2

Beyond Wildlife – Biodiversity and Human Health[1]

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Human health ultimately depends on the health of other species and on the healthy functioning of natural ecosystems.[2]

1. INTRODUCTION

The relationship of biodiversity to human health has relevance to all eight Millennium Development Goals (MDGs), but it has special and fundamental importance for goals 1, 4, 5, 6, and 7. This chapter provides a few case studies that illustrate these relationships, focusing on goals 4, 5, and 6. It should be said at the outset that while the need to divide the MDG's into distinct categories so that they may be more easily considered and studied is clear, we must also keep in mind that there are

1. The chapter has been adapted by the editor from a background paper prepared for the Equator Initiative meeting 'Biodiversity after Johannesburg' held in London, March 3-4, 2003
2. Chivian, E (ed) (2002). *Biodiversity: Its Importance to Human Health.* http://www.med.harvard.edu/chge/Biodiversity.screen.pdf

multiple interconnections and synergies between them that tend to be obscured by such distinctions. In particular, this applies to themes involving health, which affect, and are affected by, all the MDGs.

2. THE RELATIONSHIP OF HUMAN HEALTH TO BIODIVERSITY

Human health is dependent on biodiversity and on the natural functioning of healthy ecosystems. As IUCN's Chief Scientist, Jeff McNeely, notes:[3] 'To enhance these linkages [between biodiversity and human health] requires that we consider biodiversity and human health as different aspects of the same issue: that people are an integral part of Nature and must learn to live in balance with its other species and within its ecosystems.' Without a healthy population, a nation cannot hope to develop sustainably or to achieve true prosperity.

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Biodiversity supports human life and promotes health by:

1. Providing, at the most basic level, ecosystem services that;

- ◆ filter toxic substances from air, water, and soil;
- ◆ protect against flooding, storm surges, and erosion;
- ◆ break down wastes and recycle nutrients;
- ◆ pollinate crops and wild plant species;
- ◆ create and maintain soil fertility;
- ◆ sequester carbon that mitigates global climate change;
- ◆ help maintain the water cycle and stabilise local climates;
- ◆ feed, clothe, and shelter us; and
- ◆ give us a host of other goods and services that support all life, including human life, on Earth.

2. Providing medicines from plants, animals, and microbes on land, in lakes and rivers, and in the oceans.

3. Chapter 7 'Policy Options' in Chivian, E (ed) (2002). *op.cit.*

3. Providing models for medical research that help us understand normal human physiology and disease.
4. Supporting agriculture and the marine food web.
5. Reducing the risk of contracting some human infectious diseases by 'the dilution effect'; by controlling populations of vectors, hosts, and parasites; and by other means.

Box 2.1: Biodiversity-based Medicines

Plants are the basis of traditional medicine systems that have been in existence for thousands of years and continue into modern times. The World Health Organization estimates that up to 80 per cent of the population of developing countries relies on mainly plant-based traditional medicines for their primary health care and that plant products also play an important role in the health care of the rest of the world's population. Common examples of plant-based drugs include quinine – used to treat malaria, morphine – an analgesic, and the cancer drug paclitaxel. Microbes are also highly important for human health – the antibiotic penicillin being the most well known. In addition to plants and microbes there has been growing interest in the role of animals as sources of medicines including products derived from frogs and from marine snails. Natural products also have considerable value as insecticides, contributing to human health both through improved agricultural (and hence food) productivity and in the control of insect-borne diseases.

Source: Chivian, E. (ed.) (2002). *Biodiversity: Its Importance to Human Health*.http://www.med.harvard.edu/chge/Biodiversity.screen.pdf)

3. CONTRIBUTION OF BIODIVERSITY TO THE MDGS ON HEALTH

3.1 MDG 4 – Child Mortality

Biodiversity makes a significant impact on the morbidity and mortality of infants and children. For example:

- Broad spectrum antibiotics derived from tropical soil micro-organisms—such as the tetracyclines and erythromycin—that are widely used for treating infections in infants and children. As bacteria are developing widening resistance to currently used antibiotics, the search for new ones becomes ever more urgent.
- The drug vincristine, extracted from the Rosy Periwinkle (*Vinca rosea*) from Madagascar, has revolutionised the treatment of acute childhood leukemias, increasing the remission rate from 20 to 90 per cent. New chemo-therapeutic agents are in clinical trials from a variety of organisms.

