Center for American Progress

AP PHOTO/MARK HUMPHREY

Some streets were passable only by boat during the May 2010 flood in Nashville, TN

The Year of Living Dangerously

2010 Extreme Weather Cost Lives, Health, Economy

Daniel J. Weiss, Valeri Vasquez, and Ben Kaldunski April 2011

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"Crash on the levee, mama,
Water's gonna overflow,
Swamp's gonna rise,
No boat's gonna row.

"There's a crash on the levee
And, mama, you've been refused.
Well, it's sugar for sugar
And salt for salt,
If you go down in the flood,
It's gonna be your own fault."

– "Down in the Flood,"
Bob Dylan

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Introduction and summary

Small talk about the weather is an inextricable part of our daily lives but 2010 provided enough extreme weather in the United States to dominate conversations at church picnics, office water coolers, and family dinners, too. It was much worse for those who lived in the places most affected by these events. Last year, unprecedented extreme weather led to a record number of disaster declarations by the Federal Emergency Management Agency. The United States and the world were swept by flooding, severe winter storms, heat waves, droughts, hurricanes, and tornadoes.

The extreme weather of 2010 exacted a huge human and economic toll here as well. More than 380 people died and 1,700 were injured due to weather events throughout the year. And the magnitude of these events forced the Federal Emergency Management Agency, or FEMA, to declare 81 disasters last year. For nearly 60 years, the annual average has been 33. In 2010, total damages exceeded a whopping $6.7 billion. As of April 2011, FEMA had dedicated more than $2 billion in financial assistance to those harmed by extreme weather in 2010.

A February 2011 special report from Reuters noted that it's been rough going for the $500 billion U.S. property insurance business, explaining that "storms are happening in places they never happened before, at intensities they have never reached before and at times of year when they didn't used to happen."

It is precisely this uncertainty "associated with climate change that substantiates the risks to the economy and society," says George Backus, D.Engr., of the Discrete Mathematics and Complex Systems Department at Sandia National Laboratories. This is bad news for a nation just emerging from the grips of the Great Recession. Per Backus, a 2010 report from Sandia estimates that "the climate uncertainty as it pertains to rainfall alone [puts] the U.S. economy is at risk of losing between $600 billion and $2 trillion, and between 4 million and 13 million U.S. jobs over the next 40 years."

Dr. Evan Mills, a scientist in the Environmental Energy Technologies Division at the Lawrence Berkeley National Laboratory confirms that in the United States, "insured weather-related losses in recent years have been trending upward much faster than population, inflation, or insurance penetration, and far outpace losses for non-weather-related events."

It is difficult, of course, to link or "attribute" individual extreme weather events in a single year to global warming. Although the climate system is driven by the law of physics, its daily expression in the form of weather is chaotic. But it is clear that climate factors—including human influences—shape weather patterns. According to Munich Re, one of the world's largest reinsurers, "the only plausible explanation for the rise in weather-related catastrophes is climate change." And as Kevin Trenberth, Sc.D., head of the Climate Analysis Section at the National Center for Atmospheric Research, explained at the American Meteorological Society's January 2011 meeting, "Given that global warming is unequivocal, the null hypothesis should be that all weather events are affected by global warming rather than the inane statements along the lines of 'of course we cannot attribute any particular weather event to global warming.'"

In other words, says Trenberth, "it's not the right question to ask if this storm or that storm is due to global warming, or is it natural variability. Nowadays, there's always an element of both."

Atmospheric concentrations of carbon dioxide and other greenhouse gas pollutants are turning up the heat on our planet. Scientists agree that the string of disastrous weather extremes this past year are the types of severe weather that will become more frequent or ferocious as the planet continues to warm. For instance, in the "first major paper of its kind" tracking global climatic trends from 1951 to 1999, Scottish and Canadian researchers used sophisticated computer models to confirm a human contribution to more intense precipitation extremes with very high confidence.

This analysis is supported by a 2010 Duke University-led study that found, "Global warming is driving increased frequency of extreme wet or dry summer weather in southeast, so droughts and deluges are likely to get worse."

A study published in the 2011 *Journal of Climate* presents "evidence of a significant human influence on the increasing severity of extremely warm nights and decreasing severity of extremely cold days and nights."

Likewise, a report by the National Center for Atmospheric Research, Climate Central, The Weather Channel, and the National Oceanic and Atmospheric Administration shows that "if temperatures were not warming, the number of record daily highs and lows being set each year would be approximately even. Instead … record high temperatures far outpace record lows across the U.S."

Because we have not brought carbon pollution under control, the weather events of 2010 will continue to revisit us—with a vengeance. We must act quickly and unequivocally to address climate change before the threat becomes insurmountable. This includes recognizing that global warming is already affecting us both domestically and internationally.

The purpose of this report is to gather, condense, and synthesize some of the massive amount of data about extreme weather and its links to global warming. This summary of climate science can help provide context to the recent surge in extreme weather events. In this report we will catalogue the extreme U.S. weather in 2010 and then examine the consequences on our health and economy.

As we note in the conclusion, conservatives remain eager to dismiss these weather extremes by claiming they are solely due to natural variability. What's more, the House of Representatives voted to defund federal science programs that gather and analyze the data essential to understand changes in global weather patterns and other climate impacts. But all this denial cannot make this threat disappear.

Global warming and extreme weather

Global temperatures are rising at unnatural rates. Since 1900 the Earth's average temperature has risen by approximately 1.8°F. This increase is apparent in the recent spike of global temperatures: 2010 was the warmest year on record and the top 10 warmest years have all occurred since 1998. The National Oceanic and Atmospheric Administration, or NOAA, issued a "State of the Climate" report declaring the first decade of the 21st century the hottest since global weather records began in 1880. According to the report:

> *Each of the last three decades has been much warmer than the decade before. At the time, the 1980s was the ho est decade on record. In the 1990s, every year was warmer than the average of the previous decade. e 2000s were warmer still.*

Because the rise in greenhouse gas concentrations has not halted, scientists project warming during the current century will be considerably greater—some 10°F if we continue near the current emissions path. Atmospheric concentrations of carbon dioxide, or CO2, approached 390 parts per million, or ppm, in 2010, and on our current course could reach 535 ppm to 983 ppm by 2100.

