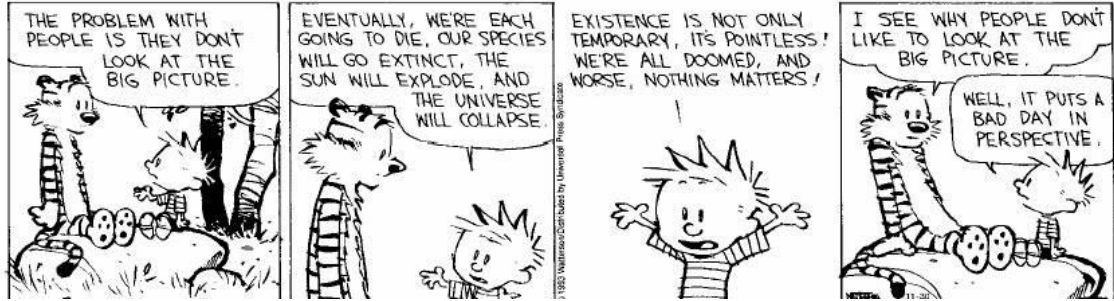


CALVIN & HOBBS

By Bill Watterson



Global warming is a “hot” topic that generates intense study and discussion on all sides. The question is not whether or not it is happening – at the present time it is clear that temperatures are indeed rising. The rate of warming has been at about 0.5 degrees Celsius per decade since the 1940s, and global sea levels have risen about 10 centimeters in the last century. The controversy is whether or not humans are causing the warming, or if it is part of a natural cycle, or if it is just a temporary aberration. For the purposes of this course, you are not required to solve this puzzle. You are being asked, however, to contemplate what is happening to global ice pack and whether we can do anything about it.

Read about science of Global Warming and explore the related links selected by the New York Times – Science – at <https://www.nytimes.com/section/climate>
One of the articles is also pasted below. Updated on December 21, 2011.

The amount of global ice and snow ebbs and flows. During the last glacial **peak** about 20,000 years ago, sea level was about 350 feet lower than it is now. Much of the earth’s water was locked up in ice and snow and more land was exposed. About 125,000 years ago, when the earth was in a very warm interglaciation, sea level was about 20 feet higher than it is now (so long Florida!).

Go to <https://www.youtube.com/watch?v=poKX6OnehTc> to learn about the disintegration of the Wilkins ice shelf in Antarctica. The reason given for this startling development is the large amount of melt water ponds accumulating on the surface of ice shelves. The Wilkins is thought to have been part of the glacial system of Antarctica for at least 400 years, and possibly for 12,000 years. Global warming is the culprit as warmer and warmer summers at the South Pole allow more melt water to accumulate, which is proved by the recent studies summarized at <https://www.carbonbrief.org/scientists-say-west-antarctic-ice-sheet-collapse-is-under-way-as-temperatures-rise>

On the other hand, the interior of Antarctica (which is a huge continent) is getting colder, and more ice and snow are building up there. This appears to be the only place on earth that is getting colder, though. And some very recent scientific results indicate that the air above Antarctica is warming. This article from *Scientific American* focuses on the growing body of knowledge concerning lakes beneath the Antarctic ice and melt water forming at the surface. <https://www.scientificamerican.com/article/the-unquiet-ice/>

All other global glaciers are in retreat (melting), including in the Americas, Africa, Europe, and Asia. Over the past 800,000 years, earth has had many ice ages. Each one has lasted about 100,000 years, separated by interglaciations of 10,000 to 15,000 years. The current interglaciation we are in began about 10,000 years ago, when organized agriculture

began. It can therefore be expected that it is about time for earth to begin entering another glacial period. But will we? Consider the evidence of increased greenhouse gases in the upper atmosphere produced by CFCs, halon, rice paddies, cattle, internal combustion engines, loss of forests, termites, etc. Bans are being promulgated against some of these causes, but not all. <http://www.nature.com/news/climate-change-melting-glaciers-bring-energy-uncertainty-1.14031> is an article about the dangers to people living in the Himalaya as glaciers there melt and the meltwater threatens them.

Another indicator of global warming is the shifting to higher latitudes of warmer climates, earlier springs, later autumns, changes in vegetation and resulting changes in animal populations. The next article is a study of the Arctic tundra, with some extraordinary photography showing the changes between the 1940s and the present. Much of the research focuses on the albedo effect – how much radiation is reflected back into space from earth. You can learn about albedo in your text (use the index to find the pages). <http://www.signonsandiego.com/news/science/20051005-9999-lz1c05shrub.html> This article is also cut and pasted below.

Explore the great comprehensive National Geographic depository of the current research on global warming at <https://www.nationalgeographic.com/environment/climate-change/> The multiple links will take you to fascinating information. Cut and pasted at the bottom of this file is the April 3, 2006 cover article from *Time*. It contains only the text. If you have access to a copy of the magazine, the photos are exceptional.

If everyone on earth lived like you do, how many more earths would we need to sustain everybody? To take a survey on your ecological footprint, go to either

www.footprintcalculator.org

<https://www.conservation.org/carbon-footprint-calculator#/>

<https://offset.climateneutralnow.org/footprintcalc>

and play the game. Include your results in your response to this forum – i.e., how many earths would we need if we all lived like you.

Questions:

1. The sale of big gas guzzlers is declining. The sale of hybrid cars is growing. Energy companies are exploring alternative energy systems that do not rely on fossil fuels. Builders are starting to tout “green” and “ecofriendly” buildings. Everybody knows what a CF lightbulb is now. “Ecofriendly tourism” is a big money maker these days. Do you think humans are doing enough to stop the production of ozone-depleting gases?
2. According to the consumer consequences game, how many earths are needed if everyone lives like you do? What changes could you make to reduce that number?
3. Do you think the observable changes in climate (as described in the articles) are anomalies and things will return to “normal” soon? Or are these definitive warnings that should be heeded? Defend your answer with evidence that you found in your readings.

The New York Times: Science. January 24, 2012



Steen Ulrik Johannessen/Agence France-Presse — Getty Images

Updated: Dec. 21, 2011

Global warming has become perhaps the most complicated issue facing world leaders. Warnings from the scientific community are becoming louder, as an increasing body of science points to rising dangers from the ongoing buildup of human-related greenhouse gases — produced mainly by the burning of fossil fuels and forests.

[Global emissions of carbon dioxide jumped by the largest amount on record in 2010](#), upending the notion that the brief decline during the [recession](#) might persist through the recovery. Emissions rose 5.9 percent in 2010, according to an analysis by the Global Carbon Project, an international collaboration of scientists. The increase solidified a trend of ever-rising emissions that scientists fear will make it difficult, if not impossible, to forestall severe [climate change](#) in coming decades.

However, the technological, economic and political issues that have to be resolved before a concerted worldwide effort to reduce emissions can begin have gotten no simpler, particularly in the face of a global economic slowdown.

