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Our Ecological Problems:
Climate Change and Global Warming

"It is an excruciating experience to watch the planet fall apart piece by piece in the face of persistent and pathological denial." *Boiling Point* – Ross Gelbspan

Although it is finally beginning to change, the primary problem is that people don't think there's much of a problem. There's no agreement on the basic facts. For 20 years, the oil and coal industries have waged a PR campaign to stop any action on global warming. They have been able to discredit science, making it just one more special interest, and scientific results a matter of opinion, rather than of fact. They have also been able to maintain the public perception that the science of global warming is still unproven. And they have kept the focus on the economy, so that the argument becomes any attempt to lower the use of fossil fuels with "harm the economy." They have been able to maintain the impression that we can choose between the current situation or changes that will economically impact the fossil fuel industry. They ignore what will happen if we continue to do nothing.

"If we continue down the path we are going, we will produce changes greater than any experienced in the past 300 million years." Kenneth Caldeira, Lawrence Livermore National Laboratory.

Weather vs. Climate

To understand global warming, you first need to understand the difference between weather and climate.
Weather is daily and local, and varies enormously.
Climate in terms of global warming, refers to the annual global average temperature.

This refers to one number, which is:
Annual —it averages temperatures over a full year, over all four seasons.
Global —it averages temperatures over the entire globe, so that both poles and the Equator are averaged.

In 1899-1901, the average global temperature was 13.88° C. The first years of this decade (2000-2002) this number was 14.52°C (58.1°F.) The 15 warmest records since recordkeeping began in 1867 have all occurred since 1980. The three warmest years on record have all come in the last five years. The Earth has already warmed 1°F. With just this 1°F of warming, seas are rising, the timing of seasons is changing, glaciers are melting, diseases are migrating, and the oceans are warming. However, the UN Intergovernmental Panel on Climate Change (IPCC) predicts there will be an increase of 2.5-10.4°F. And the IPPC says we need to reduce our use of fossil fuels *60-80% lower* than the 1990 level, just to maintain the already high level.

The Earth's climate is driven by the interactions between the oceans and the atmosphere. The sun is the source of energy for the Earth's climate system but the heat from the sun arrives mostly at the Equator. This heat warms the oceans and the atmosphere, creating circulation patterns, which transport heat north and south from the Equator. Heat is also exchanged between the atmosphere and the ocean's surface.

"By late 2003, the signals were undeniable: Global climate change is threatening to spiral out of control." *Boiling Point* Gelbspan p. 1.

The UN Intergovernmental Panel on Climate Change (IPCC)

The primary global scientific group working on climate change is the Intergovernmental Panel on Climate Change. In 1988, the IPCC was jointly established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). About 2,500 experts participate in the review process, including approximately 1,000 experts from all over the world who are directly involved in drafting, revising and finalizing the IPCC reports. This includes climate scientists from 100 countries around the world (fifty percent are from the U.S.). The IPCC does not do research itself, but organizes peer reviews of research done by member scientists. Their findings represent the largest and most rigorously peer-reviewed scientific collaboration in history. This Panel has published three five-year summaries of climate research, in 1990, 1995 and 2001. *These reports have established an international scientific consensus that climate change is happening, and that humans are responsible for it*.

The IPCC is organized into three working groups plus a task force on national greenhouse gas inventories. The three scientific working groups are: climate science, human and ecological impacts, and mitigation/ prevention. Each working group has two co-chairs (one from the developed and one from the developing world) and a technical support unit. The Assessment Reports reflect the state-of-the-art understanding of the subject matter and are written so that they are comprehensive to the non-specialist. The IPCC is the official scientific arm of the Kyoto Protocol. In August 2004, the Panel began work on the next report, which will be released in 2007.

The scientific knowledge regarding climate change is for the most part extremely open and non-proprietary. The IPCC reports and the research behind it are in the public domain. Empirical data, model results, and emissions scenarios are highly transparent and subject to rigorous scrutiny and testing according to the norms of the scientific community. (The only exception is some inventory data by national governments.)

