

Vaclav Havel

Ecosystems may go on for years exposed to pollution or climate changes without showing any change at all and then suddenly they may flip into an entirely different condition, with little warning or none at all.

Derrick Jensen

Introduction

Systems-level thinking and global data management are essential to information integration. However the 19th and 20th centuries were eras of specialization - essential, but not adequate for addressing systems-level problems such as global heating. This problem will require a synthesis of all levels of biological, chemical, and physical information at all levels of ecological

organization from single species to landscape/global. Moreover, this information must first pass academic peer review and then be converted, if necessary, to a form understandable to and operational for decision makers. For matters requiring a global perspective (e.g., global heating and ocean acidification), identification of the types of information needed for a robust assessment of the problem is essential, as well as how each category of information will be used. Also, if persuasive evidence of connections between the components is absent, the hypothesis of connectivity is faulty.

Capra (2002, p. 93) gives some superb illustrations of connections between life, mind, and society: "To say that technology is not strictly neutral, that it has inherent tendencies or imposes its own values, is merely to

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recognize the fact that, as a part of our culture, it has an influence on the way in which we behave and grow." Arguably, the United States is the ultimate automobile culture. Rarely do students walk to school as I did as a boy. Rarely is a corner grocery store within walking distance as when I was a boy. Many people commute 50 miles, or sometimes more, to work. Now that peak oil has been reached (or soon will be), the whole fabric of American society will be dramatically changed in the near future. How bad the future shock will be is not yet clear - but, it will be severe. Global heating (as James Lovelock notes, the term warming is too cozy) has made society aware of connections that received little or no attention just a few years ago. The Intergovernmental Panel on Climate Change provides persuasive evidence that humans are responsible for a large portion of atmospheric greenhouse gases.

Information Flow

Information flow between different levels of biological organization must be organized in a systematic and comprehensible way (for all interested parties) to keep both ecological and societal systems healthy and functioning. This synthesis will only work if scientific evidence is not suppressed or distorted (*e.g.*, scientific reports altered in significant ways) because it differs from political ideology. Some illustrative examples of causes of inadequacies of information flow follow.

(1) Specialists can communicate most effectively with similar specialists and are not well prepared for communicating effectively with those with dissimilar specialties.

(2) Specialized jargon commonly hampers communications among disciplines.

(3) Although the 21st century is emerging as an era of synthesis and integration, both specialization and integration are essential to the resolution of systems-level issues.

(4) Integrating scientific information will be hard, time consuming work until it becomes a ubiquitous practice and all interested parties have gained confidence in the process; it will then still be challenging but will be an accepted process.

(5) Since integrative science is a relatively new process, more resources (*e.g.*, time and money) are needed.

(6) If the global system is to be used indefinitely by humans, no component can have significant adverse effects upon other components.

(7) The complexity of global systems-level studies is beautifully documented by a publication of the World Business Council for Sustainable Development (2004), which notes that, although sustainable mobility can be achieved, it is beyond the capabilities of any one company, one industry, or one country to resolve.

The Global Commons

Ecosystems are complex, multivariate systems with self-organized patchiness (*i.e.*, diversity of habitat types) and are vulnerable to catastrophic shifts between ecosystem states (Rietkerk *et al.*, 2004). Cairns (2006) notes that economic globalization has resulted in all the world's resources becoming available to any individual or organization that has enough money to gain access to them. Since the development of global information integration is in the early stages, particularly for catastrophic ecological shifts, scientists are faced with a major challenge, especially

since time is short. May scientists rise to the challenge!

Carrying Capacity

Hardin (1972) defines carrying capacity as the level of exploitation that will yield the maximum return in the long run. His spaceship metaphor is appropriate because a spaceship on a long voyage has a finite carrying capacity that, if exceeded, will result in hardship, even death, to the passengers. Regrettably, most people have trouble visualizing this concept of Earth. Equally difficult is visualizing severe, adverse consequences if Earth's carrying capacity is exceeded as it now is. Wackernagel *et al.* (2002) provide persuasive evidence of a 24% ecological overshoot, which appears to be increasing at about 1% per year. These numbers definitely indicate inadequate integrated carrying capacity management. Astronauts in spacecrafts are well aware of and dedicated to a comprehensive, systems-level approach - the crew of Spaceship Earth needs to develop a comparable attitude toward carrying capacity. As Cairns (2003-2004) notes, billions of individuals are poorly fed, housed, and educated because economic globalization has resulted in a global commons. Resources are more likely to benefit special interest groups than the common good. In many respects, the present abuse of the global commons reduces personal responsibility to the point where it has little meaning. How else can one account for an ecological overshoot of more than 24%? Some uncertainty is always present about the consequences of stressing complex, multivariate systems at the global level of organization, but this fact does not justify failure to use every means available to reduce that stress.