For almost two decades, the United Nations has sponsored global talks, known as the [United Nations Framework Convention on Climate Change](#), an international treaty signed by 194 countries in 1992 to cooperatively discuss global climate change and its impact.

The conferences operate on the principle of consensus, meaning that any of the participating nations can hold up an agreement. In recent years, the meetings have often ended in disillusionment. The conflicts and controversies discussed are monotonously familiar: the differing obligations of industrialized and developing nations, the question of who will pay to help poor nations adapt, the urgency of protecting tropical forests and the need to rapidly develop and deploy clean energy technology.

The negotiating process itself has been under fire from some quarters, including the poorest nations who believe their needs are being neglected in the fight among the major economic powers. Criticism has also come from a relatively small but vocal band of climate-change skeptics, many of them sitting members of the United States Congress, who doubt the existence of human influence on the climate and ridicule international efforts to deal with it.

2011 Global Talks in Durban

The 2011 conference, held in Durban, South Africa, ran from Nov. 28 to Dec. 11. [Delegates from about 200 nations gathered together](#) to try to advance the world's response to intensifying climate disasters.

One of the issues still left unresolved was the future of the [Kyoto Protocol](#), the 1997 agreement that requires major industrialized nations to meet targets on emissions reduction but imposes no mandates on developing countries, including emerging economic powers and sources of global greenhouse gas emissions like China, India, Brazil and South Africa.

The United States is not a party to the protocol, having refused to even consider ratifying it because of those asymmetrical obligations. Some major countries, including Canada, Japan and Russia, have said they will not agree to an extension of the protocol next year unless the unbalanced requirements of developing and developed countries are changed. That is similar to the United States' position, which is that any successor treaty must apply equally to all major economies.

Expectations for the meeting were low, and it [ended with modest accomplishments](#): the promise to work toward a new global treaty in coming years and the establishment of a new climate fund.

The deal on a future treaty renewed the Kyoto Protocol for several more years. But it also began a process for replacing the protocol with something that treats all countries — including the economic powerhouses China, India and Brazil — equally. The future treaty deal was the most highly contested element of a package of agreements that emerged from the extended talks among the nations here.

The expiration date of the protocol — 2017 or 2020 — and the terms of any agreement that replaces it will be negotiated at future sessions.

The delegates also agreed on the creation of a fund to help poor countries adapt to [climate change](#) — though the precise sources of the money have yet to be determined — and to measures involving the preservation of tropical forests and the development of clean-energy technology. The reserve, called the Green Climate Fund, would help mobilize a promised \$100 billion a year in public and private financing by 2020 to assist developing countries in adapting to climate change and converting to clean energy sources.

2010 Global Talks in Cancún

Last year's U.N. conference on climate change in Cancún, Mexico, produced only modest achievements but ended with the toughest issues unresolved. The package that was approved, known as the Cancún Agreements, set up a new fund to help poor countries adapt to climate changes, created new mechanisms for transfer of clean energy technology, provided compensation for the preservation of tropical forests and strengthened the emissions reductions pledges that came out of the U.N. climate change meeting in Copenhagen in 2009.

The conference approved the agreement over the objections of Bolivia, which condemned the pact as too weak. But those protests did not block its acceptance. Delegates from island states and the least-developed countries warmly welcomed the pact because it would start the flow of billions of dollars to assist them in adopting cleaner energy systems and adapting to inevitable changes in the climate, like sea rise and drought.

But left unresolved was where the promised aid from wealthy nations — \$100 billion in annual climate-related funds — would come from.

The U.S. and Climate Change

The United States has been criticized at the U.N. gatherings for years, in part because of its rejection of the Kyoto framework and in part because it has not adopted a comprehensive domestic program for reducing its own greenhouse gas emissions. President Obama has pledged to reduce American emissions 17 percent below 2005 levels by 2020, but his preferred approach, a nationwide [cap-and-trade](#) system for carbon pollution, was passed by the House in 2009 but died in the Senate the next year. United States emissions are down about 6 percent over the past five years, largely because of the drop in industrial and electricity production caused by the [recession](#).

In January 2011, the [Environmental Protection Agency](#) began [imposing regulations related to greenhouse gas emissions](#). The immediate effect on utilities, refiners and major manufacturers was minor, with the new rules applying only to those planning to build large new facilities or make major modifications to existing plants. Over the next decade, however, the agency plans to regulate virtually all sources of greenhouse gases, imposing efficiency and emissions requirements on nearly every industry and every region.

The E.U. Gets Tough With Airline Emissions

In December 2011, the [European Union](#)'s highest court [endorsed the bloc's plan to begin charging the world's biggest airlines for their greenhouse gas emissions from Jan. 1, 2012](#), setting the stage for a potentially costly trade war with the United States, China and other countries.

A group of United States airlines had argued that forcing them to participate in the potentially costly emissions-trading system infringed on national sovereignty and conflicted with existing international aviation treaties.

But in [a final ruling](#), the [European Court of Justice](#) in Luxembourg affirmed an opinion issued in October by its advocate general, who had rejected their claim.

The court's decision came amid increasing pressure from some of the biggest trading partners of the 27-member bloc to suspend or amend application of the legislation to expressly exclude non-E.U. countries — at least initially. Failing that, several governments have vowed to take their own legal action or retaliate with countervailing trade measures.

Although airlines initially will receive most of the permits they will need for free, the European Union estimates that ticket prices could rise by as much as €12, or nearly \$16, on some long-haul flights to cover the cost of additional permits required.

Airlines for America, an industry lobby group and one of the plaintiffs in the case, said that its members would be required to pay more than \$3.1 billion to the E.U. between 2012 and 2020. It said its members would comply with the system “under protest,” but would also review options for pursuing the case in Britain's High Court, which had referred the original complaint to the European court in 2009.

The European initiative involves folding aviation into the Union's six-year-old Emissions Trading System, in which polluters can buy and sell a limited quantity of permits, each representing a ton of carbon dioxide. The legislation mandates that airlines account for their emissions for the entirety of any flight that takes off from — or lands at — any airport in the 27-member bloc.

The goal, European officials have said, is to speed up the adoption of greener technologies at a time when air traffic, which represents about 3 percent of global carbon dioxide emissions, is growing much faster than gains in efficiency.

Steps Toward a Response

The debate over climate questions pales next to the fight over what to do, or not do, in a world where fossil fuels still underpin both rich and emerging economies.

With the completion of the [United Nations Framework Convention on Climate Change](#) at the Earth Summit in 1992, the world's nations pledged to avoid dangerously disrupting the climate through the buildup of greenhouse gases, but they never defined [how much warming was too much](#).

Nonetheless, recognizing that the original climate treaty was proving ineffective, all of the world's industrialized countries except for the United States accepted binding restrictions on their greenhouse gas emissions under [the Kyoto Protocol](#), which was negotiated in Japan in 1997. That accord took effect in 2005 and its gas restrictions expire in 2012. The United States signed the treaty, but it was never submitted for ratification in the face of overwhelming opposition in the Senate because the pact required no steps by China or other fast-growing developing countries.