- The devastating illness, hemolytic disease of the newborn, was conquered by an understanding of the mechanisms of rhesus factor incompatibility between an Rh negative mother and her Rh positive fetus – insights that were learned from experimentation with Rhesus monkeys and other primates.

The parasitic disease Schistosomiasis, or bilharzia, provides an interesting example of the example of biodiversity-health linkages. Human schistosomiasis is caused by five species of water-borne flatworms (or flukes) called schistosomes. They infect either the gastrointestinal (including the liver) or the urinary systems and are found in Africa, the Eastern Mediterranean, the Caribbean, South America, South-East Asia, and the Western Pacific Region. The World Health Organisation notes that 'Among human parasitic diseases, schistosomiasis (or bilharzia) ranks second behind malaria in terms of socio-economic and public health importance in tropical and subtropical areas.'[4]

Schistosomiasis is endemic in 74 developing countries, infecting more than 200 million people in rural agricultural and peri-urban areas

The disease is endemic in 74 developing countries, infecting more than 200 million people in rural agricultural and peri-urban areas. Schistosomiasis can affect either the urinary tract, accompanied by progressive damage to the bladder, ureters and kidneys, or the intestines. Death is mostly due to bladder cancer associated with urinary schistosomiasis and to bleeding from varicose veins in the oesopahagus associated with intestinal schistosomiasis. An estimated 500-600 million people world- wide are at risk from the disease, with children particularly prone to infection.

Schistosomiasis occurs in freshwater when intermediate snail hosts release infective forms of the parasite. People are infected by contact with water where infected snails live. As such, the disease is often associated with water resource development projects, such as dams and irrigation schemes, where the snail intermediate hosts of the parasite breed.

The case study below describes how an outbreak of schistosomiasis was thought to be linked to over-harvesting

4. World Health Organisation fact sheets on schistosomiasis-http://www.who.int/health-topics/schisto.htm

of fish stocks in Lake Malawi. Another possible relationship of biodiversity to schistosomiasis may relate to the make up of snail populations themselves. There are suggestions that increased snail species diversity, with some species being incompetent hosts for schistosomiasis, reduces the exposure risk for humans.[5] Given that 80 per cent of those infected with schistosomiasis live in sub-Saharan Africa, effective treatment of this disease will make a big contribution to achieving MDG4 in this region (see Chapter 1).

Box 2.2: Schistosomiasis in Lake Malawi

Before 1992, Lake Malawi was one of the last fresh water lakes in Africa that was considered 'schistosomiasis-free,' but in that year, two cases of schistosomiasis were reported in U.S. Peace Corps volunteers who had been vacationing along the lakes shores. Subsequent investigations found a high prevalence of infection among native populations living along the shores of the lake and in the intermediate snail host *Bulinus globulosus*. Scientists hypothesised that the appearance of schistosomiasis in populations along Lake Malawi was the result of an increase in the numbers of Bulinus snails, due to overharvesting of their main predator, the fish *Trematocranus plachydon*.[6] The overfishing may have been the result of larger human populations turning to fish as a source of food after poor corn crop harvests, and of the increased effectiveness from using malarial bed nets for fishing.[7] This may be the first reported case of an infectious disease outbreak caused by over-fishing.

3.2 MDG 5 – Maternal Mortality

Sleeping sickness is a daily threat to more than 60 million men, women, and children in 36 countries of sub-Saharan Africa, 22 of which are among the least developed countries in the world. When a person becomes infected with Sleeping Sickness, the trypanosome multiples in the blood and lymph glands, and enters the central nervous system where it results in neurological symptoms – confusion, sensory disturbances, poor co-ordination, and sleep disturbances, the last often being irreversible, even after successful treatment. A slowing of physical and mental functioning and retardation are frequent among children who have had the disease. Without treatment, the disease is invariably fatal. The infectious trypanosome can also cross the placenta and infect the fetus, causing abortion and perinatal death.

