Ⅰ. The Winners of the Blue Planet Prize

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2002

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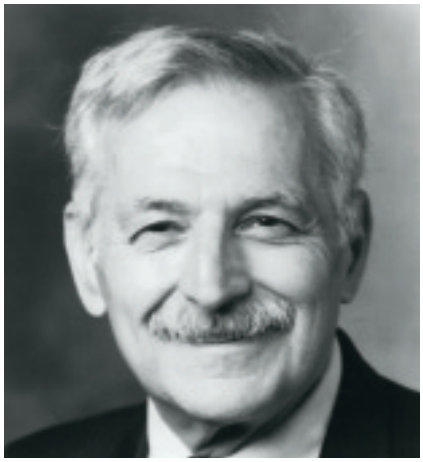
Blue Planet Prize

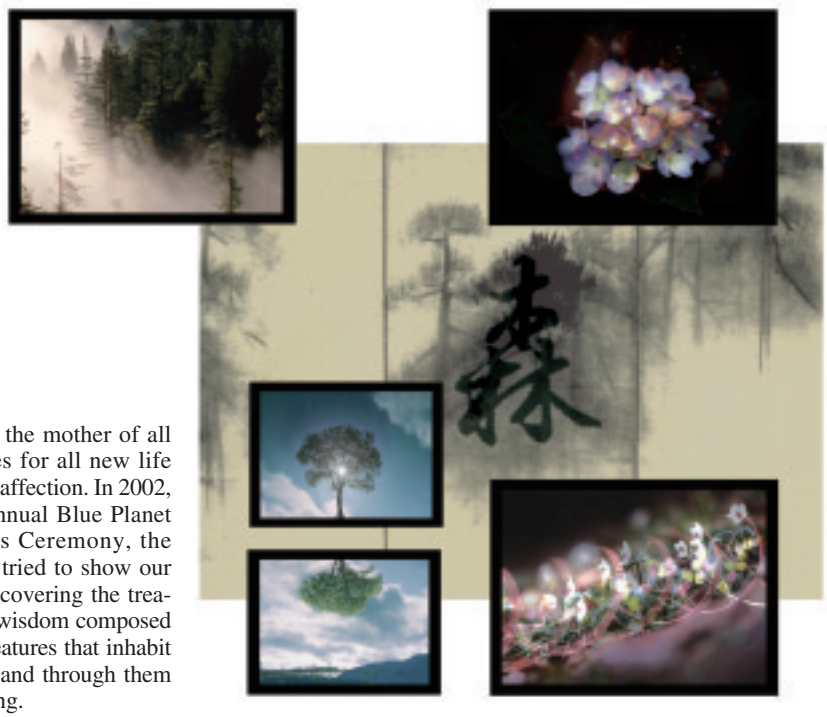
Professor Harold A. Mooney (U.S.A.)

Professor, Department of Biological Sciences, Stanford University



Professor James Gustave Speth (U.S.A.)

Dean and Professor, School of Forestry and Environmental Studies, Yale University



The Forest:
Our planet is the mother of all life. She cares for all new life with love and affection. In 2002, at the 11th annual Blue Planet Prize Awards Ceremony, the opening film tried to show our effort at rediscovering the treasure trove of wisdom composed by myriad creatures that inhabit it; the forest, and through them the joy of living.

His Imperial Highness Prince Akishino congratulates the laureates

Their Imperial Highnesses Prince and Princess Akishino at the Congratulatory Party

Hiromichi Seya, chairman of the Foundation delivers the opening address

Blue Planet Prize Commemorative Lectures

Dr. Jiro Kondo, chairman of the Selection Committee explains the rationale for the determination of the year's winners

Howard H. Baker Jr., Ambassador of the United States of America to Japan, congratulates the laureates

The prizewinners receive their trophies from Chairman Seya

Prof. Harold A. Mooney

Prof. James Gustave Speth

Profile

Professor Harold A. Mooney

Professor, Department of Biological Sciences, Stanford University

Education and Academic and Professional Activities

1932	Born on June 1 in California, USA
1957	Graduates from the University of California at Santa Barbara
1960	Obtains doctorate at Duke University
1960	Associate Professor, University of California at Los Angeles
1961	Ecological Society of America, Mercer Award
1968-1975	Associate Professor, Stanford University
1975-present	Professor, Stanford University
1976-	Paul S. Achilles Professor of Environmental Biology
1983	Merit Award, Botanical Society of America
1990	Ecology Institute Prize for Terrestrial Ecology
1992	Max Plank Research Award
1996	Eminent Ecologist Award, Ecological Society of America
2000	Nevada Medal of Science Award
2000-2003	Senior Fellow, by courtesy, Institute for International Studies, Stanford University

Professor Mooney entered the University of California at Berkley as a political science major, but dropped out of school for economic reasons and got a job on a freighter traveling down the west coast of the Americas. While transiting the Panama Canal, he read in a magazine about a "Plant Hunter for the United States Department of Agriculture," which led to a major change in his career path. Professor Mooney, who had a strong interest in plant life through his activities in the mountains of California, was extremely attracted to an occupation in which both plant exploration and adventurous travel would be possible. So he returned to the University of California at Santa Barbara in order to study botany.

In 1957, he researched the physiological processes of Arctic-Alpine plants over a vast natural range extending from Alaska to the Rocky Mountains. He studied photosynthesis and respiration of the plants using an infrared gas analyzer and equipment that he helped to design and was able to demonstrate the physiological basis for ecotypic differentiation. He showed that plants adapted their physiological processes to their local environments.

After he obtained his doctorate in 1960, he embarked on research into convergent evolution that showed that different plant species develop the same physiological characteristics in response to the same severe environments. He earned acclaim for demonstrating that similarities between different species were not limited to form, which had already been demon-

strated, but also extended to function. He accomplished this by comparing the ecology and physiological characteristics of plants in the drought-limited Mediterranean climates in the geographically disparate California and Chilean coastal regions and Mediterranean Basin.

In the 1970s, he took a broader approach to examine not only carbon gain but carbon use by plants in an area of California ranging from the desert to the White Mountains and applied a cost-benefit approach to clarify how carbon resources are allocated to different sites in plants. He had a significant impact on later studies into plant physiological ecology and advanced research into carbon gain and use in plants by showing in a detailed cost analysis how plants obtain carbohydrates and nitrogen, and how they distribute and store them to obtain the greatest effect with the lowest expenditure of energy. To date, he has authored over 400 scientific books, papers and articles.

In the latter half of the 1980s, he pursued research into the effect of the invasion of different plant species on naturally occurring species under the auspices of the Scientific Committee on Problems of the Environment (SCOPE), setting up the first global evaluation of invasive plant species. He regarded the acceleration of problems related to invasive species due to increased international commerce with grave concern, recognized the need for joint research between naturalists and social scientists, and launched the "Global Invasive Species Program" with many international institutions as partners.

Professor Mooney has been active in building up worldwide communities and networks of ecologists and scientists in recent years, especially with problems related to biodiversity and global warming. He played a central role in the International Geosphere-Biosphere Program (IGBP), having an influential part in setting the guidelines for the formulation of environmental policies. He has advanced numerous international research programs as Secretary General and Vice-President of the International Council for Science (ICSU). Furthermore, he is working to solicit the interest of the general public in many scientific topics through the media and other channels. He continues to work toward the development of new environmental sciences that will be required for the continued existence of humankind.

Essay

Ecologists, their Science and Careers, and their Role in Society

Professor Harold A. Mooney

July 2006

Gareth Edwards-Jones (2006) recently wrote an essay on "Sustainable development: What's ecology got to do with it?" He tells a very interesting story of his own career experience relating how he attended a meeting of the British Ecological Society Easter Symposium some 20 years ago when the very distinguished ecologist, John Harper asked this question in a speech, "What if a bomb went off in this auditorium right now and killed 250 of the world's best population biologists? Would it have any impact on the future of the planet and the development of the human race?" Harper answered his own question by saying, "Not one jot!" That was a dramatic statement, and as an ecological practitioner at that time I probably would have made a similar remark in a speech in my own country. I thought times had changed though, and that the ecological community was much more engaged in societal issues so I was saddened to read further in Edwards-Jones' essay that he had planned to attend a symposium on "Ecological Limits to Sustainable Development" at this year's British Ecological Society Easter meeting but learned that the symposium had been cancelled for lack of interest.

