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*Profiles*

# Health Aspects of the Millennium Ecosystem Assessment

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## INTRODUCTION

> "Human well-being and progress toward sustainable development are vitally dependent upon improving the management of Earth's ecosystems... But while demands for ecosystem services such as food and clean water are growing, human actions are at the same time diminishing the capability of many ecosystems to meet these demands."
>
> —http://www.millenniumassessment.org

Biodiversity underpins the resilience of the ecosystems on which humanity depends. Loss of biodiversity is occurring at an unprecedented rate, driven by over-exploitation of productive ecosystems and other factors. This threatens vital ecosystem services, including food production, fresh water, nutrient cycling, waste processing, fuel and fiber, flood and storm protection, and climate stability (Vitousek et al., 1997).

The Millennium Ecosystem Assessment (MA) is intended to provide a knowledge base for sustaining ecological systems, while providing for human needs. This ambitious goal has an implicit emphasis on ecological management, while recognizing that social and ecological systems are inextricably linked. The scope of public health policy in relation to ecological sustainability is difficult to define. How, then, does human health feature in the MA?

To understand the potential health impacts of ecosystem change, two aspects need to be considered: the current vulnerability of the population under consideration and its future adaptive capacity (Fig. 1). These two are closely related, since vulnerable populations are less able to plan and implement adaptive responses. Vulnerability and adaptive capacity are also tied to the other aspects of well-being (material minimum, freedom and choice, good social relations, and security). The links between ecosystem change and human health—and the limits to human adaptive capacity—are seen most clearly among impoverished communities, which lack the "buffers" that the rich can afford. Poor communities are also the most obviously directly dependent upon productive ecosystems.

Material lack is a strong determinant of health as well as other aspects of well-being. Both at the country level and within countries, poorer communities are usually less healthy than richer ones (though with some notable exceptions). At the global level, poorer countries are still battling hazards such as lack of clean water and sanitation, which contribute considerably to their burden of disease.

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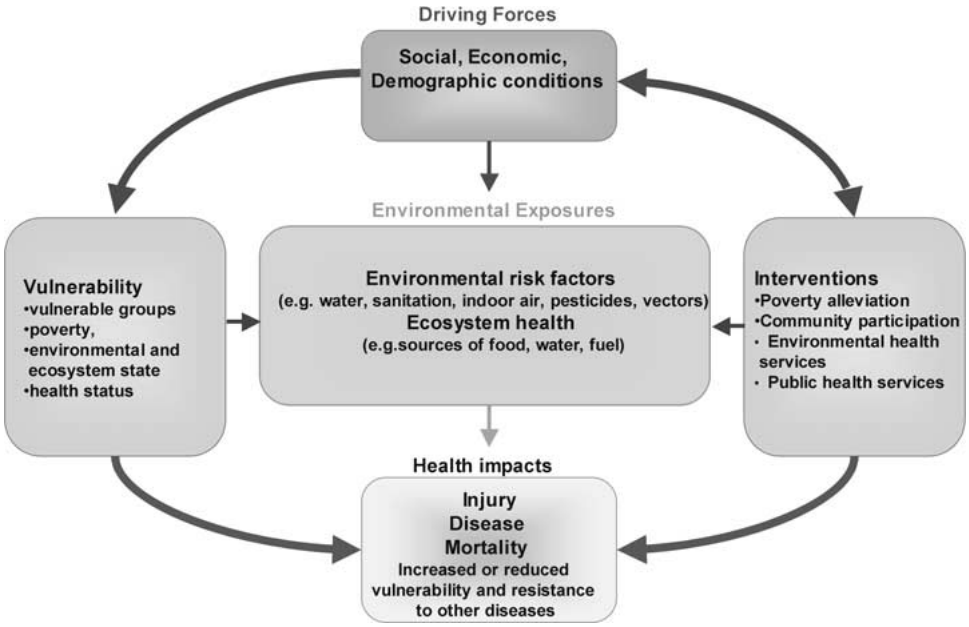


**Figure 1.** Causal pathways of ecosystem health impacts.

A conceptual framework has been completed (MA, 2003) but the reports of the main working groups are still in progress. The ''conditions and trends'' working group assesses the changing conditions of ecosystems and their services, the causes of these, and the consequences of ecosystem change for human well-being. In this working group, the ''*regulation of human infectious disease agents*'' is defined as an ecosystem service and has a separate chapter, while other health consequences of ecosystem change are covered in the ''responses'' working group (see below). The ''scenario'' working group will elaborate a range of plausible futures to describe how the quantity and quality of ecosystem goods and services may change in coming decades and, in turn, how this will affect human well-being. The responses working group will identify policies that are intended to improve the management of ecosystems, thereby increasing their contributions to development and maintaining their long-term sustainability.