It took until 2009 for the leaders of the world's largest economic powers to agree on a [dangerous climate threshold](#): an increase of 2 degrees Celsius (3.6 degrees Fahrenheit) from the average global temperature recorded just before the Industrial Revolution kicked into gear. (This translates into an increase of 1.3 degrees Fahrenheit above the Earth's current average temperature, about 59 degrees.)

The Group of 8 industrial powers also agreed in 2009 to a [goal of reducing global emissions 50 percent by 2050](#), with the richest countries leading the way by cutting their emissions 80 percent. But they did not set a baseline from which to measure that reduction, and so far firm interim targets — which many climate scientists say would be more meaningful — have not been defined.

At the same time, fast-growing emerging economic powerhouses, led by China and India, opposed taking on mandatory obligations to curb their emissions. They said they will do what they can to rein in growth in emissions — as long as their economies do not suffer.

In many ways, the debate over global climate policy is a result of a [global “climate divide.”](#) Emissions of carbon dioxide per person range from less than 2 tons per year in India, where 400 million people lack access to electricity, to more than 20 in the United States. The richest countries are also best able to use wealth and technology to insulate themselves from climate hazards, while the poorest, which have done the least to cause the problem, are the most exposed.

Background

Scientists learned long ago that the earth's climate has powerfully shaped the history of the human species — biologically, culturally and geographically. But only in the last few decades has research revealed that [humans can be a powerful influence](#) on the climate, as well.

A growing body of scientific evidence indicates that since 1950, the world's climate has been warming, primarily as a result of emissions from unfettered burning of fossil fuels and the razing of tropical forests. Such activity adds to the atmosphere's invisible blanket of carbon dioxide and other heat-trapping “greenhouse” gases. Recent research has shown that methane, which flows from landfills, livestock and oil and gas facilities, [is a close second to carbon dioxide as an impact](#) on the atmosphere.

That conclusion has emerged through a broad body of analysis in fields as disparate as glaciology, the study of glacial formations, and palynology, the study of the distribution of pollen grains in lake mud. It is based on a host of assessments by the world's leading [organizations of climate and earth scientists](#).

In the last several years, the scientific case that the rising human influence on climate could become disruptive has become particularly robust.

[Some fluctuations in the earth's temperature](#) are inevitable regardless of human activity — because of decades-long ocean cycles, for example. But centuries of rising temperatures and seas

lie ahead if the release of emissions from the burning of fossil fuels and deforestation continues unabated, according to the [Intergovernmental Panel on Climate Change](#), a group that shared the [2007 Nobel Peace Prize](#) with former Vice President Al Gore.

In addition, a report released by the I.P.C.C. in November 2011 predicted that global warming will cause more dangerous and “unprecedented extreme weather” in the future.

Despite the scientific consensus on these basic conclusions, enormously important details remain murky. That reality has been seized upon by some groups and scientists disputing the overall consensus and opposing changes in energy policies.

For example, estimates of the amount of warming that would result from a doubling of greenhouse gas concentrations (compared to the level just before the Industrial Revolution got under way in the early 19th century) range from 3.6 degrees to 8 degrees Fahrenheit. The intergovernmental climate panel said it could not rule out even higher temperatures. While the low end could probably be tolerated, the high end would almost certainly result in calamitous, long-lasting disruptions of ecosystems and economies, a host of studies have concluded. A wide range of [economists](#) and [earth scientists](#) say that level of risk justifies an aggressive response.

Other questions have persisted despite a [century-long accumulation of studies](#) pointing to human-driven warming. The rate and extent at which sea levels will rise in this century as ice sheets erode remains highly uncertain, even as the long-term forecast of [centuries of retreating shorelines](#) remains intact. Scientists are struggling more than ever to disentangle how the heat building in the seas and atmosphere will affect [the strength and number of tropical cyclones](#). The latest science suggests there will be more hurricanes and typhoons that reach the most dangerous categories of intensity, but [fewer storms overall](#).

Is shrub growth adding to climate change in the Arctic?

By Richard A. Lovett

UNION-TRIBUNE

October 5, 2005

In 1999, Matthew Sturm of the U.S. Army Cold Regions Research and Engineering Laboratory in Alaska discovered a stack of Cold War-era reconnaissance photos of Alaska's North Slope, about to be discarded by his agency's Anchorage office.

- [Longer summers are seen in the north](#)

Sturm had them shipped to Fairbanks and gave them to Kenneth Tape, a graduate student at the University of Alaska. The photos were eye-catching partly because they were huge: 9-by-18-inch prints taken with a 100-pound camera. But they were also keys to understanding how the Arctic landscape has changed in the years since they were made.

On the North Slope, there are no hurricanes, fires, glacial advances and retreats, or other disturbances that might cause plant communities to shift over time. That meant that any changes in the vegetation couldn't simply be due to regrowth on previously disturbed land. They had to be due to something else operating on a large scale, presumably climate.

To determine just what had changed, Tape's team equipped an airplane and set out to duplicate 200 of the 5,000 old prints. What they found was stunning: More than 185 of the locations had become noticeably brushier. The North Slope was still largely ground-hugging tundra, but shrubs such as willow, alder and dwarf birch had, on average, expanded their range by 39 percent.

"As the shrubs increase, lichens and herbs are losing out," Tape said, at last fall's meeting of the American Geophysical Union in San Francisco.

That's significant because caribou eat the smaller plants, while shrubs draw moose. The change appears to be happening so quickly that the local languages have barely had time to adapt. "The word for moose in the Inuit language is essentially 'big caribou,' " Tape says.

But the spread of shrubs may be doing a lot more than simply shifting wildlife habitat. It may also be helping to speed the process of Arctic warming by altering snow cover and changing the region's albedo. Albedo is simply a scientific measure of the terrain's brightness: Technically, it is the fraction of sunlight that is reflected back into space. "People go to ski areas and put on sunglasses for the very fact that the albedo is high," says Sturm. "But typically you don't see them reaching for sunglasses in a grassy field." But albedo does more than simply affect brightness. Low-albedo surfaces get warm faster in the sun than high albedo ones. That's why dark pavement gets hot on summer days. Previous studies have found that taller, leafier plants tend to be darker, reducing albedo by about 25 percent, and significantly increasing the amount of solar heating. But the most recent research shows that shrubs have an even larger effect in the winter. In the Sierra Nevada, shrubs are too deeply buried under the snow to affect the albedo. But Arctic snow rarely piles more than waist deep and is often shallower. Thus, while short tundra plants spend most of the long Arctic winter buried in a white blanket, the upper branches of shrubs rise above the snow. And because these branches are dark, they can reduce the albedo by as much as 75 percent, Sturm said.

Sturm's team rigged trolleylike cables to carry an albedo meter across plots of natural vegetation near Nome, Alaska. The research site was in a transition zone between forest and tundra, where all types of vegetation lay close enough together for all the plots to experience the same winter weather.