Gareth Edwards-Jones speculates as to why there was such a lack of interest in this recent symposium proposal, and he proposes that career development seems to take such a large role in our time allocation that little is left for venturing to the big questions relating to the relevance of what ecologists know, and learn, to societal development. There certainly is no escaping the fact that, in academia at least, the pressure for peer recognition and hence job security is intense. A number of years ago a large group of senior ecologists wrote a short piece on this dilemma (Bazzaz, et al. 1998). They contended that times had changed and that academic ecologists should now add a third task to their job description. The traditional tasks were 1) to conduct high quality research and 2) to make the results available to their peers by publishing it in the technical literature. To these they would add the additional task of 3) informing the general public (who in the end pay for the work performed) of the social relevance of their efforts. They addressed Edwards-Jones' concern for the lack of motivation, or more specifically reward, for doing so, other than personal satisfaction. The Bazzaz et al. paper called for more formal recognition, within academia, not only for the production of high quality research, but also for success in informing the public of the relevance of the research products to human well being. Making the latter case is not too difficult since the work of ecologists is central to understanding how community and ecosystem processes lead to the

ecosystem services upon which society depends.

I do certainly see changes happening in the attitudes of individual scientists and this is a very hopeful sign. I will illustrate the changes that I see with two examples. In recent years there has been the development of a global scientific assessment process. Leading scientists from around the world donate their time and expertise to critically evaluate the literature, relating these finding to the crucial environmental issues of our time, and noting the certainty of our knowledge. One of these assessments is the Intergovernmental Panel on Climate Change, or IPCC. This group has made a series of assessments through time to determine what effect the emissions of greenhouse gases has on climate change. The resulting documents are very authoritative since so many international scientists are involved and the review process is very stringent. The change in attitude that I perceived was the recognition by the participants that they had been selected by their peers for involvement in an important task. Rather than hiding these activities from one's promotion papers it was actually highlighted. This is a real change in perception by the scientists on the importance of this "extracurricular" work for the benefit of society, as well as for their own career development.

Another recent global environmental assessment was the Millennium Ecosystem Assessment, or MA. The program used the IPCC template, to a large extent, and with similar results—a very large international group of leading scientists produced the first global assessment of the status of the Earth's ecosystems and their capacity to deliver ecosystems goods and services to society. An innovation of the assessment was the involvement of young scholars as fellows for this work, in addition to the established scientists. A wonderful group of young scholars, graduate students and recent graduates, became fully engaged in the work and were very excited and rewarded by doing so. The important point is that evidently they did not get negative feedback from their mentors that it was not appropriate at their stage in career development to become engaged in this work; quite to the contrary, it was a plus to their career as well as serving an important societal role.

The second example I use to illustrate the change in attitude about involvement of scientists in outreach to society is a training program in the United States called the Aldo Leopold Leadership Program. This program is designed specifically to give young scientists the tools they need in order to communicate their scientific findings to a larger audience through newspaper and magazine articles, and in interviews with journalists from radio, print or television, as well as how to engage with decision makers about the relevance of their work to society. Each year 20 fellows are chosen. The pool of applicants has been truly outstanding throughout the length of the program, which is now more than 5 years. Obviously, the desire to communicate the best of science findings to the general public is great, and the applicants again see their selection for the program as a plus for their career and their role in society. The pool was originally set for young scholars who had just attained tenure at their place of employment so that they would not have job security as a barrier to involvement. However, through time many exceptions have been made since some absolutely outstanding pre-tenure scientists have applied because they thought that the program was important to what they wanted to accomplish in their careers. Again, I see this as a very definite change from the perceptions that Edwards-Jones noted at his science meeting.

However, the issue of scientists at an annual professional society meeting being attracted to events that address societal problems directly is another matter. Although large changes in attitude have indeed occurred, I do not see the kinds of fundamental changes in attitude that I spell out above applying to these events. Scientists at these meetings gravitate to those sessions that are most relevant to their own personal research so they can keep up with the increasingly fast moving pace of virtually all science endeavors. They look to other venues for the science/society interface, such as in the United States, the annual meeting of the Association for the Advancement of Science, which often includes many policy relevant issues, and is well attended by communicators of science from the media.

Professional Societies

There has been a rather dramatic change in the activities of ecological societies in the past few decades which also speak to the changing vision of the role of ecologists with the general public. For years the membership of these professional groups resisted formal interaction with society at large but now some, like the Ecological Society of America, have very substantial and active public outreach and policy offices.

Universities

Universities are very slow to evolve however, although the increasing development of interdisciplinary programs and large research teams give an indication of some fundamental restructuring that is occurring and is a recognition of the complexities of the problems that society faces, which need new approaches. Nonetheless, it is still devilishly difficult to pursue and get funding for interdisciplinary work, and promotions are still, at most universities, generally decided by individual research output in prestigious journals with teaching performance and public service lower on the list. With funding harder to get for research support, it is easy to understand that the prime driving force for career development is likely to be: production of very good science with little time left for the extra step of outreach, hence a real basis for Edward-Jones' concern. Further, there is some disdain, in many academic quarters, for those who address relevant societal issues and who attempt to communicate to the general public. Thus, there is not only no reward but there is almost punishment for devoting time to communicating to others rather than immediate peers. These attitudes are disappearing though and the motivation of individuals and how they can best contribute to science and society are becoming more predominant.

Professional Society Role

In summary, I think the community of scholars working on environmental issues is beginning to accept the challenge of communicating their work to society at large and that there are large changes occurring in scientist involvement in efforts to do so. Still though, there is not a universal agreement that such outreach is an appropriate role for scientists, many of whom still seem to think that placing their results in a good scientific journal fulfills their contract with society and that somehow society will find these results without further help. These attitudes though seem to be fading somewhat, however it is true that academic institutions have

been slow in recognizing and rewarding those who are conscientious and skillful in conveying their work to others outside of the literally handfuls (most commonly) of people that will read about it in a scientific journal.

As we continue to mine the Earth's resources, to an ever greater extent, it is vital that scientists who understand the consequences of the potential disruptions to ecosystem functioning and services, make these results widely available to society at large. Ecologists must assume the responsibility for not only increasing public awareness and understanding of these issues but also provide tools and approaches that will lead to a more sustainable future.

I think now we can be confident that the times have changed since John Harper's rather gloomy assessment of the relevance and engagement of the work of ecologists, including his target population biologists, to the welfare of society. If this is not the case it certainly needs to be so, and quickly.

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Lecture

The Sorcerer's Apprentice and the New Biological Order

Professor Harold A. Mooney

It is a privilege to have come to Japan and to address this audience on a few of the many issues that humanity is facing as we fundamentally alter the nature of the earth system and the resource base upon which we all depend. I, along with many others, extend an appreciation to the Asahi Glass Foundation for their dedication to the search for solutions to global environmental problems, by the establishment of the Blue Planet Prize, as well as by conducting their annual global surveys on opinions of environmental experts on the status and future of Planet Earth.

Before I embark upon the substance of my address I provide a little background on my own career, which provides the foundation for the work I will tell you about.

My early career centered on the study of the physiological adaptations of plants to their environments. This work brought me to embark on investigations in many of the world's major ecosystems from deserts to Polar Regions to the tropics. What my students and I learned was how closely ecologically tuned plants are to their local environmental conditions and of the many mechanisms that they have evolved to cope with local limitations of resources.

We also learned that a given environmental suite of conditions brought forth similar adaptive modes in organisms no matter what their evolutionary history might have been. Specifically, comparable climates in places distant in the world produced similar adaptations in the biota through convergent evolution.

These findings have shaped my own appreciation of the evolutionary constraints on how plants utilize their resources and hence on what the limitations are on the utilization of natural systems by humans in different parts of the world. We also found some universal mechanisms that plants employ to capture and utilize resources no matter what habitats they may reside. These findings enabled us to predict how plants deploy the resources they have captured to compete under differing conditions of environmental stress be it limiting water, nutrients or predator pressure.

Early involvement in international environmental science, through the International Biological Program (IBP), led me to appreciate the power of scientists from around the world working together to identify and help solve problems of universal importance to society. The IBP focused on the limitations to primary productivity in the earth's diverse ecosystems and in doing so laid the foundations for systems ecology. Subsequently, I participated in a number of programs coordinated by the Scientific Committee on Problems of the Environment (SCOPE)—a group of international scientists dedicated to assessing the status of the global environment and highlighting emerging issues.

Through SCOPE I became engaged in a number of global issues, including fire ecology, invasive species, on which I concentrate in this address, and the significance of biodiversity on

the ecosystem functioning and the services that it provides to society, which I also touch on briefly. Through other venues (primarily ICSU-the International Council for Science) I also became involved in the design of global research programs on earth system functioning and the science of biodiversity. All of these activities have impressed upon me the rapidly growing extent of human activity on the functioning of the earth system and of the urgency of educating all of us on the consequences of these changes and the options that we have, and must pursue, for building a sustainable biosphere.

