State of the Wild: Perspective of a Climatologist

10April2007

Jim Hansen

Introduction. "Animals are on the run. Plants are migrating too." When I wrote those words in 2006[1], I was trying to draw attention to the fact that climate change is underway. People do not notice climate change readily, because it is masked by large day-to-day weather fluctuations, and we reside in comfortable homes and offices.

Animals and plants, on the other hand, can survive only within certain climatic zones. The National Arbor Day Foundation, confirming a prediction[1], is redrawing its maps for the zones in which different tree species can survive. And animals are beginning to feel the stress of change, as I will describe.

Yet present examples only hint at the scale of the planetary emergency that has crystallized from climate studies in the past several years. Can just-budding changes in the wild be consistent with dramatic scientific assessment of a 'crystallizing planetary emergency'? Unfortunately, yes.

Our home planet is now dangerously near a 'tipping point'. Human-made greenhouse gases are near a level such that important climate changes may proceed mostly under the climate system's own momentum. Impacts would include extermination of a large fraction of species on the planet, shifting of climatic zones due to an intensified hydrologic cycle with effects on freshwater availability and human health, and repeated worldwide coastal tragedies associated with storms and a continuously rising sea level.

The public and policy-makers need to know the basis for these conclusions, because implications are profound. The world must move onto a fundamentally different energy pathway within a decade or it will be too late for many animal and plant species, including millions, perhaps hundreds of millions, of the most vulnerable members of our own species.

Yet understanding of the nature and causes of climate change provides essential guidance that can help craft solutions to the climate problem. Needed actions, I will argue, can help us obtain a cleaner, healthier planet, allowing us to preserve creation, the remarkable planet on which civilization developed. But it will not be easy: forces of resistance, special interests focused on short-term profits, have inordinate power in our governments, especially in America.

In this article I describe how two fundamental properties of our climate system, its predominance of "positive feedbacks" and its ponderous inertia, have together brought climate to a great tipping point, a planetary emergency. I then discuss emerging impacts of climate change on the wild. Finally I summarize fundamental data on fossil fuels, the main driver of climate change, providing an outline of actions needed to reverse the forces driving climate change.

Tipping Point. The Earth is heated by sunlight. In balance, the Earth reaches a temperature such that an amount of heat equal to the absorbed solar energy is radiated from Earth back to space. Climate 'forcings' are imposed changes on the Earth's energy balance, a temporary upsetting of the balance, which thus alters the Earth's mean temperature. Forcings include changes of the sun's brightness, volcanic eruptions that discharge small particles into the atmosphere thus reflecting sunlight and reducing solar heating, and long-lived human-made 'greenhouse gases' that trap the Earth's heat radiation.

Climate forcings can be amplified or diminished by other, induced changes within the climate system, i.e., 'feedbacks'. It is now well-known that the net effect of 'fast' feedbacks, changes that occur quickly in response to temperature change, is 'positive', i.e., they amplify the

[1] J. Hansen, *New York Review of Books*, LIII (no. 12, July 13), 2006.

temperature change. As the planet warms, the feedbacks include increasing water vapor, itself a greenhouse gas, and decreasing areas of snow and sea-ice. Loss of snow and ice cover exposes a darker surface and thus increases absorption of sunlight.

Other feedbacks, mostly 'slower', have recently become clear. Forests and shrubs are moving poleward into what were tundra regions. Vegetation is dark, so as to capture energy needed for photosynthesis, and thus expanding vegetation warms the environment. Increasing areas on Greenland and West Antarctica are becoming wet, making the ice surfaces much darker in the warm season. Increased amounts of methane, a powerful greenhouse gas, are bubbling out of melting tundra. Paleoclimate records confirm that the amounts of methane and other major long-lived greenhouse gases in the atmosphere (carbon dioxide and nitrous oxide) increase as the ocean and land surface warm. These are all positive feedbacks that will amplify climate change on time scales of decades, centuries and longer.

The predominance of positive feedbacks explains why the Earth's climate has undergone large swings in the past. These feedbacks work in both directions, amplifying negative (cooling) forcings as well as positive forcings. Thus the feedbacks have caused the Earth's climate to be whipsawed[2] between colder and warmer climates in response to even weak forcings such as insolation changes due to slight changes in the tilt of the Earth's spin axis[2].