U.S. Navy

This Cold War-era photo from the late 1940s shows tundra with typical low-growing mosses and lichen near the Noatak River in northwest Alaska.



KENNETH TAPE

The same area by the late 1990s had been transformed into a brushier landscape of alder, willow and birch shrubs. Increased shrubbery appears to be contributing even more to Arctic warming, by altering snow cover and melting permafrost.

Small shrubs didn't affect the albedo, Sturm discovered, because, like tundra, they were buried by snow. "But at some point, they get stiff and tall enough that instead of a beautiful, white snowfield, you get branches sticking up," he says.

When the study first came out in the Sept. 7 issue of the *Journal of Geophysical Research-Biogeosciences*, it was criticized by people who pointed out that during the heart of the Arctic winter, there's not enough daylight for the albedo to matter. But Sturm's only oversight was in not reminding people that the Arctic winter isn't limited to the 24-hour darkness of December and January.

"I've spent much of my life in the winter working with a headlamp," he laughs. "If anyone would know it's dark in the high north, it's me!"

What matters, he says, are the "swing" seasons of fall and spring. "They are very sunny."

In fact, during the course of taking albedo measurements, Sturm discovered that in the spring, melting began several weeks earlier in shrubby regions than in unbroken tundra. "And you notice things like warm branches breaking out of the snow on a hot day," he says.

[Graphic: Climate changes in the Arctic](#)

On the other hand, the same sun-warmed branches shaded the last remnants of the snow beneath them. The result was that while melting started earlier in shrubby areas, the last of the snow melted at the same time as in open terrain. Another surprise was that the dark branches of shrubs reduce the albedo by nearly two-thirds as much as the dark boughs of trees.

That's an important discovery, Sturm says, because shrubs can invade large tracts of land in the course of a few decades, while forests take much longer to expand their range. "So, through a simple growth of shrubs, we can have a profound impact on Arctic climate, just by darkening the landscape," he says.

Feedback effect

It also appears to be a self-perpetuating effect because, by warming the winter climate, the shrubs appear to be creating conditions conducive for even more explosive growth in the future. Sturm's study did not measure the amount by which the albedo effect elevates local temperatures, but he estimates that it is probably on the order of a couple of degrees centigrade.

In addition, shrubs trap snowdrifts that insulate their roots from the bitterest cold of the dark midwinter months.

Other researchers applaud the study for providing increased understanding of how global warming is affecting the Arctic. "It's really valuable information for the modelers," says Steve Hastings, an ecologist at San Diego State University. Real-life field data, he says, makes it possible to fine-tune climate models, allowing what were once little more than guesses to better zero in more precisely on what the future may hold.

The biggest concern among climate modelers is how changes in the Arctic are affecting the amount of carbon dioxide in the atmosphere.

For thousands of years, plants have been growing and dying in the Arctic, with their remains settling into the soil. Instead of decomposing and releasing carbon dioxide back into the air, these remains have accumulated as a huge store of peat, locked in the Arctic permafrost.

Were it not for the albedo effect, the jury would still be out on whether shrubs contribute to permafrost melting. Their tendency to create snowdrifts insulates the ground from the deepest cold and prevents it from freezing as deeply as might otherwise be the case. But they also shade the ground in the summer, reducing the impact of solar heating.

It is unclear which of these two factors is stronger, says Frederick Nelson, a geographer at the University of Delaware. But the albedo effect alters the balance by warming large tracts of lands. That contributes to the ongoing warming of the Arctic, speeding the rate at which the permafrost is melting. Permafrost melting is a problem to Arctic residents because it causes land subsidence, ruining roads and buildings. But, in a disturbingly self-perpetuating process, permafrost melting may also contribute to further warming. That's because it exposes increasing quantities of that stored peat to bacterial decomposition that might release huge quantities of carbon dioxide to the atmosphere.

"Historically, the Arctic has been a carbon sink, taking in more carbon than it's releasing and storing it in the deep freeze for 7,000 years," says Hastings. The present warming trend is akin to "pulling the plug" on the freezer. "All of that stuff is melting and decomposing," Hastings says.

CO2 threshold

Of course, it's not quite that simple. The summers of 1995 and 1996 were two of the warmest on record, but instead of releasing carbon dioxide, the Arctic temporarily went back to storing it. The reason, Hastings hypothesizes, is that the decomposition of plant matter from melted permafrost releases more than carbon dioxide: It also releases nutrients such as nitrogen and phosphorous. Temporarily, a spike in these nutrients fuels rampant plant growth, which pulls more carbon dioxide out of the air than decomposition is putting into it.

But, while this might repeat again in the future, it appears to be a temporary phenomenon. For the next few decades, most researchers expect that the Arctic will release more carbon dioxide than plant growth absorbs.

Meanwhile, human releases of carbon dioxide could also increase. "It's not going to be long before China is going to start producing every bit as much carbon dioxide per person as we do," Hastings says. "We need to look at this as a scientific question and try the best we can to put political viewpoints aside."

What the recent findings about shrubs contribute to the "scientific question" is a demonstration that, at least in the Arctic, changes can occur quickly, with self-perpetuating feedbacks that can quickly accelerate. "You shouldn't think of systems as moving on trajectories that are nice and smooth," Sturm says. "These systems almost always have thresholds."

In the case of his study, he notes, "As soon as shrubs get big enough to poke above the snow, they begin to change the winter environment in ways that change it even more."

The real question is whether these changes will be slow or explosive. "Our study indicates the

latter," Sturm says.

■Richard A. Lovett is a freelance writer based in Portland, Ore.

Farewell to the Arctic — as We Know It

By [Bryan Walsh](#) Tuesday, Sept. 27, 2011

Time. Science. Read more:

<http://www.time.com/time/health/article/0,8599,2095114,00.html#ixzz1kPhfnRe>



Polar bears near the Norwegian island of Spitsbergen, which borders the Arctic Ocean

Keren Su / Corbis

If you want to witness climate change, just head north — and keep going until you run out of globe. Of course, that's easier said than done; the Arctic is a forbidding, isolated area, short of people and encased in ice much of the year. But those who make their way to places like Barrow, Ala. — the northernmost point of the U.S. — or the icy seas of the Arctic Ocean will witness a part of the planet that is warming and changing faster than anywhere else. While the world as a whole warmed by about 1°F (.55°C) over the entire 20th century, parts of the Arctic have warmed by 4° to 5°F (2.2° to 2.7°C) just since 1950. The physical changes from global warming are visible in the Arctic almost in real time — and they are a warning for those of us who live in more comfortable latitudes. As the polar expert Walt Meier of the National Snow and Ice Data Center (NSIDC) has put it: "What happens in the Arctic doesn't stay in the Arctic."

