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The importance of biodiversity to human health: An ecological Perspective

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Introduction

THE TERM biodiversity, now enshrined in the literature, refers to the biological diversity to describe the variety of life forms at all levels, from micro-organisms to wild flora and fauna, besides the human species. However, the variety of living beings should not be viewed individually, but as a structural and functional whole, from the ecological standpoint of the natural system, i.e., the concept of ecosystem.

The European conquerors that arrived here in the fifteenth and sixteenth centuries brought infectious diseases such as smallpox and typhus, which decimated about 50 million native peoples of South America (Daszak et al., 2000). Today, with a world human population of 6.8 billion (U.S. Census Bureau, 2010) – and of over seven billion in 2012 (WorldMeters: http://www.worldometers.info/world-population/) and Brazil with an estimated 192.8 million people (IBGE, 2010), the advance of biotechnology in food production, agriculture and livestock, has provided nutritional value in quantity and quality that have a direct and positive impact on human health. This progress has an indirect impact on values. As an example, two aspects can be identified: a reduction in the use of chemical pesticides - that have potential negative effects on human health (Pimentel et al., 1991, 1995) - and the increase in grain production - which enables feeding the growing population, as in the case of soybeans in the *Cerrado* biome of central Brazil (Phipps & Park 2002, Pretty et al., 2003).

The scientific literature has shown this trend, focusing on the ethical, economic, cultural, recreational, intellectual, scientific, spiritual, emotional, and aesthetic values of biodiversity (Alho, 2008); of the environmental and economic costs of soil erosion (Pimentel et al. 1995); and human health's dependence on biodiversity (Chivian & Bernstein, 2008; Mindell, 2009a). In countries deemed to have high biodiversity, with a large territory, such as Brazil, the issue of biodiversity has a huge significance of strategic importance, including the political prominence in the global context. Consequently, land use and occupation, with increases in natural areas, has strong implications for the health and well-being.

Biotechnology has also sought new means for cure of diseases based on new chemical components or active principles of biodiversity products in the pharmaceutical potential of numerous species of micro-organisms, plants and animals, in addition to the pursuit of preventive medicine in these new products of biological diversity. This segment of scientific research has made rapid progress, with the contribution of molecular biology, genetics, genetic engineering, biochemistry and pharmacology, through the discovery of new antibiotics, antiviral agents, vaccines and even the use of nanotechnology to combat malignant tumors (Mindell, 2009b).

The importance of biodiversity to human well-being and health has only gained greater prominence when the process of loss of biological diversity alerted to the need for conservation and rational use of living resources to protect the flow of natural ecosystem services. And also in view of the escalation of human impacts on the biosphere and the recognition of the valuation of natural ecosystems and the huge potential of species for human economy in general and as a potential source of drugs in particular (Millennium Ecosystem Assessment, 2005, Chivian & Bernstein, 2008).

Ecosystem

Understanding the context of biodiversity within the concept of ecosystem implies the complex interaction between living beings and the nonliving, i.e., abiotic entities, where the species occur. Biodiversity is an important part of this dynamic natural system in terms of both structure and function. Understanding the ecosystem requires an interdisciplinary approach, with a holistic emphasis, since it is a complex natural system. The approach highlights the interactions and transactions in biological and ecological processes and between them in the natural system as a whole. It uses and expands the physical-chemical concept of thermodynamics, particularly energy transfer (Ricklefs & Miller, 2000; Millennium Ecosystem Assessment, 2005).

The system is dynamic in that it relates to the movement of energy inside it, and plants are the primary source of energy for animals. Plants are eaten by herbivores, which are preyed upon by carnivores, which in turn are eaten by other carnivores. Decomposing organisms attack the dead parts of the living system, including excrements or metabolic wastes from other decomposers. Decomposition breaks down the compounds in such a way that carbon dioxide, water and other inorganic matters fractionated by scavengers and other organisms can then be reabsorbed by plants. The system is complex because it involves multiple interconnected parts: the species, their habitats and niches, and other variables. It is holistic because it cannot be understood by analyzing its parts alone (species, the physical-chemical medium, etc.), but rather how these parts interact for the function and structure and of the natural system (Ricklefs & Miller, 2000; Millennium Ecosystem Assessment, 2005).

