

Second Annual
John H. Chafee
Memorial Lecture on
Science and the Environment

The Future of Life

Dr. Edward O. Wilson

Pellegrino University Research Professor,
Harvard University

December 6, 2001



National Council for Science and the Environment
Improving the scientific basis for environmental decisionmaking

THE NATIONAL COUNCIL FOR SCIENCE AND THE ENVIRONMENT (NCSE) has been working since 1990 to improve the scientific basis of environmental decisionmaking and has earned an impressive reputation for objectivity, responsibility, and achievement.

The Council envisions a society where environmental decisions are based on an accurate understanding of the underlying science, its meaning, and its limitations. In such a society, citizens and decisionmakers receive accurate, understandable, and integrated science-based information. They understand the risks, uncertainties, and potential consequences of their action or inaction.

Supported by over 500 academic, scientific, environmental, and business organizations, and federal, state, and local government, NCSE works closely with the many communities creating and using environmental knowledge to make and shape environmental decisions.

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**JOHN H. CHAFEE Memorial Lecture
on Science and the Environment**

**Sponsored by the National Council for
Science and the Environment (NCSE)**

PRESENTED AT
2nd National Conference on Science,
Policy and the Environment

Smithsonian National Museum
of Natural History
Washington, DC

December 6, 2001

This volume is the second in a series of books documenting the annual John H. Chafee Memorial Lecture on Science and the Environment.



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Dedication

This book is dedicated to the memory of Senator John H. Chafee who, in his 23 years representing Rhode Island in the U.S. Senate, was a leader in promoting a bipartisan, science-based approach to environmental issues.

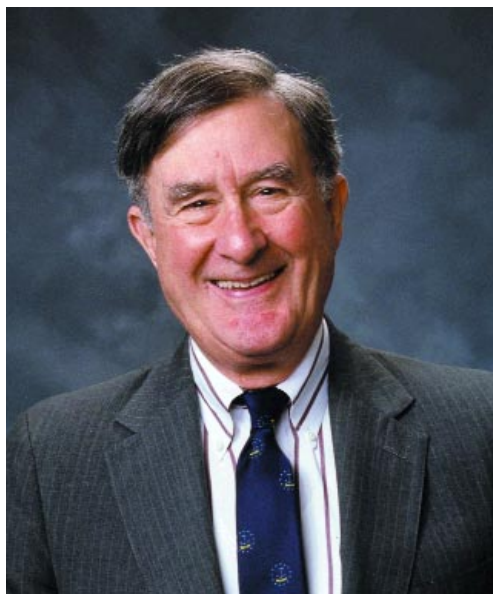




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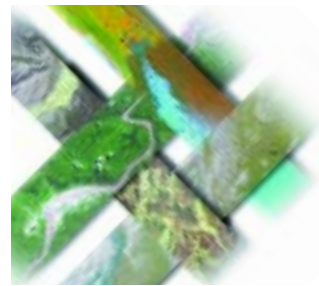
Hon. Maurice Strong, Senior Advisor to the United Nations Secretary-General; Dr. Wilson; Jan Hartke, Earth Voice.



Dr. Wilson and Stephen Hubbell, NCSE Chairman.



Attendees at the second annual John H. Chafee Memorial Lecture on Science and the Environment.



Opening Remarks

Richard Elliot Benedick, President, NCSE

I have the privilege of being president of the unique organization that is sponsoring this conference, the National Council for Science and the Environment. As president, one of my most enjoyable chores is to publicly acknowledge leaders in the fields of environment and science. After all of the outstanding high points in the first day of this two-day conference, it is extremely rewarding to see how the conference is unfolding: the brilliance of the speakers and the interaction among the participants exceed all my expectations.

After this series of highlights, it is my pleasure to welcome you tonight to an event that would be the high point of any conference in the United States — the second annual John H. Chafee Memorial Lecture.

We honor at this lecture a great senator who was a champion of all that is entailed in the vision of the National Council for Science and the Environment, namely, improving the scientific basis for environmental decisionmaking. A number of distinguished people are speaking on this subject today and tomorrow whose names are synonymous with the environmental and scientific communities.

John Chafee was an outstanding American, whom I personally had the honor of knowing and working with while I was in the State Department, responsible for population issues and subsequently for environmental affairs. None of these issues was more crucial and, at the same time, more controversial, than protection of the stratospheric ozone layer, as represented in the Montreal Protocol of 1987. It was referred to this morning by several speakers, including our keynote speaker, Donald Kennedy, president emeritus of Stanford University and now editor of the journal *Science*.

This landmark success in diplomatic history and environmental history could never have occurred without Senator John H. Chafee, and I personally was honored and deeply touched by his interest and support. For a while, it seemed as if domestic opponents of a strong treaty would prevail in undermining the American position which I was representing at tough international negotiations. But John Chafee was a pillar of strength in the halls of Congress in helping to preserve our position. The rest is history, as you all know.

Before we turn to our distinguished lecturer, I would like to introduce a member of the Chafee family, Georgia Chafee Nassikas. She has a degree in design, worked in architecture, is a passionate organic gardener, an artist and mother of four children; her husband is from Greece. Welcome, Mrs. Nassikas, speaking on behalf of the Chafee family.



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Georgia Chafee Nassikas



Thank you, Ambassador Benedick and members of the National Council for Science and the Environment. On behalf of the Chafee family, I thank the Council for holding tonight's second annual lecture in celebration of my father's environmental legacy.

We are looking forward to Dr. Wilson's lecture on the science and solutions behind sustainable development. I feel privileged to be here tonight to hear first hand from the man whose books I have so enjoyed.

How pleased my father would be to see here so many working to save the natural world around us—the air that sustains us; our

living waters, salt and fresh; our unbuilt lands, and all the wild creatures dwelling therein. My father worked tirelessly toward that goal. How fitting that this lecture bears his name.

John Chafee lived by the words of the most famous conservationist, Theodore Roosevelt, whom he often quoted:

“Of all the great questions which can come before this nation, short of the actual preservation of its existence in a Great War, there is none which compares in importance with the central task of leaving this land a better land for our descendants than it is for us.”

For John Chafee, this was indeed the central task of his long service to us, to our children and to their children to come.