The future of our planet depends on whether we significantly slow the accumulation of carbon dioxide and other greenhouse gas pollution in our atmosphere. The key to avoiding catastrophe is in our hands—the question is whether we are willing to use it in time.

According to ice core samples, tree rings, and other geological records, CO2 levels have oscillated between approximately 180 ppm during past ice ages and 280 ppm during warmer interglacial periods. NASA scientists estimate that the difference in global mean temperature between the extremes of the ice age and the hottest interglacial period is only about 9°F. This makes the nearly 1.8°F increase in global temperature over the past 100 years very significant and the potential for additional future warming downright frightening. "There is," according to an October 2010 report by Dr. Andrew Lacis of NASA's Goddard Institute for Space Studies,

"no viable alternative to counteract global warming except through direct human effort to reduce the atmospheric CO2 level."

According to projections by the U.S. Energy Information Administration, or EIA, world carbon dioxide pollution could grow from 30 billion metric tons in 2007 to 34 billion metric tons in 2020. This pollution could even jump to 42 billion metric tons in 2035. Thanks to reduced fossil fuel demand during the global recession that began in 2008 and continued through 2009, U.S. global warming pollution was reduced by more than 7 percent from 2005 to 2009. This changed in 2010 when demand began to recover and U.S. pollution again rose by 3.7 percent.

The Environmental Protection Agency, or EPA, cites human activity through fossil fuel combustion "such as coal, oil and gas in power plants, automobiles, industrial facilities" as the major source of these rising carbon emissions. Deforestation contributes to roughly 20 percent of the global increase since trees and other foliage help remove CO2 from the atmosphere.

Sea grasses, tidal marshes, and mangroves also play an important role in removing carbon from the atmosphere. Often referred to as blue carbon because they are found in coastal and ocean areas, these plants have the ability to sequester up to five times as much carbon as tropical forests. Yet they are among the most rapidly declining ecosystems on the planet. Louisiana alone loses more than a football-field-size area of coastal marshland every *hour*, resulting in the substantial release of previously stored CO2.

As Dr. Richard Alley of Pennsylvania State University explains, CO2 is the "control knob" for our climate. It regulates global temperature by trapping heat itself as well as water vapor and cloud cover in the atmosphere, much like the glass enclosing a greenhouse is designed to do and thereby earning the name "greenhouse gas." The Lacis-led NASA study concluded that while there are many different types of greenhouse gases, CO2 alone accounts for 80 percent of the strength of this terrestrial greenhouse effect.

The resulting recent steady rise in air and water temperatures is causing measurable rising sea levels, reduced snow cover, shrinking glaciers, and thawing permafrost. It has also increased water vapor in the atmosphere by 4 percent compared to 30 years ago. It has also contributed to the increased frequency and intensity of heavy downpours—one manifestation of extreme weather that caused extensive damage in the United States during 2010.

The scientific proof tracking manmade climate change has accumulated steadily for the last several decades. Preeminent climate scientists and organizations agree that humanity is facing a public health crisis that requires swift and decisive action. As a 2009 peer-reviewed study published by the National Academy of Sciences reports, the overwhelming majority of reputable climate scientists believe we have a problem. Researchers used:

> *… an extensive dataset of 1,372 climate researchers and their publication and citation data to show that 97 percent to 98 percent of the climate researchers most actively publishing in the eld support the tenets of [anthropogenic climate change] outlined by the Intergovernmental Panel on Climate Change [or IPCC] and the relative climate expertise and scienti c prominence of the researchers unconvinced of [anthropogenic climate change] are substantially below that of the convinced researchers.*

While evidence of human-induced global warming mounts, carbon dioxide pollution from major sources grows. A report released in February 2011 by the Environmental Integrity Project uses data from EPA's Clean Air Markets website to show that carbon dioxide pollution from U.S. power plants rose 5.6 percent in 2010 alone. This is the biggest annual increase since the EPA began tracking emissions in 1995. The Environmental Integrity Project report found that "Texas power plants led the pack in 2010, with nearly 257 million tons of CO2 emissions. The 10 worst states for CO2 pollution identified in the report are Texas, Florida, Ohio, Indiana, Pennsylvania, Illinois, Kentucky, Georgia, Alabama, and Missouri."

Total fossil fuel CO2 emissions in the United States rose by 3.7 percent in 2010 according to the EIA. These are the manmade contributions to global warming that cause such increasingly violent weather extremes around the nation, as our next section will detail.

Rain, thunderstorms, floods

Huge precipitation events are classified by their expected frequency of occurrence. The National Weather Service describes:

> *… a 100 year ood [as] an event that statistically has a 1% chance of occurring in any given year. A 500 year ood has a .2% chance of occurring and a 1000 year ood has a .1% chance of occurring.*

In other words, a 100-year flood is the level of flood water expected to be equaled or exceeded every 100 years, on average.

Almost every region of the United States experienced unusually heavy precipitation last year that many flood occurrences were exceeded. This prompted FEMA Administrator Craig Fugate to say, "the term '100-year event' really lost its meaning this year."


AP PHOTO/TOM STATHIS

Storm clouds carrying heavy rain move across downtown Phoenix in October 2010. A series of powerful thunderstorms hit the area with high winds, hail and, heavy rain.