Introduction to the Sorcerer's Apprentice

We are witnessing a dramatic transformation in the nature and functioning of the biotic resources that sustain us all. These changes in biological diversity are occurring at all levels—from the very genetic structure of organisms to the configuration of organisms on the landscape. Many of these changes are to the benefit of humanity, and are intentionally driven, but others are detrimental and inadvertent. In this essay I examine what is happening, what is driving these changes, and what the potential consequences of these changes are to societies? I particularly examine how fast these changes are occurring and how the increased tempo of change leaves us with limited options for corrections of trajectories that we may find unfavorable. The complexities of the biological order challenge our current understanding of the underlying forces driving and sustaining them and thus we must proceed with caution as we rearrange biotic landscapes, and the individual organisms constituting them, to provide for the activities of human societies. I conclude with a description of how scientists, at last, have mounted a comprehensive global survey of the current status of biological systems, how they are being modified and the most likely consequences of these changes and the options that we have for influencing favorable outcomes.

The Sorcerer's Apprentice

One of the most compelling movie sequences ever filmed was an episode in Fantasia where Mickey Mouse plays the sorcerer's apprentice. In this sequence, based on the poem by Goethe, and set to music by Paul Dukas, Mickey, the apprentice, using the power of the hat of the absent sorcerer, commands a broom to do his menial task of fetching water from a fountain to fill a large vat. He then falls asleep and upon awakening he finds that the broom has been very efficient and has filled the vat to overflowing. Mickey, lacks the full knowledge of the sorcerer and cannot make the broom stop. He then, uses an axe to cut the broom into pieces. Then the nightmare occurs of the pieces replicating themselves into new full brooms and resuming the task of bringing in more water, creating a flooding disaster. The sorcerer returns, and with his knowledge of how to reverse magic spells, he turns to broom back to an inanimate object and thus no longer a threat.

What is frightening about this episode is the self-replication of a tool that has gone wrong. A mistake is made, but then it is compounded by replication of the mistake. The one making the mistake, based on his incomplete knowledge, is helpless to reverse this com-

pounding error and disaster follows.

Unfortunately this exact same story is played out all over the world today, not by Mickey Mouse, but by real people, again seeking a simple solution for solving a task. The tool they invoke is an organism possessing some apparently useful property, which by its nature already has the power of self-replication. The potential for disaster is thus closer at hand than for Mickey, who only upon trying to correct his mistake compounds it by conveying self-replication upon an inanimate object.

How Organisms Used to Move Among Continents

I use this fable to introduce the topic of the movement of biological material across biogeographic borders and the consequences, both good and bad that can ensue. Before the Age of Exploration, the exchange of biotic material among continents was a rare event limited to cases of organisms floating, or rafting, in the seas and surviving journeys over great distances, or small seeds being carried, inadvertently, by migrating birds. Some microscopic organisms however are transported long distances by wind (Figure 1). The rarity of successful long distance journeys of organisms can be appreciated by the few numbers of species that were shared among continents prior to the age of exploration.

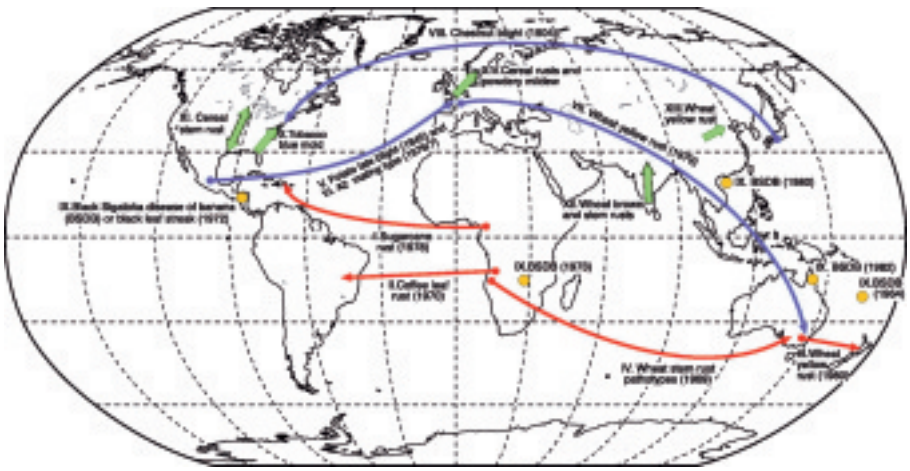


Figure 1. Long distance transport of pathogens. Purposeful and accidental human-mediated transport of organisms is the principal source of invasive species although some spores of pathogens can be transported long distances in the air stream [1]. Red arrows indicate most likely long-distance aerial transport of disease and blue arrows most likely human transport(figure content reprinted with permission from Brown and Hovmoller. 2002. Science 297:537. Copyright 2002. AAAS. Permission for the reproduction of the base map by C. Lukinbeal).

The Destruction of Global Biogeographic Barriers

The result of this lack of mixing meant that each continental area of the world developed a rich and unique biota. As evolution proceeded, complex interactions developed between predator and prey, herbs and herbivores, fungi and their hosts, and the other manifold two-way

biological interactions that occur. Populations of a given species were held in check by competition with similar organisms as well as the action of predators and pathogens. Co-evolutionary forces resulted in the development of survival strategies against specific enemies as well as the unique means of defense against these enemies such as chemical toxins of all sorts.

All of this changed with the first explorers who traversed the oceans, generally seeking economic rewards, directly or indirectly, such as gold or natural resources such as spices and herbs. Even from the first, the issue of the very good, as well as the very bad inadvertent consequences accompanied these interchanges. As a result of the "Columbian Encounter," biotic riches of lasting value were transported to Europe, such as corn, beans, and tomatoes. At the same time this encounter inadvertently introduced diseases from Europe into the Americas that resulted in the death of millions of Amerindians resulting, in large part, in the subjugation of the survivors. Today the extent of biotic exchange is enormous across continents as shown in Table 1.

A world sampling of the numbers of naturalized species

Region	Plants	Fish	Birds
Europe	721	74	27
California	1023	42	19
Australia	1952	22	32
South Africa	824	20	14
Hawaii	902	19	38
New Zealand	1623	30	36
Japan	1196	13	4

From Vitousek, et al., 1997, Elredge and Miller, 1997, Hobbs and Mooney, 1998. Enomoto,1999

Table 1. The extent of the global exchange of plant species (from [1-4]).

The New Sorcerer's Apprentices—All of Us

Good Intent

Thus even in the early stages of humans breaching the age-old biographic barriers that separated the continents, good and bad results could be seen. In the case noted above the good was "purposeful introductions" and the bad was accidental introductions. However, later the cases of the bad became augmented and many of these detrimental examples were cases of purposeful introductions that did not work out as originally envisioned. These thus are examples of the work of the Sorcerer's Apprentice—the deeds of well-intentioned people with imperfect knowledge and control over the self-replicating agents that they employed to do their work. Examples abound—the introduction of the Nile Perch into Lake Victoria to augment the food supply of the local population, which entrained a series of events that actually resulted in less food from the lake for local people, promoted deforestation, eutrophied the lake, and drastically impacted local biodiversity. Other examples include the introduction of biocontrol agents such as the cane toad and the mongoose which have caused enormous damage either ecologically or economically, or the introduction of erosion control plants, such as the kudzu

vine that did that job but unfortunately also has had a very large inadvertent impact on forest growth [5] [6].

Once established, these good deeds gone wrong are very difficult to correct because of the self-replication of the error. The sorcerer does not exist with the knowledge to right the wrong that has been inadvertently entrained. Thus brute force has to be applied and the tools at our disposal are primitive, costly and really not all that effective.

Our only hope in these cases is to use much greater caution in order to avoid such mistakes to begin with. However the pressures to repeat the mistakes are great and are getting greater as I discuss below.

Accidents Happen Once the Walls are Down

Of course it is not only cases of good deeds gone wrong that concern us but also the fact that opportunities for inadvertent accidents are increasing. No one purposefully brought the Zebra mussel into the Great Lakes (it came in released ballast water) (Figure 2) or the Formosan termite into the United States, yet both of these organisms are causing billions of dollars of damage. Again, no one purposefully introduced the ctenophore (*Mnemiopsis leidyi*) into the Black Sea, yet it arrived, again by ballast water, and successfully wiped out the commercial fishery of that region [7] (Figure 3).

