Proceedings of 2012 Blue Planet Prize Commemorative Lectures

公益財団法人 旭硝子財団
THE ASAHI GLASS FOUNDATION

CONTENTS

Dr. Thomas E. Lovejoy (USA)

Professor, Environmental Science and Policy, George Mason University

Selection rationale: Becoming the first person to clarify human caused habitat fragmentation damaged biodiversity and gave rise to environmental crisis. Since then, he has been influencing the world for environmental conservation.

Education and Academic and Professional Activities

1941	Born in USA
1955-1959	Millbrook School Becomes interested in biology while in the Millbrook School, a private boarding school providing secondary education
1964	Receives bachelor's degree in biology from Yale University
1964-1965	Yale University Carnegie Teaching Fellow
1965	Conducts research in the Brazil's Amazon region as a tropical biologist and conservation biologist. During that time, he acts as a go-between for science and local environmental policies
1971	Receives Ph.D. in biology from Yale University; receives guidance from Dr. G. Evelyn Hutchinson
1970s	Engages in activities for informing the general public about deforestation
1970s-1980s	Member of World Wildlife Fund (program director, vice president of science)
1973-1987	Leads an environmental conservation program at the World Wildlife Fund (now World Wide Fund for Nature) with Michael Soule and Bruce Wilcox
1978	Organizes the world's first international conference on conservation biology with B. A. Wilcox et al. (La Jolla) and plays a significant role in the establishment of conservation biology
1979	Launches the Biological Dynamics of Forest Fragments Project
1980	Introduces the term "biological diversity" in two publications Predicts that 20% of all species around the world will have died out by 2020 Becomes the world's first person to publish the extinction rate of species around the world (in the "Global 2000 Report to the President")
1980s:	Directs the world's attention to tropical rainforests, mainly in Brazil's Amazon region
1982	Becomes one of the creators of the television series "Nature" broadcast on PBS, Discovery Channel and many other channels, and largely influential on the general public
1987-1998	Assistant secretary for environmental and external affairs, Smithsonian Institution
1989	Introduces the debt-for-nature swap to the World Wide Fund for Nature
1989-2009	Science and environment adviser to Reagan, Bush and Clinton administrations
1992, 1997	Published *Global Warming and Biological Diversity* with Robert L. Peters Article about Biological Dynamics of Forest Fragments Project (BDFF Project) is published (Bierregaard et al. and Laurence)
1993	Science adviser to the US Secretary of the Interior
1994	Counselor to the Secretary of biodiversity and environment, Smithsonian Institution
-1998	Director of environmental conservative biology, Smithsonian Institution
1999	Chaired subcommittee of the OECD Megascience recommending establishment of a Global Biodiversity Information Facility (a global data base on biodiversity information). GBIF was created in March 2001
2002-2008	President of the Heinz Center
2008	Biodiversity Chair at the Heinz Center Advocated ecosystem restoration at a planetary scale as a means to reduce CO_2 concentrations in the

	atmosphere in an International Herald Tribune op-ed with Tim Flannery and Achim Steiner (October 28)
2009	National Geographic Society Conservation Fellow and chair of the Scientific Technical Advisory Panel for the Global Environment Facility
2010	University Professor of Environmental Science and Policy George Mason University co-chair of the review of the Third Global Biodiversity Outlook (GBO3) and presented it to the United Nations General Assembly

Major Awards Received

1998	Order of Brazil in the Grade of Grand Cross (science)
2001	Tyler Prize for Environmental Achievement
2005	Ralph W. Schreiber Conservation Award
2009	Frontiers of Knowledge Award (Ecology and Conservation Biology category)

Dr. Lovejoy is responsible for a long list of creative and important contributions to research on the severe impact of land use on biodiversity and ecosystems. As early as 1965 he began researching ecosystems in Brazil's tropical Amazon rainforest. In 1967, he started the bird banding[2] in the tropical rainforest, and observed migrant birds inhabiting the Amazon in terms of biocenology[3].

