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Biodiversity and Our Common Future

Peter Raven

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Before I begin my presentation on biodiversity, I would like to say a brief word about the Missouri Botanical Garden. Established in 1859 – the same year that Charles Darwin’s

Origin of Species was published – it is the oldest surviving botanical garden in the United States and it is still going strong.

In 1880, Chancellor William Greenleaf Elliott of Washington University, the founder of Washington University and later its chancellor, went to Henry Shaw – the English merchant who came to St. Louis in 1819 and founded this garden – and said, “Mr. Shaw,

why don’t you turn your garden and all your money over to Washington University. We can really manage it very well for you.” Shaw, who was eighty then, said, “At my age, I need time to think over serious proposals like this.”

And he thought it over and consulted his botanical advisors. They advised him it would be better to remain independent, like the other major botanical institutions of the world. What he did later, however, was a stroke of genius. It was a great benefit for both institutions when, in 1885, Shaw endowed the School of Botany at Washington University and put in his will that the Professor of Botany at Washington University should either be the first or second in command at the Garden. In 1889, Shaw passed away at the age of eighty-nine, after running the Garden personally for thirty years. William Trelease, who was a graduate of Cornell University and who had come to Washington University in 1885, was selected first director of the Garden after Shaw’s death.

The first doctoral graduate from Washington University in any field and fourteen of the first twenty graduates with master’s or doctoral degrees were products of the Washington University-Missouri Botanical Garden joint program. Subsequently, similar liaisons were established with the University of Missouri at St. Louis and St. Louis University, so that in residence at the Garden at any one time are thirty-five to forty graduate students from those institutions.

Many museums and other institutions like the Garden are seeking ways to project themselves onto the graduate stage and to be deeply involved with graduate students. But the formula that Shaw devised, along with officials of Washington University in the 1880s, appears to be the most durable and best that I know about. And it certainly has served both institutions well, as hundreds of graduates have been products of the joint program over the years.

We have permanent staff in eight foreign countries and eight other states. And since I’ve been here for thirty-three years, our way of operating has always been to encourage people to be in the best places to do their work. And that’s why we have staff members living in Madagascar, Peru, Bolivia, Paraguay, Argentina, Vietnam, China, Britain, and France.

Why are we so anxious to develop scientific expertise throughout the world, to learn

about plants and, more especially, to empower people around the globe to be able to deal with that knowledge for their own benefit? We know, intuitively, that our lives are supported by the wonderful biodiversity of plants, animals, and microorganisms that exists on our planet. But we sometimes forget – particularly when we live in cities – just how very important that biodiversity is for our happiness and for our lives. At the Garden, we try to get people out of the country or to our nature reserve, which is four square miles on the edge of the Ozarks, thirty-five miles away, to remind people of our interdependence – interdependence that I'll illustrate as we go along.

Unfortunately, much of the world is not living sustainably, although it's hard to remember that when one lives in a place like the United States or Europe where we take overconsumption for granted. One out of two people – that's 50 percent of the world's population – lives on less than \$2 a day. One in eight people is, literally, starving, in terms of the United Nation's recommended minimum caloric intake. And one out of two people is malnourished in respect to at least one critical dietary element as calculated by the World Health Organization.

It's the condition of the human race and its numbers that is the major problem concerning biological diversity. If you live in a country like the United States, it is easy to say that population is the major problem. But if you think about it a little more deeply, you could rapidly come to understand that consumption and the kinds of technology that we use are also very important in setting the stage for the world of the future.

For example, people in rural Brazil or rural Indonesia live at about one-fortieth of the consumption level of people in the United States. If you consider that we've added 135 million people to the population of the United States since the end of World War II, then you realize that the impact of the extra people in the United States on the world – in terms of levels of consumption, levels of pollution, uses of inappropriate technologies that may themselves be destructive – is about equal to the impact on the world of all the entire population of developing countries – 4.2 billion people. It is not justifiable to say that population is the only factor. It's our lifestyle and our way of dealing with the world that is truly significant. There are various ways of gradually showing the impact that people have on the environment.