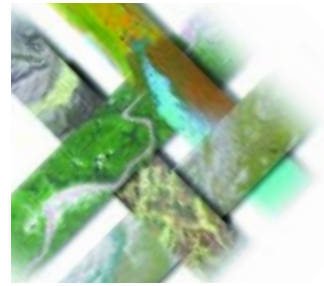
His giant energies were called upon in many efforts, large and small: in sweeping national laws to keep clean our air and water and to preserve the nation's coastline; in more local work to restore salt marshes and protect rare birds and in his personal forays along our roadsides picking up litter. He moved on a broad front. He never stopped; he rarely rested.

My father often said, “Given half a chance, nature will rebound and overcome tremendous setbacks, but we must—at the very least—give her that half a chance.”

And through his leadership we have indeed given nature more than half a chance—and she has rebounded. Once more the delicate piping plover flutters above our beaches. Once more the mighty striped bass courses the sea along our

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coast. Once more thrive the grassy shallows lining our bays and coves, the breath of life to a cosmos of creatures. Through him we have healed so many of the wounds we once inflicted.

It is today fashionable for politicians to avow deep commitment to the environment. Words are one thing; work is another. In the Senate, the big bills get passed only through long, hard labor by those truly committed to the cause. In politics there are many who flock about to drink the wine of success, far fewer are those who toil in the vineyards.

John Chafee toiled to the very end.

Thank you all for being here tonight.

Introduction

Stephen Hubbell, Board Chairman, NCSE



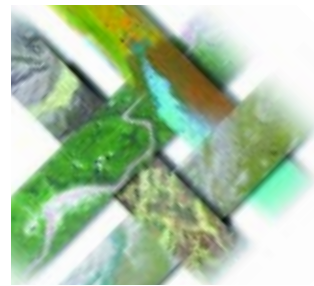
I have an astonishingly difficult task. How do you introduce the singly most famous living scientist in the world? Ed Wilson has been truly an intellectual giant for the last forty years, with a history of revolutionizing field after field. I'd like to try to introduce him from a very personal perspective.

When I was a graduate student at Berkeley in the 1960s, Ed had just published a revolutionary book, *The Theory of Island Biogeography*, with his colleague from Princeton, Robert MacArthur. I remember studying this book in a graduate seminar, and it threw out almost everything I had ever learned in ecology. The theory set forth a radical notion

that dismissed the rules that we thought operated to construct ecological communities of species. Yet the theory seemed to predict things extremely well.

The theory wasn't uniformly accepted, but it started a revolution in at least three separate disciplines that I can name, one of which is conservation biology — which really is the founding of much of the environmental movement today dealing with endangered species and the future of biodiversity on the planet. Another was revitalizing the then-languishing field of biogeography, the study of the distribution of species on large landscapes. The third, neutral macroecology, wasn't really realized until I began applying the theory to my own work and I found that there were implications of the theory that went far beyond what was in that original book. I've recently published a book building on his theory, which he was kind enough to review favorably.

That said, it is remarkable that after reinventing my field, Ed Wilson went on to reinvent three or four others. About 10 years later he published *Sociobiology: The New Synthesis*, which revolutionized behavioral ecology and the study of social behavior in animals and humans, and had a huge impact in the social sciences. He followed up with his seminal book *On Human Nature*, which won him his first Pulitzer Prize. Then, not content to rest on his laurels, he took a look at the biodiversity crisis. First he helped edit a National Academy of Sciences book on biodiversity with a collection of distinguished



authors pointing out the fact that indeed, there was a crisis, that we were losing species at an accelerating rate worldwide, and that we had to pay attention to this problem in a serious way.

He then wrote two more books in that vein. *Biophilia* examined his hypothesis that perhaps people have an inborn love of nature and an evolutionary hypothesis for why this was so. Then he wrote *The Diversity of Life* — a beautiful book that probably many of you have read — which makes the case that we really have a moral and ethical obligation to save nature. And so he explored the evolutionary underpinnings of our love for nature and our care for it, which doesn't necessarily follow from many traditional evolutionary hypotheses.

More recently Ed is championing an international effort to catalogue life on Earth. It is desperately overdue. Many of you are probably aware of the fact that we are still largely in the Linnaean stage of describing and naming new species. We don't know how many species there are on this planet even to the nearest order of magnitude, and this is scandalous. The science of biodiversity is essentially in the Middle Ages — in a sense, it's as if we were still cutting open bodies to find out what organs are inside. And so we need a crash program — a Manhattan-like project to understand life on Earth and what we need to do to save it. If we don't know where and how nature lives, it's extremely hard to design policies to preserve it. And Ed is championing that effort in a very effective way.

I have one personal story to tell about Ed's connection to me and my father, who was an evolutionary biologist, an entomologist at the University of Michigan. Ed tells me that when he was a young graduate student presenting a controversial theory on subspeciation, my father, then an older entomologist, was in attendance. A very kind and wonderful gentleman, my father came up to Ed afterwards and said "Ed, I wish I had written those words." And Ed wrote to the editor of my recent book, "I am now happy to recycle those words about Steve's book." I was very touched by that.

You can get to know Ed by reading *Naturalist*, and I recommend it. It is an "ant" of a good read [audience laughs]. He really tells you what it was like to grow up being a "natural" naturalist — it just happened automatically. He simply fell in love with critters and made the study of critters the centerpiece of the rest of his scientific life. And of course, he wrote *the* definitive book on his favorite critters, *The Ants*, with his colleague Bert Holldobler, for which he won his second Pulitzer.

Ed has transformed so much of science in this country and the world that he truly is a giant. He's probably my greatest living scientific hero today — and probably that is true for a great many of you as well. I am truly honored to be able to make this introduction.

I give you Professor Edward O. Wilson.

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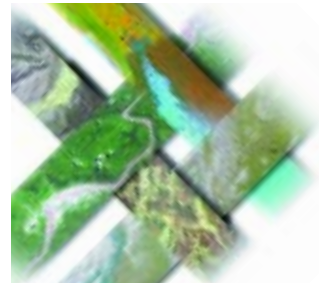
by Dr. Edward O. Wilson

Thank you Steve Hubbell. And I can say without hyperbole, because I said it with complete sincerity at the time of its publication, his neutral theory of community organization is revolutionary in its own right and is, as one reviewer has called it correctly, an instant classic. He is surely in the foremost rank of our ecologists, a rarity who has made major contributions in theory and also through a lifetime of field research composed empirical studies of diversity as it actually exists.