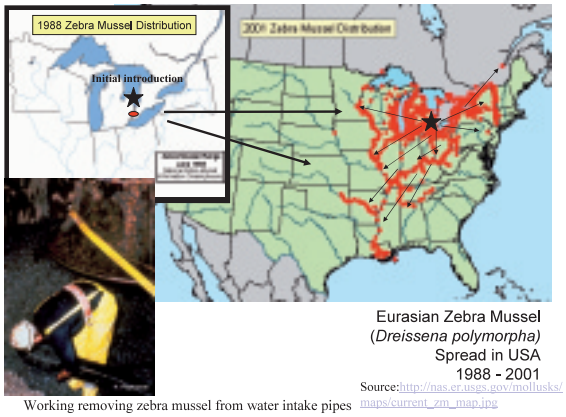
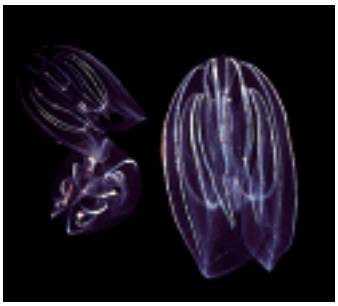


Figure 2. The explosive invasion of the zebra mussel into the United States (source-http://nas.er.usgs.gov/mollusks/maps/current_zm_map.jpg).

The Destruction of a Fishery



In 1982 *Mnemiopsis leidyi* (left) invaded the Black Sea evidently as a result of the discharge of ballast water from the United States. This invasion contributed to a sharp decrease in local fisheries. A subsequent inadvertent introduction and invasion by a predator of the Mnemiopsis is leading to a recovery of the fishery.

Figure 3. The dramatic impact of invasive species on fisheries (from [7, 8]). Photo of *Mnemiopsis leidyi* by E. Prosser Armstrong and used with permission.

We are still woefully inadequate in our capability to predict which organisms, of all that are crossing biogeographic barriers, will successfully establish, and spread, once they do arrive [9]. We do know that quite often those species that are successful are so in part because they have escaped their co-evolved pests and competitors.

Given the cases of introductions, both purposeful and inadvertent, that have gone on to create ecological and economic havoc in their new homes, there is the obvious need for considerable precaution in purposefully introducing new organism as well as protecting borders against inadvertent introductions.

The Forces Against Caution

The forces that work against caution include:

Ignorance

Many individuals of modern societies are becoming detached from understanding the natural base that sustains us all. They are unaware of the detrimental consequences of certain alteration of landscapes through human activities much less the potentially devastating effects of introducing new biotic material into a region. Thus the issue of invasive species is not high on the agenda of individuals much less of decision making-bodies that respond to public pressures.

Lack of capacity

Certain nations that have suffered the devastating effects of large numbers of invasive species have instituted elaborate systems for intercepting potentially invasive species. These systems are costly and require highly trained people to operate. They are however cost-effective in the long run since interception of even one potentially damaging invasive species can have large economic impacts. It has been demonstrated that interception is cheaper and more successful than eradication, which may not even be possible even if desired once an invasive species becomes established. Unfortunately not all nations have the economic means to establish surveillance systems at their borders, nor a pool of trained people to run them. Thus infection spots of invasive species are maintained in many nations that could have been avoided by more effective border control.

Increasing global connectivity

The job of border control is made extremely difficult by the increasing numbers of potential intercontinental transport vectors (ships and airplanes and the goods and humans that accompany them) that cross borders every day. Even with a highly developed inspection system the US agricultural border stations can only sample a small fraction of these shipments that arrive every day. There are now over 45,000 registered cargo-carrying vessels in the world and the ballast water that they carry inadvertently deposits organisms in places far distant from points of origin. It is estimated that as many as 7000 species of marine life are transported daily around the world in ballast water on any given day [10].

Global trade promotion

Trade without caution. In recent years there has been a large effort to decrease barriers to international trade as is embodied in the efforts of the World Trade Organization. The result of this aggressive policy is the agreement that if a nation has some concern about the potential detrimental impact of an import they must do the risk assessment analysis to demonstrate this danger. Thus the burden of proof is on the potential victim, not the potential perpetrator of environmental damage, or the one who will profit from the potential trade, leaving the costs of mediating any undesirable consequences to the general public. This runs counter to the concept of the precautionary principle that was developed to protect society against potential hazards embodied in poorly understood ecological interventions.

Even before aggressive promotion of international trade there have been dangers of the intercontinental exchange of first class mail containing seeds that are not subject to inspection or of the transport of potentially invasive horticultural material through traditional exchange routes.

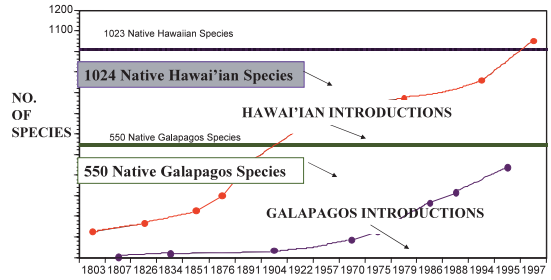
Adding to the potential dangers of the institutionalized and routine promotion of global trade is the illicit illegal movement of potentially invasive organisms, through promotion on the internet.

The Forces For Caution

What are the forces working to counter the movement of organisms across biogeographic borders? There are a number of treaties that address the movement of unwanted organisms away from points of origins. These include the IPPC, Intergovernmental Plant Protection Convention, which is directed principally at pests of agricultural plants and CITES, Convention for International Trade in Endangered Species of Wild Fauna and Flora, focused on trade of endangered species. The Convention of Biological Diversity had no directive toward trade restriction although it recently adopted a decision to "evaluate introduction pathways."

National Protection Plans

Various nations and regions have trade restrictions and border inspection of biological material to varying degrees. Some are very restrictive, such as New Zealand. Other areas, such as the Galapagos Islands, even though they have extraordinary biodiversity to protect, have until recently, had no restrictions on imported biological material with very sad consequences toward which millions of dollars are now being expended to correct (Figure 4).



From Eldredge and Miller, 1998, Tye, 2001, and Wester, 1992.

Figure 4. Time course of plant introductions into the Hawaiian and Galapagos Islands. There are now as many established plant species on these islands, as there are native species (Data from [11-13]).

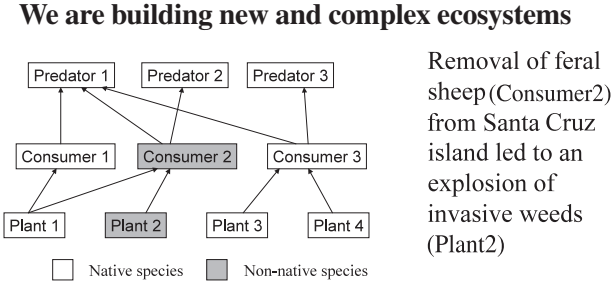
The Consequences of the New Biology

Sharing global resources

As noted earlier the benefits of the exchange of biotic materials across borders have been immense, particularly in agriculture, animal husbandry, horticulture, and fisheries. With more rapid and distant trade these benefits are increasing in terms of the availability of biological products year round, everywhere.

The changing course of evolution and ecological interactions

There is a cost to this convenience, a dark side to the movement of organisms, that is, the potential for the release of those that can cause undesired and continuing damage because of the Sorcerer's apprentice effect and its magnification as fundamental ecological and evolutionary processes are disrupted. There is wide documentation of how new organisms entering into new territory are not only evolving to fit the new conditions but are also changing the evolutionary trajectory of those impacted native species. New hybrids are being formed that are swamping out native distinctiveness. New complex food chains are being established that make it very difficult to manage these systems without undesired consequences (Figure 5). Ecosystems are always in a state of flux however these disruptions can totally alter their nature and bring them to a new functional status [14].



Zavaleta, Hobbs and Mooney, 2001

Figure 5. Invasive species are building new food webs in ecosystems adding to the complexity of control efforts. Removing one invasive species may lead to the explosive development of another (from [15]).

Enhancement and disruption of ecological services

Of course, purposeful introductions can enhance the ecosystem services, in addition to providing useful goods, which can aid human societies, such as erosion control, soil nitrogen enrichment, toxic cleanup, water clarification and so forth. Even accidental introductions, such as zebra mussels, can provide services such as water clarification, but unfortunately also many unwanted effects such as species extinctions and clogging water works. But even those introduced species that may provide useful services may escape and do great unintentional damage, as was the case with kudzu vine that originally was introduced for erosion control.

It is the disruption of ecological services provided by natural ecosystems that are of most concern and unfortunately examples abound around the world many of which are accompanied by very large economic consequences. These include the destruction of important forest trees by invasive diseases, the devastation of crops by invasive pests and pathogens, the clogging of water ways by pernicious water plants, the promotion of large and unseasonal fires by weedy grasses, the acceleration of the loss of water from watersheds, rendering rangelands less productive [16].

