

LESSONS FROM
Environmental Collapses
OF PAST SOCIETIES

Dr. Jared M. Diamond
University of California, Los Angeles

FOURTH ANNUAL JOHN H. CHAFEE MEMORIAL LECTURE
ON SCIENCE AND THE ENVIRONMENT

January 29, 2004



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 for 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.

The Council operates a range of innovative activities in the areas of:

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JOHN H. CHAFEE MEMORIAL LECTURE ON SCIENCE
AND THE ENVIRONMENT

LESSONS FROM
Environmental Collapses
OF PAST SOCIETIES

Dr. Jared M. Diamond
University of California, Los Angeles

Sponsored by the
National Council for Science and the Environment

Presented at the
4th National Conference on Science, Policy and the Environment
Ronald Reagan Building and International Trade Center
Washington, DC

January 29, 2004

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

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ISBN 0-9710439-6-5

For citation purposes, please use:

Diamond, Jared, *Lessons from Environmental Collapses of Past Societies*. Fourth Annual John H. Chafee Memorial Lecture on Science and the Environment. Washington, DC: National Council for Science and the Environment, 2004.

This volume is the fourth in a series of books documenting the annual John H. Chafee Memorial Lecture on Science and the Environment. The lecture was delivered at the 4th National Conference on Science, Policy and the Environment: *Water for a Sustainable and Secure Future* (Craig Schiffries, Conference Chair) on January 29, 2004, in Washington, DC.

National Council for Science and the Environment
1707 H Street, NW, Suite 200
Washington, DC 20006-3918
Phone: 202-530-5810
Fax: 202-628-4311
E-mail: info@NCSEonline.org
Web: www.NCSEonline.org

 Printed on recycled paper with soy inks.

Manufactured in the United States of America.



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The National Council for Science and the Environment is grateful to the following sponsors for making possible the Fourth Annual John H. Chafee Memorial Lecture on Science and the Environment:

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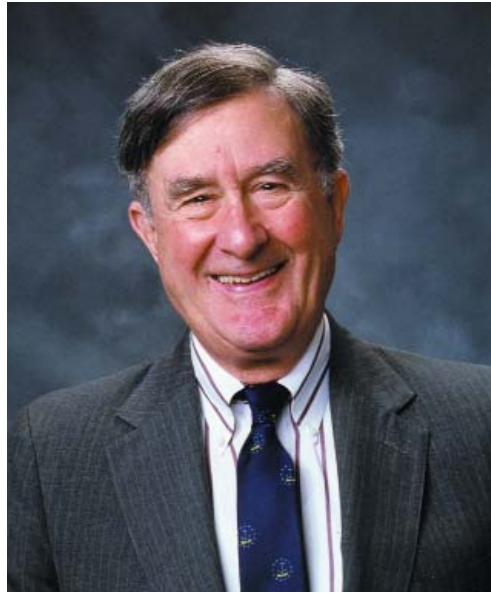
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DEDICATION

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





Top, from left: Dr. Stephen Hubble, NCSE; Hon. Russell Train, former EPA Administrator; Dr. Thomas Lovejoy, Heinz Center; Amb. Richard E. Benedick, NCSE; Dr. Jared Diamond, UCLA; Senator Lincoln Chafee; and Dr. Craig Schiffries, NCSE, gather before Dr. Diamond's featured lecture. Right: A questioner at Dr. Diamond's lecture. Below: Attendees at NCSE's 4th National Conference on Science, Policy and the Environment in Washington, DC.





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OPENING REMARKS

STEPHEN P. HUBBELL, CHAIRMAN, NCSE

Welcome to the Fourth Annual John H. Chafee Memorial Lecture, which will be given by Jared Diamond. My name is Stephen Hubbell, and I serve as Chairman of the National Council for Science and the Environment (NCSE). I am always in awe of this enterprise. It started about 15 years ago with a very small office in Washington and has become an exciting force for environmental science and policy.



Tonight we honor the memory of Senator John H. Chafee, who was a great champion for the environment, for clean air, and for clean water. He really believed that science could play an important role in improving our quality of life. In these memorial lectures, we attempt to marry science, policy, and human ecology. Tonight, we have one of the best of the best at doing this.

First, I would like to introduce Russell Train. Russell was a pioneer in the very kind of enterprise that we are trying to build at the National Council for Science and the Environment. He was the second Administrator of EPA, President of the World Wildlife Fund, and Undersecretary of the Interior. He

has done just about everything. It is truly a pleasure to have you here, Russell.

In a moment I'd like to invite Senator Lincoln Chafee to say a few words about his father. First, I have a personal story to relate about his father, which I hope won't be too embarrassing to him. My wife, Leslie Kilham, now deceased, was the niece of Peter Kilham, a sometimes inventor. He made many inventions that didn't go anywhere, but one of them was successful. It is the Droll Yankee Birdfeeder. I'll bet you that half of the audience owns one of these, or one of the cheap knockoffs. I'm told that Lincoln's roommate was involved in one of the knockoff companies.

Peter was a lot of fun, and Leslie and I would visit him in the summertime and watch the fireflies and chat. On two of those occasions, John Chafee was there when I returned from a hike. One of those days he asked me what I did. I told him that I was in school and thinking



about becoming an ecologist. He said, I imagine that means you care about the environment. In those days, I didn't really know what the environment was, but I said, yes, I did care about the environment. He talked at great length about valuing nature and valuing the environment. He discussed what it meant to be a good citizen and a good steward of the environment.

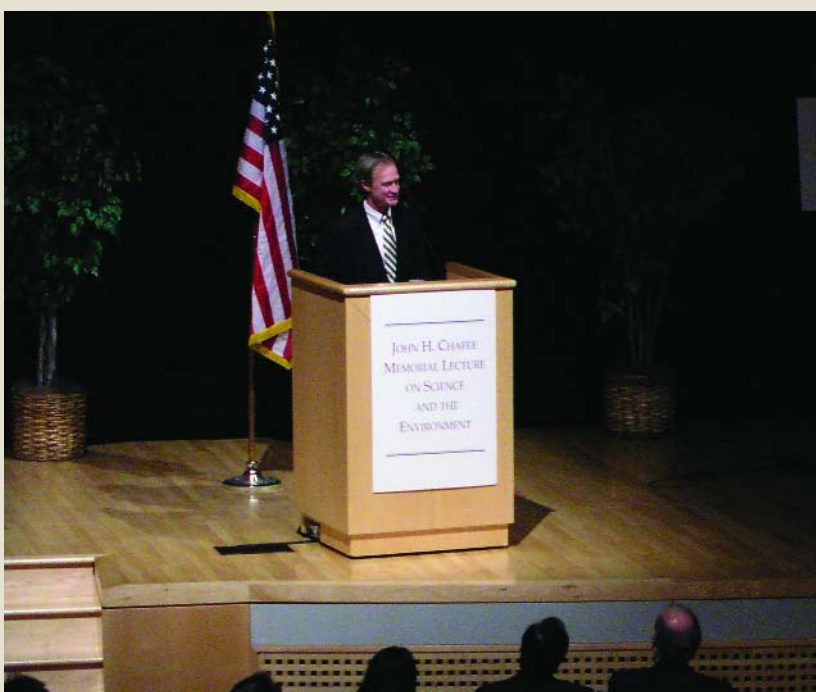
At the end of this conversation, he asked what I was going to do about the environment. I didn't have an answer at the time. I felt rather embarrassed. I then went on to found the National Council for Science and the Environment. So, Lincoln, it is all your father's fault. It is my honor to invite Senator Lincoln Chafee to say a few words about his father.

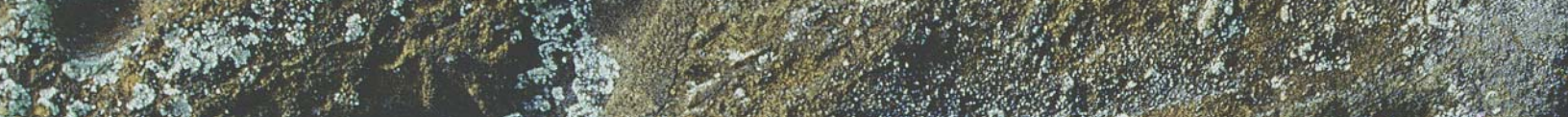
LINCOLN D. CHAFEE, UNITED STATES SENATOR

Thank you Steve for your kind words. On behalf of the Chafee family, I wish to thank the Council for your continued commitment to celebrating the work and environmental legacy of my father by hosting the annual John H. Chafee Memorial Lecture. It is a true testament of my father's lifelong commitment to expanding scientific knowledge in order to better understand and protect our environment.

As our world becomes increasingly more complex, we realize the importance of science-based decisions in responding to our multifaceted environmental challenges. Issues such as climate change, water quality and quantity, estuary restoration, and invasive species impacts on our natural environment are all scientifically relevant matters facing Congress today. In order to make informed decisions, policymakers must work with scientists to arrive at positive and constructive solutions. We must harness the best that science has to offer.

During the past three years, this lecture series has focused on a number of pressing environmental issues. At the inau-





gural John Chafee lecture in 2001, the Council invited Nobel Prize laureates Sherwood Rowland and Mario Molina to discuss their startling discovery of the ozone hole over Antarctica and the dramatic difference scientific knowledge had to bear in ushering in the Montreal Protocol. During their lecture, Rowland and Molina described the scientific and political process by which they raised the link between human-produced chlorofluorocarbons (CFCs) and depletion of the ozone layer as an urgent global issue. That evening, Molina stated:

Isn't it a responsibility of scientists, if you believe that you have found something that can affect the environment, isn't it your responsibility to actually do something about it, enough so that action actually takes place? There was nobody else at that time that would actually fulfill that role. So that's why Sherry [Rowland] and I, pretty consciously then, decided to take that additional step to make sure the government would actually pay attention.


In further explaining the important nexus between science and policy, Rowland touched on the economic implications of environmental decisionmaking, such as those of banning CFCs worldwide:

The value of the CFCs produced in 1974 was about \$2 billion, and the industrial efforts that depended upon that were estimated at \$200 billion by the industry. So they did not exactly leap to follow our suggestion that they quit putting it into the atmosphere.