In 1987, Dr. Lovejoy began his fieldwork in the Amazon as a researcher with the Smithsonian Institution and an onsite researcher with the World Wildlife Fund (now World Wide Fund for Nature). Appointed as a leader of a collaborative project of the Smithsonian Institution and the Instituto Nacional de Pesquisas da Amazonia (INPA) in 1979, he led American and Brazilian researchers and performed a pioneering landscape experiment[1], the largest long-term such experiment in the history of landscape ecology. The experiment, known as the Biological Dynamics of Forest Fragments Project (BDFFP), were supported by the early work of Dr. Lovejoy about bird banding[2] started in 1967, Dr. Lovejoy's group based its research on the unique concept of minimum critical area[4] of ecosystems. The research showed marked superiority of a well-organized protected zone over a compactly fragmented protected zone of the same acreage in terms of species survival. It also provided useful guidelines for the design and management of large natural parks and reserves. Apart from leading to 600+ academic papers, well over 100 theses and numerous books, the project has provided Latin American biologists with important venues for fieldwork training for many years. Disappearance and fragmentation of habitats, discovered in the project, are now considered to be one of the great threats to biodiversity along with climate change.

In the 1970s, Dr. Lovejoy was devoted to activities for educating the public on the impact of decreased tropical rainforest. In 1980, he published an estimated species extinction rate and became the world's first person to sound the alarm for species extinction at the policy level.

Dr. Lovejoy was also the first to clarify the unpredictable and profound characteristics of “habitat fragmentation” affecting biodiversity and carbon pool dynamics through, for example, the accelerated destruction of rainforest. Through his research, he put forth profound insight into environmental conservation science and its practice. One outstanding contribution was developing debt-for-nature swaps[5], an important policy mechanism for addressing the impact of major change such as deforestation and climate change on tropical rainforests, and for the protection of natural landscape. Since 1989, debt-for-nature swaps have been implemented in upward of , definitely, more than 11 countries. An environmental foundation worth much more than $1 billion has been established with an aim of conserving nature and a biological protection area of at least one million hectares. Debt-for-nature swaps are among the largest sources of financing to support international environmental projects.

The Brazilian government awarded Dr. Lovejoy the Order of Rio Blanco decoration for his commitments to numerous environmental conservation activities in Brazil, and he was the first environmental scientist to receive the award. In 1998, the Brazilian government also awarded him the Order in the Grade of Grand Cross in Science.

Other career highlights

Dr. Lovejoy was born on August 22, 1941 in New York. He became interested in biology at the age of 14 as a student at the Millbrook School (Millbrook, NY). He received a bachelor's degree (1964) and Ph.D. (1971) in biology from Yale University. In 1964-1965, he was the Yale Carnegie Teaching Fellow. He also served as an assistant researcher of the Belem Project at the National Museum of Natural History of the Smithsonian Institution and the planning executive assistant at the Academy of Natural Sciences, Philadelphia. From the mid-1970s to mid-1980s, he assumed many important positions, including program director, science vice president and executive vice president at the World Wild Fund for Nature (WWF, United States). In 1987, he was transferred to the Smithsonian Institution as assistant secretary for environmental and external affairs. He was appointed as science adviser to the US Secretary of the Interior in 1993, counselor to the Secretary of biodiversity and environment at the Smithsonian Institution in 1994 and director of conservative biology there until 1998. Serving on the advisory council for science and the environment in the Reagan, Bush and Clinton administrations, Dr. Lovejoy exerted influence based on his unique analysis and understanding of ecosystems. He also trained environmental conservation specialists from Latin American and Caribbean nations in an effort to help improve the global environment. He worked for the World Bank as its chief biodiversity adviser and a leading specialist concerning environmental issues of Latin American and Caribbean countries.

Dr. Lovejoy was one of the chairs of the Society for Conservation Biology in its first years. He has been a member of numerous science/conservation boards and advisory groups, such as the New York Botanical Garden, Global Environment Facility (GEF), Committee for the National Institute for the Environment, Royal Botanic Gardens, Kew, World Wildlife Fund and Resources for the Future and World Resources Institute.