The partner of feedbacks in the present climate 'conspiracy' is the great inertia of oceans and ice sheets. Say a climate forcing, such as increasing greenhouse gases, occurs. Because of the heat capacity of the ocean, even after a few decades only about half of the eventual warming has occurred. Ice sheets may be even more sluggish, but accumulating evidence shows that they can respond dramatically on the time scale of centuries and perhaps decades.

The upshot of inertia and feedbacks is additional climate change 'in the pipeline'. Even if we stop increasing greenhouse gases today, more warming will occur. The importance of this warming in the pipeline is magnified by the present status of the Earth's climate.

Civilization developed during the Holocene, a period of relatively tranquil climate now almost 12,000 years in duration. The planet has been warm enough to keep ice sheets off North America and Europe, but cool enough for ice sheets on Greenland and Antarctica to be stable. Now, with rapid warming of 0.6°C in the past 30 years, global temperature is at its warmest level in the Holocene[3].

This warming has brought us to the precipice of a great "tipping point"[4]. If we go over the edge, it will be a transition to "a different planet"[4], an environment far outside the range that has been experienced by humanity. There will be no return within the lifetime of any generation that can be imagined, and the trip will exterminate a large fraction of species on the planet.

A tipping point occurs when the climate state is such that, because of large 'ready' feedbacks, small additional forcing can cause large climate change. The ready feedbacks today are provided by Arctic sea ice, the West Antarctic ice sheet, and much of the Greenland ice. Little additional forcing is needed to trigger these feedbacks because of global warming that is already in the pipeline.

Casualties of passing this tipping point would include more than wildlife and indigenous ways of life in the Arctic, and the coastal environments and cities submerged by rising seas. The increased global warming would have world-wide effects via an intensified hydrologic cycle. In the U.S., for example, the great tier of semi-arid states from West and Central Texas, through Oklahoma, Kansas, Nebraska, and both Dakotas would likely become more drought-prone and

---

[2] J. Hansen, M. Sato, P. Kharecha, G. Russell, D.W. Lea and M. Siddall, *Phil. Trans. Royal Soc.*, in press, 2007.
[3] J. Hansen, M. Sato, R. Ruedy, K. Lo, D.W. Lea and M. Medina-Elizade, *Proc. Natl. Acad. Sci.*, **103**, 14288-14293, 2006.
[4] J. Hansen, Is there still time to avoid dangerous anthropogenic interference with global climate? Amer. Geophys. Union, 6 December, 2005.

ill-suited for agriculture. Africa will see a great expansion of dry areas. Large populations in Asia and South America will lose their primary fresh water source as glaciers disappear.

The Earth's history tells us that atmospheric greenhouse gases are now near the dangerous level, beyond which these tipping points become unavoidable. But, in one sense, that is good news. It means that actions must be taken soon to slow and even reverse greenhouse gas growth. That is possible. And if we choose that course, there will be many ancillary benefits for the wild and for humans. But that course will not happen without recognition of what is needed, a conscious choice for a changed energy strategy, and prompt actions, as discussed below.

State of the Wild. Climate change is emerging while the state of the wild is stressed by other forces. Pressures include destruction of habitat, hunting and resource use, pollution, and introduction of exotic competing species. Climate effects are magnified by these stresses, including human-caused fragmentation of ecosystems. As a result, continued business-as-usual greenhouse gas emissions threaten many ecosystems and their species, which together form the fabric of life on Earth and provide a wide range of services to humanity.

Animals and plants migrate as climate changes, but their potential escape routes may be limited by geography or human-made obstacles. Polar species can be pushed off the planet, as they have no place else to go. In Antarctica, Adelie and emperor penguins are in decline, as shrinking sea ice has reduced the abundance of krill, the penguins shrimp-like food source[5].

Arctic polar bears are also feeling the pressure of melting sea ice. Polar bears hunt seals on the sea ice and fast in the summer, when the ice retreats from shore. As ice is receding earlier, populations of bears in Canada have declined about 20%, with the weight of females and the number of surviving cubs decreasing a similar amount[6].