That's bad news, since not only is the warming threat in the Arctic bad, it's almost certainly intensifying. Earlier this month scientists at the NSIDC announced that Arctic summer sea-ice extent had fallen to its second lowest level since at least 1979, and likely long before that. Just 1.67 million sq. mi. (4.32 million sq km) of the Arctic sea was covered by ice as of mid-September — a little larger than the all-time record low of 1.608 million sq. mi. (4.16 million sq km) set in September 2007. And that may be a lowball figure: a separate group of researchers at the University of Bremen in Germany did their own estimate earlier this month and reported that there was even more melt in 2011 than in 2007. ([See pictures of the effects of global warming.](#))

The differences between the two estimates are academic; the larger point is that the current sea-ice extent is more than 1 million sq. mi. (2.5 million sq km) below the 1979–2000 average. That means the Arctic has lost an area greater than all the U.S. states east of the Mississippi. And what ice remains appears to be getting thinner and weaker as well. "There is plentiful data to suggest that the ice is thinning as well as shrinking in area," Nick Toberg and Till Wagner, polar-ocean physicists from Cambridge University, wrote to me recently in an e-mail from the Greenpeace ship *Arctic Sunrise*, where they were doing sea-ice fieldwork north of Norway. "It's a downward spiral because after successive seasons of thinner ice, each [year] gets worse than the one before it."

The question now is what's going to happen to the Arctic as we keep adding carbon emissions to the atmosphere and the climate keeps warming. Some scientists worry that Arctic sea ice may be going from a downward spiral to a "death spiral," one from which there is no escape even if we can manage to reduce carbon emissions. As more ice melts, more dark open water is exposed, which absorbs more heat, accelerating the melting. (White sea ice, by contrast, reflects sunlight, slowing warming.) Until recently, many scientists thought it might take until the end of the century for the North Pole to become completely ice-free during the summer. Now there are estimates that we could see a naked North Pole by 2030 or even earlier. "The melting is happening faster in the real world than it has in the models," says James Overland, an oceanographer for the National Oceanic and Atmospheric Administration.[\(See photos of the Arctic.\)](#)

That's why doing fieldwork on Arctic sea ice is so important. Models and satellite data can only take you so far. For full accuracy, someone actually has to go to the far north and measure. On their research trip, Toberg and Wagner went to the north Greenland Sea and measured sea-ice thickness at multiple sites using power drills, snow-depth measurements and GPS readings. "Drilling is still the most accurate, and only direct way, of measuring thickness of the ice," they wrote. "This involves simply poking a tape measure down a hole drilling in the ice to note both the total depth of the ice and the thickness of the freeboard [the ice above the water line]." The work is basic science at its best.

But it's not all that simple. Toberg and Wagner are also working with laser 3-D scanners that enable them to capture a high-resolution replica of an ice floe — essentially allowing them to take the ice back to the lab, something that would otherwise be impossible without the help of a very large refrigerator. That data gives them a much deeper understanding of what's happening to Arctic ice, a big improvement over what you can get from satellites, which struggle to measure ice below the water level. (And as anyone who watched *Titanic* knows, that's where most of the ice hides.) "Snow cover, surface meltwater and the high variability in ice properties hide the full picture of what is happening with the ice under the sea," write Toberg and Wagner. "The information we gather can help verify satellite data and ultimately improve the accuracy of complex computer models."[\(See TIME's special report on the world's endangered species.\)](#)

The more on-the-ground information scientists can gather the better because ice, despite its seeming simplicity, is extremely complex. The rate of melting in the Arctic isn't just a function of temperature change; local weather conditions, snow cover and ocean currents can also influence ice loss. That's what makes it so difficult to predict exactly how rapidly we might see

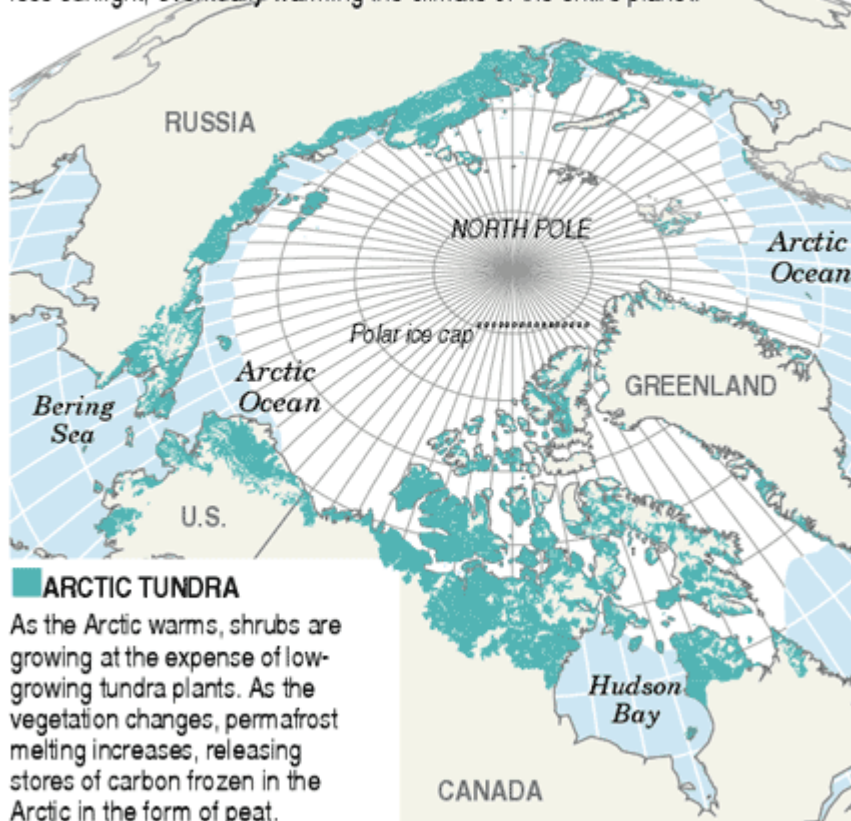
the Arctic go ice-free. Scientists at the National Center for Atmospheric Research even predicted in a recent study that Arctic sea-ice melt might pause or reverse over the next decade, depending on northern-wind patterns. But that would simply be a pause in the inexorable decline — inexorable, that is, if we don't curb carbon emissions soon. At that point, Arctic ice becomes a memory, and we will find ourselves on a very different planet.

[Read about the melting Arctic ice.](#)

[Read about an Arctic mystery in Alaska.](#)

Climate changes in the Arctic

Arctic tundra found across northern Alaska, Canada and Siberia controls much of the earth's heat balance. Highly reflective snow cover reflects sunlight back into space. But if the cover melts, it will reflect less sunlight, eventually warming the climate of the entire planet.



SOURCE: Alaska Geobotany Center

SHAFFER GRUBB / Union-Tribune

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HEADLINE: Polar Ice Caps Are Melting Faster Than Ever... More And More;
Land Is Being Devastated By Drought... Rising Waters Are Drowning Low-Lying
Communities... By Any Measure, Earth Is At ... The Tipping Point The climate is crashing, and
global warming is to blame. Why the crisis hit so soon--and what we can do about it

BYLINE: Jeffrey Kluger; With reporting by David Bjerklie; Andrea Dorfman/; New York;
Dan Cray/ Los Angeles; Greg Fulton/ Atlanta; Andrea; Gerlin/ London; Rita Healy/ Denver;
Eric Roston/ Washington

BODY:

No one can say exactly what it looks like when a planet takes ill, but it probably looks a lot like Earth. Never mind what you've heard about **global warming** as a slow-motion emergency that would take decades to play out. Suddenly and unexpectedly, the crisis is upon us.