Molina follows by making an important comparison between the scientific knowledge and international efforts to ban CFCs through the Montreal Protocol with the current understanding of carbon dioxide and climate change impacts. By showing a graph of the skyrocketing carbon dioxide levels in the atmosphere since 1958, Molina states:

These are historic measurements that show another situation similar to CFCs; namely, in steady increases over time in the concentration of carbon dioxide in Earth's atmosphere, clearly attributable to human

These lectures have been invaluable for contributing to our knowledge of environmental issues, and for serving as a catalyst for scientists and policymakers to reach common ground on national and global environmental challenges.



activities. This increase, of course, has consequences for the climate. There are indeed some scientific uncertainties about how our climate system will respond, but the measurements are there, and changes are under way.

In 2002, at the second John Chafee lecture series, the world renowned biologist E.O. Wilson spoke on the topic of biodiversity and the challenges we as humans face in preserving our natural systems in order to slow the effects of human influences on worldwide biodiversity loss. In his lecture, Wilson states:

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 the 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.

These words remain with us today, particularly as we face continuing challenges for protecting our remaining ecosystems and reducing species loss through habitat preservation, both domestically and internationally.

Last year, National Science Foundation Director Rita Colwell spoke about the importance of environmental research and environmental education at all levels for guiding our environmental future. She stressed the importance of knowledge in science and technology for understanding the vulnerabilities of our natural systems by stating:

Today, and for the far future, the well-being of individuals and of the nation will depend on knowledge and skills in science, engineering, and technology. How well we prepare each of our citizens in these areas will determine how well we are prepared as a nation to confront the obstinate environmental issues that we face in this new century.

In totality, these past lectures have been invaluable for contributing to our knowledge of environmental issues, and for serving as a catalyst for scientists and policymakers to reach common ground on national and global environmental challenges. Tonight, Professor Jared Diamond will add to our understanding of sustainability by speaking about the world's historic societies, and links between societal collapses and environmental constraints.

Once again, I thank the Council for its important role in improving our scientific knowledge of environmental issues, and I look forward to tonight's lecture.

INTRODUCTION

STEPHEN P. HUBBELL

It is a great pleasure to introduce our distinguished guest, Professor Jared Diamond. I've known Jared as a personal friend and colleague for more than 20 years. He is a scientific hero of mine because I've always admired, but never quite mastered, the marriage of rigorous science with public outreach and scientific writing for the public. Jared is the master of this, so much so that, in some sense, he is probably acclaimed more for his public writing than his science. His works are translated into 23 languages.

Too few scientists take this route of connecting their science to the public. This is one of the things NCSE does and encourages its partners to do. Yet there is something that separates Jared from other scientists who write for the public. This is the originality of his scholarship and his remarkable ability to synthesize many different disciplines in his writings while remaining accessible to a very broad audience.

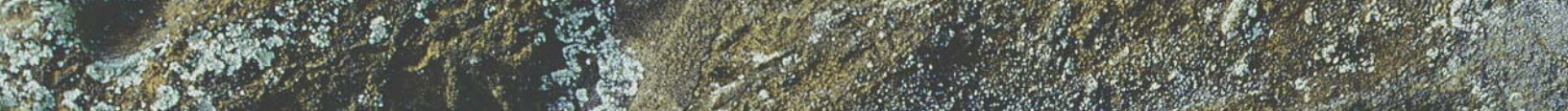
Jared has many achievements, but in my opinion the most dazzling is his book *Guns, Germs, and Steel: The Fates of Human Societies*. This is the book that won him the Pulitzer

Prize. It also won him the Cosmos Prize, which is Japan's equivalent of the Nobel Prize. He has also received the National Medal of Science, which is the highest scientific honor in this country.

Guns, Germs, and Steel is awesome because it proposes a radical change in the Western view of civilization and the history of mankind. It basically proposes that the diversity of cultures arose largely from geography and from historical accidents of where animals and plants could be domesticated, rather than from some hegemony associated with harder work or better brainpower of the West.

He came to these insights from his long and deep personal experience





in Polynesia. Early on, he puzzled over the fact that so many of these societies seem to be so different, yet they had a common ancestral society that was only a few thousand years old. By examining these cultures, he came to realize that they had very different ecological resources to exploit and that this was largely the explanation for the differences between these cultures. He then developed this into a comprehensive ecological theory of history, which says that the study of history needs to be deeply and fundamentally infused with science, particularly with ecology and evolutionary biology, but also with the earth sciences. With this he has completely remade the landscape of history.

This book is probably one of the top books of the last century, if not of all time. I urge you to read it if you have not yet done so.

The book also questions the excesses of Western materialism. It opens with a New Guinea aboriginal friend asking Jared, “Why do Westerners have so much cargo?” A friend of mine once observed that life is about stuff. My wife has a good friend who has been traveling in India. She is very proud of the fact that she travels light. One time she was packing her bag in a hotel in Delhi when a barefoot maid came in and saw that she was traveling with one pair of walking shoes and a pair of flip flops for the shower. The maid looked at the shoes and said, “Ma’am, why do you have four shoes? You only have two feet.”

Tonight Jared is going to tell us about his forthcoming book, the sequel to *Guns, Germs, and Steel*. He will speak about lessons from environmental collapses of past societies. Please welcome Professor Jared M. Diamond, the 4th Annual John H. Chafee Memorial Lecturer.

Diamond theorizes that the study of history needs to be deeply and fundamentally infused with science, particularly with ecology and evolutionary biology, but also with the earth sciences.



THE JOHN H. CHAFEE MEMORIAL LECTURE

LESSONS FROM
ENVIRONMENTAL COLLAPSES
OF PAST SOCIETIES

Dr. Jared M. Diamond

University of California, Los Angeles

It's a great pleasure and honor to be with you this evening, among admired old friends and new friends, to present the Fourth Annual John H. Chafee Memorial Lecture on Science and the Environment, sponsored by the National Council for Science and the Environment. I have at least three associations with this occasion.

First is a personal association with Steve Hubbell, whom I met 20 years ago, when his recent great book was still just a germ of an idea and being worked out in its early stages. Steve and I share a passion for biogeography. Second, the National Council is dedicated to improving the scientific basis for environmental decisionmaking, and that's the area to which I've



EASTER ISLAND PHOTOS COURTESY RANDALL D. SNODGRASS

devoted much of my own time and efforts over the last two dozen years. Finally, John Chafee dedicated himself to translating environmental science into public policy.

I also feel another, much more specific, bond with John Chafee and with his legacy, although I did not know him personally. It's a bond that may seem strange to those of you born after 1945. Both John Chafee and I spent intense, fascinating, formative months of our lives in the jungles of the southwest Pacific island of Guadalcanal in the Solomon Islands. I was in those jungles in 1974 and 1976, studying birds. John Chafee was there during World War II, in 1942, and he was not studying birds. I found the jungles of Guadalcanal difficult enough to get around in, even though nobody was shooting at me. John Chafee must have found those jungles even more difficult, because people were shooting at him. I was only 5 years old when John Chafee landed on Guadalcanal, but the images of the Guadalcanal campaign that came to me through the newspapers and radio formed my fantasy life and the fantasy life of my schoolmates as we were growing up. Thirty-two years later, I, too, found my firsthand experience of those jungles unforgettable. When my wife and I were planning our wedding and wanted to pick a wedding date that had extra meaning, we chose to be married on the 40th anniversary of the American recapture of Henderson Airfield on Guadalcanal in 1942.

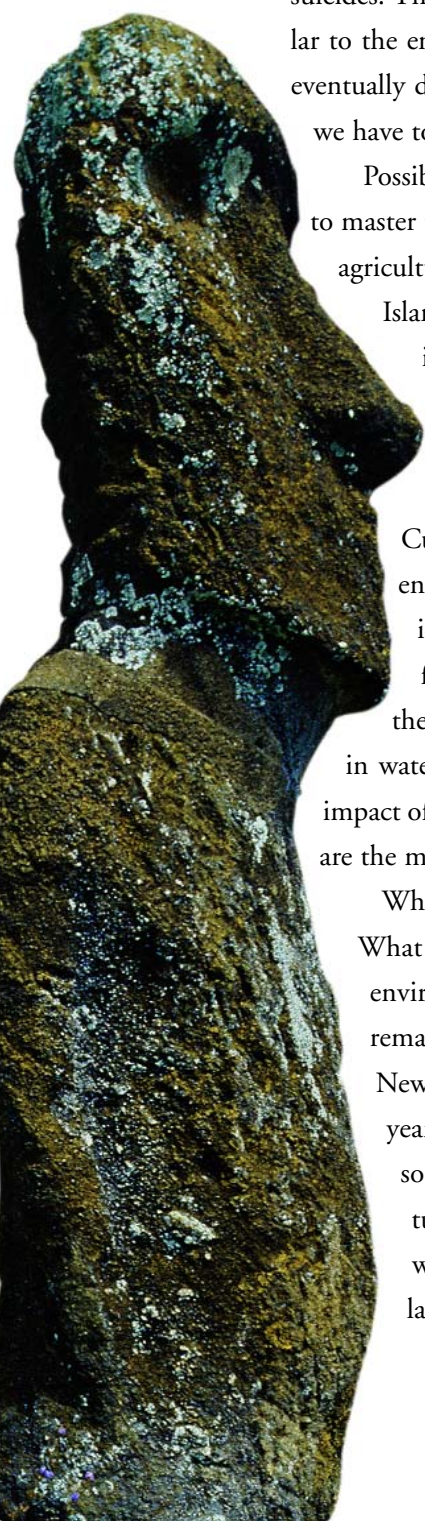
I'd like to tell you this evening about an area in which both the natural sciences and the social sciences can inform public policy. It's the area of my next book, which should be published in January 2005. The book took off from a mystery, the mystery of ancient civilizations that collapsed — like Angkor Wat and the Maya cities — leaving behind abandoned monuments. By collapse of a society, I mean a drastic decrease in human population numbers and/or in political, economic, and social complexity over a large area for a long time.

Why do societies collapse? That question presents a romantic mystery, but it also presents the big intellectual and scientific problem of why some societies collapsed, while others did not. Even more than being a romantic mystery and an intellectual and scientific problem, it's an important problem of public policy. There is overwhelming recent evidence from archeology and other disciplines that some mysterious collapses consisted of self-inflicted ecological suicides. These were a result of human impacts on the environment, causing problems similar to the environmental problems that we face today, even though those past societies that eventually did collapse had far fewer people and far less potent destructive technology than we have today.