5. personal communication, Thomas Kristensen (2001).
6. McKaye K, Stauffer Jr. JR, Louda SM. (1986). 'Fish predation as a factor in the distribution of Lake Malawi gastropods'. *Experimental Biology*; 45:279-289
7. personal communication. M. Cetron (2001).

In 1999, only 45,000 cases were reported, but it is estimated by the WHO that as many as 500,000 people are thought to have the disease. It is clear from these figures that a majority of people with African Sleeping Sickness will die without ever having been diagnosed. In certain villages in some provinces in Angola, the Democratic Republic of Congo, and southern Sudan, the prevalence rate is between 20 and 50 per cent. Sleeping sickness has become the first or second greatest cause of mortality, even ahead of HIV/AIDS, in those provinces.[8]

Changes in biodiversity can, however, have a significant impact on the spread of the disease.[9] In Uganda it was found that the tsetse fly *Glossina fuscipes*, the vector of the disease, multiplied rapidly in breeding sites provided by thickets of the plant *Lantana camara*, which had invaded cotton and coffee plantations abandoned during civil unrest in Uganda during the 1980s. This chain of events resulted in an epidemic of acute sleeping sickness in Busoga, Uganda, with cattle acting as intermediate hosts.

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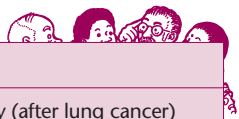
In East and West Africa, the presence of vertebrates that are incompetent reservoirs or hosts for trypanosomiasis may act to reduce the likelihood that humans will become infected. In West Africa, tsetse fly species feed preferentially on pigs, the natural reservoir, while in East Africa, they feed on cattle. Other vertebrates besides pigs and cattle may serve to protect humans from getting trypanosomiasis through what has been called the 'dilution effect'.[10] Dilution would occur if wild vertebrates provided blood meals for tsetse flies, but did not infect them with trypanosomes, thus reducing the prevalence of fly infection and the rates at which the flies bit reservoir hosts and people.

3.3. MDG 6 – HIV/AIDS and Malaria

The loss of biodiversity resulting from the 'bushmeat' trade in chimpanzees, gorillas, and other primates in the West

8. http://www.who.int/emc/diseases/tryp/trypanodis.html; http://www.who.int/inf-fs/en/fact259.html
9. Molyneux D H. (1997). 'Patterns of change in vector-borne diseases'. *Annals of Tropical Medicine and Parasitology,* 91:827-839
10. Ostfeld RS, Keesing F. (2000). 'The function of biodiversity in the ecology of vector-borne zoonotic diseases'. *Canadian Journal of Zoology* 78:2061-2078



Box 2.3: Biodiversity and Cancer

Breast cancer is the second leading cause of cancer deaths in women today (after lung cancer) and is the most common cancer among women, after non-melanoma skin cancers. In the year 2000, there were 59,167 reported cases of breast cancer and 26,616 deaths in Africa; 69,924 cases and 22,735 deaths in South America, and 205,682 cases and 95,632 deaths in Asia. While breast cancer is less common in younger women than in those over 50, it tends to be more aggressive, which may explain why survival rates among younger women are lower.

Cancer of the ovary has a relatively low incidence worldwide, but it is a leading cause of death from gynecologic cancers, as it is often detected only when there is extensive disease and when cures are hard to achieve. While ovarian cancer is primarily a disease of older women in western industrializsed countries, it can be found in younger women in developing countries as well.

In both breast and ovarian cancers, genetic factors are prevalent, but environmental factors, perhaps related in part to exposure to some endocrine disrupting synthetic organic chemicals, are being increasingly implicated in rising cancer rates. Better early detection may also play a role. It may therefore be expected that the incidence of these cancers may rise in the developing world as women in these countries begin to adopt western diets and lifestyles.

