State of the Global Environment

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Preface

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The State of the Global Environment

While often treated as separate environmental problems, the different stresses that human activity is putting on the global environment do not operate independently of one another. A human analogy would be interactions between various medicines or foods, as for example, a compound in grapefruit greatly increases the effect of statins to the point that they can inflict liver damage. An environmental example would be the combined impact of an alien invasive species, the Emerald Ash Borer, on the American Ash because with climate change the beetle's numbers grow larger with longer summers. Indeed as environmental stresses grow in intensity the interactions become ever more important, but at the moment not very much is known about them.

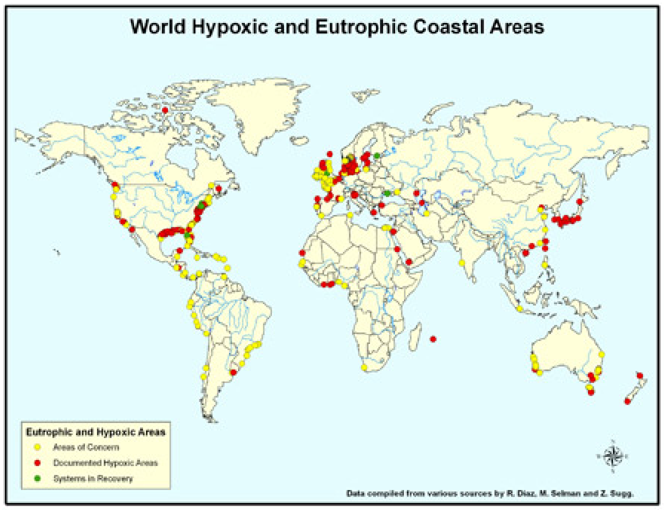
Living systems (biodiversity, ecosystems) together with non-living elements linked by geography act in an integrating fashion. So the environment is where one can see the consequences if not necessarily the detail of the interactions. And since environmental problems by definition affect living systems, it is biodiversity which integrates the effects of the various environmental stresses (from human made chemicals all the way to climate change). The number of endangered species in various groups of organisms has been increasing very rapidly and the general view is that extinction rates in the latter part of the twentieth century were 100 to 1000 times the normal background rate. As climate change and other environmental drivers tighten their grip, we are not far from increasing that by an order of magnitude.

The oceans which cover two thirds of the Earth's surface are affected by both direct and indirect factors. A recent study on the human impact on marine ecosystems concluded that no part of the oceans is unaffected, and that 41% of ocean ecosystems are affected by multiple drivers. It is now evident that industrialized fishing has managed to remove 90% of the large predatory fish. Biodiversity loss has been demonstrated to be increasingly reducing the ocean ecosystem services of food production, maintenance of water quality and ability to recover from natural and human caused disturbances. (Conversely, it has been demonstrated with biodiversity restoration that services recover; marine protected areas sited to protect fish refugia actually improve fisheries productivity in neighboring waters).

Coral reefs are increasingly affected by climate change which induces bleaching events disrupting the fundamental partnership between coral animals and associated algae that is the heart of the reef ecosystem. In very warm years, bleaching can kill up to 90% of the corals in a region. The 1998 El Nino event resulted in 16% mortality of the world's reefs. The prospect of is for chronic bleaching as the climate warms further. An additional negative factor is increasing acidity of the oceans. The oceans are now 30% more acid (0.1 pH unit) than in pre-industrial times. The combination of these two factors (if greenhouse gas concentrations reach 500 ppm) will exceed anything that occurred within the past 420,000 years. Corals under such conditions will cease to be an important part of reef systems with negative effects on associated fisheries, tourism, and people.

Ocean acidification has only recently been recognized as a problem. Scientists were so focused on the benefit to slower greenhouse gas accumulations of carbon absorbed by the oceans, that they overlooked the fraction that becomes carbonic acid and has consequently been increasing acidity. This has profound implications not only for corals but for any organism that builds shells or skeletons from calcium carbonate. This includes planktonic organisms that in untold numbers are at the base of food chains. Ocean acidification is an additional effect of greenhouse gas concentrations separate from the consequences for climate. Effects are already evident at the base of food chains in the North Atlantic and off Alaska.

Oceans are suffering additional problems from land-based sources of pollution, and ocean circulation facilitates transport of pollutants globally. There are multiple kinds of pollutants but the two major ones are nitrogen and phosphorous. Indeed the nitrogen cycle



is so disrupted that about twice as much nitrogen is available globally (in biologically active form) as normal. So eutrophication problems have expanded from enclosed seas to include multiple and indeed, a growing number of dead zones around the world. One of the most prominent is in the Gulf of Mexico. Dead zones promote harmful algal blooms and large areas devoid of oxygen inimical to fisheries.