Possible cases of societies that destroyed themselves in the past because of an inability to master their environmental problems include the societies of the Fertile Crescent, where agriculture and metal tools arose, Mycenaean Greece, Easter Island and some other Pacific Islands, the Western Roman Empire, Classic Lowland Maya civilization, the Anasazi in our Southwest, Angkor Wat in Cambodia, Great Zimbabwe in Africa, Cahokia near modern St. Louis, Norse Greenland, Harappan Indus Valley civilization, and so on.

These collapses are relevant to the environmental problems that we face today. Current environmental problems include the water problems on which this conference is focusing, and also problems of deforestation, the impending end of the tropical rain forests, overfishing, soil erosion, soil salinization, global climate change, full utilization of the world's fresh water supplies, our approach to a photosynthetic ceiling, exhaustion of cheap energy resources, accumulation of toxic chemicals in water, food, and soil, increase in human population, and increase in the per capita impact of our population. Many of those factors are what destroyed past societies, and they are the main threats to us today.

What can the past teach us about why some societies are more unstable than others? What can the past teach us about how some societies did succeed in overcoming their environmental problems? Of course, there are societies that did not collapse, and that remained intact over a long time, such as Japan, Tikopia Island, Tonga Island, and the New Guinea highlands. Human society has been going on there for thousands of years without any signs of an environmental collapse. What is it, then, that makes some societies more fragile than others? Is it that some societies have the misfortune to occupy fragile environments, or is it instead that the societies themselves were organized in a non-adaptive way, or do both of those factors explain the collapses or successes?



Environmental problems don't exist in isolation. They interact with climate change, for example. If a society is hammering its environment, it may be able to get away with it as long as the climate is in its favor, but the society may collapse when the climate gets cold or hot or dry or wet.

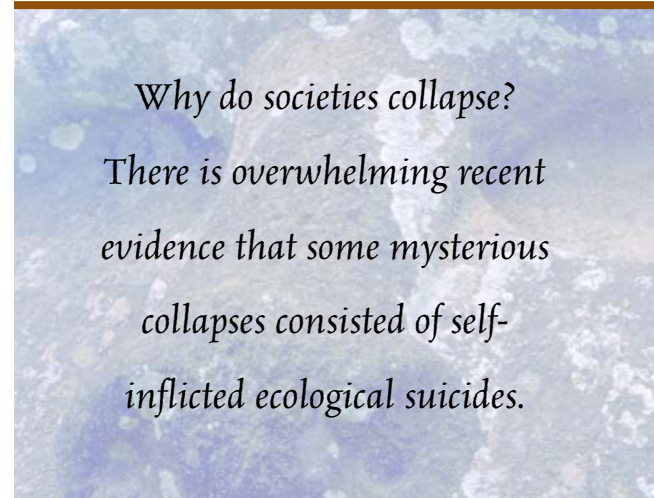
Environmental problems also interact with trade with friendly neighbors. A society may depend for support on friendly neighbors, and so it may collapse if the neighbors collapse from their own environmental problems. Think of the 1973 Gulf oil crisis and its risk to us.

Societies also face problems with attacks by hostile neighbors. If a society is weakened by its own environmental problems, then hostile neighbors may use the opportunity to step in and destroy a society that previously had been strong enough to oppose them. For example, there has been a long-standing argument whether the fall of the Western Roman Empire was really caused by hostile barbarians or whether those barbarians just dealt the final blow to a Rome weakened by internal factors.

Finally, there's the question of a society's responses. When a society is facing environmental problems, what are the political, economic, social, and cultural reasons that enable some societies to solve their problems and that prevent other societies from solving them?

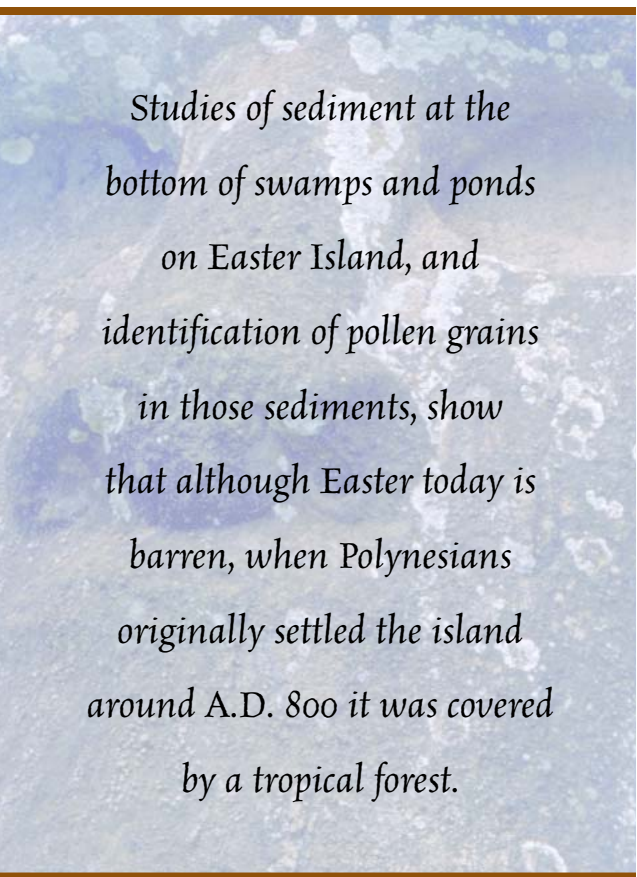
This evening I'm going to talk only about deforestation, which is really just one of the 12 major environmental threats that we face today. There will be four parts to my talk. First, I'll give you an example of a society that did collapse because of inadvertent deforestation: Easter Island in the Pacific Ocean. Then I'll talk about the natural science aspect of the collapse. Why is it that Easter Island was extreme among Pacific Islands? Third, I'll talk about the social science aspect of this. Why is it that Easter Islanders, and only some other societies, made mistakes? Finally, I'll talk about policy outcomes as regards forestry management in the modern world.

Let's start with Easter Island. It's a remarkable place, but not many of us have been there because Easter Island is the most remote habitable scrap of land in the world. It's an island in the southeastern Pacific Ocean, 2,300 miles west of the coast of Peru, and 1,300 miles east of Pitcairn and Henderson Island. It's a very isolated human society in a fragile environment. Easter Island is relatively dry, receiving only 40 inches of rain per year, and as I'll also explain to you, that's only one of Easter's problems.



Why do societies collapse?

There is overwhelming recent evidence that some mysterious collapses consisted of self-inflicted ecological suicides.



Studies of sediment at the bottom of swamps and ponds on Easter Island, and identification of pollen grains in those sediments, show that although Easter today is barren, when Polynesians originally settled the island around A.D. 800 it was covered by a tropical forest.

Easter is best known for the famous mystery of its giant stone statues. These statues on average weigh 12 tons but can be as heavy as 270 tons. They average 10 or 15 feet tall. The biggest one erected was 32 feet tall, and there was one of 70 feet, the height of a five-story building, that was not successfully erected. Those gigantic stone statues were transported as far as nine miles from the quarries where they were carved. All this was done by Polynesians with only stone tools — no metal tools, no draft animals, no domestic animals other than chickens, no wheels — and only human muscle power.

It's been a mystery for a long time: how and why did the islanders carve and erect the statues? When Europeans discovered Easter Island in 1722, the islanders themselves were in the process of pulling down and breaking those statues that their ancestors had erected with such enormous effort. So, who erected them, how, and why did they then tear them down?

The ecological origins of the collapse of Easter Island society became clear beginning 20 years ago, through studies by paleobotanists. Easter is barren today. There are no native trees on Easter Island more than seven feet tall. That was

something that already puzzled the first European to visit Easter, the Dutch navigator Jakob Roggeveen, who arrived there in 1722 on Easter Day and saw these gigantic statues. He wrote in his diary that, to transport and erect them, the islanders must have required wood and rope, but there were no trees to provide the wood and rope. Where were the necessary trees?

Today the only trees belong to exotic species brought in during the 20th century. But studies of sediment at the bottom of swamps and ponds on Easter Island, and identification of pollen grains in those sediments, show that when Polynesians originally settled the island around A.D. 800 it was covered by a tropical forest. There were at least two dozen species of trees, including a relative of the Chilean wine palm that was formerly the world's largest palm tree. The Chilean wine palm is now the largest living palm tree at three feet in diameter, but the Easter Island palm could reach seven feet in diameter and at least 65 feet tall.

The island today also has no native land birds whatsoever. There is only one sea bird that breeds on Easter Island itself. But, again, studies of the bones of birds in archeological deposits show that Easter Island used to have at least six species of native land birds, including parrots and rails and owls, and at least 25 breeding sea bird species.

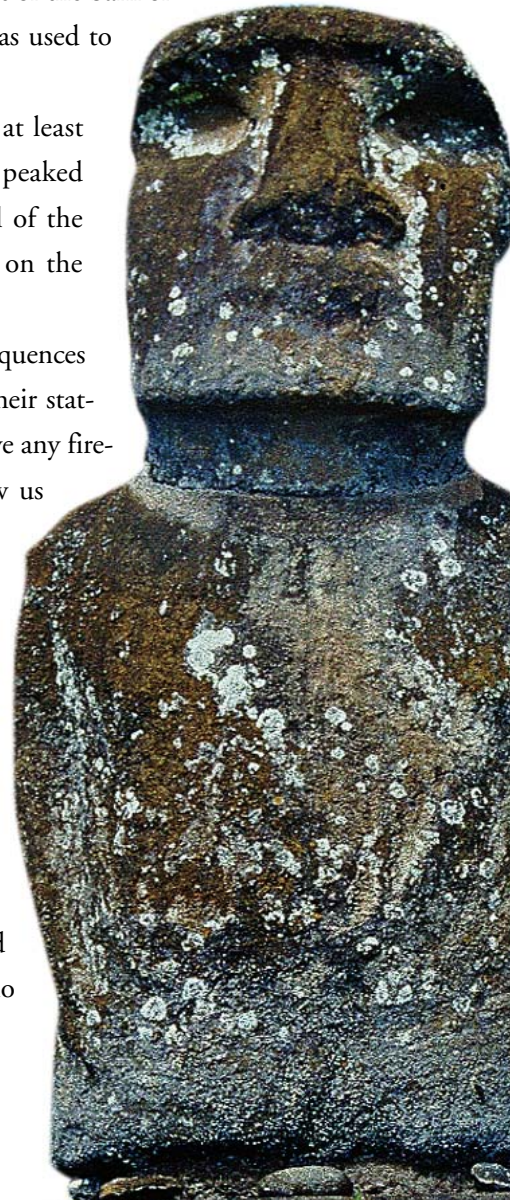
After Polynesians settled the island in A.D. 800, they of course began to clear the forest for a number of reasons. They cleared the forest for gardens because they were farmers. They cleared the forest for firewood, and for big logs out of which to make their dugout canoes to go fishing. Evidence of those ocean-going canoes that they must have had lies in the fact that, in the bone deposits in early Easter Island middens, the most common food item was dolphins. Yet dolphins don't come close to the shore of Easter Island. In order to catch or harpoon dolphins, the islanders would have had to go far offshore in dugout canoes. This is the only Pacific Island diet in which dolphins played a big role.