In general, human activity has three major negative impacts on the natural environment: (1) Loss of and change to natural habitats and biodiversity; (2) Predatory exploitation of resources; and (3) Introduction of alien species in ecosystems. Another three big impacts are being currently perceived: (4) Increase in pathogens; (5) Increase in environmental toxicants; and (6) Climate change. All this involves important issues in terms of biodiversity degradation by human activities, pollution, and human population explosion associated with the multiple uses of natural resources (Chivian & Bernstein, 2008).

The definition of ecosystem, due to its structure and ecological processes is important for this approach. The ecosystem structure comprises the heterogeneous structure of vegetation and all micro-organisms and fauna associated with the habitat, while the ecosystem function encompasses ecosystem processes, i.e., interactions between the elements of the natural system, with an emphasis on biodiversity (Ricklefs & Miller, 2000).

Ecosystem services are defined, then, as human benefits derived from the ecosystem function and its processes. Consequently, ecosystem function is the ability of the natural process of providing goods and services to meet human needs. Ecosystem services are, therefore, attributes of the natural ecosystem function and process that are of value to humans. This distinction is made to separate the ecosystem function that occurs naturally, with no connotation of service to man, i.e., the physicochemical interactions and biological characteristics of each natural ecosystem. The term ecosystem services, on the other hand, implies the satisfaction of human needs: biogeochemical cycles and nutrients for plants, and food production, water cycle, air, climate and the use of biodiversity for the production of food and drugs (Millennium Ecosystem Assessment, 2005; Chivian & Bernstein, 2008). The study of ecosystems has received contributions from computer science, including mathematical models with the use of IT analog and digital features in two main areas: the environment and the biota (Burkett et al., 2005).

How interactions benefit ecosystem services

While ecosystem services play a key role for the health and well-being of man, the loss of biodiversity in Brazilian biomes, such as deforestation and burning in the Amazon, has affected global climate change (Shukla et al., 1990). The project Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) was an international initiative implemented in Brazil between 1995 and 2005, which produced research to answer the following question: "How do forest conversion, its regeneration and selective logging influence carbon storage, nutrient dynamics and the gas stream vis-à-vis the sustainable use of resources in the Amazon?" This project has generated important studies on the topic, some of which are listed below.

Ecosystem services support life in the biosphere, and man, also as a biological species that breathes like other pulmonates need fresh air, uncontaminated water and other benefits of biodiversity. These so-called ecosystem services also include climate regulation, e.g., the role of the Amazon forest in evapotranspiration, in the water cycle, in the relationship between the El Niño and La Niña phenomena and climate. They act in the detoxification of pollutants, in the control of agricultural pests and disease vectors, in the carbon and nitrogen cycle and in the cycle of other nutrients that are essential to life and food production, in the knowledge of the active principles of the genetic programming of microorganisms, plants and animals that have applications as medicine.

Nature and society

In the evolutionary time scale, the emergence of modern man is recent, since the ecosystem function has been evolving for many thousands of years (Allègre & Schneider, 1994). To give an idea of the time scale, in contrast to the 300,000 years since the emergence of *Homo sapiens*, South American mammals considered to be recent have an evolutionary history of 15 million to 65 million years (Webb & Marshall, 1982). The rapid evolution of modern man has enabled the change to cultural and technological adjustment, thus favoring the rapid growth of the global population, particularly after the so-called industrial revolution (Ehrlich & Ehrlich, 1997). However, at the beginning man lived with epidemics such as plagues and pests, as reported in the Bible and in more recent documents (McKeown, 1988).

Today, there is no doubt that the impact of the human population on nature is big, leading to a drastic loss of biodiversity (Sala et al., 2000; Brazil, 2008). This biotic degradation, especially in tropical regions, concerns authorities and environmentalists worldwide.

The production of medicinal drugs and agricultural productivity depend on the genetic information contained in different species of microorganisms, plants and animals obtained, for example, by transferring genes from wild disease-resistant species to domesticated species that serve as food for man. Or, using biotechnology techniques, repeat in laboratory the active principle contained in the genetic programming of wild species that may lead to the cure of diseases.

There is also the link between ethnomedicine, used by traditional peoples in Brazil, and the scientific, technical and commercial use of biodiversity by the pharmaceutical industry. Another aspect is the so-called biopiracy, considered the third most profitable type of trafficking, behind drugs and guns (RENCTAS, 2001). Some studies have discussed the link between traditional medicine and implications for public health and the relevance of biodiversity (Alves & Rosa, 2007).