" We have met the enemy, and he is us." Pogo (Walt Kelly)

Reports available from the IPCC

You can download from http://www.ipcc.ch/index.htm both a Summary for Policy Makers and a Technical Summary for all three areas:

- "Climate Change 2001: The Scientific Basis"
- “Climate Change 2001: Impacts, Adaptation and Vulnerability"
- "Climate Change 2001: Mitigation"

The full text of the three 2001 Reports is also available on line, or your can order the books.
At http://www.ipcc.ch/pub/pub.htm, the IPCC says that they produce Assessment Reports and Special Reports; Technical Papers; Methodology Reports; and Supporting Material.
At http://www.ipcc.ch/pub/online.htm, you can also order or download the Special Reports on:

- Methodological and Technological Issues in Technology Transfer (2000)
- Emissions Scenarios (2000)
- Land Use, Land-Use Change, and Forestry (2000)
- Aviation and the Global Atmosphere (1999)
- The Regional Impacts of Climate Change: An Assessment of Vulnerability (1997)

The IPCC has, so far, published five Technical Papers:

- Climate Change and Biodiversity (June 2002).
- An Introduction to Simple Climate Models used in the IPCC Second Assessment Report (Feb 1997).
- Stabilization of Atmosphere Greenhouse Gases: Physical, Biological and Socio-Economic Implications (Feb 1997).
- Implications of Proposed CO 2 Emissions Limitations (Oct 1997).
- Technologies, Policies and Measures for Mitigating Climate Change (Nov 1996).

The IPCC also caries out the work on greenhouse gas inventory-related methodologies and Practices. This has led to publishing two papers:

1). Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (1996).
2.) Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000).

Two Primary Causes of Greenhouse Warming

The climate's sensitivity to warming depends critically on *feedbacks* that may amplify the initial warming, accelerating the rate of warming. There are two primary causes of global warming.

1. We are *destroying the carbon sinks* on the Earth, which sequester (absorb and store) carbon. There are three major carbon dioxide sinks: *theatmosphere, the land, and the oceans.* Land based sinks include forests, peat bogs, and the tundra. Plants naturally absorb carbon dioxide and give off oxygen in the process of photosynthesis, so the CO2 is taken out of the atmosphere. We are cutting down forests, which reduces the number of trees that will take CO2 out of the atmosphere, and also the CO2 in the trees is released. Peat bogs and tundra store enormous amounts of CO2 in the plants that have died over millennia, but have not decomposed (releasing their CO2) because it is frozen most of the year. Warming is already causing these areas to thaw, so the plant matter is decomposing, releasing it's stored CO2. By one estimate, the bogs of Europe, Siberia and North America hold the equivalent of 70 years of global industrial emissions.

"We are taking the reins of the geochemical cycles of the Earth. It's really frightening." David Archer, an expert in global carbon cycles University of Chicago. "Alarm over Acidifying Oceans" *New Scientist* 25 September 03

2. We are *releasing greenhouse gases*, especially CO 2 into the atmosphere, primarily through the use of fossil fuels.

Carbon Dioxide Carbon dioxide accounts for three fourths of the predicted increase in the greenhouse effect.

Methane A molecule of methane (CH 4) traps 20 times as much heat as a carbon dioxide molecule. Sources of methane include landfills, natural gas and petroleum systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment, and certain industrial process.

Water Vapor is also a Greenhouse Gas Water plays an important role in our weather, in part, because of its enormous energy-storing capability. Climate scientists expect the warming will set off a series of feedbacks, of which the three biggest, at least in the next few decades, will be from ice, water vapor and clouds. As *ice* in the Arctic melts, it is replaced by open water, bare rock, or tundra. When there is ice, it reflects heat back into space, but when it melts, the open sea is dark, and it absorbs more heat from the sun, accelerating warming.

Water vapor , like CO 2, traps heat and is a potent greenhouse gas. Warming will cause more water to

evaporate, because the warmer air will hold more water vapor. This increases the amount of water vapor, which in turn, accelerates the rate of warming. Extra water vapor in the air will at least double the direct warming effect of CO 2.

Clouds are the primary unknown. During the day, they can shield the Earth from the sun's heat keeping the Earth cooler. Or at night, clouds can trap the heat rising from the ground, making the Earth warmer. Whether the clouds warm or cool the Earth depends on the cloud's height, depth, color, and density. Researchers now realize how little is known about how many and what sort, of clouds there are. The extent to which clouds control the planet's thermostat may be between two and four times greater than previously thought, he says. Most disturbing, one scientist says, is that "*climate models used to forecast the effect of global warming have so far failed to pick up on this* [clouds]."

"If we continue down the path we are going, we will produce changes greater than any experienced in the past 300 million years." Kenneth Caldeira Lawrence Livermore National Laboratory

Consequences of Global Warming

1) *Global Warming will Change Weather Patterns*. The warming should create an overall trend toward both increased precipitation (warm air holds more water) and increased evaporation. Where precipitation is greater than evaporation, there will be floods. Where evaporation is greater than precipitation, there will be droughts. T he increased warming and the unpredictable changes will greatly impact agriculture. Another predictable result is an increase in the number of extreme precipitation events.