People also hunted the land birds, hunted the sea birds, and ate the fruit of the palm trees. The palm trees were also used to transport the statues. Statues were transported on prepared roads with wooden crossbeams and then dragged over the roads. Then, logs from the now-extinct forest were used to lever the statues into a vertical position. The forest thus was necessary for providing the beams to transport and erect the statues. Also, out of the bark of one of the species of trees, Easter Islanders obtained natural rope that was used to drag the sleds on which these statues were mounted.

The population grew after settlement in A.D. 800 until it reached at least 15,000, maybe 30,000 people. By the time that Easter's population peaked around 1620, all of the trees had been cut down and were extinct. All of the land birds were extinct, and only one of the sea bird species was left on the island itself.

The elimination of the forest, and also of the birds, had practical consequences for the islanders. Without trees they could no longer transport or erect their statues. The last statue was put up around 1620. Without trees they didn't have any firewood, except for agricultural wastes. Again, archeological middens show us that, early on, the islanders were burning charcoal from the native trees, but at the end of the archeological sequence they were reduced to burning sugar cane scraps. Without trees, they lacked mulch and other fertilizers to fertilize their gardens, and so agricultural yields for their crops decreased. Without trees they had no canoes, so they couldn't go out to sea to hunt dolphins. By then, they had hunted the last of the sea birds.

Around 1680, according to Easter Island oral tradition, there was a revolution. Until then, Easter Island had been a chiefdom with a paramount chief, and the chiefs claimed a connection to the gods by divine descent. They thereby claimed the ability to bring prosperity, crops, and rain. When the chiefs, because of the destruction of the forest, were no



longer able to bring prosperity, and people started starving, there was a revolt. The chiefs were overthrown, and a new caste of military leaders took over.

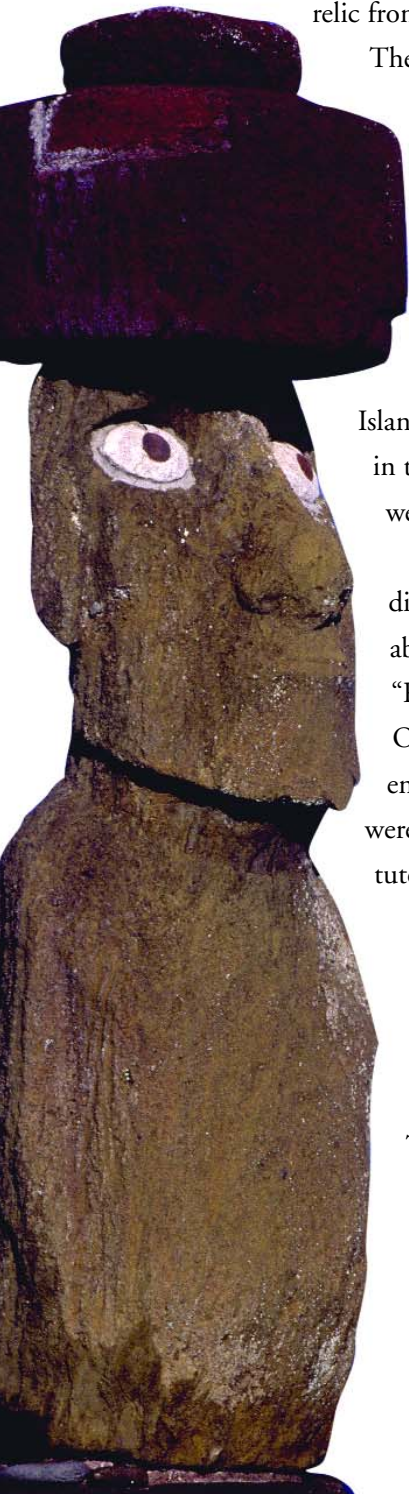
With the end of availability of dolphins as the largest animal edible on Easter Island, Easter Islanders turned to the next largest animal available to them: humans. Easter Island society collapsed in an epidemic of cannibalism. Traditionally, the worst insult that you could say to an Easter Islander was, “The flesh of your mother sticks between my teeth.” That’s a relic from that cannibal era.

There was then a population crash. Between 70 and 90 percent of the population died out. And after the crash there was no possibility of rebuilding the society, because the trees and the soil fertility that were the society’s basis had been undone.

While there are other past societies that destroyed themselves, I have found that the story of Easter Island grabs my students and readers more than that of any other society, because the metaphor is so clear. Easter Island was isolated in the Pacific Ocean. Once the trees were cut down and people had no more canoes, they couldn’t escape — there was nowhere to go when they got into trouble. Easter Island was so remote that there was nobody to come help them. Easter Island isolated in the Pacific Ocean is seen as a metaphor for Planet Earth isolated in the universe. If we too get into trouble, there’s no place we can go, and nobody will come to help us.

I keep saying to myself, somebody must have cut down the last palm tree. What did the Easter Islander who cut down the last palm tree say? Did he shout, “What about our jobs? Do you care more for trees than for people?” Or maybe he said, “Respect private property rights! Get the big government of the chiefs off our backs.” Or, perhaps that last islander said, “You predict environmental disaster, but your environmental models are untested. We need more research.” Or, perhaps his words were, “Never fear, technology will solve our problems somehow. We shall find substitutes for wood.”

There were, however, thousands of other Pacific islands besides Easter Island. Why was it Easter that was the site of the worst population crash? And why was it one of the worst examples of deforestation in the Pacific? Those thousands of Pacific Islands began to be settled by humans around 1200 B.C., and the last of them, New Zealand, was settled around A.D. 1200. Out of those thousands of islands occupied by people, the only ones that approached Easter in its degree of deforestation were Nihoa in the Hawaiian group, where one



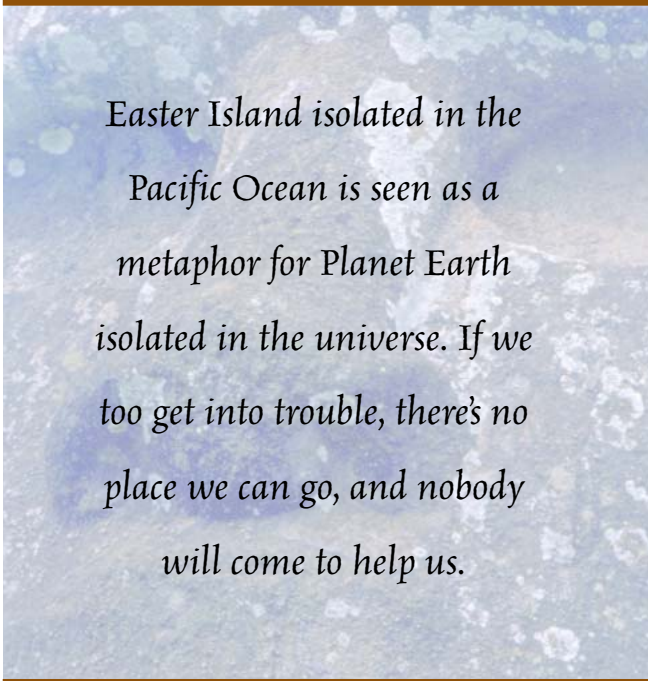
palm species survived, and Necker in the Hawaiian group, where no trees survived. Those three islands, then, were virtually deforested.

Other Pacific islands that were largely but not completely deforested included Mangareva, most of the Cook and Austral islands, and the leeward sides of the big Hawaiian and Fijian islands. Then there were Pacific islands where primary forest remained at high elevation and where there were secondary forests and grasslands and ferns at low elevation. That was the case in the Societies, Marquesas, and the windward sides of the big Hawaiian and Fijian islands. Finally, there were Pacific islands that even on European arrival were still largely covered with forest, such as Tonga, Samoa, Makatea, the wet side of New Zealand's South Island, and most of the Bismarck and Solomon islands.

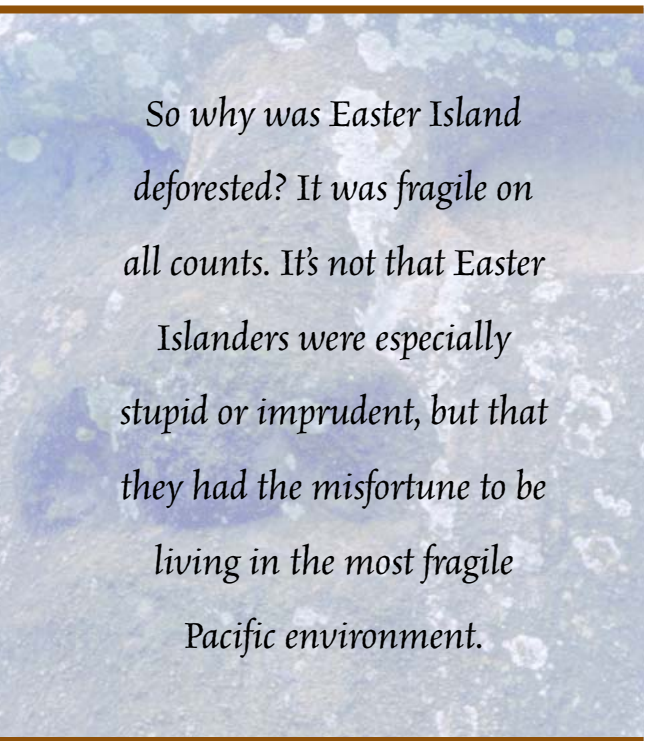
Why all this variation? Why did some islands get completely deforested, some largely deforested, some partly deforested, and some barely deforested at all?