The apparent good news is that the U.S. Fish and Wildlife Service is considering whether it will protect polar bears under the Endangered Species Act[6]. I say apparent, because the announcement was made only after the Fish and Wildlife Service was taken to court for failure to

Figure 1. Polar bear numbers are in decline. In some populations the weight of females and the number of cubs have decreased about 20 percent. ***(Image Credit: Paul Burke, First People)***

[5] L. Gross, As the Antarctic ice pack recedes, a fragile ecosystem hangs in the balance, PLoS Biol. 3(4):e127.
[6] E. Pennisi, U.S. weighs protection for polar bears, *Science* **315**, 25, 2007.

act. And connection of polar bear plight to greenhouse gas emissions has been drawn only by those bringing suit, not by the government.

Government priorities were further illuminated by a 'practice' press conference on Arctic sea ice conducted at NASA. When a member of my group, in response to a query about how sea ice loss might be stemmed, suggested that greenhouse gas emissions could be reduced, a government 'minder' leaped to his feet proclaiming "that's unacceptable", on the grounds that it was a policy statement.

It is understood that scientists should not make policy. That right belongs to the public and their elected representatives. But if scientists are prohibited from connecting dots, as climate research inherently does, and communicating that information, those communication constraints pose a threat to our home planet and the fabric of life upon it. Unfortunately, the response of our government has been an attempt to 'kill the messenger'[7]. But I digress.

Life in alpine regions, including the biologically diverse slopes leading to the mountains, is similarly in danger of being pushed off the planet. As a given temperature range moves up the mountain the area with those climatic conditions becomes smaller and rockier, and the air thinner. The resulting struggle for life is already becoming apparent in the southwest United States, where the effects are hastened by intensifying drought and fire.

The Mount Graham red squirrel survives now on a single Arizona mountain, one of the 'islands in the sky' in the American Southwest. These 'islands' are green regions scattered on mountains in the desert. Stresses on this species include introduction of a grey squirrel that raids the food middens built by the red squirrel. Classified as endangered, the Graham red squirrel population rebounded to over 500 by 1999[8], but has since declined to between 100 and 200[9]. Loss of the red squirrel will alter the forest, as its middens are a source of food and habitat for chipmunks, voles and mice.

The new stress driving down Graham red squirrel numbers, perhaps toward extinction, is climatic: increased heat, drought and fires. Heat-stressed forests are vulnerable to prolonged beetle infestation and catastrophic fires. Rainfall still occurs, and when it does it can be

Figure 2. Mount Graham Red Squirrel survives on a single mountain in Arizona, one of dozens of 'islands in the sky', green regions surrounded by desert. Green islands and squirrels are pushed higher as temperature rises and will be pushed off the planet if global warming continues. ***(Credits: PHOTOSMITH, 2004, Claire Zugmeyer and Bruce Walsh, University of Arizona.)***

[7] J. Hansen, Swift boating, stealth budgeting, and unitary executives, *World Watch* **19(6)**, 25-31, 2006.
[8] C. Jordan, Computers may help save Mount Graham red squirrel, *Univ. Arizona News*, April 27, 2006.
[9] T. Egan, Heat invades cool heights over Arizona desert, *New York Times*, 27 March 2007.

substantial because warmer air holds more water. But dry periods are more intense and resulting forest fires burn hotter, thus leaving an almost-lifeless 'scorched earth' so devastated that lower reaches of the forest cannot recover, becoming part of the desert below.

Might the Graham red squirrel be 'saved' by transplantation to a higher mountain, where it could compete for a niche? One difficulty would be the 'tangled bank' of interactions that has evolved among species[10]. What is the prospect that humans can understand, let alone reproduce, all the complex interactions that create ecological stability? 'Assisted migration' thus poses threats to other species[11], as well as uncertain prospects for those that are transported.

The underlying cause of the climatic threat to the Graham Red Squirrel, and millions of other species, is continued 'business-as-usual' increase of fossil fuel use. The best chance for all species, including humans, is a conscious choice by the latter species to pursue an alternative energy scenario, one leading to stabilization of climate.

