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Editorial

Detecting the Health Effects of Environmental Change: Scientific and Political Challenge

Scientists fluent in ecology and the earth sciences understand that the current scale of human-induced changes to the biosphere entails risks of systemic dysfunction. Ecosystem processes, being complex and often nonlinear, are somewhat unpredictable in their responses to major external stressors (Egler, 1986; Levin, 1999; Gunderson and Holling, 2002). These issues are not yet prominent or well understood within population health research circles. Yet it is a reasonable expectation that this ongoing impairment of Earth's life-support functions poses substantial risks to human health.

It is axiomatic that humans rely on functioning ecosystems (potable water, breathable air, arable land, and food-producing ecosystems) for survival. Substantial evidence, including that from high-resolution paleoclimatic data, shows the link between abrupt climate changes (typically aridity) and the collapse of ancient societies (Weiss and Bradley, 2001). Severe and prolonged droughts forced the abandonment of agricultural settlements and the collapse of the Akkadian empire in Syria just before 2200 BC (Lemcke and Sturm, 1997; Cullen et al., 2000) and the collapse of the classic Mayan civilization in Mesoamerica in the ninth century AD (Brenner et al., 2001). Beyond these extreme examples, however, we have very little detailed knowledge about how changes to ecosystem functioning affect human health and well-being. The work of the Intergovernmental Panel on Climate Change has not yet identified certain evidence of effects on human health attributable to climate change (McMichael and Githeko, 2001). Similarly, the nearly completed Millennium (Ecosystem) Assessment project has documented very few clear examples of adverse effects on human health due to human-induced ecosystem changes.

This situation is both scientifically tantalizing and politically important. For example, consider the political aspect. We are dealing with complex, and not yet widely understood, changes in large biogeophysical systems. Models can be used to estimate future human biological and social impacts on the assumption, for example, that current trends in global climate change will continue. However, for many policy makers (confined within more immediate electorally defined time horizons), such future-displaced forecasts of adverse consequences may lack relevance. To make the topic tangible and substantial, we should strive to link currently observable adverse health effects of environmental changes with the likely future effects of large-scale biogeophysical environmental changes impinging on whole populations. Then, if we can communicate how the well-being and health of human populations is jeopardized by these global environmental changes, we will illuminate society's understanding of the essentials of sustainability.

As researchers, various scientific issues tantalize us. First, effects on human health emerge only gradually (in human experiential terms), because changes to system functioning and to the pattern of environmental events occur over decadal time. The early evidence of health effects, in general, is therefore rather marginal.

Second, most human health outcomes are multifactorial in their causation. A movement of highland malaria to higher altitudes could result from land-use change, population movement (including from the more malarious lowlands), changes in pesticide programs, and regional climatic changes (Hales and Woodward, 2003; Reiter et al., 2004). Apportioning causal influence among such coexistent—and often interacting—factors is difficult.

Third, recent research into the effects of climate change has shown that various nonhuman systems have already apparently begun to respond to the recent global warming trend (Houghton et al., 2001). This inference has relied on pattern recognition across diverse settings and outcomes. For instance, there is much evidence from multiple sites of a retreat in nonpolar glaciers and a reduction in snow cover. There has also been a widespread trend for plants, birds, and insects to shift toward higher latitudes and elevation and for breeding to start earlier in the season. Ecosystems are maintained by autonomous processes (whereby biota regulate energy, nutrients, and water) and, within limits, can self-correct in response to external disturbances (Levin, 1999). However, the chronic and substantial disturbances resulting from today's anthropogenic environmental changes will diminish—or overwhelm—this capacity for biotic regulation and adaptation, and nonlinear changes in systems may then occur.

A fourth consideration, underscored by the experience of the Millennium Assessment project, is that the various global environmental changes differ in the ease with which their health effects can be detected. The main health risks from stratospheric ozone depletion and the associated increase in ultraviolet radiation exposure are relatively straightforward: increased rates of skin cancer and ocular cataracts. The health effects of climate change are more diverse. Some (such as the direct effects of temperature extremes and changes in the distribution of certain mosquito-borne infections) are readily predictable. However, we still lack much information about baseline relationships between climate and disease occurrence for many vectorborne and rodentborne diseases, for most waterborne and foodborne diseases, and for aeroallergen exposures and respiratory disorders. We have also not yet developed a good understanding of the complex linkages among climate, food yields, water shortages, and population displacement.

The consequences for human well-being and health of disruptions to ecosystems are much more diverse and remain largely unstudied. It is therefore difficult to quantify current and future health effects of biodiversity losses and other changes to ecosystems. We are, however, acquiring new understanding of how the processes of forest clearance, agricultural practice, animal husbandry, river dams, and irrigation systems affect the emergence or the geographic and seasonal range of infectious diseases in humans.

Nonhuman species are mostly unbuffered by protective and adaptive devices of the kind afforded by human culture. The ice sheets, glaciers, birds, bees, and butterflies are directly exposed to changes in climate. Humans, however, live under shelter, wear clothes, trade their way out of food shortages, control mosquito populations, treat some sicknesses effectively, build sea walls and dikes, and have emergency disaster response capabilities. Highly developed countries will be better able to protect themselves from some of the predicted effects by virtue of their access to adaptive technologies and their ability to redirect resources from other parts of the health system. Nonetheless, the costs of avoiding large-scale environmental health effects will ultimately be at the expense of attending to other health outcomes, and many countries will not have sufficient resources. Subsistence or small-scale agricultural communities will be most vulnerable, and future population pressures will reduce their ability to use traditional methods of responding to ecosystem deterioration, such as habitat tracking (Weiss and Bradley, 2001). Our traditional public health responses to these threats may need to be re-evaluated in recognition of the fact that many nonhuman systems are already substantially challenged. For example, broad-acre clearing of vegetation around settlements to reduce bushfire risks has implications for local biodiversity and would reduce much-needed carbon sinks.

A new generation of epidemiologists and other health researchers is beginning to engage in this complex area. Indeed, recent international scientific reviews, such as those of the Intergovernmental Panel on Climate Change and the Millennium Assessment, have helped highlight areas in which information about how environmental changes affect human well-being and health is deficient. Success with this emerging research agenda requires a broad multidisciplinary foundation. Global environmental changes affect human health mostly via complex systems-based changes, including processes mediated by social and economic disruptions. Hence, there is a need for a high level of interactive interdisciplinary research and for a journal such as *EcoHealth*.

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