Dr. Lovejoy is a fellow at the American Academy of Arts and Sciences, American Association for the Advancement of Science, American Ornithologists' Union, American Philosophical Society and Linnean Society of London.

He received the Tyler Prize for Environmental Achievement in 2001, Ralph W. Schreiber Conservation Award in 2005 and BBVA Foundation Frontiers of Knowledge Award in Ecosystems and Conservation Biology in 2009. He was appointed as Conservation Fellow for *National Geographic* in 2009.

In 2002-2008, Dr. Lovejoy was President of the Heinz Center (Washington, D.C.), a research institute on science, economy and environment, and is currently its biodiversity chair. In 2010, he was appointed as University Professor of environmental science and policy at George Mason University (US).

Dr. Lovejoy made pioneering achievements in the field of biodiversity, which is regarded today as a serious topic of concern in the global environment. Notably, he warned the entire world of the fact that the tropical Amazon rainforest, the "lungs of the Earth," is facing a crisis. In 1980, he coined the term "biological diversity," which was abbreviated later as "biodiversity" , popularized worldwide and is already common knowledge for people connected with the environment. This fact alone speaks of the significance of influence he has exerted. Through publications and lectures, Dr. Lovejoy is committed to informing the general public on the possibility that population increase, depletion and extinction of habitat environments, climate change, environmental pollution, excessive deforestation and other forms of excess exploitation of plant and animal life could induce a rapid increase of species extinction worldwide. He has been proactively devoted to numerous efforts such as testifying before the US Congress and the broadcast of the television series “Nature,” which was well received by audiences and became a long-running hit.

Dr. Lovejoy has published numerous scientific papers and coauthored or coedited the following books.

Key Environments: Amazonia (coauthored with G. T. Prance); *Global Warming and Biological Diversity* (coauthored with R. L. Peters); *Ecology, Conservation and Management of Southeast Asian Rainforests* (coauthored with R. Primack) and *Lessons from Amazonia* (coauthored with R. O. Bierregaard Jr., C. Gascon and R. Mesquiuta)

Climate Change and Biodiversity (coauthored with Lee Hannah)

1 Landscape experimentation involves analysis of the extensive impact of “habitat fragmentation.” This is aimed at studying the impact on the entire tropical rainforest as the system accompanying changes in land use. As the original habitats of organisms are replaced by farmlands, urban areas and artificial forests, a decrease in the ratio of habitat to landscape is referred to as “loss of habitat.” Isolation of a habitat area resulting from a decrease in its acreage is referred to as habitat fragmentation.

2 In bird banding, birds are released after a small band with a symbol or number is attached around their leg. Then they are collected and identified by the number written on the band in order to obtain accurate knowledge on their movement and longevity.

3 Biocenology aims to clarify the relationship among organisms inhabiting the same area (interspecies relationship) or to obtain knowledge about their mechanisms (community structure).

4 In a fragmented and small island-like patch, species decrease due to unsustainability of the biodiversity existent before fragmentation. The inflow of new species shrinks and, consequently, species extinction is triggered.

5 This is a mechanism for requiring implementation of a nature reserve conservation program on the condition that the accumulating foreign debt borne by developing countries is shouldered.

A Wild Solution for Climate Change

Dr. Thomas E. Lovejoy

When the nations of the world returned to Rio this past June, it was apparent that collectively they had failed to address the great environmental problems of our planet at the scale and with the urgency required. Nothing demonstrates that better than the planetary boundaries analysis produced by Johan Rockstrom of the Stockholm Environment Institute and his colleagues in 2009. This now classic diagram shows that for those environmental vectors for which adequate data exist that three have been seriously transgressed. One is the distortion of the nitrogen cycle: as a consequence of agriculture and other human activities, the planet now has twice the natural mount of biologically active nitrogen. The second is climate change, which, for reasons I will explain in this lecture, is surely underestimated in the diagram. The third and by far the greatest is loss of biological diversity. This latter is exactly what is to be expected: by definition environmental problems affect living systems so biodiversity basically integrates all environmental problems. In this talk I will dwell principally on biodiversity and climate change which are very tightly linked both negatively or positively.