Loggerhead turtles provide a partial conservation success story, at least for the present. These great creatures, adults weighing about 300 pounds, spend their entire lives at sea. Only adult females, beginning at age about 25 years, return to the beach at night at intervals of 2-3 years to bury a clutch of about 100 eggs in the sand. After a two-month incubation, if they survive predators, hatchlings emerge from the ping-pong-ball-sized eggs, and head to the sea, if they are not disoriented by beach lights.

Globally, loggerhead turtles are in decline because of capture in fishing nets, loss of nesting habitat, lighted beaches, and pollution. However, some recovery has occurred in the largest nesting area in the United States, which stretches over 20 miles of Florida coastline from Melbourne to Wabasso Beach. Concerted efforts to mark off and protect turtle nests, and minimize beach and nearby lighting, have helped to at least stabilize the South Florida subpopulation of turtles[12].

Climate change may place a new stress on these turtles. The Florida beaches are increasingly lined with sea walls to protect against rising seas and storms. Sandy beaches seaward of the walls are limited, and they may be lost if sea level rises substantially. Again the best hope for avoiding this problem is stabilization of climate.

Figure 3. Loggerhead turtle decline has been arrested by protection of nesting areas on Florida beaches and other measures, but these areas will be threatened by rising sea level. Left: adult loggerhead; center and right: hatchling emerging from egg and heading to sea (Credits: Wikimedia Commons, Turtle Time Inc., U.S. Fish and Wildlife).

[10] J.M. Montoya, S.L. Pimm & R.V. Sole, Ecological networks and their fragility, *Nature* **442**, 259-264, 2006.
[11] C. Zimmer, A radical step to preserve a species: assisted migration, *New York Times*, 23 January 2007.
[12] Fish and Wildlife Service, Loggerhead Sea Turtle, www.fws.gov/northflorida/SeaTurtles%Factsheets/loggerhead-sea-turtle.htm

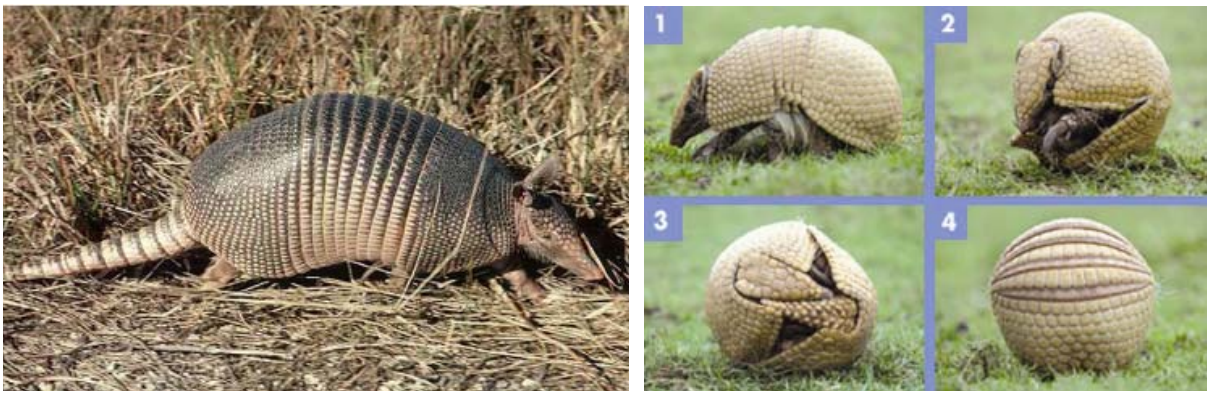

Figure 4. Left: North-American nine-banded long-nosed armadillo. Right: Armadillo curling into protective armor. ***Credits: MSN Encarta and Mark Payne-Gill, National Geographic Society.***

Some creatures seem more adaptable to climate change. The armadillo, discussed earlier[1], is likely to extend its range northward in Nebraska, Iowa, Illinois, Indiana, Ohio and Pennsylvania. This prehistoric critter is a survivor, having been around over 50 million years. Sometimes known as the poor man's pig, perhaps he can provide sustenance in event of climate catastrophe. It would be better, though, if his movement provided warning of climate change.