## Dependence of Human Health on Ecosystem Services

Rather than giving a detailed review of this field, here we summarize some of the conceptual issues. The effects of ecosystem disturbance on human health may be relatively direct, or occur at the end of long, complex causal webs, dependent on many intermediate events, and subject at many points to modifying influences. We offer the following categories as a way of thinking about these issues (Butler et al., in press)—see Table 1.

## Direct Effects

Examples include physical injury, due to damage to an ecosystem provisioning or regulating function. For example, loss of climate stability may lead to increased mortality during heat waves; lack of forest cover on a denuded hill may lead to lethal landslides.

## Mediated Effects

In this category, some aspect of ecosystem activity influences or contributes one or more intervening variables in the causal chain. Many communicable diseases that affect humans involve a third species, as vector or alternate host, which in turn is influenced by other ecological factors. Examples include changes to the distribution and behavior of vectors, which transmit diseases such as malaria and dengue fever.

The incidence of many fecal–oral diseases, spread by poor hygiene, drinking water contaminated by human pathogens, and inadequate water purification is highly sensitive to damage to the water provisioning or regulating function of ecosystems. Both droughts and floods can exacerbate water-borne infections, a major cause of morbidity and mortality. Though these are obviously influenced by

**Table 1.** Typology of Ecosystem Health Impacts

| | Direct | Mediated | Modulated | Systems failure |
|---|---|---|---|---|
| Causal mechanism | Simple, necessary, and sufficient exposures | Necessary ecological determinants | Complex causation; strong influence of social factors | Emergent properties, thresholds, feedbacks, |
| Temporal scale | Days | Weeks/months | Years | Long term |
| Spatial scale | Local | Local/regional | Regional | Global |
| Number affected | Hundreds | Thousands | Millions | Millions–billions |
| Example | Injury from extreme climate event | Communicable disease transmission | Regional famine, major conflict | Linked social-ecological systems |

Increasing length and complexity of causal web
Wider scale of distribution and impact
Increasing complexity and risk of "surprises"
More difficult to attribute and forecast

climatic factors, the severity of floods and droughts depends on ecological factors, such as deforestation, land use, and the macro-ecological factors that influence climate patterns and climate change. Droughts and depleted ground water aquifers are also likely to increase waterborne infections, for example, by reducing water available for washing hands and food.

## Modulated Effects

This category refers to effects of wide-spread ecological change upon human health that may be subtle and indirect, and which often entail complex interaction with social conditions (Butler et al., in press). These effects are potentially very important, since many people may be affected and the resulting burden of disease may be very large.

Ecosystem and climatic changes may be important causes of hunger and malnutrition, especially in the presence of poor governance and inadequate access to credit and aid. As a result of impaired nutrition, many diseases, especially among children, are aggravated. Droughts, floods, and mismanagement of natural resources may jeopardize economic security and bring disease to wildlife, crops, herds, and flocks. Examples include recent famines in southern Africa that have been due to a combination of human, ecological, and climatological factors. The public health catastrophe in North Korea, encompassing famine, population loss, and reduced life expectancy, has been precipitated by a series of repeated "natural" disasters, including floods, drought, and consequent crop failure, occurring against, and deepening, a background of serious economic decline. In contrast, rich populations can largely avoid the adverse effects of local damage to productive ecosystems, at least in the short term, by importing food.

The connections between ecosystem functioning and human health are bidirectional, since where there is environmental disruption leading to poor health, there may be compounding effects and "vicious cycles" established. For example, land degradation and soil loss leads to crop failure, hunger, and health problems. But there are effects in the other direction also: populations with many health problems can put less energy and time into growing crops, preventing erosion and managing agricultural resources (Woodward et al., 2000).

An extreme environmental event, brought on by a combination of extreme weather and ecosystem change, especially if in a poor country, may damage infrastructure, reduce food security, and lead to large outbreaks of infectious diseases. If this is on a sufficient scale or in association with other events, governance may be affected (Butler, 2000). In turn, this could exacerbate poverty, lead to more complex problems, and thus "entrap" poor populations in repeated cycles of suffering, disease, and disaster. An historic example of interdependence of social and ecological systems is the collapse of the ancient Mesopotamian civilization. This was contributed to by increasing salinization which changed the nature of, and eventually reduced, total grain production.

## Systems Failure

Potentially the most significant category of effects of ecosystems on health is disturbance of ecological systems at a global scale (McMichael, 2001). Ecosystem disruption damages health through complex pathways. This means that local conditions exert a very strong influence on the nature, magnitude, and timing of the effects on health. Human societies have developed methods (such as agricultural systems or water supplies) that allow natural resources to be appropriated for social benefit. Piped water supplies and other resource appropriation systems provide human populations with a buffer in times of environmental change. These social adaptations are usually designed to minimize local impacts, so that many effects of ecosystem disruption on health are displaced, either geographically (such as the costs of rich countries' overconsumption) or into the future (e.g., long-term consequences of climate change or desertification).