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Look at the kinds of zoning that we like in the United States. For example, from 1945 through 1973, we paved over an area the size of the state of Ohio, as people fled to distant suburbs and got cars to get out there. The next time you hear people screaming about an intolerable two-cent increase in the gas tax that is bringing this country to its knees, remember that before the war in Iraq ever started, America had been spending, on the average, \$30 to \$60 billion a year around the Persian Gulf to help stabilize the political situation there and protect our supply of oil. It becomes a kind of a vicious circle – people living farther and farther away, depending more on automobiles, using up more and more land and resources.

Jack Benny used to say that Los Angeles would wake up to the coughing of the birds. David Letterman, I think, came up with a better one when he said; "Autumn is my favorite time of the year in Los Angeles. It's when the birds change colors and fall out of the trees."

Human impact really began in earnest with the development of crop agriculture. In the Fertile Crescent, at the eastern end of the Mediterranean, people were living in small villages before they developed crop agriculture. But with the growth of agriculture and the ability to get supplies of food that would let local populations outlast difficult seasons, those villages began to grow into towns, and eventually into even larger entities.

This growth began only about 10,500 years ago, around 425 generations, which is not very long. At that time, the entire human population of the world amounted to something like three or four million people – about the population of Greater St. Louis. And those

three or four million people were scattered throughout Eurasia, North and South America, and Australia and Africa. With the invention of crop agriculture, the human population began to increase rapidly.

In the complex societal systems that emerged, most of what we think of as civilization today began to develop. Thus, for example, our first written language comes from about 5,500 years ago in Sumeria – between Baghdad and Fallujah: two place names that we wish we weren't quite so familiar with. Written languages began to develop as people became specialists in many different professions: scribes, philosophers, religious and civic leaders, and many others. In the 2-million-year history of people on Earth and the 10,500-year history of agriculture, this all took place over a very short time.

By the time of Christ, there were several hundred million people in the world; and between Medieval and Renaissance times, about half a billion. When the Reverend Thomas Malthus was saying that human population growth was bound to overcome our ability to feed ourselves in the 1790s, there were about 800 million people in the world. By comparison, there are now 1.3 billion in China and 1.1 billion people in India. We reached a billion people early in the nineteenth century, 2 billion people in 1930, 2.5 billion people in 1950. And since then, in the ensuing fifty-four years, the population has gone from 2.5 billion people – which already was an unprecedented level that would have been unimaginable earlier – to the 6.3 billion people who are living today.

Since 1950, we've lost about 20 percent of the world's topsoil – much of it in developing countries, where its loss could least be afforded. We've lost about 20 percent of the agricultural land in the world, partly due to urban sprawl, partly to desertification, partly to overfertilization. So we're presently feeding 6.3 billion people on 80 percent of the land that we had available to feed 2.5 billion people in 1950. We cut about a third of the forests without replacing them. We increased carbon dioxide, the main factor in global warming, in the atmosphere by about six times. Over the last fifty years, we have lost about 6 to 8 percent of the ozone layer, which increases the incidence of malignant skin cancer by about 20 percent.

Much agriculture now depends on drawing up artesian water. In the north China plain, which feeds about 40 percent of the 1.3 bil-

lion people of China, the water table is dropping 1.5 meters a year. And over much of India, which has 1.1 billion people, the water table is dropping by about a meter a year. Since energy is subsidized in India, it's theoretically cheaper to drill more from below than it is to deal with surface water. So much of the surface water is polluted, it is simpler to keep drilling more wells than to clean it up.

With the total population growth not expected to level off for fifty years or more, when an extra two billion or more people will have been added, and with half of the world living in a state of poverty and/or malnutrition, it's pretty obvious that it's going to be very difficult to live up to any happy dreams in the future.

We must adjust our consumption, our technology, and our population levels in order to attain a sustainable world in the future.

Experts estimate that we use about 55 percent of the renewable supplies of fresh water, most of it for agriculture at rates that are subsidized. What do we do to increase our supplies of water, when a very large portion of people in the world have no access to dependable supplies of fresh water to begin with, and there are no obvious options now? This will be an increasingly serious problem in the future.