The Good, the Bad and the Ugly

What we have learned then from the movement of biological material around the world is that great benefits and riches have been gained at the same time great damages and economic losses have been incurred. This is actually part of the larger story of human modifications of natural ecosystems—great benefits have been gained in terms of food and fiber production, control of floods and fires to a certain degree, and so forth but at the same time fundamental changes have occurred to these systems that threaten their long term sustainability such as the losses and extinction of biodiversity and loss of topsoil. As in the classic movie, "The Good, the Bad and the Ugly" there are sometimes difficulties in distinguishing the good from the bad in these modification states in natural systems since in part these assessments depend somewhat on the beholder and their own particular interests, which are often based on very short term considerations. What may be of benefit to one segment of society is a detriment to another. However, the point that I would develop further below is that our analysis of good and bad, in terms of human well-being gained from natural resources, is often incomplete since it generally only considers a modification of a single resource in isolation from that occurring to other resources and hence the total net gains and losses, or goods and bads, are not perceived and hence are not a guiding force for resource management.

Dangerous Ignorance and Tinkering in the Dark

So, thus far what I have said is that we are fundamentally changing the very nature of biological systems that have evolved through the millennia by deleting species and parts of ecosystems as well as by adding new species where they have not previously occurred. In addition we are altering, in a major way, the many drivers of ecosystem functioning by modi-

fications such as inadvertently adding nutrients [17]. We know that these changes are having dramatic impacts on the capacity of ecosystems to sustain human populations, both positively and negatively. At the same time we are relatively ignorant on how ecosystems, with their co-evolved members operate, much less how they will respond to the addition of new players introduced purposefully or accidentally. At the most fundamental level we haven't even described the myriad species that inhabit the earth or is there much possibility that will be able to do so using traditional methods because of the sheer size of the task but also because of the loss of technical capacity to do so. We have very little capacity to account for the numbers of critical organisms and how their abundances and ranges are changing, except for the largest of mammals and birds. We are generally ignorant of the role that species play in ecosystems except in the most general way. For example we often cannot predict a priori what the consequences will be of the removal of many species to the operation of ecosystems, or of additions, as noted earlier. We are often caught off guard by outbreaks of pests. In sum, being an ecologist is a life full of surprises because of our lack of basic knowledge added to the general complexity of ecosystems such as the non-linearity of their responses to perturbations induced, either naturally, or due to human activities. It is not that such knowledge is unobtainable; it is just that it is hard to come by, and gaining such knowledge has not been a high priority in many nations. This knowledge takes scientists, time and resources. As noted above we not only lack focus and resolve on these issues but we also are losing the capacity to attack the problems. As society shifts more attention to the promises of new technology, such as molecular engineering, it is losing capacity, not only in identifying the pieces of ecosystems but also in studying how these pieces function, since the field of physiology, both plant and animal, is being neglected.

We are putting substantial resources into human health but not into learning about the fundamental ecological foundation in which humans derive their livelihoods and well-being. In the U.S. for example, a nation which spends a great deal of money on science, 90% more is spent on human health research and development than on natural resources and the environment. This ratio is even more skewed when considering basic research alone [18].

It is small wonder that ecologists have embraced the precautionary principle so readily in dealing with proposed interventions in ecosystems. It is not that they are trying to stop change it is just that they still lack the capacity to offer knowledge on outcomes with a high degree of certainty and because of the nature of complex systems; such knowledge may never be fully obtainable. Why are they concerned with the proposition to fertilize the oceans in order to sequester more carbon? Why are they concerned with unrestricted free trade of live biological materials? The primary reason is that we cannot predict the full outcome of these interventions and hence cannot be confident of the proposed long-term benefits.

The Task Before Us—Lifting the Darkness

The job of getting the information we need to understand and better manage our natural world is daunting. However it is encouraging that there are the beginnings of a commitment to assess our current knowledge base on the operation of biotic systems and on their capacity to

deliver the goods and services upon which societies depend. This effort is certainly overdue and as was noted recently, we have been 'flying blind' in making environmental decisions since our knowledge base is so poor. We have, however, made enormous strides in the past couple of decades in understanding the basic operation of the earth as a coupled system—how the atmosphere interacts with the earth and how the earth's climate system is regulated and interacts with biogeochemical cycles. This information was crucial in assessing the potential impacts of the activities of humans on global climate change. However we, as yet, do not have comparable capacity to understand fully the consequences of these climatic changes, much less the other global changes that are occurring, on the operation of ecological systems in time and space. In order to get this information we need a comprehensive evaluation of the pieces of ecosystems, how they interact as a functioning whole and how they respond to perturbations. This information is now becoming available. This last decade has seen a concerted effort to learn the role of biodiversity in the functioning of ecosystems and the development of an understanding the role of ecosystem functioning in providing the goods and services upon which societies depend [19]. The task thus is to bring this information together on functioning and services and to in turn relate these to how humans are altering the fundamental capacity of ecosystems to provide these services.

Recently, a global analysis, the Millennium Ecosystem Assessment was conducted on the status of the world's ecosystems and the services they provide [21]. The results were not encouraging in many ways since it was concluded that virtually all of the Earth's ecosystems have been transformed by human action and that the past 50 years has seen the most rapid rate of change in history. Accompanying these changes has been a great loss in the capacity of these systems to provide clean water, erosion control, disease regulation, pollinator services, to say nothing of the losses of biodiversity and cultural values. A consequence of many of these perturbations, accompanied by a globalized economy, is the fostering of invasive species, such as pests and emerging diseases, which in turn often degrade services even further.

Conclusion

We are engaged in massively disrupting and degrading those ecosystems upon which societies have been built and whose services we depend upon. An important element of these disruptions is the homogenization of the Earth's biota and the increasing occurrence of invasive species that cause great economic damage as well as ecological perturbations. These invasive species are not subject to "recall" once they become established. It is important that we fully appreciate and understand what we need to do in order to sustain those natural and managed ecosystems that sustain humans and the role that invasive species can cause in ecosystem functioning and service provision. The escalation of those elements fostering the transport and establishment of invasive species lend some urgency to our task.

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Profile

Professor James Gustave Speth

Dean and Professor, School of Forestry and Environmental Studies, Yale University

Prof. James Gustave Speth
Education and Academic and Professional Activities

1942	Born in South Carolina, U.S.A.
1964	Graduates from Yale University
1966	Graduates from Oxford University (Economics)
1969	Graduates from Yale University Law School
1970-1977	Senior Attorney for Natural Resources Defense Council
1976	National Wildlife Federation's Resources Defense Award
1977-1981	Member of U.S. President's Council on Environmental Quality (1979-1981 Served as Chairman of the Council)
1982	Establishes World Resources Institute (WRI)
1982-1993	President, WRI
1992	Natural Resources Council of America's Barbara Swain Award of Honor
1993-1999	Administrator, United Nations Development Programme (UNDP)
1997	Special Recognition Award (Society for International Development)
1998	Decorated by the Governments of Senegal and Morocco
1999	Environmental Law Institute Lifetime Achievement Award
1999-present	Dean, School of Forestry and Environmental Studies, Yale University

Professor Speth was raised as the son of a farm machinery dealer in the cotton-growing area of South Carolina and after public schools there went on to graduate from Yale University with top marks in political science. Later, after studying economics as a Rhodes Scholar at Oxford University, he graduated from Yale University's law school in 1969. During the late 1960s, when student movements around the world were seeking to promote public welfare, he decided to focus his energies on public interest law and to create a new non-profit legal group to defend the environment.

He enlisted a group of students and faculty at Yale Law School and helped to establish the Natural Resources Defense Council (NRDC) in 1970. Drawing on the latest science and economic understanding, he initiated the lawsuits that led to the regulation of toxic water pollutants, the protection of freshwater wetlands, and termination of the plutonium breeder nuclear reactor program in the United States. For three decades, NRDC has had a major impact on protecting environmental quality.

After his role in NRDC was recognized, he was appointed to President Carter's Council

on Environmental Quality and became the chair in 1979. At CEQ, he brought the threat of global climate change to public attention and called repeatedly for action to forestall global warming. In 1980, the Council released the landmark *Global 2000 Report*, a government survey that linked available data and computer models to analyze population, environment, and development conditions likely at the start of the 21st century. The report pointed out that in the year 2000, the global environment could face difficult prospects including population pressures, heightened pollution, and resource degradation. *Global 2000 Report* was widely hailed and became a fundamental reference.

In 1982, he founded the non-profit research organization, the World Resources Institute (WRI), and served as its president for over a decade. The Washington-based WRI is a think tank that addresses the fundamental question of how societies can achieve development that satisfies human needs while sustaining the natural environment. WRI also provides technical guidance and assistance to governments and NGOs in developing nations interested in sustainable natural resource management. It is particularly active in policy research related to the prevention of global warming and the maintenance of biodiversity. At the Rio Earth Summit, it contributed to the adoption of important treaty articles related to both these topics.

