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Biodiversity: Our greatest natural resource

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There is a growing concern among scientists, including health care professionals and environmentalists, about the lack of understanding by the public as well as policy makers at all levels of government of the simple concept that human health is inseparable from the health of the natural world. So how can health care providers and biomedical researchers address this important problem when they do not have environmental issues as their primary professional focus? At present there is no system available to the health care community either directly or through their organizational structures for education and action about biodiversity, even though there are some excellent opportunities for their involvement. In a report of the NIH to the US Senate¹ one aspect of this problem was addressed as follows:

Perhaps the best way to illustrate the importance of biodiversity is by analogy to the diversity of human knowledge stored in books. When the library in Alexandria was consumed by fire in 391 AD, when Constantinople was sacked in 1453, or when Maya codices were burned in the 16th century auto-da-fe, thousands of works of literature were destroyed. Hundreds of works of genius are now known to us only by their titles or from quoted fragments. Thousands more will

never be known; several millennia of collective human memory have been irretrievably lost.

Like books, living species represent a kind of memory, the cumulative record of several million millennia of evolution. Every species has encountered and survived countless biological problems in its evolutionary history; molecules, cells, and tissues record their solutions. Because we are biological beings ourselves, nature offers a vast library of solutions to many of our current health, environmental, and economic problems. Unfortunately, that precious and irretrievable information is now being destroyed at an unprecedented rate.

Physicians, who themselves are well-trained scientists, and many of their health care colleagues can readily understand the issue of biodiversity protection when the information is presented in this way. The 500,000 US physicians are the most widely geographically distributed, scientifically trained professionals in the nation. If they and their health care colleagues can obtain the benefits of the knowledge, experience, and wisdom developed over many years by the scientific environmental community in a systematic, organized way, and can be included as equal partners in a national effort, they could add significantly to the public educational efforts under way.

BIODIVERSITY SUPPORTS HUMAN HEALTH

Serious consequences are associated with the loss of biologic diversity as a result of environmental degradation, excessive use of resources, and the mounting pressures from the world's growing population. The loss of biodiversity changes the way human disease spreads among people and diminishes the supplies of raw materials that are available for discovering and developing new drugs. In addition, the loss of biodiversity threatens future food production and water quality. Experts from

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many fields of medicine and biology agree that human health depends on the health of our environment and the preservation of biodiversity.

There is an ancient saying among the Crow Indians that "We are not inheriting this planet from our parents, we are borrowing it from our children." The present generation of adults has an important responsibility to preserve the quality of life on our planet and to pass on to our children and grandchildren a healthy environment with a full range of species. There is a valid concern about the future of our environment that requires every individual to increase the effort being made to preserve biodiversity.

There is mounting evidence from many sources that biodiversity is declining. Biologists studying our rainforests, oceans, and other ecosystems have documented that we are losing biodiversity more rapidly than ever before and that the loss of biodiversity will be reflected in lost opportunities to develop new types of medicine, food, and other natural products. Scientists from many disciplines including botany, anthropology, and pharmacology are studying the knowledge and habits of many indigenous peoples. From these studies we are beginning to learn that they have passed on from generation to generation important information about the usefulness of local plants. There is a pressing need to gather more of this information before it is lost as the young people in these tribes become "modernized." As we learn more about the importance of preserving biodiversity, it becomes obvious that each of us individually and together has an important role to play in the preservation of biodiversity.

Each of us should care about biodiversity for many reasons. A species that seemed unimportant to us yesterday may become an extremely valuable economic resource tomorrow. For example, 57% of all of the medications prescribed in the United States are derived from sources in the natural world. Many of these began as folk remedies, and aspirin is an example of one of the most commonly used drugs that comes to us with a long history of use by many different primitive civilizations.

Each of us must learn that the loss of a species from the natural world is permanent. Whether it be an animal, a plant, or an indigenous culture, efforts must be made to protect and preserve these vital resources.

You might ask first, "What is biodiversity?" Biodiversity is the variety of life in the plant and animal world that exists on every continent and in every ocean. Biodiversity is the fabric that is formed by the interweaving of all of the plants and animals that exist. It includes genes, living species, habitats, and ecosystems. It is the sum and substance of our planet's natural systems.

Many forces in the world today are bringing about

changes that are causing a loss of biodiversity. As each species is lost prematurely, we lose an opportunity to learn about the function of living things and how they are interrelated. The loss of biodiversity results in a degraded or poorer ecosystem and causes that ecosystem to function in a diminished way. Ultimately the loss of biodiversity leads to a loss of goods, services, and protective barriers. As species disappear and rainforests are degraded, for example, new and ominous diseases emerge that pose a serious risk to the well-being of human beings.

In some parts of the world, the loss of biodiversity has been accelerated greatly. Primitive forest regions rich in biodiversity are being cut down at the rate of hundreds of acres an hour to produce lumber, paper, and other raw materials or simply to create farmland without regard for the costs that will be paid by future generations. One extreme example is that 98% of the dry, west coast forests of Central America are now gone.