In January 2010 the most powerful low-pressure system in 140 years of record keeping brought havoc in the form of floods, hail, and hurricane-force winds to northern California, eastern Oregon, and the Southwest, including Nevada, Arizona, and Utah. In October the so-called "Chiclone" spun up over Minnesota, bringing severe thunderstorms and strong winds and leaving a swath of destruction from the Dakotas to the Great Lakes in what forecasters dubbed the worst weather system to hit the Midwest in 70 years. The storm drew its destructive power from the transfer of heat that occurred when the sharp temperature contrast between record warmth in the Southeast and average cold in the North collided.

Paul Douglas, a renowned meteorologist from Minnesota, said this "unprecedented, historic storm" could become commonplace in a warmer climate. "We have to get acclimated mentally and physically for this kind of world where these kinds of supercharged storms are more frequent," he warns.

December 2010 delivered an unusually wet Christmas to southern Californians in the form of a weeklong rainstorm that caused severe flooding. These raging waters washed away highways and homes throughout the greater Los Angeles area. Flooding of this magnitude spreads urban environmental toxics and increases the risk of waterborne diseases, and in 2010 caused nearly $3.9 billion of property damage.

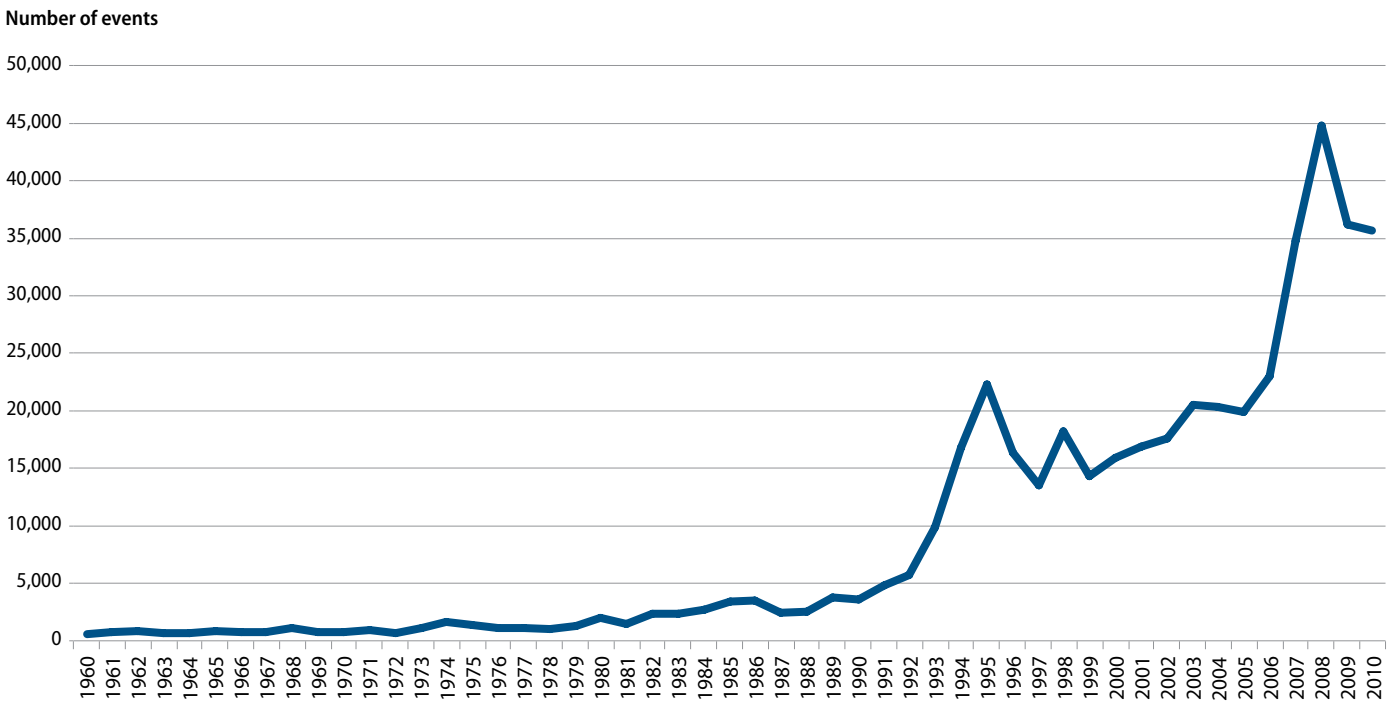
The Midwest is known for long winters that bring arctic temperatures and heavy snow. Winter precipitation replenishes several of the great river basins in the United States, including the Mississippi, Missouri, Ohio, and Colorado river basins. But winter is under attack from rising global temperatures and greenhouse gas emissions. According to the U.S. Global Change Research Program 2010 report, "Temperatures are rising faster in winter than in any other season, especially in many key agricultural regions. ... the Midwest and northern Great Plains have experienced increases of more than 7°F in average winter temperatures over the past 30 years" (page 76).

These rising temperatures increase the water-holding capacity of the air, and this has been observed in rising levels of atmospheric moisture. This in turn increases the "supply of moisture for all storms," explains Trenberth.

Iowa, the Dakotas, and Minnesota have all experienced record flooding over the past three years. Fargo, ND, has had a particularly bad run over the last two decades. It suffered ongoing flooding from the adjacent Red River. There were nine "10-

Precipitation events

The frequency and intensity of precipitation events has increased dramatically over the past 50 years



Source: NOAA.

year floods"—floods that are expected to occur only once every 10 years—during the past 20 years, including one in March 2010. There was also a 100-year flood in 2009. Taking these record flooding levels into account, the U.S. Army Corps of Engineers raised its 100-year-flood estimates nearly a foot in May 2010, effectively increasing the amount of water necessary to qualify for a very rare flood event. In other words, flood levels that were once rare are now classified as common.