Biopiracy involves the illegal use of and trade in plants and animals - many of them as pets, like macaws and parrots – as well as many others for use also in the pharmaceutical industry. According to extensive documentation (http://www.amazonlink.org/biopirataria/), these materials are taken out of the country and patents for them are registered by large laboratories in other countries, with economic loss to Brazil. As an example, the patent for *jaborandi* (*Pilocarpus pennatifolius*) was registered by the German pharmaceutical company Merck in 1991. The well-known *açaí*, the fruit of the Amazonian palm tree *Euterpe oleracea*, had its name registered in Japan in 2003. Japan ultimately relented and canceled the patent in view of the pressure it was under. Another famous Amazonian plant, *cupuaçu* (*Theobroma grandiflorum*), had a patent filed by the company Asahi Foods, from Japan, between 2001 and 2002, and by the British cosmetics company "Body Shop" in 1998. The patent for another Amazonian plant, *copaíba* (*Copaifera sp.*) was registered by the French company Technicoflor in 1993.

The Brazilian scientific community has endeavored to patent products derived from biodiversity research to protect their results for application in pharmaceutical and other uses (Moreira et al., 2006).

Translocated genes and active products identified in wild species have played an important role for the production of medicines. These drugs include quinine, aspirin, artemisinin and the production of fungicides. To give another example, the literature emphasizes the peptide compounds of some species of gastropods found in coral reefs. These peptides are so abundant that they may be similar to the alkaloids of higher plants and to the secondary metabolism of bacteria (Aguirre et al. 2002). Another example is a new painkiller drug, which is a thousand times stronger than morphine and is derived from the toxins of marine snails of the genus *Conus*, also found in coral reefs. These toxins are found in the venom used by predator snails to catch their prey (Chivian & Bernstein, 2008).

Of every 150 drugs prescribed and marketed in the United States, 118 are made from products of biodiversity such as plants, fungi, bacteria and animals (Chivian & Bernstein, 2008). It is estimated that 80 percent of people in developing countries rely on traditional medicine to meet their basic health needs, and that 85 percent of the drugs produced by traditional medicine involve the use of plant extracts and therefore are drugs originating in nature (Farnsworth, 1988).

The genetic programming contained in each species is unique and original and when the species is extinct, this information is lost forever. To illustrate, researchers have shown great interest in the metabolism of the polar bear (*Ursus maritimus*), which is threatened due to the impact of global warming in the polar region. It turns out that this animal can hibernate for long periods of time with no food and water, without defecating or urinating and with no weight loss; some females can even give birth and feed their cubs with no access to food. Which mechanism is that, contained in the genetic programming of bears that allows that to happen? Would this active principle play a role in the control of human osteoporosis or in type 2 diabetes? Maybe this secret is stored in the genetic programming of the polar bear (Chivian & Bernstein, 2008).

How ecosystem disturbances affect the dynamics of diseases

The destruction of and change in natural ecosystems with loss of biodiversity result from human interference in nature, including urban sprawl, the conversion of natural vegetation into pastures or farmland, climate change and major infrastructure projects such as new roads in the Amazon, hydroelectric plants, human settlements, the accidental or intentional introduction of invasive species by man, and other forms of change to the natural environment. For example, in Brazil the vector of dengue fever, a disease that affects thousands of people every year, is the mosquito *Aedes aegypti*, originally from Africa, probably from the Ethiopian region during the slave trade. It is also the vector of urban yellow fever (WHO, 2007). It is a household mosquito that thrives in urban sprawls. Another species is the *Aedes albopictus*, introduced in Brazil in 1986, which can be the secondary vector of dengue fever in rural and urban areas (Segura et al., 2003; Walker, 2007).

Species of coral reefs such as *Mussismilia braziliensis* and *Mussismilia hispida* found in the Archipelago of Abrolhos, which stretches from the coast of Espírito Santo to the south of Bahia, have been affected by a disease that turns them whitish, different from the healthy ones. This disease is caused by the bacteria *Vibrio coralliityticus*, *V. alginolyticus* and *V. harveyi*. The microbial diversity associated with human presence is postulated as a hypothesis of the impact of man on the transmission of these bacteria associated with the organic and fecal contamination that potentially affects corals (Thompson, 2009, 2010).