Friends, colleagues, thank you for giving me this opportunity to present the Chafee Memorial Lecture. I take it as a signal honor to present a lecture in memory of John Chafee, a great patriot (what pleasure it gives me to be able to use that word unabashedly), a great senator, and a great environmentalist. I consider it an exceptional honor to do so here in the Smithsonian, and in Washington — from which emanate so much policy and action that affect the world environment.

As we peer forward, well into the 21st century, which is really the business of this conference, it will serve well to ask this question: What might we have overlooked about our place in history? What are we most at risk of forever losing, most likely toward the end of the century? The answer, I think, is this: much of life, the rest of life, or the creation if you will, a lot of our environmental security, and just as





important, part of what it means to be human. Our relations with the rest of life can be put in a nutshell: scientists have found the biosphere (and this has been due in good part to work just in the last few decades) to be richer in diversity than ever before conceived. And that biodiversity, which took over three billion years to evolve, is being eroded at an accelerating rate by human activity. The loss, to conclude this synopsis, will inflict a heavy price in wealth and security and spirit.

The bottom line in global economics, I suggest, is different from that widely assumed by our leading economists and public philosophers. They have mostly ignored the numbers that count. Consider the following: the world population has now edged well past six billion and is on its way to nine billion or more by mid century, before mercifully peaking and starting to descend. Per capita fresh water and arable lands are dropping to levels that resource experts consider very risky. The key statistic is the ecological footprint — which is the average amount of productive land and coastal marine environment appropriated by each person (not in a single block, for example, around where you might live in Maryland or Texas, but in bits and pieces from around the world) needed for your food, water, housing, energy, transport, commerce, and waste management. Each person, for example, on average draws down a little bit of Costa Rica for coffee, a little bit of Saudi Arabia for oil, and so on. In the developing world, with five billion of the six billion people, the ecological footprint is about two-and-a-half acres. In the United States it is ten times as much: about 24 acres. For every person in the world to reach present American levels of consumption with existing technology would require four more planet Earths. The people of the developing countries may never want to attain our level of profligacy, but in just trying to achieve a decent standard of living, they have joined the industrial world in converting the last of the natural environment and reducing a large part of the planet's fauna and flora to endangered status or final extinction.

At the same time, *Homo sapiens* have become a geophysical force. We have driven atmospheric carbon dioxide to the highest levels in at least the last 200,000 years, unbalanced the nitrogen cycle, thinned the protective ozone layer of the atmosphere, and initiated global warming that will ultimately be bad news everywhere. Our unbalanced relation to the natural environment began a long time ago as a mistake in capital investment. Humanity, having appropriated the Earth's natural resources during the Neolithic Revolution (starting 10,000 years or so ago) chose to annuitize the resources with a short term maturity reached by progressively increasing payouts. That's basically what we have done and are doing. At the time that seemed a wise decision, and



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viewed in the short term it still does. After all, the result is rising per capita production and consumption markets awash in oil and grain — and also in optimistic economists cheerfully monitoring GDPs and competitive indices.

But there is a problem. The key elements of natural capital, as opposed to market capital (in other words, Earth's arable land, groundwater, forests, marine fisheries, and petroleum) are finite and not subject to proportionate capital growth. They are furthermore being decapitalized by over-harvesting and habitat destruction. Therefore with population and consumption continuing to increase up and up, the per capita amount of resources left to be harvested is falling and destined to be harvested at a faster and faster pace in the future. The long-term prospects are not promising.

Humanity, awakened at last to the realities of the natural economy that underlies the market economy, has begun an earnest search for alternative sources of materials and energy. Altogether the 21st century is destined, in my opinion and that of many here I suspect, to be the century of the environment. The immediate future is usefully conceived as a bottleneck. Science and technology, combined with a lack of self-understanding and a paleolithic obstinacy that led to our ruinous environmental practices, have brought us to where we are today. Now science and technology combined with foresight and moral courage and common sense, both drawn from a more enlightened ethic than has hitherto ruled public philosophy, must see us through the bottleneck and out, one hopes, by the end of the century.

There are two collateral effects of the bottleneck phenomenon worth reminding even this exceptionally well-informed group. The first is: the rich grow richer and the poor grow poorer. The income difference between the fifth of the world's population in the wealthiest countries and the fifth in the poorest countries was 30 to 1 in 1960, 60 to 1 in 1990, and it's now 74 to 1. Eight hundred million people remain in what the United Nations classifies as absolute poverty: no sanitation, no clean water, rampant disease, and periodic starvation. Even if the income differential is dismissed as a humanitarian issue, it should be considered a security issue. It is a setting for resentment and fanaticism and the arrival of suicide bombers seeking a better world somewhere else.

But the second collateral effect (and the one to which I've personally paid a great deal of attention and want to address more fully tonight) is the accelerating destruction of the natural environment leading to the mass extinction of ecosystems and species. The damage already done can't be repaired within any period of time that has meaning for the human mind. The more it is allowed to grow, the more future generations will suffer for it in ways both well understood now and



still unimagined. “Why,” future generations will ask, “by needlessly extinguishing the lives of other species, did you diminish our own?” The radical reduction of the world’s biodiversity is the folly our descendants will least likely forgive us.

Let me review some of the basic facts now concerning biological diversity (or biodiversity for short). First of all, what is biodiversity? It is all of heritable variation of life on Earth. To rescue that from banality, biologists recognize and analyze separately biodiversity at three great levels of organization, starting with ecosystems. The next level down is species, which compose those ecosystems and range enormously in size and ecological function. And the third level is genic variability within the species.

How much biodiversity is there? We now estimate that about 1.5 million to 1.8 million species of plants, animals, and microorganisms have been described. And it’s a bit of a scandal, as Steve Hubbell was indicating, that we don’t even know how many species we’ve already accounted for. Among those species we know, of course, the insects and the flowering plants dominate in diversity, that is, in numbers of species. The reason for that is simply that they formed a partnership toward the end of the Mesozoic on the land (which has such highly diverse topography and opportunities for isolation of populations and species formation) and together pumped the world’s biodiversity up to the high level that we have today. If you were to look at this in what we call the specienscape, where each major group is represented by a single organism in proportion to its group’s size, insects would be represented by, for example, a beetle, which would loom like a Goodyear blimp over a minute elephant (representing the paltry 4,500 species of mammals, the group to which we belong). And then of course there are the fungi: 60,000 to 70,000 species known, but experts estimate that there are over one and a half million species out there, and therefore they have considerable representation in the specienscape. This brings me to the point of the exploration of this planet.

