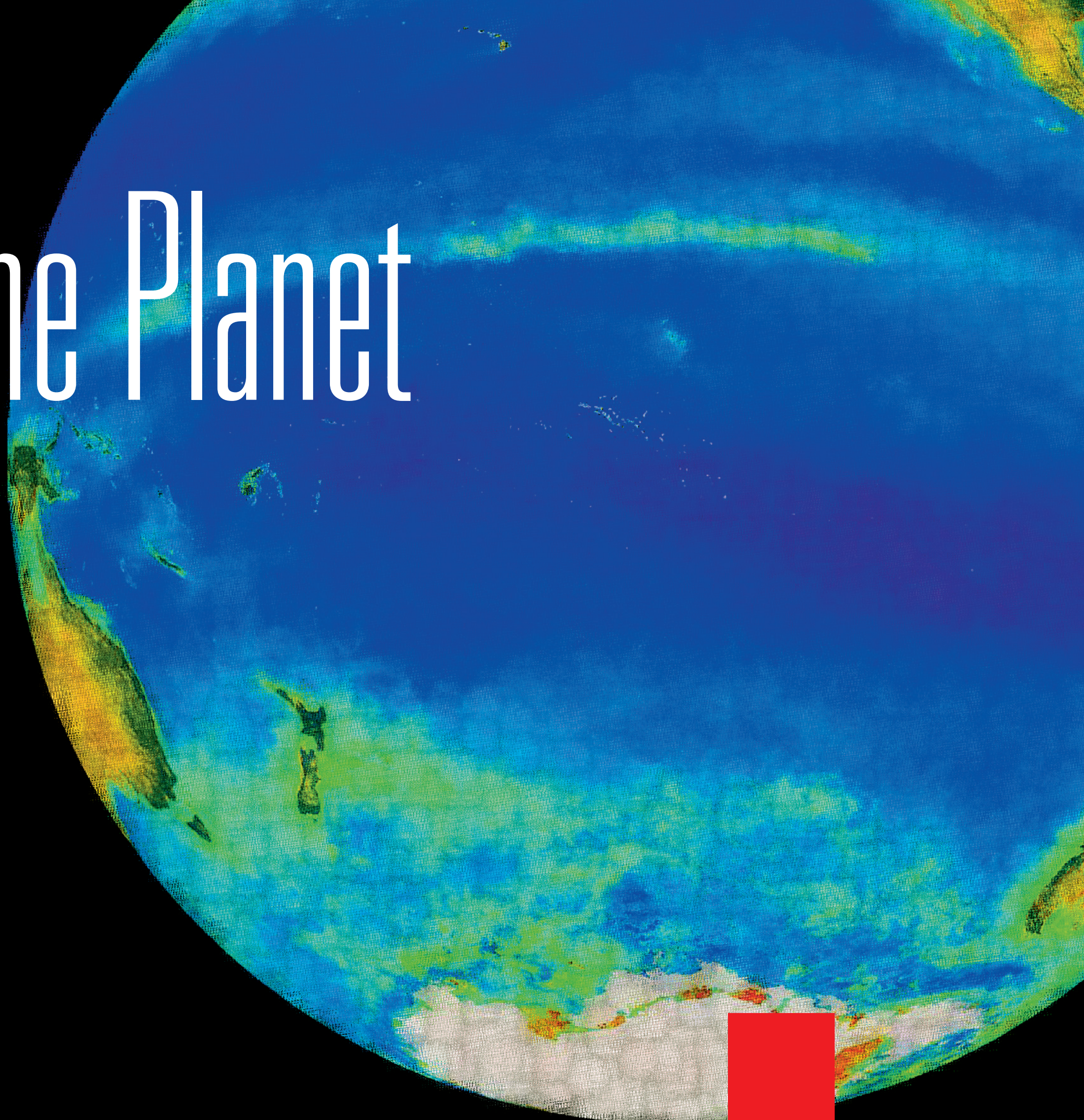
State of the Planet



earth matters

The Columbia Earth Institute: Winter
Issue 8

earth matters

A Publication of the Columbia Earth Institute

state of the planet

by Roberta Balstad Miller and Faye Steingold Yates

...about this Issue

Lamont-Doherty Earth Observatory, the largest component in the Columbia Earth Institute and arguably the organization that singlehandedly laid the scientific foundation for creating the Earth Institute, celebrated its 50th anniversary this year. Since its founding in 1949, the Observatory has been at the forefront of virtually every major discovery in the earth sciences. For example, Lamont-Doherty scientists provided the framework for the theory of plate tectonics, created the first computer model to predict El Niño, and discovered that the Earth's core is spinning faster than the planet itself.

In a tribute to the Observatory's Jubilee, the Earth Institute, together with the Vetlesen Foundation, the Doherty Foundation, the Schlumberger Foundation, Graphic Image, Inc., and the Lamont Advisory Board, hosted a conference on the State of the Planet on November 15-16, 1999. Held in the Rotunda of Low Library on Columbia's Morningside Heights campus, the Conference brought national leaders in science, public policy, business, journalism and even poetry together with Lamont-Doherty scientists to assess not only changes in and on the Earth and its environment but also the impacts of these changes. This issue of *EARTHmatters*, which contains papers prepared by the speakers at the State of the Planet Conference, is devoted to the scientific, public policy, and human issues discussed in the meeting. In the words of Robert Hass, the former Poet Laureate of the United States, who read a poem prepared for the occasion, participants in the Conference spoke to "the riddle we have to interpret,/the future we have to answer to."

The Conference consisted of four half-day sessions, each focused on a different aspect of the impacts of changes in and on the planet: Living in Earth's Changing Climate; Living in a Human-dominated Biosphere; Living with Finite Natural Resources; and Living with Natural Hazards. Participants in the Conference, in addition to the speakers whose papers are featured here, included William F. Baker, President of WNET, Cornelia Dean, Science Editor of *The New York Times*, Ira Flatow, host of National Public Radio's "Science Friday," and Joan Konner, Dean Emerita of Columbia University's Graduate School of Journalism. These four moderated the sessions, which were carried live on www.earthscape.com.

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by Robert Hass

STATE OF THE PLANET

On the occasion of the 50th anniversary of the Lamont-Doherty Earth Observatory

Berkeley, California

1.

October on the planet at the century's end.
Fresh gusts of Pacific wind, on a hillside
On the California coast, are battering a huge,
Scaly, green-black, shank-needled Himalayan cedar,
One of the ancients of the earth, which rocks
As if it were amused. Beneath it, copper-leaved
And sculptural, a Japanese plum. Not Japanese
And not a plum, it doesn't seem to mind its name.
Leaves shivering, it struts and dances in the wind.
Beneath it, a schoolgirl—one of the six billion
Of her hungry and curious kind—buffeted,
Hair flying, negotiates a painted crosswalk,
Gait as elegant and supple as the young
Of any of earth's species. The red satchel
On her quite straight back contains a book,
Dog-eared, full of instructive illustrations,
With a title like Getting To Know Your Planet.

That book will tell her that the earth this month
Has yawed a little distance from the sun,
And that the air, cooling, has begun to move,
As sensitive to temperature as skin is
To a lover's touch. (We call this restlessness
The wind.) It will also tell her that the air—
It's likely to say the troposphere—has trapped
Emissions from the cars, idling like mine
While she crosses, and is making a greenhouse
Of the atmosphere. The book will say that climate
Is complicated, that we may be doing this, and if
We are, it may explain that this was something
That we did quite accidentally, which she can
Understand, not meaning to have spilled the milk.
She's one of those who's only hungry metaphorically.

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2.

Poetry ought to be able to comprehend the earth,
To set aside, from time to time, its natural idioms
Of ardor and revulsion, and say in a style as sober
As the Latin of Lucretius, who reported to Lady Venus
On the state of things two thousand years ago—
"It's your doing that under the wheeling constellations
Of the sky," he wrote, "all nature teems with life"—
Something of the earth beyond our human dramas.

Topsoil: going fast. Rivers: dammed and fouled.
Cod: about fished out. Haddock: about fished out. Pacific salmon
Nosing against dams from Yokahama to Kamchatka
To Seattle and Portland, flailing in their rage to breed.
Most of the ancient groves are gone, sacred to Kuan Yin
And to Artemis, sacred to the gods and goddesses
In every picture book of myths she's apt to read.

The book will try to tell her what life is, give her
The amazement of it. Flung off from the sun.
A molten core still pouring rivers of black basalt
Across the earth sometimes from the old fountains
Of its origin. The long cooling. The unexpected, essentially
Miraculous bacterium infused with a green pigment
That broke down carbon dioxide gases, took in the carbon,
Turned it into sugar, gave off molecules of oxygen
The child on her way to school is breathing,
And so bred life. Something then about the double helix
Of the dna. And consciousness, how it came to be
And write the book she's reading. How some almost-biped
Mammal stopped suddenly, looking at stars so bright they seem
To creak, and made the wondering gutteral, "Gha" or "Urth"
To say, "Where am I? I am here." or "I am here. Where am I?"

3.

Somewhere in the book there may be photographs of fossils.
If she lived in Michigan, or the Ukraine, not California, she'd
Find, in this same storm, fossil limestone of Devonian corals
Washed up on a beach, and study the faint white markings—
She might have to lick the stone, if the wind is drying it
Even as she holds it, to bring the picture back
Of what a million years ago life was: a honeycomb with mouths.

4.

Lucretius, we have grown so clever that a mechanic
Learned in natural philosophy has taken the gene
For luminescence from a jellyfish and put it into mice.
If you extinguish the oil lamp, they give off greenish light.
An artist in Chicago—think of it as a lively trading city
In Dacia or Thracia—has asked to be taught the method
So he can market a breed of dog that glows in the dark.

5.

No use to rail against our curiosity and greed.
They keep us awake. Greed is the appetite for life
And is, for all its furious urgency, compatible
With intelligent restraint. In the old paintings
Of the Italian Renaissance they made of it
An allegory and a dance: appetite for life
Meets chaste restraint, and the result is beauty.
The dance resembles wheeling constellations.
That's where science and poetry come in. To keep
Alive our sense of wonder at the earth itself
And at its teeming life. To be the pause of wonder,

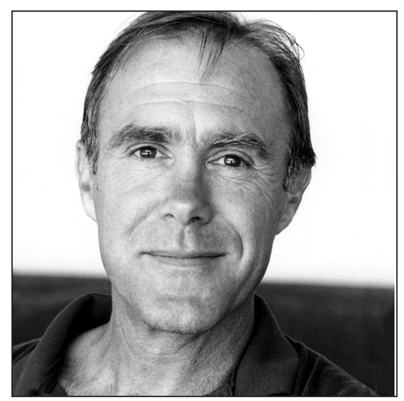
In which an alert caution might grow up,
Even humility or reverence. What is not compatible
With restraint is greed dressed up as rationality,
Especially under television lights. You've heard
The speeches in all the diets and congresses
On earth; it will drive out every time the beauty
Forethought gives our species. One would like to think
Beauty moves the IMF, that the black-and-white flash
Of a flock of buntings in October wind, headed south
Toward winter habitat, would find that the December fields
Their kind has known and mated in for thirty centuries
Or more, were still intact, that they will not go
The way of the long-billed arctic curlews who flew
From Newfoundland to Patagonia in every weather,
And are gone now from the kinds on earth. The last of them
Seen by any human alit in a Texas marsh in 1964.

It will tell her that the gleaming appliance
That kept her milk cold in the night, was made
With chloroflourocarbons, that they react with ozone,
Have eaten a hole above the tropopause where oxygen
Makes the ozone out of ultraviolet light. It will
Not, unless I'm much mistaken, tell her that,
Whenever there's a flash flood in Washington, D.C.
Storm drains disgorge the excrements of senators
Into the slow river which flows past housing projects,
Underfunded schools where the young pledge allegiance
And are taught to read Getting to Know Your Planet.

There may be photographs of pools of oil — the blood
Of the rainbow boa in the old stories of *la selva* —
Where the great trees housed the ten thousand kinds
Of beetle, reptiles no human eye has ever seen
Changing color on the hot, green, unchanging leaves
Whenever a faint breeze stirs them, above
An understory of bromeliads and orchids whose womb-
Or mouth-like flowers are the shape of desire
In human dreams. And butterflies, larger than her palms
Held up to catch a ball or ward off fear. Along the river
Wide-leaved banyans where flocks of noisy parrots, fruit-eaters
And nut-eaters, rise in successive blue and yellow flares.
It will seem like poetry forgetting its promise of sobriety
To say that the rosy shinings in the thick brown current
Are dolphins leaping, where oil spills from the bank.

6.

She leans a little in the wind. As if she were a mariner.
The earth and its heated atmosphere, its cargo
Of everything alive, is swimming in a sea we hardly understand
Our own primitive astronomical maps of. The young know this story
From the disaster films they flock to see. Because we're humans,
There's always a love story in it somewhere,
Even as the ship goes down. In fact, we are capable
Of sending the ship down to intensify the story,
To sweeten the honey with which we fling our species
Out ahead of us. Let the children have their movies.
Our problem, mother of all life, of what Lucretius called
'The shining sunlit world,' is to feed them and to inhabit
The pause of wonder in which foresight might give back
Its human beauty to the earth of many things. Blessings
On the ship. Terror for the ship, and pity for it
And its hapless crew. For her, standing at the prow,
Our lucky charm, and hope, and heiroglyph,
The riddle we have to interpret, the future we have to answer to.



Robert Hass *was Poet Laureate of the United States from 1995 to 1997. His books of poetry include* Field Guide, Praise *and* Human Wishes*. He also received the National Book Critics Circle Award for his book of essays,* Twentieth Century Pleasures*. Mr. Hass teaches at the University of California, Berkeley, and is editor of the poetry periodical,* The Essential Haiku*. Mr. Hass created this poem for Lamont-Doherty Earth Observatory's 50th anniversary.*

From the Secretary-General of the United Nations

It is with great pleasure that I send my warmest greetings to the State-of-the-Planet Conference, being held in celebration of the Lamont-Doherty Earth Observatory's fiftieth anniversary. Over the past fifty years, the Observatory has been a part of most of the major discoveries and advances in Earth science. Its achievements stand out in its field.

A State-of-the-Planet conference at this point in time is very appropriate, not only to mark the Observatory's own milestone, but also as part of our general reflection on the human condition as we approach the millennial milestone. It is a time to take stock of the past and look towards the future.

Just as the work of the Observatory encompasses the entire planet, so do environmental issues affect everyone in the world. Problems such as climate change, natural hazards, and humankind's impact on the environment are transnational ones that concern everyone. They may even affect international peace and security. From every point of view, they are of the highest concern to the United Nations.

Already, we have made severe inroads into the Earth's natural resources. We must ensure that future development is sustainable, and that the depleted resources are replenished. The research conducted at places like your Observatory will be invaluable in helping us to do this.

Kofi A. Annan

SESSION ONE:

Living in Earth's Changing Climate

Some slightly paraphrased sound bites from Session One of the State of the Planet Conference.

Wally Broecker

I started in the global warming business in 1975, but since that time the gap between what we know and what we need to know in order to understand climate has been growing, rather than shrinking. What we do know, however, is that climate can and does switch quickly from one quantum state to another in a matter of decades. That's not a dragon we should want to poke.

Richard Lindzen

History shows that a reigning scientific consensus, such as the role of so-called greenhouse gases in global warming, is often wrong, and can in fact become dogma that impedes scientific advance. Reductions in these impediments to scientific inquiry may well prove to be more important than reductions in global carbon emissions.

Jim Hansen

Interesting problems like global warming are complicated and our tools are imperfect, but that doesn't mean that we can't make reliable forecasts of future climate. I believe that the coming decade will be the warmest in the history of the U.S.. But the bottom line is, I can't predict what climate will be like in 100 years, because it's not a physical sciences problem . . . it's a social sciences problem.

Sheri Rowland

We are four years into the total ban on CFCs and are seeing some positive results. Still, the momentum of ozone depletion will carry well through the coming century. Ironically, we create ozone where we don't want it (smog) and destroy it where we need it (the upper atmosphere).

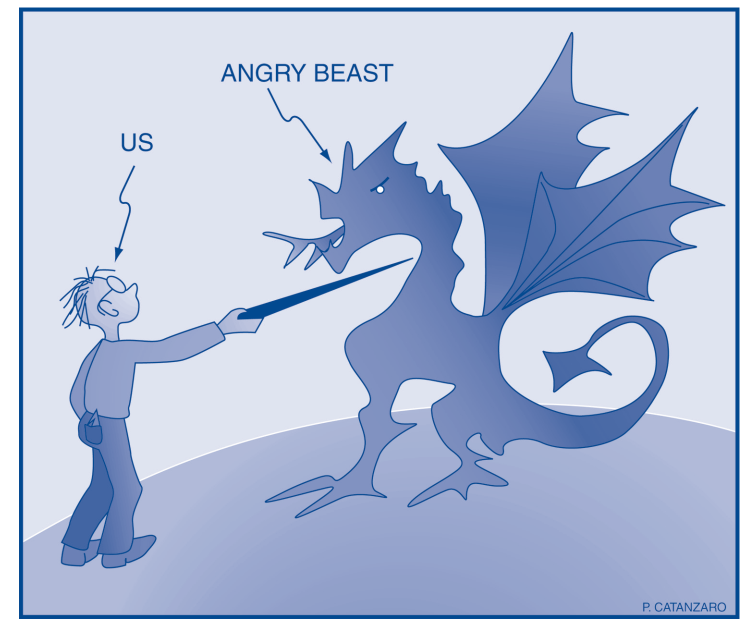
Gale Christianson

Some would argue that the El Niño year of 1998 represents the template for our future climate, one characterized by wild swings and violent storms. Most scientists agree that global warming due to greenhouse gases is a problem, and that if we are even 70 percent sure of it, that's reason enough to take action now.

EDITOR'S NOTE: All of the sound bites throughout this issue were crafted by Kurt Sternlof, Senior Science Writer at the Columbia Earth Institute.

by W. S. Broecker

Poking the Angry Beast



By adding greenhouse gases to the atmosphere we are nudging the Earth's climate system. Atmosphere-ocean simulations suggest that the response to this nudge will be a steady intensifying global warming whose magnitude will reach 3 or so degrees centigrade by the end of the 21st century. While freely admitting that there remains a sizable error associated with model-based estimates of the magnitude of the warming and also that reliable regional details are as yet lacking, almost all atmospheric scientists accept the model-based prediction that, if we continue along our business-as-usual track, a significant warming will surely occur. There is, however, one prominent detractor who is convinced that one critical element common to all the simulations is seriously flawed, namely, their prediction that the water vapor content of the entire atmosphere will rise in proportion to the increase in the sea surface vapor pressure resulting from the warming. As water vapor constitutes the most powerful component of the atmosphere's greenhouse capacity, this creates a positive feedback which leads to a two- to three-fold amplification of the primary warming resulting from the additional CO_2, CH, CFCs. . . alone. MIT's Richard Lindzen is convinced that rather than increasing with rising global temperatures, the water vapor content of the air descending over the planet's desert regions will decrease and that the magnitude of this decrease will be large enough to compensate for the primary warming. Based on his qualitative reasoning, Lindzen states with complete confidence that no warming will occur. Because Lindzen's message is music to the ears of industrialists and their congressional allies, it receives nearly equal attention to the cautionary warnings coming from hundreds of other scientists.

I am a member of a smaller subgroup who fears that the response to a major warming may not be linear. Rather, at some point the warming may trigger a reorganization of the Earth's climate system. We know from records kept in polar ice and rapidly accumulating sediment that such alternate states exist. We also know through the counting of annual layers in cores from Greenland's ice cap that transitions from one of these states to another were accomplished in three to four decades and that during these transitions climate flickered much as fluorescent lights do when first turned on. The impacts of these changes in state were very large and global in extent.

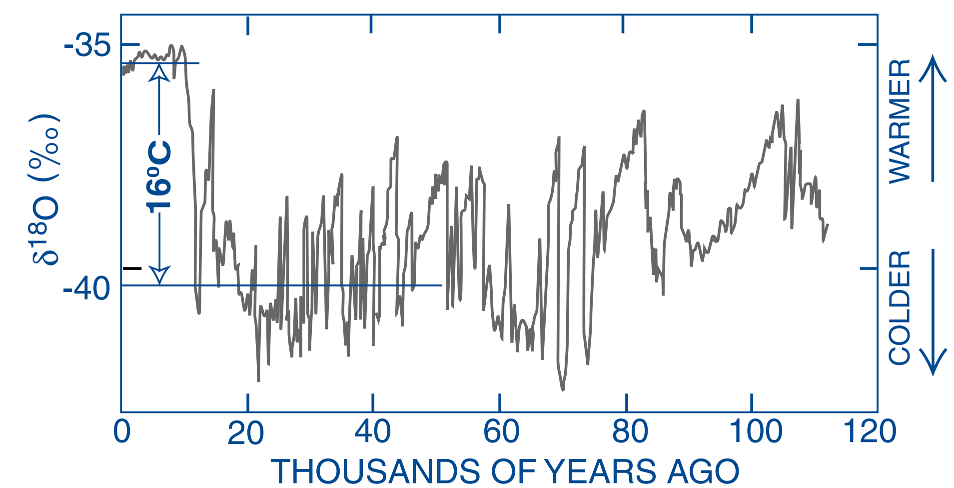
I believe that these reorganizations were triggered from below, i.e., by changes in the pattern of the major ocean current systems. It turns out that there exists a large-scale interaction between the ocean and atmosphere. The geography of surface temperature, of wind regimes and of mountain ranges leads to net transports of water vapor from one place to another on our planet. Polar regions receive more water as precipitation and river runoff than they lose via evaporation. The consequent dilution of the salt content of polar surface waters counters the enhancement of density created by the cold temperature. Water evaporated from the Atlantic Ocean finds its way to the Pacific. This tends to enrich the salt content of surface waters in the Atlantic and deplete it in those in the Pacific, allowing deep water to form in the northern Atlantic but not in the northern Pacific.

The salt content differences created by atmospheric transport of water vapor must be compensated by transports of salt through the sea. In other words, salt must move from the warm regions of the planet to polar regions and from the Atlantic to the Pacific. Were the ocean at steady state, these transports would just balance the gains and losses of fresh water. But as the ocean has a number of alternate routes by which this might be accomplished, it is not necessary that a single steady state exist. Rather, it is possible that the ocean acts as an oscillator in which salt inequities build until they trigger a reorganization of currents. While this new pattern will tend to alleviate the density differences created by the inequities in salt distribution, it will at the same time create others. Hence, an oscillation.

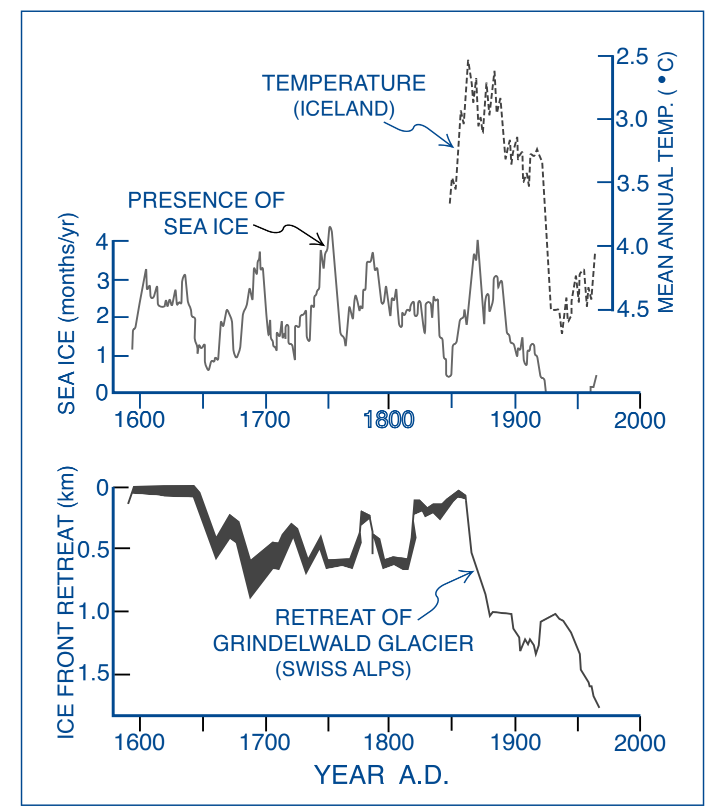
My colleague, Gerard Bond, has made the important discovery that the pattern of transport of ice-rafted debris in the northern Atlantic undergoes a 1500-year cycle and that this cycle has been operative during both times of glaciation and of interglaciation (Bond *et al.*, 1997). Its most recent manifestation was the Medieval Warm (800 to 1200 A.D.) Little Ice Age (1350 to 1870 A.D.) climate oscillation.

Evidence is mounting that the ocean's large-scale so-called thermohaline circulation is at the root of the 1500-year cycle. One piece of evidence in support of this conclusion is that there is one part of the world, the continent of Antarctica, whose millennial duration climate changes are clearly antiphased with respect to those for the rest of the planet. An obvious explanation is that a seesaw exists between deep water formation in the northern Atlantic and deep water formation in the Southern Ocean. An exciting discovery by Gary Clow of the U.S. Geological Survey that Antarctica was 3 degrees centigrade colder during the Medieval Warm than during the Little Ice Age led me to propose that deep water formation in the Southern Ocean was much stronger during the Little Ice Age than now (Broecker *et al*., 1999). In this way, I could explain the apparent inconsistency of CFC inventory in the deep Southern Ocean which requires weak deep water formation during the last couple of decades and the distribution of radiocarbon which requires strong deep water formation over the last deep sea ventilation cycle (i.e., the last ~800 years).