"[Global Warming] would cause massive droughts, turning farmland to dust bowls and forests to ashes. Picture last fall's California wildfires as a regular thing." David Stipp " Climate Collapse - The Pentagon's Weather Nightmare" *Fortune* Feb 9, 2004.

2) *Global Warming will alter the oceans.* The entire ecosystem of the North Sea is in a state of collapse, "record sea temperatures are killing off the plankton on which all life in the sea depends, because they underpin the entire marine food chain. Fish stocks and sea bird populations have slumped." Kenneth Caldeira of the Lawrence Livermore National Laboratory said, "We are changing the chemistry of the ocean and we don't know what it's going to do."

"Drought stress, pollution, insect attack, ultraviolet light—the critical issue here is not whether any particular synergism will occur, it is the increase in the aggregate risk of a major surprise. As the pressures build, so does the chance of triggering some unanticipated "super-problem." Chris Bright *State of the World 2000* p, 36

3) *Global Warming will Change Ecosystems and Habitat*. In addition to habitat loss from urban sprawl and pollution, warming will also be a major factor. "A quarter of all species of plants and land animals, or more than a million in all, could be driven to extinction." Massive extinctions have occurred *five times* during the earth's history. The last one was the extinction of the dinosaurs, 65 million years ago. Scientists are calling what is occurring now, the *sixth mass extinction*.

4)Global Warming will Change Weather, Creating more Extreme Storms. A s the atmosphere warms, the climate not only becomes hotter but more unstable, creating more extreme precipitation events.

5) *Global Warming will be a public health issue* . Warming will increase the spread of infectious diseases, and heat stress, and also malnutrition because of its impact on agriculture. A heat wave can be deadly. I n August 2003, a major heat wave in Europe killed an estimated 35,000 people.

6) *Global Warming Will Cause Ice to Melt and Seas to Rise* . The ice sheets in the two poles and Greenland, and in mountain glaciers around the world, are melting. Climate models indicate that global warming will

be greatest at high latitudes, especially in the Arctic. For the first time since civilization began, sea level has begun to rise at a measurable rate. Studies have suggested that the global sea level has risen about 7.8 inches over the last 100 years, and could rise another 9-88 centimeters (4-36 inches) in this century. Sea rise from the melting ice also threatens island nations. If the sea level rises in the range expected by the IPCC, many island nations, as well as all low-lying coastal areas, will be under water. The affects of sea-level along the coast will cause flooding, erosion, and saltwater intrusion into aquifers and freshwater habitats.

7) *Global Warming could Create Abrupt Warming.* A recent report by the National Academy of Sciences, *Abrupt Climate Change: Inevitable Surprises*, said "Large, abrupt climate changes have repeatedly affected much or all of the earth, locally reaching as much as 10°C change in 10 years. Available evidence suggests that abrupt climate changes are not only possible but likely in the future, potentially with large impacts on ecosystems and societies."

"To the long list of predicted consequences of global warming — stronger storms, methane release, habitat changes, ice-sheet melting, rising seas, stronger El Niños, killer heat waves — we must now add abrupt, catastrophic coolings. Whereas the familiar consequences of global warming will simply force expensive but gradual adjustments, the abrupt cooling promoted by man-made warming looks like a particularly efficient means of committing mass suicide. "William H. Calvin, "The Great Climate Flip-flop," *The Atlantic Monthly* January 1998.

8) *Global Warming may Create Abrupt Cooling*. Global warming could, in as little as a few years, trigger abrupt cooling in Europe. Europe is warmed by the huge Atlantic Ocean current that flows north from the tropics bringing with it, warm water and warm moist air. But that current could shut down. When the warm current gets to the North Atlantic near Greenland, the warm water evaporates, leaving the salt behind. This surface water is more salty than the water below, and therefore, it is more dense, and it sinks, in a process called "flushing." The water drops to the bottom of the ocean and the current moves down the coast of Africa deep in the ocean. As it drops, more water is pulled up from the Gulf Stream to replace it.

If the water on top were no longer more salty than the water below it, the flushing could slow or stop. Water could be "freshened" in two ways. Either by an increase in precipitation (fresh water), which will be one of the characteristics of global warming, or by adding fresh water to the sea from the melting of ice in the Arctic and in Greenland. The results of abrupt cooling would be catastrophic. In Europe, 25 percent of their heat comes for these currents. Europe is actually quite far north, Rome is even with Chicago and London with Duluth. If the current stopped, Europe's weather would become like Canada or Siberia.