Problems in freshwater systems abound, and freshwater biodiversity is declining more rapidly than terrestrial or marine. There are two principal reasons. One is that freshwater drainage concentrates pollution from the land. The second is that people tend to think of naturally occurring water not as a living aquatic ecosystem naturally brimming with life, but rather simply as a liquid of importance for drinking, agriculture, and hydropower (172 of 292 large river systems are affected by dams including eight of the most diverse biogeographically). The current (under)estimate of freshwater animal species is about 125,000 species.

There are of course good parts to the story in pollution clean up, recovery of some freshwater fisheries, and freshwater protected areas but freshwater tends to be dominated by concerns about supply and quality. The Washington Post just reported that the city's water was considered safe for drinking but not safe for the National Aquarium to keep freshwater fish in without elaborate treatment.

Concerns about supply are very real of course whether it is serious overdrawing of groundwater from aquifers, or the decline in glaciers which can be important sources such as for the water supply for La Paz, the great Chinese rivers or the Ganges. The latter is driven by climate change; as a consequence, water availability is projected to decline up to 80% in 130 investigated rivers.

Approximately 50% of the earth's wetlands have been drained or converted to other purposes since 1900. The consequences include huge carbon releases from peat deposits, flash flood and drought-prone watersheds and local climatic changes. This affects fishery productivity and actually makes floodplain communities vulnerable to major climatic events. Integrated watershed management at the basin scale and coastal zone management have successfully addressed such problems in some instances.

Terrestrial ecosystems have been subject to massive conversion for multiple purposes from agriculture to human settlements. That includes massive deforestation over many centuries with close to half of all tropical forests cleared in the last 50 years. Most of the lowland tropical forest is gone in parts of Southeast Asia. In my view, the Amazon forest is perilously close to a tipping point at which the hydrological cycle that maintains it will be undercut creating a serious drying trend in the basin plus drying south of the Amazon as well.

Grassland, savannahs and dry forests have been cleared to a major degree in many instances initially for grazing stock. Little of the prairie remains in the United States and only a bit more than 20% of the cerrado region of Brazil (with important biodiversity) remains. Further pressure on remaining terrestrial ecosystems will come from pressures to increase food production for the additional three billion increase in human population, as well as for bio-fuels.

Critical areas for global biodiversity have been identified, namely "biodiversity hotspots" where there is a concentration of uniquely occurring species under great pressure. These are primarily terrestrial but a new analysis will add marine ones. These clearly are some of the first places to send the conservation "fire engines", but that does not substitute for protecting other important areas of biodiversity like the remaining wilderness areas, or the need for biologically functional landscapes and waterscapes in general.

Land degradation is a major way in which the terrestrial environment is affected with negative consequences for biodiversity, water availability, soil fertility/agriculture as well as carbon accumulation and storage. Much like water quantity and quality, it is very directly related to human well being, as well as indirectly through the degradation of ecosystem services. It can occur because of sheer misuse of the land as in the eroded landscapes of Madagascar and the denuded lands of Haiti. It can also occur in less direct ways such as in parts of Australia where clearing of natural vegetation causes the water table to rise above a salt layer creating a salinity problem. Salinity can also be caused by irrigation whether in the former Fertile Crescent or parts of the American west.

The productivity of green plants that is at the base of so many food chains on earth is measured as Net Primary Productivity (NPP) and is essentially plant growth net of plant respiration (the metabolic activity of existence). It also can be used as a first approximation of the overall state of the planet's ecosystems and the health (or degradation) of the land. A major fraction of NPP has been appropriated for human use and it is a cause for concern, especially in a world concerned about sufficient food, both now and for growing population, that NPP on land has declined by 12%.

Species are clearly affected in other ways. Invasive species can have massive impacts. For example the chestnut blight eliminated a keystone species, the American Chestnut, in North America, and a comb jellyfish (*Mnemiopsis leidyi*) introduced in ballast water from the eastern coasts of the Americas undercut a quarter of a billion dollar anchovy fishery in the Black Sea. Globalization, with its proliferation of trade and travel, has greatly augmented the rate at which alien species are introduced around the world. Clearly reducing the rate at which alien species are introduced is far more effective than dealing with the consequences once they have taken hold.