And this frequent drenching is becoming far from unusual. According to the National Oceanic and Atmospheric Administration, precipitation has been above average in the Midwest for the last three decades. More frequent floods, often the product of severe snow, hurricanes, or driving rain, are an expected result of global warming. Rising temperatures over the ocean cause more water vapor to condense, contributing to increased rainfall. The intensity of individual rain events has increased dramatically over the past 50 years, concurrent with greenhouse gas levels (see chart).

Trenberth acknowledged the link between global warming, intensifying super storms, and record-breaking rainfall events, lamenting that it is "unfortunate that the public is not associating these [storms] with the fact that this is one manifestation of climate change. And the prospects are that these kinds of things will only get bigger and worse in the future."

These predictions coincide with observed data in the USGCRP's "Global Climate Change Impacts in the United States" report tracking trends from the past century. The report shows that "one of the clearest precipitation trends in the United States is the increasing frequency and intensity of heavy downpours." It is predicted to result in "rainfall that will measure 10 percent to 25 percent higher than current averages" by the end of this century. In other words, super floods like the one that devastated Nashville in May 2010 will increasingly threaten human health and economic security in the interior of the country.

Storms that bring heavy rain, lightning, hail, strong winds, and tornadoes account for a large portion of the damage sustained by infrastructure, property, and crops in the United States. Together, hail and other heavy precipitation were responsible for property damage of more than $920 million. As of April 2011 FEMA had given more than $56 million in disaster assistance to Iowa alone following two flooding events in the summer of 2010.

Climate models predicting increased frequency and intensity of downpours proved terrifyingly prescient this past May when a powerful line of thunderstorms caused a catastrophic 1,000-year flood along the Cumberland River basin in Tennessee and parts of Kentucky and Arkansas. The storms dumped record rainfall across middle and western Tennessee during an unforgettable three-day stretch that began the morning of May 1. The swollen rivers caused billions of dollars of damage to property and infrastructure in 52 of Tennessee's 95 counties. The flood was estimated to have cost Nashville the equivalent of an entire year's worth of economic activity in goods and services from damaged buildings and lost business operations. The National Climatic Data Center put the city's damages from this event at more than $2.2 billion.

Nearly one year later, Nashville is transforming the tragedy of the flood into an opportunity for infrastructural change. As Greenwire reports, the city plans to establish "large-scale preserves in each bend of the [Cumberland] river," creating a series of natural flood barriers by:

> *… increasing the city's parkland and green in astructure by 6,000 acres in the next 10 years and by another 6,000 by 2035.*

More than $320 million in federal aid money has been provided to help Tennessee victims rebuild their lives but many people sustained heavy losses that cannot be covered by public money or insurance. According to the National Climatic Data Center, 20 people were killed. It also left thousands of people homeless. This was from a storm system that climate scientists believe will become the norm in a warming climate. See photos of the flood damage here.


AP PHOTO/J. SCOTT APPLEWHITE

After a week of record-breaking snowfall, snow is piled in front of the Lincoln Memorial in Washington in February 2010.

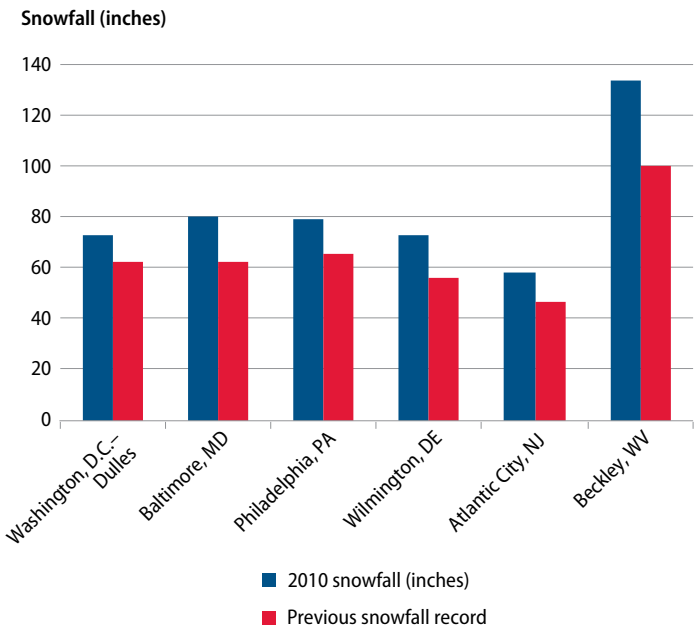
Snow and ice

Recent trends support the U.S. Global Change Research Program finding that seasonal storm tracks are shifting northward and the strongest storms are likely to become stronger and more frequent. Meanwhile, rising average temperatures have caused the seasonal ice coverage of the Great Lakes to decrease by roughly 30 percent over the past 40 years. The resulting rise in

evaporation rates has increased moisture in the air, generating heavier snowfalls. Meanwhile, diminishing ice cover means less insulation from the sun for deeper lake waters, warming them and storing still more heat that delays winter freezing in shallower areas. Less and later-forming ice leaves fish eggs dangerously exposed to waves and speeds coastal erosion, since ice usually acts as a protection.

Early in 2010 both the Eastern Seaboard and vast swaths of the Midwest were subject to a series of outsized winter storms, inspiring President Obama to dub the second wave of record-breaking snowfall in Washington, D.C., "Snowmageddon." The apocalyptic storms of 2010 dealt a hefty $535 million blow to state and federal coffers to pay for snow removal and damages as FEMA issued disaster declarations up and down the East Coast and across the Great Plains.

Select 2009–2010 cold season snowfall records



Source: NOAA.

December 2010 also saw multiple heavy snowfalls, especially in the upper Midwest and Northeast. Snow cover in North America was the seventh largest on record for December, according to NOAA's Satellite and Information Service. This marked the fourth-consecutive December with "above average snow cover extent for the continent." In 2010 Philadelphia set a record for the largest January–December snowfall with more than 67 inches. All told, severe winter storms nationwide accounted for 30 fatalities, 39 injuries, and more than $112 million in damages in 2010.