It certainly looked that way last week as the atmospheric bomb that was Cyclone Larry--a Category 5 storm with wind bursts that reached 180 m.p.h.--exploded through northeastern Australia. It certainly looked that way last year as curtains of fire and dust turned the skies of Indonesia orange, thanks to drought-fueled blazes sweeping the island nation. It certainly looks that way as sections of ice the size of small states calve from the disintegrating Arctic and Antarctic. And it certainly looks that way as the sodden wreckage of New Orleans continues to mold, while the waters of the Atlantic gather themselves for a new hurricane season just two months away. Disasters have always been with us and surely always will be. But when they hit this hard and come this fast--when the emergency becomes commonplace--something has gone grievously wrong. That something is **global warming**.

The image of Earth as organism--famously dubbed Gaia by environmentalist James Lovelock--has probably been overworked, but that's not to say the planet can't behave like a living thing, and these days, it's a living thing fighting a fever. From heat waves to storms to floods to fires to massive glacial melts, the global climate seems to be crashing around us. Scientists have been calling this shot for decades. This is precisely what they have been warning would happen if we continued pumping greenhouse gases into the atmosphere, trapping the heat that flows in from the sun and raising global temperatures.

Environmentalists and lawmakers spent years shouting at one another about whether the grim forecasts were true, but in the past five years or so, the serious debate has quietly ended. Global warming, even most skeptics have concluded, is the real deal, and human activity has been causing it. If there was any consolation, it was that the glacial pace of nature would give us decades or even centuries to sort out the problem.

But glaciers, it turns out, can move with surprising speed, and so can nature. What few people

reckoned on was that global climate systems are booby-trapped with tipping points and feedback loops, thresholds past which the slow creep of environmental decay gives way to sudden and self-perpetuating collapse. Pump enough CO₂ into the sky, and that last part per million of greenhouse gas behaves like the 212th degree Fahrenheit that turns a pot of hot water into a plume of billowing steam. Melt enough Greenland ice, and you reach the point at which you're not simply dripping meltwater into the sea but dumping whole glaciers. By one recent measure, several Greenland ice sheets have doubled their rate of slide, and just last week the journal *Science* published a study suggesting that by the end of the century, the world could be locked in to an eventual rise in sea levels of as much as 20 ft. Nature, it seems, has finally got a bellyful of us.

"Things are happening a lot faster than anyone predicted," says Bill Chameides, chief scientist for the advocacy group Environmental Defense and a former professor of atmospheric chemistry. "The last 12 months have been alarming." Adds Ruth Curry of the Woods Hole Oceanographic Institution in Massachusetts: "The ripple through the scientific community is palpable."

And it's not just scientists who are taking notice. Even as nature crosses its tipping points, the public seems to have reached its own. For years, popular skepticism about climatological science stood in the way of addressing the problem, but the naysayers--many of whom were on the payroll of energy companies--have become an increasingly marginalized breed. In a new *TIME*/ABC News/Stanford University poll, 85% of respondents agree that global warming probably is happening. Moreover, most respondents say they want some action taken. Of those polled, 87% believe the government should either encourage or require lowering of power-plant emissions, and 85% think something should be done to get cars to use less gasoline. Even Evangelical Christians, once one of the most reliable columns in the conservative base, are demanding action, most notably in February, when 86 Christian leaders formed the Evangelical Climate Initiative, demanding that Congress regulate greenhouse gases.

A collection of new global-warming books is hitting the shelves in response to that awakening interest, followed closely by TV and theatrical documentaries. The most notable of them is *An Inconvenient Truth*, due out in May, a profile of former Vice President Al Gore and his climate-change work, which is generating a lot of prerelease buzz over an unlikely topic and an equally unlikely star. For all its lack of Hollywood flash, the film compensates by conveying both the hard science of global warming and Gore's particular passion.

Such public stirrings are at last getting the attention of politicians and business leaders, who may not always respond to science but have a keen nose for where votes and profits lie. State and local lawmakers have started taking action to curb emissions, and major corporations are doing the same. Wal-Mart has begun installing wind turbines on its stores to generate electricity and is talking about putting solar reflectors over its parking lots. HSBC, the world's second largest bank, has pledged to neutralize its carbon output by investing in wind farms and other green projects. Even President Bush, hardly a favorite of greens, now acknowledges climate change and boasts of the steps he is taking to fight it. Most of those steps, however, involve research and voluntary emissions controls, not exactly the laws with teeth scientists are calling for.

Is it too late to reverse the changes global warming has wrought? That's still not clear. Reducing our emissions output year to year is hard enough. Getting it low enough so that the atmosphere can heal is a multigenerational commitment. "Ecosystems are usually able to maintain themselves," says Terry Chapin, a biologist and professor of ecology at the University of Alaska, Fairbanks. "But eventually they get pushed to the limit of tolerance."

CO2 AND THE POLES

As a tiny component of our atmosphere, carbon dioxide helped warm Earth to comfort levels we are all used to. But too much of it does an awful lot of damage. The gas represents just a few hundred parts per million (p.p.m.) in the overall air blanket, but they're powerful parts because they allow sunlight to stream in but prevent much of the heat from radiating back out. During the last ice age, the atmosphere's CO2 concentration was just 180 p.p.m., putting Earth into a deep freeze. After the glaciers retreated but before the dawn of the modern era, the total had risen to a comfortable 280 p.p.m. In just the past century and a half, we have pushed the level to 381 p.p.m., and we're feeling the effects. Of the 20 hottest years on record, 19 occurred in the 1980s or later. According to NASA scientists, 2005 was one of the hottest years in more than a century.

It's at the North and South poles that those steambath conditions are felt particularly acutely, with glaciers and ice caps crumbling to slush. Once the thaw begins, a number of mechanisms kick in to keep it going. Greenland is a vivid example. Late last year, glaciologist Eric Rignot of the Jet Propulsion Laboratory in Pasadena, Calif., and Pannir Kanagaratnam, a research assistant professor at the University of Kansas, analyzed data from Canadian and European satellites and found that Greenland ice is not just melting but doing so more than twice as fast, with 53 cu. mi. draining away into the sea last year alone, compared with 22 cu. mi. in 1996. A cubic mile of water is about five times the amount Los Angeles uses in a year.

Dumping that much water into the ocean is a very dangerous thing. Icebergs don't raise sea levels when they melt because they're floating, which means they have displaced all the water they're ever going to. But ice on land, like Greenland's, is a different matter. Pour that into oceans that are already rising (because warm water expands), and you deluge shorelines. By some estimates, the entire Greenland ice sheet would be enough to raise global sea levels 23 ft., swallowing up large parts of coastal Florida and most of Bangladesh. The Antarctic holds enough ice to raise sea levels more than 215 ft.