The biosphere is laced with man made chemicals, with about 70,000 different ones currently existing and 1,500 new ones created every year. Rapidly developing and proliferating use of nanotechnology is a relatively new category of contaminants in which the atom or molecule in question changes its properties at the nano scale. Some of the early chemicals recognized to have deleterious environmental effects were the chlorinated hydrocarbons such as DDT, and the chlorinated fluorocarbons (CFCs) that affected and still affect the ozone layer.

The persistent organic pollutants (POPs) include compounds recognized as having important deleterious effects and requiring control and management. Only a small number (twelve) are formally recognized under the relevant treaty which promotes sound chemical management. Probably the greatest priority for man made chemicals in general is to rapidly increase our knowledge about them and their effects.

Heavy metals in the environment are important and related to man made chemicals. Lead and mercury are clear examples that effect living systems human and otherwise.

Distortion of major global cycles such as carbon and nitrogen are changing distributions and concentrations with consequences ranging from eutrophication to climate change from the greenhouse gases. Sulfur has been a problem at least regionally with acid rain in various parts of the world. These distortions are analogous to electrolyte imbalances in our body chemistry and should raise similar concern and action.

Carbon dioxide, methane and some nitrogen compounds are important greenhouse gases and are changing the climate of the planet. For the past 10,000 years there has been an unusual period of climatic stability. It is a period in which agriculture, human settlements and civilization came into existence such that the entire human enterprise is based on the assumption of a stable climate. Ecosystems similarly have adjusted to a stable climate. As a consequence, climate change has grave implications for human welfare and all living things on the planet.

The Earth is already 0.8 Degrees C warmer than in pre-industrial times and current CO_2 concentrations are close to 390 ppm compared to pre-industrial 280 ppm. The lag between an increase in greenhouse gas concentrations and the consequent trapping of additional heat means the Earth is already destined to warm by another 0.5 degrees C even if the increase in greenhouse gas concentrations ceased today.

Almost everywhere on the planet, nature is already responding to the climate change that has already occurred, changing timing of life cycles, and changing where species occur. More disturbingly, it has triggered some first threshold changes in ecosystems: e.g. coral bleaching and massive coniferous tree mortality from native pine bark beetles (in North America and Europe) that have an additional generation because of longer summers. In the Arctic we are seeing threshold changes in physical nature (ice to water) with major consequences for species with ice related natural histories, e.g. polar bears and Arctic cod. Further, melting ice in the Arctic is already affecting climate in those high latitudes and there are possible consequences for global ocean circulation. Drying trends have already begun in some parts of the world and the changing hydrology has implications for water supplies and agriculture.

The implication in my view is that 2.0 degrees C increase (merely 0.7 degrees beyond where the Earth is pretty much committed) is higher than what would avoid major disruption of ecosystems. If we are already seeing threshold changes in ecosystems and system change like acidification of the oceans, the picture at 2.0 should be grave. At 2.5 the IPCC predicts dieback of the Amazon forest. At 2.75 degrees C the IPCC projects loss of 20 to 30% of all species.

The most important implication is that James Hansen is correct in identifying 350 ppm as the target greenhouse gas concentration level, and that the challenge is to overshoot as little as possible before returning to it. This also means that the threat of climate change is more urgent and grave by far than has been recognized, with major implications for ecosystem services, human welfare and human migration and associated potential conflict. Collectively, efforts to change to a low or no carbon energy base (“mitigation”) have so far been trivial. It also means that it is too late to avoid engaging seriously with adaptation programs for human and natural systems which are already necessary, indeed overdue. Care must be taken so that energy and adaptation solutions do not create further environmental problems in and use and biodiversity loss, etc.

It is important to recognize that currently the only means of consequence for removing CO_2 from the atmosphere is using biological means to sequester carbon. All ecosystems have the ability to contribute to sequestering carbon, but the role of forests is paramount. Stopping deforestation will eliminate 20% of current global annual emissions, and active reforestation, afforestation and plantation forestry can convert some atmospheric carbon into plant tissue. Maintaining deep peat carbon storage is also essential.

The preceding overview of the global environment shows a world headed for massive impairment of natural systems and soaring extinction rates, with global biogeochemistry already seriously out of balance, and interacting drivers of environmental change. It clearly makes the case for generous replenishment of the GEF. It also highlights the need for new development models and ones that are far less resource intensive. Even with no addition in population we are in a situation where the current human population cannot live an industrialized world lifestyle nor can it live as hunter gatherers. We are caught in a situation where the efficiency of markets (and accounting for environmental costs as externalities) reduces the cost of resources, materials, and energy to the point their overuse is causing global environmental problems. That needs to be replaced with creative substitutes that contribute to human welfare and reduction of inequity not just in the short term but also in the longer term.

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