Extreme temperatures, drought, wildfire, smog

While the eastern coast of the United States becomes increasingly vulnerable to severe precipitation, the Southwest faces a different but equally challenging future.

Higher temperatures are driving an increase in evaporation rates, drying out soil and vegetation. Climate models are also showing a change in rainfall patterns in the future where precipitation during summer months is projected to decrease.

Together, these factors will lead to increasingly severe droughts. Droughts can affect regions for decades with major, lingering impacts on human health, water supplies, and agriculture. In the United States and around the world, this temperature increase may translate into devastating droughts, water shortages, wildfires, and poor air quality.

A 2010 report by the National Center for Atmospheric Research predicts the Southwest will become drier and more arid. In an echo of the ancient mega-droughts that once defined this region, it could face near permanent drought conditions by late this century if current warming trends continue. This will cause major water supply, irrigation, and agricultural problems for major metropolitan areas, including Los Angeles, Phoenix, and Las Vegas where rivers, reservoirs, and aquifers are being drained and depleted.

Lake Mead is the massive manmade lake formed by the construction of the Hoover Dam, and a major drinking water supplier to nearby Las Vegas. The lake's water level is more than 130 feet lower than just nine years ago, a result of the severe decade-long drought in the West. It will take 13 years to 15 years of average flow conditions to refill Lake Mead and mega-reservoir Lake Powell following the severe drought conditions that plagued this region from 1999–2004.

In addition to threatening water supplies, droughts also stunt crop growth. FEMA estimates that droughts cost the U.S. economy between $6 billion to $8 billion annually due to lost and damaged crops

The global land and ocean surface temperature for 2010 tied with 2005 as the warmest of the 131-year records. In September Los Angeles recorded its hot-test day ever, clocking in at a broiling 113°F. NOAA reported that nationwide August was drier and warmer than normal when weather conditions were averaged across the country. 2010 also marked the 34th consecutive year that overall global temperatures were above average.

The Southwest is and will continue to be the hardest hit by rising temperatures and their resultant wildfires and drought conditions. In the past 15 years, 30 percent of the western United States experienced severe drought conditions as defined by the Palmer Drought Severity Index, which assesses "the relative dryness or wetness affecting water-sensitive economies." According to the U.S. Global Change Research Program, the future impact of spiking CO2 levels will be further exacerbated by changes in atmospheric circulation patterns, causing the dry zone just outside the tropics to expand further into the southern United States.

An October 2010 peer-reviewed report, "Drought Under Global Warming: A Review," led by National Center for Atmospheric Research scientist Aiguo Dai, used computer climate models and a comprehensive index of drought conditions to determine that most of the Western Hemisphere "may be at threat of extreme drought this century if nothing is done to curb greenhouse emissions." By the 2030s, the study indicated that large portions of the central and western regions of our nation could experience particularly severe conditions, with Palmer Drought Severity Index ratings as low as -4 to -6 (-4 is classified as extreme drought). By century's end, parts of the United States could see these readings fall to -8 to -10, the equivalent of desert conditions. According to Dai and his colleagues:

The reduction in water levels due to drought on Lake Mead can be seen by the white ring around the shore at the Hoover Dam in Boulder City, Nevada.

We are facing the possibility of widespread drought in the coming decades, but this has yet to be fully recognized by both the public and the climate change research community. If the projections in this study come even close to being realized, the consequences for society worldwide will be enormous.

By reducing moisture in the soil and vegetation, global warming sparks a greater vulnerability to wildfires. These sometimes uncontrollable events contribute to poor air quality and trigger enormous, costly response efforts. Rising global temperatures in recent years are creating an "unprecedentedly fire-prone environment" according to the National Academy of Sciences. Such an environment may cause the median annual area burned by wildfire in Montana to jump by 200 percent to 500 percent by midcentury. Similar prospects are in store for Montana's western neighbors, according to the National Academies' Stabilization Targets for 2010. This comes at a huge cost: In 2010 wildfires caused nearly $245 million in property damages.

According to Headwaters Economics, "fighting wildfires costs U.S taxpayers $3 billion annually, more than twice what it cost them two decades ago."

Hurricanes and tropical storms

Higher temperatures and water vapor concentrations are directly related to the intensification of extreme weather events such as hurricanes that will bring stronger winds, heavier rain, and larger storm surges to the East Coast and the Gulf of Mexico.

Hurricanes are "threshold" events. They do not form unless sea surface temperatures are above 80°F. As the ocean surface is warmed by the sun, and rising CO2 levels amplify atmospheric radiation, an increasingly greater rate of evaporation is required to balance the ocean's heat intake. Dr. Kerry Emanuel, professor of atmospheric science at the Massachusetts Institute of Technology, explains that as ocean water evaporates and transfers heat from the sea surface back into the atmosphere, the exchange:

> *. . . gives you an upper bound of hurricane wind speed, and the upper bound turns out to be a very good predictor of how strong hurricanes can be. We realized way back in 1987 that CO2-induced warming would increase that speed limit on hurricanes. It surprised us how much power increase you got with just a li le bit of increase in the sea surface temperature.*

AP PHOTO/NOAA

This image from NOAA collected on August 28, 2005 shows Hurricane Katrina near the mouth of the Mississippi River.

Climate models and observed data suggest that the deadliest hurricanes, Category 4 and Category 5 storms, will become more common with a warming atmosphere while "reducing the number of less powerful storms." For every 1.8°F increase in tropical sea surface temperatures, precipitation rates are projected to increase by 6 percent to 18 percent, and the surface wind speeds of the strongest hurricanes will increase by between 1 percent and 8 percent. Already over the past 30 years, annual sea-surface temperatures in the primary Atlantic hurricane development region increased nearly 2°F. This warming coincided with an increase in the high-intensity hurricanes whose names have gone down in infamy: Gustav, Katrina, and Rita.