I've been collaborating for the past couple of years with the archeologist Barry Rolett at the University of Hawaii. Barry assembled a wonderful database from the logs of early explorers and European visitors. He tabulated the forest cover at the time of European contact on 81 Pacific Islands, representing the outcome of deforestation before European arrival. We also tabulated nine physical variables that we thought might be connected to the degree of deforestation, in order to understand the environmental factors underlying fragility. Then we did statistical analyses of our 81 data points and our nine independent variables. We did correlation analysis, multiple regression, residual analysis, and tree analysis.

We correctly anticipated six environmental variables whose variation among Pacific Islands we thought would be predictive of deforestation. The two most important, as we expected, were rainfall and latitude. You might expect that on a wet island when you chop down trees, new trees will grow up quickly, so the forest may reach a steady state of re-growth against logging. The other most important variable governing plant re-growth besides rainfall is temperature. Trees grow faster on a hot island, like New Guinea, than on a cold island, like New Zealand's South Island or Easter Island. A conclusion of our statistical analysis was thus that the degree of deforestation increased with decreasing rainfall and increased with latitude, meaning as it got colder.



Easter Island isolated in the Pacific Ocean is seen as a metaphor for Planet Earth isolated in the universe. If we too get into trouble, there's no place we can go, and nobody will come to help us.



So why was Easter Island deforested? It was fragile on all counts. It's not that Easter Islanders were especially stupid or imprudent, but that they had the misfortune to be living in the most fragile Pacific environment.

Four other effects we also anticipated correctly. We anticipated that higher-elevation islands would be less deforested than low islands, for a number of reasons. High islands produce what is called orographic rain, which comes down to the lowlands as streams, carrying nutrients and dust. We expected that remote islands would be more deforested than islands with neighboring islands, because remote islands didn't have any escape valve where any human population surplus could bleed itself off. We anticipated that big islands would end up less deforested than little islands, again, for a number of reasons, such as that it takes more time to chop down the forest on a big island, that a big island has a higher area-to-perimeter ratio and so lower human population densities and less impact, and a big island is more likely to have some areas unsuitable for gardens. A sixth variable that we predicted correctly was the presence of a coral terrain called makatea, which is just

awful to get around in, razor sharp, and hard to log, and we were right in anticipating that makatea islands would end up less deforested.

There were also environmental variables predictive of deforestation that we hadn't anticipated. One is island age. Older islands ended up more deforested than young islands, and the reason is that these Pacific Islands are volcanic, and the older the island and the longer the time since the last volcanic activity, the more time there's been for rain to leach the nutrients out of the soil. Low nutrient levels in the soil may then become rate-limiting for regrowth of vegetation.

Another surprise to us was what happened on islands west of what geologists call the Andesite Line of the Pacific. Volcanoes west of that line blow out ash that can be carried in the winds for a thousand miles, while islands east of the line, such as the Hawaiian Islands, don't blow out ash but produce lava, which is not carried in the wind. West of the Andesite Line, ash from volcanoes can get carried for long distances and restore soil fertility, even on old islands. Our observation was that islands west of or near the Andesite Line therefore got less deforested than islands far east of the Andesite Line, because of higher soil fertility.

The final surprise was that dust fallout from Central Asia was the ninth predictor. From the steppes of Central Asia, dust is carried up into the atmosphere and is blown east across the

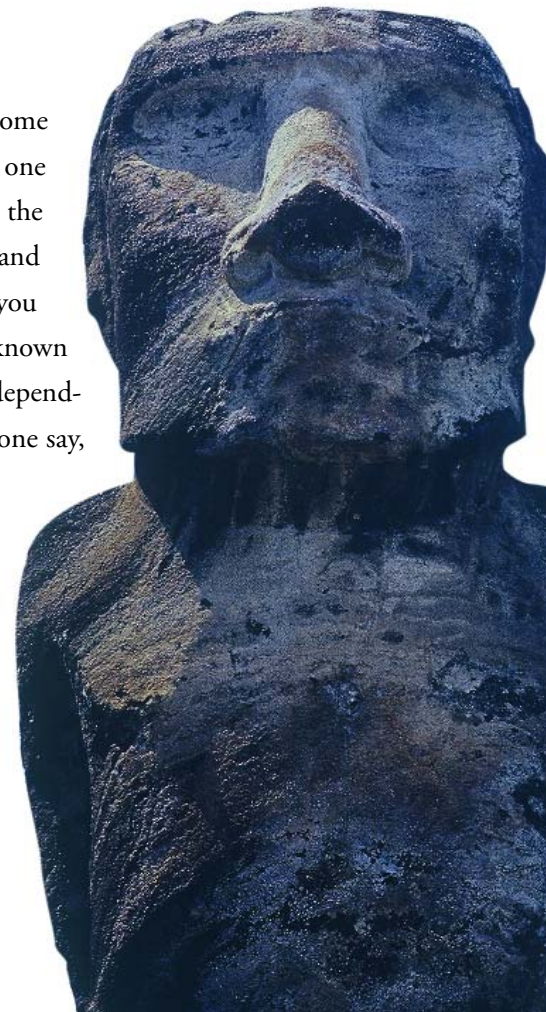
Pacific. The further east you get in the Pacific, the cleaner the air gets because more dust has fallen out. So the least dust fallout in the Pacific is on the easternmost of the Polynesian islands, Easter Island. Deforestation then increases, going eastwards, in part because of decreasing dust fallout.

Those then were the nine predictive variables, the nine environmental risk factors, for deforestation. So why was Easter Island deforested? It was fragile on all nine counts. It's not that Easter Islanders were especially stupid or imprudent, but that they had the misfortune to be living in the most fragile Pacific environment. Easter Island has the third highest latitude of Polynesian islands. It has the lowest ash fallout because it's furthest from the Andesite Line. It has the lowest Asian dust fallout, the second greatest isolation, it's a relatively dry island, somewhat low in elevation, somewhat small in area, and the island is a mosaic of an old volcano and a younger volcano. The old volcano of Easter got deforested first. Easter Island has none of the awful makatea terrain to act as a refuge for forest.

Thus, the Easter Islanders had the decks stacked against them. Those are the environmental factors predicting deforestation in the Pacific. When you put those nine factors back into our regression equations, the equations predict correctly that the worst deforestation in the Pacific should be on Easter, Nihoa (the island with one palm tree left), and Necker Island.

So, one can draw on the natural sciences to understand why some environments are more fragile than other environments. But one has to ask, why does a society make mistakes? One can draw on the social sciences to try to understand why some people make mistakes and others don't. As the Easter Islanders were cutting down the forest, you would think that the chiefs and the people themselves would have known perfectly well that they were cutting down the forests on which they depended for firewood and to transport statues and canoes. Why didn't someone say, "Stop it!"? That was a failure of group decisionmaking.

There are lots of other examples of such failures. There were two interesting episodes of group decisionmaking by President Kennedy and his advisors. Their group decisionmaking at the time of the Bay of Pigs was disastrous. After the Bay of Pigs, Kennedy brought together a group of advisors to figure out not only what specifically had gone wrong at Bay of Pigs, but also what had gone wrong with his decisionmaking, and he changed the decisionmaking process so



that at the time of the Cuban missile crisis, the thinking and the group decisionmaking were different, with a happier outcome.

Another disaster of group decisionmaking was the introduction of rabbits into Australia. Can you believe that Australians intentionally introduced rabbits? In fact, it took them five tries, since the rabbits went extinct after the first four tries. Rabbits today consume half of the pasture vegetation of Australia.

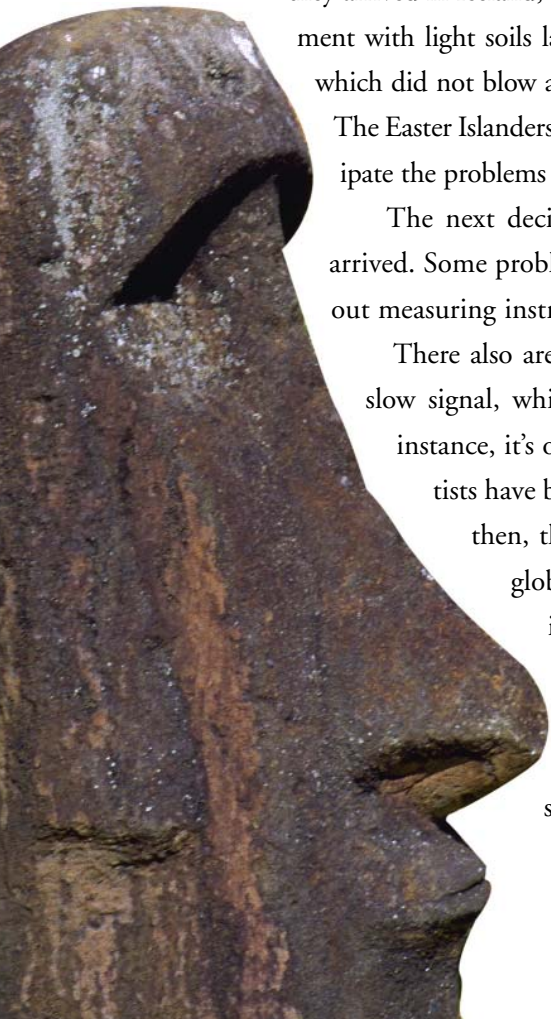
Many societies, including ours today, overfish. Why do we make these mistakes? As another example, consider the looting of American businesses by their CEOs in recent years. Why do the businesses do this? Why does American society set itself up in a way that this is possible? It's a problem in the social sciences, why groups end up making decisions that are disastrous for the group.

I've arrived at a hierarchy, a sequence of four decision points, that may result in good or bad decisionmaking. The first decision point is whether or not a society anticipates a problem. A society or a group may fail to anticipate a problem before the problem appears, especially if they've had no prior relevant experience of such problems. Australians introduced rabbits because they didn't know the bad things that introduced animals could do. Similarly, the Vikings, when they arrived in Iceland, ended up deforesting Iceland because they were not used to an environment with light soils laid down by volcanoes. They were used to the heavy soils of Norway, which did not blow away, so they could not anticipate problems of deforestation in Iceland. The Easter Islanders came from wet, high, equatorial islands, and they were not able to anticipate the problems of dry, low, high-latitude islands.

The next decision point is failure to perceive a problem when the problem has arrived. Some problems are literally imperceptible. You can't see salinization of soil without measuring instruments. Leaching of soil nutrients in Australia, again, was invisible.