FEEDBACK LOOPS

One of the reasons the loss of the planet's ice cover is accelerating is that as the poles' bright white surface shrinks, it changes the relationship of Earth and the sun. Polar ice is so reflective that 90% of the sunlight that strikes it simply bounces back into space, taking much of its energy with it. Ocean water does just the opposite, absorbing 90% of the energy it receives. The more energy it retains, the warmer it gets, with the result that each mile of ice that melts vanishes faster than the mile that preceded it.

That is what scientists call a feedback loop, and it's a nasty one, since once you uncap the Arctic Ocean, you unleash another beast: the comparatively warm layer of water about 600 ft.

deep that circulates in and out of the Atlantic. "Remove the ice," says Woods Hole's Curry, "and the water starts talking to the atmosphere, releasing its heat. This is not a good thing."

A similar feedback loop is melting permafrost, usually defined as land that has been continuously frozen for two years or more. There's a lot of earthly real estate that qualifies, and much of it has been frozen much longer than two years--since the end of the last ice age, or at least 8,000 years ago. Sealed inside that cryonic time capsule are layers of partially decayed organic matter, rich in carbon. In high-altitude regions of Alaska, Canada and Siberia, the soil is warming and decomposing, releasing gases that will turn into methane and CO₂. That, in turn, could lead to more warming and permafrost thaw, says research scientist David Lawrence of the National Center for Atmospheric Research (NCAR) in Boulder, Colo. And how much carbon is socked away in Arctic soils? Lawrence puts the figure at 200 gigatons to 800 gigatons. The total human carbon output is only 7 gigatons a year.

One result of all that is warmer oceans, and a result of warmer oceans can be, paradoxically, colder continents within a hotter globe. Ocean currents running between warm and cold regions serve as natural thermoregulators, distributing heat from the equator toward the poles. The Gulf Stream, carrying warmth up from the tropics, is what keeps Europe's climate relatively mild. Whenever Europe is cut off from the Gulf Stream, temperatures plummet. At the end of the last ice age, the warm current was temporarily blocked, and temperatures in Europe fell as much as 10°F, locking the continent in glaciers.

What usually keeps the Gulf Stream running is that warm water is lighter than cold water, so it floats on the surface. As it reaches Europe and releases its heat, the current grows denser and sinks, flowing back to the south and crossing under the northbound Gulf Stream until it reaches the tropics and starts to warm again. The cycle works splendidly, provided the water remains salty enough. But if it becomes diluted by freshwater, the salt concentration drops, and the water gets lighter, idling on top and stalling the current. Last December, researchers associated with Britain's National Oceanography Center reported that one component of the system that drives the Gulf Stream has slowed about 30% since 1957. It's the increased release of Arctic and Greenland meltwater that appears to be causing the problem, introducing a gush of freshwater that's overwhelming the natural cycle. In a global-warming world, it's unlikely that any amount of cooling that resulted from this would be sufficient to support glaciers, but it could make things awfully uncomfortable.

"The big worry is that the whole climate of Europe will change," says Adrian Luckman, senior lecturer in geography at the University of Wales, Swansea. "We in the U.K. are on the same latitude as Alaska. The reason we can live here is the Gulf Stream."

DROUGHT

As fast as global warming is transforming the oceans and the ice caps, it's having an even more immediate effect on land. People, animals and plants living in dry, mountainous regions like the western U.S. make it through summer thanks to snowpack that collects on peaks all winter and slowly melts off in warm months. Lately the early arrival of spring and the unusually blistering summers have caused the snowpack to melt too early, so that by the time it's needed, it's largely gone. Climatologist Philip Mote of the University of Washington has compared

decades of snowpack levels in Washington, Oregon and California and found that they are a fraction of what they were in the 1940s, and some snowpacks have vanished entirely.

Global warming is tipping other regions of the world into drought in different ways. Higher temperatures bake moisture out of soil faster, causing dry regions that live at the margins to cross the line into full-blown crisis. Meanwhile, El Niño events--the warm pooling of Pacific waters that periodically drives worldwide climate patterns and has been occurring more frequently in global-warming years--further inhibit precipitation in dry areas of Africa and East Asia. According to a recent study by NCAR, the percentage of Earth's surface suffering drought has more than doubled since the 1970s.

FLORA AND FAUNA

Hot, dry land can be murder on flora and fauna, and both are taking a bad hit. Wildfires in such regions as Indonesia, the western U.S. and even inland Alaska have been increasing as timberlands and forest floors grow more parched. The blazes create a feedback loop of their own, pouring more carbon into the atmosphere and reducing the number of trees, which inhale CO₂ and release oxygen.

Those forests that don't succumb to fire die in other, slower ways. Connie Millar, a paleoecologist for the U.S. Forest Service, studies the history of vegetation in the Sierra Nevada. Over the past 100 years, she has found, the forests have shifted their tree lines as much as 100 ft. upslope, trying to escape the heat and drought of the lowlands. Such slow-motion evacuation may seem like a sensible strategy, but when you're on a mountain, you can go only so far before you run out of room. "Sometimes we say the trees are going to heaven because they're walking off the mountaintops," Millar says.

Across North America, warming-related changes are mowing down other flora too. Manzanita bushes in the West are dying back; some prickly pear cacti have lost their signature green and are instead a sickly pink; pine beetles in western Canada and the U.S. are chewing their way through tens of millions of acres of forest, thanks to warmer winters. The beetles may even breach the once insurmountable Rocky Mountain divide, opening up a path into the rich timbering lands of the American Southeast.

With habitats crashing, animals that live there are succumbing too. Environmental groups can tick off scores of species that have been determined to be at risk as a result of global warming. Last year, researchers in Costa Rica announced that two-thirds of 110 species of colorful harlequin frogs have vanished in the past 30 years, with the severity of each season's die-off following in lockstep with the severity of that year's warming.

In Alaska, salmon populations are at risk as melting permafrost pours mud into rivers, burying the gravel the fish need for spawning. Small animals such as bushy-tailed wood rats, alpine chipmunks and piñon mice are being chased upslope by rising temperatures, following the path of the fleeing trees. And with sea ice vanishing, polar bears--prodigious swimmers but not inexhaustible ones--are starting to turn up drowned. "There will be no polar ice by 2060," says Larry Schweiger, president of the National Wildlife Federation. "Somewhere along that path, the polar bear drops out."

WHAT ABOUT US?

It is fitting, perhaps, that as the species causing all the problems, we're suffering the destruction of our habitat too, and we have experienced that loss in terrible ways. Ocean waters have warmed by a full degree Fahrenheit since 1970, and warmer water is like rocket fuel for typhoons and hurricanes. Two studies last year found that in the past 35 years the number of Category 4 and 5 hurricanes worldwide has doubled while the wind speed and duration of all hurricanes has jumped 50%. Since atmospheric heat is not choosy about the water it warms, tropical storms could start turning up in some decidedly nontropical places. "There's a school of thought that sea surface temperatures are warming up toward Canada," says Greg Holland, senior scientist for NCAR in Boulder. "If so, you're likely to get tropical cyclones there, but we honestly don't know."