In 1896 Swedish scientist Svante August Arrhenius asked a very important question, namely, why is the Earth a habitable temperature for humans and other forms of life? Why isn't it too cold? The answer, of course, was the greenhouse effect caused by greenhouse gases that warm the Earth. Impressively, Arrhenius calculated with pencil and paper what doubling pre-industrial levels of CO_2 would do to the average temperature of the Earth, and came up with a figure that is very close to what modern supercomputer models produce.

What Arrhenius would not have known is the detailed history of the climate over the last hundreds of thousands of years, and most particularly, the impressive stability of the climate for the past ten thousand years. That ten millennium period includes all recorded human history, a significant part of the unrecorded history, the origins of agriculture and the origin of human settlements. Essentially the entire human enterprise is based on the assumption of a stable climate.

In that same ten thousand year period all ecosystems have been adjusting to a stable climate.

That is now changing rapidly. Pre-industrial levels of CO_2 in the atmosphere were 280 parts per million (ppm). Current levels are approaching 400 ppm with 400 ppm levels already recorded in some recent Arctic readings. Although there is a lag time for radiant energy to accumulate as a consequence, the Earth's climatic system is responding pretty much as anticipated. The planet is now 0.8 to 0.9 degrees warmer than in pre-industrial times, and global emissions are exceeding the worst case scenario of the last report of the Intergovernmental Panel on Climate Change (IPCC).

There are already signals of response in nature. Some of these involve the solid and liquid phases of water. The most dramatic involve the decline in extent and thickness of the Arctic ocean ice as it has gone through its annual cycle of advance and retreat. Most recently ice twice the size of Manhattan broke off a Greenland glacier.

We also see it in later freezing times and earlier break up of ice of northern hemisphere lakes. Glaciers are in retreat in most parts of the world. Glacier National Park in Montana will soon be that only in name. In the tropics most glaciers are in retreat such that they will gone in less than 15 years.

Other physical changes include sea level rise. Initially just from the physical expansion of water with warmer temperatures, it now is augmented by melt water from glaciers on land. On the Eastern Shore of Maryland, the Blackwater National Wildlife Refuge is experiencing both sea level rise and natural subsidence of the land. It is well on its way to becoming a marine refuge. Intense Tropical Cyclones are probably increasing in frequency. The evidence for that and greater frequency of intense weather events is getting stronger all the time. There is no question about the increased frequency of wildlfire in the western United States. It stems from warmer summers and earlier snow melt.

It is, however, the biological response that this lecture will focus on. Plant species are adjusting their annual cycles. Lilacs are blooming earlier in New England. Several plant species are blooming earlier at the Royal Botanic Garden at Kew. Undoubtedly similar changes are being observed here in Japan. It is not just plant species that are adjusting their timing. Animals are as well. In the United States, tree swallows are migrating earlier, nesting and laying eggs earlier. Even two species of birds have ceased to migrate.

More important, species are changing where they occur. The Edith's Checkerspot butterfly, one of the two most studied butterfly species in North America, has clearly been moving northward and upward in altitude in response to the warming climate. In the Sierra Nevada of California in the vicinity of Yosemite National Park, snow only goes down to 3500 feet above sea level instead of the historical 2,000 feet. As a consequence the Ponderosa Pine which depends on the winter snowpack is dying out at that altitude. In Joshua Tree National Park, the Joshua trees are moving out of the park as they seek their required conditions. The National Arbor Day Foundation, the purpose of which is to help people who like to plant trees, has found it necessary to publish a new hardiness zone map which guides tree planters as to which species are likely to be successful where they live.

Such change is also occurring in the oceans. Fish distributions and plankton distributions are changing. In Chesapeake Bay, the largest estuary in North America, the eelgrass communities are very sensitive to an upper temperature limit. As a consequence the southern boundary of eelgrass communities has been moving steadily northward year after year.