There also are problems that are virtually invisible because they involve a small or slow signal, which gets buried in lots of up-and-down noise and fluctuations. For instance, it's only within the last few years that most previously unconvinced scientists have been willing to admit that global warming is a real phenomenon. Until then, there were legitimate grounds for doubt whether, given the wiggles of global temperature up and down each year, we would need a longer record in order to convince ourselves that global warming is real. Our current President still is not convinced.

A third reason why a group may fail to solve a problem, even when it has perceived the problem, is that it may not even try to solve the problem because of what's called rational behavior on the part



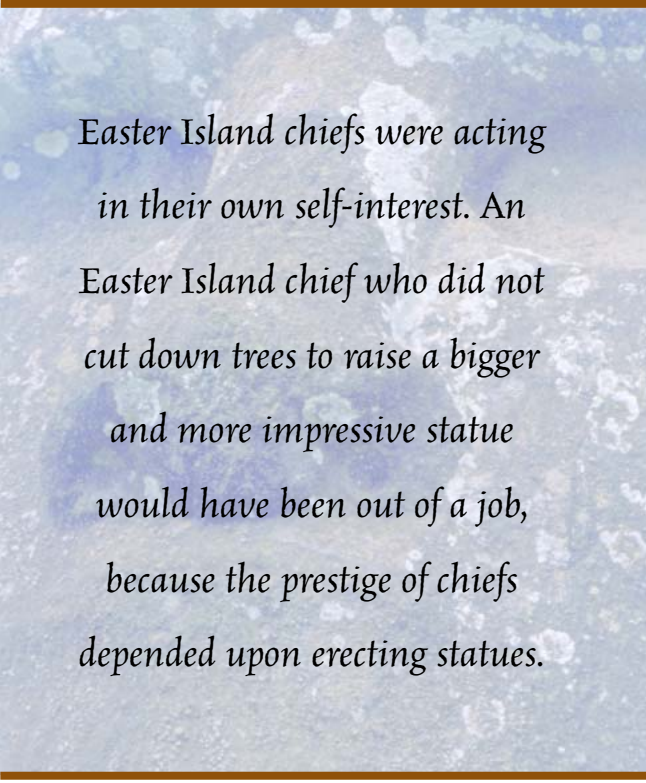
of a group — that's to say clashes of interest. This behavior was especially surprising to me, but it turns out to be common. One such example of a clash of interest is the so-called tragedy of the commons, i.e., the overfishing or overharvesting of a common resource. This problem of clashes of interest is especially frequent where there is a decision-making elite that is able to insulate itself from the consequences of its action. It is then correct strategy, at least in the short-term, for the elite to loot the coffers and to take everything for themselves, even though it may in the long run be bad for their own great-grandchildren. The executives of Enron perceived quite correctly what was in their own self-interest.

Similarly, Easter Island chiefs were acting in their own self-interest. An Easter Island chief who did not cut down trees to raise a bigger and more impressive statue would have been out of a job, because the prestige of chiefs depended upon erecting statues. Similarly, the Maya kings who got into problems with deforestation were acting in their own self-interests for prestige, although in the long run it was disastrous for their kingdoms.

In addition to clashes of interest there may be clashes of values. For instance, religious values were part of the reason behind the collapse of Easter Island and Norse Greenland society. In the American West the frontier values associated with logging, mining, and ranching made sense in the 19th century, but those frontier values no longer make sense in many cases today. It's hard for people to stop doing something that is intimately tied to their strongest held values.

Finally, a society may fail to solve a problem because some problems are just too difficult to solve, given available technology. In California we have not figured out how to eliminate introduced agricultural pests like Mediterranean fruit flies, nor have we come up with a cost-effective solution for the forest fire problem in the American West.

Thus, when we try to understand the collapse of Easter Island society, there is a body of information from the natural sciences that we can draw on that helps us understand why some environments are more fragile than others. Some people are dealt a tougher deck of cards than others. We can also draw on the social sciences to understand group dynamics, and to understand why some groups solve their problems and why other groups are less likely to solve their problems.



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It turns out that there are lots of people who care about environmental issues and who are willing to pay a premium for forestry products that have been credibly certified as having been obtained in a sustainable way.

The last thing that I want to talk about today has to do with policy implications. Given the problems of deforestation in the past dragging down societies, what can we do today to avoid modern society getting dragged down by deforestation?

Today, much deforestation is in the hands of large logging companies — big businesses. When one thinks of big businesses, it's easy to get depressed and to feel impotent. There are lots of bad things that big businesses do. You can read the newspaper any day and see examples. As individuals we may feel helpless confronted with a corporation with a capitalization of \$450 billion. What can we do if that corporation sets its mind to doing something?

Well, the fact is that corporations usually try to act in their own self-interests. Some corporations have realized that it's in their interests to have sound environmental policies, and others have not. But in the forestry sector and in some other sectors, corporations that do practice sound

environmental policies still can have an image problem. Most of us are so disillusioned with big businesses that, if a large company like an international oil company says, "We love the environment and we take good care of it," and they put an advertisement in *The New York Times* saying that, none of us will believe it. Within the last few decades, it was first the oil companies and then some logging companies that recognized that they had a credibility problem, and some fisheries and a few mining companies have been coming around to the same point of view. That is, some large businesses have recognized that there are economic costs to the company, as well as to society as a whole, of destructive environmental practices.

I've spent a lot of time during the last four or five years talking to people — especially in the oil industry, and in the last year also to people in the mining industry — to try to find out their perception of their self-interest. They tell me that there have been wake-up calls. For the oil industry, wake-up calls included the Exxon *Valdez* accident, and, before that, the Santa Barbara oil spill, which warned oil companies that careless environmental practices may result in a \$4.5 billion accident. The Bhopal chemical spill served as a wake-up call to the chemical industry, as did the Buffalo Creek Dam collapse of 1972 to the coal mining industry. Belatedly, the closure of Papua New Guinea's Panguna copper mine and the resulting total loss of a huge capital investment served as a wake-up call to at least a couple of the

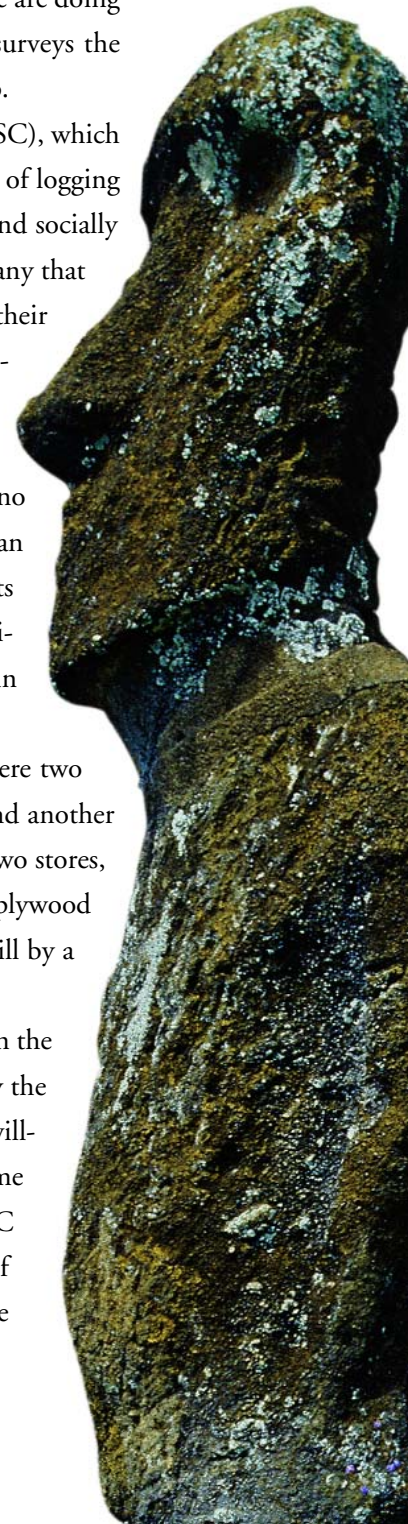
largest hard rock mining companies. ChevronTexaco, whose practices I've had much opportunity to observe in the last five years while doing bird surveys in the oil fields that they managed in Papua New Guinea, realized that it draws big economic advantages from clean environmental practices. But, how on earth are they going to convince the public?

The solution that's evolved in the last decade is what's called independent third-party certification. Namely, you don't have the loggers themselves say, "We love trees and we are doing sustainable logging." Instead, you set up an independent third-party body that surveys the logging operations independently to see whether the loggers are doing a clean job.

The first of these efforts that I'm aware of is the Forest Stewardship Council (FSC), which was launched as a joint collaboration between World Wildlife Fund and a number of logging interests in 1993. That council arrived at a set of 10 criteria for environmentally and socially sustainable logging. The FSC then certifies independent assessors. A logging company that wants to have a green reputation then asks such an assessor to come in to assess their operation. The loggers have to pay for the assessment, and the assessing bodies commonly don't say "yes" the first time. They may say, "No, you flunk." Or, they may say, "You've got to clean up this, this, and this, and, if you clean it up, we'll come back in a year and we'll reconsider." So the loggers pay for the assessment with no guarantee that they're going to get approved. If they get approved, though, they can put an FSC seal of approval on their logging products. It turns out that there are lots of people who care about environmental issues and who are willing to pay a premium for forestry products that have been credibly certified as having been obtained in a sustainable way.

An experiment was done in a couple of Home Depot stores in which there were two bins put next to each other. One bin contained some plywood with FSC labels, and another bin contained plywood of the same cost without the FSC label. This was done in two stores, one in a rural area, and the other in a liberal university town. The FSC-labeled plywood out-sold the non-labeled plywood by a factor of 11 to 1 in the liberal town, and still by a factor of nearly 2 to 1 in the rural area.