We do not know to the nearest order of magnitude how many species of plants, animals, and microorganisms there are on Earth. It’s almost certainly more than 5 million, it could be 10. But it could be, particularly due to the unknown depths of variation of species composition of bacteria and archaeans (the single cell, very primitive organisms that form the foundation of all ecosystems), as high as 100 million. We don’t know. We just haven’t begun to explore the biosphere. We live on a little-known planet with a razor thin biosphere,



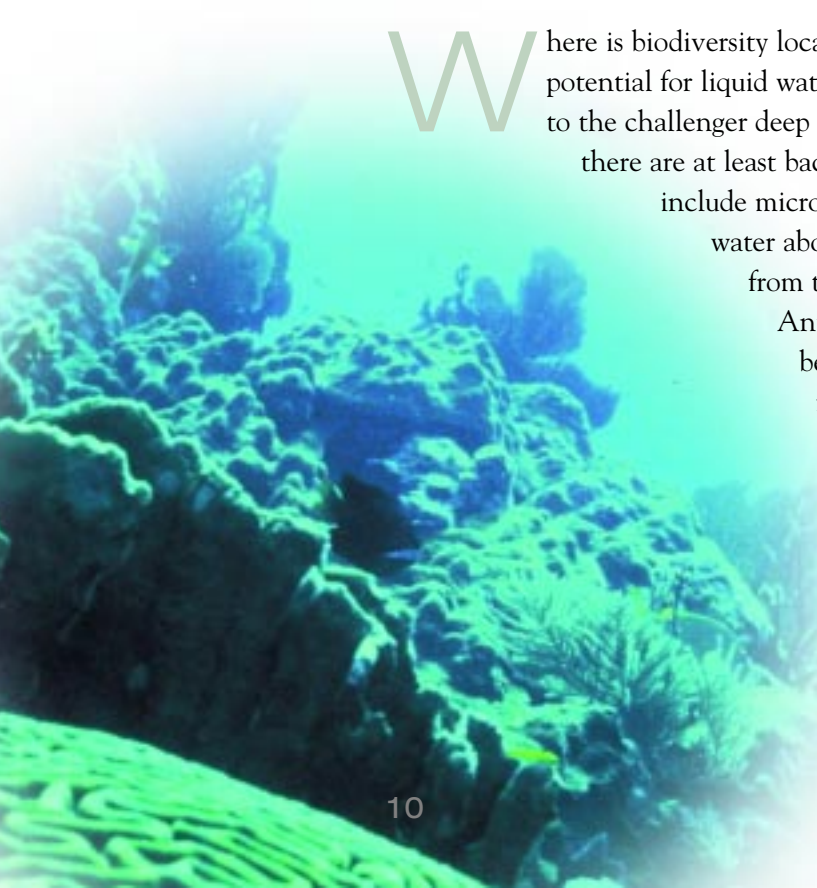


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so thin you can't even see it edgewise from a space shuttle, that contains such enormous complexity that we haven't really explored it properly. We know less about it than we do the surface of Mars and the moon.

The black hole of biodiversity is the bacteria. And the next level down is the diversity of genes we have just begun to explore, the genetic variation within species. Just to give you a feeling of how great that variation is, or the amount of genetic material, if you took the four strands, the four molecules that make up the total composition of a single genetic composition from the nucleus of a single human cell (somatic cell), and you put them end on end, you get in real space a molecule about a meter long, but it's only two billionths of a meter wide — you can't see it. If you could magically enlarge that molecule to the size of the width of wrapping string, then our single cell material would stretch approximately 1,820 miles. That would be from New York to Dallas. And if you walked along that string, ticking off the base pairs that make up the letters of the code, you'd be counting about 100 every inch. A lot of that is unique to *Homo sapiens*, as it would be to a fungus, a small insect, a Sequoia, and so on. This image will give you an idea of what we lose when we allow one species to go extinct. The average age of a species before the coming of humanity was very roughly 1 million years. We've speeded up extinction and thus shortened that span by roughly 1,000 times. The amount of information that is lost is approximately equal in pure bits to all of the editions of the Encyclopedia Britannica published since the eighteenth century.



Where is biodiversity located? Everywhere there is liquid water or the potential for liquid water. Pole to pole from the summit of Everest to the challenger deep at 36,000 feet below the ocean surface, there are at least bacteria and other microorganisms. These include microscopic fungi, some of which also thrive in water above the boiling point in the thermal vents from the sea floor, supercooled water in the Antarctic ice gardens, and two or more miles below Earth's surface drawing energy from the metabolism of inorganic chemicals and therefore independent of life above. (The organisms down there incidentally — to make them easy to remember — are called the SLIMES. That stands for Subterranean Lithoautotrophic Microbial Systems. That will be on the exam.)



Most of the species of known organisms occur in tropical moist forest — tropical rainforest. It covers about 6 percent of the Earth’s land surface and is down to about half of what it was before humanity began cutting it. The tropical rainforest is still largely unexplored. The part that is least explored is the canopy, where the photosynthesis occurs and where we know there is an enormous amount of biological diversity. It’s been very hard to get into because of the difficulty of climbing trees in the tropical forest. These typically go straight up until they begin to branch near the canopy. Their surfaces are typically smooth or have spines, and when you get up to the top there are these gardens of epiphytes — gesneriads and orchids and even cacti — that are densely packed together on the branches. These are homes to swarms of stinging wasps and ants. Tarzan would not have survived 15 minutes. So it’s been a challenge for our more athletic young men and women who want to get up there. One of the methods that are being developed include using a crane, as is being done in a pilot experiment of the Smithsonian Tropical Research Institute (STRI). When the investigator gets out onto the arm of the crane it circles around, and the investigator is able to lower himself up and down. An enormous volume of rainforest canopy can be reached. But the investigators just can’t hang there, they’ve got to have a protected cage with a door — because the Africanized, so-called “killer,” bees are very abundant, and you don’t want to bump into a nest hanging 100 feet above the rainforest floor. Investigators are able to travel around almost as though floating through air and get out to the tips of the trees — the branches — where people have never been before and so much of life is concentrated and the productivity of the forest is based.