But why do we use these lessons from the past as the basis for concern for the future? The reason is that were the planet to warm by several degrees, then not only would polar surface waters become warmer but the associated enhanced transport of water vapor via the atmosphere would cause a reduction in polar salinity. Eventually the ocean would respond by reorganizing its circulation. In the past, these reorganizations were accompanied by very large (during glacial time) and moderate (during interglacial time) global climate changes. Thus, were another reorginization to occur, a sizeable response would be expected. Of course, if Richard Lindzen's prediction proves to be correct, there will be no greenhouse warming and hence no threat to the ocean's thermohaline circulation. I wish that I could share in his confidence in this regard. But I can't. Instead, I'm worried.



The magnitude of the depletion in "heavy" oxygen in the ice recovered from a 3-kilometer-long boring made at Greenland's summit provides a proxy for changing air temperature. As can be seen, except for the present interglacial, Greenland's climate has been highly unstable.



The Little Ice Age: As summarized by Grove (1988), the relatively mild conditions in the region around the northern Atlantic during the Medieval Warm period underwent a deterioration during the 13th and 14th centuries A.D. One victim of this cooling was the Viking colony in Greenland. Because grain could no longer be grown and the northern sea ways became clogged with ice, it had to be abandoned. Conditions are thought to have remained generally cold until late in the 19th century when, as shown in the above diagram, the sea ice surrounding Iceland began to wane and the glaciers in the European Alps began a sustained retreat.

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by Richard S. Lindzen

Climate: PROBLEM SOLVING AND ITS IMPEDIMENTS

"Physical science in our day lies beyond the intellectual grasp of most men ... This exclusion of most of us from the mode of thought which is habitually said to be the characteristic achievement of the modern age is bound to be experienced as a wound given to our intellectual self-esteem. About this humiliation we all agree to be silent; but can we doubt that it has its consequences, that it introduces into the life of mind a significant element of dubiety and alienation which must be taken into account in any estimate that is made of the present fortunes of mind?"

LIONEL TRILLING *Mind in the Modern World, New York 1973 pp. 13-14.*

"Relevant lessons from the history of the natural sciences are, in a nutshell:

1. The prevailing consensus in a discipline is usually wrong,b because new discoveries will overtake it.

2. The consensus often delays those discoveries, by inertia if not by outright opposition.

3. As a result, the revolutionary discoveries often come from outsiders, not considered to be experts.

4. Scientists never learn from history." NIGEL CALDER, SCIENCE WRITER

With these quotes in mind, let us consider some of the impediments to problem solving in contemporary science. Calder already mentions the insidious reliance on consensus. However, there are two others that most of us recognize:

1. The organization of science into large programs, and

2. The requirement by funding agencies that research follow identifiable lines judged by peer review.

These last two serve to cast the "reliance on consensus" in concrete; similarly, without these last two items, the first item would not matter as much. In an important sense, Trilling's observation forms a psychological subtext for all three impediments, especially when one realizes that humanists and historians are not alone in the pain of incomprehension.

The elevation of consensus to dogma, and the growth of bureaucratic control, the replacement of theory by model simulations, the replacement of (real not computer) experiments by observational programs, all represent, I would suggest, a societal response to the pain described by Trilling.

Saul Bellow noted that "A great deal of intelligence can be invested in ignorance when the need for illusion is deep." Perhaps, the current illusion is that science is easily understood and managed by everyone.

All scientists above a certain age, have, from their personal experience, favorite examples of what we might call "pre-impediment" scientific achievements. My own is the discovery of how the quasi-biennial oscillation (QBO) of the tropical lower stratosphere works. Here, the prevailing winds blow from east to west with speeds of about 20 m/s (about 40 mph) for about a year, and then reverse and blow from west to east with speeds of about 30 m/s (about 60 mph) for about another year. The average periodicity is 26 months, and it is this period rather than periods of 1 year or six months which dominates the circulation of the lower tropical stratosphere. The disturbance appears to be propagating downwards.

In his classic monograph, *The Nature and Theory of the General Circulation of the Atmosphere* (W.M.O., 1967, p. 10), Ed Lorenz (sometimes referred to as the father of chaos theory) refers to this phenomenon as follows: "Indeed, we are continually encountering new features whose existence we had not anticipated from years of familiarity with the governing laws. One of the more spectacular of these is the recently discovered 26-month or quasi-biennial oscillation... There now exists an extensive literature on the subject, but we still are awaiting a satisfactory explanation which is not surprising when we recall that even the trade winds and the prevailing westerlies at sea-level are not completely explained."

The first attempts at solution were quite strange in retrospect. Suggestions tended to focus on identifying natural antecedents for the periodicity (the fifth harmonic of the sunspot cycle, the gestation period of elephants, distorted subharmonics of the annual cycle). There were even attempts to relate the periodicity to the chemical relaxation time for ozone photochemistry. However, within a year of Lorenz's manuscript, the currently accepted explanation was published. It involved the synthesis of a number of seemingly disparate results discovered over the previous eight years. (A review of the history can be found in Lindzen, 1987, Bull. Amer. Met. Soc., 68, 329-337.)

Norwegians Arnt Eliassen and Enok Palm had, in 1961, discovered that vertically propagating gravity waves transferred momentum. In 1966, in a study of atmospheric tides, I discovered that long period waves which could not propagate vertically in middle latitudes, could propagate as internal gravity waves sufficiently close to the equator. This provided the basis for the explanation by Matsuno in Japan in 1966 and me in 1967 of the equatorially trapped short period (4-15 days) waves observed by Yanai and Maruyama in Japan in 1966 and Wallace and Kousky in the U.S. in 1968. In the meantime, the geophysical fluid dynamicists, Booker and Bretherton in the UK in 1967 had demonstrated that the momentum carried by gravity waves would be deposited in the ambient flow near levels where the mean flow and wave phase speed coincided, and the American meteorologists, Wallace and Holton in 1968 had determined that only a momentum source that actually followed the QBO could account for the oscillation. It was my good fortune to realize that the Booker-Bretherton mechanism applied to the observed equatorially trapped waves would provide the requisite momentum source (actually in ignorance of the Wallace-Holton result), and in a paper by myself and Holton in 1968, we showed that the new mechanism when inserted into the Wallace-Holton model produced the QBO quite realistically. The incoherent jumble of dates reflects the rapidity of work and communication as well as the vagaries of the publication process. Within a few years, Plumb and McEwan in Australia in 1974 actually replicated the mechanism in the laboratory. For purposes of this article, the points I would like to emphasize are the following:

- The theory has never been reduced to a point where it can be understood by the layman in seconds or even minutes.
- The oscillation has no external forcing; it arises autonomously from the dynamics of the atmosphere.
- The successful development of the theory was never part of any funding proposal.
- No program was ever established to explain the phenomenon.

Parenthetically, I should add that no current climate GCM displays the QBO at all, although a highly specialized Japanese GCM does get an oscillation with a very reduced magnitude and a substantially different period.

Let us now turn to the topic of interest to this audience: climate change. Here we have what is constantly referred to as a "consensus" supporting a picture which is meant to be readily understandable by all with those who note problems with the picture marginalized as skeptics. This picture has been misleading to both the public and even to scientists — few of whom have actually worked on the physics of the so-called greenhouse effect. The result has almost certainly been to impede the actual solution of the problem.

Let us look at the commonly presented picture of the greenhouse effect (Figure 1 taken from the first two scientific reports from the Intergovernmental Panel on Climate Change). It illustrates a highly oversimplified picture of the greenhouse effect wherein the presence of greenhouse substances inhibits the cooling of the Earth's surface leading to warmer surface temperatures. Anyone who has worked on this problem knows that this picture is profoundly wrong for a number of reasons, beginning with the fact that the Earth's surface does not cool primarily by radiation. Generally left unmentioned is the fact that the Earth's main greenhouse substances are

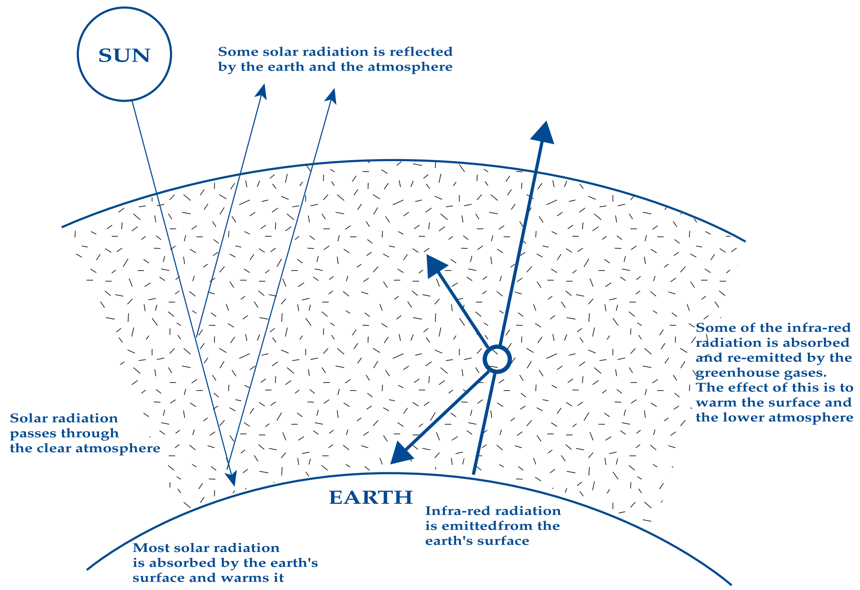


Figure: 1

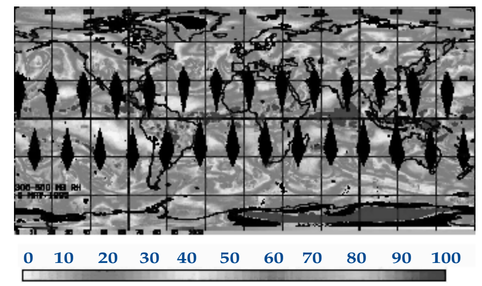


Figure: 2

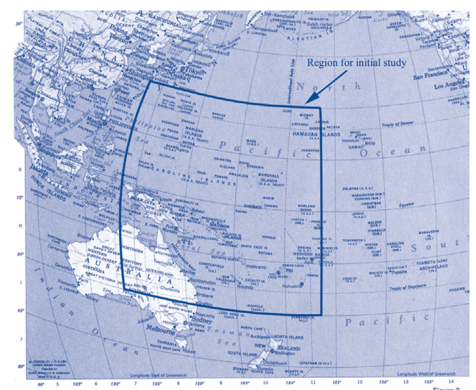
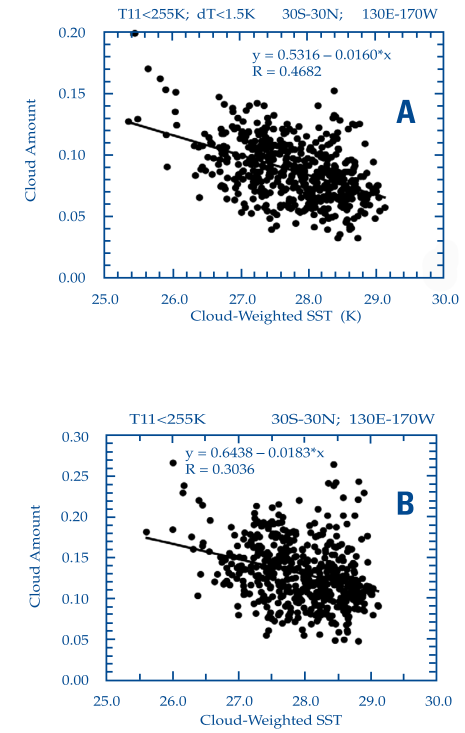


Figure: 3

water vapor and clouds. Nor is it stressed that a doubling of CO_2 alone leads to no more than about a 1ºC increase in temperature. Predictions of greater warming depend on water vapor and clouds changing in such a manner as to greatly amplify the effect of increasing CO_2, and these feedbacks have increasingly been acknowledged as being uncertain. However, I have come to realize that the main error with the popular picture is that it is one-dimensional. That has led us to think of the earth as responding to an average humidity and cloud cover. This was somewhat understandable since until the past decade we really didn't have reliable measurements of water vapor. However, developments in satellite sounding and *in situ* measurement have changed this. Figure 2 (supplied by Roy Spencer and Danny Braswell at NASA-Huntsville) illustrates the distribution of relative humidity on May 5, 1995 retrieved from microwave data taken from a military satellite. Although the figure shows results for a layer between about 6 and 9 km, it is representative of the region from about 3 km to 16 km. What we see is that in the tropics we have regions of very dry air and regions of very moist air with sharp transitions between the two regions. Cooling occurs mostly in the dry regions, and the moist and dry regions are tied together by the atmosphere's motions. In addition, we have learned a number of things from both observations and theoretical analysis: namely, that there are no sources of moisture in the dry regions which are about as dry as they can get; that the source of water vapor in the moist regions is the evaporation of precipitation from clouds that arise from ice thrown off by cumulonimbus towers; and that, consistent with this, the areas of upper level cloudiness and high relative humidity largely coincide. Finally, the moist regions are about as moist as they can get. The above leads to the conclusion that feedbacks in the tropics are most likely associated with changes in the relative areas of cloudy/moist air and clear dry air — something that doesn't readily emerge from a one-dimensional picture. However, given that geostationary satellites measure upper level cloudiness with fine spatial and temporal resolution, and given that high cloud in the tropics is a surrogate for high relative humidity, we have an opportunity to measure this feedback by seeing how the area of cloudy/moist air changes with the surface temperature associated with cloudy/moist regions. Using Japanese GMS5 data for the western Pacific (Figure 3 shows the coverage) that M.-D. Chou has been archiving at NASA/Goddard Space Flight Center since January 1998, I have with Chou and A.Y. Hou, studied exactly this relation. The results are shown in Figure 4. They show that a 3C increase in cloud-weighted surface temperature leads to a 45 % reduction in the cloudy/moist area. (Note that the definition of cloud cover varies; we, therefore, focus on the percentage change rather than absolute amounts.) Simple calculations show that if one were to fix such a reduction in the tropics and allow the surface temperature of the whole earth to equilibrate with this reduction, it would lead to a temperature reduction of about 9C. This means that we have a very large negative feedback that would reduce the response to a doubling of CO_2 to about 0.3C (or if one took the model positive feedbacks to be correct in the extratropics to about as much as 0.4-0.5C).

What we seem to have discovered is that the tropical cloudy/moist regions act as an adaptive infrared iris that opens and closes so as to resist changes in surface temperature.

So how do the climate GCMs behave? We have begun testing a number of models for their cloud response to the observed changes in SST in the regions covered by GMS5. Figure 5 shows that at least one model completely misses the phenomenon. This is also true for two other models tested so far, though details vary.



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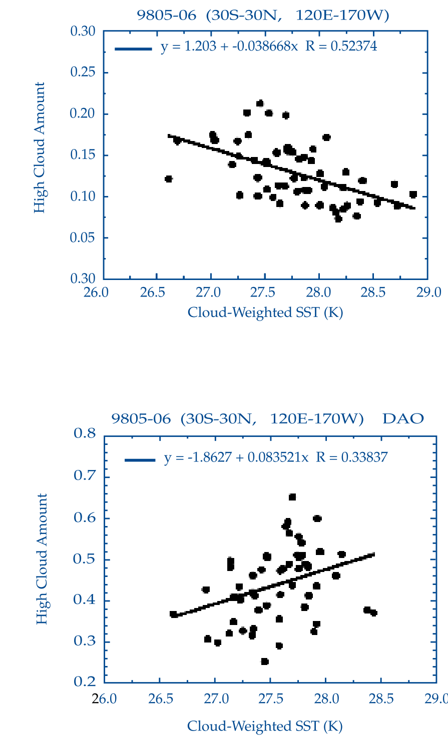

Figure: 5

Figure 1: Schematic of Greenhouse Effect. From IPCC, 1994.

Figure 2: Horizontal distribution of relative humidity on May 5, 1955 for layer from 500-300mb. This figure was supplied by Roy Spencer.

Figure 3: Region used for preliminary examination of relation between upper cloud coverage and cloud-weighted sea surface temperature.

Figure 4: Scatter plots of upper cloud coverage v. cloud-weighted sea surface temperature for period January 1, 1998 to September 30, 1999. a. Subset of all clouds for which brightness temperature was less than 255K that were particularly thick. b. All clouds for which brightness temperature was less than 255K. Note that while cloud coverage is different in a and b, the percentage reduction in coverage in both panels is about 45% for a 3K increase in cloud-weighted sea surface temperature.

Figure 5: Same as Figure 4b except that panel b is from a GCM forced by observed sea surface temperature, and the period covered is only June-July of 1988.

So where does this leave us vis-a-vis Lamont's (the planet's and everyone else's) next 50 years?

- Scientific curiosity can surmount impediments to inquiry, but impediments don't help.
- Man may be causing much less warming than models currently suggest; don't depend on models to replace understanding. Also don't depend on oversimplified schematics.
- The climate is almost certainly going to be different and it behooves us to understand why.
- The reduction of impediments to scientific inquiry may prove more important than the reduction of carbon emissions.

Let me end with a paraphrase of an address by Einstein on the occasion of Max Planck's 60th birthday in 1918. The paraphrase is from Columbia professor Fritz Stern's collection of essays *Dreams and Delusions*:

"It is a many-mansioned building, this temple of science." If one of G-d's angels were to cast out the merely ambitious and the merely practical from this temple there would remain "somewhat peculiar, reserved, lonely fellows … who despite these common characteristics would resemble each other less than do those who were expelled from the crowd." What led the true followers to the temple? Einstein cites Schopenhauer that one of the strongest motives that lead to art and science is "a flight … from everyday life with its painful rawness and desolate emptiness, away from the chains of one's own ever-changing desires." Planck's "inexhaustible endurance and patience" he attributes to: "an emotional state, which makes possible such achievements [and which] resembles the state of a religious person or a lover: the daily striving does not spring from a precept or a program, but from an immediate need."

I suggest we toast Planck's "immediate need."

ACKNOWLEDGMENTS

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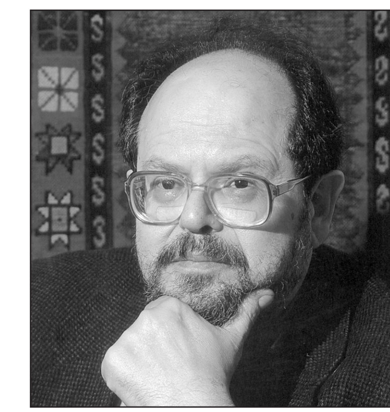

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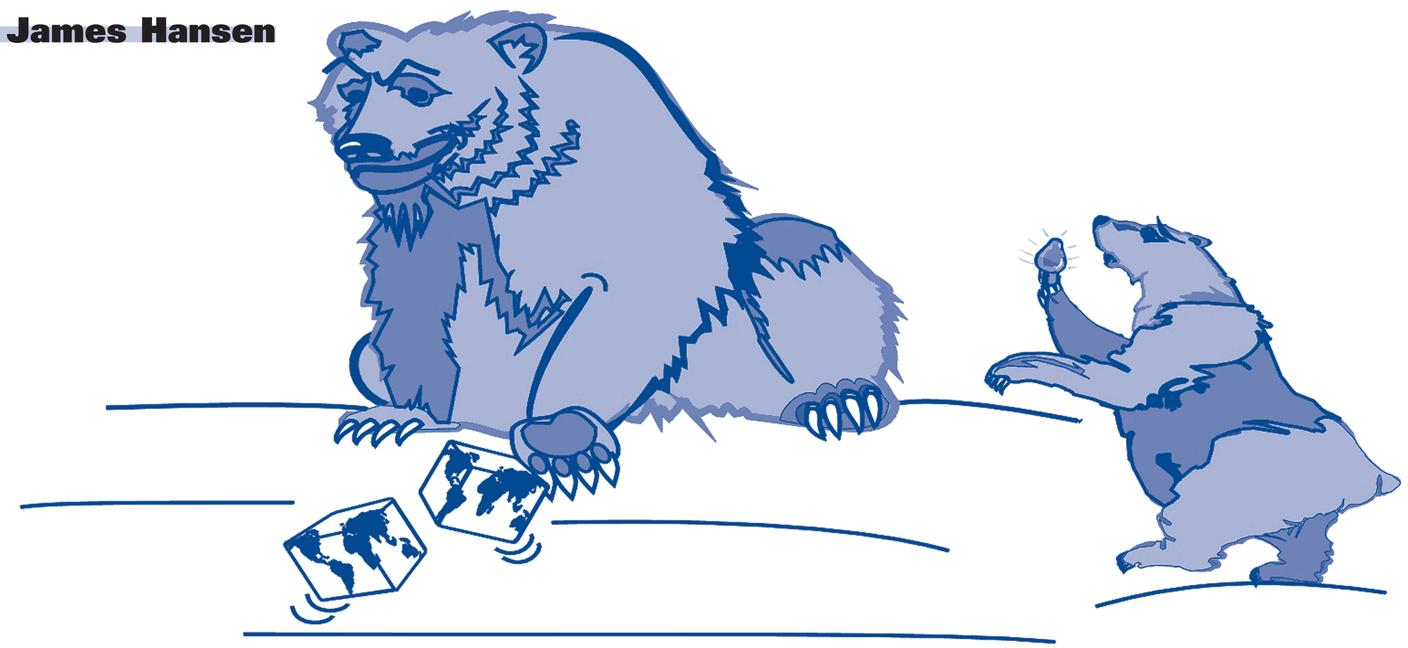
by James Hansen



GLOBAL WARMING, PLAYING DICE, AND BERENSTAIN BEARS

In the summer of 1988 I testified to the U.S. Senate that the world was getting warmer and that the dominant cause was probably human-made greenhouse gases. The Senate, and the public, wanted to know the cause of parched conditions in the Midwest, where the Mississippi had practically dried up. I said that our numerical climate model indicated a tendency for more frequent and severe droughts as the world became warmer, but a specific drought was a matter of chance, dependent on fluctuating meteorological patterns.

Although that testimony increased public awareness of global warming, it was soon evident that I had communicated poorly. On a Jeopardy quiz show the "answer" was that I had said the Midwest drought was caused by the greenhouse effect. People have a predilection for deterministic explanations of climate fluctuations. Even Albert Einstein abhorred the notion of chance in nature, saying "God does not play dice." But the science of quantum mechanics, with Einstein a major contributor, proved that uncertainty plays a big role in physics and in the world.

One result is chaos in weather and climate. Temperature and precipitation patterns fluctuate in ways unpredictable beyond a few weeks at most. Yet climate, the average weather, can be changed in a deterministic way by a "forcing," such as an increase of atmospheric gases.

I tried to explain forcings and chaos with colored dice. One die represented normal climate for 1951-1980, with equal chances for warm, average and cool seasons. The other die was "loaded" due to forcing by greenhouse gases, such that the chance of an unusually warm season increased from 33 to about 60 percent, as calculated by our climate model for the late1990s.

When Albert Gore asked me to testify to the Senate again, in 1989, I wanted to explain the greenhouse effect better. I held up a one-watt Christmas tree bulb, saying that the human greenhouse effect is heating the Earth by an amount equal to two of these bulbs over every square yard of the Earth's surface. In 100 years this heating could double or quadruple, depending on how fast we put greenhouse gases into the air.

This added heating intensifies dry conditions, when and where it is dry. But, over oceans and wet land, added heating increases evaporation, which eventually falls as rain. So my testimony was that global warming, paradoxically, increases both extremes of the hydrologic cycle. It causes more intense droughts and forest fires, but, at other places and times, it causes heavier rainfall, more intense storms fueled by latent heat of water vapor, and greater flooding.

Unfortunately, this discussion was lost in a tempest caused by alterations to my testimony inserted by the White House Office of Management and Budget. The brouhaha may have helped keep attention on the global warming topic, but it failed to illuminate the scientific issues and uncertainties. And the public global warming "debate" continues to contrast opposite intransigent positions, rather than exemplifying how science research really works.

I suggest to students that they view the debate in the media the way young Berenstain Bear viewed the botched bicycle lessons of Papa Bear: "This is what you should not do." A good scientist does not act like a lawyer defending the position of a client.

The fun in science is its objectivity. First exhilaration occurs when a young scientist compares alternative ideas or models with observations and discovers how something works. When the observations are of the Earth's climate, it is awesome to think that our models can capture and predict the effect of the sun, volcanoes and greenhouse gases. But awe is tempered by realization that the "laboratory" is home to billions of people and wildlife.

Climate will change in the next few decades, regardless of our actions. But we can slow the planetary experiment as we develop better understanding.

What have we learned about the greenhouse effect in 10 years? Bad news and good news. The bad news is that the world is warming, as predicted. The frequency of unusually warm seasons has increased to about 60 percent. Record warm temperatures occur more often than record cold. The year 1998 was, on global average, the warmest year in the history of instrumental data.