In 1993, he was appointed to head the United Nations Development Programme (UNDP), which has offices in more than 130 developing countries and an annual budget of over $2 billion. In the *Human Development Report* released in 1994, he advocated a new concept of "human security" that included environmental security. This concept of global human security addresses common problems that threaten human safety, such as narcotics, terrorism, communicable diseases, environmental destruction, natural resource depletion, natural disasters, ethnic conflict, and refugee outflows.

In 1999, Professor Speth was appointed Dean of the Yale University School of Forestry and Environmental Studies where he is seeking to build the first truly global school of the environment and to train a new generation of environmental leaders from around the world, goals to which he brings a wealth of experience.

Essay

The Heart of the Matter

Professor James Gustave Speth

Central to the mission of America's environmental schools is the development of professional environmental managers. The majority of our graduate students at Yale are in our Master of Environmental Management program. But what exactly is environmental management?

When I am asked this question, I reply that environmental management is the new business of bringing our human enterprise into harmony with the natural world of which we are a part. And I add: It's the most important thing in the world.

I know this may sound exaggerated, but I think the truth of this statement will become clear in the years ahead. The enormous expansion of the human enterprise in recent decades has brought us to the threshold of a fundamentally new era in which environmental management must quickly emerge as the number one priority of governments and peoples everywhere.

Consider first that environmental losses are already great. Half the world's tropical and temperate forests are gone. Half the wetlands and a third of the mangroves are gone. Ninety percent of the large predator fish are gone, and 75 percent of marine fisheries are now overfished or fished to capacity. Twenty percent of the corals are gone, and another 20 percent severely threatened. Species are disappearing at rates 100 to 1000 times normal. Most agricultural land in drier regions suffers from serious deterioration. Persistent toxic chemicals can now be found by the dozens in essentially each and every one of us.

Consider also that human activities are now large relative to natural systems. We severely depleted the earth's stratospheric ozone layer without knowing it. We have pushed atmospheric carbon dioxide up by one-third and started the dangerous process of warming the planet and disrupting climate. Everywhere earth's ice fields are melting. We are fixing nitrogen at a rate equal to nature's; one result is the development of at least 150 dead zones in the oceans due to overfertilization. We already consume or destroy each year about 40 percent of nature's photosynthetic output, leaving too little for other species. Freshwater withdrawals doubled globally between 1960 and 2000 and are now approaching a quarter of all river flow. The following rivers no longer reach the oceans in the dry season: Colorado, Yellow, Ganges and the Nile, among others. We live in a full world, dramatically unlike the world of 1900, or even that of 1950.

Consider also that all we have to do to destroy the planet's climate and its biota is to keep doing exactly what we are doing today, even with no growth in the human population or the world economy. But human activities are growing – dramatically. It took all of history to build the $7 trillion world economy of 1950, and today we add that amount of economic activity every 5 to 10 years. The world economy is poised to double and then double again by mid-cen-

tury. This economic growth cannot resemble the growth of the past; it requires new designs and new technologies. Everything must be different – construction, manufacturing, energy production, transportation, forestry and agriculture, all very different.

Finally, consider that political, technological and social changes take time. We are now in the most important race in human history – the race to change our politics, our technology and our personal consumption choices much faster than the world economy grows. Only unprecedented action taken with a profound sense of urgency can forestall an appalling deterioration of our natural assets. This is the challenge of environmental management.

To prepare for this race, we are building a new academic field, an inter-discipline called "environment." It is the rigorous scientific study of the interactions between human societies and the natural world of the biosphere. Knowledge generated in this new field becomes the basis for environmental management. We need a new generation of professionals trained in environmental management, and we also need the knowledge of environment to infuse the traditional professions – business, law, science and engineering, medicine, and so on – and to motivate a revolution in personal choice as each of us carries out daily life as consumer, family member, investor, joiner, worshipper, worker, and voter. Environmental management thus becomes a civic responsibility of the first order.

It is good that we are now in the midst of a necessary and timely paradigm shift in our thinking about environmental management. In 1970, when the modern era of environmental concern was born, the environmental style was confrontational; business was the enemy. Today, we must try to put collaboration ahead of confrontation. Business must be on board, not overboard. We must all be environmentalists now.

In 1970, we created a separate environmental sector; today, we must make every economic sector an environmental sector. Every government agency must be an environmental protection agency.

In 1970, it was "put the polluters in a straightjacket." Today, it is let them out of the regulatory tangle if they can show they have a solution that is better. Then, our approach was command and control; today, it must also be goals and incentives.

In 1970, we were *against*; today, we must be *for*. Then, we defined problems; today, we must design solutions. Then, we responded; today we must anticipate.

In 1970, technology was the devil that got us into this mess. Today, we know that technology– soft and hard – must get us out of this mess. In 1970 it was end of pipe; today we must end the pipe.

In 1970 we saw an unguided market taking us over the cliff. Now, we know that the market can be guided for environmental as well as economic goals. But that guidance requires government action to get the prices right – environmentally honest prices. Anti-government ideologues would rob us of the power of collective action for our common future.

In 1970, it was environmental protection; today, it is sustainable development – sustainable development in the poorer countries, for we will never sustain the biosphere unless the poorer countries are realizing their development and anti-poverty objectives, and sustainable development for the rich, for success at the triple bottom line of environment-economy-society is a more worthy goal than achieving another 3 percent growth in GDP.

In 1970, it was national; today, it is "glocal." Pollution has gone global; species have gone global; and so must environmental management. Global governance must come to the environment. We need a WEO as strong as the WTO. Environmental diplomacy is not a sideshow; it's the main event. But, in the end, we know that all action is local. Our lives are local lives. The struggle begins locally.

In 1970, we took a top-down approach; now, we must encourage innovative bottom-up, grassroots approaches – green jazz that is unscripted, improvisational and creative.

In 1970, we were too elitist. Now we must stress justice and equity: equity among nations, equity within nations, equity between the sexes, all in addition to equity to future generations. We have created wonderful protected areas but sometimes neglected the poor, the minorities, the victims, the indigenous peoples. Let their environmental rights now be asserted.

In 1970, it was species; today it is ecosystems. We should have always known this: Human societies are utterly dependent on provisioning by nature's ecosystems. But we forgot it.

We must at long last take Aldo Leopold and his land ethic seriously. "A thing is right," he said, "when it tends to preserve the integrity, beauty and stability of the biotic community." Just as we have rights, the land community does also.

In 1970, we looked for government leadership. Today, we must often do it ourselves, with or without government. Business is often ahead of government; scientists are often ahead of government; consumers and environmentalists are often ahead of government. We should not wait for government. We must push it forward with us. Politicians ride the waves, as everyone knows. Citizens make waves.

In 1970, we were from Mars; today, we must be from Venus. Then, we broke things down to the component parts and laid out rational plans of attack. Now we know the most important resource is human motivation – hope, caring, our feelings about nature and our fellow humans. Today we need the preachers, the philosophers, the psychologists, and the poets! In one poem, W.S. Merwin said: "On the last day of the world I would want to plant a tree." And in another: "I want to tell you what the forests were like/I will have to speak a forgotten language."

"After the final no," Wallace Stevens wrote, "there comes a yes. And on that yes the future of the world depends." Despite the daunting projections of environmental decline, we affirm that we will win this struggle for the future. Yes.

And here we come full circle, for there is something vital from 1970 that we need to rekindle and rebuild, rather than move beyond, and that is the extraordinary spirit of that moment and the widespread popular demand for far-reaching change. One can hear that demand plainly in the words citizens of Santa Barbara sent to the U.S. Congress in 1970 shortly after the devastating oil spill there: "We, therefore, resolve to act. We propose a revolution in conduct toward the environment…Today is the first day of the rest of our life on this planet. We will begin anew."

It can seem that we are now a long way from the prosaic subject of environmental management, but we are actually at the heart of the matter.

Lecture

Coming to Terms with Global Environmental Deterioration

Professor James Gustave Speth

I should begin by expressing my great appreciation in receiving the Blue Planet Prize. It is an honor indeed to receive this Prize from such a distinguished organization and to join Harold Mooney and the other extraordinary individuals and groups that have been previously recognized by you. I am deeply grateful.

A great tragedy is fast unfolding. Over 20 years ago the alarm was sounded regarding a set of linked threats to the global environment. Today, the rates of environmental deterioration that stirred the international community 20 years ago continue essentially unabated. The steps that governments have taken over these two decades represent the first attempt at global environmental governance. It is an experiment that has failed.

It would be comforting to think that all the international negotiations, summit and conference agreements, conventions and protocols have at least got us to the point where we are prepared to act decisively – comforting but wrong. The problems have gone from bad to worse; we are not yet prepared to deal with them; and, at present, some major countries lack the leadership to get prepared.

