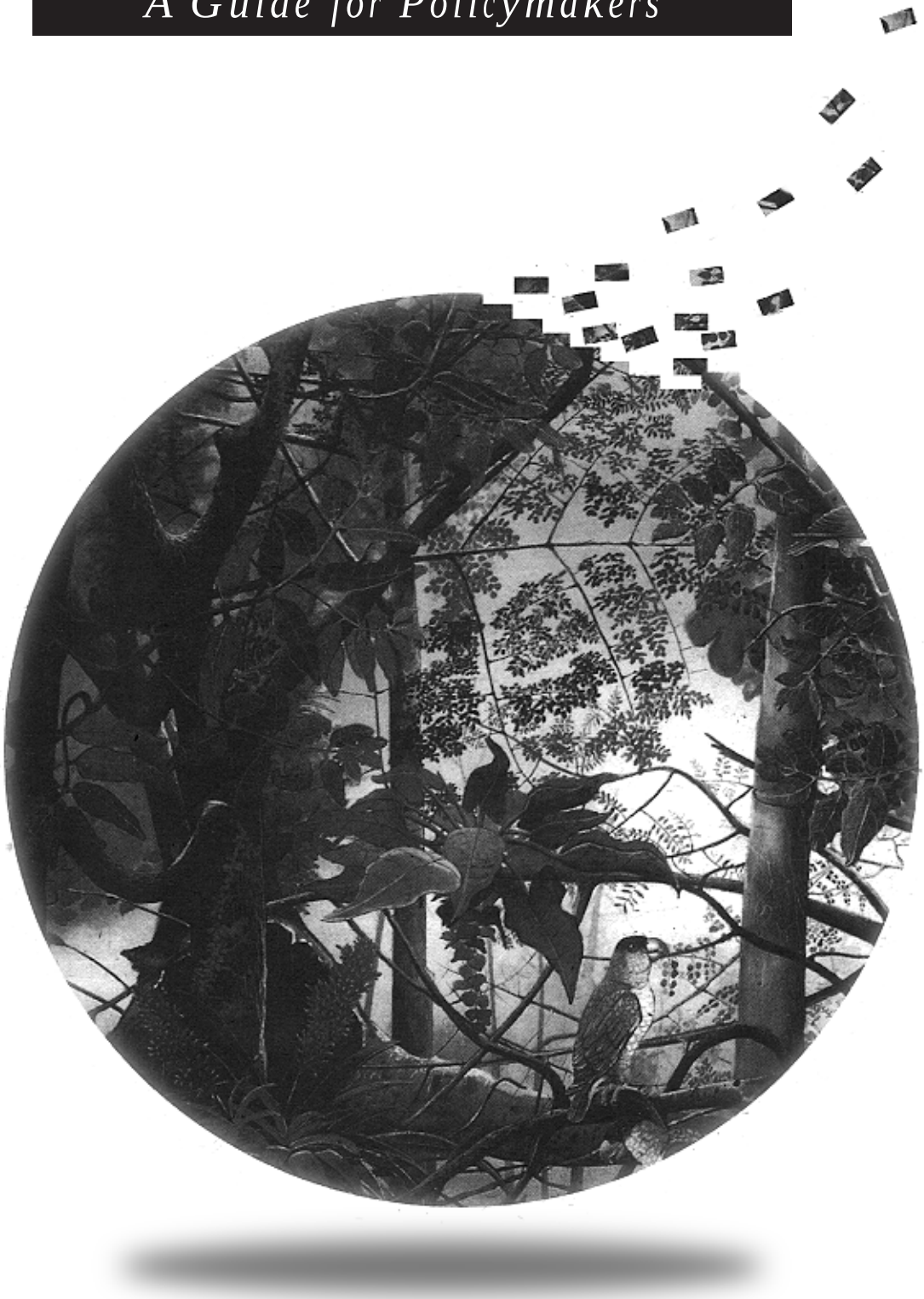
BIODIVERSITY AND HUMAN HEALTH

A Guide for Policymakers

Biodiversity

- keeps populations of disease-causing organisms in check
- assures sufficient food and water supplies
- alleviates mental fatigue
- provides warnings of toxins and other environmental health hazards
- provides source materials for drugs
- provides models for medical discoveries



Center for Biodiversity and Conservation
American Museum of Natural History

Human Health

The loss of biodiversity–the Earth's plants, animals, fungi and microbes and all the wisdom contained in their interactions and genetic diversity–has had and will continue to have profound consequences for human health.