WHAT WE CAN DO

So much for environmental collapse happening in so many places at once has at last awakened much of the world, particularly the 141 nations that have ratified the Kyoto treaty to reduce emissions--an imperfect accord, to be sure, but an accord all the same. The U.S., however, which is home to less than 5% of Earth's population but produces 25% of CO2 emissions, remains intransigent. Many environmentalists declared the Bush Administration hopeless from the start, and while that may have been premature, it's undeniable that the White House's environmental record--from the abandonment of Kyoto to the President's broken campaign pledge to control carbon output to the relaxation of emission standards--has been dismal. George W. Bush's recent rhetorical nods to America's oil addiction and his praise of such alternative fuel sources as switchgrass have yet to be followed by real initiatives.

The anger surrounding all that exploded recently when NASA researcher Jim Hansen, director of the Goddard Institute for Space Studies and a longtime leader in climate-change research, complained that he had been harassed by White House appointees as he tried to sound the global-warming alarm. "The way democracy is supposed to work, the presumption is that the public is well informed," he told TIME. "They're trying to deny the science." Up against such resistance, many environmental groups have resolved simply to wait out this Administration and hope for something better in 2009.

The Republican-dominated Congress has not been much more encouraging. Senators John McCain and Joe Lieberman have twice been unable to get through the Senate even mild measures to limit carbon. Senators Pete Domenici and Jeff Bingaman, both of New Mexico and both ranking members of the chamber's Energy Committee, have made global warming a high-profile matter. A white paper issued in February will be the subject of an investigatory Senate conference next week. A House delegation recently traveled to Antarctica, Australia and New Zealand to visit researchers studying climate change. "Of the 10 of us, only three were believers," says Representative Sherwood Boehlert of New York. "Every one of the others said this opened their eyes."

Boehlert himself has long fought the environmental fight, but if the best that can be said for most lawmakers is that they are finally recognizing the global-warming problem, there's reason

to wonder whether they will have the courage to reverse it. Increasingly, state and local governments are filling the void. The mayors of more than 200 cities have signed the U.S. Mayors Climate Protection Agreement, pledging, among other things, that they will meet the Kyoto goal of reducing greenhouse-gas emissions in their cities to 1990 levels by 2012. Nine eastern states have established the Regional Greenhouse Gas Initiative for the purpose of developing a cap-and-trade program that would set ceilings on industrial emissions and allow companies that over perform to sell pollution credits to those that underperform-- the same smart, incentive-based strategy that got sulfur dioxide under control and reduced acid rain. And California passed the nation's toughest automobile- emissions law last summer.

"There are a whole series of things that demonstrate that people want to act and want their government to act," says Fred Krupp, president of Environmental Defense. Krupp and others believe that we should probably accept that it's too late to prevent CO2 concentrations from climbing to 450 p.p.m. (or 70 p.p.m. higher than where they are now). From there, however, we should be able to stabilize them and start to dial them back down.

That goal should be attainable. Curbing global warming may be an order of magnitude harder than, say, eradicating smallpox or putting a man on the moon. But is it moral not to try? We did not so much march toward the environmental precipice as drunkenly reel there, snapping at the scientific scolds who told us we had a problem.

The scolds, however, knew what they were talking about. In a solar system crowded with sister worlds that either emerged stillborn like Mercury and Venus or died in infancy like Mars, we're finally coming to appreciate the knife-blade margins within which life can thrive. For more than a century we've been monkeying with those margins. It's long past time we set them right.

BOX STORY:

TIME / ABC NEWS / STANFORD UNIVERSITY POLL SEEING THE PROBLEM, NOT THE SOLUTION MORE PEOPLE THINK THE EARTH IS GETTING WARMER, but they're split on whether humans are the cause Has the world's temperature been going up slowly over the past 100 years? Yes '97 - 76% '98 - 80% '06 - 85% No '97 - 22% '98 - 18% '06 - 13% Is the temperature increase caused mostly by things people do, by natural causes or by both equally? Humans 31% Nature 19% Both 49% MOST PEOPLE AREN'T AWARE OF THE BROAD SCIENTIFIC CONSENSUS on warming. The majority sees it as a problem for future generations

Do you think most scientists agree with one another about global warming, or do you think there is a lot of disagreement on this issue? Most agree - 35% A lot of disagreement - 64% Is global warming ... already a serious problem? 44% ... a problem for the future? 54% Don't know: 2% How much do you think can be done to reduce the amount of future global warming? 60% A great deal - 28% A good amount - 32% 38% Just some - 22% Hardly anything - 16% A STRONG MAJORITY WANTS MORE DONE, but there's little appetite for higher taxes to reduce energy consumption Do you think the Federal Government should do more to try to deal with global warming? Should do more - 68% Should do less - 5% Is doing

the right amount now - 25%

Percentage who favor the following as a way for the government to try to reduce global warming: Increase taxes on electricity so people use less of it - 19% Increase taxes on gasoline so people use less of it - 31% Give companies tax breaks to build nuclear power plants - 41% Give companies tax breaks to develop alternative energy sources - 87% This TIME/ABC News/Stanford University poll was conducted by telephone March 9-14 among 1,002 adult Americans by TNS of Horsham, Pa. The margin of error is 3 percentage points.

Data for 1997 and 1998 are from an Ohio State University poll. "Don't know" responses omitted for some questions.

NOTES: See also additional images in Cover Image file and Table of Contents of same issue. See also 6 related articles on pages 36-61 of same issue.

GRAPHIC: PHOTO: ARCTICNET--NCE AT SEA - In the Canadian high Arctic, a polar bear negotiates what was once solid ice. Bears are drowning as warmer waters widen the distance from floe to floe; PHOTO: BOBBY HAAS--NATIONAL GEOGRAPHIC IMAGE COLLECTION MOONSCAPE - Cattle struggle across parched land in Ethiopia. The amount of the earth's surface afflicted by drought has more than doubled since the 1970s; PHOTO: ANUPAM NATH--AP ADRIFT - Banana-leaf rafts save Indian villagers washed out of their homes. Creeping seas and increasingly savage monsoons make for deadlier floods; PHOTO: JULIE SPROTT--ALASKASTOCK KINDLING - Once cool and wet, forests like this in the Yukon are falling victim first to drought, then to fire; PHOTO Then - The South American Andes are crusted with glaciers, and the Upsala Glacier in Argentina is one of the grandest--or it was. In 1928, the ice sprawled before the photographer's lens; PHOTO: GREENPEACE Now - The Upsala Glacier in 2004. The ice is retreating at least 180 ft. per year, and Andean guides now paint hash marks on mountain walls to show where the boundaries used to be

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