A plant-based drug is, however, proving to be an effective agent for treating cancer. As a result of a massive screening programme by the U.S. National Cancer Institute to find new pharmaceuticals, the drug Taxol was discovered in the bark of the Pacific Yew Tree (*Taxus brevifolia*) in old growth forests of the U.S. Pacific Northwest. In early clinical trials, it was found to be effective for inducing remission in cases of advanced ovarian cancers that were unresponsive to other forms of chemotherapy, and it has since been shown to have significant therapeutic benefit for other advanced malignancies as well, including lung cancer, malignant melanomas, lymphomas, and metastatic breast cancers. The mechanism of action is unlike that of other cancer chemotherapeutic agents. The discovery of Taxol has led to an entire new class of even more effective semi-synthetic 'taxoids' for cancer treatment.

Sources: http://www.imaginis.com/breasthealth/statistics.asp
McGuire WP, *et al.* (1989). 'Taxol: A unique antineoplastic agent with significant activity in advanced ovarian epithelial neoplasms'. *Annals of Internal Medicine;* 111:273-279; Nicolaou KC, Guy RK, and P Potier (1996). 'Taxoids: New weapons against cancer'. *Scientific American;* 274(6):94-98

African forests is a stark example of how species may be endangered by human activity and how the loss of our closest relatives may have significant implications for human health.[13] It is believed that a sub-species of chimpanzee (*Pan troglodytes troglodytes*) may be the original source of the HIV-1 epidemic, caused by the transmission of the chimpanzee simian immunodeficiency virus (SIVcpz) to humans on multiple occasions via blood exposures from the hunting and butchering of chimpanzees for bushmeat.[14] Similarly HIV-2 is thought to have its origins from the SIV

13. http://www.med.harvard.edu/chge/biobrief.html (for the complete videotaped congressional briefing with Jane Goodall, Beatrice Hahn, Stuart Pimm, Robert Engelman, and Eric Chivian held by the Center for Health and the Global Environment on Feb. 19, 2002 'Bushmeat and the Origin of HIV/AIDS—A Case Study of Biodiversity, Population Pressures, and Human Health.'
14. Hahn BH, Shaw GM, De Cock KM, and PM Sharp (2000). 'AIDS as a zoonosis: scientific and public health implications'. *Science;* 287:607-614

The extensive killing of primate species along with loss of their habitat not only threatens many of them with extinction, but, in depriving researchers of their most important research model, may also prevent full understanding of the dynamics of HIV/AIDS infections, and success in discovering an effective treatment

carried by the sooty mangabey (*Cercocebus atys*) (SIVsm). Recent research[15] has identified 13 other distinct SIVs in other primate species from Cameron that were killed for bushmeat or were kept as pets. The extensive killing of primate species along with loss of their habitat, therefore, not only threatens many of them with extinction, but, in depriving researchers of their most important research model, may also prevent full understanding of the dynamics of HIV/AIDS infections, and success in discovering an effective treatment. Moreover, exposure to new SIVs from the bushmeat trade in other wild primate populations may result in future HIV-AIDS-like epidemics.

Another aspect of biodiversity that relates to HIV/AIDS involves the search for medicines from natural sources to treat the disease. The story of the potential anti-HIV drug *Calanolide* provides a tragic reminder of what we risk losing with species loss. Chemists from the U.S. National Cancer Institute identified a novel agent (named Calanolide A) from the leaves and twigs of a tree *Calophyllum langierum* found in Sarawak. It was discovered on a return visit to Sarawak that the original tree was gone and that other *C. langiurum* trees could not be found. It was not clear whether the species was extinct. A close relative *C. teymannii* was identified and was found to contain a weaker drug, named Calanolide B, which, while having anti-HIV activity and the same mechanism of action (it is a non-nucleoside reverse transcriptase inhibitor), nevertheless was not as potent as Calanolide A. Calanolide B is currently in clinical trials, the result of a successful venture between MediChem Research and the government of Sarawak.