The diversity of these rainforests is legendary. From a single tree I identified, for example, 43 species of ants living in the tree including 26 genera (and that’s about equal to the total diversity — total number of ant species — found in all the British Isles). But one doesn’t have to go to tropical rainforests to see great and unexplored diversity. In just an ordinary forest, say mixed hardwood and conifer forest around here, you can see a world that is still far beyond our understanding. The forest floor looks two dimensional as we walk over it and look down (like Godzilla in New York City), but it’s not. If you cut it — come into it from the side, magnifying it greatly so you’re looking at a cross section from the dead leaves at the top of the litter and down a few centimeters — you can see a number of zones in which the size of the space is declining and in which the leaves are being increasingly chopped up and converted. You’re also getting changes in chemical composition, in nutrients available, in temperature, in light. You therefore have an immense array of niches at



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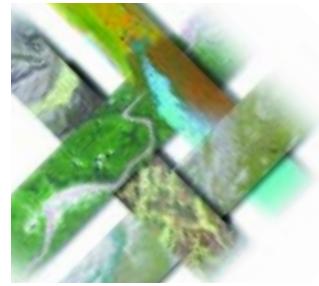
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a micro level. These are real niches into which vast numbers of species have radiated in their evolution and specialized to fill. Their existence is what keeps these forests healthy. These are what we lose — this diversity — when we, for example, convert old growth forests by clear cutting in favor of second growth or tree farms.

Now on a personal note, here is the way to get many young people into science. Most young people have a “bug period” — or they are capable of having it. They have a true and unabashed sense of wonder, and they can still work directly in nature and derive enormous pleasure from it. And then not only can they live a more fulfilling life by knowing what lies out there to see and wonder about and explore as they reach maturity, but also if they want they can go into a scientific career — this is one of the broad pathways into a scientific career. And believe me, it’s environmental science that’s going to count in this century.

It is the destruction of habitat where we are doing the most damage to the diversity of life. Habitat destruction is at the top of the ways human activity is destroying biodiversity. NASA has found that about five percent of the Earth’s land surface is burned every year. Five percent. And that includes vast areas of the Amazon Orinoco basin and the Congo basin, which are still mostly sparsely inhabited. The destruction has been — terrifying is the only word I can use to describe it when you see the maps through time of how the forests have been reduced in some of the biologically richest areas of the world. For example the magnificent Mata Atlantica, the Atlantic forest of Brazil, one of the real hot spots of the world, has been reduced to less than ten percent of the original forest cover. Fortunately, the Brazilians now have begun serious conservation and restoration projects for this particular forest area.

I wish I could say the same for the Philippines. In the last hundred years, the forest there has been mostly destroyed. Now we know with a fair degree of precision how much of the biodiversity we lose as the area comes down in size. This is a subject that both Steve Hubbell and I have worked on, for example, among other investigators. As you go from the large islands of the West Indies — we can use this as a model field situation — the large islands such as Cuba and Hispaniola down to the smallest islands like Saba, the number of species drops off, depending on the group and the geographic area, between the third and sixth root for the most part. The fourth root is a very commonly used figure. Now if you take the fourth root just as an example, this means that with a 90 percent reduction in area (to 10 percent of the original cover) you will eventually lose roughly half the species. They will be either eliminated immediately or doomed to early extinction.



We can see this occurring for example in our national parks, which are “habitat islands.” They are well protected, but you can picture them as islands of natural environments in an increasingly hostile sea of ranch land and other converted forest and grassland. And sure enough, the species have been declining. They’re declining to a new level which may or may not be equilibrial now, but in time it probably will be equilibrial. There is an actual decline overall of mammal species in 14 national parks in western North America. None of the 299 mammal species in these parks has yet become globally extinct, that is extinct in all the national parks and elsewhere. But there is a cumulative curve leading toward extinction in all of these parks combined. The tropical rainforest is disappearing worldwide at the rate of about one half a percent to one percent a year. The remaining cover of rainforest is about equal to the coterminous 48 states, and the rate of destruction is equal to from half to all of the state of Florida each year. This translates to as much as a quarter of one percent of the species in these rainforests extinguished or doomed to early extinction each year.

In addition to the destructive effects of habitat loss should be added invasive species. Invasive species are alien species that are destructive in some way either to humanity or to the natural environment. And they include the “friendly” fire ant from South America, a gift of Brazil and Uruguay to the southern United States, a major pest. I don’t know if it’s actually extinguished any species yet, but it’s markedly modified much of the insect fauna from the Carolinas to Texas. Another example of an invasive species — and probably the most repellent — is the brown tree snake from the Solomon Islands or New Guinea, which was introduced to Guam shortly after the Second World War and proceeded to build up enormous populations of a thousand or so per square mile. It grows to about eight feet long. It’s poisonous and it specializes on birds as prey — it has wiped out virtually all of the native land birds of Guam.

The flood of invasive species around the world is growing, partly as a result of globalization. And every part of the world is receiving invasive species from somewhere. Hawaii has been largely taken over in the lowlands by invasive species. What you see in Hawaii is largely a fauna of alien species. Rarely would you ever see a native bird on the islands. You see a few native plants and a few native insects, but





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mainly the biota is reconstituted from species that occur in other parts of the world, a synthetic fauna. To give you an example of how extensive it is, I recently sent two assistants to the Juan Fernandez archipelago, which is this remote group of islands off the coast of Chile. It had never been collected for ants, and I had to know, I just had to know what was out there! They brought back collections, which included the fearsome Argentine ant (which is such an enormous pest in California and Australia and really destructive in South Africa). They discovered that the species has taken hold on these remote islands and appears to be spreading rapidly.

How fast are species going extinct? By two separate measures, the area-species curve, and by tracking individually the velocity of species traveling through the IUCN red data for 40 years, we have estimated the current rate of extinction worldwide of species is conservatively between 100 to 1,000 times higher than it was before the coming of humanity — when it was very roughly one species per million per year. And some believe that those brackets are too low, that the increase could be on the order of 10,000 times higher. Because as entire ecosystems are eliminated, as in those Philippine forests, the rate jumps dramatically up as you approach the end game, and the forest or whatever it is, is shrinking toward unsustainable amounts of resource. It's entirely possible then, some analysts say even likely, that if the present rate of habitat destruction and spread of alien species continues, and that's a big if, because it depends on how committed we are to doing something about our living environment, we could lose half the species of plants and animals on Earth by the end of the century.

Hawaii is a dramatic example of how drastic local extinction can be.