The obvious question laid out by the Brundtland Report, the report of the World Commission on the Environment and Development, is: Can all nations achieve the standards of prosperity now in developed countries, using available technologies?

In 1947, when Gandhi was visiting England, a reporter said, "Mr. Gandhi, now that India is going to become independent, will it achieve a standard of living like that of the United Kingdom?" And Gandhi said, "When I look at the map, about half of it is colored red, which means it's the British Empire. The wealth of the British Empire comes from these countries all over the world. And it's not obvious to me how India – a much larger country in population, with no empire – can achieve those standards of living."

So how many planets do we need to have all nations achieve the same level of prosperity now in developed countries? If we were to

use our present population and our present standards of living, our affluence and our technology, to bring everybody up to the standards of Europe and the United States, we would use about 120 percent of what we grow and produce per year – up from 70 percent as recently as 1970. That's definitely a frightening relationship, because it indicates that we would need another two copies of the planet Earth to enable all of the people who are living today to enjoy the same level of prosperity that we do now in industrialized countries. It means that the productive systems of the world – the potentially sustainable systems of the world – are being progressively degraded by the way we're using them at the present time. This projection strongly suggests that not only do we need to reach a level population, but we need to find levels of affluence and consumption that can be sustained in the long run, and we also need to develop technologies that are not as damaging as the ones that we use at present, and to keep improving them into the future.

When I was on the faculty at Stanford in the 1960s, we calculated that if you used the entire gross economic product of the world, you could export twelve people to the nearest planet that was likely to be habitable each year. That calculation indicates clearly that we must depend on our existing resources in our efforts to develop sustainability, and we must adjust our consumption, our technology, and our population levels in order to attain a sustainable world in the future.

In the middle of our runaway consumption – which is well beyond the levels that the world can sustain – we have the problem of biodiversity. Over 80 percent of the organisms in the world – not counting bacteria – are completely unknown, lacking even scientific names. If you breed a tropical rain forest, nineteen of the twenty kinds of organisms that you'll be bringing up will never have been seen by a scientist, will be completely unknown, and will have no name. Even if it does have a name, what that name is likely to tell you is: There's a dead one in the bottom of a bottle on a shelf in The Natural History Museum in London that somebody got somewhere in the Central Amazon in 1860.

The number of species of organisms for which we have a reasonable amount of information is more like fifty thousand or one hundred thousand, and that's it. For all the others, even knowing what they are won't lead to any useful information. Without a reliable census of the species of organisms on Earth, it is very

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difficult to estimate how many species are becoming extinct. We can, however, estimate extinction rates by reference to well-known groups of organisms, especially those that have hard body parts and are well documented in the fossil record – about one per million per year over the past sixty-five million years – since the great extinction at the end of the Cretaceous period.

Then we come to a written record that we can compare directly with that of about four hundred years ago. Over the last four hundred years, about one hundred species per year have become extinct. Now we're up to several thousands per year, and with the rate of habitat destruction and the other forces that I have discussed, we'll very soon be eliminating tens of thousands of species per year. The vast majority of them will be unknown at the time that they're lost. We won't even have known that they existed.

We are currently spending tens of billions of dollars trying to determine if there was one species on Mars, two to three billion years ago, which might be preserved in the rocks to demonstrate that life once existed there. Now place yourself on Mars, coming to Earth to find this great diversity of organisms that we've been treating with a cavalier kind of disdain, low funding, and disinterest.

Habitat destruction is a major force in driving organisms extinct. It is estimated that the Amazon Forest will be about 5 percent of its present size by the middle of this century. Couple this fact with our well-established relationships between members of species and size of habitat. Habitat destruction is the only force taken into account in estimating that two-thirds of all the species on Earth will be extinct by the end of this century if present trends continue. But then, there are many other factors. What about gathering plants in the wild? Ginseng, for example, is hound-

ed throughout its range in North America and it is not alone. Most people in the world depend on wild plants as their source of medicine and are basically harvesting them very rapidly.