Then the experiment was repeated with the certified plywood costing more than the uncertified plywood. Not surprisingly, more people in both towns preferred to buy the cheaper plywood. The interesting thing is that one-third of all customers were still willing to pay more money for the certified plywood. That's the reason why Home Depot, the largest wholesaler of forestry products in the world, got behind the FSC movement and a couple of years ago made a decision over the course of the next half dozen years to phase out non-certified logging products. In addition, Lowe's and the

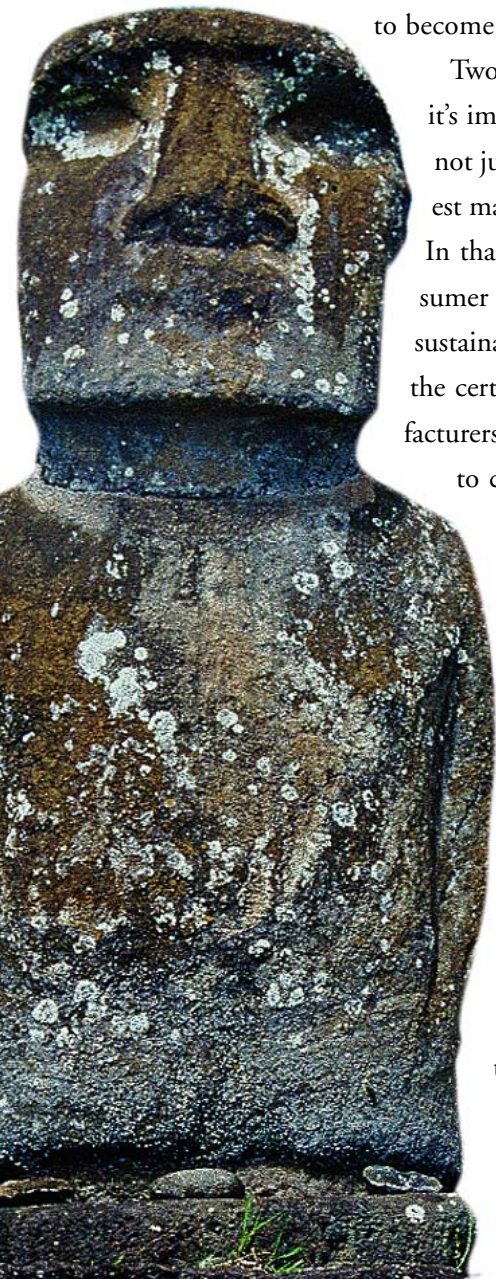


largest British supplier of forestry products have made a commitment, either now or gradually, to phase into using only certified products. That's not because they are being nice, but because they see consumer advantage to it.

After the Forestry Stewardship Council was set up, World Wildlife and the world's largest wholesaler of seafood products, Unilever in the U.K., set up a corresponding organization called the Marine Stewardship Council (MSC), to draw up criteria for sustainable fisheries. That began in 1998, and now among the large retailers that have committed themselves to certified fisheries products are Whole Foods in the United States, and Sainsbury's which is the second largest supermarket chain in Britain. Entire fisheries that are certified include the Alaska Salmon Fishery and the Australian Rock Lobster Fishery. It looks as if, on the near horizon, the West Coast Pollock Fishery, the largest fishery in the U.S., is going to become certified.

Two lessons were learned from this certification effort. The first lesson is that it's important to trace out the chain of custody. That's to say, what is certified is not just somebody's forest, because the logs from a cleanly managed certified forest may still get mixed in the sawmill with the logs from a dirtily managed forest. In that case, when the logs from that sawmill are made into furniture, the consumer in Home Depot would not have assurance that that furniture came from a sustainably managed forest. The essence of certification is chain of custody, to trace the certified products from the loggers to the wholesalers to the furniture manufacturers, and finally to a Home Depot store. Interestingly, once certification began to catch on, some industries then paid certification the ultimate compliment by setting up knockoffs of their own: their own so-called certification organizations, some of which involved self-certification. The logger says, I operate a clean operation. But these knockoffs set up by logging companies, without independent third-party assessment, do not trace through the chain of custody.

The other practical lesson that has come from these business certification efforts in the last decade has been the importance of identifying susceptible points in a supply chain on which the public can put pressure. Until I got into this area a half a dozen years ago, I had fantasies about marching in front of various stores to protest their practices. I wondered why consumers don't put pressure on the retailers. But I've been learning in the past year that you have to think carefully where you're going to put the pressure.



In the case of the big oil companies that extract the oil, many of them own the gas stations. When people were angry at the Exxon *Valdez* oil spill, they knew where to take out their anger: by not buying Exxon gasoline. Similarly, in the case of the coal industry, there are only one or two market steps between the coal mines and the consumers, which are the power generation plants. The public that becomes aware of a dirtily operated coal mine knows where to protest.

That's not the case in hard rock mining, logging, or fishing. There are up to nine steps between a hard rock mine and your buying the product in the store. We're learning the lesson that what consumers have to do is to find a large retailer that is sensitive to public pressure, or to locate business buyer groups that do care about their image, and to put pressure on them. We consumers can leave it to that large retailer or that buyer group to trace back the chain of nine steps, to figure out who made that dirty copper or the dirty timber, and to put pressure on the dirty producer.

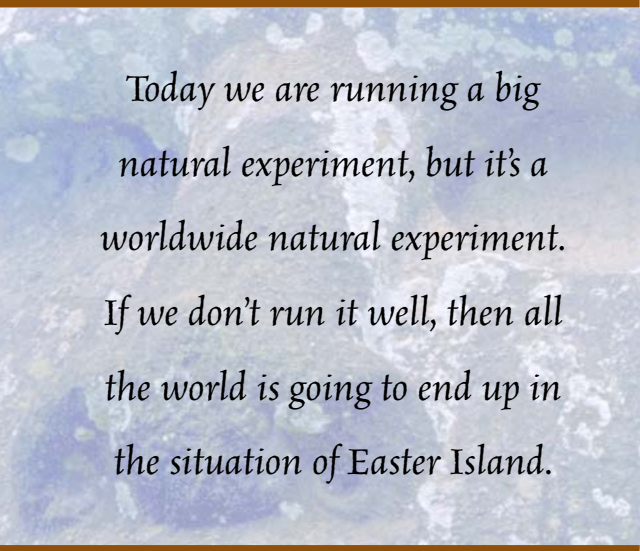
I'll give you a couple of examples. I don't have the faintest idea where the gold in my wedding ring was mined. There is no way that any of us with gold rings could know, because gold from different mines gets mixed and brought together, and it's stockpiled for up to 20 years. You can't know whether the gold in your wedding ring was mined this year from an especially filthy gold mine, or whether it came three years ago from one of the few gold mines with sound practices.

But Tiffany's jewelers, which is one of the major gold retailers in the United States, caught wind that there were going to be public protesters outside of their stores saying that their gold comes from gold mines that pollute rivers with cyanide. Tiffany's then decided that they were going to find out where their gold came from, and they were going to put pressure on the gold mines so that Tiffany's could then tell the public, "We get our gold from only clean sources." In effect, it was Tiffany's that did the work of tracing out the supply chain.

Another example is titanium. Until I got into this area within the last few months, I didn't have the faintest idea where titanium is used. It turns out that it's used not only in space vehicles, but also in many paints and in various metal surfaces that will operate at high tem-

What consumers have to do is find a large retailer that is sensitive to public pressure, and put pressure on them.

We consumers can leave it to that large retailer to figure out who made that dirty copper, and to put pressure on the dirty producer.



Today we are running a big natural experiment, but it's a worldwide natural experiment. If we don't run it well, then all the world is going to end up in the situation of Easter Island.

peratures. There have been titanium mines that operate in a very dirty way, but many of them are in Australia anyway, so I'm not in a position, and most American consumers aren't in a position, to protest against dirty Australian titanium mines.

But one of the major purchasers of titanium is Dupont, because Dupont uses titanium in its paints. Dupont puts its name on lots of its products. Dupont got wind of trouble brewing and did not want the public marching up and down in front of hardware stores, saying, "Don't buy Dupont paint because it buys titanium from filthy sources." It was Dupont that put pressure on the Australian titanium mines to clean up their act. Dupont

was able to trace where the titanium came from.

Again, once Home Depot caught on to the economic value of certification, it put pressure on loggers in Chile and in South Africa to clean up their act. Those loggers are remote from the American public, and we don't know about them and couldn't trace or influence them. Home Depot does have influence on them.

Finally, as far as fisheries are concerned, again, if it were not for the MSC label in seafood stores, I wouldn't know what fish in stores are harvested using long lines and other destructive techniques, and what fish come from fisheries that are managed sustainably. But Unilever, the large wholesaler, is subject to consumer pressure, as are Sainsbury's and Whole Foods, and so they were the ones who tracked down where the fish came from. They're the ones who were able to put pressure on the fisherman, nine steps removed from the supermarket, in a way that we consumers cannot.

In short, I'm interested in learning from history. I find history fascinating in its own right, but history also consists of lots of natural experiments, some of which ended badly, and some of which ended well. Today we are running a big natural experiment, but it's a worldwide natural experiment. If we don't run it well, then all the world is going to end up in the situation of Easter Island. We don't want to make mistakes. There are six and one-half billion of us today, whereas there were only 15,000 Easter Islanders. Today we have metal tools and nuclear power, whereas the Easter Islanders had only stone chisels, and so we have much more potent destructive technology.

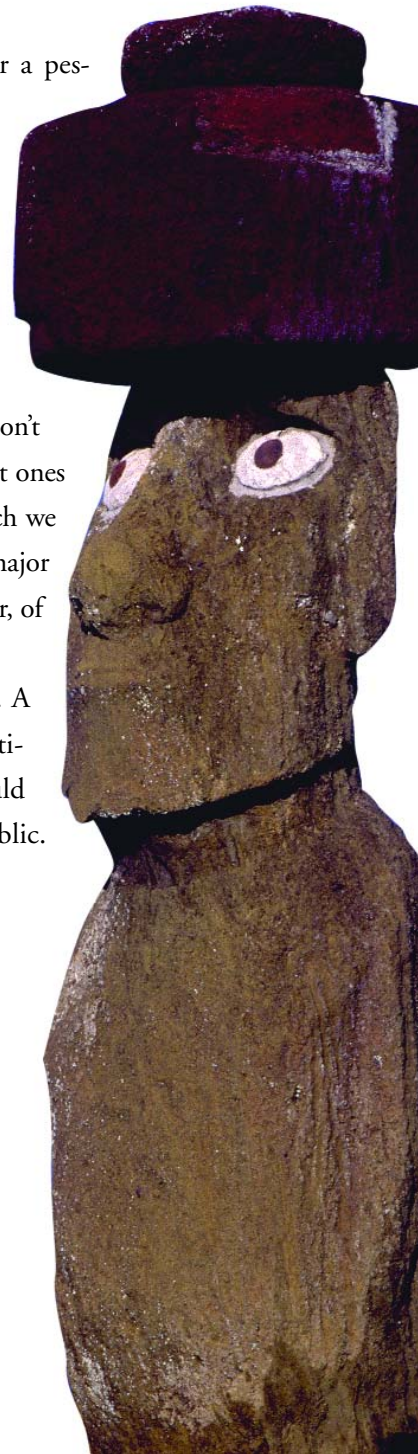
THE JOHN H. CHAFEE MEMORIAL LECTURE

But we have a great advantage over the Easter Islanders. Unlike the Easter Islanders, we have archeologists, books, and television, and so we can see the environmental messes that are being made elsewhere in the world, and we can also see the environmental messes that have been made in the past. We thereby have the possibility of learning from other societies, a possibility that Easter Islanders did not. We can learn which environments are fragile and where you have to be more careful, and that turns out to be rather complicated. We can learn why it is that societies may make mistakes, and so we can alert ourselves to the risks of unsuccessful group decisionmaking.