Remarkable climate extremes have occurred recently: the Chicago heat wave of 1995, a run of 29 days of 100 degree temperature in Dallas in 1998, floods in the Midwest in 1993 and 1997 and in the Southeast in 1999. The high natural variability of climate prevents unique association of these events with global warming. But a quantitative index of temperature and moisture changes reveals that climate extremes are increasing at most places in the sense predicted for global warming. And we can predict with reasonable confidence that the record annual and decadal temperatures for the contiguous 48 U.S., set in the 1930s, will soon be broken.

The good news is that the growth rate of greenhouse gases has slowed. In the 1980s the rate was four more light bulbs per square yard in 100 years. Despite increased population and energy use, the rate has slowed to three more light bulbs per 100 years, rather than increasing to the five bulbs that were in the most popular climate forcing scenarios. Credit for the slowdown belongs in part to the public, legislatures, and businesses that phased out chlorofluorocarbons. Also methane and carbon dioxide growth rates slowed, for reasons that are not well understood and are perhaps only temporary.

What's to be done? First, we must avoid providing "lessons in what not to do." Immediate, economically wrenching, constraints on energy use have negligible effect on climate forcings. But the other extreme, denial of the greenhouse problem, is equally foolish. Climate change is real, and it is a complex problem.

Climate will change in the next few decades, regardless of our actions. But we can slow the planetary experiment as we develop better understanding. We need bi-partisan common sense strategies to encourage greenhouse benign technologies that continue the positive changes in our long term energy use trajectory. This is good for business and it will provide us the option to eventually stabilize climate, thus maintaining a healthy planet for humans and bears.

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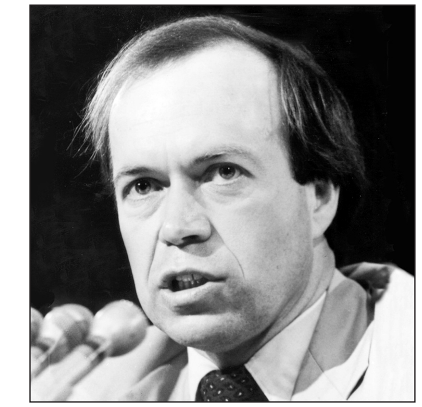

James Hansen *has directed the NASA Goddard Institute for Space Studies since 1981, while also serving as an adjunct professor of Earth and Environmental Sciences at Columbia University since 1978. His research interests include the development of three-dimensional global climate models, unraveling the mechanisms of climate change, and projecting the climatic impact of human activity, as well as radiative transfer in and remote sounding of planetary atmospheres. For NASA, Dr. Hansen has served as principal investigator for the photopolarimeter experiments aboard both the Pioneer Venus and Galileo Jupiter orbiters, and for the interannual climate variability portion of the Earth Observing System Interdisciplinary Investigation. In 1996, he was elected to the National Academy of Sciences.*

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By F. Sherwood Rowland

ATMOSPHERIC OZONE

THE GOOD AND THE BAD

During the last two decades, the word "ozone" and the phrase "ozone layer" have come into everyday usage, and even the descriptions of "good" ozone and "bad" ozone are commonly heard. More remarkably, the adjectives convey correctly the qualitative significance of the effects of ozone in different parts of the atmosphere. Ozone, the triatomic form (O_3) of oxygen, accounts for only 3 molecules of every 10 million in Earth's atmosphere where it is spread very unequally with about 10% of ozone and 90% of all the molecules in the troposphere—the lowest 6 miles (polar) to 9 miles (equator). The stratosphere has the reverse—about 90% of the ozone and 10% of the molecules—with only 0.1% of the latter lying above its top altitude of 30 miles. Stratospheric ozone is formed by the action of solar ultraviolet (UV) radiation on ordinary molecular oxygen (O_2), and almost all of it remains there until removed by chemical reaction. Some of the ozone found in the troposphere descended from the stratosphere, and some was formed *in situ* by photochemical reactions. Ozone itself possesses two chemical capabilities: it is a strong absorber of UV radiation, especially the most harmful, and it reacts readily with many other molecules. The difference between the good and the bad ozone lies in its ability to react, usually deleteriously, with the molecules which make up the surfaces of biological species, e.g. the lining of human lungs, or the leaves of green plants. In the stratosphere, with no reactive biological surfaces present, the "good" ozone protects the thriving biology at Earth's surface by intercepting most of the strongest, harmful UV radiation. On or near Earth's surface, however, the direct chemical reaction of the "bad" ozone with biological surfaces far outweighs its good UV-protective function. The ozone problems caused by mankind in our atmosphere now are two-fold — our releases of some volatile chemicals have been destroying the "good" ozone in the stratosphere, and of other compounds have been forming more "bad" ozone near the surface.

Much attention has been given since 1974 to the depletion of stratospheric ozone, particularly by chlorine atoms transported upward while part of the chlorofluorocarbon gases. These CFC molecules are inert in the lower atmosphere, surviving unchanged on the average for five to ten decades. These molecules eventually wander randomly into the middle stratosphere above most of the ozone, absorb energetic solar UV radiation and release highly reactive chlorine atoms, capable of chain lengths as high as 100,000 — that is a single Cl atom participates in a long series of ozone-destroying reactions which convert 100,000 ozone molecules back into ordinary oxygen. Smaller amounts of bromine carried in Halon molecules used in fire prevention also initiate chain reactions which add to the ozone loss.

Ozone in nature has always naturally been changed back into ordinary oxygen by other reactions, chiefly catalytic chains involving oxides of hydrogen and nitrogen. As production of CFCs accelerated during the 1960s and 1970s, the reactions of chlorine became a significant addition to the natural processes, and ozone went away faster than previously, leaving fewer molecules to intercept solar UV radiation. Now, only about 30% as much ozone exists over Antarctica every spring, while ozone in the temperate latitudes has decreased since 1960 by about 10% in winter and spring, and 5% in summer and autumn.

A major consequence of these losses in stratospheric ozone is that larger amounts of harmful UV-B radiation reach Earth's surface with effects on the biological species there. The primary effects of UV-B on humans are skin cancer and cataracts. The Montreal Protocol of the United Nations banned further production and release of CFCs and Halons in the industrial countries after January 1, 1996, and their atmospheric release has now been reduced almost to zero in compliance with this treaty. However, because of the 50 to 100 year lifetimes of CFCs, stratospheric ozone recovery will stretch into the 22nd century.

A small part of stratospheric ozone has always descended down into the troposphere. During the 20th century, this has been increasingly augmented by additional ozone formed by photochemical reactions near the surface. This ozone first became noticeable 40 years ago as one of the two important ingredients of urban smog—small dust particles are the other. The process by which this ozone was formed has been firmly established for more than two decades, and involves the release in city traffic of combustible carbon compounds (CO and hydrocarbons) and nitrogen oxides (NOx), coupled together with weaker solar UV not absorbed by stratospheric ozone. Because the same combination of chemical reactions also occurs during the daylight burning of agricultural wastes or forests, an increase in ground-level ozone is a major consequence of biomass burning. Plumes from such burning have been traced for many thousands of miles over both the Atlantic and Pacific oceans.

Chlorine from CFC's destroys Ozone in the Stratosphere;

$$Cl + O_3 \longrightarrow ClO + O_2$$
$$ClO + O \longrightarrow Cl + O_2$$
$$\text{sum: } O + O_3 \longrightarrow O_2 + O_2$$

As the global number of megacities, and the density of traffic in them, both increase rapidly, the total amount of ozone formed near the surface has increased very markedly over the past century. Moreover, the pollutants released from individual cities also travel great distances downwind, merging into a general regional pollution, and then beyond. Satellite observations now show the summertime existence in both northern and southern hemispheres of increased levels of ozone circling the globe in the temperate latitudes. Experience in the U.S. and western Europe shows that stringent controls on automobile emissions can reduce ozone as in Los Angeles, but smog is still getting worse in most large cities globally, with increases in the populations of both people and automobiles without effective emission controls.

When smog first appeared in Los Angeles, the belief arose that the special geography of a basin surrounded by mountains was probably a necessary factor for ozone formation, in addition to the three factors of burnable carbon compounds, NOx, and UV radiation. The ubiquitous nature globally of pollution as a near-universal companion to dense automotive traffic has demonstrated, however, that geography is only a minor contributor. Generally speaking, it appears to be true that the impact of ground level ozone upon humans has to rise to a truly obnoxious level before the necessary emission controls can become politically feasible. For the present then, mankind has succeeded in putting a cap on the loss of the "good" stratospheric ozone, but will probably continue to breathe ever larger quantities of the "bad" ground-level ozone during the next several decades. One consolation, however, is that the ozone experienced at the surface lasts only a few weeks and must be renewed on a daily or weekly basis. When controls are finally introduced, they become effective immediately after full implementation. Stratospheric ozone depletion, on the other hand, is controlled not by the lifetime of the ozone, but by the lifetime of the CFCs—so major recovery there will require many decades.

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by Gale Christianson

From Benevolence to Menace:

AN HISTORIAN'S BIOGRAPHY OF GLOBAL WARMING

One day in the early nineteenth century, the natural philosopher Jean-Baptiste-Joseph Fourier, who had escaped no less than four appointments with the guillotine during the French Revolution, began to ponder the question of how Earth stays warm enough to support the diverse range of flora and fauna inhabiting its surface. Taking pen in hand, he set down a novel hypothesis. When energy from the Sun is irradiated back into sky from the great oceans and landmasses of the world, some of it is trapped by water vapor and the other gasses that surround the planet, forming a protective shield of warmth. In effect, Earth's atmosphere acts much like a giant bell jar, without which all life would surely perish, further evidence to Fourier, who was educated by the Jesuits, of God's benevolent hand. The resulting article, titled "General Remarks on the Temperature of the Terrestrial Globe and Planetary Spaces," was published in 1824 and largely forgotten by all but a few members of the scientific community.

Meanwhile, the Industrial Revolution spread northward from the Midlands of England into the heart of Europe as coal rapidly replaced wood as the West's major energy supply. By the mid-1800s, the tall chimneys, each constructed of a million or more bricks and hundreds of tons of mortar, had far eclipsed the great cathedrals of medieval Europe, rising as high as 450 feet. They spewed their burden of gases and other effluents high into the atmosphere round the clock, where it was believed the pollutants would disperse without harm.

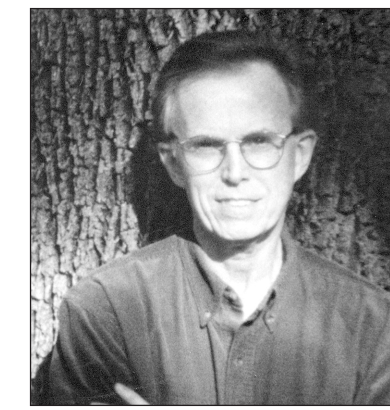
In the early 1890s, some seventy years after Fourier published his bell jar hypothesis, the paper drew the attention of the Swedish chemist Svante August Arrhenius, who would one day claim the Nobel Prize for his work in electrolytic dissociation. Arrhenius had traveled extensively throughout Europe and began to ponder the potential effects of carbon dioxide and other gases on Earth's atmosphere. The exponential rise in fossil fuel consumption, he believed, might well contribute to the natural global warming by the Sun. Simply put, the gasses emitted by industrialization would trap more heat, causing the temperature to rise as a direct result of human intervention. On Christmas Eve of 1894, he rolled up his sleeves and began what he later described as "the most tedious calculations" of his life. Winter turned to spring, spring to summer, and summer to autumn, and still Arrhenius labored on, filling countless pages with thousands of equations and mathematical symbols reminiscent of ancient runes — perpendicular, oblique, with the occasional squiggle for good measure.

When he finished at last, Arrhenius determined that a doubling of carbon dioxide in the atmosphere would lead to an average temperature increase of five to six degrees Celsius (nine to 11 degrees Fahrenheit), to which he attached the term "hothouse," or what would be renamed the

"greenhouse effect" decades later. Yet in a version of his paper presented to the Swedish Academy, he displayed no alarm; indeed, the thick-blooded Scandinavian thought global warming a good thing, particularly for those, like himself, who inhabited the northern latitudes, where the harshness of winter would be significantly reduced and agriculture expanded. But he also contended that it would take at least three millennia for atmospheric carbon dioxide to double. By then, humanity would have long since exhausted its supplies of fossil fuels — coal, oil, and natural gas — never living to see his predicted rise in temperatures.

What Arrhenius did not realize is that seemingly small fluctuations in temperatures — on the order of two degrees Celsius — had already wrought great changes in earlier civilizations and would do so again. By 1300 A.D. the Anasazi peoples of the American Southwest had abandoned their cliff palaces forever in the wake of cooler temperatures and diminished rainfall; in Viking Greenland the settlements founded by Eric the Red also succumbed to a colder climate during this same period, the "wind-time, wolf-time" of the ancient sagas. Then, six hundred years later, the wind came rolling down the Plains, scattering 650,000 "Okies" like leaves in windrows, all because of a persistent drought and a rise in temperature of a few degrees, a mere shrug of eternity.

Now, thanks largely to the pioneering work of Charles Keeling, a chemist who spent most of his career at the Scripps Institute of Oceanography in La Jolla, just up the coast from San Diego, scientists see a direct correlation between the rise in carbon dioxide levels and the average temperature of Earth. Keeling traced the increase of atmospheric carbon dioxide from some 280 parts per million (ppm) during the late Victorian era to the current levels of some 370 ppm. The past century has seen the temperature of Earth rise a little over one degree Fahrenheit, with no end in sight. The 1990s were warmer than the 1980s; the 1980s were warmer than the 1970s; and the 1970s were warmer than the 1960s. The year 1998 was the warmest in recorded history, and it, too, may soon be eclipsed in the record books. It is projected that by 2050 average temperatures will rise by another three to four degrees Fahrenheit, perhaps setting off a series of seemingly "natural" disasters of far greater magnitude than those already attributed to the greenhouse effect: the melting of the ice caps, increasingly powerful storms, drought, flooding, the spread of insect-borne diseases, beach erosion, the death of the oceans' corals, and the further degradation of ecosystems and species, to name but a few. Indeed, some scientists believe that those temperamental siblings, El Niño and La Nina, may be the climate templates of the future rather than the periodically destructive weather events of the present. While civilizations, with the exception of some of those inhabiting the low-lying islands of the world, will hardly disappear, all would suffer, with those along the equator and below it perhaps bearing the brunt of the burden. In sum, global warming is no longer the benevolent phenomenon that Svante Arrhenius once thought it to be, but a looming presence that has entered into our game of playing dice with the Earth.



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SESSION TWO

Living in a Human-dominated Biosphere

Some slightly paraphrased sound bites from Session Two of the State of the Planet Conference.

Bill Clark

All in all, the twentieth century has been a good time to be human, in terms of reduced infant mortality, increased health and longevity, and increased personal wealth. But the journey has really just begun. A transition to sustainability is both possible and necessary, and the central challenge of the coming decades will lie in managing the specific syndromes of regional environmental degradation.

Joel Cohen

Anyone older than 39 and a half years has witnessed a doubling of the Earth's human population, from 3 billion in 1960 to 6 billion today. And the present population of 6 billion would have been unsustainable with the agricultural methods of 1960. Thus far, knowledge-based revolutions have enabled us to accommodate this growth, but we will have to gain much more knowledge if we are to make it happily through the next century.

Paul Epstein

There are direct human health effects associated with extreme weather events, such as the recent cycle of drought, heat and deluge experienced in the eastern U.S.. We need to integrate health considerations into our environmental research, planning and response. The potential costs of continuing with business as usual are huge.

Peter Singer

It is time to introduce ethics into our discussion, as one can never deduce them from science alone. And we need to take that next step in expanding the bounds of our ethics to include all sentient beings on Earth in our assessment of the state of the planet.

Robert Kaplan

The best way to approach the future is with an outlook of constructive pessimism, because the only way to avoid tragedy is to cultivate a sense of it in advance.

Wilfred Beckerman

The ripple effects into the future of respecting human rights in the present is really the best legacy we can bequeath to unborn generations. And by the same token, given human nature, it is inconceivable that a time will come when strict vigilance on human rights becomes unnecessary.

Admiral James Watkins

Some considerable credit is due the former USSR (aka "The Evil Empire") for spurring oceans research in the name of national security. But we shouldn't need that kind of reason to strive to understand our environment. We need to get serious in the federal government about the true value of scientific research and its application to society's needs.

by William C. Clark

A TRANSITION TO SUSTAINABILITY

This celebration of the 50th Anniversary of Lamont-Doherty Earth Observatory comes at a singular time in human history. For most of Lamont's first 50 years, and the lives of those who founded it, each passing year added more people to the Earth's population than did the year before. For most of Lamont's second 50 years, and the lives of the children of its present members and admirers, each passing year will almost certainly add fewer people to the Earth's population than did the year before. Other comparably profound transitions are underway in humanities interactions with the planet. We are passing from a history in which human populations have been predominantly rural, through a present that has become — and a future that will be — predominantly urban. And we are moving from a century dominated by its children to an era in which aging adults will be in the majority. As a result of all these changes, the Earth's human population is unlikely to double again, instead leveling off at perhaps 10 to 11 billion people — most of whom will be older adults living in cities — by the end of the century we are now entering. Can these profound demographic transitions also constitute a transition toward sustainability — toward a world in which the people meet their needs while nurturing and restoring the planet's life support systems?

This is the question posed in a recent study by the National Research Council's Board on Sustainable Development on "Our Common Future: A transition toward sustainability" (NRC, 1999). Looking back over the toll of human development on the environment over the first half-century of Lamont's existence suggests that the answer may well be negative. However, the Board also found reason for optimism — for believing that with adequate investments in the development of science, technology, institutions and political will, Lamont's centennial could indeed be celebrating significant progress on the pathway toward sustainable development.

> The world is too complex and our knowledge too uncertain to allow any pathway for avoiding such destructive interactions of development and environment to be plotted in advance.

The Board's analysis of possible development scenarios, their environmental implications, and plausible social responses suggests that the greatest threats to sustainability over the next fifty years may well not be the individual environmental problems that have occupied most of the world's attention over the last half century. Rather, the most intractable problems may well involve the cumulative, interactive stresses arising from multiple human activities. In specific places rendered particularly vulnerable through combinations of their physical and social circumstances, such stresses may result in downward spirals of degradation such as have been observed in the *Grand Banks, Aral Sea, and Black Triangle* (WGBU, 1997).

The world is too complex and our knowledge too uncertain to allow any pathway for avoiding such destructive interactions of development and environment to be plotted in advance. What we can do, however, is design strategies for intelligent navigation that integrate incomplete knowledge with experimental action into programs of adaptive management and social learning. Such a strategy will require targeted action programs where we know enough to begin the journey before us, focused research efforts where our knowledge limitations are most binding, and a commitment to improving our institutional capacity for learning.

The Board proposed an agenda for priority actions to achieve widely accepted goals in each of the sectoral areas identified more than a decade ago in the Brundtland Commission's report on "Our Common Future" (WCED,1987):

- Accelerate current trends in fertility reduction, achieving a 10% reduction in the global population otherwise forecast for mid-century.

- Accommodate the expected doubling to tripling of the urban system in a habitable, efficient and environmentally friendly manner.

- Reverse declining trends in agricultural production in Africa; sustain historic trends elsewhere.

- Accelerate improvements in the efficiency of energy and materials use, at least doubling historical rates of improvement.

- Restore degraded ecosystems, while conserving biodiversity elsewhere.

In addition to these efforts to apply existing knowledge, the Board recommended a focused research agenda for what might be termed "sustainability science:"

- Develop a research framework that integrates global and local perspectives to shape a "place-based" understanding of the interactions between environment and society.

- Better characterize the concept of environmental limits as embodied in such ideas as "critical loads" and "carrying capacities" so that precautionary policies can be given a sound scientific foundation.

- Improve understanding and documentation of the fundamental "transitions" — not only in demographics, but also in material and energy efficiency, economic globalization, and governance — that are likely to be interwoven with a sustainability transition.

- Analyze the determinants of variation in consumption patterns around the world, with a view towards understanding alternatives to the most environmentally abusive means of enhancing human well-being.

- Explore the design of incentives (in markets, remedies for market failure, and information) for technical innovations that can produce more human value with less environmental damage.

- Develop indicator systems that can chart progress toward the goals of meeting human needs while preserving life support systems, while at the same time providing information on the efficacy, efficiency and fairness of actions taken to attain those goals.

Finally, the Board highlighted the need for building institutional capacity in three main areas central to the pursuit of a sustainability transition:

- Better means for linking long term research and development to social goals, as pioneered in certain areas of military and public health planning.

- More effective integration of research systems across global, regional and local scales as exemplified by the modern agricultural research system.

- Improved connections among academia, private sector and government in a range of novel knowledge-action collaboratives.

There is little precedent for mobilizing science and technology in the ways and at the scale necessary to substantially increase the prospects for progress on a transition toward sustainability. But if the end of the journey cannot be foreseen, the next steps seem sufficiently clear — and exciting to provide Lamont-Doherty and its Earth Institute cousins a good start on another 50 years.

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This text is excerpted from the National Research Council's 1999 report "Our Common Journey: A transition toward sustainability" (Washington: National Academy Press). The author served as co-chair of the study that produced the report. The selection of which portions of the report to reproduce here is the responsibility of the author.

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by Joel E. Cohen

6 BILLION PEOPLE: BUT WHO'S COUNTING?

The world population had 6 billion people for the first time in history on Tuesday, Oct. 12, according to the statistical agencies of the United Nations. Never mind that the population clock maintained by the U.S. Bureau of the Census (http://www.census.gov/cgi-bin/ipc/popclockw) passed 6 billion people in July 1999. Why do the Bureau of the Census and United Nations disagree by three months? Is either one right?

Roughly 20 percent of the world's people have not been counted since 1990. Nobody knows precisely how many people have not been counted, because they have not been counted. The likely error in any estimate of the world's population is probably at least 120 million. The estimate of 6 billion on Oct. 12 could have been too high or too low by roughly the population of Japan.

All that can be said with honesty is that, sometime last year, this year, or next year, we will have 6 billion people. That milestone, whenever its exact date, is a good occasion to look back on the most extraordinary century in human demographic history and to look forward to the next.

At the beginning of the 20th century, there were 1.6 or 1.7 billion people on Earth, and large parts of the Earth had never been censused. The population passed 2 billion around 1927, 3 billion in 1960, 4 billion around 1974, 5 billion around 1987, and 6 billion one of these days. Think about that.

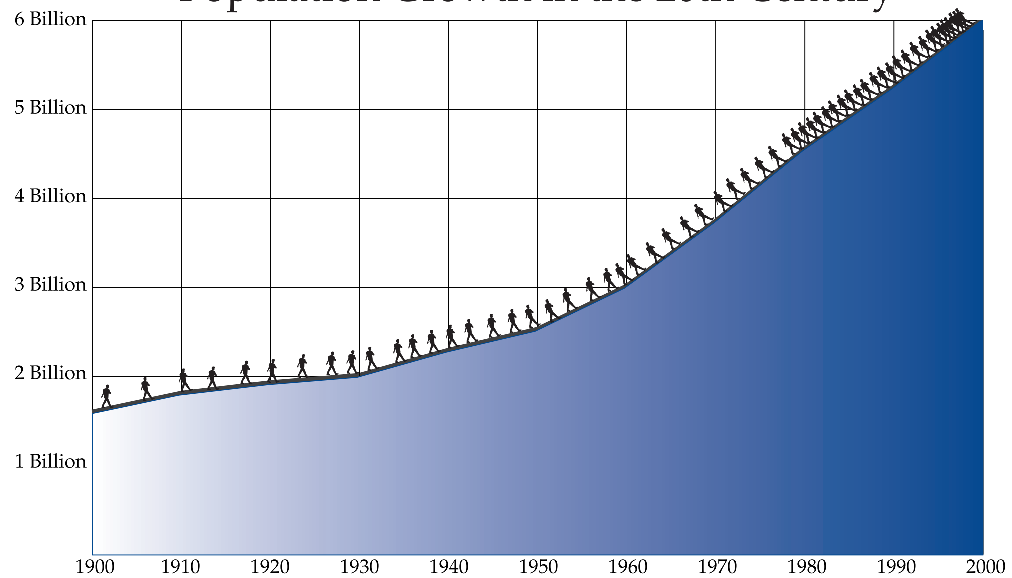
It took from the beginning of time until 1927 to put the first 2 billion people on the planet. We added the most recent 2 billion in just 25 years. Never before the second half of the 20th century had any human being lived through a doubling of the Earth's population. Now, anyone 39 years old or older has seen the number of people double in his or her lifetime.

Less visible than this colossal increase, but just as important, are two other demographic milestones that were little noticed when they were passed. Between 1965 and 1970, the population growth rate of the world reached its all-time peak of 2 percent per year and began to decline. It has now fallen to 1.3 percent per year. Between 1985 and 1990, the absolute annual increase in population reached its all-time peak of perhaps 86 million people and began to decline. It has now fallen to 77 million or 78 million additional people per year. This rate of increase is equivalent to about 150 added people per minute, the difference between 250 births per minute and 100 deaths per minute. While population growth is now slower than at its peak, it still vastly exceeds the estimated 10 million people who were added to the population each year at the beginning of the 20th century.