We now know, due partly to excellent work done here at the Smithsonian, that there were upwards of 140 species of birds on Hawaii before the arrival of the Polynesians in 400 A.D. And they included Hawaiian eagle, flightless ibis, huge gooselike birds with bills like those of a tortoise, and many other remarkable forms — including many beautiful honeycreepers. Now only 25 are left. The Polynesians wiped out quite a few and European and other colonists after the 18th century wiped out a great many more. Of the 25 that are left, most are endangered to some degree and a couple of them are so endangered they're not expected to survive more than a few more years.



Let me turn to the bottleneck, the period we are now in, in which the greatest challenge is to raise the lives of people everywhere to a decent level, while bringing through intact as much of the natural environment as possible. That would be my suggestion as the great goal of the 21st century. Its two objectives are intertwined. They are synergistic in such a way that progress in one enhances progress in the other.

I'll close then with a dispatch from the global biodiversity front, where I've been active on the Boards of Directors of several of the major conservation organizations, to tell you a little of what is being done about the hemorrhaging of ecosystems and species and how the problem can be partly solved. First, it turns out that large blocks of the last remaining natural environment and wilderness areas can be preserved at surprisingly low cost and in such a way as to yield greater profit. This is what counts also to the countries owning them. It's as simple as this: logging companies, which we have sort of intuitively thought must be economic juggernauts that cannot be stopped, are actually operating on a very thin profit margin and they can be out-bid by conservation groups using private gifts which are then leveraged by grants from the Global Environment Facility, the World Bank, and other organizations for as little as \$10 an acre and often much less. Conservation concessions, as opposed to logging concessions, can be established in countries otherwise prepared to give away logging rights cheaply. It is possible to turn the policy around 180 degrees to preserve the forest instead. Or a trust fund can be set up the same way with the proceeds being paid to the country for preserving and managing large reserves. Or the logging rights can be purchased, in some cases for as little as \$1 an acre. Or finally the land itself can be purchased outright. By these means, for example, Conservation International and The Nature Conservancy have recently added over 2 million acres to the parks and reserves of Bolivia, Guyana, and Suriname. They and the World Wildlife Fund are also offering research and management expertise to promote the use of this land to the countries that own them. Income from tourism and other non-invasive income sources can quickly be made more profitable than timber leases and agricultural conversion. Other developing countries around the world are now exploring similar arrangements.

Another point of entry is the preservation of "hot spots," those particular forests and coral reefs and other local habitats that are both endangered and contain the largest number of plant and animal species found nowhere else. Twenty-five of the terrestrial hot spots cover only 1.4 percent of the land area of Earth but are the exclusive home of an astonishing 45 percent of all known species of vascular plants and 36 percent of mammals, birds, reptiles, and



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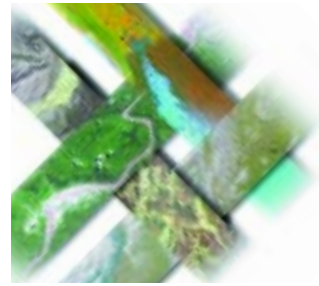
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amphibians. In other words, a large minority of the world's known fauna are limited to 1.4 percent of land, which is not overwhelmingly expensive to preserve. This is an approach promised by Conservation International and the World Wildlife Fund among American-based NGOs to provide the means for moving swiftly to save, or at least put in a holding pattern, a substantial amount of the world's biodiversity.

Not all of the hot spots are in remote jungles. Some are close at home, the Hawaiian rainforest for example, the temperate rainforest in the Pacific Northwest, the coastal sage scrub of California, and the Lake Wales Sand Ridge of central Florida are among America's leading hot spots. These are among the parts of the U.S. on which resources should be focused immediately and with some urgency in order to save a large part of the diversity of life — and it can be done.

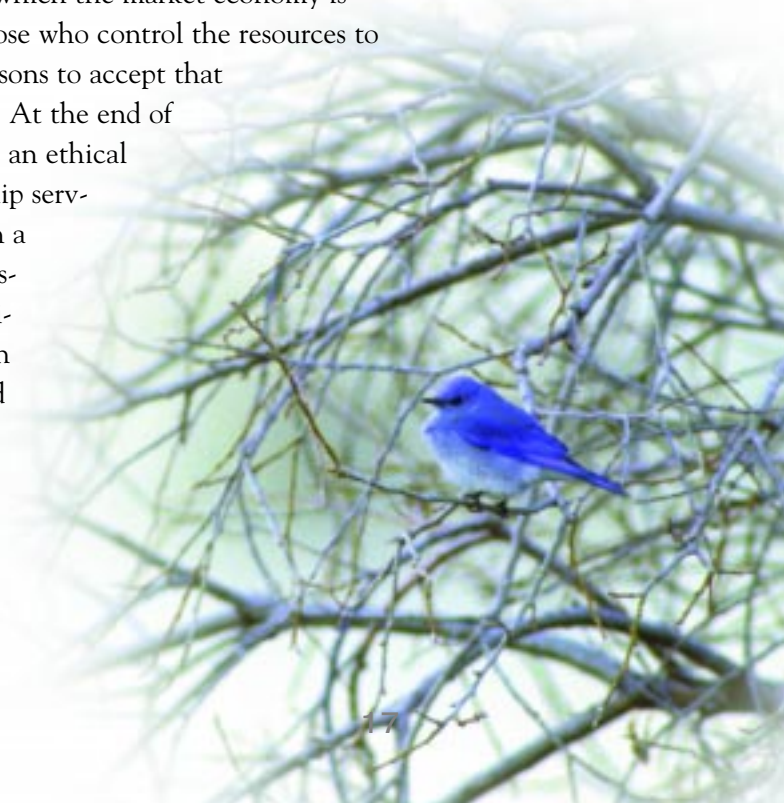
It is clear that progress in global conservation — and I think this is a conception that has been very well and repeatedly illustrated today and in today's session — is dependent on joint enterprises of the private sector, government, and science, a true iron triangle. We have to know exactly what is at stake, what is the status of many of the endangered species, what most needs to be done to save them, how to do it, and how to develop a strategy of aid and development attractive to people everywhere and to their governments. And to allude to the bumper sticker problem posed by *Science* Editor Don Kennedy this morning, we have to learn how to sweep constantly back and forth between local and global to get the job done. Right now it's the private sector, working through environmental non-governmental organizations, that forms the spearhead of the global conservation effort, particularly by invention of new and cost-effective methods. The largest of these organizations, including Conservation International, The Nature Conservancy, IUCN, World Wildlife Fund US, and World Wildlife Fund International are reaching operating budgets in the \$100 million level. They are acquiring enough influence to form partnerships with the World Bank and the United Nations, as well as to work with the CEOs of larger corporations. They are backed by hundreds of smaller NGOs, operating in cities, countries, and internationally. The NGOs are in general more entrepreneurial, innovative, and flexible than governments. But make no mistake: governments, especially those of the industrialized countries, still must do the heavy lifting and will have to assume a much larger role in the future.