The changes are not just occurring in Arctic, boreal and temperate regions they are also occurring in the tropics. There the changes are sometimes less about temperature except at high altitudes, but more about moisture. In Costa Rica's legendary Monteverde cloud forest, clouds now form with increasing frequency at higher altitude. The result is an increasing number of dry days which could have extremely serious consequences for an ecosystem that depends almost entirely on condensation from clouds as its source of moisture.

Decoupling events are occurring when two tightly associated features use different mechanisms for timing (principally day length vs. temperature). For example snowshoe hares, which change their fur color for seasonal camouflage, are now increasingly seen in bright white winter pelage against no longer white landscapes. On the north coast of Alaska the Black Guillemot nests on shore but flies to the edge of the ice to feed on Arctic Cod. The distance to the sea ice has been getting greater and greater and now at least one nesting colony has failed because the roundtrip distance is too great.

What I have been describing is no longer a matter of individual example or anecdote. Rather it is now statistically robust: nature is on the move almost anywhere scientists are looking in the world.

The foregoing constitutes relatively minor ripples in the fabric of life. The real question is what does it look like looking ahead to a world with more climate change?

When a species' biology is well known it is possible to make projections of where the current climate envelope in which it lives is likely to occur in the future. So the sugar maple so beloved in New England, will -- according to all five major computer models -- occur in a future with double pre-industrial levels of CO_2 only in Canada. Americans who enjoy autumn foliage, maple sugar and syrup will have to make an international trip. Similar kinds of projections have been made for the European beech.

Climate change is not only about temperature. It is also about moisture. For a terrestrial organism the two most important physical parameters are temperature and moisture. For an aquatic one it is temperature and pH (or acidity). All of these are changing. Climate change driven drought has combined with land use change in the Lake Chad Basin so the lake today is only 5% the size it was 35 years ago.

Freshwater ecosystems and species will be affected not only by drought but also by temperature. An example would be cold-water trout species.

Species that occur at high altitudes will be quite vulnerable because at a certain point they can no longer move further up in altitude because there simply will be nowhere to go. One example would be the rabbit relative, the American pika, which occurs in a number of colonies at high altitude in the Rocky Mountains. Projections for the unique (endemic) vertebrate species of the Australian (Queensland) rainforests indicate progressive extinction with increasing warming.

Coastal species will experience change from sea level rise but island species will be even more vulnerable. Those on low lying islands will face their islands disappearing. Those on high islands may be no better off as the climate to which they have adapted no longer occurs and they have nowhere to go to track their required conditions.

So the most immediately vulnerable species will be those occurring in high parts of the landscape, and those on islands. Of course those species with natural histories tightly linked to ice will be exceedingly vulnerable. There are many such species not just the polar bear.

With greater climate change the management challenges for biodiversity conservation become significantly more difficult because of a variety of complications.

The first complication involves human impact on landscapes. Climate change, of course, is nothing new in the history of life on Earth. Glaciers came and went in North America and Eurasia without apparent significant loss of biodiversity. The major difference between the present day and then is that the landscapes are highly modified by human action and most habitats are severely fragmented. The consequence is that as species endeavor to track their required conditions, they are dealing with landscapes that are virtual obstacle courses.

The degree of obstruction is fairly easily dealt with by programs that restore natural connections in landscapes. Restoring riparian vegetation along streams and rivers is not only important for water quality, freshwater ecology and addressing soil erosion, it also puts great connectivity back into landscapes. The ideal will be to move from a world where nature survives in isolated enclaves in human dominated landscapes to one in which human aspirations are pursued within a natural matrix.

A second complication is that biological communities and ecosystems do not move as units. Rather it is individual species that move – each in its own direction and at its own rate. With greater climate change such as occurred after the retreat of the last glacier in Europe, the individual species move and as a result the ecosystems essentially disassemble with the surviving species reassembling into novel ecosystems which are hard to imagine in advance. In an analysis of one insect, two mammal and three tree species after the retreat of the last European glacier, it is clear there is no pattern in common.

A third complication is that even though computer models are all about linear and gradual change, it is clear that there will be both abrupt climatic and ecological change. For example, in the climatic system the global conveyor belt in the oceans that moves heat around the globe (and affects the climate system) has been known to shut down in the geologic past.