These changes are so dramatic that they are beginning to have a serious impact around the world. As we lose biodiversity we will begin to experience adverse social, economic, and scientific consequences. It has now been recognized that the loss of species represents a loss of opportunities.

The NIH has recently published a report describing the importance of conserving biodiversity, and in that report the Director of the NIH, Dr Harold Varmus,² points out that understanding and conserving biodiversity are among the most important research priorities and policy issues of our generation.

Our global population continues to increase at a rate that causes many to ask whether this population growth rate is sustainable. In many parts of the world the population is doubling every 25 to 30 years. In these areas it is clear that population pressure is destroying many valuable and irreplaceable ecosystems.

WHY IS BIODIVERSITY DECLINING?

The primary cause for loss of species is the destruction of their habitat or home. Scientists have documented that population pressure is the major cause for declining biodiversity but that this is followed by other factors including increased industrialization with the expansion of cities and factories. These in turn often produce pollution of the air, water, and soil in the region. This is happening all around the world, and the result has been a measurable increase in the amount of carbon dioxide in our atmosphere. As the carbon dioxide content increases, there is a very slow increase in the surrounding temperature on the surface of the earth. Even minor changes in temperature of 1 or 2 degrees produce a major effect on the ecosystems and biodiversity in the

area. This is a very controversial topic, and there is disagreement with regard to the rate at which these changes are occurring and the outcome of this process. A great deal of research is needed in this area because we still have a lot to learn about all of these issues.

But we do know the main cause for decreasing biodiversity around the world. Ecosystems are being changed most rapidly by the conversion of wilderness areas to farms. And of course the reason behind this conversion is the species *Homo sapiens*, to which each of us belongs.

The destruction of biodiversity is accelerating at the present time. Scientists have been able to calculate that we are losing biodiversity at approximately 1000 times the rate at which it disappears naturally. If we are unable to slow down the rate at which we are losing biodiversity, it is predicted that 5% to 20% of the species currently alive will disappear within 25 years.

Complex environmental habitats provide the home and life support for most species. Rivers and oceans are polluted, and as wetlands and rainforests disappear, so does the biodiversity that they contain.

During the past 2 centuries, not only have we lost thousands of species of insects, amphibians, and plants, but we have also lost 112 species of birds and mammals and are losing flowering plants at 100 times the natural rate of extinction for plants.

The exact rate at which species are disappearing is not known exactly by scientists. Within the widely ranging predictions, a moderate estimate is that an additional 25% of species will be lost during the next 50 years. Despite what we do not know about this matter, two things are certain: (1) once a species is lost it can never be replaced, and (2) the total range of biodiversity is shrinking.

WHAT EXACTLY DO WE MEAN WHEN WE TALK ABOUT SPECIES?

What does the word *species* mean? A plant, animal, insect, or bird is a member of a group of similar living beings. We call these groups species if they are capable of mating together and reproducing offspring that have the same characteristics. Some species are very common, like ants or people. Other species are extremely rare, like whooping cranes or giant condors. Some of the larger species are so rare that we can count the number left in the world, and we are very worried that this number is so small that the species may become extinct.

Scientists are not exactly sure how many species there are. Estimates range from 5 million to 25 million, and most scientists believe that there are between 12 and 15 million different species. Only about 2 million species have been named and studied, so we don't know anything about most of the species on this earth. This is

important because it is estimated that species are disappearing at a rate of approximately 17,000 to 27,000 species per year. This would be the loss of 2 or 3 species each hour. Some highly respected biologists have predicted that at the current rate of species disappearance, by the time the year 2100 rolls around, we human beings will have experienced the equivalent of a thermonuclear winter unless effective action is taken within the next decade.

Why does declining biodiversity threaten your health? As thousands of species are being lost, we are losing potential medicines that will never be found and never be available to cure disease. We are also losing potential new food products and natural products that might be helpful in fighting the diseases that cause crop loss. For example, there are natural pesticides that maintain the balance of plant life in every ecosystem, and these are likely sources for new organic pesticides that may never be discovered. It is likely that research in the field of biodiversity will uncover the molecules and organisms needed to fuel an explosion of biotechnology into the twenty-first century. Biotechnology and the companies associated with it have become major economic factors in developed countries and provide income and jobs for thousands of people.

Some opponents of the environmental protection movement have criticized the efforts that are being made to preserve existing ecosystems. They have suggested that ecosystems can be restored through human ingenuity. Usually this is not the case, and efforts to restore a damaged ecosystem are only partially successful and require centuries for recovery. For this reason, it is essential that we preserve existing ecosystems.

BIODIVERSITY SUPPORTS HUMAN HEALTH

Some of the most important and commonly used medicines in the United States originated from plants. For example, the most common heart medicine is derived from the foxglove plant, one of the most common medicines for leukemia comes from the rosy periwinkle, the most effective chemotherapy for ovarian cancer originates in the bark of the yew tree, and aspirin originates from the bark of the willow tree. In fact, of the 10 drugs used most often by doctors in the United States, 8 originated in the natural world.