The year of living dangerously

2010 U.S. extreme weather events and the human and economic costs

Event type	Total events	Events that caused $1,000+ in damage	Federal aid for FEMA declarations ($ millions)	Total property damage ($ millions)	Total crop damage ($ millions)	Total combined damage ($ millions)	Fatalities	Injuries
Tornado	1,372	662	565.88	1,791.33	26.34	1,817.67	47	646
Flood	6,545	2,644	848.90	3,836.93	68.19	3,905.12	91	310
Snow and ice	4,678	232	535.46	97.06	15.00	112.06	30	39
Hurricanes/tropical storms	30	13	46.24	12.54	3.01	15.55	0	0
Precipitation	1,046	78	*	6.56	1,044.10	1,050.66	1	6
Hail	10,624	716	*	915.96	101.88	1,017.84	0	42
High wind	2,062	370	*	12.42	0.68	13.10	7	17
Thunderstorm	16,728	8,018	*	200.11	7.25	207.36	15	292
Ocean/lake surf	233	34	*	52.75	0.00	52.75	63	64
Lightning	841	681	*	65.35	0.45	65.80	28	179
Fire	204	63	*	244.59	2.03	246.62	1	24
Strong wind	524	437	*	10.22	0.53	10.75	10	28
Drought	199	0	15.24**	0.00	5.81	5.81	0	0
Fog	158	11	*	1.15	0.00	1.15	0	0
Dust storm	40	3	*	0.14	0.00	0.14	0	0
Extreme temperatures	506	7	*	0.52	0.20	0.72	95	75
Totals	**45,790**	**13,969**	**1,996.49**	**7,247.63**	**1,275.47**	**8,523.10**	**388**	**1,722**

Notes:

Chart includes declarations in Puerto Rico and the Virgin Islands.

Total property damage includes damages from FEMA emergency disasters in as well as declared disasters.

*Denotes information that has been combined with other event data.

**Denotes data obtained from the Farm Service Agency. Number refers strictly to monies distributed by Livestock Forage Disaster Program.

We saw this phenomenon in action during the past five years. The year 2005 ties with 2010 for the warmest year on record—when Hurricane Katrina delivered a level of devastation above and beyond that of many of its recent predecessors.

The Atlantic hurricane season was above average, with 19 named storms, 12 hurricanes, and five major (Category 3 or higher) hurricanes. Between 1966 and 2009 there were an annual average of 11 named storms, six hurricanes, and two major hurricanes. Crop losses and property damage cost the federal government more than $46 million in disaster assistance. Damages from these storms clocked in at nearly $16 million (see chart).

We now turn to some of those consequences.

The consequences of extreme weather on public health and agriculture in the United States and abroad

In 1989 President George H.W. Bush issued a directive establishing the U.S. Global Change Research Program. Congress formally instituted the Global Change Research Act in 1990 and 13 federal agencies began coordinating their investigative efforts into global climate change. This work has continued under the next three presidents, including the George W. Bush administration.

The U.S. Global Change Research Program has clearly and prudently aggregated and communicated the impacts of global warming on America's weather and economy. Its authoritative 2009 report explains the science of climate change and its national and regional impact on U.S. weather, water supplies, agriculture, and society. Comprehensive studies like this one are validated by the extreme weather events of 2010, which according to NASA is tied with 2005 for the dubious distinction of being the warmest year on record.

The stress that these weather extremities put on our country's infrastructure is becoming very expensive. Clark Miller, associate director of the Consortium for Science, Policy & Outcomes at Arizona State University, explains, "The technological infrastructure of the United States was designed to operate within a particular range of climatic parameters, and the climatic conditions within which these infrastructures now operate are moving outside of that range with greater frequency."

These stressors are also dangerous to our national energy security, as an April 2011 report by the National Wildlife Federation points out. Intensifying weather events "could cause major disruptions in the existing systems that deliver energy to the nation." According to the study, the extensive oil-and-gas infrastructure in the hurricane-prone Gulf Coast region is particularly at risk. Likewise:

Coal transport across the Midwest and Northeast will face more flooding disruptions, [while] electricity generation in the Southwest will be limited by water shortages — About 89 percent of electricity in the United States is generated in thermoelectric power plants that require water for cooling.

As the changing climate continues to exacerbate this already stressed system, we will be forced to update and adapt our energy, water, and transportation infrastructure to withstand the abuses of increasingly intense weather patterns.

Public health

Smog is a manmade phenomenon that has its own season corresponding to the hottest months of the year, May through September. The extreme heat of these months cooks up airborne nitrogen oxides and volatile organic compounds in the presence of sunlight, forming ground-level ozone, or smog. The hotter the weather, the worse the smog is, especially in urban areas where high concentrations of harmful pollution are trapped by stagnant air. This perfect storm of heat-amplified pollutants can trigger asthma attacks and exacerbate or generate respiratory ailments. Children, seniors, and those with respiratory diseases are most at risk, but smog can seriously damage even healthy respiratory systems.

Despite rising temperatures, "code red" air quality days have been declining across the United States due to pollution controls required by the Clean Air Act. These "red alert" warnings indicate when the air is unhealthy even for people who are not part of vulnerable populations or without pre-existing conditions.

For the past 40 years, the EPA has steadily reduced smog ingredients released into the atmosphere under the authority of the Clean Air Act. But this progress will be undone by a warming nation. Higher temperatures will worsen smog, spelling more disease and death for our most vulnerable populations: children, the elderly, and people suffering from asthma, bronchitis, emphysema, or heart conditions. According to the EPA, half of all Americans—158 million people—live in counties where air pollution already exceeds national health standards. As a 2011 joint report from Health Care Without Harm, the Alliance of Nurses for Healthy Environments, and the National Association of School Nurses explains, "Carbon dioxide pollution can worsen asthma in several ways, such as by driving climate change (rising temperatures increase ozone smog concentrations) and by increasing production of airborne allergens like ragweed pollen."