The Global 2000 Report

Global-scale environmental challenges first moved into politics in the US when President Carter asked a group of us in his administration to prepare what became the 1980 *Global 2000 Report to the President.* Our task was to sketch what trends might unfold between 1980 and 2000 in population and environment if societies stayed with a business-as-usual approach. Now, from the perspective of 2002, we can look back and see what actually happened.

First, *Global 2000* projected that population would grow from 4 billion to 6.3 billion by 2000. The actual number was 6 billion, so we were more or less on target. The report projected that deforestation in the tropics would occur at rates in excess of an acre a second, and for twenty years, an acre a second, that is what has happened. It projected that 15 to 20 percent of all species could be extinct by 2000, mostly due to tropical deforestation. Stuart Pimm and Peter Raven have recently estimated conservatively that there are about seven million species of plants and animals. Two-thirds of these species are in the tropics, largely in the tropical humid forests. They estimated that half the tropical forests have been lost and, with them, that about 15 percent of tropical forest species have already been doomed. So there is evidence that our species loss estimate was not far off the mark.

The report projected that about 6 million hectares a year of drylands, an area about the size of Maine, would be rendered barren by the various processes we describe as desertifica-

tion. And that continues to be a decent estimate today.

We predicted that:

"Rising CO_2 concentrations are of concern because of their potential for causing a warming of the earth… the doubling of the CO_2 content of the atmosphere could be expected after the middle of the next century…The result could be significant alterations of precipitation patterns around the world, and a 2 degree to 3 degree Celsius rise in temperatures in the middle latitudes of the earth."

Twenty-two years later, this description still falls neatly within the range of current estimates.

In other words, the basics about emerging global-scale environmental concerns were known more than 20 years ago. Some projections, like those on the prices of food and minerals, *Global 2000* got wrong, but on most of the big issues of population, environment and development, the report pointed squarely to the trend and the stakes. Other reports – from the United Nations Environment Programme, the Worldwatch Institute, and elsewhere – were saying much the same around this time. So, political leaders and others were on notice twenty years ago that there was a new environmental agenda, more global, more threatening and more difficult than the agenda that spurred the environmental awakening of the late 1960's and early 1970's.

Major Global-Scale Environmental Challenges

Today, our information on global environmental trends is far more complete and sophisticated, but it is not more reassuring.

- Half the tropical forests are gone, and non-OECD countries are projected to lose another 10 percent of their forests by 2020. But this data gives an unduly rosy picture. Cryptic deforestation – the cumulative impacts of fire, El Nino-driven drought, and fragmentation in major forest areas, such as those in Brazil and Borneo – greatly exacerbate the effects of forest clearing. And much of what's left is under contract for logging. Eighty percent of Borneo's forest cover is said to be allocated to commercial logging and plantations.
- A fourth of bird species are extinct, and another 12 percent are listed as threatened. Also threatened are 24 percent of mammals, 25 percent of reptiles and amphibians, and 30 percent of fish species. The rate of extinction of birds and mammals today is estimated at 100-1000 times the natural background rate.
- We are now appropriating, wasting, or destroying about 40 percent of nature's net photosynthetic product annually. This does not leave much for other species. We are consuming about half the available fresh water. Most people will soon live in water stressed areas. We are fixing nitrogen at rates that exceed nature's, and among the many consequences of the resulting overfertilization are fifty dead zones in the oceans, one in the Gulf of Mexico the size of New Jersey.
- Globally, we have lost a third of agricultural land due to soil deterioration over the last forty years.

- In 1960 five percent of marine fisheries were either fished to capacity or overfished. Today 70 percent of marine fisheries are in this condition.
- Half of the world's mangroves and wetlands have been destroyed.
- Hardest hit of all are freshwater ecosystems around the globe.

On top of these processes of biotic impoverishment comes the biggest threat of all, global climate change. Few Americans appreciate how close we are in the United States to the widespread changes in the American landscape. The best current estimate is that, absent major corrective action, global warming over the lifetime of an American born today will likely make it impossible for about half the American land to sustain the types of plants and animals now on that land. A huge portion of our protected areas – everything from wooded lands held by community conservancies to our national parks, forests, and wilderness – is now threatened. In one projection, the much-loved maple-beech-birch forests of New England simply disappear. In another, much of the Southeast becomes a huge grassland savannah unable to support forests because it is too hot and dry.

Underlying Forces Driving Deterioration

We know what is driving these global trends. The much used "IPAT equation" sees environmental Impact as a product of the size of human Populations, our Affluence and consumption patterns, and the Technology we deploy to meet our perceived needs. What this useful IPAT formulation can obscure, in addition to the impacts of poverty, is the vast and rapidly growing scale of the human enterprise. It took all of history for the world economy to grow to $6 trillion in 1950. Today, it grows by more than that every five to ten years. Since 1960, gross world product has doubled, and then doubled again.

Today the world economy is poised to double and then double again in the lifetimes of today's students. We could not stop this growth if we wanted to, and most of us would not stop it if we could. Half the world's people live on less than $2 per day. They both need and deserve something better. Economic expansion at least offers the potential for better lives, though its benefits in recent decades have been skewed.

There are good reasons to believe that the next doubling of world economic activity will differ in some respects from the growth of the past. But there are equally good reasons to believe that the next doubling of the world economy will, from an environmental perspective, look a lot like the last. The U.S. Energy Information Agency predicts a 65 percent increase in global CO_2 emissions between 2000 and 2020. The OECD estimates that its members' CO_2 emissions will go up by about a third percent during this period. Motor vehicle use in OECD countries is expected to rise by 40 percent by 2020.

The Challenge Today

The implications of all this are very profound. We have entered the endgame in our traditional, historical relationship with the natural world. The current Nature Conservancy campaign has an appropriate name: they are seeking to protect The Last Great Places. One senses that we are in a rush to the finish. Soon, metaphorically speaking, whatever is not protected will be paved.

The work of Pimm and Raven suggests that the loss of half the tropical forests costs us

15 percent of the species there. But further forest destruction will be disproportionately costly. More generally, attacks on the environment will be increasingly consequential. Whatever slack nature cut us is gone.

Humans dominate the planet today, as never before. We live in a full world. We impact hugely on the great life support systems of the planet. Nature as something independent of us is dead. We are in a radically new ethical position because we are at the planetary controls.

Limits of Environmental Governance to Date

Looking back, it cannot be said my generation did nothing in response to Global 2000 and similar alerts. Progress has been made on some fronts. There are outstanding success stories, but rarely have initiatives been commensurate with the problem. For the most part, we have analyzed, debated, discussed, negotiated these issues endlessly. My generation is a generation, I fear, of great talkers, overly fond of conferences. But on action, we have fallen far short. As a result, the threatening global trends highlighted 20 years ago are still very much with us, depletion of the stratospheric ozone layer being the notable exception.

But if we have not actually done much, perhaps we have in these 20 years laid a good foundation for rapid and effective action today. Perhaps all the international conferences, treaties and action plans have given us the policies and programs we now need, and we can at last get on with it. Here we arrive at a second set of distressing trends, those in the area of policy and institutional development.

The results of twenty years of international environmental negotiations are, if truth be told, rather limited. It is not that what has been agreed, for example, in the framework conventions on climate, desertification and biodiversity, is wrong or useless. Those conventions have raised awareness and stimulated some useful national planning exercises. But these treaties are mostly frameworks for action: they do not drive the changes that are needed. And the same can be said for the extensive international discussions on world forests, which have never reached the point of a treaty. In general, international environmental law and its 250 treaties is plagued by vague agreements, minimal requirements, lax enforcement and underfunded support.

The weakness of those international treaties should not be a surprise, given that they were forged in negotiating processes that give maximum leverage to any country with an interest in protecting the *status quo*. Similarly, the international institutions created in the United Nations to address these issues – the United Nations Environment Programme and ECOSOC's Commission on Sustainable Development – are among the weakest multilateral organizations and are presumably kept that way intentionally.

A deeper question is whether we are on the right track with the current emphasis on negotiating global agreements. My own view is that we have badly over-invested in international environmental law to the neglect of other approaches, including measures that would enhance the prospects for effective agreements.

The Kyoto Protocol is an effort to step beyond the framework and reach a binding, action-forcing agreement on climate change. There are three things one can say in favor of the Kyoto Protocol:

- A bird in hand is worth two in the bush;
- sooner the world gets a clear signal that the industrial nations have capped CO_2 emissions, the better;
- The developing countries are correct in wanting to see the industrial countries act first and most, and the Kyoto Protocol takes this approach.

These are powerful considerations, and the Bush Administration should join with the rest of the world in supporting this agreement. It is deplorable that it has not, and, unfortunately, the Administration's recently announced climate initiative would allow U.S. emissions to rise at the same rate they did for the past decade.