For the first time in history, human reproduction is coming under human control. Currently 44 percent of people live in countries where fertility is below the level required to replace the population in the long run. As much as any achievement of civilization, this is one to be proud of, and to build on. While more than half of all couples in developing countries now use contraception, hundreds of millions more do not because of poverty, lack of education, and lack of access. In the opulent U.S., an estimated 57 percent of all conceptions are not intended.

Human impact on the Earth rose even faster than human numbers in the 20th century. Emissions of carbon to the atmosphere from human activities grew from a half billion tons to 7.3 billion tons per year, raising the carbon dioxide concentration in the atmosphere by

Population Growth in the 20th Century



> As much as any other single line of action, universal basic and secondary education would enhance our chances of a sustainable future.

about 20 percent. Today's level is higher than at any time in the last 150,000 years. Emissions of nitrogen from the combustion of fossil fuels grew 20-fold, to 25 million tons per year. Human activities account for 40 percent of the nitrous oxide, 70 percent of the ammonia, and at least 80 percent of the nitric oxide emitted to the atmosphere from all sources. World water withdrawals from all renewable freshwater sources grew 8-fold, to roughly 4,000 cubic kilometers per year currently. Humans now withdraw annually roughly a quarter to half of all available renewable freshwater. As the gross domestic product of the human economy increased 16-fold during this century, humans altered the habitats and populations of many other species, raising widespread concerns about extinctions. No one knows whether people can continue to transform carbon, nitrogen, water and other living species at present rates without severe damage to biogeochemical cycles and processes and systems that support human and all other life.

What about the future? Barring global catastrophes, most demographers expect that by the middle of the next century the world's population will be larger, growing more slowly, more elderly, and more urban than it is now. Putting precise numbers on any of these predictions is chancy. For example, in 1998 the U.N. estimated world population in 2050 at 8.9 billion, nearly three billion people more than we have now. Just a few years ago, the U.N.'s best guess for 2050 was a billion larger. This change shows that demographers are better at forecasting the demographic consequences of choices people might make about fertility and mortality and migration than at predicting what those choices will be.

The future will be strongly influenced by human choices. Here are four choices about population, economics, environment and culture that can make the next century a better century.

First, we can help make every human conception a wanted conception, every birth a wanted birth. We can help the 56 percent of the world's people who live in countries with continuing high fertility to achieve family sizes at or below replacement levels of fertility. We can do it by educating girls and boys and by providing health services, including reproductive health and family planning services, to every man, woman and adolescent. Research shows that healthy, educated parents generally choose to have fewer, healthier, better educated children.

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Second, we can organize our economic production efficiently. Until now, economic production has been a linear process: we extract some resource from nature, industry transforms it, consumers use it, and we throw what is left away. In the 20th century, the global economy is so big that this mental picture is obsolete. There is no longer any "away" to throw things away to. Industrial ecology presents a new organization of economic production. The by-products of one economic activity become the inputs and resources of another. Instead of linear, independent production processes, the economy becomes a network of industries and consumptive activities feeding other productive activities, just as a food web in ecology links all species in a network of feeding and recycling.

Third, we can create a more conscious, forward-looking relationship with our physical, chemical and biological environments. An Earth wired with sensors will make it possible to monitor the impact and consequences of our own activities. Existing worldwide networks of weather stations, tide gauges and seismic sensors are early steps toward instrumenting the Earth. To understand the Earth's history and future and our place in it, we need to install more instruments in the atmosphere, continents and oceans at all depths and elevations. In biology, we do not understand the functions provided by most species and ecosystems on Earth, and we cannot replace the genetic information produced by the last 4 billion years of evolution. We can stop throwing out living parts of the Earth before we read the instruction manual.

Fourth, no one can anticipate the challenges humans will face one-quarter, one-half or one century from now. But we can ensure that future generations are healthy, educated and supplied with the social and material means to respond to whatever challenges come their way. Universal education would improve individual lives and provide society with a reserve of competence to face surprising challenges. It would have favorable effects on fertility, economic productivity and enterprise, environmental understanding and preservation, and human capacities to innovate and to adapt. There are 1.25 billion children in the world today between 6 and 16 years old. Using information technology, we could probably educate all of them better than we do now at a global average cost of $500 per child per year. That would cost less than 2 percent of the gross world product of about $32 trillion. As much as any other single line of action, universal basic and secondary education would enhance our chances of a sustainable future. How can we afford not to educate all the children?

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by Paul R. Epstein

Climate Stability & Public Health

Climate change and the biological responses to it are occurring at a rate unforeseen just several years ago. Worldwide, extreme weather events, compounded by long-term warming, are profoundly impacting public health, and the aftershocks of the events are rippling through economies. The flooding associated with Hurricane Mitch (Nov. 1998), for example, spawned a cluster of disease outbreaks (cholera, malaria and dengue fever) and caused over $5 billion in damages. If more frequent and intense extreme weather events continue to be a primary manifestation of climate change, harnessing climate data to better forecast future disease outbreaks can enable early warnings and motivate prevention.

Wide swings in weather and sequential extremes can yield surprises. In the New York City region, a "surprise" explosion of mosquito populations in September 1999 ushered in West Nile-like viral encephalitis. But the conditions favoring diseases that cycle among birds, urban mosquitoes and humans are well understood. Mild winters and prolonged droughts (both associated with climate change) decrease predators and favor city-dwelling mosquitoes (Culex pipiens) that breed in stagnant, polluted waters. Mild winters reduce snow cover, thus diminish spring run-off, exacerbating subsequent droughts. The July 1999 heat wave may have amplified the maturation and circulation of viruses among mosquitoes and congregating birds, while the late August rains unleashed a new crop of Aedes mosquitoes, that may have acted as additional "bridge" vectors to humans. West Nile virus may have recently evolved in virulence, as it has not previously killed birds in such numbers.

During the 1997/98 El Niño event, the Horn of Africa received up to 40 times the average rainfall, crippling infrastructure and precipitating a cluster of diseases: tens of thousands of new cases of cholera and malaria and 89,000 cases (with nearly 1000 deaths) of Rift Valley fever. By tracking El Niño/Southern Oscillation (ENSO) indices and Indian Ocean sea surface temperature (SSTs), combined with vegetation changes detected by remote sensing satellites, forecasts of Rift Valley fever epidemics can be made 5 months in advance of outbreaks. Early warnings of conditions conducive to disease outbreaks can give sufficient time for interventions, such as vaccination of livestock and treatment of mosquito breeding sites.

In general, climate constrains the range of infectious diseases, while weather affects the timing and intensity of outbreaks. Uncovering these associations is aided by increased understanding of the Earth's climate system, in particular how land and sea surface temperatures and pressure gradients drive winds and weather. The atmosphere holds 6% more water vapor with each 1ƒC rise in temperature. The resulting increase in evaporation and greater residence time for water vapor in the atmosphere boost humidity and heat indices, fuel storms, and reinforce the greenhouse effect (the trapping of heat by atmospheric gases such as carbon dioxide). An increase in cloud cover blocks outgoing heat, contributing to disproportionate warming at night and during the winter — conditions that are unhealthy for humans but advantageous for insects that transmit infectious diseases. A moisture-laden atmosphere also generates more tropical-like downpours that create breeding grounds for mosquitoes, propel rodents from burrows, and flush nutrients, chemicals, and microorganisms into waterways.

Understanding the evolution of weather anomalies will require integrating data from the ENSO with local SSTs and, eventually, with decadal-to-centennial cycles in climate variability and human influences. Changes in atmospheric chemistry may have so altered Earth's heat budget that natural climate modes such as ENSO have been modified. Studies suggest that the ocean is becoming warmer at intermediate depths and around both poles. If the world's oceans are a long-term heat sink for this century's global warming, then this has profound implications for marine life and terrestrial weather patterns.

With disproportionate warming at high latitudes and high elevations, and winter and nighttime, most summit glaciers are in retreat. Seven of Antarctica's ice shelves are in retreat and polar researchers suspect that melting at the base of the Greenland ice sheet may be sculpting fault lines that could diminish its stability. Contemporaneous changes in greenhouse gas concentrations, ozone levels, the cryosphere, ocean temperature, land use, and land cover challenge the stability of our epoch, the Holocene — a remarkable 10,000-year era that followed the retreat of the great ice sheets from temperate zones. High-resolution ice core records suggest that greater variance from climate norms may indicate greater climate instability, increasing the potential for rapid shifts between stable climate states.

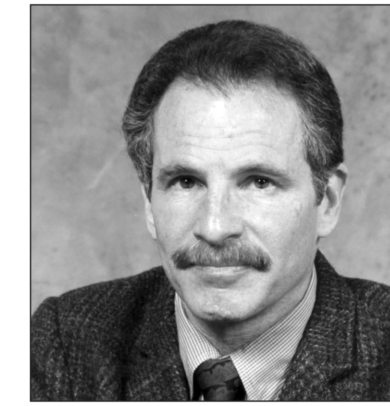
Shrinking of Earth's ice cover (cryosphere) has implications for water (agriculture, hydropower, and health) and for albedo and climate stability. The impacts of warming and changing weather patterns on forests, agriculture, marine life, and water may hold the most profound consequences for global health. Ultimately, potential changes in thermohaline circulation and polar ice cap integrity pose the greatest threats to society and to our well being.

The costs of extreme weather events and associated emerging infectious diseases are mounting. The 1998 summer floods in China, for example, killed 3700 individuals, displaced 223 million people, and cost $30 billion. All told, weather-related losses—combining growth of coastal settlements, ecological vulnerabilities, and extreme weather—grew exponentially from the 1980s to the 1990s; losses of $90 billion in 1998 eclipsed the losses of $55 billion for the entire decade of the 1980s. Recent events in the US demonstrate that no nation is immune to weather extremes and associated epidemics, and there are consequences for international trade, travel, and tourism.

There are solutions to the increased burden of emerging infectious diseases. Greater surveillance and response capability are essential. Health early-warning systems based on climate forecasting and remote sensing can generate timely, environmentally-friendly public health interventions (such as treating mosquito breeding sites, in lieu of large-scale pesticide spraying).

Concerns for our health in the face of global change raise the urgency of ecological restoration and development of non-polluting energy sources. Clean energy helps to stabilize the climate and can power health facilities, pump water for irrigation, and purify it for consumption. Renewable and energy-efficient technologies can become the new engine of economic growth, driving improvements in public health. Ultimately, we must shed inherited economic burdens and adopt new financial mechanisms — incentives, subsidies, and funds — to reverse environmental assaults on public health, protect the global commons and achieve healthy, clean, and equitable development in the coming century.

This article was adapted from "Climate and Health," an article in the July 16, 1999 issue of *Science* (285:347-348).



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by Peter Singer

ETHICS

Beyond the Species Barrier

At least since Darwin, we have known that the forests and animals were not placed on Earth for us to use. They have evolved alongside us.

THE TRADITIONAL VIEW

According to the dominant Western tradition, the natural world exists for the benefit of human beings. God gave human beings dominion over the natural world. Human beings are the only morally important members of this world. Nature itself is of no intrinsic value, and the destruction of plants and animals cannot be sinful, unless by this destruction we harm human beings. But this traditional Judeo-Christian view of the world is based on a creation myth that was decisively refuted more than a century ago. At least since Darwin, we have known that the forests and animals were not placed on Earth for us to use. They have evolved alongside us. The assumptions that derive from that myth, however, are still with us. If we can succeed in clearing them away, the consequences for our way of living will be as far reaching as any changes in human history have ever been.

In any serious exploration of environmental values a central issue will be whether there is anything of intrinsic value beyond human beings. To explore this question we first need to understand the notion of "intrinsic value." Something is of intrinsic value if it is good or desirable in itself. The contrast is with "instrumental value," that is value as a means to some other end or purpose. Our own happiness, for example, is of intrinsic value, at least to most of us, in that we desire it for its own sake. Money, on the other hand, is only of instrumental value to us. We want it because of the things we can buy with it, but if we were marooned on a desert island, we would not want it. (Whereas happiness would be just as important to us on a desert island as anywhere else.)

Now consider any issue in which the interests of human beings clash with the interests of nonhuman animals. Since we are here concerned especially with environmental issues, I'll take as an example Australia's kangaroo industry, which is based on killing free-living kangaroos in order to profit from the sale of their meat or skins. As a community, Australians must decide whether to allow this industry to exist. Should the decision be made on the basis of human interests alone? For simplicity, I shall assume that none of the species of kangaroos shot is in danger of extinction. The issue therefore is one about whether, and to what extent, we consider the interests of individual nonhuman animals.

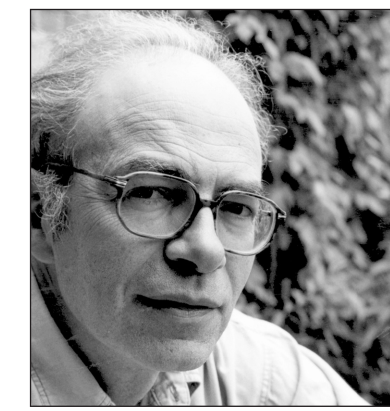
AGAINST SPECIESISM

In my view, the fact that a being is not a member of our species should have no effect on the weight we give to its interest in not being in pain. To think that species membership alone should make a difference in how much weight we give to a being's interests is to display a bias or prejudice towards members of our own species, and against members of other species. This bias, which I call speciesism, is similar in structure to other indefensible form of discrimination, such as racism and sexism.

It might be said that there are morally relevant differences between humans and other species which are greater than the differences between the different races or sexes of human beings. Here, by "morally relevant differences" people will have in mind such things as the ability to reason, to be self-aware, to act autonomously, to plan for the future, and so on. It is no doubt true that, on average, there is a marked difference between our species and other species in regard to these capacities. But this does not hold in all cases. Dogs, horses, pigs and other mammals are better able to reason than newborn human infants, or humans with profound intellectual disabilities. Yet we bestow basic human rights on all human beings, and deny them to all nonhuman animals. In the case of human beings we can see that pain is pain, and the extent to which it is intrinsically bad depends on factors like its duration and intensity, not on the intellectual abilities of the being who experiences it. We should be able to see that the same is true if the being suffering the pain is not of our species. There is no justifiable basis for drawing the boundary of intrinsic value around our own species. If we are prepared to defend practices based on disregarding the interests of members of other species because they are not members of our own group, how are we to object to those who wish to disregard the interests of members of other races because they are also not members of our own group?

LOOKING AHEAD

The argument I have just offered shows that while the dominant Western tradition is wrong on the substantive issue of how we ought to regard non-human animals, this same tradition has within it the tools — in its recognition of the role of reason and argument — for constructing an extended ethics that reaches beyond the species boundary and addresses the human/animal relationship. There is no objection of principle to this extension. The principle that must apply is that of equal consideration of interests. The remaining difficulties are about exactly how this principle is to be applied to beings with lives — both mental and physical — that are very different to our own. That is certainly a major problem, but we can make progress with it only if we begin on the right ethical basis.



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by Robert Kaplan

The Ends of the EARTH

Humankind in the 21st Century: The Explosion of Conflict

Knowing a lot about history does not mean you will be able to predict the future in politics. But it does mean that you are likely to be slightly less surprised by what happens in the near and middle term future — which is the best that anyone could hope for.

If I were trying to predict 100 years ago what the dangers and the evils of the 20th century would be, it would be nearly impossible to do so because three words did not exist then in common usage: fascism, totalitarianism and inflation. None of those words came into usage until later in the century, in the 20s and 30s. So we may not even have names yet to describe some of the problems and evils and good things that may happen in the next century. By looking at history, the closest historical model I can find to what I see around me as I travel around the world reporting, is a description of the world by Arnold Toynbee who wrote in the middle of the 20th century. Toynbee said that the evils of the 20th century, such as Nazism and Fascism, have come about because of the way that democratization (mass democracy, mass movements, labor movements, etc.) in Europe and Japan chain-reacted with industrialization. At the very beginning, the incubators of the Nazi party and the Fascist party were not necessarily evil. They were labor movements, populist movements. One did not know where they would go. And without industrialization — railroads, the telegraph, etc. — Hitler and Stalin would not have been able to do what they did.

The way that mass popular democracy chain-reacted with industrialization is likely to be the way in the next century that democratization, world-wide, is going to chain-react with post-industrialization. And because post-industrialization is different from industrialization, the evils and problems we are going to have are going to be different. Democracy by itself and technological improvement by itself are not necessarily good — or evil. Everything depends upon the circumstances in which they are applied.

DEMOCRATIZATION

The real conundrum with democratization is that democracy tends to work best when it is instituted last, when it is the capstone of many other forms of social and institutional development. If you have a society where there is a sizable middle class that pays income taxes, where institutions are staffed by literate bureaucrats, and where the main issue is which ethnic group, if any, controls what territory, then democracy is the capstone for development and tends to improve daily life and provide greater political stability. The more organically and slow-moving that democracy develops, the better. When the first election is on page nine in the newspapers, rather than on page one, it's usually a good sign. Places like Taiwan and South Korea are examples of this kind of organic development. What we see today, however, is that democracy is developing in places where there are often no institutions to speak of — in places where literacy rates, especially among women, are very low, in places where the main questions of the society, like which ethnic group, if any, controls what territory are not resolved at all. Thus, when you have an election, you often get a weak government with a minority in parliament. This tends to further weaken stability, with the prospect of significant problems ahead. There are examples of this all over. Twenty or thirty years from now, when historians write the history of the wars of the Yugoslav succession in the 1990s, one of the themes will surely be how the end of authoritarianism and the birth of elections in Slovenia, Croatia, and Serbia, either fast-forwarded ethnic cleansing or legitimized such an act after the fact.

The genocide of Rwanda occurred in the context of the democratization of society. In societies where you do not have a very developed class structure, where almost all of the population are peasants living in subsistence agriculture, and where when you suddenly organize political parties for elections, people have no means of dividing up their political loyalties except by ethnicity and territoriality. Thus, political parties in peasant societies reify and harden and institutionalize already existent ethnic divides. In Algeria, one saw a round of elections that led to a civil war, whereas in Tunisia next door, there were no elections and the society has been at peace. In Sudan, in 1985, fully legitimized democratic elections led to the worse military tyranny in Sudan's post-colonial history. Venezuela has 40 years of democracy and nothing much to show for it, where the elite has all of its money in Miami bank accounts. Perhaps the best example here is the different experiences of China and Russia. In the last 18 years or so, more people have seen their material lives improved more dramatically and an explosion of their personal freedoms in China than at any time in recorded economic history. This occurred under an autocracy, a one-party autocracy. In Russia, however, a cold-turkey democracy has led to a practical collapse of living standards and virtual anarchy in many parts of the country outside the greater Moscow-Kiev-St. Petersburg areas. In fact, if Russia had had an extra five or eight years of Gorbechev capitalist-trending authoritarianism, the average Russian would probably live much better today and be much more secure.

So the real issue for stability is not democratization. It is the size of the middle class. In societies that have big middle classes, stability can be taken for granted. In societies that don't, it cannot be taken for granted. The real political problem in our world in the next 20 years is that most human births will tend to occur among the poorest sectors of the world and in the poorest sectors of the richer parts of the world. That means that while middle classes increase in absolute terms, in relative terms, middle classes are either staying the same percentage of society or getting smaller, which does not bode well for political stability.

What I see ahead in the coming decades is a return to what the ancient Greeks called hybrid regimes, or mixed regimes. In other words, a regime that mixes elements of democracy and elements of military or oligarchic business rule in various combinations.

Some examples. Turkey is officially a democracy. It is a member of NATO. You cannot be a member of NATO unless you are a democracy. But in fact the military plays a very large role in daily Turkish political affairs. The key political institution in Turkey is the National Security Council, not the parliament. And in the National Security Council, the generals come with dossiers with which to lecture and the civilian politicians come as tourists in order to listen. Peru, is another example of a mixed hybrid regime, where you have a leader who has been democratically elected twice, but has done away with many constitutional imperatives, and basically governs through the security services. Jordan is another example of a hybrid regime where you have a royal family but you also have a very feisty parliament which limits and constricts what the royal family can do. But the royal family can step in anytime it sees fit. A case in point: the Jordanian parliament was against the peace treaty with Israel. The royal family stepped in and abrogated what the parliament did.

TECHNOLOGICAL IMPROVEMENT

Now to the problems of technological development. The industrial revolution was about bigness. It was about big aircraft carriers, big tanks, big factories and big railroads. In order to take advantage of the industrial revolution, you had to own geographical space. You had to have won out in a political power struggle. That is why the crimes of Hitler and Stalin and Mao were so large — never before in history had a dictator had such power behind him because of the industrial revolution.

But the post-industrial revolution is, of course, about smallness. It is about miniaturization. It is about a telephone jack, plastic explosives, and the biotech revolution, which leads to biological weapons, etc. You do not need to win out in the political power struggle to take advantage of the post-industrial revolution. You can have many terrorist groups, many embittered minorities who have lost out, who do not own geographical space, but still can be empowered because of the post-industrial revolution.

We have been told that the computer and the internet will bring us together. But people were saying similar things about movable type during Gutenberg's revolution. And it led, indirectly, to the religious wars. That is because with the diffusion of knowledge, you also get a vulgarization of knowledge. Because knowledge feeds into the heads and brains of many people who are not uneducated or highly educated, but badly educated. And there is nothing as dangerous as people with a little bit of education. If you want to see any examples, look at the educational background of Hitler or Stalin.

I believe that, in effect, that we are going to have a world of many smaller, complex evils. We may not have one or two or three or four big villains of the next century. But we are going to have an increasingly complex, unstable world with a lot of regional wars and upheavals. And when I mention democratization chain-reacting with post-industrialization, add into that the factors of resource scarcity and urbanization, which are key here.

People in cities are harder to govern than people in remote areas. People in rural areas often grow their own food, so they are not susceptible to price fluctuations. Thus, politicians tend to have an easier job with rural populations than urbanized populations. Increasingly, however, rulers around the world are going to have to deal with more urbanized populations, which means that the margin of error is going to be wider and the margin for success is going to be narrower.

This is a world where we are going to see not fewer intelligence agencies, but a boom in intelligence agencies because with so many people and so many weapons of mass destruction, figuring out intention and infiltrating groups are going to be increasingly important. This is nothing I say happily, but it happens to be a fact that much of the plutonium caught at airports in the last decade was done through the work of intelligence agencies that had penetrated groups. So the end of the cold war does not mean the end of intelligence agencies. The greatest spies may just be being born at this moment.

The world I describe, when you boil it down, may not be any worse than the world of the 20th century. It will be far more complex, far more unstable, but on the other hand, we may not have the great, grand centralized evils that we had in the last century.

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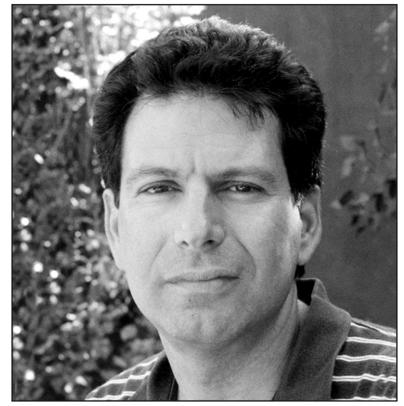
I think the way that rulers, democratic or undemocratic, are going to cope with this world, is by a return to ancient classical realism. That is because classical realism is based on the assumption that politics is driven by interest and necessity. And when interest and necessity are properly calculated, history rewards rulers with the appellation of heroes. For people in an increasing complex world of different moral value systems, to act only morally, is to automatically bring their own society into conflict with other societies that have a different value system. Also, when people think only morally, they tend to dismiss and delegitimize those who disagree as immoral, and therefore compromise becomes more difficult in the political realm. However, enlightened self-interest automatically recognizes the self-interest of others, and therein lies compromise.

James Madison wrote in Federalist 51, that men and women are irredeemable, that all one can do is to set ambition against ambition, selfishness against selfishness. It was from that dictum that the division of powers of the U.S. government was developed. We have to think like the framers of the Constitution in terms of constructive pessimism. The U.S. was built on constructive pessimism and it turned out to be a happy society for most people. The French Revolution was built on optimism, and it ran into problems immediately, with Napoleon's dictatorship. The only way to avoid tragedy is to cultivate a sense of it in advance.



Robert Kaplan *is a contributing editor to* The Atlantic Monthly. *He also writes for* The New Republic *and has published six best-selling books on international affairs that have been translated into a dozen languages.* The Ends of the Earth, An Empire Wilderness: Travels Into America's Future, The Arabists: The Romance of an American Elite *and* Balkan Ghosts *have all earned praise from* The New York Times. *Mr. Kaplan has reported from over 75 countries during more than 20 years as a freelance journalist, and his essays, such as "The Coming Anarchy" and "Was Democracy Just A Moment," regularly excite debate in the highest circles of government.*

Mr. Kaplan can be contacted through the editorial offices of The Atlantic Monthly.