Canada's agriculture supports about 28 million people. Canada has excellent soils, and is able to grow its own food, but it lacks Europe's winter warmth and rainfall. Europe today has more than 650 million people, and if it became as cold as Canada, it could grow only a fraction of the food they need.

It is uncertain how likely this event is, but the point is that it is quite plausible: ice core research shows that it has already happened at least eight times in the Earth's recent history. The last two were 12,700 years ago, and 8200 years ago. In the second one, it took only four years for the flushing to shut down. There already are indications that the North Atlantic is increasingly being freshened by melting glaciers, increased precipitation, and fresh water runoff making it substantially less salty over the past 40 years. There is also evidence that the circulation has slowed down measurably in the last decade or so.

Consider the consequences if Europe suddenly had the climate of Siberia (and Scandinavia became uninhabitable). The entire world economy would collapse, There would be mass famine. All this is occurring while the rest of the world continues to warm. Europe couldn't grow enough food because it would be too cold. The rest of the world would have food shortages due to droughts, water shortages, and cropland loss. All of this, in a world full of nuclear weapons.

"One of the most shocking realizations of all time has slowly been dawning on us: the earth's climate does great flip-flops every few thousand years, and with breathtaking speed. In just a few years, the climate suddenly cools

worldwide. With only half the rainfall, severe dust storms whirl across vast areas. Lightning strikes ignite giant forest fires. For most mammals, including our ancestors, populations crash." William Calvin *A Brain for All Seasons: Human Evolution and Abrupt Climate Change*.

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LINKS ON GLOBAL WARMING

General Web Sites on Global Warming
Environmental Defense http://www.undoit.org/
EPA site on Global Warming http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html
Forum on Science and Technology for Sustainablility http://sustsci.harvard.edu/
Global Change Master Directory http://gcmd.gsfc.nasa.gov/
Global Warming International Center http://www.globalwarming.net/
Hadley Centre for Climate Prediction and Research http://www.met- office.gov.uk/research/hadleycentre/index.html
Intergovernmental Panel on Climate Change http://www.ipcc.ch
Natural Resources Defense Council (NRDC) http://www.nrdc.org/globalWarming/default.asp
Real Climate http://www.realclimate.org/
New Scientist http://www.newscientist.com/hottopics/climate/
Sierra Club on Global Warming http://www.sierraclub.org/globalwarming/
Union of Concerned Scientists http://www.ucsusa.org/global_environment/global_warming/ind ex.cfm
United Nations Framework Convention on Climate Change http://unfccc.int/index.html
US Geological Survey Global Change Research Program http://geochange.er.usgs.gov/
World Resources Institute http://climate.wri.org/
World Wildlife Fund http://www.worldwildlife.org/climate/index.cfm
Worldwatch Institute http://www.worldwatch.org/features/climate/

Ice Melting
Global Ice Measurements from Space http://www.GLIMS.org
Institute of Arctic and Alpine Research, University of Colorado http://instaar.colorado.edu
International Research Institute for Climate Prediction http://iri.ldeo.columbia.edu/ climate/cid/index.html
National Snow and Ice Data Center http://www-nsidc.colorado.edu
World Glacier Inventory http://nsidc.org/data/glacier _inventory/index.html
World Glacier Monitoring Service http://www.geo.unizh.ch/wgms
Worldwatch Institute Climate Mini Site http://www.worldwatch.org/ topics/climate.html

Governmental and University Sites
American Geophysical Union, www.agu.org,
Intergovernmental Panel on Climate Change, www.ipcc.ch
National Oceanic and Atmospheric Administration, www.noaa.gov
National Center for Atmospheric Research, www.ncar.ucar.edu
Geophysical Fluid Dynamics Laboratory, www.gdfl.gov
Hadley Centre (UK), www.meto.gov.uk
Goddard Space Flight Center, www.gsfc.nasa.gov
Lamont-Doherty Earth Observatory, www.ldeo.columbia.edu
Climate Diagnostic Center , www.cdc.coaa.gov
Goddard Institute for Space Studies, http://www.giss.nasa.gov/
U.S. Global Research Change Program, www.usgrcp.gov
U.S. Global Change Resources, www.gcrio.org:9080/nav/toc_pg.jsp