In summary, 'business-as-usual' global warming of several degrees Celsius would surely cause mass extinctions. Isotherms (lines of constant temperature) move poleward and upward at increasing rates in that scenario. Species unable to keep pace affect many other species through the web of interactions among species[10]. Prior large global warmings in the Earth's history, the most recent occurring 55 million years ago with release of large amounts of Arctic methane hydrates[13], have resulted in extinction of about 90 percent of the species on the planet. Preservation of creation, the planet that we know, requires an alternative scenario.

State of the Planet. Global warming is beginning to be recognized. But there is a huge gap between what is understood about global warming – by the relevant scientific community – and what is known about global warming – by those who need to know, the public and policy-makers.

The crystallizing scientific story reveals an imminent planetary emergency. We are at a planetary tipping point. We must move onto a new energy direction within a decade to have a good chance to avoid setting in motion unstoppable climatic change with irreversible effects. The 'dangerous' CO_2 level is at most 450 ppm, and it may be less[14]. CO_2 has already increased from pre-industrial 280 ppm to today's 383 ppm, and it is now increasing about 2 ppm per year. Global disasters can still be avoided, but only if we act promptly.

Before outlining steps needed to defuse the global warming time bomb, it is useful to emphasize a distinction among pollution problems arising in the fossil-fuel-driven industrial revolution. When the industrial revolution began in Britain it was powered first by coal, the most abundant of the fossil fuels. Later discoveries of oil and gas, more mobile and convenient fossil fuels, provided energy sources that helped power the developed world to ever greater productivity and living standards.

We did not face up to the dark side of the industrial revolution until it was thrust in our face. London choked on smog. A river in the United States burned. Forests were damaged by acid rain. Fish died in many lakes. These problems were traced to pollutants from fossil fuels.

---

[13] D. Archer, "Methane hydrates and anthropogenic climate change", Biogeosci. Disc., 4, 9931057, 2007.
[14] J. Hansen et al., "Dangerous human-made interference with climate: a GISS modelE experiment", Atmos. Chem. Phys. Disc., 2006.

We have solved or are solving those pollution problems, at least in developed countries. But we did not address them until they hit us with full force. That approach, to wait and see and fix the problems post facto, unfortunately, will not work in the case of global climate change. On the contrary, ignoring the climate problem at this time will lock in future catastrophic climatic change and impacts that will unfold during the remainder of this century and beyond[2,14].

But there is no reason for gloom and doom. Instead, we must resolve to move rapidly to the next phase of the industrial revolution. In doing so, we can help restore wonders of the natural world, of creation, while maintaining and expanding benefits of advanced technology.

Actions that are needed become apparent upon review of basic fossil fuel facts. Figure 5a shows estimated amounts of CO_2 in each fossil fuel reservoir: oil, gas, coal and unconventional fossil fuels (tar sands, tar shale, heavy oil, methane hydrates). A significant fraction of oil and gas has already been used (dark portion of bar graph). Proven and anticipated reserves are based on Energy Information Administration estimates. Other experts estimate higher or lower reserves, but the uncertainties do not alter our conclusions.

Data on fossil fuel reservoirs must be combined with knowledge about the 'carbon cycle'. The ocean quickly takes up a fraction of fossil fuel CO_2 emissions, but uptake slows as CO_2