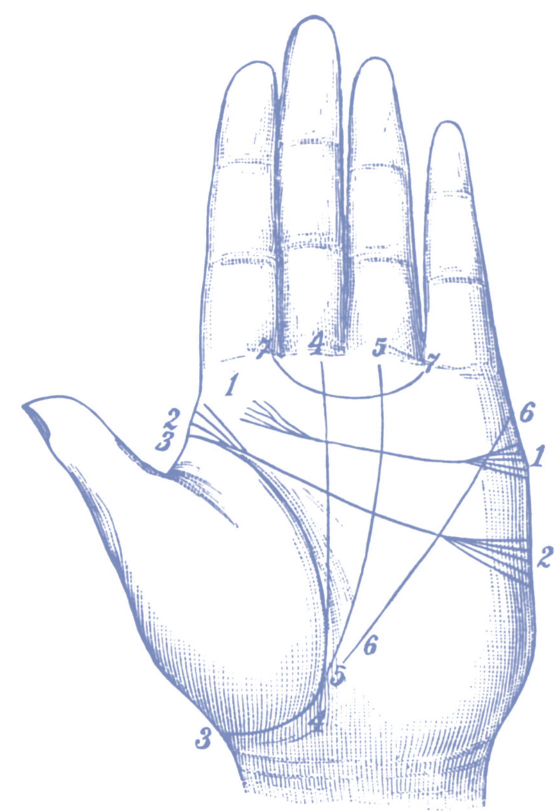
by Wilfred Beckerman

OUR OBLIGATIONS TO Future Generations

The growing concern during the last three decades with the impact of economic growth on the environment has led to a widespread belief that we are failing to respect the constraints on our policies imposed by the imperatives of intergenerational justice.

This has been accompanied by calls to pursue policies of "sustainable development" or to respect the claims of intergenerational equity. I think all these beliefs and claims are fatally flawed and that, together with their background scare stories about imminent environmental catastrophe, they only distract attention from what ought to be our most important bequest to future generations, namely to bequeath to them a more decent society in which there is greater respect for basic human rights.

First, future generations cannot have rights. The basic reason for this is that future generations cannot have — in the present tense — anything. They cannot have long hair or a taste for Mozart. They will have interests when they are there, and they may well then have rights. But their rights will only be rights to what is available at the time; not to anything that is no longer available. It makes little sense to say that our right to see a live Dodo has been violated by the inhabitants of the Mauritius islands three centuries ago.



Secondly, since future generations cannot have rights, the interests that they will have cannot be covered by any coherent theory of justice. A crucial feature of all theories of justice is a set of principles that enables people to agree on the allocation of rights to whatever desirable assets or opportunities might be the source of conflict and be the subject of dispute. This enables people with conflicting interests to co-exist under conditions of some scarcity, without recourse to violence or other threats to life and liberty.

The banner of "sustainable development" under which innumerable international and national bureaucracies and commissions and research programmes have been set up and financed seems quite untenable. The most widely accepted definition is that sustainable development means that there must never be any decline in per capita welfare in the future. Welfare can go up, so presumably higher per capita welfare is a good thing. But it must never decline, since this would be a bad thing. But if periods of decline are needed in order that the subsequent increases are even greater why should this be ruled out?

It is often claimed that we must respect the objective of intergenerational egalitarianism. Now, in the first place, egalitarianism even at any point of time is a very difficult objective to defend. What matters is the relief of poverty. Few people — apart from those consumed by envy — would prefer a

Our most important obligation to future generations is to bequeath to them a "decent society" in which there is respect for basic human rights, tolerance for differences in conceptions of the good life, and democratic institutions and traditions that enable people to sort out their inevitable conflicts peacefully and free of fear of oppression and humiliation.

society in which total equality was achieved simply by bringing everybody down to the level of the most deprived. And egalitarianism between generations is an even more absurd objective. For we should hope that future generations will be better off than we are and that welfare will continue to increase indefinitely, thereby adding to the intergenerational inequality that has been increasing since time immemorial.

None of the above implies that we have no obligations to future generations. But "rights" do not exhaust the whole of morality, so we should still take account of the interests that future generations will have and of the way that our present actions will affect those interests. We have to try to predict which will be the most important interests that future generations will have and how they compare with the interests of the present generation.

As far as incomes are concerned, in the very long run the main source of economic strength is based on technological and scientific progress, and, above all, the rate at which the resulting inventions and innovations are diffused. This is a function of variables which are all tending to increase, some at a phenomenal rate. In particular, the number of highly educated people in the world — especially those having technological and scientific qualifications — is increasing so rapidly that it far surpasses the corresponding number of people having similar qualifications only two or three decades ago, and is likely to go on expanding rapidly. And there is no physical limitation on the growth of this human capital.

Secondly, the rate of international diffusion of innovation and technical progress — which many studies have shown to be decisive in determining growth rates — will continue to accelerate.

These two underlying forces for long-run growth suggest that the average annual long-run growth of output per head over the next century should be above that of the last forty years. And this has been 2.1 per cent per annum. So to be on the safe side, I shall assume that the annual average growth rate of real incomes per head over the next 100 years or so will be about 1.5 per cent. The power of compound interest being what it is, this means that world average real incomes per head in the year 2,100 or so would be 4.14 times as high as they are now!

This growth of incomes will eventually trickle down to the poorest nations, though, as has been seen during the post-war years, mis-management and corruption in some can often prevent this for very long periods of time. Of course, poverty, both absolute and relative, will no doubt always persist, even in democratic countries with flourishing economies Some people will always fall through what might have appeared to be more or less "foolproof" safety nets in the form of universal income maintenance programs. Others will remain poor on account of being trapped in a vicious circle of poverty — family breakdown, parental neglect or abuse, crime, drugs, and vicious environments that are features of many cities in affluent and democratic countries.

But leaving aside these sociological influences, there does not seem to be any economic mechanism that should make the overall distribution of incomes become markedly more unequal

than it is today. In that case a continual rise in income levels must lead to a substantial reduction in 'absolute poverty' even if "relative poverty" might always persist. At least there are no insuperable material obstacles to the alleviation of poverty over the course of the long-term future in the same way that there are insuperable obstacles to the spread of universal peace and harmony and goodwill among all human beings. Human sensibilities do not keep pace with technical progress.

Climate change will not be an obstacle to increased prosperity. I am not qualified to talk about the scientific aspects of climate change since I am not a scientist or a film star or a politician or a member of the British Royal Family. But there are good reasons to believe that, for the world as a whole, the net economic effects will be significant by comparison with the vastly higher incomes that the world will enjoy by the end of the coming century.

As for any possible constraint on growth arising from material shortages, it may suffice to say that predictions to the effect that we cannot go on using up resources at the current rate because we shall run out of them have been made since the days of Ancient Greece. The basic reason why we shall never run out of any resource is that its price will always rise to prevent it. Insofar as we may go through periods in which demand for some material increases faster than supply, the rise in its price will set off innumerable favourable feed-backs, such as a greater search for new sources, technological improvements in extraction and refining, a shift to substitute materials, a shift away from use of the end-products embodying the material in question, and so on.

As I pointed out nearly thirty years ago, the world has managed very well without any supplies at all of Beckermonium, a product named after my grandfather who failed to discover it in the 19th Century. Of course, if the world were suddenly totally deprived of some major source of, say, energy overnight there would be chaos. But that sort of scenario only happens in science fiction.

The safest prediction that can be made for the long-term future is not in the field of economic growth or environmental change, but in the field of human conflict, namely that there will always be potential conflict between peoples for all sorts of different "reasons" and that can easily lead to horrific violations of basic human rights. At the same time one can also predict with great confidence that people will always want life and security, and freedom from fear, discrimination and humiliation. And the best guarantee that these permanent needs, which are the essence of what constitutes a human being, will be satisfied is a society that protects basic human rights and provides the maximum liberty compatible with similar liberty for others. Thus, by contrast with the long-term prospects for poverty and the environment, it seems virtually inconceivable that there will be any decline in the need for eternal vigilance in defense of basic human rights. It is for this reason that our most important obligation to future generations is to bequeath to them a "decent society" in which there is respect for basic human rights, tolerance for differences in conceptions of the good life, and democratic institutions and traditions that enable people to sort out their inevitable conflicts peacefully and free of fear of oppression and humiliation.

Wilfred Beckerman *is an Emeritus Fellow of Balliol College at Oxford University, England, having recently retired there as a Fellow and Tutor in Economics. Previously, he had been Professor and Head of the Department of Political Economy at University College in London. Dr. Beckerman authored* Small is Stupid, *as well as several other books and numerous academic articles on economics, politics and the environment. Dr. Beckerman has served on the Royal Commission on Environmental Pollution, and chaired the Academic Panel of Economists for the UK Department of the Environment from 1991 to 1996.*

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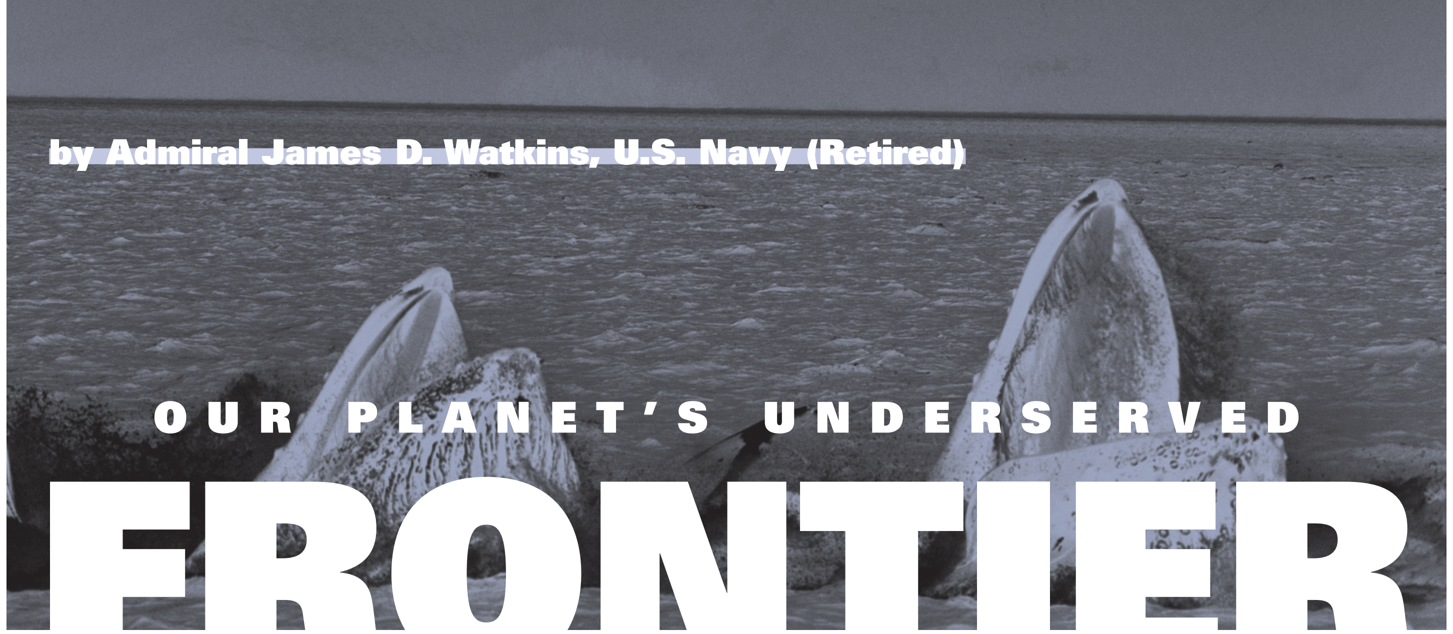

by Admiral James D. Watkins, U.S. Navy (Retired)

OUR PLANET'S UNDERSERVED FRONTIER

Realization is finally settling in on the fact that there will be a significant increase in the world's population with a projected trend for even higher population densities in coastal zones and attendant new patterns of disease distribution that foretell potential regional disasters of epic proportions.

A number of strong public statements about the importance of the oceans have been made, just in the past year alone, by prominent U.S. national leaders in the fields of public policy, science and technology, health, scientific exploration, and politics. One of these was made recently by President Clinton:

"We must continue the critical dialogue that has begun and build together across party, regional, economic, and other interests a comprehensive ocean agenda for the 21st century."

Why all this attention now? What has changed? Well, the world has undergone staggering changes over just the last 10-15 years:

- Economic might instead of military power has emerged rapidly as the driving force for assuring our future national security and health as a nation.
- Potential threats of global warming and other climate change challenges are dominating the debate among those who set our national research agenda.
- Realization is finally settling in on the fact that there will be a significant increase in the world's population with a projected trend for even higher population densities in coastal zones and attendant new patterns of disease distribution that foretell potential regional disasters of epic proportions.

With these and other powerful and dynamic factors at work, we asked ourselves five years ago: Have we, the U.S. ocean science and technology policy-making community, done what we needed to do to ensure the oceans are effectively engaged in bringing their impressive powers to bear on improving the human condition? Are we satisfied that our community is properly positioned as a cohesive force to be responsible and effective in addressing ocean-connected issues? Our answer was a resounding no.

Within this context, then, and with the support of ten premier academic oceanographic institutions, including Columbia University, and several Federal agencies, we established the Consortium for Oceanographic Research and Education (CORE). One of the first efforts CORE undertook was development and implementation of the National Oceanographic Partnership Program. CORE, now 60 institutions strong, took the lead in establishing for the first time, a formal program to coordinate cross-cutting research requirements among the nine Federal agencies. This program was established by an Act of Congress in 1996. Program oversight is provided by a National Ocean Research Leadership Council (NORLC), currently chaired by the Secretary of the Navy, and includes a top official of each participating agency.

The program has had two specific impacts to date. First, it has brought about $125 million of new and badly needed Federal appropriations and matching funds to ocean research. This is the first major influx of new funds into the ocean science community in more than a decade. The new partnership program has also forced discussion of ocean issues at the highest level of the Federal Government.

So, where are we now? As you know, we ended the International Year of the Ocean about one year ago. Nations around the world celebrated, raising public awareness of the importance and fragility of the oceans and proclaimed their commitment to preserve this shared resource. As we learned and marveled about the oceans, we also suffered globally from the effects of El Niño and its La Niña, perhaps the single most dramatic phenomena to raise public consciousness of the oceans in recent years.

In the U.S., the Vice President chaired the first ever White House Oceans Conference in the summer of 1998. The Conference called together leaders from academia, industry, the Federal Government, and the environmental community to discuss issues and opportunities in the oceans. In terms of ocean research, several important themes emerged. The report of this White House Conference, promulgated only a few months ago and entitled "Turning to the Sea: America's Ocean Future," made 135 recommendations covering a broad range of concerns related to the various themes of the Conference — economic benefits, global security, marine resources, ocean science education, ocean research, ocean observations, and ocean and coastal exploration.

One of the most exciting new science initiatives included in these 135 recommendations, was to create an integrated ocean observing system. This system would provide information necessary to make quantum leaps in our ability to forecast, on longer time scales, regional weather and climate; provide information on battle space environment for national security; better manage our fisheries; greatly improve agricultural planning; and alert us early to ocean-driven human health threats. The first interim plan for such a system was delivered to Congress in May of 1999 concurrently with a letter signed by over 1,800 ocean-interested scientists that ended with the following plea:

"We, the undersigned, urge the U.S. government to commit to, plan, and implement a sustained national program of ocean observations, with funding and resources supplemental to those currently available."

To this end, we are working closely with the Congress and the Administration to help launch the U.S. on a major new ocean observation initiative commencing in fiscal year 2001. If we are successful, then the U.S. will be in a position to link up with many international partners who have been poised for some time to join in such an endeavor.

With the new millennium approaching, then, we can see progress being made in gaining new and necessary understanding of our Earth and its oceans as a system. Activities like this Conference, the 1998 International Expo in Lisbon, the U.S. National Ocean Conference last summer, the passage and implementation of the U.S. National Oceanographic Partnership Act of 1996, the emergence of many thoughtful studies from our prestigious National Academy of Sciences and the likelihood that the U.S. will commit resources to field an integrated ocean observing system in collaboration with international partners, all combine to add significant momentum to achieve much greater understanding of our greatest shared international resource. If we persevere in this endeavor, then there is new-found hope that we will be successful in raising ocean science and technology to its rightful place in national and international decision-making as we turn the corner into the next century.

As founding president of the Consortium for Oceanographic Research and Education, ADMIRAL JAMES WATKINS *champions the interests of ocean research institutions world-wide, thus continuing his devotion to both public service and the sea. After capping a 40-year naval career with five years as Chief of Naval Operations for the Reagan administration, he chaired the President's Commission on the AIDS Epidemic and then served as Energy Secretary under the Bush administration, there directing the development of the nation's first comprehensive energy strategy.*

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SESSION THREE:

Living with Finite Natural Resources

Some slightly paraphrased sound bites from Session Three of the State of the Planet Conference.

Mikhail Gorbachev

Nature can live without us, but we cannot live without nature. We must promote an approach in our dealings with the environment that reasonably limits consumerism while valuing the virtue of "enoughness."

Marc Reisner

The 20th Century can rightly be called "The Age of Dams," or even "The Age of Infinite Liberty Taken with Planetary Hydrology." And as Faustian bargains go, dams are in the same league as nuclear power plants — ripe with readily apparent, short-term benefits that obscure enormous, long-term costs.

William O'Keefe

I question the ubiquitous premise of limits that underlies almost any discussion of natural resources and the environment. We human beings have proven ourselves infinitely resourceful at pushing back the frontiers of external limits, and there's no reason to think that will change. As some bright person aptly put it, "The Stone Age didn't end because we ran out of stone."

Jesse Ausubel

Humans, the tool-makers, keep inventing all the time such that limits are fleeting obstacles at most. Whenever we reach the boundaries of a niche in which we find ourselves, we simply invent our way into a new, roomier niche. In this sense, the resources around us are elastic.

Alan Meier

The question, "Where does our electricity go?" is every bit as important as, "How is it generated?" The fact is, a growing percentage of it now leaks away through appliances not in use, with surprisingly significant ramifications for the global environment.

Mike Crow

A cherished mythology of the modern world is that humanity's collective creativity and intellect can overcome any external obstacle. That may be true. But can we overcome the limits to comprehension and cooperation within ourselves, which have resulted in many of the obstacles to environmental sustainability we now face?

ACCEPTING TO LIVE IN A FINITE PLANET

GREEN CROSS
International

[Editor's note: The following letter was received from Mr. Gorbachev and read at the start of Session Three.]

I am honored to address this audience on the occasion of the 50th anniversary of Lamont-Doherty Earth Observatory of Columbia University, which has contributed in so many ways to scientific evaluation of the environmental status of our planet. Unfortunately, I could not join you in person but my thoughts are with you and I wish the conference very fruitful discussions.

Man has long thought of himself as the master of nature and felt that he could make use of it in any possible way. As a result, the entire natural environment that evolved over billions of years, and which led to the emergence of mankind and human society, is now under serious threat.

The environmental crisis is global: deforestation, desertification, natural resources depletion, and air, water, and soil pollution. Mankind has the power to transform nature, to alter the biosphere with environmentally destructive technologies and to destroy the planet with weapons of mass destruction.

It is a fact that today only one-third of the world's population enjoys good, normal or acceptable living conditions whereas two-thirds suffer malnutrition, hunger, poverty and backwardness. This means that the economic choices and way of life adopted in recent history have only served to lead us to a dead-end: a global ecological crisis.

With the accelerated growth of the global population, which started at the beginning of this century with 1 billion and will certainly reach 10 billion by the middle of next century, and the over-consumption of natural resources, scientists all around the world will confirm that humanity is headed towards an unpredictable future.

Through these activities, mankind disrupts the global ecosystems to such an extent that irreversible disruptions can create extremely serious ecological and human catastrophes. It is still impossible to quantify them exactly, but we cannot wait until then to undertake real preventive measures. For the first time in the history of mankind, we are able to elaborate scenarios about the evolution of the planet which becomes real forecasts based on scientific data and analysis. The knowledge of the planet's physical limits gives new responsibilities to mankind, leading to deep social, economical, scientific, technical and political adaptations

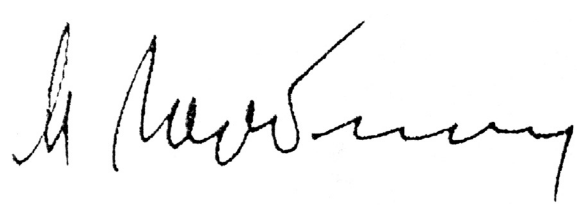
The need to stabilize the pressure out on the biosphere by the growth in population and natural resources over-exploitation, does not mean stabilizing poverty and backwardness, which is what the global market will do if left to its own devices. If we have a situation where only a few live at the expense of the many, we cannot expect anything good to come.

As President of the Green Cross International, I believe one of the most important things is the shaping of a new value system, because nature can live without us but we cannot without nature. Instead of a hedonistic approach, we should promote an approach that reasonably limits consumerism and which promotes the virtue of "enoughness." If we insist on consumerism as the new utopia, nature will reject such a system as surely as cultural diversity rejected the totalitarian system. It is also a question of protecting nature for ourselves. After all, many of us already live in urban zones with noxious air; and already, one out of two people on the planet have access only to bad quality water.

Some question the existence of such a crisis situation, but from knowledge of ecological problems I have gained over the past few years it is important to state that this crisis really does exist. It represents a real danger for the survival of humankind. If we manage to settle the global ecological crisis and live in harmony with nature, we can deal with other issues; if we fail to do so, it will be senseless to take up any other matters. This is the number one problem for the next century and the centuries beyond.

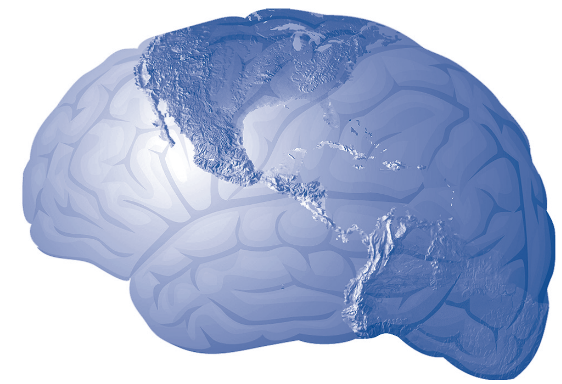
We must learn to live at one with nature. Nature does not bear grudges but it must not be brought to the point where it can no longer sustain human society and the continuance of humankind on earth.

Our generation has to face a difficult challenge but, as recent history has proved, walls of difficulty, like the Berlin Wall, can fall. Let me wish to the participants of the State of the Planet conference a great success, and Green Cross International, the global non-governmental organization that I represent, is always open for cooperation in the future.



Michail Gorbachev

by William F. O'Keefe



ARE RESOURCES FINITE IN A WORLD OF UNLIMITED INTELLIGENCE?

The first question for any panel on "Living with Finite Natural Resources" is the fundamental one: Are natural resources really "finite" in any practical sense that affects the decisions that we as a global society must make over coming decades or even centuries?

I suggest that the answer to this question is "no." Furthermore, I do this in full knowledge of the Brundtland Report, which defined Sustainable Development as the ability of humanity "to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs." I do not hesitate to embrace this statement as a moral standard, because applying it to our current situation indicates that humanity is basically on the right track.

My view follows the path of the late Julian L. Simon, a buoyant optimist about the state of the human condition at the end of the 20th Century (*Wired* magazine called him "The Doomslayer") whose death was a sad day for the cause of reason and rationality in public policy.

He was fascinated by this issue of the finite character of natural resources, and wrote a book called *The Ultimate Resource*. This title referred to human beings and their intelligence, enterprise, and creativity. Simon's major point was that this resource is not finite. Human beings are infinitely resourceful, providing that their social, economic, and political structures support human innovation and enterprise.

Particular physical resources may appear constrained in the short term, but experience demonstrates that people push back the limits. They find new supplies, they learn how to get more out of what is available, or they substitute different resources for the shrinking ones.

There are numerous examples. The substitution of fiber optic cable for copper is an important one. We once heard, after all, about the forthcoming "copper shortage." Petroleum is another obvious example. Ever since the first well was drilled in 1859, we have been "running out." All the while, new techniques of discovery and recovery have kept expanding known reserves, which are now higher than anytime in history.

Oil is particularly interesting, because, unlike copper, which can be used over and over, it is not recyclable. Burning it for energy uses it up. Thus, supplies of oil are by definition finite, if a long enough time horizon is used, because their physical quantity cannot be unlimited. At some point the human race may well wring the last drop of economical oil out of the last piece of shale.

This raises a profound question, which is: SO WHAT? We care mostly about oil only for the energy it provides. There are other sources of energy. Energy efficiency will continue to improve. We will find ways to harness solar energy that do not require us to pave the world with panels.

Society will re-examine its strange phobia about nuclear fission. We may develop fusion. Fuel cells are likely to become efficient and cheap. We might run out of oil; but we will not care because we are in no danger of running out of energy.

To sum up, the title of this panel suggests that many natural resources are declining and non-renewable, and that society's task is to manage scarcity. I can think of none that meet these criteria, if we focus on the purpose served by a resource rather than on the resource itself. Given the power of price signals, the extensive potential for substitution, and the accelerating wonders of human intellectual capacity, it's hard to imagine ever hearing of one.

I may not fear scarcity, but there are some real hobgoblins out there. The biggest is the "finite resources" argument itself. Its end point could logically lead to a case for resources, so as to preserve them for future generations. But who decides the rationing period, acceptable uses and acceptable alternatives, and who bears the costs of those decisions? Can anyone honestly make the case that some organizational arrangement will do a better job than the market?