The International Satellite Cloud Climatology Project, http://atmospheres.agu.org
Total Ozone Mapping Spectrometer, http://jwocky.gsfc.nasa.gov
Carbon Dioxide Information Analysis Center – Global Change Data and Products, http://cdiac.esd.ornl.gov/by_new/bysubjec..html#climate
Max-Planck-Institut fuer Meteorologie, www.mpimet.mpg.de
World Climate Research Programme, www.wmo.ch/web/wcrp
World Meteorological Organization, www.wmo.ch
National Weather Service – Climate Prediction Center www.cpc.ncep.noaa.gov
NOAA Paleoclimatology Program, www.ngdc.noaa.gov/paleo/globalwarming/home.html
International Research Institute for Climate Prediction, http://irieo.columbia.edu
Dept of Energy – Energy Effecience and Renewable Energy, http://www.eere.energy.gov
U.S. Geological Survey – Global Change Research, http://geochange.er.usgs.gov
National Science Foundation – Global Change Research Programs, http://www.geo.nsf.gov/egch/
Global Change Data and Information System, www.globalchange.gov
NASA – Destination Earth, www.earth.nasa.gov
USDA – Agricultural Research Center – Global Change, www.ars.usda.gov/research/progra,s/programs.htm?NP_CODE=204
U.S. GCRIO US -Global Change Research Program Budget and Program Info, www.gcrio.org:9080/nav/go.jsp?g=46&gs=511
MIT Joint Program on the Science and Policy of Global Change, http://web.mit.edu/afs/athena.mit.edu/org/g/globalchange/www/

Magazines/Journals
New Scientist, www.newscientist.com/news
Science (AAAS), http://www.sciencemag.org
Nature, http://www.nature.com
Science Daily/Earth Sciences, (no subscription required) www.sciencedaily.com/directory/Science/Earth_Sciences

Web Pages with many Climate Links
Global Change Master Directory, http://gcmd.gsfc.nasa.gov/Resources/pointers/glob_warm.html
NCAR – Atmospheric Links Section, http://www.cgd.ucar.edu/cms/agu/Links.htm
Tom Fiddaman's Climate Policy Bookmarks, www.sd3.info/climatebookmarks.html#ClimateScience
NOAA Office of Global Programs – Climate Related Links, www.ogp.noaa.gov/library/clmtsites.htm

Data Resources
UCAR – Links to many data resources http://dss.ucar.edu/other_resources/
Satellite Data, http://www.ssmi.com/msu/msu_browse.html
U.S. Geological Survey – real time stream flow, water table, precip, etc, http://waterdata.usgs.gov/nwis
NCAR – Climate Analysis Section Data Sets, http://www.cgd.ucar.edu/cas/catalog/outline.html
NSDIC – Snow and ice data, http://nsidc.org/data/catalog.html
NOAA – Paleoclimate data, http://www.ngdc.noaa.gov/paleo/globalwarming/paleodata.html
National Climatic Data Center –Climate Data, http://lwf.ncdc.noaa.gov/oa/climate/research/2003/perspectives.html
NASA – Global Change Master Directory, http://gcmd.gsfc.nasa.gov/index.html
Goddard Institute for Space Studies, Data and Images, Surface Temp., http://www.giss.nasa.gov/data/update/gistemp/maps/
USDA - Major World Crop Areas and Climatic Profiles, http://www.usda.gov/oce/waob/jawf/profiles/mwcacp2.htm
Climactic research Unit (UK) – Climate Monitor Online, http://www.cru.uea.ac.uk/cru/climon/

FOOTNOTES

Earth Policy Institute http://www.earth-policy.org/Updates/Update20.htm.

Woods Hole Oceanographic Institute. http://www.whoi.edu/institutes/occi/currenttopics/abruptclimate_15misconceptions.html

"Peat bogs harbour carbon time bomb" By Fred Pearce New Scientist, July10-16 2004, p. 9

http://www.epa.gov/methane/

"Harbingers of doom?"*New Scientist* vol 183 issue 2457 - 24 July 2004, p.44

"Harbingers of doom?"*New Scientist* vol 183 issue 2457 - 24 July 2004, p.44

"Oceans' Acidity Worries Experts" *Atlanta Journal-Constitution*, Sept. 25, 2003, and "Alarm over Acidifying Oceans," *New Scientist*, Sept. 24, 2003.

http://earth-policy.org/Indicators/indicator8.htm

Abrupt Climate Change: Inevitable Surprises http://www.nap.edu/catalog/10136.html. Can be read on-line.

An Abrupt Climate Change Scenario and Its Implications for United States National Security, prepared October 2003, By Peter Schwartz and Doug Randall of the Global Business Network, for the Pentagon. (The full Report is available as a PDF file at http://www. gbn.org.)