At the present time about \$6 billion a year is spent worldwide on conservation. Proceeding from both private and government sources, most of it ultimately from government, a recent estimate suggests that about \$28 billion annually is needed to sustain a sample of all the world's natural ecosystems,



marine as well as terrestrial, and a large part of the biodiversity. But as a first step, \$28 billion in one investment, as estimated by economists and biologists in the Defying Nature's End Conference held at Cal Tech last year, wisely placed in hot spots and tropical wilderness areas could save upwards of half or more of the species. One payment. And if that seems a large price to save so much of nature and biodiversity, keep in mind that it is only one thousandth of the combined gross domestic product of the world, that is, the annual combined gross domestic product. One thousandth.

The central problem of the new century, in my opinion and to repeat, is therefore how to raise the poor to an endurable quality of life, making them partners in the conservation effort worldwide while preserving as much of the natural world as possible. Both the poor and biological diversity are concentrated in the developing countries. The solution to the problem must flow from the recognition that both depend one on the other. The poor, especially the nearly one billion who remain absolutely destitute, have little chance to improve their lives in a devastated environment. Conversely, the natural environment, where most of the biodiversity hangs on, cannot survive the press of land-hungry people who have nowhere else to go. I hope that tonight I've added to the conviction, which I know is widely shared here and by growing numbers of other thoughtful people of all walks of life, that this problem can be solved. We can now concentrate on solutions. We cannot afford to accept anything less than proposed solutions with a timeline and a concrete goal and a budget and a way of recruiting people. These are the prerequisites to shifting the paradigm of the economy of the world, in which the market economy is joined sustainably to the natural economy. Those who control the resources to do this must be recruited. They have many reasons to accept that goal as a necessity, not least their own security. At the end of the day, however, the direction we take will be an ethical decision. All politics is ethical, even if just in lip service, and it will be an ethical decision to launch a true and effective global and environmental rescue operation. We should, as a matter of principle, save every scrap of biodiversity that we can hold on to. A civilization able to envision God and an afterlife and embark on the colonization of space will surely find the way to save the integrity of this planet and the magnificent life it harbors. Thank you.

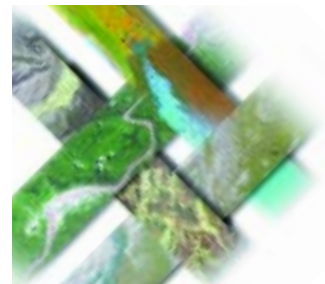


Questions & Answers

Q I noticed your map of the U.S., with places that had problems and places that were doing better. I noticed that the least densely populated states had the fewest problems. However, of densely populated states, New Jersey, Massachusetts, and John Chafee's Rhode Island were doing very well. What are they doing right?

A The question was why have some of those industrialized and densely populated states shown on that map done so well. I suspect that it has something to do with having eliminated most of the species at an early stage, so we don't notice the loss now. But it also has to do with the fact that historically some states have much smaller faunas and floras. The faunas and floras for example of the southeastern United States — Alabama, Tennessee, Georgia and Florida — are very rich and vulnerable, particularly the aquatic fauna. Hawaii is an example of a very fragile environment, and the colonists hit it in a devastating way. California has large numbers of species that have gone extinct even in recent times, in part because it's so big, it has so many species, and it has a varied topography where many of the species are limited to just small areas. So I don't think you can explain it culturally.

Q I want to thank you for your presentation. I would like to remind the audience that the first national conference on biological diversity was held in this exact auditorium in 1986. This is a worthy successor. I think there was a point here mentioned by Dr. Wilson which is extremely important to the concept of sustainability. And that is the current levels, the current lifestyles, the current standards of living in Europe and America cannot be achieved by the world at this point. It would take four times the production capacity of the Earth, the consumption of natural resources, to bring the population of this globe up to the standard of living which probably 98 percent of us in this audience enjoy right now. That's something that we really need to take to heart — that this is the essence of sustainability. Until we come to grips with that issue, which is going to be heavily science driven, we cannot solve the issue of sustainable development on



the Earth. I would also like to point out that the \$28 billion that you mentioned to approach the conservation of a huge proportion of the biological diversity on this Earth is only two-thirds of that which the president is now proposing for an increase of the U.S. budget for the defense department in the war on terrorism, which is \$40 billion, and the bailout of the American industry and New York City in trying to repair the damage. We need to look at these scales of investment. \$28 billion versus \$40 billion. If we can get the political constituency on Capitol Hill to do this, we can answer these problems.

A Thank you.

Q My question is exactly along those lines. I think I speak on behalf of many people in this room in saying that I am in absolute awe of the way that you have so gracefully incorporated complex scientific theory into some very practical policy issues. And my question to you is, what do you see as the scientists' role in bridging the gap between current consumption patterns and where we need to go to protect environmental diversity?

A What is the role of scientists? I thought that might be self-evident. The scientists themselves devoted to basic research have a great many major problems to solve and areas to explore, not least of which is to get on with a complete biodiversity map of the world. And recently we did have a summit conference on the continental and in some cases global initiatives around the world, in order to get a concerted effort. All of the heads of the initiatives who attended the summit ended up endorsing the idea of trying to achieve the goal within 25 years.

Q Dr. Wilson, my name is Brian Czech, I'm a conservation biologist for the National Wildlife Refuge System, so I guess that makes me part of that iron triangle of conserving lands in the United States for the purpose of biodiversity conservation. The thing I wonder about, is as long as we have a national goal of economic



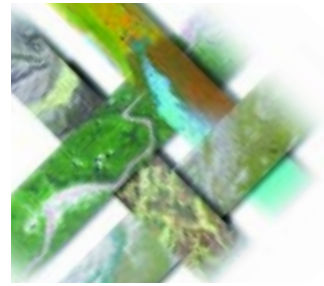
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growth, which of course we do, those lands will come under increasing pressure for production, and the political boundaries — for example the refuge system and also the private conservation lands, like The Nature Conservancy — will be compromised as time goes by unless we replace that goal with a goal of a stabler, steady state economy. And I recall asking you about two and a half years ago when I first signed on with the Fish and Wildlife Service what you thought about that issue, and you were into the ecological economics movements. But I didn't hear any of that come out in the talk this evening, so I just wonder how you would intend for us to pursue that aspect of conservation and biodiversity.