The importance of bush meat – hunting for animals in natural forests – is increasing year after year in Africa and throughout the tropics. When an oil company goes to Africa or South America to drill, it doesn't say, "Here's some food." It says "Here are some guns. Go out and get what you need to feed yourself." Another very important factor: all along the coast of Africa, European fishing boats are sucking the fisheries dry so that in places like Ghana, which really depend on fish, there aren't any fish. The fish are all being brought back to Europe as luxury foods. As a result, people in Africa are turning more and more to bush meat, leading rapidly to the extinction of many species.

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Then there's the matter of introduced species such as the zebra mussel in the United States. Alien invasive species of plants and animals are the likely cause of extinction of at least a third of the endangered plants and animals in this country. They are moving around the world at a frightening pace; in Hawaii, for example, they are the cause of extinction or likely extinction of every endangered plant and animal. It's estimated that in the United States we lose about \$140 billion a year to alien invasive species.

In comparison to the \$155 billion spent on the entire criminal justice system in the United States, \$140 billion looks pretty big. It's also about a third of our military budget, giving you an idea, even in nonbiological terms, of how important the problem of invasive species is. Yet people continue to drag plants and

animals all over the world and they literally eat up biodiversity wherever they are introduced.

Next we come to climate change. The International Panel on Climate Change (IPCC), now in its fourth cycle of climate modeling, has made it very clear that climate is changing rapidly, in some places more rapidly than in others. Human-produced gasses are the major component in climate change. For example, all alpine and sub-alpine habitats in the United States will be lost by the end of this century. In the Alps, not only are the glaciers receding rapidly, but famous climbs, like the north face of the Eiger, can no longer be undertaken: the north face never freezes and you can't climb up the rotten rocks.

So there are three major causes for extinction – alien invasive species, climate change, and hunting and gathering – that aren't even taken into account when we say that two-thirds of the species may be lost over the course of this century. This is an extraordinarily serious development for human beings because we depend entirely on biodiversity, and specifically on plants, as our source of food. Moreover, 70 percent of the people of the world depend directly on plants as their source of medicine, and at least 25 percent of the prescription drugs written in the United States also have a "suborder" base. With the hunger for nutraceuticals in Japan, Europe, and the United States, plants that people are using as their source of medicine are being scrounged right out of existence. For example, curare, used for muscle relaxation in thoracic surgery, is based on knowledge gained from groups of Indians hunting in the Amazon who use it as a muscle relaxant as well.

It's also important to remind ourselves that we live in the very early days of a revolution in biology – the double helix: fifty-one years ago, the first transfer of a gene from one unrelated kind of organism to another; thirty-one years ago, widespread use of genetically altered products in medicine and then, fifteen to twenty years ago, in crops; in the last five years, knowledge about genomics and the comparison of gene families across different kinds of organisms. Here is the biology and the technology that we expect to be able to use to make the world sustainable. Can you think of anything more stupid than driving two-thirds of these kind of organisms into extinction, 80 percent of them completely unknown before we even get our hands on them to see how they might be useful?

Where are we heading? If you think that human ingenuity is going to get us out of this, well, it's not. Human ingenuity is extremely important in finding better ways to move into the future, but I think that we are sapping the productive capacity and the diversity of the world extremely rapidly, yet slowly enough that a single lifetime doesn't give us a very clear focus on it. Think about what the place where you grew up looks like now, and you

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will have a pretty good snapshot of what rapid change means. It is leading to better ways to fight diseases, travel, talk on the telephone, and, heaven help us, communicate on the Internet, but it's not making the world more beautiful or interesting or diverse or philosophically better, more musical or more cultured or more poetic or anything else.

By our pell-mell rush toward success, development, and consumption, we are destroying the world at a rate that is unworthy of us in terms of the benefits we have. But what we do now is going to affect the final product when we do achieve some kind of stability. We're not engaged in a pell-mell rush toward extinction; we're engaged in a pell-mell rush toward a less interesting, duller world. What are the individual parts going to look like? What's Chicago, St. Louis, Boston, or Bolivia going to look like? What is going to be the sum total of the activities of a lot of people doing a lot of different things to affect the outcome?