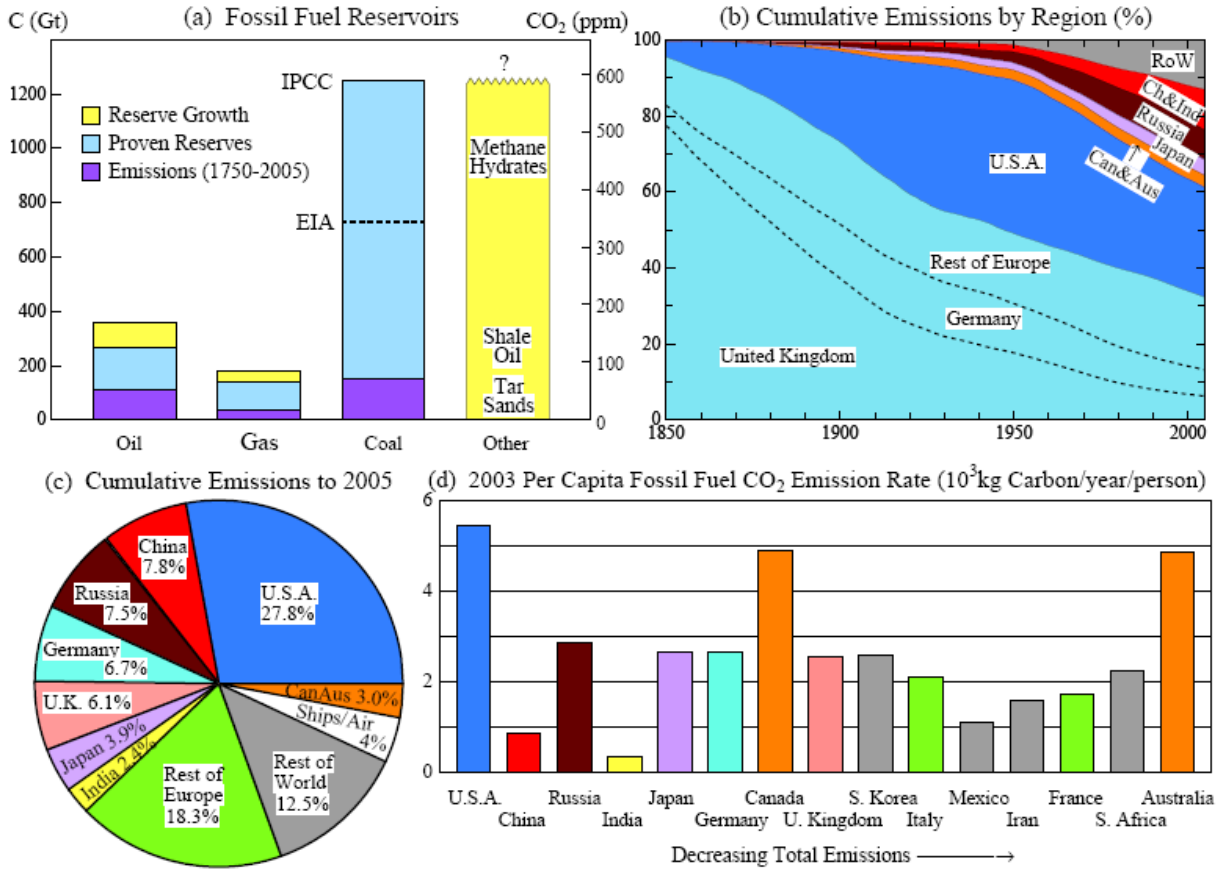

Figure 5. (a) Carbon dioxide contained in fossil fuel reservoirs, the dark areas being the portion already used, (b, c) Cumulative fossil fuel CO_2 emissions by different countries as a percent of global total, (d) Per capita emissions for the ten largest emitters of fossil fuel CO_2[14,15] .

[15] Marland, G., T.A. Boden & R.J. Andres, "Global, Regional, and National Fossil Fuel CO_2 Emissions", in *Trends: A Compendium of Data on Global Change*, Carbon Dioxide Information Analysis Center, Oak Ridge Natl. Lab., U.S. Dept. Energy, Oak Ridge, 2006.

added to the ocean exerts a 'back pressure' on the atmosphere. Further uptake then depends upon mixing of CO_2 into the deep ocean and ultimately upon removal of CO_2 from the ocean via formation of carbonate sediments. As a result, one-third of fossil fuel CO_2 emission remains in the air after 100 years and one-quarter still remains after 500 years.

One conclusion from these fossil fuel facts is that readily available oil and gas resources alone will take atmospheric CO_2 to the neighborhood of 450 ppm. Coal and unconventional fossil fuels could take atmospheric CO_2 to far greater levels. These carbon reservoirs are an important boundary condition in framing solutions to the climate crisis.