Global Tipping and Breakpoints

Never before in history have humans had such major effects upon Earth's ecosystems. Never before have humans pushed Earth's ecosystems so rapidly toward major tipping and breakpoints whose locations are not precisely or even approximately known. Still, ecological early warning signs are related to such events. For example, increased variability is often characteristic of complex systems about to experience disequilibrium. Biological communities with low numbers of individuals per species often display dominance of one or more formerly low density species when under stress, and the total number of species usually declines. Since ecosystems and their communities usually differ markedly from region to region, selecting appropriate attributes to monitor requires sound professional judgment and knowledge about each particular system. All monitoring projects should have explicit statements regarding those conditions requiring immediate remedial action and a list of personnel available and qualified to do so. Also needed are: (1) monitoring of selected attributes for each particular ecosystem or habitat, (2) integrating connections with other monitoring efforts within the larger ecological landscape of which the smaller system is a part, and (3) integrating connections at the global level. Global heating is a good example of this issue. It is caused by greenhouse gas emissions all over the planet. Emissions reductions will only be effective if they have a global target that all nations agree is essential and are willing to take the necessary remedial measures.

The general public globally and its political representatives will not like the expense of generating information at different

levels of biological organization until they realize that human well being and, very probably, survival, depend upon it. Much time will be needed before the world accepts the urgent need for this type of scientific information in greater quantity and quality. Then, scientific teams must be formed to gather, integrate, and synthesize the information, but time is probably very short before more major ecological and societal thresholds are crossed. Arguably, major resistance to these changes will occur because major social changes will be necessary, which are based on scientific evidence that guides policy decisions likely to enhance the probability of leaving a habitable planet for posterity.

National and Global Security

The United Nations Security Council is convening a meeting to discuss the effects of global heating on security (Leopold, 2007). The United States has appointed a committee of 11 generals and admirals to discuss the same subject. Although these reports will not be available for some time, clearly these groups would not have been formed if persuasive evidence were not already available that climate change is a threat to both national and global security. John Ashton, Prime Minister Blair's special ambassador to the UN, noted that the changing climate in Darfur has essentially driven two communities of people into competition for the same land (De Sousa, 2007). The violent conflict in Darfur has already claimed more than 300,000 lives and is one of the early signs of threats to global security resulting from climate change. The UN has just released the third 2007 report by the Intergovernmental Panel on Climate Change, and the preliminary releases indicating it would be grim were correct

(Anonymous, 2007). Australia's "Big Dry" has already received much attention (Marks, 2007). In fact, the US panel of general and admirals warned that climate change is already a "threat multiplier" in the world's fragile regions, "exacerbating conditions that lead to failed states - the breeding ground for extremism and terrorism" (Homer-Dixon, 2007). One of the world's most populous nations, China, has a number of environmental problems.

Illustrative Examples of Disruption

Many other problems now not associated with climate change could well disrupt both information gathering and integrating information. For example, honeybee colony collapse disorder has cost some beekeepers half their colonies or more (*e.g.*, Barrionuevo, 2007a). At present, no one can say what is causing the bees to become disoriented and fail to return to their hives. Arguably, honeybees are the insects that are most important to the human food chain since they are the principal pollinators of hundreds of fruits, vegetables, flowers, and nuts. Obviously, the declining number of bee colonies, which has been going on since the 1940s, will affect the supply of foodstuffs. This occurrence, in turn, will affect societal stability, which is essential to gathering and integrating the information needed for coping with security risks at both global and national levels.

Finally, attempts have been made to alter scientific evidence, not only by non-scientists in the US government but even in the World Bank. One of Paul Wolfowitz's (formerly a senior staff member of US President George W. Bush) two, hand-picked deputies, Juan José Daboub, attempted to water down references to climate change in one of the World Bank's

main environmental strategy papers (Guha, 2007). In an era when climate threatens global security, any alteration of scientific information could cause as much damage as terrorists. Furthermore, post-peak oil may well destabilize nations (*e.g.*, the United States) addicted to cheap, abundant oil. As a news release from the Oil Depletion Analysis Centre (ODAC, 2007) indicates, new oil projects cannot meet world needs in this decade. The website "Past Peak" (2005) reported that "the net present value of all discoveries for the 5 oil majors during 2001/2/3 was less than their exploration costs" (as reported by Energy Pulse, November 17, 2004). In short, finding and pumping new oil often costs more than the oil is worth. The period after peak oil will be a huge destabilizing shock to nations addicted to cheap, abundant energy.