The vision created by the finite resource argument is based on rejection of human history, compounded by a deeply ingrained distrust of technology and economic rationality. It is devoid of faith in both current and future generations of humanity. Were it implemented, it would cause the catastrophe of poverty and blight that it purports to seek to avert. But the vision has political power, and that is a source of deep concern.

Also to be feared is the deadening hand of bureaucracy. Our reliance on command-and-control regulation is leading to intellectual stagnation. As a study by the Environmental Law Institute last year noted, innovative environmental technologies are simply not being developed, due to a structure of regulation that discourages them. This is ominous. A leash on human resourcefulness is crippling and creates a self-fulfilling prophecy. Doomsayers assert: It's a crisis! Let's redouble our efforts. So we get more of the ineffective policies that brought about the crisis in the first place. The market is self-correcting; bureaucracies are self-protecting.

In sum, I fear a combination of a flawed finite resources argument with the controlling hand of concentrated political power, in which a fear of scarcity leads to politically imposed controls. Those controls then sap the creative energies of society and choke off the resiliency upon which our destiny depends. The crisis created by the controls becomes an excuse for even more controls. Major interest groups both public and private spring up with a vested interest in the system that has developed, and the spiral steepens. In the field on public choice this has been called the Bootlegger and Baptist theory of regulation.

Our real responsibility to future generations is to avoid acting like shriveled misers, fearful of spending a single coin from our treasure of natural resources, huddled in a gloom of self-imposed poverty. We owe it to them to take counsel from our strengths, not our weaknesses, and from our hopes, not our fears. Only if we do this will the future will be bright, and their frontiers be without limits.

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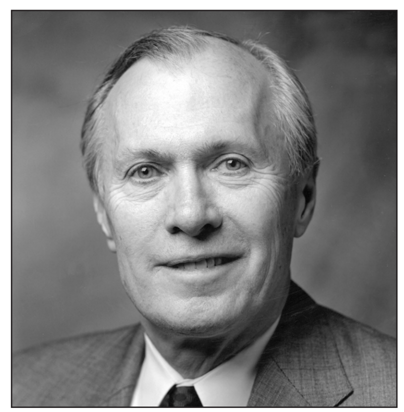

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by Marc Reisner

The Age of DAMS and its Legacy

Off all we have invented, done, and undone during the twentieth century, little is of greater, or more lasting, consequence than a dam. Waterworks — dams and aqueducts — were, of course, being built long before our century dawned. An inverted, pressurized siphon was found in the ruins of Nineveh, the center of Assyrian civilization. Bridges that conveyed aqueduct water to Roman capitals still stand. A 110-foot Sri Lankan dam built in 460 AD reigned as the world's highest dam for a millennium. The ability to manipulate water was, in ancient times, almost synonymous with might and wealth.

Our distant forebears built their waterworks with human and animal labor. We build ours with machines that do the work of ten thousand slaves, with refined materials and engineering techniques, with infinitely more wealth to finance the job. So the scope of water development in this century, and its consequences — for better and worse — utterly eclipse what the ancients achieved. Without Hoover, Glen Canyon, and Oroville dams and some of the longest aqueducts in the world, Los Angeles would still be a collection of outsize villages. The Bay Area — a deceptive place, as dry as North Africa behind its exotic camouflage — and Phoenix, Las Vegas, Denver, and Salt Lake City could not exist without complex and massive waterworks.

Simply put, the twentieth century has been the Hydraulic Century, the Age of Dams. It was the Age of Levees, too. The Age of Infinite Liberty Taken With Planetary Hydrology. There never was — and I suspect, there never again will be — an era of such gargantuan, and disruptive, civil engineering works.

Wallace Stenger, the late novelist and western historian, opined that the Age of Dams began not with the construction but the destruction of a dam. On May 31, 1888, a privately-owned dam erected on a fork of the Conemaugh River by the Pennsylvania Canal Company failed during a series of tremendous rainstorms, and the 50,000 acre-foot reservoir — perhaps the largest in the world at the time — wiped Johnstown, Pennsylvania and 2200 souls off the face of the earth. That historic disaster convinced a lot of people that the private sector had no business building dams. And that new prejudice led directly to the Reclamation Act of 1902, which brought the Federal government into the water-development business. But the Federal agencies that would build America's largest dams — the Bureau of Reclamation, the Corps of Engineers, the Tennessee Valley Authority — did not hit their stride until a cluster of historic events occurred about a century later: the Great Depression, the Dust Bowl, and the election of Franklin Delano Roosevelt.

Early in Roosevelt's second term, the five largest edifices on Earth — Hoover Dam, Bonneville Dam, Grand Coulee Dam, Fort Peck Dam, and Shasta Dam — were in various stages of construction at the same time. Each great new dam was the envy of civil engineers from around the world — a great many of whom were trained in, or by, the U.S.

Yet it is remarkable how quickly the Golden Age of Civil Engineers came and went — in the U.S., at least. Hoover Dam marked the true beginning of the Age of Dams. But just half a century later, a catastrophic dam failure — the collapse of the Bureau of Reclamation's Teton Dam in Idaho — quickly brought it to a close. Teton Dam is an example of a dam that shouldn't have been built: a Congressional gift to a small (but politically powerful) collection of potato farmers who applied a hundred inches of water to their irrigated crop, but demanded more. It was a dam erected, over the strenuous objections of geologists with the USGS, whose taxpayer-financed cost greatly outweighed any conceivable benefits. After Teton's collapse — which killed eleven people and caused a billion dollars in damage — the politics of water development took a spinning turn. Five months later, the U.S. elected Jimmy Carter, the first president whose aim, it seemed, was the same as that of most environmentalists: to stop dam construction altogether.

In the American West, the last two great federal dams were both completed at the end of Jimmy Carter's term, and both are in California: the Bureau of Reclamation's New Melones Dam, the most controversial in U.S. history, and the Corps of Engineers' Warm Springs Dam, a 320-foot behemoth on an aptly-named stream called Dry Creek. In the West, with the exception of a couple of off-stream reservoirs and rehabilitated dams, we have done nothing mentionable since. It's pretty much the same throughout the U.S.. So now, going into the next century, we inherit the schizoid legacy of the Age of Dams: on the one hand, a bold and visionary era, with great social and economic benefits. On the other, a shortsighted, politically corrupted, and, in environmental terms, endlessly damaging one.

The socio-economic benefits of water development are undeniable. Even environmentalists acknowledge them. The problems created by water development are still under-valued, and they will get worse. Here, in a nutshell, are some of the big ones:

- the sedimentation of reservoirs on which millions of people have come to depend;
- the ruin, through salt build-up, of millions of acres of once-fertile soil;
- the creation of cities in deserts where they arguably shouldn't exist, and then their vulnerability to earthquakes, which can destroy aqueducts and cause dams to collapse;
- the stoppage of river-borne sediment and the erosion of river deltas and ocean shorelines;
- the disappearance of world treasures like the Aral Sea in Russia and Tulare Lake in California, as the rivers that fed them are diverted elsewhere;
- the collapse of great fish habitats, like the Caspian Sea's sturgeon and the Great Lakes' lake trout;
- the insidious bio-accumulation of methylated mercury in water, fish, and ultimately humans;
- the displacement of millions of people from fertile river valleys;
- the rampant deforestation that accompanies most dam projects in rainforest zones.

Solving a problem as complex, immense, and expensive as this will be difficult. We cannot do so without sealing up the oil corridor channels, taking down the Missouri River dams, and breaching the levees — at least south of New Orleans. The economic and social repercussions would be awesome. But the economic and social repercussions of doing nothing are also awesome. For the next three or four decades, until the Gulf of Mexico is at New Orleans' door and the tidal surge from a Category 5 hurricane threatens to put that city twenty feet under water, we can shove this dilemma onto our children and grandchildren.

But there is one problem that must be addressed immediately. In California, 80 percent of our salmon and steelhead populations have been lost since the 1950's. Every major river draining the Sierra Nevada is now blocked by dams, and the biggest, utterly impassable dams are at low elevations keeping salmon from their historic spawning habitat. Annual spawning numbers, which were once in the million-plus range, statewide, now amount to a few thousand fish in the half dozen streams where they survive at all.

In the Pacific Northwest, the situation is worse. The Columbia River was once the most prolific salmon watershed on Earth, with annual spawning runs amounting to 15 million fish — some of which went over a hundred pounds. It is now about 7 percent of what it was.

How did the salmon crisis become so critical? Well, for one thing, the effects of dams tend to be both delayed and progressive. Spawning populations slowly declined. Then a drought episode really decimates them and they have an awful time recovering because there is too little spawning habitat left. But viewing the situation more broadly, one is forced to conclude that the West's frontier mentality has boomeranged and smacked us right in the face. We had a pretty good idea, even decades ago, what the environmental consequences of water development would be, but we told ourselves that there were always other rivers, other salmon runs, other wetlands — we couldn't run through such abundance. Or we simply decided, in the end, that the tradeoff was worth it. What no one foresaw in the forties and fifties and sixties was an imminent, epochal shift in public attitudes toward nature, which led to legislation like the Endangered Species Act. Now the public demands protection or restoration of species and landscapes and river-scapes. Few people appreciate how difficult that will be without some sacrifice of water, and, most importantly, some deconstruction of the grand edifice we have built.

Thus far — in California, and also in the Pacific Northwest — we've tried to solve the dilemma mainly by sacrificing water or hydroelectricity: by bypassing turbines or reallocating water, mainly from irrigation agriculture, to environmental needs. We've also built hatcheries, which according to many biologists is a Band-Aid approach that will ultimately make things worse; we've installed fish ladders and fish screens; we've even removed a few tiny dams. But reallocation of water supply remains the principal recovery strategy. In my view, it's a strategy that could ultimately backfire. In California and especially in the Northwest, giving salmon and steelhead more water — but not more spawning habitat — has improved things only marginally, if at all. Also, reallocation is a zero-sum game with major losers, and that is bad politics. If we're serious about saving our salmon from extinction, we've got to try something else. Several things, actually.

First, we have to expand the available spawning habitat for our anadramous fisheries. That means we must modify or demolish some dams — not Shasta, not Grand Coulee, but a number of small and antiquated dams that offer minimal benefits (a smidgen of hydroelectricity) and perhaps a handful of fair-sized dams that offer serious regional benefits and whose removal or modification will be ferociously resisted by various interest groups.

For example, the removal of dams in Washington, according to biologists, could bring back a run of 350,000 salmon and steelhead — with a sacrifice of only thirty megawatts of hydroelectricity. The Savage Rapids Dam on Oregon's Rogue River, which the Bureau of Reclamation wants to remove, is another. The local water board voted twice to remove it only to be recalled (both times) by its constituency; the Wise Use movement, which abhors dam removal, is a potent force in that part of the world.

At the same time, we have got to develop new water supplies. We can't let stringent water-conservation mandates and farmland fallowing become the only strategies for meeting new urban and environmental needs. Politically, that just won't work.

But water transfers — reallocation legitimized by capitalism — still aren't enough. We need new water storage — which doesn't necessarily mean new dams. There are plenty of opportunities to store water underground. William Mulholland himself, the father of the Los Angeles water system, was a great proponent of that strategy, before he started building dams.

There is little that is radical about any of these ideas. Since when is the market system radical? There's no law that says dams have to be permanent. We can take them down if they're unsafe, so why can't we take down a few taxpayer-financed dams if they cause more environmental, social, and economic disruption than they're worth? We can store water, benignly, underground, in depleted aquifers; and we can increase aquifer-storage potential through conjunctive-use programs — where, say, a water district foregoes some of its surface-water entitlement and sells it down-river during a drought, then falls back on groundwater during that period, and later, actively recharges the aquifer when a wet cycle returns.

What has hamstrung efforts to inaugurate a modern water era in the arid West is less a set of laws or rules than a concept that, in my view, has been taken to an almost ludicrous extreme. Its name is consensus. It's become the mantra of the CalFed program, which has been vested with great responsibility for both restoration and new water supply in California. In the northwest, they seek consensus on salmon issues — but never find it — from morning to night. Dams that, according to polls, the majority of people want to remove, aren't removed — because some people remain opposed, and many modern politicians are petrified of proceeding without consensus. In California, it's been the same story with new water storage, even underground water storage.

The problem with consensus is that we abdicate an ability to make anything happen whenever an outspoken minority doesn't want it to. So we waste money on solutions everyone can buy into, but which achieve little. Consensus-seeking makes us all feels good. But it is, in Margaret Thacher's apt phrase, the negation of leadership. It substitutes minority tyranny for minority will.

More to the point, how was it that we built so many dams? That we decimated our salmon and dried up our waterfowl habitat? Was there consensus? There was not. By the fifties, when some of the most objectionable projects were yet to be built, there was powerful opposition from fishermen and hunters, conservationists, Indians, ordinary citizens — even from conservatives who felt the federal government had no business building dams in the first place. But we built them anyway.

Most of us don't want to lose our wild salmon. Most of us want to restore some of our wetlands. Most of us don't want a totally regulated Colorado River any more than our forebears wanted a totally unregulated one. We may even want to stop New Orleans and southern Louisiana, the greatest coastal wetlands on the continent, from disappearing into the Gulf of Mexico.

In the end, we need leadership willing to take this country where it wants to go — not where entrenched power and money insist it stay. Serious leadership, more than anything, is what's missing in America today.

Marc Reisner *is best known as the author of* Cadillac Desert*, which details the American West's ecologically disastrous dependence on dams and aqueducts in pursuit of an "artificial paradise."* Cadillac Desert *was made into a four-hour documentary periodically aired on PBS since 1997. Mr. Reisner also authored* Game Wars*, the true story of an undercover wildlife agent now due for production as a feature film, and co-authored* Overtappped Oasis*, a prescription for western water policy reform. Co-founder with the Nature Conservancy of the Ricelands Habitat Partnership, he also consults with the Institute for Fisheries Resources and the American Farmland Trust, and is at work on a new book about California's inclination toward natural and manmade disasters.*
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by Jesse H. Ausubel

Resources Are Elastic

Knowledge, not more cropland or more timberland, is what now grows productivity, and science and engineering are the most powerful forms of knowledge. They demonstrate their effectiveness every moment.

With most animal populations, the niches that encase the populations are of constant size. Animal societies growing in a given niche have dynamics neatly fitted by equations with a constant limit or ceiling. In short, from a niche point of view, resources are the limits to numbers. But access to resources depends on technologies. When the animals can invent new technologies, such as when bacteria produce a new enzyme to dismantle a sleepy component of their broth, then we face a problem. New growth pulses suddenly pop up, growing from the prior.

Homo faber, the toolmaker, keeps inventing all the time, so that our limits are fleeting. These moving edges confound forecasting the long-run size of humanity. Expansion of the niche, the accessing and redefinition of resources, keeps happening with humans.

One of the greatest technological shifts was the industrial revolution. If we take the "industrial revolution" as one huge innovation, we can reconceive the population history of England and other countries in two phases.

The early English, islanders conceptually similar to the bacteria in a petri dish, could not directly expand their territory to support more people. In fact, by Roman times the English had already cleared a large fraction of their land for crops and animal husbandry. English population shows a slow rise, leveling around 5 million people in the year 1650. Perhaps sensing their local limit, the English were actively colonizing abroad during the 17th and 18th centuries and exporting population. The Island population remained rather level until nearly 1800. But meanwhile, another pulse of 50 million had begun, bringing England to its current population. Faster and cheaper transport, new energy sources, and other features of the industrial revolution made it possible for more English to eat in the same dish.

The growth of human populations demonstrates the elasticity of the human niche, determined largely by technology. For the homo faber, the limits to numbers keep shifting, in the English case by a factor of 10 in less than two centuries.

Now let me briefly scan two resources about which we worry, farmland and forests. Is farmland finite in any useful sense? For centuries, farmers expanded cropland faster than population grew, and thus cropland per person rose. When we needed more food, we ploughed more land, and fears about running out of arable land grew. But fifty years ago, farmers stopped plowing up more nature per capita. Meanwhile, growth in calories in the world's food supply has continued to outpace population, especially in poor countries. Per hectare, farmers lifted world grain yields about 2 percent annually since 1960. Two percent sounds small but compounds to large effects: it doubles in 35 years and quadruples in 70.

Vast frontiers for even more agricultural improvement remain open. On the same area, the average world farmer grows only about 20% of the corn or beans of the top Iowa farmer, and the average Iowa farmer lags more than 30 years behind the yields of his most productive neighbor. Top producers now grow more than 20 tons of corn per hectare compared with a world average for all crops of about 2. From one hectare, an American farmer in 1900 could provide calories or protein for a year for 3 people. In 1999 the top farmers can feed 80 people for a year from the same area. So farmland again abounds, disappointing sellers who get cheap prices per hectare almost everywhere.

Forests tell a similar tale. Forests are cut to clear land for farms and settlements and also for fuel, lumber, and pulp. In the rich countries, nevertheless, forests have re-grown in recent decades. Since 1950 the volume of wood on American timberland has grown 30%, while European forests have similarly increased in volume. In the U.S., the intensity of use of wood defined as the wood product consumed per dollar of GDP has declined about 2.5% annually since 1900. Today an average American consumes about half the timber for all uses as a counterpart in 1900.

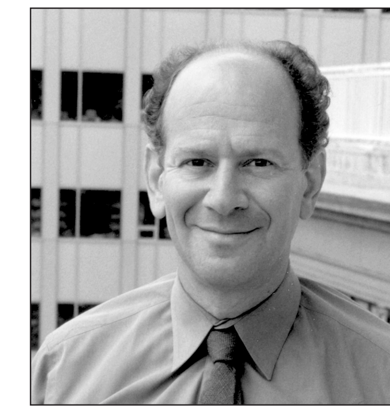
In the U.S., likely continuing fall in intensity of use of forest products should more than counter the effects of growing population and affluence, leading to an average annual decline in the amount of timber harvested for products. A conservative annual improvement in forest growth would compound the benefits of falling demand. Unmanaged forests now yield yearly an average of 1-2 cubic meters of commercially valuable species per hectare. Potential in

secondary temperate forests ranges between 5 and 10 cubic meters. Many commercial plantation forests now reliably produce more than 20 cubic meters a year, and experimental plots have yielded over 60 cubic meters. Compounded, the rising tree growth and falling wood demand should shrink the extent of U.S. logging by half in 50 years.

By the middle of the 21st century, rising productivity of well-managed forests should comfortably allow 20% or less of today's forest area of about 3 billion hectares to supply world commercial wood demand. In fact, 5% of world forests could suffice. Our vision of Earth's surface in the year 2050 should be more forest cover, say 200 million hectares more than today, and most of the world's forests reserved for Nature.

Knowledge, not more cropland or more timberland, is what now grows productivity, and science and engineering are the most powerful forms of knowledge. They demonstrate their effectiveness every moment. Wisely used, science and technology can liberate the environment, can spare the Earth. Food and fiber decoupled from acreage as well as carbon free hydrogen energy and closed-loop industrial ecosystems can assuage fears about vanishing species, changing climate, and poisoning metals. And about finite resources. The greatest threat to future well being is the rejection of science. Having come this far, the 6 billion cannot take the road back. Without science, the elastic band will snap back.

Exploring, inventive humanity exemplifies the lifting of carrying capacity. Through the invention and diffusion of technology, humans alter and expand their niche, redefine resources, and violate population forecasts. In the 1920's, the leading demographer, Raymond Pearl, estimated the globe could support two billion people, while today about six billion dwell here. Today, many Earth observers seem stuck in their mental petri dishes. The resources around us are elastic.



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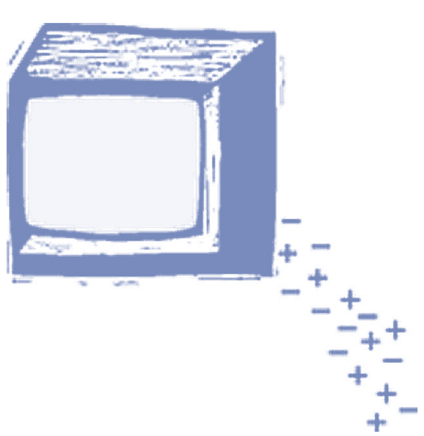
by Alan Meier

Reducing Electrical Leaking to a Trickle



Leaking electricity found in our televisions, VCRs, garage door openers, cordless phones and many other applianc- es has a surprisingly large impact on the global environment.

WHAT IS LEAKING ELECTRICITY?

Electronics play an increasingly pervasive role in home appliances and office equipment. This is generally a good thing because the electronics help provide new features and amenities. Electronic controls can also reduce energy use by providing the services only when consumers actually need them. On the other hand, these electronic features often continue to consume energy even while switched off or not performing their principal service. This phenomenon has acquired several names, including "standby power," "standby losses," "leaking electricity," "waiting electricity," "free-running power," "off-mode power," and "phantom loads." The leaking electricity found in our televisions, VCRs, garage door openers, cordless phones and many other appliances has a surprisingly large impact on the global environment.

WHAT APPLIANCES HAVE LEAKING ELECTRICITY?

Figure 1 shows appliances with standby power (the technical term for leaking electricity) in American homes. The number of appliances with standby power consumption is rapidly growing both in number and diversity. An appliance probably has standby power use if it has any of the following features:

- It gets power from the mains through a stand-alone power supply.
- It has a remote control.
- It has a soft touch keypad.
- It charges the battery of a portable device.
- It is warm to touch near the switch when switched off.
- It doesn't have an "off" switch.

A brief inspection of any home or office will reveal many appliances having one or more of these criteria. We conducted an informal survey of homes and found that the average upper-middle class house had eight appliances with stand-alone power supplies. Many homes will have over 15 appliances with standby power consumption.

We (and our colleagues around the world) have measured standby power use in hundreds of appliances. In Figure 1, we also show the minimum, average, and maximum values for each appliance.

It is surprising to see the range in standby for a single appliance. For example, compact audio systems have standby varying from 1.3 watts to 28.6 watts. Some of the range is caused by differences in features among the appliances; for example, certain audio devices have larger and brighter displays than others. But most of the variation arises from differences in design and choice of components, resulting in some units consuming four times as much power to provide the same services as others. Certain appliances also consume nearly as much power while switched off as switched on. Most television set-top boxes (also called "cable boxes") show nearly no change in power between the two modes. We also found several models of compact audio equipment and VCRs with similar "on" and "off" power.

Where does the standby energy go? First, it is important to realize that the components providing the actual services, that is, the clocks, sensors, displays, etc., typically consume only a few milliwatts but the total standby power consumption may be a thousand times larger! Most standby power is lost as heat by the transformer (or power supply) converting the electricity from the mains voltage to a lower voltage. Some power is converted to heat even when there is no load and further losses occur when supplying the small amount of power needed for standby

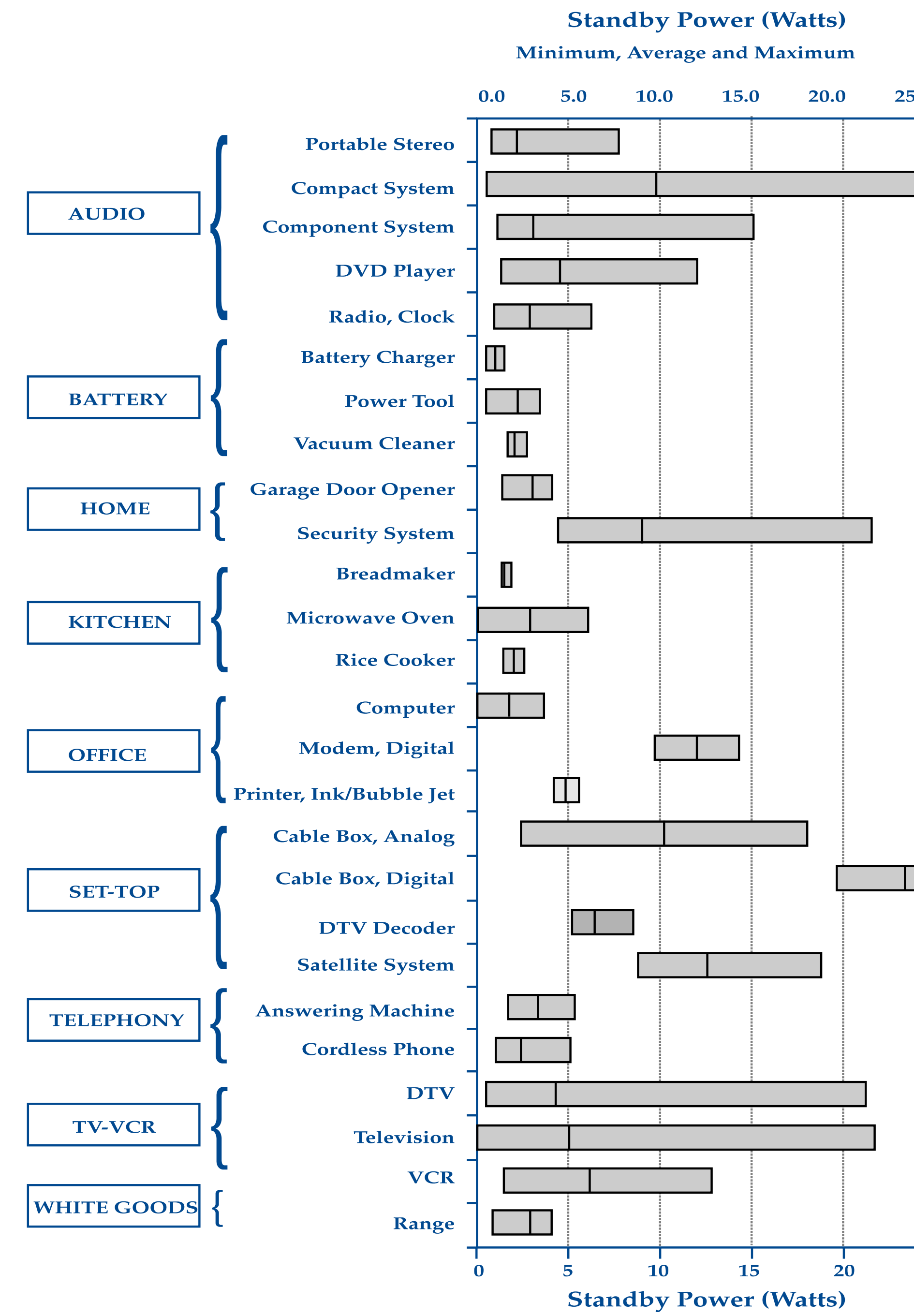


Figure 1

operations. Many appliances keep circuits energized even when they are not needed, which further adds to the losses.