Similarly, there are many aspects of biodiversity loss and ecosystem alteration that relate to the risk of malaria infection. Rice cultivation in urban areas, for example, can create ideal breeding sites for mosquitoes – the vectors of malaria, as can poorly designed irrigation systems, such as those which occurred in the 1990s in rural India. The links

15. Peeters M, Courgnaud V, Abela B, Auzel P *et al.* (2002). 'Risk to human health from a plethora of simian immunodeficiency viruses in primate bushmeat'. *Emerging Infectious Diseases;* 8(5): 451-457

between deforestation in tropical forests and occurrence of malaria has been extensively studied. Contributory factors include: creation of stagnant pools – particularly as a result of road building; the removal of overhead trees whose falling leaves would have neutralised the alkalinity of standing water; removal of under-story plants and litter that would have served to drain standing water; and increased light and temperatures on the forest floor accelerating photosynthesis by algae. The consequence of all of these changes are an improvement in the habitat quality for larval Anopheles mosquitoes, and a higher potential for reproductive success. Some species of mosquitoes, like *Anopheles darlingi* in Amazonia, benefit more from these changes than others, and tend to out-compete rival species that are less effective vectors for malaria.

Although there does not seem to be documentation for the effects on malarial incidence from a loss of mosquito predators, it would stand to reason that lowered populations of some song birds, bats, dragonflies, amphibians, reptiles, and other species would lead to more outbreaks of disease.

4. ENHANCING THE LINKAGES BETWEEN BIODIVERSITY CONSERVATION AND IMPROVED HUMAN HEALTH

Partnerships are clearly important in the context of health and biodiversity in order to enhance collaboration at the local, national and international levels. In particular, engagement of the private sector is critical

The Millennium Development Goals stress the need for strategic partnerships to deliver on development objectives. Such partnerships are clearly important in the context of health and biodiversity in order to enhance collaboration at the local, national and international levels. In particular, engagement of the private sector is critical if life-saving drugs are to be made accessible and affordable in developing countries. But as well as partnerships, maximising the contribution of biodiversity to health objectives requires attention to a wide range of issues.[16] One option is to consider developing a 'Green List' list of species that are vitally important to human health so that

16. These issues are explored in detail in Chivian (2002) *op.cit.* and summarised here.

effective conservation strategies can be put in place before these species become endangered. These would include, among countless others, pollinators of food crops, apex predators in terrestrial and marine ecosystems, and predators of vectors that carry human diseases. Other priority issues include:

1. The need to improve policy-maker and public understanding of the links between biodiversity and human health so that they are considered comprehensively and together when planning and implementing all development projects.

2. The need to balance the valid concerns of countries and indigenous peoples for the preservation of their natural resources (and of their social and cultural values), with the pressing need for society to be able to use those resources to discover new pharmaceuticals or research models that relieve human suffering.

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3. The collection and development of such samples must be scientifically managed and carefully monitored so that the natural functions of the ecosystems from which the samples are taken are maintained and their biodiversity conserved.

4. Trade in all biodiversity products, whether endangered or not, should be monitored to provide early warning that an organism may be in danger of being over-harvested. At the same time, there needs to be more support to enhance the knowledge base about species and their ecosystems so that monitoring and regulation is based on sound scientific data.

5. Water management projects such as the construction of dams and irrigation systems should consider the effects of these practices on populations of disease vectors, particularly mosquitoes and snails, and develop adequate means of disease mitigation.

6. Agricultural development should incorporate means of mitigating disease risk by avoiding the overuse of

antibiotics in livestock and poultry, preventing close spatial associations between domesticated and wild animals to prevent transmission of infectious agents between them, reducing the potential of livestock and poultry as pathogen reservoirs in the local transmission of human vector-borne diseases, and avoiding the destruction and fragmentation of natural habitat that can increase disease risk.

7. Preserving high levels of biodiversity within vertebrate communities should be given the highest priority as a means of reducing the risk of some vector-borne diseases.

8. The scope of the MDG indicators should be expanded to move beyond an exclusive focus on mortality and to include men and women who are not bearing children, including older women.

Separating health goals from other environment and development goals reinforces the widely held misconception that human beings are separate from the environments in which they live. People will not do what is necessary to protect the global environment until they begin to understand the risks that disruptions to physical, chemical, and biological systems present to themselves and to their children. There is no more effective way to help them achieve this understanding than to frame discussions about development and the environment in the concrete, personal terms of human health.

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