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Human Health, Biodiversity, and Ecosystem Services: The Intertwined Challenging Future

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In a world where scarcity of food, water, and fuel is an immediate challenge and not just a future specter, the maintenance of biodiversity and ecosystem services is critical to human health and welfare. The climate change wild card adds insecurity as to what biotic resources and tools may be needed for human adaptation to food supply disruptions, ecosystem alterations, shifting disease patterns, and other health threats. There is great uncertainty about the future interaction between human health and changes in biodiversity. In many ways, we are collectively experimenting blindly with the ecology of the entire planet. However, we know enough to describe several major challenges and important research needs.

State of the Science: Strengths and Shortcomings

This book has explored the effects of biodiversity on four major determinants of human health and well-being: ecosystem services, constraint of infectious disease, medicinal resources, and quality of life (see this volume, chapter 1). We have described what is known about those relationships, as well as the significant gaps in knowledge, particularly about human drivers and biodiversity. The movement of species to new areas and other anthropogenic alterations in biological diversity have both positive and negative effects, many of which are unanticipated. We need to increase our understanding of the optimal relationship between people and other species—one that maximizes human health and welfare as well as biological diversity in both the short and long term.

For some anthropogenic drivers, there are very clear, well-documented links that lead all the way from biodiversity alteration or degradation to impacts on human health. For example, the shift to irrigated agriculture, which increases food production and nutrition, also increases available habitat for mosquitoes, raising the incidence of mosquito-borne diseases such as malaria and dengue fever (see this volume, chapter 2). A similar case can be made for Lyme disease, for which human-caused habitat fragmentation, suburbanization, and the resultant growing deer and deer mice populations with little predation have boosted both the number of ticks and the potential for interactions with people.

For other drivers, the links are inferred, but rigorous documentation is lacking. For example, many studies have demonstrated cause-and-effect relationships among anthropogenic land conversion, degradation of watersheds, and human health threats (e.g., eutrophication, increased contaminants, and pathogen introduction) (see this volume, chapters 3, 8, 9, and 10). However, few data exist to link and quantify the relationships between alteration of biodiversity and water quality, or to explain the role of aquatic biodiversity in human health (see this volume, chapter 8).

For certain drivers, our understanding of the links is still very weak. Climate change is an important example, in part because the scope of the projected changes in temperature, precipitation, and other factors are outside our recent human experience, particularly during the short period in which we have been conducting ecological research. The studies that do exist are almost all correlational, with essentially no experimental work. However, logical extrapolation and inference all lead to an expectation of increases in tropical diseases in North America and Europe. Yet lack of rigorous studies (even correlational ones) and lack of experimental work to nail down mechanisms (especially geographic variation in the thermal ecology of diseases) make projections very vague, with high uncertainty for any given region (see this volume, chapter 14).

Future Research Needs

Science has been successful in unearthing a vast amount of information on human physical and mental health, biodiversity, and ecosystem functions and processes. Less clear, however, are the relationships between and among these diverse areas, such as the links between microbial diversity, human health, and ecosystem services. In large part, this may be due to the paucity of collaboration across disciplines—particularly the medical, natural, and social sciences. The recent call for the expansion of interdisciplinary education has been answered by many universities around the world, but this is still a new and complicated endeavor. It is still uncertain whether those educated in this manner will be more effective at addressing current and future challenges than strictly disciplinary scientists and practitioners.

While interdisciplinary research teams have made headway into unraveling some complex global phenomena such as the biogeochemical processes of climate change, other relationships, such as the consequences of biodiversity loss for human well-being and health, remain opaque. Identifying and mediating the trade-offs among global human population growth, agriculture, and maintenance of native biodiversity is becoming more urgent. Which land use practices will best serve human health (e.g., degrees of agricultural intensification) while maintaining current levels of biodiversity (e.g., location of agricultural land)? Can we apply biological and ecological knowledge to improve sustainability and avoid, or at least manage, irreversible changes in biodiversity, ecosystem functioning, and related factors affecting human health and well-being?

A few additional research needs stand out. The increasing scarcity of freshwater around the world, the concomitant loss of aquatic biological diversity, and the ongoing introduction of invasive plants, animals, and pathogens highlight the need for expanding investigations into the effects of altering biodiversity on ecosystem function, water quality, and disease transmission. Our knowledge of the functional effects of altered microbial communities on ecosystems, and ultimately on human health, lacks both depth and breadth and will require systematic investigation to fill this gap. Perhaps most challenging is gaining a better understanding of the ecological role of pathogens and the relative trade-offs between human health and well-being and conservation of biological diversity.