GLOBAL IMPLICATIONS OF STANDBY

The standby power use by an individual appliance is typically very small, not more than a few watts, but standby is significant because it is a continuous consumption and because so many appliances exhibit this behavior. The average U.S. home has about 50 watts of standby. This corresponds to 5% of the home's total electric bill.

There are over 100 million homes in the U.S., so standby consumes roughly 5GW. After accounting for transmission and distribution losses and generation reserves, standby is responsible for about 8 GW. This corresponds to the output of 8 large power plants. The true consumption is probably closer to twice this number because the commercial and industrial sectors also have equal amounts of equipment with standby.

Standby power is probably responsible for one percent of the world's CO_2 emissions. This may seem like a relatively small amount but the majority is consumed by appliances that are switched off or not performing their principal functions.

TECHNOLOGIES TO REDUCE STANDBY

It is technically feasible to reduce standby in most cases to below 1 watt per appliance. This corresponds to roughly a two-thirds reduction in today's typical appliance. A 1-watt target may not yet be economic in all situations today, but the trend is in that direction. Some appliances, such as certain cell phone chargers, have already fallen below 0.5 watt. Manufacturers are using new technologies primarily to decrease size of the charging units rather than saving energy, so the extra cost may not justify the energy savings. The greatest improvements are likely to occur in the power supplies. Recent innovations in the design of power supplies, notably "switch-mode" technologies, have cut no-load losses to as little as 0.25 watts and maintained very high conversion efficiencies at low power.

THE FUTURE OF LEAKING ELECTRICITY

An increasing number of new appliances have standby power use. If no special measures are undertaken, global standby power energy use will gradually increase. This trend, along with the global nature of the problem, has spawned an international initiative to reduce standby. The need to reduce CO_2 emissions has provided another reason. By reducing leaking electricity to just one watt per appliance — a trickle — global CO_2 emissions could be reduced by nearly one percent.

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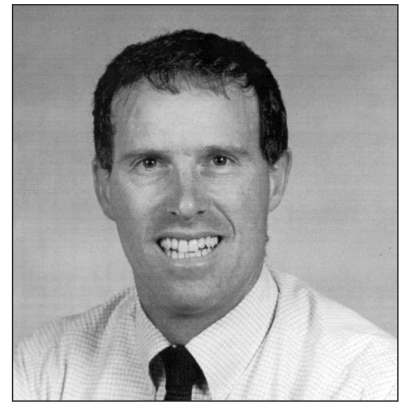

Alan Meier *is the building scientist for the Energy Analysis Department of the Lawrence Berkeley National Laboratory.*

His research centers on investigating the real and potential energy savings from such conservation measures as efficiency improvements in buildings, the use of standby power modes for electrical appliances, energy test procedures, and the value of so-called "miscellaneous" end use. Dr. Meier has published over 100 papers and articles on efficient building and equipment energy use. He is executive editor of Home Energy Magazine, *and editor-in-chief of the journal* Energy and Buildings.

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by Michael Crow

THE LIMITS OF US

Ask any scientist to tell you about his research, and sooner or later the topic of parameters will arise — the parameters of the problem, the solid ground of what is known that implies constraints on what is unknown. Mathematicians refer to these limits as "boundary conditions."

René Descartes established the first boundary condition of modern science early in the 17th Century when he postulated, "I think, therefore I am." It is outward from this modest but powerful statement of individual certainty that science has carved the clearing of knowledge in which we now stand, considering the state of the planet.

And what do we find ourselves talking about? Global warming, ozone holes, pollution, overpopulation, deforestation and the rampant extinction of other species – questions of sustainability. These are problems of our own making, byproducts of our success as the dominant species on Earth. The issue turns out not to be the state of the planet so much as the state of us, and the collective effects on the environment of our limits as human beings.

Outwardly, there appear not to be any boundaries to what humankind is capable of understanding, conceiving, constructing, and attaining. Yesterday's limit is today's hurdle is tomorrow's forgotten bump in the road of progress. A cherished mythology of the modern world is that our collective creativity and intellect can overcome any external obstacle. That may be true, but can we overcome ourselves? It seems that during the 350 years since Descartes himself ceased to think and be, we have made precious little progress in expanding our own boundaries.

> We are an inherently competitive species —— competitive among ourselves, with other species and with our environment.

And so I propose this expression of the current state of our planet –

The dynamic, interactive system of complex biogeochemical cycles that constitute Earth's surface environment is falling significantly and increasingly under the influence of a single, dominant life-form. This life-form, notable for its ability to learn, reason, communicate, plan and act cooperatively, nonetheless exhibits serious limitations in all these same defining characteristics. These limitations render it a net threat to the future viability of life on the planet. What will happen depends on the ability of this life-form to evolve past its limitations, both as individuals and as a species.

If we all disappeared tomorrow, or reverted to a world-wide population of a million or so australopithecines, the planet would readily recover from our presence in a blink of geologic time. But in fact, the dodo is gone forever, while we are now more than 6 billion strong. Our inability to understand

If we all disappeared tomorrow, or reverted to a world-wide population of a million or so australopithecines, the planet would readily recover from our presence in a blink of geologic time.

or even acknowledge our intellectual and organizational limits, and then create mechanisms to address them, has placed our species' dynamic and successful nature in direct conflict with Earth's future.

The following summary of facts, drawn from William Clark (a contributor to this issue) illustrates the kind and degree of our collective impact.

- We have caused the extinction of over 20% of Earth's bird species.
- We have increased atmospheric carbon dioxide by about 30%.
- We are now consuming more than 40% of annual terrestrial production.
- We are diverting and using more that 50% of all freshwater runoff.
- We are now harvesting more than 60% of the total available marine fishery.
- We have increased atmospheric methane by more than 140%.
- We have introduced more than 70,000 synthetic chemicals into the environment to date.
- We have doubled the rate of atmospheric nitrogen fixation.
- We have raised the sediment load in the world's rivers by 5 times.
- We have increased the liberation of lead into the environment by 20 times.
- We have increased the overall rate of species extinction by as much as 1,000 times.

A sobering legacy for the future, but the truly incredible thing is that we've "accomplished" all this, and more, with hardly a thought for the consequences of our actions. These are the largely unintended effects of our success at colonizing the planet and manipulating the environment for what we perceive to be our own benefit. And although the degree of these effects is due largely to our burgeoning population, it lies within our power to drastically mitigate all of them starting tomorrow, simply by agreeing collectively to do so.

What then stands in the way of prudent, moderating action? Precisely the limits of us — our:

- Socio-biological limits,
- Comprehension limits,
- Scientific limits,
- Socio-economic limits,
- Philosophical limits,
- Technological limits,
- Organizational limits, and
- Personal limits.

It's a long list of seemingly intractable shortcomings. My attitude in airing them, however, is not one of hopelessness, but rather optimism and purpose. As the saying goes, in recognizing one's faults lies half the cure. So although I don't have solutions to offer, there is value in getting the ball of self-awareness rolling. Here then are a few observations regarding the very human boundary conditions that confront us.

SOCIO-BIOLOGICAL LIMITS

We are an inherently competitive species of free agents – competitive among ourselves, with other species and with our environment. This is not conducive to thoughtful cooperation or environmental stewardship. We have difficulty in translating between group and individual risk, and are limited in our capacity to think across generations. We have evolved a nomadic tendency of solving problems by moving away from them, which is no longer viable.

COMPREHENSION LIMITS

We are limited in our ability to comprehend questions of scale, large numbers, and the cumulative effects of billions of people over thousands of generations. We cannot seem to comprehend that our individual actions amplify into global consequences that we ourselves may not perceive, and so the concept of sustainability remains foreign to us.

SCIENTIFIC LIMITS

Our scientific culture is not outcome driven, but rather values knowledge for its own sake. Neither is it stable, as it revolves around the always-uncertain-theory that will always be replaced. Scientific knowledge and insight are controlled by a small, highly-educated elite. This elite is itself characterized by cliques and factions that hamper communication between fields, and impede the flow of scientific knowledge into other decision-making realms.

SOCIO-ECONOMIC LIMITS

We have evolved no method for valuation that extends beyond a few decades, and generally ascribe no inherent value at all to natural resources. We exhibit a strong and accelerating tendency to organize ourselves into artificial and fundamentally unsustainable urban environments.

PHILOSOPHICAL LIMITS

We seem to be limited in our ability, or will, to acknowledge our role as the organism exerting the greatest effect on the environment, and with the greatest capacity to govern those effects. Perhaps this is due to the lack of any comparative context. We are operating without precedent and have no answer to the question, "Why are we here?"

TECHNOLOGICAL LIMITS

We are in the throes of an historic, short-sighted dependence on "cheap" hydrocarbon power. This addiction is at the root of many of our greatest environmental problems, and forecloses any real progress toward alternative energy sources. We allow short-term market forces to make our technological decisions, and do not understand the law of unintended consequences. Thus the future is in the hands of the low-bidder, who only cares about today's artificial bottom line, and new technologies are adopted with little consideration for their long term consequences. Technologically speaking, we leap before we look.

ORGANIZATIONAL LIMITS

Our science is composed of fragmented and disjointed fields of inquiry, populated by minimally adaptive knowledge-building enterprises that have difficulty storing, organizing, synthesizing, translating and transferring information. Our dominant world culture is organized on the tenets of short-term consumerism, rather than long-term sustainability.

PERSONAL LIMITS

We tend each to be governed by the overwhelming dominance of the illusion, and delusion, of group understanding. We think that we understand what is happening, that at least somebody understands, and we are not humbled by the fact that we do not. And perhaps the most fundamental human boundary condition of all is the finality of self. We are all inescapably governed by self-interest, particularly immediate self-interest. When push comes to shove, with few arguable exceptions, what matters most to anyone is "me, here, now."

So, there are a lot of limits to us, a lot to think about and work on. I suggest that we get started, individually and collectively, as soon as possible, myself as much as anyone. That I say these things neither makes me a saint, nor grants me special dispensation. As executive vice provost of Columbia, I am a sinner and a consumer of the highest order, using up hydrocarbons and other natural resources like there is no tomorrow.

More than once, I have been labeled a communist for my views – an elitist, totalitarian communist at that. The concept of collective will and action, after all, carries justifiably strong negative connotations in many circles. Yet that is what is necessary. How we achieve it, if we achieve it, is up to us. A good start would be expanding our notions of self-interest beyond the bubble of individual existence.

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SESSION FOUR: Living with Natural Hazards

Some slightly paraphrased sound bites from Session Four of the State of the Planet Conference

Dennis Mileti

A modern fallacy of our approach to dealing with natural hazards and disasters is that we can use technology to control nature and make ourselves 100 percent safe. That is not true. What is true is that we, not nature, are responsible for our own disasters because of how and where we choose to develop the earth.

Rutherford Platt

The U.S. has evolved a disaster-response edifice of Byzantine complexity, inefficiency and inequity — one which fosters the illusion that government will always underwrite the financial risks of development in hazardous areas, while at the same time ignoring the fact that people with the least at risk financially are, in fact, the most vulnerable to loss.

Brenda Bell

Perhaps it is a mistake to approach natural hazards strictly from the standpoint of risk to life and property. Individual people will always be willing to accept those risks, knowing that the odds of losing their personal gamble with nature are low.

Encho Gospodinov

The lack of political will, desire and imagination on the part of policy makers worldwide to recognize and address the threat of predictable natural catastrophes, which repeat themselves again and again, condemns hundreds of millions of people each year to enormous suffering.

CONCLUDING REMARKS

John Mutter

The need to build bridges of cooperation among the sciences, and close the chasm that separates scientific culture from the rest of humanity, has become urgent, perhaps even necessary to a stable and secure future. This conference represents a step in that direction.

by Dennis S. Mileti

Disasters by Design

Natural hazards and disasters are not a problem that can be solved in isolation. Rather, a disaster is a symptom of broader and more basic problems that include narrow and short-sighted development patterns, cultural premises, and attitudes toward the natural environment, science, and technology. A way for people to take responsibility for disaster losses, to own that humanity designs future hazard losses through its daily decisions, and to link hazard mitigation to sustainable development is needed.

One problem is that many of the accepted methods for coping with hazards have been based on the idea that people can use technology to control nature to make themselves totally safe. What's more, most strategies for managing hazards have followed a traditional planning model: study the problem, implement one solution, and move on to the next problem. This approach casts hazards as static and mitigation as a positive linear trend. But events during the past quarter-century have shown that natural disasters are not linear problems that can be solved in isolation. Another problem is that some efforts to head off damages only postpone them. For example, communities behind levees may avoid losses from floods those structures were designed to prevent. But such communities often have more property to lose when those structures fail, because additional development occurred that counted on protection. To redress those shortcomings, a shift is needed to sustainable hazard mitigation which links natural resources management with local economic and social resiliency, viewing hazard mitigation in a larger context.

A NEW APPROACH TO HAZARDS

A shift in strategy is needed to cope with the complex factors that contribute to disasters in today's — and especially tomorrow's — world. Here are the main guidelines for improving our ability to mitigate hazards.

Adopt a global systems perspective. Rather than resulting from surprise environmental events, disasters arise from the interactions among the earth's physical systems, its human systems, and its built infrastructure. A broad view that encompasses all three of these dynamic systems and interactions among them can enable us to find better solutions.

Accept responsibility for hazards and disasters. Human beings — not nature — are the cause of disaster losses, which stem from choices about where and how human development will proceed. Nor is there a final solution to hazards, since technology cannot make the world safe from all the forces of nature.

Anticipate ambiguity and change. The view that hazards are relatively static has led to the false conclusion that any mitigation effort is desirable and will — in some vague way — reduce the grand total of future losses. In reality, change can occur quickly and nonlinearly. Human adaptation to hazards must become as dynamic as the problems presented by hazards themselves.

Reject short-term thinking. Mitigation as frequently conceived is too short-sighted. In general, people have a cultural and economic predisposition to think primarily in the short term. Sustainable mitigation will require a longer-term view that takes into account the overall effect of mitigation efforts on this and future generations.

Account for social forces. Societal factors, such as how people view both hazards and mitigation efforts or how the free market operates, play a critical role in determining which steps are actually taken, which are overlooked, and thus the extent of future disaster losses. Because such social forces are now known to be much more powerful than disaster specialists previously thought, growing understanding of physical systems and improved technology cannot suffice. To effectively address natural hazards, mitigation must become a basic social value.

Embrace sustainable development principles. Disasters are more likely where unsustainable development occurs, and the converse is also true: disasters hinder movement toward sustainability because, for example, they degrade the environment and undercut the quality of life. Sustainable mitigation activities should strengthen a community's social, economic, and environmental resiliency, and vice versa.

FOSTERING LOCAL SUSTAINABILITY

Sustainability means that a locality can tolerate — and overcome — damage, diminished productivity, and reduced quality of life from an extreme event without significant outside assistance. To achieve sustainability, communities must take responsibility for choosing where and how development proceeds. Toward that end, each locality evaluates its environmental resources and hazards, chooses future losses that it is willing to bear, and ensures that development and other community actions and policies adhere to those goals.

Six objectives must simultaneously be reached to mitigate hazards in a sustainable way and stop the trend toward increasing catastrophic losses from natural disasters.

Maintain and enhance environmental quality. Human activities to mitigate hazards should not reduce the carrying capacity of the ecosystem, for doing so increases losses from hazards in the longer term.

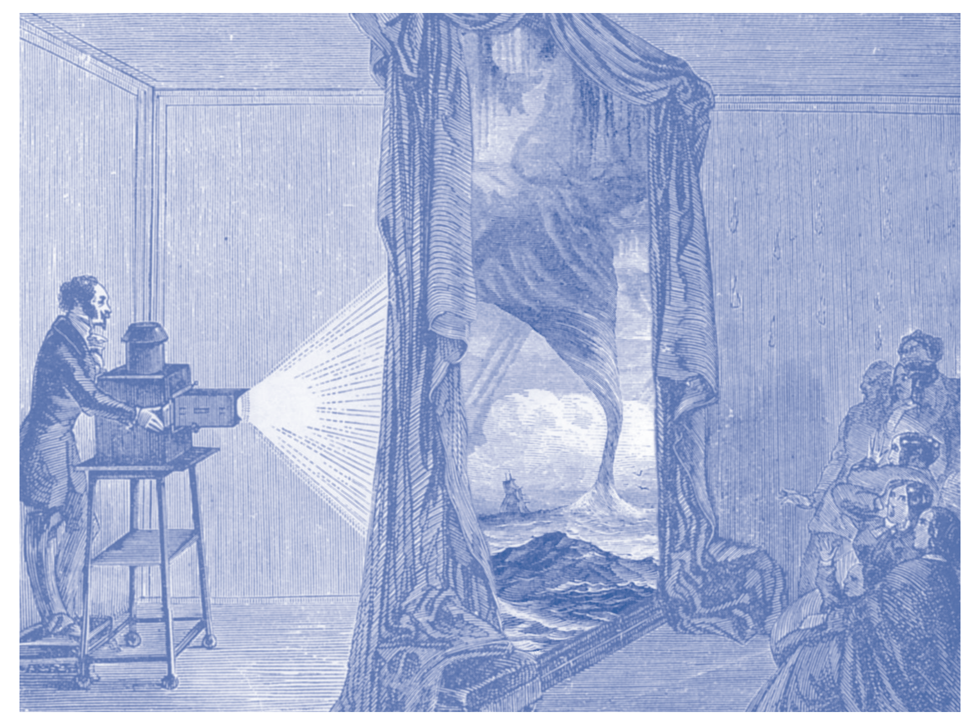
Maintain and enhance people's quality of life. A population's quality of life includes, among other factors, access to income, education, health care, housing, and employment, as well as protection from disaster. To become sustainable, local communities must consciously define the quality of life they want and select only those mitigation strategies that do not detract from any aspect of that vision.

Foster local resiliency and responsibility. Resiliency to disasters means a locale can withstand an extreme natural event with a tolerable level of losses. It takes mitigation actions consistent with achieving that level of protection.

Recognize that vibrant local economies are essential. Communities should take mitigation actions that foster a strong local economy rather than detract from one.

Ensure inter- and intra-generational equity. A sustainable community selects mitigation activities that reduce hazards across all ethnic, racial, and income groups, and between genders equally, now and in the future. The costs of today's advances are not shifted onto later generations or less powerful groups.

Adopt local consensus building. A sustainable community selects mitigation strategies that evolve from full participation among all public and private stakeholders. The participatory process itself may be as important as the outcome. A long term, comprehensive plan for averting disaster losses and encouraging sustainability can offer a locality the opportunity to coordinate its goals and policies. A community can best forge such a plan by tapping businesses and residents as well as experts and government officials. And while actual planning and follow-through must occur at the local level, a great deal of impetus must come from above. Nothing short of strong leadership from state and federal governments will ensure that planning for sustainable hazard mitigation and development occurs.



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by Rutherford H. Platt

Natural Disasters, Politics, & Property Rights in the U.S.

PRIORITIES IN CONFLICT

Worldwide, the insured and uninsured costs of weather-related disasters reached an estimated record of $92 billion in 1998, according to Munich Reinsurance and the Worldwatch Institute, more than 50 percent greater than the previous peak year of 1996, and more than the entire decade of the 1980s. The toll is much higher when non-weather disasters are considered. The January 17, 1995 earthquake in Kobe, Japan caused more than $100 billion in damage, and over 6,300 deaths. In the U.S., Dennis Mileti and his colleagues at the University of Colorado at Boulder estimate that "a conservative estimate of the actual average dollar losses from 1975 to 1994 is $500 billion, or about a half billion dollars per week." (*Disasters by Design*, Joseph Henry Press, 1999, p. 66).

Horrific as these numbers are, the real costs of natural disasters are much higher when indirect or "hidden" costs are considered. The economic toll of the 1994 Northridge Earthquake was raised from $24 billion in documented costs to about $44 billion to include $20 billion in "hidden costs" of deductibles absorbed by property owners and damage to uninsured structures. Business losses not covered by insurance and social costs of family disruption are other forms of hidden disaster costs. A recent study by the Heinz Center for Science, Economics, and the Environment in Washington, DC, attempted to identify (without quantifying) the full range of overt and hidden costs for Hurricane Hugo, which occurred 10 years ago, including business disruption, social costs to individuals and families, and environmental costs to natural resources (*The Hidden Costs of Coastal Hazards*, Island Press, 1999).

Response to natural disasters in the U.S. and elsewhere tends to be reactive, fragmented, and costly. Over the past half-century, the U.S. Congress has created a legal edifice of Byzantine complexity to respond to natural disasters. The federal disaster apparatus includes laws, agencies, programs, policies, and strategies, many of them intended to operate in "partnership" with state and local governments, nongovernmental organizations, and the private sector. Federal assistance is provided under approximately 50 different laws and executive orders to households, businesses, farms, states, municipalities, special districts, and nongovernmental organizations. A wide range of financial strategies is utilized including: direct grants to stricken communities and lower income families and individuals; low-cost flood and crop insurance programs; low-interest disaster loans, federal public works programs, e.g., to rebuild beaches, highways, and remove debris; disaster unemployment benefits; mental health and legal services: and federal income tax deductions for uninsured casualty losses.

Since 1994, the Federal Emergency Management Agency has commendably tried to instill hazard mitigation into its disaster preparation and recovery programs. And since 1997 it has sought to promote community sustainability through its "Project Impact" program. But these efforts are frequently stymied by the larger political process under which Congress and the President respond to demands from constituents, local communities, and state governors for abundant federal assistance on favorable terms without strings attached. The property rights movement of the past decade has undermined the political will of government at all levels to restrict private development in hazardous areas without compensation. Furthermore, building and rebuilding in areas known to be hazardous are often inadvertently promoted by government itself. The federal tax code, in particular, rewards real estate speculation, no matter how risky a site may be. And the availability of affordable federal flood insurance, even along eroding coasts, fosters the illusion that government will always underwrite the financial risks of building in areas of obvious hazard. Several collateral public policy issues concerning disaster assistance are briefly summarized below:

CROSS-PURPOSES. Well-intended government programs sometimes undermine each other. The vast array of federal spending and economic benefit programs such as highway construction, housing, urban renewal, shoreline stabilization, and water pollution abatement may undercut the goals of hazard mitigation by indirectly sponsoring development and redevelopment in areas of recurrent hazard. Even within the arena of disaster assistance, certain government agencies may be funding rapid redevelopment even as others call for retreating from hazardous locations. Federal, state, and local authorities also may conflict over the pace, location, and character of rebuilding after a natural disaster.

SELF-RELIANCE. In its 1995 report, the U.S. Senate Bipartisan Task Force on Funding Disaster Relief charged that the federal government discourages state, local, and individual self-reliance by offering federal disaster assistance too readily. This and other critiques raised the question as to whether federal assistance in less-than-catastrophic events discourages states and local governments, as well as private citizens and businesses, from providing for their own needs in routine, foreseeable natural events. Of particular concern are benefits provided under the Federal Disaster Assistance Act of 1988 (Stafford Act) pursuant to a Presidential disaster declaration. President Clinton has issued declarations at record rates, averaging more than one per week in 1996, 1998, and 1999. Few would quibble about the need for federal assistance in true catastrophes involving billions of dollars in losses. But heavy rain and snowstorms, flash floods, and simply "bad weather" now seem to be eligible for the "Presidential Hug." Some observers have charged that disaster assistance has become a new form of political "pork barrel" to transfer federal resources to localities beyond the strict requirements of compassion and clear need.

COST SHARING. The Stafford Act specifies a 75/25 ratio of federal/nonfederal cost sharing of disaster assistance costs under a Presidential declaration. But in at least 15 disasters during the 1990s, Presidents Bush and Clinton have raised the federal share to 90 percent (e.g. Hurricane Fran), or even 100 percent (Hurricane Andrew). Federal cost-sharing has declined or vanished for other sectors of public spending, such as wastewater treatment plants, parks and open space, and low

> The vast array of federal spending and economic benefit programs, such as highway construction, housing, urban renewal, shoreline stabilization, and water pollution abatement, may undercut the goals of hazard mitigation by indirectly sponsoring development and redevelopment in areas of recurrent hazard.

income housing. Ironically, replacement of local infrastructure that would not normally qualify for federal cost-sharing may be eligible for a 75% federal grant if it is damaged in a declared disaster. Furthermore, there is no limit to funding available for disaster relief: Congress has repeatedly approved emergency "supplementary appropriations" of billions of dollars to cover the federal costs of particular disasters.