A recent editorial posted on American Medical News noted that the physical evidence of climate change is becoming apparent in doctors' waiting rooms:

> *Patients are presenting with illnesses that once happened only in warmer areas. Chronic conditions are becoming aggravated by more equent and extended heat waves. Allergy and asthma seasons are ge ing longer.*

EPA scientists, engineers, and economists are developing cost-effective standards to reduce carbon dioxide pollution from coal-fired power plants and oil refineries. Unfortunately, the House of Representatives voted on several occasions to block the EPA from setting or enforcing such rules, and added such measures to the must-pass spending bill for the remainder of FY 2011. President Barack Obama and Senate Majority Leader Harry Reid (D-NV) forced Speaker of the House John Boehner (R-OH) to abandon them as part of the final spending compromise.

Meanwhile, the Senate defeated four amendments to an unrelated bill that were designed to prevent EPA from setting carbon dioxide pollution reductions. Fortunately, none of them received a majority of votes, let alone the 60 necessary to end debate and add them to the bill.

These actions ignore the recommendations of 4,500 scientists and health care professionals that urged the government to "Support full implementation of the Clean Air Act and resist any efforts to weaken, delay or block progress toward a healthier future for all Americans."

The House disregarded science and ignored public health to appease the oil industry by blocking these safeguards.

Agriculture

While global warming has added a full week to the Midwestern growing season over the past century, it is far from being a good thing. Rising temperatures will increase the risk of crop loss to more frequent floods, heavy rain, heat waves, fires, drought, pests, and plant epidemics that thrive in warmer conditions. Such setbacks delivered a nearly $1.3 billion hit to U.S. farmers in 2010 (see events chart, "Total Crop Damage").

Jake Caldwell, Director of Policy for Agriculture, Trade, and Energy at the Center for American Progress, writes that "the consequences of climate change on agriculture could well be even more severe in the coming decades." This will impact not only global food prices but human migration patterns. In the summer of 2010 alone, extreme weather drove a 50 percent increase in the cost of wheat.

Higher temperatures will harm crops that thrive in cooler environments, like potatoes or lettuce, and if temperatures exceed optimal thresholds for pollen viability, even those plants that grow best in warmer climates will not be able to create seeds to reproduce in future seasons, according to the 2010 U.S. Global Change Research Program report. As Caldwell points out, harvest forecasts and food production are clearly at risk from the negative effects of rising temperatures, prolonged drought, and increased evaporation and water consumption. And a rising sea level will lead to more intense flooding and the potential loss of limited arable land.

Government spending on federal flood and crop insurance rose over the past 30 years. The Government Accountability Office analysis, "Climate Change: Financial Risks to Federal and Private Insurers in Coming Decades Are Potentially Significant," found that the combined future risk for federal flood and crop insurance reached more than $900 billion in 2005—a 340 percent increase from 1980 insurance figures (in 2005 dollars).

According to FEMA, the droughts that can cause up to $8 billion in crop losses in the United States each year are indicative of the burden that increasingly frequent extreme weather events will place on private and public insurers.

Other nations also suffered from extreme weather in 2010

In addition to extreme weather in the United States, 2010 was a year of living dangerously in other nations, too. Dr. Jeff Masters of Weather Underground reported:

> *e year 2010 now has the most national extreme heat records for a single year—nineteen. ese nations comprise 20% of the total land area of Earth. is is the largest area of Earth's surface to experience all-time record high temperatures in any single year in the historical record."*

Russia saw a devastating heat wave, drought, and wildfires. Massive rainfall in Australia caused a 500-year flood while drenching downpours caused a 100-year flood in Pakistan. These and other extreme weather events caused crop losses at home and abroad, causing wheat prices to spike dangerously in 2010. This generated worldwide fears of food insecurity. Recent unrest in the Middle East is also linked to high food prices, even as rising uncertainty about climate change's impact on harvests spurs ill-advised hoarding of grain supplies and export bans.

Meanwhile, Munich Re reported in its annual worldwide review that:

> *2010 was the year with the second-highest number of loss-related natural catastrophes … since we began keeping global statistics in 1980. With 960 loss events due to natural hazards, the number of catastrophes documented in 2010 far exceeded the average for the last ten years (785 events). e overall economic loss amounted to some $150 billion.*

Worse yet, the company cautions that these staggering numbers only represent about 40 percent of the total losses attributable to weather-related events, because uninsured or underinsured assets and lost economic activity are difficult to quantify.

These are all sobering findings, yet conservatives in Congress continue their efforts to suppress the scientific work needed to understand and cope with climate change, and want to destroy the tools essential to address this crisis. Why they do so is the subject of the next section.

Conservatives oppose scientific steps to understand extreme weather patterns

Consensus in the scientific community that global warming poses a clear and present danger to American lives and livelihoods has done little to convince climate science deniers about the urgent need for action. Lack of information is no longer a viable excuse given the mountain of scientific information and data on global warming. Scientifically, it is the most studied problem in history. Climate modeling is indeed a complex concept but global warming patterns are clearly visible in the forecasts that dictate our activities and affect our economy

Responsible government officials recognize this growing threat. In a 2008 letter to President George W. Bush, then-EPA Administrator Steven Johnson told the president that the scientific evidence of human-induced global warming mandated that he make a positive "endangerment finding" that described the perils of carbon pollution to public health and the environment in accordance "with the latest science of climate change." In Johnson's words, the "state of the latest climate change science does not permit a negative finding, nor does it permit a credible finding that we need to wait for more research."

President Bush, however, ignored both the scientific and legal need to act. EPA Administrator Lisa Jackson finally made the overdue endangerment finding in December 2009.