Deforestation and burning in the Amazon forest contribute to increased emissions of carbon dioxide into the atmosphere (Werf van der et al., 2009). Infrared rays absorbed by gases released by burning into the atmosphere generate heat. It is called the greenhouse effect. Climate change, which was discussed during the UN Conference in Copenhagen in December 2009, has had an impact on biodiversity in many ways, including through the proliferation of disease-vector insects. Studies conducted by Shuman (2010) show that with the gradual increase in temperatures and rainfall patterns, this climate change can be expected to have a substantial effect on outbreaks of infectious diseases transmitted by vector insects and contaminated water. Vector insects tend to be more active at higher temperatures. For example, tropical mosquitoes such as the *Anopheles* species that transmit malaria require temperatures above 16°C to complete their life cycle. These species lay their eggs in water. Consequently, hot and rainy seasons will be conducive to the outbreak of millions of new cases (Shuman, 2010). According to this study, temperatures are expected to increase between 1.8 and 5.8°C by the end of this century; the hydrological cycle is also expected to change, since warm air holds more moisture than cold air.

Alien or invasive species are those that occur outside their area of distribution and are usually introduced by humans either intentionally or accidentally, but that cause problems to ecosystems and other species where they are introduced (Wittenberg & Cock, 2001). An example of that is the African snail *Achatina fulica* introduced in Brazil in the 1980s by breeders interested in replacing the *Helix aspersa* snail, for human consumption. The fact is that today this African snail is found in virtually all Brazilian biomes and is the intermediate host of the nematode *Angiostrongylus cantonensis*, pathogen that causes meningoencephalic angiostrongyliasis in humans, a disease already reported in various parts of the country (Caldeira et al., 2007).

The interaction of domestic animals with wild animals and with men has led to the emergence of new diseases. Recently, there has been an outbreak of spotted fever, also known as tick fever, caused by bacteria of the genus *Rickettsia*, in Campinas (SP), transmitted by ticks of the genus *Amblyomma*, ectoparasites of capybaras, brought into cities such as Piracicaba (SP) by capybaras following the rivers flowing through these cities (Barci & Nogueira, 2006).

The outbreak of human infection by hantavirus in various locations in South America, including rural Cerrado areas near Brasilia, is related to human contact with wild rodents of the genus *Akodon* and *Necromys* (Alho, 2005a; Brasil, 2007). In 2010 the Center for Disease Control at the Health Secretariat of the Federal District recorded an increase in cases of hantavirus infection, with five casualties. The School of Medicine of Ribeirão Preto, Universtity of São Paulo, published a recent study by Figueiredo et al. (2009), showing that 80 percent of cases of hantavirus infection in Brazil are caused by the hantavirus Araraquara, with increasing occurrence of expansion due to anthropogenic changes in the occupation of natural environments.

Other examples were the recent occurrences of avian flu and influenza A-H1N1. Natural habitats have disappeared or been greatly modified, reduced and fragmented, thus affecting the relative wild stock *vs.* domestic stock *vs.* man and allowing for the appearance of diseases. Finally, the modification of natural ecosystems makes the environment more susceptible to the emergence of diseases.

Deforestation caused by the advance of human occupation that result in the conversion of natural vegetation into pasture or farmland, as has occurred in the Atlantic Forest and is currently occurring at an accelerated pace in the Cerrado, the surroundings of Pantanal and in the Amazon, affects the spread of pathogens in wildlife. There is evidence of this impact on several taxonomic groups, but it has been well documented for birds (Sehgal, 2010). Birds are affected by viral, bacterial and fungal pathogens, and act as reservoirs for numerous zoonotic pathogens. The pathogenic avian influenza is caused by the H5N1 virus, most commonly found in waterfowl. This virus has a high potential to adapt to genetic change and become pathogenic for domestic fowl and man. Besides viruses, birds can host bacteria and fungi such as *Mycobacterium avium*, which causes avian tuberculosis, and *Vibrio cholerae,* which causes cholera. Protozoa that cause diseases in birds, including malaria, such as *Plasmodium*, *Haemoproteus* and *Leucocytozoon* are transmitted by blood-sucking mosquitoes of the genus *Culex* and others. In some countries, the supply of peanuts as food for garden birds has led to the emergence of *Salmonella typhimurium* and *Escherichia coli.*