Abrupt change is already being observed in biological systems. The coniferous forests of western North America (from southern Alaska to southern Colorado) are experiencing severe die-back (of up to 70% of the trees in some places) because of native bark beetles. With milder winters more beetles overwinter and with longer summers the beetles are able to get in an additional generation. The result is the balance totally turned in favor of the beetles, with serious implications for forest management and fire management. It is hard to envision what these forests will ultimately become.

Similar abrupt change has been observed in tropical coral reefs. There is a fundamental partnership between a coral animal and an alga which lies at the heart of the tropical reef ecosystem. It supports the incredible Technicolor world with great diversity and productivity that benefits the 1/12th of humanity that lives within 100 meters of the reefs.

The partnership is quite vulnerable to just brief periods of warmer water. That causes the animal to expel the alga and then the entire system collapses in what are known as “bleaching events”. The world goes black and white. The diversity, productivity and human benefit crash. This was first observed in 1983 and has been occurring with increasing frequency ever since. With the current climate trajectory, the outlook for tropical coral reefs is bleak.

Climate change is also driving even larger scale change, which can be considered “system change”. One incipient system change involves the vast Amazon forest. The Amazon depends on moisture which comes off the Tropical Atlantic and then is recycled as the air mass moves towards the Andes. As a consequence the Amazon depends on a hydrological cycle which makes perhaps half of the rain in the Amazon.

When rain falls, a significant percentage – 75% in some cases – is returned to the westward moving airmass by evaporation from the complex surfaces of the forest and transpiration of the trees. When the moisture laden air hits the high wall of the Andes most of the water falls as rain forming the Amazon River system. Some of it is deflected and among other things provides rain south of the Amazon to Brazil's major agro-industrial area and all the way into northern Argentina.

There has long been a question of how much deforestation would cause the hydrological cycle to degrade. Then several years ago the Hadley Center's climate change model projected drying in the southern an eastern Amazon at 2.5 degrees of warming. A later run showed it happening at 2.0 degrees. It did not appear in a more recent Hadley run. Ominously, perhaps as previews of Amazon Dieback, the Amazon experienced its worst drought recorded history in 2005 followed by an even more severe drought in 2010.

In the meantime individual research projects on fire and deforestation were pointing to drying of the forest. This led to the World Bank investing one million dollars into a modeling study that for the first time examined the combined effects. The results suggested there could be a tipping point leading to Amazon Dieback at about 20% deforestation – quite disturbing since deforestation stands at close to 19%. The good news is that a proactive reforestation program of mixed natural and production forests could both build back the margin of safety and bring some economic return to the degraded and deforested land.

In 2005 an even greater system change was recognized, namely acidification of the oceans. Until then the role of the oceans in absorbing some of the CO_2 emissions had been considered fortunate, but that some of it would turn into carbonic acid had been ignored. As a consequence the oceans today are 0.1 pH unit more acid than in pre-industrial times – which is 30% more acid since the pH scale is logarithmic.

Beyond the shocking notion that humanity has managed to change the physics and chemistry of two thirds of the planet, this has enormous implications for the tens of thousands of marine species from corals, to mollusks, fish and small plankton that build shells or skeletons of calcium carbonate. They utilize a carbonate equilibrium which is temperature and pH dependent. The colder and more acid the water the harder it is to mobilize the calcium. Effects are already being experienced in oyster beds, and at the base of food chains in the North Atlantic and off Alaska. There, a key affected element in the food chains consists of sea butterflies or pteropods – tiny little snails with a modified foot like wings which enables them to flap and keep themselves up in the water column.

Coral reefs are in double jeopardy> The elevated CO_2 levels in the atmosphere cause warming of ocean waters that affects them seriously. They also push pH to levels where they can't mobilize their needed carbonate.

The above leads to a serious conclusion: the two degree of warming /450 ppm of CO_2 targets of the international negotiations are, in fact, too high. Ice melt is such that the last time the planet was two degrees warmer the oceans were at least four to six meters higher. That will obliterate many island nations as well as flood lower Manhattan and the site of the 1992 Earth Summit and the recent Rio + 20.