A second boundary condition is the Earth's energy imbalance, which defines the 'momentum' of the climate system. Creation of 'a different planet', with an ice-free Arctic and eventual disintegration of ice sheets, can be averted only if planetary energy balance is restored at an acceptable global temperature, i.e., one that avoids these catastrophic changes. Estimates of permissible additional warming must be refined as knowledge advances and technology improves, but the upshot of crystallizing science is that the 'safe' global temperature level is, at most, about 1°C greater than year 2000 temperature. It may be less.

A 1°C limit on added global warming implies a CO_2 ceiling of about 450 ppm[14]. There is some 'play' in the CO_2 ceiling due to other human-made climate forcings that cause warming, especially methane, nitrous oxide, and 'black soot'. The 'alternative scenario'[16], designed to keep additional warming under 1°C, has CO_2 peaking at 475 ppm via an assumed large reduction of CH_4. However, human-made sulfate aerosols, which have a cooling effect, are likely to decrease and tend to offset reductions of positive non-CO_2 forcings. Therefore 450 ppm is a good first estimate of the maximum allowable CO_2. Indeed, if recent mass loss in Antarctica is the beginning of a growing trend, it may be that even 450 ppm is excessive and dangerous.

The low limit on allowable carbon dioxide has a bright side. Such a limit requires changes to our energy systems that would do more than solve the sea level problem. They would leave ice in the Arctic and avoid dramatic climate changes in other parts of the world. Air pollutants produced by fossil fuels, especially soot and low level ozone, also would be reduced, thus restoring a more pristine, healthy planet. Most species on the planet could survive.

An outline of the strategy that humanity must follow to avoid dangerous climate change emerges from the above boundary conditions. It is a four-point strategy.

First, coal and unconventional fossil fuels must be used only with carbon capture and sequestration. Existing coal-fired power plants must be phased out over the next few decades. This is the primary requirement for avoiding 'a different planet'.

Second, oil and gas must be 'stretched' so as to cover needs for mobile fuels during the transition period to the next phase of the industrial era 'beyond petroleum'. This 'stretching' can only be achieved if there is a continually rising price on carbon emissions. Innovations will be unleashed if industry realizes that this rising price is certain. Efficiency standards, for vehicles, buildings, appliances, and lighting are needed, as well as a carbon price. The carbon tax will also avert the threat of emissions from unconventional fossil fuels, such as tar shale.

Third, because CO_2 is already near the dangerous level, steps must be taken to 'draw down' atmospheric CO_2. Farming and forestry practices that enhance carbon retention and storage in the soil and biosphere must be supported. In addition, burning biofuels in power plants with carbon capture and sequestration can draw down atmospheric CO_2 [17], in effect

---

[16] Hansen, J. M. Sato, R. Ruedy, A. Lacis & V. Oinas, *Proc. Natl. Acad. Sci.*, **97**, 9875-9880, 2000.

[17] Hansen, J. <http://www.columbia.edu/~jeh1/20070319105800-43018.pdf>Political Interference with Government Climate Change Science. Submitted text accompanying oral testimony given Mar. 19 during <http://oversight.house.gov/story.asp?ID=1214>hearings on "Political Interference with Science: Global Warming", Part II" of the Committee on Oversight and Government Reform of the U.S. House of Representatives. (http://www.columbia.edu/~jeh1/20070319105800-43018.pdf), 2007.

putting anthropogenic CO_2 back underground where it came from. CO_2 sequestered beneath ocean sediments is inherently stable[18], and other safe geologic sites may also be available.

Fourth, steps must be taken to reduce the non-CO_2 forcings discussed above.

Implementation requires recognition of responsibilities. Figure 5b shows cumulative CO_2 emissions by region as a function of time. This quantity measures responsibility for global climate change at a given time[14]. Current responsibility is summarized in the pie chart, Figure 5c. Europe bears a large responsibility. Responsibility of the United States is more than three times that of any other single nation, and it will continue to be the largest for at least several decades, even though China is now passing the United States in current emissions.