We also cannot overstress the importance of new, rigorous interdisciplinary studies that combine study of the autecology of diseases and their vectors in the wild, research on the ecology of disease transmission from the wild into human populations, and the study of societal susceptibility to potential new epidemics. This is a complex set of relationships, mediated in part by the health system in place, including the ability to recognize and treat diseases, to respond and adapt quickly, and to anticipate the potential spread of diseases into surrounding regions.

Global-Scale Challenges

One critical factor that may be very difficult to predict is human reaction to future scarcity and stress in response to these interlocking challenges and trade-offs. In the short time that it has taken to write and edit this volume, biofuels have first been hailed and widely adopted as the solution to both fossil fuel shortages and greenhouse gas emissions, then broadly rejected as contributing to high food prices, scarcity, and starvation, and having a negative, or at best neutral, effect on net carbon emissions. Biofuel decisions, which may be distorted by political or economic crises, could have global-scale consequences for land use and the distribution of species.

In the background of the relationship between human health and biodiversity churns the continuing rapid growth of humanity. For at least the next 20 years, the net addition to population is projected to average 75 million people per year globally (United Nations 2007). Much of the population growth will occur in areas where human health is at greatest risk because of poverty and natural resource scarcity, and where there is the significant potential for disease transmission from the wild into human populations. The trade-offs between human well-being and the competing uses of solar energy, resources, and physical space for food supply, energy production, ecosystem services, and biodiversity maintenance will become more difficult as the global population rises toward 9 billion over the next few decades. Those decisions may well be mediated more by political events and immediate crises rather than science or long-term ecological and social planning (see this volume, chapter 5).

As countries with large populations and rapid economic growth such as China and India move to the foreground of world leadership, the balance of trade and its pathways are shifting. With this change both the center of power for environmental policy and the philosophy behind it may also shift. It could also be the case that global corporations more than national governments control the future spread of species, particularly genetically modified organisms. The ecological and human health ramifications for the planet in the 21st century may be just as dramatic as those that occurred when the New World began to exchange species and diseases with Europe, Africa, and Asia several centuries ago (Mann 2005).

In the context of these changes in the distribution of species and the human forces shaping it, further development of the concept and practice of biosecurity is necessary (Meyerson, Meyerson, and Reaser, in press). Biosecurity should comprehensively address not only chronic threats such as invasive alien species that erode the security of natural resources, food resources, human health, and economy stability, but also acute situations such as sudden offers of aid in the form of seed in a famine or natural disaster.

Well-intentioned policy solutions may also have unforeseen effects. For instance, the Convention on Biological Diversity (CBD) has had unintended consequences not only for species, but also for the science needed to catalog and understand them. Some smaller nations, without the resources to assess their own biodiversity or the capacity to enter into international scientific collaborations under the CBD, have essentially closed their doors to foreign researchers. Meanwhile, logging and other practices that cause habitat destruction and species loss are much less constrained in practical terms (see this volume, chapter 15).

Similarly, long-term policy choices may be overtaken by events. In response to recent high food prices and food supply uncertainty, there appears to have been a significant decline in resistance to the use of genetically modified crops and organisms (GMOs). Faced with life- and health-threatening disruptions such as hurricanes or droughts and the possibility of starvation, concerns over the potential ecological effects of GMOs may be quickly put aside in favor of immediate food supply (Zerbe 2004). In a crisis, the factor that determines the introduction of new species or genotypes could well be the willingness of particular donors at that moment rather than consideration of long-term effects. In human society as well as in ecosystems, major disturbances can provide opportunities for the introduction of new species and diseases.

Our global-scale unplanned ecological experiment has been under way for centuries, since the development of worldwide trade routes (Mann 2005). It has accelerated with human advances such as the green revolution, technological discoveries and improvements, and ubiquitous and constant air travel. In the long run, the ability to continue improvement in human well-being and to extend its benefits to the largest number of people may depend on our ability to identify and maintain the equilibrium between conservation and production. In other words, humans need to understand and maintain biodiversity in a way that maximizes the multiple immediate and long-term benefits for humans. Identifying that optimal condition depends on our understanding of the effects of biodiversity on human long-term well-being, the global heterogeneity of needs and resources over time, and the varying circumstances among regions. This understanding is still in its early stages.

Planetary processes such as climate change, population growth, and the introduction and spread of invasive species (including emerging infectious diseases) further complicate the situation and the challenges. Recent heightened concern about the limits of the global agricultural system to supply both the food and fuel needs of the human population may have the welcome side effect of broadening public and political understanding about the interconnectedness and fragility of the biological assets of the planet and their direct link to human health and well-being. In response to these serious challenges, this book adds to our understanding of the complex links between biodiversity and human health, with the hope that this knowledge will lead to decisions that maintain the best possible balance.

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