The federal government, and particularly FEMA, are still struggling to define, achieve, evaluate, and improve their efforts in hazard mitigation. Despite abundant rhetoric, it remains unclear what mitigation really means, and who should pay for it.

EVALUATION. After 3 decades of the advent of the National Flood Insurance Program, 2 decades since the formation of the Federal Emergency Management Agency (FEMA), and over 1 decade since the Stafford Act, there has been no systematic effort to evaluate the effectiveness of various approaches to natural disaster mitigation. The federal government, and particularly FEMA, are still struggling to define, achieve, evaluate, and improve their efforts in hazard mitigation. Despite abundant rhetoric, it remains unclear what mitigation really means, and who should pay for it.

The same applies, all the stronger, to the international arena. The International Decade for Natural Hazard Reduction (the 1990s) has expired. Despite the formation of over 100 national committees in the response to the United Nations challenge in launching the Decade, it is unclear how much hazard mitigation has actually been achieved worldwide. Clearly, population growth and international investment are exerting pressure to intensify development along coasts and estuaries, in river lowlands, and on unstable slopes, including areas left vacant in earlier waves of development. The extent to which the International Decade has influenced the location and durability of such new growth is unknown.

PROPERTY RIGHTS VS. THE PUBLIC INTEREST. The U.S. since the mid-1980s has experienced an aroused "property rights movement." Private property owners enjoy a certain measure of freedom from governmental control under the Fifth Amendment to the U.S. Constitution which provides that " . . . no private property shall be taken for public use without just compensation." This provision has been interpreted through court decisions to apply not only to literal taking of property but also to regulation of land use which is deemed excessive or arbitrary. On the other hand, the protection of the public health, safety, and welfare requires that government be able to restrain "unreasonable" use of private property through land use and building controls without paying compensation to the owner. These two competing interests — private economic gain vs. public safety — have struggled with each other throughout the 20th Century. While courts have generally upheld hazard area regulations, a highly publicized decision of the U. S. Supreme Court (Lucas v. South Carolina Coastal Council 112 S.Ct. 2886, 1992) held that denial of a state building permit on an eroding coast required compensation to the owner. Whatever the legal significance of the Lucas decision as a precedent, it has undoubtedly cast a broad cloud over environmental and hazard area land-use regulations in the U.S.

REPETITIVE DISASTER LOSSES. A 1998 study by the National Wildlife Federation found that 40 percent of National Flood Insurance payments were for repetitive losses to structures that had received earlier payments, with total payments sometimes exceeding the value of the structure. This was attributed in part to a failure to enforce FEMA requirements concerning "substantially damaged" structures. At Oakland, California, 3,300 homes were destroyed by a 1991 wildfire in an area subject to repetitive fires. Furthermore, the dangerous Hayward Fault lies a few hundred yards downslope from the burned area. Nevertheless, the site has been substantially rebuilt with even larger homes. Coastal homes similarly are rapidly replaced after hurricane damage, as in North Carolina after Hurricane Fran in 1996.

National policy thus needs to address the elimination of repetitive losses to the same buildings and sites. Building more strongly, as in earthquake retrofitting and elevation of coastal structures, is promoted by FEMA. But forbidding any rebuilding in areas of clear and continuing risk is sometimes the only reasonable policy although government officials are loathe to do so. While politics drives the disaster assistance program, it should not be allowed to deter necessary adjustment of settlement patterns and infrastructure to eliminate vulnerability.

SOCIAL EQUITY. Federal disaster benefits available to victims of U. S disasters, on the whole, are directed towards individuals with economic assets at risk. The National Flood Insurance Program covers losses to insured structures and their contents due to floods. While tenants may purchase contents insurance, most coverage under the NFIP protects real estate owned by the policy holder. Similarly, Small Business Administration low-interest disaster loans are extended to individuals and businesses who demonstrate the ability to repay them. Most forms of disaster assistance are not needs-based, except for limited grants to low-income victims.

The moral for both U. S. and international disaster policy-makers is that the commendable goal of "making people whole" after a disaster may result in very different sets of benefits being offered in relation to the recipient's socioeconomic status: The more you have at risk, the more you are eligible to receive from the government after a disaster. This policy ignores the reality that the less you have, the more you may suffer from disaster in terms of personal, emotional, social, and economic impacts. In other words, those with the least resources are the most vulnerable to natural disasters.

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by **Brenda Bell**

Learning from LANDSLIDES


Robert L. Shuster, USGS

Though mistakenly perceived as strictly local phenomena, landslides may be the most widespread geologic hazard on Earth. Their necessary components are simple: gravity, steep slopes and unstable sediments, all of which abound in the Earth's temperate zones.

In October, 1996, it began raining in the Pacific Northwest as it does every fall. But that year it never seemed to stop. Odd things began to happen. Houses slid down hills, avalanches of mud descended upon railroads and highways. Pipelines broke when sodden soil shifted. The Earth was falling apart all over the Seattle area. Yet people seemed to shrug off these events as isolated, freakish, almost amusing occurrences.

The public mood changed after January 19, 1997. Early that morning a mudslide destroyed a house and killed a family of 4 at Rolling Bay, a beachfront community on an island near Seattle. Geologists call avalanches of this sort debris flows; they move with terrific force and without warning. This one took only 3 seconds. I thought about those 3 seconds a lot, for our teenage daughter had been babysitting in the house only a few hours before it was flattened by the slide.

That afternoon I stood in the rain at Rolling Bay as the bodies were being dug from the mud and wondered how such a thing could happen. There was ample evidence of previous landslides up and down the beach — here, a road blocked by mud; there, a house tagged "unsafe to occupy." We had lived on the island for years — why hadn't we known how unsafe this beach was? And why did people persist in staying here when signs of danger were all around them?

I began asking these questions as a mother, but wound up seeking answers as a journalist. The result of that research appeared in *The Atlantic Monthly* as "The Liquid Earth," an examination of the landslide hazard issue. In that article the tragic scene at Rolling Bay becomes part of a larger, more complex picture that includes the public's general failure to apprehend natural Earth processes and the risks they pose; the underfunding of programs dealing with landslide hazards, and the difficulties in crafting effective land-use policies those hazards require.

Though mistakenly perceived as strictly local phenomena, landslides may be the most widespread geologic hazard on Earth. Their necessary components are simple: gravity, steep slopes and unstable sediments, all of which abound in the earth's temperate zones. Though slides can be triggered by volcanic eruptions and earthquakes, the most common cause is simply water, in the form of intense rainfall, snowmelt or river flow. Much of the West Coast, with its crumbling mountain ranges and exposure to Pacific storms, is ideal debris flow habitat. But landslides of one sort or another occur in every state; in fact, the unlikely cities of Pittsburg and Cincinnatti incur some of the highest landslide costs in the U.S.

Slides cause greater loss of life and property than is generally realized, especially in Third World countries. Most victims of the 1998 earthquake in Afghanistan were killed not by the quake itself, but by collapsing hillsides. Hurricane Mitch in Central America set off one million mudslides. And there's evidence that the earth is slipping more often, thanks to encroaching development in vulnerable areas, deforestation and severe weather events linked to global climate change. California normally suffers $100 million in slides each year; in 1998, an El Niño year, the losses came to $1 billion. Almost none of it was insured.

On the island where we live, landslide insurance is now impossible to obtain anywhere it may actually be needed. But it will take more than a lack of insurance to keep people out of places like Rolling Bay. For starters it will take detailed landslide hazard maps correlated with rainfall predictors and backed up with a large dose of political will. Unlike earthquake fault zones, landslide hazard zones are relatively narrow and easy to avoid. No one predict can when a slide will occur, but the right maps can show exactly where the unstable slopes are. Mathematical models can then predict with reasonable accuracy which rainfall events will create ground moisture conditions conducive to landslides. The most extensive slope mapping project in the country is now underway in Seattle, and the U.S. Geological Survey is seeking $20 million in new funding to map more cities. It's a bold move for an agency whose entire landslide hazard program limps along under a $2.5 million budget.

We gravitate to the edges of things — of rivers and oceans, canyons and hilltops. They are beautiful places to live, we pay dearly for them, and that investment is hard to walk away from. When bad things happen, we quickly forget. A geologist in Santa Cruz, California, where dozens of people perished in debris flows in 1982, says our collective disaster memory goes back only two years. At Rolling Bay, where landslides killed four people and destroyed or badly damaged seven homes, there is now talk of bulldozing the remaining houses — and building condominiums in their place.

What are the lessons to be learned here? The most obvious one is that the Earth is a more dangerous place than we realize. "We all live with risks," says UC Berkeley geomorphologist Bill Dietrich. "But we have some sense of those risks. Most people have no sense of the landslide risk." Japanese children learn in school how debris flows work; we have a responsibility to educate ourselves about these natural systems. And surely we can find the money to allow science to help us learn to live with them. Cities and communities need laser altimetry topographic maps to show exactly where landslide hazards are and where land-use restrictions are needed. They also need more landslide warning systems like the one the USGS developed in the Bay Area but cancelled for lack of funding — a mere $50,000 a year.

Perhaps we make a mistake when we approach any natural hazard strictly from the standpoint of risk or economic loss. People will always be willing to take extraordinary risks, knowingly or unknowingly — and statistically their chances of losing that gamble in their lifetime may be small. Instead we should approach these hazards from a position of profound respect — not for the awful destruction they wreak, but for the life our physical world makes possible, and all the marvel that life contains. Natural hazards aren't unsettling events that happen every now and then. They're always happening, somewhere, all the time. It's the way the Earth breathes. How we deal with that comes down to how we choose to live on this Earth — and as we are constantly being reminded, we can and do choose.

Brenda Bell *is a journalist and essayist, Ms. Bell has published articles in* National Geographic, The New York Times, Los Angeles Times Magazine, Utne Reader, Bellingham Review *and others. Of particular note is her article, "The Liquid Earth," published in the January 1999 issue of The Atlantic Monthly and addressing the general failure of government in dealing with landslide hazards. This failure, Ms. Bell contends, "raises troubling questions about our awareness of the most elemental Earth processes, our relationship to the Earth, and human nature itself."*

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by Encho Gospodinov

Living with Natural disasters: A View from the Field

In the early hours of that hot August 1999 day the phone of the Head of the Bulgarian Red Cross Rescue Service, Mr. Pencho Babukchiev, "got red and almost melted" as he described the situation after many urgent calls from Ankara, the Turkish capital. The first of a series of strong earthquakes that hit Turkey during the second half of 1999 made the Turkish Red Crescent Society ask for help from its neighbours.

And it came. The Bulgarian Red Cross rescue teams, with proper equipment and sniffing dogs, left Sofia within hours after the plea for help from the disaster-stricken area. It was nothing new for them: they have done it before in Armenia, Macedonia, and other neighbouring countries, saving people under the rubble, hit by floods, snow avalanches or technological disasters. Days later, both countries' heads of state received the teams as heroes for what they had been able to do.

But this is not the end of the story. What stays behind this success is a combination of factors and strategies, involving scientific circles, the International Federation of Red Cross and Red Crescent Society's HQ in Geneva, the vision of the American Red Cross and the experience of the Red Cross Societies in the Balkan region to cope with many natural and man-made disasters. As Assoc. Prof. Stefan Gladilov, Secretary General of the Bulgarian Red Cross put it: "The more you suffer, the more you learn." It is not a secret that the Balkan area is historically known as a disaster prone area challenging for decades the academic world, the local governments and the Red Cross and Red Crescent Societies in the region.

When a disaster strikes, very often the first humanitarian power to act in the field is the Red Cross system. The reasons? Partly because of its history: since 1863 the Red Cross (and later the Red Crescent) Societies proliferated throughout the world and started assisting millions of people in need every year in times of natural and man-made disasters and military conflicts. Today the Geneva based International Federation, which unites 176 National Red Cross and Red Crescent Societies from all continents, is the biggest humanitarian network with some 300,000 professionals, over 100 million volunteers, spending annually more than 20 billion USD on humanitarian assistance to more than 200 million people worldwide.

The other reason is that the Red Cross has its structure practically in every country in the world. This enables it to act swiftly through its professional and voluntary teams before and after the disaster strikes. Its services are much cheaper due to the voluntary work compared with those of the government agencies and UN structures. That makes the Red Cross a desired partner and implementing arm for many other agencies which do not have field structures or experience — or which do not want to create parallel programs and bodies to those of the Red Cross.

All this might sound a bit like "humanitarian propaganda," but this is true: the Red Cross Movement, together with its founder Henry Dunant has four (4) Nobel Peace Prizes and unlike many other newly born charities continues to work quietly, focusing on the most vulnerable people wherever they might be.

But again, this is not the full picture. The field experience tells my colleagues and me that in this "global village" today no one can work in isolation. Coping with natural disasters means new types of co-operation between the academic world, the government institutions and both the humanitarian (not-for-profit) and corporate sectors. All those 4 players must get even closer and work out strategies, which will make field operations much more efficient, dynamic and less expensive. The role of scientists is crucial since there are new elements and trends in today's climate changes, socio-economic cataclysms and the ability of the other 3 players to work closely in both disaster preparedness and disaster relief.

According to Dr. Peter Walker, Director of Disaster Policy at the International Federation HQ in Geneva and one of the driving forces behind the famous annual *World Disasters Report*, what is much needed today is "further development of response mechanisms that are rapid, flexible and effective in response to the most vulnerable." This means finding a new common denominator among the players mentioned above, combining scientific knowledge with field experience and operational power.

The other lacking element today, based on what I have experienced in Armenia during the fatal quake in 1988, followed by various tragedies in Romania, Bosnia, Mexico, Greece, Poland, etc., is the synergy between the international and domestic disaster preparedness plans. According to my colleague, Dr. Peter Walker, "There is an urgent need to establish or update national disaster preparedness plans which incorporate linkages to international systems of disaster response, and have clearly defined and agreed roles and responsibilities for the national independent disaster response organizations."

This means that all local and international players have to further harmonize their working plans and budgets, to avoid unnecessary duplications which we still see today in the field, to combine effectively their experience and human resources, to make better use of donors' money without competing for the same "part of the funding cake." At the same time, the governments should accept the unique role of the international organizations and make better use of their rich experience. On their side, both governments and NGOs should constantly pay attention to what the scientists say.

Had this been the case, at least part of the December 1999 tragedy in Venezuela could have been averted. The weather forecast was clearly warning the authorities that the rain might cause severe damage.

In its recently adopted Strategy 2010, the International Federation puts disaster preparedness and disaster response as 2 of its 4 major priorities for the next decade. And if more that 300 million people are affected every year by natural disasters and if more than 90% of the victims are in the developing countries, the message to us is very clear: invest more in disaster preparedness well in advance, train both local residents and the authorities for the (disaster) day, listen to the academic world, think globally and act locally. As the Roma (Gypsy) people in Central Europe say: "Get ready for the Winter, and if the Summer surprisingly comes, so much the better."

Why then did I start with the Bulgarian Red Cross rescue team story? Because it illustrates how a relatively small domestic humanitarian unit, supported by the Federation HQ strategy and funded by the American Red Cross was able to play an important international life saving role. These people were not heroes: they just did their professional humanitarian duty combining knowledge, experience, vision, and government support under one well known logo: Help cannot wait.

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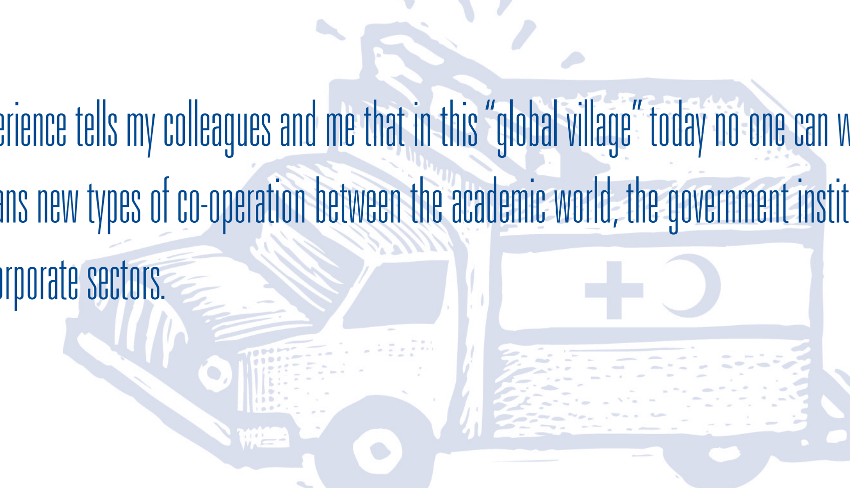

The field experience tells my colleagues and me that in this "global village" today no one can work in isolation. Coping with natural disasters means new types of co-operation between the academic world, the government institutions and both the humanitarian (not-for-profit) and corporate sectors.

by John Mutter

The Snovian Disjuncture and the State of the Planet

I think it is fair to say that when the organizers of the State of the Planet Conference first put together an agenda, it was not universally well received. Our idea was to gather together some of the world's leading natural scientists, scholars and opinion leaders from many intellectual domains (some very distant from the Earth sciences) and have each provide a unique perspective on the condition of the planet that sustains our existence. The issue of concern, of course, was the one that C.P. Snow identified in his famous Rede Lecture of 1959, "The Two Cultures and the Scientific Revolution." What we were told was that we were mixing oil and water — that putting together thinkers from the physical sciences with those from social sciences, the humanities, and the liberal arts and expecting anything worthwhile to come of it was a dream. No doubt Baron Snow of Leicester would have thought it would never work either. But now, 50 years after the birth of Lamont-Doherty Earth Observatory and 40 years after the Snovian disjuncture was illuminated, and on the eve of the new millennium, we very much felt that the need for the gulf between these two intellectual domains to be bridged had become urgent and we needed to start to build that bridge.

The need arises because the future of society as we know it today on our planet may depend on it. I appreciate that may sound overly dramatic, but consider the following: In the closing moments of the 20th century, we have heard Wally Broecker suggest that the present day climate in which our society emerged is unusually warm and stable. For most of the last several hundred thousand years, the earth's climate was cold and highly unstable. The temperature record from the Greenland ice cores is a stunning icon of our time that proclaims that we are living in a climatic aberration. As active agents in this environment we are well capable of unintentionally destabilizing the life-sustaining ether around us. The very fact that there is debate between Jim Hansen and Dick Lindzen about whether human activity has caused global warming implicitly acknowledges that human activity can modify the climate. In the most alarming scenarios, we might even send the planet back into a very hostile, very cold state. Apart from inconvenience, a rapid change to a cold state would bring huge global disruption as crop producing areas would dramatically shift. A resource rich country could well become resource poor in a couple of decades. It took only 3 successive drought years (together with some extremely bad farming practices) to create the Oklahoma Dust Bowl, which led to the largest internal population re-distribution in the U.S in the 20th century. The ability of society to re-adjust to a new rapidly developed cold climatic phase is unknown and the potential for deadly conflict arising over greatly diminished resources is very plausible.

If humankind's activities are putting our planet at risk, and many scholars from a wide range of disciplines believe we are doing just that, we can be sure of two things. One is that the natural sciences must provide the key role of understanding the physical processes that cause the risk and must estimate the magnitude. The second is that we have come to realize that scientists cannot simply sound a warning and expect Congress or society at large to listen and take action. The authority of scientific statements is not absolute. Mitigating the risks associated with human interaction with Earth processes will require changes in human behavior. Effecting such changes is well outside the realm of the natural sciences, requiring intellectual domains that deal with the human condition.

It is not difficult to conjure up any number of other disturbing scenarios. We have built great centers of commerce and culture in geologically active settings where cities can be lain flat by earthquakes that our science still cannot predict. The recent tragedy in Turkey is a timely example. Human activity does not normally cause earthquakes (the filling of large dams is an important exception), but we are responsible for the associated tragedy because we populate areas subject to earthquakes. Even if we had reasonable prediction skill, how would society react to an announced date (with statistical uncertainty) on which an earthquake was to happen? Would that rid the world of unscrupulous builders and government officials who erect dwellings built to kill in earthquake-prone areas? Similar remarks could be made about volcanoes. Generally, we know approximately when a volcano will erupt, but not how large the eruption will be. Mt. Rainier, just outside Seattle, is a volcano that is in many ways very similar to Mt. Saint Helens. While the damage from the Saint Helens' eruption was immense, the loss of life was low because the surrounding areas were relatively unpopulated. Not so for Mt. Rainier where the growth of Seattle has put many people at risk from even a modest eruption – and how would a warning be handled? How would a large population be moved perhaps a month before an eruption of unknown size was to occur? Is it possible to somehow discourage people from living in harm's way in the first place? These are not questions for seismologists or volcanologists. They are questions that can only be answered by those who deal with human behavior along with scientists who understand the risks.

We can now predict the phase of the El Niño Southern Oscillation (ENSO) to what we say is a useful skill level. This is a huge scientific achievement, one of the singular contributions to climate science of this century. But what does useful skill mean? A 90% consistency in forecasting accuracy may seem useful in probabilistic terms, but it is not really useful until we learn how to take advantage of that skill to mitigate the economically harmful effects of extreme events. We are just learning how to do this now at the International Research Institute for Climate Prediction, located on Lamont's campus, where climate scientists work together with social scientists to advance forecasting capability and develop tools that allow those forecasts to be effectively used in countries that suffer economic disruption and human suffering when unprepared for the extremes brought on by the events.

We know that every inch of our planet's surface biosphere has been touched by human activity. Even those parts that may appear to be natural are that way because we allow them to be. Ecosystem fragmentation and biodiversity loss in a world where population climbs exponentially could harbor serious consequences for life on our planet. And if that's true, and ecologists tell us it is, then reversing the loss and rejoining the fragments (if that's even realistic) requires the management of human activity — not one of the disciplines of the natural sciences. Finally, the future will surely see clean water become scarce. Hydrologists can tell us just how clean and just how scarce, but managing a planet with scarce clean water is a challenge for policy makers globally.

As Joel Cohen has observed, at the end of this century all of the things we used to be able to assume about drinkable water, breathable air, and the many other natural assets that sustain life on the planet, can no longer be assumed. Securing the health of society in a world where the usual

Mitigating the risks associated with human interaction with Earth processes will require changes in human behavior. Effecting such changes is well outside the realm of the natural sciences, requiring intellectual domains that deal with the human condition.

assumptions have failed — where humankind is too often desperately unhappy and near death — is an issue of monumental complexity but prodigious importance and grave urgency.

In the last half of the century, humankind has made a critical passage from tenants on the earth, occupying space that nature provided, to both tenant and landlord. We are now part of the earth system in every conceivable way. Our effect on the planet has become "geological" in scope and magnitude. We have become "geology." The ramifications of this transition from disengaged observer and experimenter, to one who is part of the experiment is a culture shock that echoes around the academe.

All of this suggests to me that Baron Snow's chasm must be crossed because the need to cross it has become urgent. Until now there has been no real need to bridge the divide — now there is. The natural sciences must strive to learn all there is to know about the way the Earth functions, from its inner core to its outer atmosphere, in all its wondrous complexity. Everything counts, everything matters. But to understand, predict, and manage those components of the Earth system that sustain life, which humans modify through their activity, and which present risks to our society, the natural sciences must develop a true union with the social sciences and humanities. We recognize that the two epistemic cultures are utterly different; their methods and styles of knowledge construction and the metrics by which knowledge is valued exist in completely different spaces. But I believe those spaces must be merged because the solutions we require do not lie exclusively in one or the other. The poet's voice will need to be heard along with the scientist's quantified caution.

I will close with a single, simple thought. Although our planet may seem vast and robust — and it surely is, under the actions of any single individual — when it is subjected to the actions of 6, 8 or 10 billion people, it is a fragile place. We need to understand it completely and in its entirety through research in the natural sciences. At Lamont-Doherty Earth Observatory, we have just completed 50 years of doing just that — and we plan to continue in that mode in the new millennium. But we also need to learn how to treat the planet well through science coupled to social process. We have spent 50 years attempting to understand the natural world — the "acts of God." Now we will tackle the more challenging task of understanding the actions of humans. This represents a new challenge for the Observatory, but one that we must accept, for if the planet were to break in our hands, I don't think we would know how to fix it.

John C. Mutter *is Director of Research and Interim Director of the Lamont-Doherty Earth Observatory, as well as a Professor of Earth and Environmental Sciences at Columbia University. A student of marine seismology and tectonics, Dr. Mutter conducts research into the mechanisms and processes of seafloor spreading, continental extension, and the development of passive continental margins. In addition to having written a number of popular science articles, he has authored over 70 journal articles, and has traveled the world's oceans during more than 30 research cruises.*

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She leans a little in the wind. As if she were a mariner.
The earth and its heated atmosphere, its cargo
Of everything alive, is swimming in a sea we hardly understand...

FROM THE POEM STATE OF THE PLANET BY ROBERT HASS

earth matters

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