That's a hopeful sign. People often ask me, "Jared, are you an optimist or a pessimist?" My answer is that I'm neither. I'm not an optimist or a pessimist: I'm a cautious optimist. If I thought that we really were going to be overrun by the juggernaut of evil big businesses, my wife and I would never have had children. Conversely, if I thought that the problems of the world were trivial and that the world is proceeding surely in a good direction now, then I might not have decided to devote myself at this stage in my career to convincing the public of the importance of environmental problems.

I see our environmental problems as serious ones, ones that will do us in if we don't solve them, but I also see them as solvable. The problems that we face today are not ones beyond our control. It's not that our biggest risk is an asteroid collision about which we can do nothing, which would wipe us out like the dinosaurs. Instead, all of our major problems today are problems caused by us. They are problems such as those of water, of forests, of fisheries, and of climate change.

We are the ones who cause the problems, and so we can stop causing them. A little new technology will help, but it's not essential. What's really needed is political will. If we agreed that we wanted to solve these problems tomorrow, we could do so. The important thing now is for all of us to go convince the rest of the public. Thank you.



QUESTIONS AND ANSWERS

QUESTION: I enjoyed your first book, but it looks like I'm not going to enjoy this new book very much. Civilization is an experiment, I certainly agree with that, but history shows us that societies that create links between man and nature that effectively bring current practices in line with sustainability, that is, societies that have rule of law and private property and decentralized institutions, actually achieve sustainability as you said.


Oil policy is far more sustainable than water policy. That's not an accident. You seem to disparage all of the institutions that seem to have allowed us to have a good economy. Is that what you really think?

ANSWER: I have misspoken if it appears that I have disparaged so many institutions, because my conclusion is that some human societies have institutions that solve their problems, and some human societies don't. We, today, have some institutions that are going in the right direction and some institutions that are going in the wrong direction. My goal is to select more of the constructive institutions, to identify hallmarks of constructive institutions, and to try to discourage the bad institutions. As for your prediction that you won't enjoy my next book, I promise you that you will love it, because, among other reasons, it will give cause for optimism. Our problems are solvable.

QUESTION: Following up on the business of constructive and destructive societies, when I was young I was taught that African countries were overpopulated. But one thing that I've often noticed is that all of the countries that are having the most trouble feeding their people are, in fact, having trouble controlling civil war. You don't seem to address the problem of war very much in this, and that seems to be an enormous factor in whether a society will be able to turn its sufficient energy to constructive purposes.

ANSWER: You are correct: in my talk lasting just 45 minutes there were some major things, including war and disease, just as a starter, that I did not have a chance to discuss. I did, though, briefly allude to war, at the beginning, when I said that I have a checklist of five factors that I use to look at vulnerability of societies.

One of those factors is, in effect, war. The observation is that, when societies get into trouble, often the form that the collapse takes is being taken over by hostile neighbors. But it's also the case that, when environmental resources get short, societies collapse in an epi-

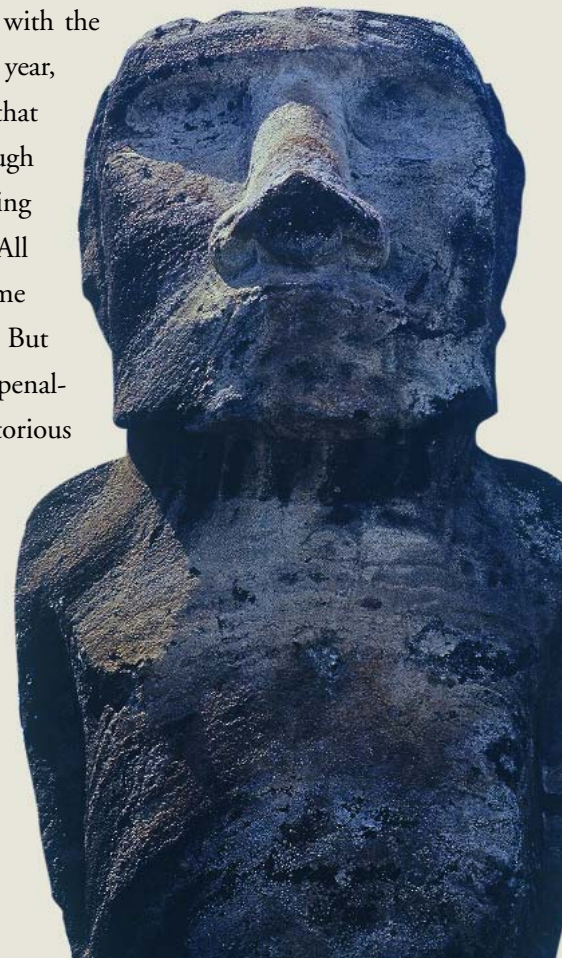


demic of war because people are now fighting in dead earnest for shrinking resources. Easter Island is a good example: its society collapsed in a paroxysm of warfare.

QUESTION: Thank you very much for your talk. I commend you very much for looking at the human dimension, the archeological record, and using that to elucidate something about today and the future. One of the questions I have, as a natural scientist myself, is how do we continue to look at the social sciences and how do we encourage young social scientists to become more involved in today's issues and scientific problems? I feel that there's a real disconnect, and even at this conference I feel that there is not enough engagement between the natural and social scientists.

ANSWER: You've put your finger on two separate problems. One is the relation between the social sciences and the natural sciences, and the other is the relation of either of those sciences to public policy. Just to take the second of those, it is a source of frequent disappointment to me to see the large number of academics, maybe even the majority of my colleagues, who do not get involved in the public implications of what they're doing. If they, the people who know most about their specialty, won't get engaged with the public, then how is the public going to know about it? Or, I see each year, when the NSF or NIH budget comes out, academics complaining that this government does not understand science and is not investing enough in science. Why not? Partly, because most academics are not putting enough of their time into explaining science and into public policy. All right, different people have to do different things, and it's okay if some people don't want to talk about their areas of expertise to the public. But where I really feel badly is that there are plenty of people who actually penalize those academics who do try to speak out in public issues. A notorious example was what happened to Carl Sagan (his being rejected for membership in the National Academy of Sciences). There are lots of other examples.

My plea to all of you here is that, if you have some area of expertise, don't keep it inside yourself, but share it. It may well have implications.



APPENDIX I

BIOGRAPHY OF SENATOR JOHN H. CHAFEE (1922-1999)

Senator John H. Chafee (R-RI) was born in Providence, Rhode Island, in 1922. He earned 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.

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. He was then elected Governor by a 398-vote margin in 1962. He was reelected in 1964 and 1966 — both times by the largest margins 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. 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 people with disabilities. In 1990, Senator Chafee spearheaded the Republican Health Care Task Force. 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 co-chaired the centrist coalition that 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 DR. JARED M. DIAMOND

Dr. Jared M. Diamond is Professor of Geography, Environmental Health Sciences, and Physiology at the University of California, Los Angeles. One of the nation's foremost scientists, he excels at combining his knowledge of physiology, ecology, conservation biology, and human history to address complex environmental problems. Since 1977, he has been devoting much of his time to popular science writing in order to convey understanding of important scientific issues to the general public. He has published eight books, two monographs, and nearly 600 articles. In 1998, he was awarded the Pulitzer Prize for his book *Guns, Germs, and Steel: The Fates of Human Societies*, which was a national best seller.

Dr. Diamond has also contributed extensively to the field of conservation biology. He has led 19 expeditions to study the birds of New Guinea and nearby islands. These expeditions have done much to clarify the ecological assembly of species communities and the factors controlling extinction and immigration and hence species diversity. Dr. Diamond has also studied methods of identifying extinction-prone species in nature reserves. The results of this research led to his assisting in the design of comprehensive national park plans for Indonesian New Guinea, Papua New Guinea, and the Solomon Islands.

Dr. Diamond is the recipient of numerous awards, including the National Medal of Science, the Tyler Prize for Environmental Achievement, a MacArthur Foundation Fellowship and Japan's International Cosmos Prize. He has received awards from a wide range of scientific societies, including the American Gastroenterological Association, the American Ornithologists' Union, the American Physiological Society, and the National Geographic Society. In recognition of his conservation work, he was awarded the Carr Medal and the Conservation Medal of the Zoological Society of San Diego.

He is an elected member of the National Academy of Sciences, the American Philosophical Society, and the American Academy of Arts and Sciences. His book on human evolution, *The Third Chimpanzee*, won Britain's Science Book Prize and the *Los Angeles Times* Science Book Prize. Dr. Diamond also serves on the Board of Directors of the World Wildlife Fund and is a contributing editor to *Discover* magazine.

Dr. Diamond earned his Bachelor of Arts degree at Harvard College in 1958 and his Ph.D. in 1961 from the University of Cambridge, England, in the fields of physiology and membrane biophysics. He was a Junior Fellow of the Society of Fellows at Harvard University from 1962-1966 and then joined the faculty of the UCLA Medical School, where he remains today. He has also held the position of Research Associate in Ornithology at the American Museum of Natural History since 1973 and the Los Angeles County Museum of Natural History since 1985.

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1707 H Street NW, Suite 200
Washington, DC 20006-3918

Telephone: 202-530-5810
Fax: 202-628-4311

E-mail: info@NCSEonline.org
www.NCSEonline.org

Copyright © 2004 NCSE
ISBN 0-9710439-6-5

 Printed on recycled paper.