The message in all of these citations is that events that could destabilize human society are likely to occur in the near future. These events are likely to disrupt the gathering of and synthesis of information needed to cope with and diminish stresses on both natural systems and human society.

Post Integration

Although integration of data from different levels of biological organization should be a continuous process, humankind is justified in using the massive amount of evidence on global heating and many other environmental problems for immediate remedial measures because a global environmental crisis already exists. However, one can reasonably inquire "then what?" after the integration is robust. Former US Vice-President Gore's documentary on global heating ("An Inconvenient Truth") has received much attention in the United States

and has won two major awards. Despite the fact that a large percentage of the public believe (about 80% in one poll) that climate change is a major problem and will have adverse effects upon their lives, very few are lowering their energy consumption. This situation has been called the "green gap" (Comment, 2007), which essentially means that, while humans pay lip service to the urgency of the problem, they are resistant to doing something about it. Worse yet, the poor countries of the world will suffer most from global heating caused primarily by anthropogenic greenhouse emissions from the world's wealthiest countries (Revkin, 2007). For example, Africa has accounted for less than 3% of the global emissions of carbon dioxide from fuel burning since 1900, yet its 840 million people face some of the greatest risks from drought and disrupted water supplies. Finally, more than 60 nations, mostly in the Third World, will have existing tensions hugely exacerbated by the struggle for ever scarcer resources (Lean, 2007). Clearly, the wealthy nations must do far more for poor nations than they are now doing. For example, reducing the risk of producing many millions of environmental refugees is an act of enlightened self interest, as well as a humane act. So, too, would be American help in reducing the spread of the deadly hemorrhagic form of dengue fever that is increasing dramatically in Mexico (Associated Press, 2007). Similarly, in Russia, tropical diseases, such as malaria, are appearing (Dybas, 2007). Also, more than 3,000 cases of infections caused by hantaviruses have been reported in Russian cities and towns. Obviously, more developed countries are not immune to climate-related disease outbreaks either.

As Johnson (2007) remarks: "Our efforts in social mission must be self critical. It is not enough to do good if we can do better. To discern ways in which our efforts can be more productive is a key to developing and practicing ethical foresight. This requires the hard work of thinking seriously and thoroughly about issues." Clearly, this approach has not been used for the effects of global climate change for either poor nations or for other life forms. The Intergovernmental Panel on Climate Change report released Friday 6 April 2007 notes that, by 2080, it is likely that 1.1. to 3.2 billion people worldwide will experience water scarcity, 200 million to 600 million will be threatened by hunger, and each year an additional 2 million to 7 million will be victims of coastal flooding. Shockingly, the world's poor will suffer most, although they are the least to blame for climate change. The report further predicts that 20-30% of the planet's species will be threatened with extinction if temperatures rise 1.5 to 2.5°C, which is on the lower side of the end of the century forecasts (Intergovernmental Panel on Climate Change, 2007). This report also addresses refugee crises unlike any previous ones (Blakemore, 2007). Predictably, no major attention has been given to either giving help to the refugees or stopping the climate change displacing them from their homes.

Loss of Ecosystem Services :

Ecosystems services are the processes through which natural systems and their component species sustain and fulfill human life. Examples are assimilation of atmospheric carbon dioxide, which has resulted in a livable climate; pollination of crops; food from oceanic fisheries; regulating services, such as flood control-in short, Earth's biological life support system. Ecosystem services have

had no prior costs to bring them into production. They were not deliberately produced to benefit humans, although they have made Earth habitable for humans for 160,000 years. Until these services are disrupted or lost, their value will not be evident to humankind. At present, with rapid climate change, protecting the ecosystems that provide these services is much cheaper than replacing them by use of technology, when that is possible (Costanza *et al.*, 1998, Kennedy *et al.*, 1997).

When the agricultural system fails to deliver the foodstuffs society demands, adverse effects upon ecosystem services will be obvious. For example, the Chinese have produced tofu, a dietary staple, from soybeans for thousands of years. However, China's very rapidly growing economy has resulted in increased demands for pork, poultry, and beef, which require higher volumes of protein rich soybeans as animal feed (Barrionuevo, 2007b). The soybeans are grown in Brazil, about 15,000 miles from China. To clear land for growing soybeans, large tracts of the Amazon forest are removed, thus diminishing storage and uptake of carbon dioxide (the major greenhouse gas) and production of oxygen. If the forests are burnt, as often occurs, large amounts of carbon are no longer stored, and burning the trees increases atmospheric carbon dioxide. Since China is also plagued by scarce water supplies and 1,000 tons of water is needed to produce 1 ton of grain, the market for land and water are rapidly growing.