Preserving and keeping national parks and other kinds of similar reserves is a very important strategy for conservation, but it can be badly impacted by climate change. The coexistence with organisms that we can tolerate in modified lands is going to have a great deal to do with how many organisms survive. Alien invasive species must be controlled. We need to save plants and other organisms in cultivation or, when we can, try to keep tissue culture slides in order to try to

keep them for the future. We must do a great deal of education and communication with one another about the importance of biodiversity. Otherwise, none of this effort will be supported by anyone.

Increasing scientific capabilities around the world, by any means possible, is one of the most important things that scholars can do to secure the future not only for the United States, but for the entire world. We've got to reach a higher level of morality and realize that people around the world don't have the opportunities that we do. The alienation of women and children throughout the world is unforgivable, unmistakable, and a true characteristic of world civilization. There is no way that women and children can contribute their unique talents to a sustainable world until they're encouraged to be part of their societies, achieving similar levels of education with men, sharing the same privileges, benefits, and work as men.

We need to deal seriously with air pollution, especially the air pollution that affects climate change. In 1991, Stephen Schmidheiny, a Swiss industrialist who developed the World Business Council for Sustainable Development in the years prior to the Rio summit, wrote in a brilliant opinion piece in the *New York Times*: "There is no greater gift that American industry can give to European and Japanese industry than going on pretending that global warming does not exist. By doing so, you are giving us time to invent and patent all the things that you will want to buy desperately from us later, when you come to your senses. And basically, once again, put-

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ting yourself in the same position that you did in the early 1970s, when you wisely decided that small, efficient Japanese cars had no place in the American economy. Thank you, America."

We need to find alternative sources of energy and energy conservation. In constant dollars, the U.S. Department of Energy now spends 15 percent of what it did in 1979 for energy conservation and alternative energy and in 1979, we thought there was a problem. Shell and British Petroleum, the two major European oil companies, spent 15 percent of their pretax income in these areas. American oil companies – virtually none. Which would you rather invest in?

Ultimately, sustainability begins with every one of us. As I pointed out, in the United States, we consume thirty to fifty times what the poorer people of the world do and we can

make many, many choices here that will be significant, including promoting internationalism, learning more and spreading that knowledge, and especially voting, being engaged in the political process. What about automobiles? Choices about places to live? What are we going to do about it, individually? To say that none of this makes any difference is simply to postpone the obvious outcomes. It all makes a huge difference. What about sustainable use of seafood? What about composting? Catching rainwater? Green architecture – building with things that can be recovered later and building with materials that have low cost to the environment? Building energy effectively? Recycling? Environmental literacy? In every university that I have anything to do with, I say that environmental literacy for undergraduates is a prerequisite to living intelligently in a modern world. So far, only the University of Georgia has an environmental requirement for every single undergraduate. Should we be optimists or pessimists? Does the tree get cut down or are we about to learn something about it?

As Gandhi said, the world provides enough to satisfy every man's need, but not every man's greed. Let's be more thoughtful. Let's try to remember how much we enjoy evenings of companionship like this and the finer things that we've achieved and realize that without attending to the sustainable base of all of this, the biodiversity of our world cannot and will not be preserved for our grandchildren and their grandchildren. ■

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Robert M. Wald (University of Chicago) and John Katzenellenbogen (University of Illinois at Urbana-Champaign)



Gerald Early (Washington University in St. Louis), Leslie Berlowitz (American Academy), and Patricia Meyer Spacks (University of Virginia)

Midwest Meeting – St. Louis



Peter Raven speaking on biodiversity



Missouri Botanical Garden



Priscilla McDonnell, John McDonnell (McDonnell Douglas Corporation), and David Forney (MIT)



Martin Dworkin (University of Minnesota), Vice President of the Midwest Center, presided at the meeting.