The requirements to avoid a 'different planet' with global disasters are not yet widely recognized. Germany's intention to replace nuclear power plants with coal is incompatible with climate stabilization. Europe, the United States, and other developed countries should place a moratorium on new coal-fired power plants until carbon capture and sequestration is ready. The responsibilities indicated by Figure 5 do not permit the argument that a moratorium in developed countries must await a moratorium in developing countries.

China and other developing countries must recognize that old-technology coal power plants must be 'bull-dozed' in the near future. In the near-term, it is reasonable for a limited number of new coal power to be built with the latest technology that can be retrofitted for CO_2 sequestration. Climate change will hit developing countries hardest (for example, most of the mega-cities located near sea level are in developing countries), providing strong incentive for moving promptly to technologies that do not release CO_2.

Greenhouse gas emissions by vehicles, buildings, and industrial processes should be addressed via both standards and a carbon price. The carbon price must be ratcheted upward so as to optimize sustainable economic growth. Barriers to energy efficiency must be removed. An example is the fact that most utilities today maximize profits by selling more energy.

Fossil fuels are remarkable concentrations of energy, created by nature over eons. The power of hundreds of horses is harnessed in a single automobile, and 100,000 horses in the throttle of locomotive. Some of these fuels are so readily plundered from the Earth that we use them profligately. Recognition of the unusual concentration of energy and the intrinsic value of the finite reservoir of fossil fuels aids energy planning.

Whatever the source of future vehicle power, efficiency will be premium. As a first step, the California requirement for 30 percent efficiency improvement has great value. In contrast, a proposed national plan for 20 percent ethanol in vehicle fuels, envisaged to be derived in large part from corn, does more harm to the planet than good. It would do little to reduce CO_2 emissions, it would degrade retention of carbon in soils and forests, and it would strike hard at the world's poor through increased food prices.

There are a variety of ways that renewable or other CO_2-free energies may eventually power vehicles. Governments should not dictate the nature of those solutions.

Biofuels are likely to play a major part in our energy future. As a native Iowan, I like to imagine that the Midwest will come to the rescue of compatriots threatened by rising seas. Native grasses appropriately cultivated, perhaps with improved varieties, can draw down atmospheric CO_2. The prairies from Texas to North Dakota may contribute, if we get on with solving the climate problem before super-drought spreads from the west to the prairies. If we act soon, we can keep the prairies as productive land. Positive feedbacks work in both directions.

A final picture. It is worth thinking about how our children and grandchildren, within a few decades, will look back on us. The picture that I fear has the polluters, the utilities and

[18] House, K.Z., D.P. Schrag, C.F. Harvey & K.S. Lackner, "Permanent carbon dioxide storage in deep-sea sediments", *Proc. Natl. Acad. Sci.* **103,** 12291-12295, 2006.

automakers, standing in court demanding the right to continue to emit CO_2 for the sake of short-term profits. The disturbing part of the picture is that we, through our national government, are standing alongside the polluters, officially as a hulking 'friend of the court', arguing against limitations on emissions. It is a picture of both ignorance and greed. Is this the picture of our generation that we want to leave for our children to remember us?

We live in a democracy and policies represent our collective will. We cannot blame others. If we allow the planet to pass tipping points, to the detriment of the wild and humanity, it will be hard to explain our role to our children. We cannot claim, with legitimacy, that 'we did not know".

The state of the wild is in our hands. We can still paint a bright picture. A drive for energy efficiency and clean energy sources will produce good high-tech jobs. Farming will get a boost by growing plants for biofuels. Restoration of clean air will be universally beneficial.

The recent decision by the Supreme Court that the Environmental Protection Agency can and should regulate greenhouse gas emissions is a step in the right direction. However, much more is needed. The great danger is minimalist actions: more words than deeds, even nostrums such as a huge government-defined ethanol program. (There is merit in a moderate program, as a step toward a scientifically-based biofuel approach.)

In my view, special interests have undue sway with our government and have been effective in promoting minimalist actions. Fossil fuel companies insist on promoting fossil fuels, rather than making the scale of investments needed to become broader energy companies.

Preserving the state of the wild requires a strong grass-roots effort. The public must demand, from government and industry, increased priority for the environment and for the planet that we leave for future generations.