That said, we must guard against letting debates about the Kyoto Protocol deflect attention from addressing the long-term challenge of holding cumulative global emissions of carbon dioxide and other greenhouse gases below certain levels. Also, we still have a long way to go to make the protocol's flexibility mechanisms, land use provisions and other difficult and complex provisions actually work effectively in the real world.

The bottom line, in any case, is that however one looks at the matter, we are in poor shape when it comes to climate policy. The twenty years have not been put to very good use.

Promoting the Transition to Sustainability

How then should we move forward? I believe there are seven dimensions where progress, indeed transformation, is necessary to achieve sustainability. There are hopeful developments in each of these seven areas, and we should build on them. We should be promoting these transitions – investing much more heavily in them – because they address directly the underlying drivers of large-scale environmental deterioration.

The first of these transitions to sustainability is the need for an early demographic transition to a stable world population. Here there is definite progress. The mid-range projection for 2050 was recently 10 billion people; now it is 9 billion. One projection of developing country population in 2100 was 10.2 billion. Analyses suggest that an escalation of proven approaches could reduce this number to 7.3 billion, with global population leveling off at 8.5 billion. The main need here is adequate funding for the United Nations' Cairo Plan of Action, which is being underfunded by half.

The second transition is the human development transition to a world without mass poverty, where the prospects for widely shared prosperity are good. Environmentally, we need this transition, first, because over much of the world poverty is an important destroyer of environment; the poor have no choices other than to lean too heavily on a declining resource base. But we also need this transition because the only world that works is one in which the aspirations of poor people and poor nations for fairness and justice are being realized. Developing country views in international negotiations on environment are powerfully shaped by fear of the costs of environmental measures, preoccupation with their own compelling economic and social challenges, and distrust of industrial country intentions and policies. Sustained and sustainable human development provides the only context in which there is enough confidence, trust, and hope to ground the difficult measures needed to realize environmental objectives.

There is some good news to report on the development front. An impressive consensus

has emerged around objectives. The international community has come together with a concerted commitment to the goal of halving the incidence of absolute poverty by 2015. This goal and others dealing with health and education were endorsed by all governments in the Millennium Assembly of the United Nations. Eliminating large-scale poverty is no longer an impossible dream. It could be accomplished in the lifetimes of today's young people. But, as with population, a serious threat to achieving these goals is limited development assistance, in this case compounded by protectionist trade regimes, and heavy debt burdens.

The third transition is a transition in technology to a new generation of environmentally benign technologies. We need a worldwide environmental revolution in technology. The only way to reduce pollution and resource consumption while achieving expected economic growth is to bring about a wholesale transformation in the technologies that today dominate manufacturing, energy, transportation, and agriculture.

The good news here is that across a wide front, technologies that would bring about a vast improvement are either available or soon can be. From 1990 to 1998, when oil and natural gas use grew globally at a rate of 2 percent annually, and coal consumption grew not at all, wind energy grew at an annual rate of 22 percent and photovoltaics at 16 percent. Denmark now gets eight percent of its energy from wind; Japan last year installed 100 megawatts of photovoltaic power. Transformation of the energy sector must rank as the highest priority.

The fourth transition is a market transition to a world in which prices reflect the full environmental costs. The needed revolution in technology and the equally needed changes in consumption patterns will not happen unless there is a parallel revolution in pricing. The corrective most needed now is environmentally honest prices. Full cost pricing is everywhere thwarted today by the failure of governments to eliminate environmentally perverse subsidies (estimated globally at $1.5 trillion) and to ensure that external environmental costs are captured in market prices.

One of the most hopeful developments today is the tax shift idea adopted in Germany and many other European countries. Moving in four stages starting in 1999, the German policy is to shift the tax burden from something one wants to encourage – work and the wages that result – to something one wants to discourage – energy consumption and the pollution that results.

The fifth transition is a transition in consumption from unsustainable patterns to sustainable ones. Here, one very hopeful sign is the emergence of product certification and green labeling and public support for it. This trend started with the certification of wood products as having been produced in sustainably managed forests and has now spread to fisheries and to building design. Increasingly, consumers are voting green in the marketplace, and that is driving change. Another hopeful sign is the new legislation in Europe and Japan requiring that consumer durables be recycled; some require that manufacturers take back their products when use is finished.

New Initiatives in Global Environmental Governance

The sixth transition is a transition in governance. The World Business Council for Sustainable

Development has sketched several broad paths in environmental governance. One they call "FROG" First Raise Our Growth. Let's solve our economic challenges first, it says. FROG is a business-as-usual scenario, leading to huge environmental costs, social inequity, and often social instability. It is a failure scenario, even in the eyes of business leaders.

The two other scenarios are success scenarios in which sustainability is vigorously pursued. But they are very different. In one, "GEOPolity," people turn to government to focus the market on environmental and social ends and rely heavily on intergovernmental institutions and treaties.

The final scenario is a "JAZZ" world of unscripted initiatives, decentralized and improvisational. There is abundant information about business behavior; good conduct is enforced by public opinion and consumer behavior. Governments facilitate; NGOs are very active; business sees strategic advantage in doing right thing.

The initial international response to the global change agenda has been to try to move the world from FROG to GEOPolity. It isn't working. Getting serious about governance requires new action on two mutually supportive fronts:

- Pursuing a radically revised approach to GEOPolity
- Taking JAZZ to scale

The current world of GEOPolity is a world that is designed to fail. It can be redesigned for success by insisting on new norm-setting procedures and new institutions, including a World Environment Organization. The case for an effective WEO is as strong as for an effective WTO. The international community knows how to create plausible multilateral arrangements and has often done so in other, mostly economic, areas.

A second path to the future is to implement measures that can take JAZZ to scale. JAZZ is the most exciting arena for action today, with an outpouring of bottom-up, unscripted initiatives from business, NGOs, governments, and others.

- Seven large companies – DuPont, Shell, BP Amoco, Alcan among them – have agreed to reduce their CO_2 emissions 15 percent below their 1990 levels by 2010. Indeed, Alcoa is reported to be on track to reduce its emissions 25 percent below 1990 levels by 2010, and DuPont is on schedule to reduce emissions by 65 percent.
- Eleven major companies – DuPont, GM, IBM among them – have formed the Green Power Market Development Group and committed to develop markets for 1000 megawatts of renewable energy over the next decade.
- Home Depot, Lowes, Andersen and others have agreed to sell wood (to the degree it's available) only from sustainably managed forests certified by an independent group against rigorous criteria. Unilever, the largest processor of fish in the world, has agreed to the same regarding fish products.

NGOs had important roles in forging these corporate initiatives. They are the real maestros of JAZZ. Local governments, universities and other entities have also contributed. Over 500 local governments have now joined a campaign to reduce greenhouse gas emissions.

Finally, there is the most fundamental transition of all – a transition in culture and consciousness. Clearly we need new habits of thought – a new world view. Paul Ehrlich recently wrote that, "Our global civilization had better move rapidly to modify its cultural evolution and

deal with its deteriorating environmental circumstances before it runs out of time." He notes that the potential for conscious evolution is evident in great social movements that societies have already experienced, such as the abolition of slavery and the civil rights movement. It is possible that we are seeing the birth of something new – a change of consciousness – in the anti-globalization protests, in the far-reaching and unprecedented initiatives being taken by some private corporations, in the growth of NGO's and their innovations, in scientists speaking up and speaking out, and in the outpouring of environmental initiatives by the religious community. We must certainly hope that something new and vital is afoot. And, ironically, what may drive this consciousness as much as anything else is the reality of anthropogenic climate change.

These are all hopeful signs, but to be honest we must conclude that we are at the early stages of the journey to sustainability. Meanwhile, the forward momentum of the drivers of environmental deterioration is great. We are moving rapidly towards a swift and appalling deterioration of our natural world. Time is the most important variable in the equation of the future. What we will do tomorrow we should have done yesterday. Only a response that in historical terms would come to be seen as revolutionary is likely to avert these changes.

A phenomenal expansion of economic activity is projected for the decades immediately ahead. An already full world will soon be very full indeed. Down one path, this growth can protect, regenerate and restore the environment. It can provide sustainable livelihoods for the world's poor, and lead to large improvement in the quality of life for all. There is still world enough and time for this century to see the coming of a future more wondrous, intimate, and bountiful than our scenarios can imagine. But this world will not be won without a profound commitment to urgent action. President Kennedy often told the story of the aged Marshal Lyautey of France debating with his gardener about planting a certain tree.

"It will not bloom," the gardener argued, "for decades."

"Then," said the marshal, "plant it this afternoon."

Thank you.

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Professor James Gustave Speth

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