It also is clearly too high for ecosystems. Coral reefs require 350 ppm/1.5 degrees or lower. So we are clearly overshooting what might be considered a “safe level of 350 ppm”. Indeed to stop at 2.0 degrees global emissions have to peak in 2016.

So what can be done? Some things are obvious like revising conservation strategies. That would include restoring natural connections in the landscape to facilitate species as they track required conditions, as well as reducing other stresses to minimize negative synergies with climate change.

Another obvious thing is to limit greenhouse gas concentrations by radically revising the energy base for society away from fossil fuels and in favor of various renewable and alternate energies. Important on the agenda should also be minimizing and eliminating the emissions from tropical deforestation (perhaps 15% of current emissions) and other forms of ecosystem destruction and degradation.

As this is clearly insufficient, we must begin to manage the planet’s carbon cycle. That consists of a dynamic of fossil fuel emissions and emissions from deforestation that together contribute 26% of absorbtion by the oceans, 29% by the land, with 45% ending up in the atmosphere adding to the greenhouse gas burden. Part of the challenge is that greenhouse gases stay in the atmosphere trapping radiant heat for hundreds and thousands of years.

That leads an imperative to find ways to pull carbon dioxide out of the atmosphere. Biology can be particularly helpful. Twice in the history of the Earth there have been extremely high CO_2 levels from various geological causes that subsequently were brought down to pre-industrial levels primarily by living processes. The first occurred more than 300 million years ago when plants emerged on land and the second was with the advance of modern flowering plants. This was not just the product of photosynthesis converting CO_2 into plant material. It also involved the creation of soil and the work of myriad soil organisms. It was a virtual biodiversity symphony.

In the current situation, a significant portion of the excess CO_2 in the atmosphere in fact derives from three centuries of ecosystem degradation and destruction – perhaps as much as 40%. Ecosystem restoration at a planetary scale can pull as much as 50 ppm of CO_2 out of the atmosphere over a 50 year period -- or sooner, if the program is accelerated. That is the difference between current levels of CO_2 and what has been suggested (350 ppm) as safer or more judicious.

The above could be achieved by sequestering half a billion tons of carbon per year in reforestation and improved management of forests. It could include an additional half a billion tons of carbon in restoration and improved management of grasslands and grazing lands. A third half a billion tons per year could be sequestered by altering agro-ecosystems from ones which leak carbon to ones which accumulate carbon. These measures would also lead to better grazing, greater soil fertility, and ecosystems more resilient in the face of climate change and other stresses they will experience. There is a parallel and important potential in marine ecosystems – the so-called blue carbon agenda.

All of this would have to be achieved in a world with increasing demand for agricultural production for the (at minimum) two billion additional people expected to be added to a seven billion global population, as well as to some degree for biofuels. Smart management would do this without any further reduction in biodiversity. It would do so out of recognition that 1) we will need to increasingly use biological systems and processes for many purposes because they are inherently cleaner than non-biological ones, and 2) that biodiversity represents a vast living library about working solutions in nature to various problems of biological systems – all of which are potentially of great practical importance.

The 50 ppm will not be enough, however, so there is a serious need to identify economical non-biological ways to pull CO_2 out of the atmosphere. There are no fundamental impediments to doing so; the issue is finding ways to do it that are inexpensive.

Thinking about all of this in the wake of Rio + 20, it is easy to despair when considering the lack of leadership and the weak outcome of the international negotiations. While there is an incredibly urgent need for real leadership, in the mean time there is significant mobilization on the part of civil society and industry. The private sector is so large there can be no sustainable development without its mainstream participation and embrace of green economy initiatives . This calls for a new role for the corporation which, among other things, recognizes the paramount importance of biology in the way the planet works and human society can thrive.

Basically society has to recognize that our planet works as a combined biological and physical system, and that it must be managed in ways that respects and builds on that. We can, in fact, engage biology to re-green the living planet, and make the planet more habitable for humans and other forms of life.