Environmental change and ecosystem disruption can threaten the world's food supply and the quality and quantity of fresh water. Chronic malnutrition weakens the immune system, increasing susceptibility to intestinal parasites, hepatitis, malaria, and respiratory infections. Contaminated water, due to agricultural runoff and the destruction of watersheds and wetlands, can cause diarrhea, cholera, dysentery, and other water-borne infectious diseases. These are just a few of the consequences of habitat destruction.

Species loss removes raw materials for treating illnesses of all kinds and for new processes of biotechnology. Species who might serve as medical models critical to life-saving research and species which warn us about environmental threats to humans may cease to exist. Also forfeited are opportunities to better understand the numerous wild species closely related to vectors and pathogens of emergent and existing diseases. Infectious agents and disease carriers are much more quickly identified and controlled if their close relatives are known to science.

BIODIVERSITY LOSS THREATENS • THE FOOD WE EAT • THE WATER WE DRINK • THE AIR WE BREATHE • THE MEDICINES WE TAKE

Ecosystem Disruption

- Changes in supply and quality of fresh water leading to increased transmission of water-borne diseases.
- Changes in food supply leading to increased malnutrition and, hence, to more immuno-compromised people in the world.
- Increases in parasites, disease-causing organisms, and disease-carrying organisms.
- Reduced opportunities for alleviation of mental fatigue.
- Increased global climate change.

Ecosystem Disruption and the Spread of Infectious Diseases

Natural ecosystems and the species that maintain them protect humans against pests, pathogens, and parasites. Human-caused damage to existing habitats can change the equilibrium between predator and prey, between host and parasite. Ecological changes can modify the behavior of disease organisms. Parasites may switch to humans when their natural hosts become rare or disappear altogether. Humans may be exposed to "new" diseases when agricultural expansion or other encroachments bring people into close contact with wild animals.

- AIDS is an example of a "new" disease that most likely resulted from host switching by a pathogen, when the virus leapt from green monkeys or other simians to humans.
- Leishmania, once a rural parasitic disease, became epidemic in cities when rodent populations fluctuated in number and sandflies began to bite humans instead of mice.

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This child was diagnosed with leukemia. Because of vincristine, a medicine derived from the flower of the rosy periwinkle, a plant originally found in Madagascar, she has an 80 percent chance of survival.

PREDATORS AND PREY

Predators that controlled both pathogens and disease carriers can be killed off, leading to the emergence of new diseases and the resurgence of old diseases that predators previously kept in check.

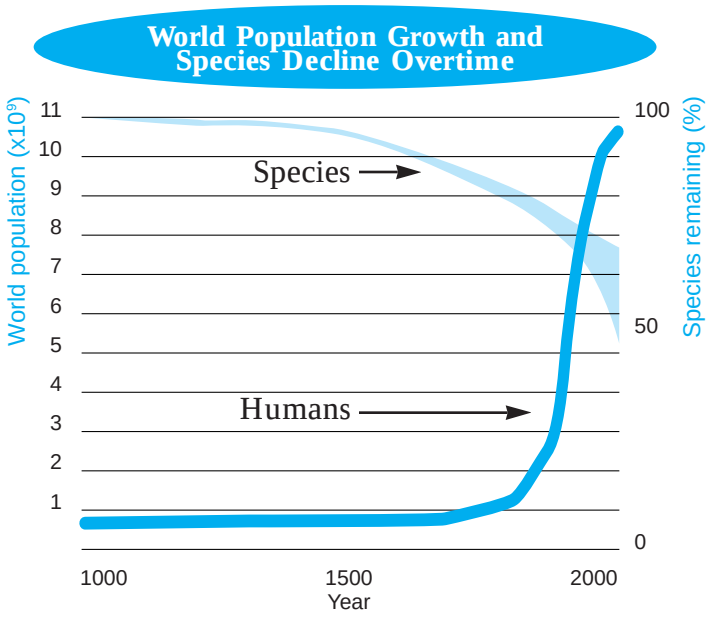
- The outbreak of hantavirus in the Southwest occurred when a combination of land use and climatic changes eliminated rodent predators. A 10-fold increase in the number of deer mice exposed people to a huge mouse population that carried the hantavirus.
- Viral hemorrhagic fevers–like Ebola and Machupo, both carried by previously-rare species of mice–are among the newest emerging infections that are almost always fatal to humans. The Machupo virus appeared suddenly in eastern Bolivia when new areas were converted to agriculture and excessive use of DDT killed off the cats that preyed on the rodents.
- Deer, which no longer have significant predators in New England, greatly increased in number, carrying the ticks that cause Lyme disease to suburban areas and into contact with people and their dogs and cats. By 1992, Lyme was the most reported vector-borne disease in the United States.