Land occupation and use

Increased human activity has impacted natural ecosystems, disrupting the structure and function of the natural system and causing loss of and changes to biodiversity, as observed, for example, in the Cerrado biome (Alho, 2005b). As a result, the most habitat-sensitive and habitat-demanding species disappear, while other opportunistic species benefit from the change in order to grow in abundance. These are disturbances that have an impact on human well-being and health. This change affects the pathogens, which are agents of diseases (viruses, fungi, bacteria, protozoa and helminthes), in the populations of arthropods such as mosquitoes and other vector animals that transmit pathogens to humans. They also alter the reservoirs of diseases, i.e., species that serve as hosts to pathogens, which include wild and domestic animals besides man. And there are a number of circumstances of environmental disturbance that favor the interaction of the pathogen with its vector and with wild and domestic stocks, besides man (Bogitsh et al., 2005), especially when it invades and colonizes wild areas. This fact implies a retroactive direction: this relationship threatens the conservation of intact biodiversity. For example, ectoparasites such as ticks can transmit a great diversity of microbes (viruses, bacteria, protozoa) to humans, domestic animals, and from these to wild species.

In fact, major infrastructure works in Brazil, particularly in the Amazon, face outbreaks of endemic diseases such as malaria, yellow fever, dengue fever, leishmaniasis and arboviruses (Vasconcelos et al., 2001). Usually they are related to processes of deforestation and precarious settlements, the accumulation of garbage and the pollution of water bodies.

Infrastructure projects such as road construction attract workers from the cities to the construction site, thus leading to local and regional population increase and clusters of workers and their families in the construction sites. This intense mobilization of people, whether official or not, profoundly alters the environment in the region of the main construction site. Although entrepreneurs seek to surround themselves with control and mitigation measures, unofficial migration usually creates a satellite human population in search of job opportunities. The situation is compounded by the introduction of alien species, domestic or otherwise, including cats and dogs, which generally cause another related negative effect – the increased transmission of infectious diseases from wild animals to domestic animals and from these to humans (Millennium Ecosystem Assessment, 2005).

Domestic animals accompanying man such as cats, dogs, horses, cattle, and alien species such as plants, molasses grass, grasses, insects, rats and others, interact with wild species, facilitating the transmission of infectious diseases. Cats and dogs hunt and eat wild animals such as lizards, amphibians, bird and mammal young (Wittenberg & Cock, 2001). The occupation of new areas by humans, particularly in environments previously uninhabited or with low human density, has increased the transmission of endemic diseases and the proliferation of disease vectors due to the proximity of these migrants to wildlife reservoirs and vectors of certain diseases. The opening of new roads, consolidated in the Amazon as a form of deforestation, contributes to this interaction. Domestic dogs brought by humans also act as a reservoir for disease by interacting with human clusters.

Wild-type vaccinia virus, from the genus *Orthopoxvirus*, has caused bovine vaccinia in cattle, although it also affects humans by causing skin lesions similar to those of smallpox, and contaminates wild animals. A study involving 344 wild mammals rescued from the filling of the reservoirs of the power plants of Lajedo and Ipueiras in the State of Tocantins, indicated the presence of antibodies to the virus in over 25 percent of capuchin monkeys *Cebus apella* and 48 percent of infected howler *Alouatta caraya* (Abraham et al., 2010). The ratio of this virus involving humans, domestic animals and wildlife is still largely unknown from the standpoint of medicine.

These human clusters in disorganized settlements located in newly occupied areas contribute to the formation of puddles or streams with lower circulation, favoring the development of toxic blue-green algae, which are harmful to the biota, and of aquatic weeds as well as the proliferation of disease vectors. In places with higher anthropogenic activity and modification of water bodies, the growth of aquatic weeds, for example of the genera *Cyperus* and *Pistia* may favor the emergence of mosquitoes that are vector of diseases. The increase in the population of anopheline mosquitoes increases the risk of malaria transmission. Other vectors like mosquitoes, black flies and snails also contribute to the aggravation of various diseases, besides malaria, yellow fever, dengue fever, arboviral infections, filariasis and schistosomiasis. These changes may also favor the appearance of *Mansonia* mosquitoes, which can transmit arboviruses that cause encephalitis in humans (Quintero et al. 1996). The health surveillance service of the Ministry of Health alerts to the close relationship between infrastructure projects in the Amazon and malaria outbreaks. Environmental changes favor the proliferation of mosquitoes of the genus *Anopheles*, which are the vectors of the protozoan *Plasmodium* that causes malaria (Quintero et al., 1996; Withgott & Brennan, 2007). Over 40 percent of the world human population lives in areas of malaria transmission, and each year between 350 million and 500 million people contract the disease, with about one million deaths per year (Withgott & Brennan, 2007). Two drugs used to treat malaria are from wild plants: quinine, from *Cinchona officinalis* with another three species, and artemisinin, from *Artemisia annua*.