The reports of the Intergovernmental Panel on Climate Change (2007) are superb examples of how information flow and integration thereof should be handled. They also demonstrate how many people and how much time are essential to complete a global

level task involving a complex problem. The reports also demonstrate that policy makers attempt, often successfully, to "soften" the impact of scientific statements. Policy makers and politicians, who are rarely credentialed scientists (and, therefore, lack qualifications), try to alter the conclusions involving a complex, multivariate scientific issue. Of course, policy makers have a responsibility to communicate the basis of their decisions to their constituency, but not to alter the parts of a scientific report that are distasteful to them.

Unexpected Events

Climate change will almost certainly produce many unexpected events. A recent example is a study that suggests the Southern Ocean is slowing losing its capacity to buffer the world from rising concentrations of carbon dioxide (Zarembo, 2007). The Southern Ocean surrounds Antarctica and stores about a one-third of the carbon stored by the planet's five oceans. If this finding is confirmed, it would result in acceleration of the accumulation of atmospheric carbon dioxide. However, the possibility exists that the measurements of carbon dioxide changes were so subtle that they could easily be sampling errors. On the other hand, they might well be correct. In short, the "worst case scenario" might be about to occur. When faced with risks at the global level, stabilizing or reducing carbon dioxide emissions seems an obvious choice until one considers the stiff resistance to either choice if the economy will be affected. The usual bureaucratic approach is "more studies are needed." However, if a major ecological tipping point is exceeded while waiting for more information, harsh penalties may result. For example, scientists at Bristol University report that a previously unexplained surge of

carbon dioxide levels in the atmosphere in recent years is due to more greenhouse gas escaping from trees, other plants, and soils because global heating was making vegetation less able to absorb anthropogenic carbon dioxide emissions (Adam, 2007). Since two unexpected events (*e.g.*, less oceanic absorption and less vegetational absorption) could easily occur, additional precautions to avoid crossing an ecological threshold seem prudent.

Science, Policy, Religion, and Global Security

A bipartisan proposal in the US Congress calls for the US Central Intelligence Agency and the Pentagon to elevate global heating to a national defense issue (Bender, 2007). In 2003, two Pentagon analysts wrote a comprehensive report on the possible national security implications of an abrupt change in climate, including the prospect of nuclear powers struggling to feed their people and being forced to fight over shared rivers. The Pentagon Report noted that, in over 200 river basins involving multiple nations, conflict could occur over access to water for drinking, irrigation, and transportation. How prophetic! At present, however, politicians in some countries will be more anxious than ever to alter or suppress scientific publications that are not congruent with their political agenda.

A battle is also occurring in the US Congress over stem cell research. Both houses (Representatives and Senators) will have to attempt resolving the differences in the bills and, if successful, will send the compromise bill to the President, who has already announced that he will veto it. After listening to the debate in the US Senate, I concluded that scientists have found a promising solution for many human afflictions,

but they are being blocked by politicians for reasons that have nothing to do with science. Much more research is needed, as always, but it will hardly be adequate when carried out with inadequate material (*e.g.*, dead stem cells). The process of integration of any type of information will be badly damaged if information flow is blocked and research is suppressed for political, religious, and other reasons.

Conclusions

Never before in human history has humankind had the ability to alter global climate so dramatically. Of course, not all greenhouse gases are of anthropogenic origin, but a significant number are, so humans have control over them. Coping with global climate change effectively will require vast amounts of information that will be most useful if integrated so that connections to other components and the whole are quite clear. In addition, scientists must learn to communicate more effectively with each other in a transdisciplinary fashion, but also with the general public and its political leaders. Corporations must become more aware, as many have already done, that protecting the biospheric life support system is an act of enlightened self interest because both their executives, employees, and customers are all crew members of Spaceship Earth. New costs of gathering and integrating the information flow may initially appear excessive until the cost of doing nothing is carefully considered.

The educational system has a major role in preparing students to be crew members of Spaceship Earth. The present crisis (*e.g.*, ecological overshoot) is the result of billions of individual decisions (*e.g.*, how much fossil fuel to use); consequently, enlightened individual decisions made with a global

perspective (*i.e.*, ecocentric rather than anthropocentric) are essential. The time remaining to make an effective transition to an ecocentric lifestyle is short, but every delay will make the transition more difficult.

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