Fresh Water

New York City's water supply–the largest unfiltered water supply in the nation–is purified by microorganisms as the water passes through the soil of the Catskills. Without this natural watershed, the City would have to build a water treatment plant at a cost of over $4 billion.

Loss of Species

Habitat loss and fragmentation, over-exploitation of species, introduction of non-native species, pollution and contamination and global warming are the mechanisms of species extinction. One-quarter of all existing biological species may become extinct within the next 30 or 40 years. These animals, plants, fungi, and microbes might have been the sources of foods and medicines. Drugs derived from these lost species might have treated currently incurable diseases, or newly-emerging infectious diseases, or even have provided new medicines to replace drugs to which disease organisms have become resistant. But we will never know what unique properties they possess.



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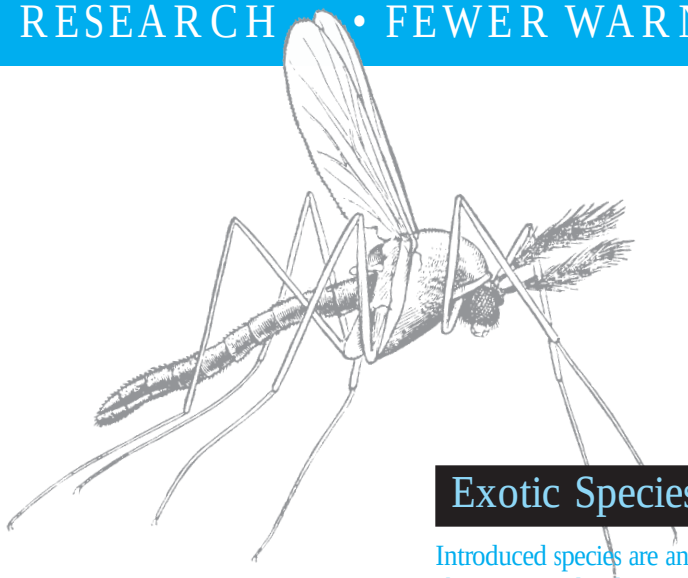
SPECIES LOSS • FEWER RAW MATERIALS FOR NEW DRUGS TO BATTLE INCURABLE DISEASES • FEWER MODELS FOR MEDICAL RESEARCH • FEWER WARNINGS OF ECOSYSTEM DISRUPTION



Exotic Species

Introduced species are another threat to human health and to the preservation of biodiversity. An alien species that has no predators, parasites, nor pathogens introduced into a new environment can flourish unchecked.

The Asian tiger mosquito, which can carry the viruses for yellow fever and dengue fever, arrived in the United States in 1985 aboard a shipment of waterlogged used tires sent from Japan to Texas. Within two years, the mosquito had spread to 17 states.

Predators and prey, parasite and host evolved together over millions of years and their interactions are central to biological control. Each keeps the other in balance.

Nature's Pharmacy

Animals, plants, and microorganisms are a major source of medicines to treat disease. They have already provided us with treatments for such major afflictions as cancer, heart disease, hypertension, inflammatory disorders, and a range of bacterial, fungal, and viral infections.

Yet only a tiny fraction of biological species has been studied for potential therapeutic effect. Only 2-5 percent of the estimated 250,000 species of higher plants have been studied – and we are currently losing about one plant species each day.

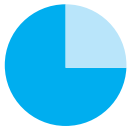
Of the 150 most commonly prescribed drugs in the United States, 57 percent contain at least one major active compound derived from, or patterned after compounds from nature.