Leishmaniasis is associated with people who invade, deforest and occupy natural areas. Both cutaneous and visceral leishmaniasis are caused by pathogenic protozoa of the genus *Leishmania* and have as vector mosquitoes of the genus *Phlebotomus* and *Lutzomyia*. They are reservoirs of pathogens carried by wild rodents, marsupials and domestic dogs. Moreover, human clusters contribute to the pollution of water bodies and open sewers, favoring contamination by fecal Coliforms. These people, when in contact with venomous animals such as snakes, can suffer serious accidents and are also vulnerable to attack by horseflies and other insects that benefit from environmental change (WHO, 2007).

This environmental change, with consequent insect attacks, can also be illustrated by the outbreak of stable-fly (*Stomoxys calcitrans*) that has been occurring in cattle farms and close to sugar and alcohol-related activities in the Central-West region of Brazil. It is an insect that looks like a common housefly, but because it is a hematophagous insect, it attacks livestock and torments man with its stings. Infestations of these flies in the warm months of the year, attacking cattle and rural workers, has worried farmers and mill owners, and EMBRAPA's (2010) National Beef Cattle Research Center has called attention to this epidemic through technical notes. The establishment of new sugar and alcohol mills and the accumulation of straw and vinasse favor the proliferation of fly larvae, whose adults invade the nearby stables.

Rabies is a zoonotic disease caused by viruses, which involves the interaction of man and domestic animals such as dogs, cats, cattle and swine herds with hematophagous bats. The main species of bat is *Desmodus rotundus*. This viral disease, its transmission agent and its hosts, including humans, are strongly associated with environmental change. Bat attacks on humans are part of this interaction. Environmental change and the introduction of domestic animals, which provide abundant food to hematophagous bats, unbalance the ratio of ecological communities of bats, favoring an increase in populations of hematophagous bats. Bats are the second largest transmitter of rabies to humans, while dogs are the main vector of the virus (WHO, 2007).

Biodiversity conservation and the protection of natural ecosystems do not necessarily imply confronting the progress of humanity and the return of society to primitive coexistence with nature. As a result of advances in biotechnology, new agricultural production techniques have enabled the production of food and new drugs for humanity. The social, scientific and technological progress of humanity has to be celebrated. However, the defense of biodiversity is also intrinsic in humanity by applying the biophilia hypothesis, according to which humans have an innate attraction to other life forms in nature (Kellert & Wilson, 1993). It is the connection that we unconsciously seek to maintain with intact nature, its plants and its animals. Biophilia implies man's innate attraction to the living things of nature, unlike the phobia or aversion we feel for pollution, junk heap, and stench in the air, fish mortality from the contamination of rivers, criminal deforestation, and clusters of marginalized, malnourished and sick humans.

Added to the defense of the values of biodiversity for ecosystem services that benefit human well-being and health, and the proven value of this huge collection of genetic diversity that has provided relevant services to the production of drugs, are the ethical and aesthetic values of biodiversity. Ethical, for acknowledging that man is not the only living species that has the right to life, with the recognition of the intrinsic value of biodiversity. And for recognizing the aesthetic value of biodiversity, for the opportunity of enjoying and contemplating its beauty - currently disseminated by planned and sustainable ecotourism - and for the pleasure of recreation in intact nature.

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Abstract – Brazilian biodiversity is recognized as one of the most expressive in the terrestrial biosphere and plays an important role to human well-being and health, providing basic products and ecosystem services. The products or goods from natural ecosystems include pharmaceutical material, food such as fishery, timber, and many others. Natural ecosystems also provide essential life-supporting services such as purification of air and water, climate regulation, reproductive and feeding habitats for extraction, as well as maintenance of organisms responsible for cycling soil nutrients, making them available to plant absorption. Environmental disruption has impacted human well-being and health, resulting in severe social poverty with the spread of diseases. Increase in vector--borne and diseases in humans and animals occur as a result of negative anthropogenic interventions in the natural ecosystems.

Keywords: Biodiversity, Environmental disruption, Ecosystem services, Habitats, Diseases.

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