Social adaptations may minimize, displace, or postpone effects of ecosystem disruption on human health, but there are limits to what can be achieved. These adaptations are often at the expense of other, less powerful populations, from whom the ecosystem service is appropriated. For example, downstream populations along India's Narmada river are increasing their access to fresh water, but at the expense of displaced, more vulnerable communities who have been ousted by the rising water impounded by the construction of numerous dams.

As we have suggested above, living systems are not infinitely robust and accommodating to human needs at local and regional scales. Human societies can and do adapt to the loss of local and regional ecosystem services in a number of ways (most obviously, by increased storage of water, changing to new food sources, or migrating to new areas). However, these methods are likely to become less effective as increasingly stressed global ecological systems interact with increasingly stressed populations. Global ecological problems such as loss of biodiversity, climate change, or depletion of water resources have the potential to compound global social problems such as poverty and inequality.

There is broad agreement that human influence on global ecosystems is already substantial, and that poverty and inequality are increasingly urgent global social issues. Progressive loss of ecosystem services could lead to a kind of "gridlock," as stressed human populations compete for the limited services that remain. In this scenario, migration to unaffected areas will become impossible, while appropriation of dwindling resources will be increasingly difficult. Although this undesirable outcome is not implausible, current scientific methods are not able to provide quantitative predictions of how likely it is.

## Responses

Further ecosystem change is inevitable due to increasing human population size and per capita levels of resource consumption. To limit the damage to human health caused by these changes, preventive strategies that reduce the driving forces of consumption and population increase are needed. Precautionary measures to ensure ecological sustainability would safeguard ecosystem services and therefore benefit health in the long-term.

Consideration of ecosystem change enlarges the scope of health responses by highlighting "upstream" causes of disease and injury. The health sector can make an important contribution to reducing the damage caused by environmental disruptions, but the greatest gains will be made by interventions that are partly or wholly located in other sectors. The health sector bears responsibility for showing the links and indicating which interventions are needed.

Where a population is burdened by poverty-related disease and lack of essential resources such as shelter, nutritious food, or clean water, protection and repair of ecosystem services is unlikely to be an immediate priority for public policy. Nevertheless, the poorest and most disadvantaged communities, who are most obviously dependent upon local ecosystem services, could be among the first to benefit from ecosystem protection. There are economic considerations also: a healthy community is more capable of sustainable development than an unhealthy one.

Where excessive consumption (especially of food) causes ill-health, substantial reductions in consumption would have major health benefits as well as reducing pressure on life-support systems. This type of "win-win" solution is only possible for wealthy populations, where a substantial burden of ill health is caused by excessive food energy intake, compounded by lack of exercise. For example, in rich countries, implementing better transportation practices and systems could lead to decreased injuries, increased physical exercise in sedentary populations, and reductions in local air pollution and greenhouse gas

emissions. Integrating national agriculture and food security policies with the economic, social, and environmental goals of sustainable development could be achieved, in part, through ensuring that the environmental and social costs of production and consumption are more fully reflected in the price of food. Reduced consumption of animal products by these populations would also have benefits for human health and for ecosystems.

## Conclusions

A minimum set of ecosystem types and functions is essential for human health. While the size, resilience, and distribution of this set is currently uncertain, pressures of human consumption and population have moved many components of the biosphere towards, or perhaps already beyond, threshold points, beyond which may lie large-scale, irreversible, and harmful consequences. For all the difficulties, it is most important that health considerations are woven through all sections of the MA. Both human health and the environment would benefit from a redistribution of resources if this leads to basic entitlements being distributed more equitably and a reduction in overconsumption of natural resources. Such changes could improve human health in the short-term, as well as contributing to poverty reduction and long-term ecological sustainability.

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## References

Butler C (2000) Entrapment: global ecological and/or local demographic? Reflections upon reading the BMJ's "six billion day" special issue. *Ecosystem Health* 6:171–180

Butler C, Corvalan C, Koren H (in press) "Human health, well-being and global ecological scenarios" *Ecosystems*

McMichael A (2001) *Human Frontiers, Environments and Disease: Past Patterns, Uncertain Futures,* Cambridge, UK: Cambridge University Press

Millennium Ecosystem Assessment (MA) (2003) *People and Ecosystems: A Framework for Assessment and Action,* Washington DC: Island Press

Vitousek P, Mooney H, Lubchenco J, Melillo J (1997) Human domination of earth's ecosystems. *Science* 277:494–499

Woodward A, Hales S, Litidamu N, Phillips D, Martin J (2000) Protecting human health in a changing world: the role of social and economic development. *Bulletin of the World Health Organization* 78:1148–1155