Ten Most Frequently Prescribed Drugs in the United States

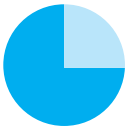
Rank	Drug name (generic)	Use	Source organism
1	Conjugated estrogens	estrogen replacement therapy	animal
2	Amoxicillin	antibiotic	fungus
3	Ranitidine	ulcers	animal
4	Nifedipine	heart disease/ high blood pressure	synthetic
5	Levothyroxine	thyroid hormone replacement therapy	animal
6	Digoxin	heart disease	plant
7	Alprazolam	antianxiety/sedative	synthetic
8	Enalapril maleate	high blood pressure	animal
9	Cefaclor	antibiotic	fungus
10	Amoxicillin +clavulanic acid	antibiotic	fungus+ bacterium

Of the 150 most prescribed drugs in these medical specialties

Cardiovascular drugs such as digitalis
1/2 derived from nature,
1/2 synthesized



Infectious diseases drugs such as amoxicillin
3/4 derived from nature,
1/4 synthesized



General medicine drugs such as codeine
3/4 derived from nature,
1/4 synthesized

WHY WE NEED NEW DRUGS • DRUG RESISTANT PATHOGENS • INCURABLE DISEASES • NEW OR "EMERGENT" DISEASES

"Wonder" Drugs

Some of today's most useful drugs are derived from nature's pharmacy:

- Quinine and quinidine, the latter still one of the most effective drugs in treating cardiac arrhythmias, are derived from the bark of the Cinchona tree.
- Pilocarpine, the anti-glaucoma drug of choice, is isolated from a tropical plant long used in traditional medicine in South America.
- Capoten, used to treat hypertension (with $1.3 billion in annual sales), was discovered through research on the venom of a New World rainforest viper.
- Taxol, from the bark of the Pacific Yew tree, may be the most promising medication known for the treatment of ovarian and breast cancer.
- A new bacterial species that lives at extremely high temperatures in the hot springs of Yellowstone National Park led to the isolation of polymerase enzymes that revolutionized DNA and RNA research – a Nobel Prize winning discovery.

Add to these aspirin, originally extracted from the willow tree; digitalis, from the foxglove plant; and streptomycin, neomycine, and erythromycin derived from tropical soil fungi.

Nature provides the raw materials that are essential to the development of new drugs and medicines. There is an urgent need to find medicines for existing ailments that are now untreatable or uncurable. We need new drugs as new infectious diseases emerge and known diseases become resistant to existing drugs.

Nature is also the source of traditional medicines, which form the basis of primary health care for 80 percent of the world's population. Nor should we overlook the restorative aspects of nature that are essential for our mental well being.

Medical Models and "Early-Warning Species

With the loss of species, we are also losing valuable medical models that help us understand human physiology and disease.

Medical Models

Osteoporosis, a largely untreatable condition, afflicts 25 million Americans, results in 1.5 million bone fractures and 50,000 deaths annually, at a cost to the U.S. economy of $10 billion in direct health care costs and lost productivity each year.

Bears hibernate, but do not lose bone mass. Understanding how bears prevent bone loss during four to five months of immobility (the only vertebrate that can do this) could lead to ways of preventing or treating osteoporosis.

People with chronic renal failure are now totally dependent upon dialysis. Renal failure in the U.S. alone costs $7 billion annually.

Bears do not urinate for months during hibernation. Humans, by contrast, would die after a few days if unable to excrete their urinary waste. Research on bears might lead to effective treatments for kidney disease.

Sharks, which are being lost in record numbers, are studied to identify chemo-therapeutic agents for the treatment of malignant tumors.

Sharks rarely develop tumors or infections. Why not? Some clues have been discovered. Researchers have isolated a substance from one shark species that strongly inhibits the growth of new blood vessels toward solid tissue tumors, thereby preventing their growth.

As many infectious organisms develop resistance to currently used antibiotics, new drugs become increasingly important.

Squalamine, a compound that has been isolated from the tissues of the dogfish shark, has shown extremely potent activity in tests against a variety of bacteria, fungi, and parasites by mechanisms not fully understood but that seem different from those of all existing antibiotics.

Other organisms provide different kinds of models.

- One type of sea squirt, the sea grape, is the only animal besides humans to form stones naturally in their kidney-like organs. By studying the formation of both uric acid and calcium oxalate stones in these creatures, scientists are trying to understand the mechanisms by which kidney stones and gout develop in humans.
- The horseshoe crab has one of the largest and most accessible optic nerves and the largest photoreceptors of any animal. A great deal of what we know about the basic mechanisms of human vision has been learned from the study of this creature.
- The armadillo is the only animal to acquire leprosy when injected with the *Mycobacterium leprae* experimentally. *Mycobacterium* diseases include several opportunistic infections such as *M. avium* that attack AIDS patients.