A Well, you know we have a huge job in persuading Americans to look after their own national forest and wildlife preserves. I think that in one way Americans have been sold a bill of goods and might be quickly persuaded if they knew it. The deception concerns the economic potential of logging and mining on public lands. A very interesting figure which comes from the U.S. Forest Service report of 1999: the income produced by our national forests, which I think is what, 8 percent of the land area of the United States, was about \$85 billion. Eighty percent was from recreation, including hunting and fishing, 13 percent from logging, and still less from mining. When Americans hear those figures I think they're going to be less impressed by arguments that we need to intrude on national land in order to favor or save the American economy. Logging and mining are in fact anti-theftical to the use of the land that is producing the most income.

Q Dr. Wilson, I spent most of my conservation life with The Nature Conservancy and with the World Resources Institute, both of them looking at policy and preserving habitat. Recently I've been in the political arena. You have given an outstanding talk, expanding the knowledge of the already committed. But our problem is a black hole of understanding, one mile to the west of here (i.e., the White House) and two miles to the east (i.e., Capitol Hill). What do you suggest we do about that? Because we can convince each other and get wonderful arguments, but if we don't get the votes and the understanding and the programs, it will all go down the drain.



I'll say one thing we can do is elect people with scientific and environmental backgrounds like John Chafee to the Congress. The composition of the U.S. Congress lacks people with backgrounds, particularly scientific backgrounds, to address these issues. Approximately half of the legislation coming before the Congress is said to have some important scientific issue in it, obviously including all that concerns the environment. I'm sure there are environmentally knowledgeable people on the staff, but we need people at the top who understand the key issues and treat them with passion on behalf of the American people. I think the problem is the following: most of our political leaders and political intellectuals, our talking heads on Sunday morning television and writers of syndicated columns, were educated in the social sciences and in the humanities. Almost none of them were educated in the natural sciences, and that shows. There is such a huge imbalance in the media, coming at us around the clock, and therefore in the perception of the American people.

Thank you very much.



Appendix 1

Biography of John H. Chafee (1922-1999)

Senator John H. Chafee (R-RI) was born in Providence, Rhode Island, in 1922. He held degrees from Yale University and Harvard Law School.

Upon the United States' entry into World War II, Chafee left Yale to enlist in the Marine Corps, and then served in the original invasion forces at Guadalcanal. In 1951 he was recalled to active duty and commanded a rifle company in Korea.

John H. Chafee began his political career by serving for six years in the Rhode Island House of Representatives, during which time he was elected Minority Leader. Running for Governor in 1962, Chafee was elected by 398 votes. He then proceeded to be reelected in 1964 and 1966 — both times by the largest margin in the state's history. In January 1969 he was appointed Secretary of the Navy and served in that post for three-and-a-half years. He was elected to the U.S. Senate in 1976.

As chairman of the Environment and Public Works Committee, the Senator was a leading voice in crafting the Clean Air Act of 1990, which strengthened pollution emissions standards. He led successful efforts to enact oil spill prevention and response legislation and a bill to strengthen the Safe Drinking Water Act. Senator Chafee was a long-time advocate for wetlands conservation and open space preservation and was the recipient of every major environmental award.

As senior member of the Finance Committee, Senator Chafee worked successfully to expand health care coverage for women and children and to improve community services for persons with disabilities. In 1990, Senator Chafee spearheaded the Republican Health Care Task Force and became a prominent figure in the national health reform debate. He went on to lead the bipartisan effort to craft a comprehensive health care reform proposal in 1994.

Senator Chafee also was a leader in efforts to reduce the federal budget deficit and cochaired the centrist coalition which produced a bipartisan balanced budget plan in 1996. He was an active proponent of free trade and was a strong supporter of the North American Free Trade Agreement (NAFTA). He served as chairman of the Republican Conference for six years.



The Senator received awards and endorsements from such organizations as The National Federation of Independent Business, The American Nurses Association, The League of Conservation Voters, The Sierra Club, Handgun Control Inc., Planned Parenthood, Citizens Against Government Waste, and the National PTA.

On October 24, 1999, Senator John H. Chafee died from congestive heart failure. He is sorely missed.



Appendix II

Biography of Edward O. Wilson

Dr. Edward O Wilson, Pellegrino University Research Professor Emeritus at Harvard University, is one of the most highly respected scientists in the world today. Hailed as “the new Darwin” by Thomas Wolfe and one of “America’s 25 Most Influential People” by *Time* magazine, he has twice received the Pulitzer Prize (one for *The Ants* and a second for *On Human Nature*). He has been honored with the highest scientific award in the field of ecology, the Crafoord Prize from the Royal Swedish Academy of Sciences, and he received the U.S. National Medal of Science. His best-selling book, *The Diversity of Life*, which brought together knowledge of the magnitude of biodiversity and the threats to it, made him a leader in the environmental movement and an advisor on preservation legislation at the highest levels of the U.S. government. For his conservation work he has received the Audubon Medal of the National Audubon Society and the Gold Medal of the World Wide Fund for Nature. He has received in total some 75 awards in international recognition for his contributions to science and humanity and is the recipient of 27 honorary doctoral degrees from North America and Europe.

He is a pioneer in the field of sociobiology and one of the most sought after science lecturers in the world. His accomplishments include pioneering work on chemical communication in the 1950s to 1970s, featuring a first comprehensive account of pheromones in ants, and (with William H. Bossert) a first evolutionary analysis of the physical and chemical properties of pheromones; the creation (with Robert H. MacArthur) of the theory of biogeography, a basic part of modern ecology and conservation biology; the creation of the discipline of sociobiology, in 1975; the first modern syntheses of knowledge of social insects (1971) and (with Bert Hölldobler) of ants in particular, in 1990. He also edited the volume *Biodiversity*, which in 1988 introduced the term and launched worldwide attention to the subject. In 1984, with *Biophilia*, he introduced the concept of a genetically based tendency to affiliate and bond with parts of the natural world. Today he continues entomological and environmental research at the Museum of Comparative Zoology. His most recent book, *The Future of Life* (2002), offers a plan for saving Earth’s biological heritage.

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