Digoxin, which is pharmacologically classified as a digitalis glycoside, is currently commonly used in the treatment of congestive heart failure, atrial fibrillation, atrial flutter, and paroxysmal atrial tachycardia. Pharmacodynamically, digoxin has both inotropic (increased force of heart contraction) and antiarrhythmic (prevents irregular rhythm) actions. Digoxin is the *third* most commonly prescribed medication overall in the United

States. Many people are alive today because of its beneficial effects. This medication was introduced into modern medical practice because of the ethnobotanical inquiry by William Withering in 1775. In fact, one study showed that of the 150 drugs prescribed most often by doctors, 57% are derived from natural sources.³

The world has been excited by the technology that allows hearts, kidneys, and livers to be transplanted from one person to another. This life-saving surgical technique is possible only because of a drug called cyclosporin, which is derived from the rainforest. Cyclosporin was developed from fungi that were tested as antibiotics. A substance was found that blocked the antibody formation that is caused when an organ from one person is placed in the body of another. Cyclosporin prevents antibody formation and allows the body to accept an organ from another person.⁴

Quinine has certainly relieved more suffering than any other in history. For 3 centuries it stood virtually alone as the sole effective treatment for a life-threatening infectious disease—malaria. Malaria is a protozoan disease that affects a million people who live in tropical environments. Before discovery of the therapeutic properties of the cinchona bark, which contains quinine, there was no effective treatment for this disease.

Medical researchers in all parts of the world are now engaged in the screening of plants for medical use. The very best prospects for clinical effectiveness are evaluated in clinical trials in hospitals and medical centers.

For several decades the National Cancer Institute has been actively engaged in research for new medicines that would be effective against various forms of cancer. This search is carried out through the Cancer Drug Discovery Program and involves bioprospecting in 30 different countries. A number of new drugs that may eventually prove to be helpful in treating cancer are now undergoing testing.

The National Cancer Institute has been involved in the discovery and development of natural products as an untapped source of drugs with potential clinical efficacy. The development of new products can be encumbered by many problems, as demonstrated by the paclitaxel (Taxol) story. For successful Food and Drug Administration (FDA) approval of new medications, cooperation and communication among many persons from diverse backgrounds—including ecologists, nonmedical scientists, government scientists, and medical scientists—is necessary. Paclitaxel was first discovered to have antineoplastic activity in 1964, and only in 1992 was this drug approved by the FDA for treatment of advanced ovarian cancer.

This medication is a very important chemotherapeutic agent derived from the natural world, which empha-

sizes how crucial the preservation of our forests is to our health. The lives of many people may be saved by the discovery of a novel drug component of the pacific yew, which before the early 1960s was considered nothing more than a useless shrub. If the west coast forests had been harvested 50 years ago, paclitaxel would not have been discovered.

E. O. Wilson once said, “The loss of species is the folly our descendants are least likely to forgive us.”⁵ This sums up the philosophy of focusing on the preservation of habitats to stop the loss of species during our generation.

When species are lost, we lose potential foods, medicines, and new products. We lose plants that grow in the wild and may be more resistant to infection and drought than the plants that have been bred for maximum production. We lose the molecules and genes that are needed for scientists as they advance the field of biotechnology, and we lose the animal models that are necessary for us to understand life on earth. Of great importance as well is the economic loss, the jobs that never develop, the good health of the public, and the resources that are necessary to maintain the quality of our lives.

AGENDA FOR ACTION

Many persons who would like to help are frustrated because this seems to be such a large problem that they do not know where to start. It is obvious that 5 key steps must be addressed by various groups. We need more science to understand the details of habitat preservation and species protection. We need to focus our efforts in the areas where they are most likely to have an immediate effect. We need to promote practical change that will protect biodiversity and recognize that radical approaches and extremism for a good cause can prevent us from achieving our goals. Most of all, we need to educate the decision makers around us, and we must educate the young. This is where each of us can help.

The fundamental message that we as physicians and health care professionals can offer to those who view our efforts is that human health is inseparable from the health of the natural world. We can get involved locally by adopting practices that will lead to green homes, green offices, and ultimately to a green world. This will promote better health through reduction of our consumption, reuse of many items, and recycling of other products. We all need to remember to reduce, reuse, recycle. We need to become educated consumers.

In many of our communities there are biologic centers such as aquaria, zoos, botanical gardens, and parks. Many of these facilities have educational programs that attract children and adults seeking more information about the natural world. By organizing your local

efforts and becoming involved in these biological centers, you may become an important educational resource for the next generation.

All of us must support environmental preservation. We can learn more about fair bioprospecting and encourage practices that will promote this activity. We can encourage sustainable resource use and support political movements such as the drive to maintain clean air and clean water laws. Now is the time for each of us to make a personal commitment on behalf of the protection of our most precious natural resource—biodiversity.

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