This three-week old Roseate tern chick was hatched with crossed mandibles. Other gross abnormalities caused by chemical pollutants in Long Island Sound were chicks with deformed legs, feet, eyes, wings and feathers.

Photo by Mary LeCroy, AMNH.

The Diversity of Life

"Early-Warning" Species

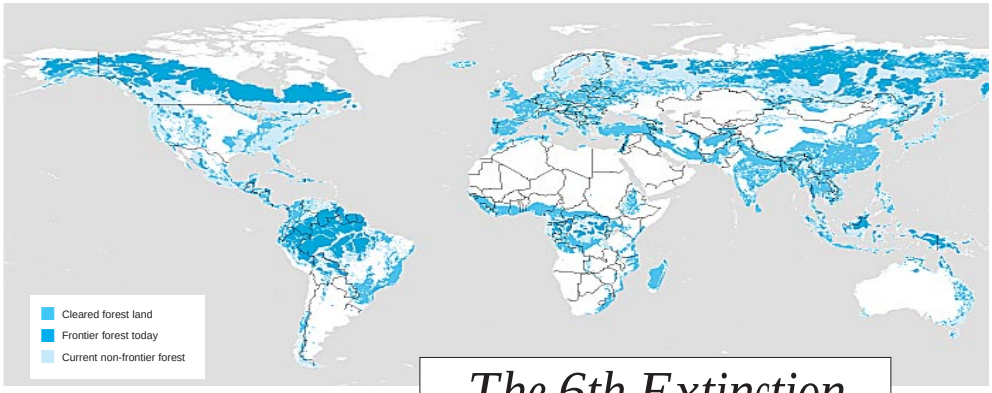
Some organisms may be so uniquely sensitive to specific assaults on the environment that they can warn us of potential threats to human life and well-being.

- A wide variety of amphibians, reptiles, birds, and some marine and land mammals show endocrine and reproductive effects that may be caused by exposure to synthetic chemicals in the environment. Some chemical pollutants may mimic hormone activity in these animals and, by doing so, disrupt embryonic development and reproductive functioning.
- Reproductive failure among beluga whales in the1980s was traced to high concentrations of PCBs, DDT, and Mirex (an insecticide carried by the eels that belugas eat) in their tissue.
- Populations of frogs, toads, and salamanders have declined sharply in many parts of the world, even in undisturbed habitats, presumably as a result of opportunistic infections.

- The appearance, in 1970, of severely deformed Roseate tern chicks on Great Gull Island, a research station of the American Museum of Natural History, showed, for the first time, that wild populations could be affected by industrial chemicals. Toxic chemicals were found in the terns and in the fish they ate, providing an early warning of pollutants in Long Island Sound.

Biological diversity is the key to the preservation of life on Earth. It encompasses the immense range and variety of life forms – the differences within and between gene pools, species, populations, and entire ecosystems. It sustains and supports all living things, from microbes to humans. Without this diversity, life itself would become extinct.

The Earth has experienced five mass extinction episodes over the last 500 million years. These mass extinctions were caused by terrestrial and extraterrestrial events. We are now in the midst of the sixth mass extinction as species vanish in a time span of mere decades rather than millions of years. Although the Earth recovered from previous extinctions, it required 20 to 100 million years to do so.



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The 6th Extinction

This sixth mass extinction is caused entirely by humans. The pressures of overconsumption of our natural resources are compounded by population growth. For the first time in the history of the planet, we are altering the basic chemistry, physics, and physiology of the Earth. We are changing the atmosphere, the oceans, and the land.

We are

- *overexploiting natural resources*
- *destroying and degrading the habitats of animals and plants*
- *introducing alien species into new environments*
- *polluting and contaminating the environment with toxic substances*
- *changing the climate of the globe*

Conserving Biodiversity

That human health and well-being depend upon the conservation of biodiversity is still largely unappreciated. Biodiversity conservation requires bold new thinking about the way we manage the Earth. Every policy and action must recognize that:

- The resources of the Earth are finite.
- Nature's components are unique and, once lost, irreplaceable.
- We depend on biodiversitiy in some way all day, every day.

We ignore at our peril the nature of our dependency on the diversity of life and the intertwining of the components of living systems. If we do not now preserve biodiversity there will soon be little left to preserve. When that happens, humans themselves may become an endangered species.

Biodiversity and Human Health

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