Nonetheless, a panoply of right-wing and Big Oil-influenced legislators attempt to repeal scientific findings by legislative fiat. On June 10, 2010—after six months of extreme weather—Sen. Lisa Murkowski (R-AK) offered a resolution to undo the global warming endangerment finding, though it failed by a vote of 47-53.

On April 7, 2011, the House of Representatives voted to pass H.R. 910 by a vote of 255-172. It would block the EPA from setting standards to reduce carbon dioxide pollution from power plants, oil refineries, and other major sources. No Republican voted against it, while 19 Democrats voted for it. On party-line votes, they also defeated an amendment offered by Rep. Henry Waxman (D-CA) that would have accepted the scientific findings of the Environmental Protection Agency that:

Congress accepts the scienti c ndings of the Environmental Protection Agency that climate changes is occurring, is caused largely by human activities, and poses signi cant risks for public health and welfare.

This nonbinding endorsement of climate science failed by a vote of 184-240. Only one Republican voted for it, while three Democrats voted against it.

In addition to climate science denial, House Republicans plan to slash funds that would add to the base of scientific knowledge about the causes and impacts of global warming. The House-passed Republican budget for the remainder of fiscal year 2011 sliced 2010 funding for NOAA programs by $454 million, or 14 percent. In so doing, it failed to include a one-time budget increase of approximately $800 million that would have funded the purchase of new environmental satellites. Michael Conathan, Director of Oceans Policy at the Center for American progress, warns that the country is due for an overhaul of its aging environmental satellite infrastructure, and if the investment isn't made now, U.S. taxpayers may be forced to spend up to $3.5 billion to correct the error in later years.

Aside from the increased cost of purchasing the satellites themselves, the impact on the day-to-day economy would be tremendous. NOAA demonstrated the severity of this affect by compiling a series of forecasting mockups that showed, "Model runs without NOAA afternoon satellite data would likely not predict the severity of high-impact weather with sufficient accuracy or lead-time to allow proactive community preparedness and mitigation."

As Rep. Peter DeFazio (D-OR) bluntly noted in an interview with Think Progress, "If you cut on detection of tidal waves, volcanic eruptions, severe weather events, weather buoys, satellite observation and weather patterns, those sorts of things, people will die."

In addition to the system's weather, climate, and disaster prediction capabilities, NOAA Administrator Dr. Jane Lubchenco reiterated the importance of environmental satellites to search and rescue efforts. During her April 13 testimony before the Senate Committee on Commerce, Science, and Transportation's Subcommittee on Oceans, Atmosphere, Fisheries, and the Coast Guard, she said:

e expenditures on satellites are mission critical for NOAA. People's lives and property depend on them. is year 21 people have been rescued because of NOAA satellite tracking, and 91 have been rescued since last October.

Dr. Lubchenco explained that the FY 2011 continuing resolution's disinvestment in weather satellites will cause a minimum 18-month delay for the launch of the first satellite in the Joint Polar Satellite System, or JPSS, and result in cost increases of three to five times current estimates.

The earthquake and subsequent tsunami that devastated Japan in March 2011 is a tragic reminder that we must employ modern science and technology to predict and warn of disasters. Tens of thousands perished in that disaster, but thanks to Japan's investment in state-of-the-art tsunami detection systems, many were spared.

Scientists predict that temperatures over most of the United States are very likely to increase by more than the global average this century. And given the evidence, legislators from states that are particularly vulnerable to extreme weather events would do well to work toward reducing the carbon dioxide pollution driving these drastic climate changes. But climate science deniers persist in Congress. Last month, the Republican majority in the House blocked the EPA from limiting harmful GHG emissions in a 249 to 177 vote.

And on April 6, the House Republican majority rejected the scientific conclusion that global warming is primarily human induced during debate over H.R. 910, a bill to permanently remove the EPA's ability to set carbon dioxide pollution reduction standards. By a 184-240 vote, they rejected Rep. Henry Waxman's (D-CA) amendment to H.R. 910 that stated, "Congress accepts the scientific findings of the Environmental Protection Agency that climate change is occurring, is caused largely by human activities, and poses significant risks for public health and welfare."

Only one Republican voted to endorse scienti c ndings while three Democrats rejected them. The Hill noted, "The House rejected a Democratic amendment Wednesday that would have put the chamber on record backing the widely held scientific view that global warming is occurring and humans are a major cause."

Now more than ever, it is important for progressives in Congress to hold the line on these climate science denial efforts to blind our nation to the dangers of global warming.

Conclusion

The future is now

The extreme weather in 2010 could be a preview of a not-too-distant future should we fail to reduce carbon dioxide pollution. Continued pollution will increase the risk of harmful, damaging extreme weather events. Scientific evidence presented in the Intergovernmental Panel on Climate Change's Fourth Assessment Report warns, "Both past and future anthropogenic carbon dioxide emissions will continue to contribute to warming and sea level rise for more than a millennium, due to the time scales required for removal of this gas from the atmosphere."

Recent weeks have seen a continuation of extreme weather. A single devastating storm system brought waves of tornadoes, thunderstorms, and floods to the southern United States on April 15 and 16, leaving an estimated 45 people dead. Alabama, Georgia, Mississippi, and North Carolina were particularly hard hit, with the latter also suffering severe crop losses.

e New York Times reports that the system:

> *… was unusual for its size and duration ... the storm would calm itself a bit at night and then gain renewed strength with the day's heat, said Greg Carbin, warning coordination meteorologist at the National Oceanic and Atmospheric Administration. … it was unusual in that all of the weather stemmed om one huge storm.*

Wildfires, too, have already made their mark in 2011. In Texas, five occurred in a two-week span, aided and abetted by hot weather and high winds. The Associated Press reported that centenarian cowboy N.L. Winter has never "in his 106 years on the rolling plains of West Texas … seen anything like the fires of the past week."

These events indicate that 2010 was not an anomaly but rather a frightening preview of the future.

In order to avoid future extreme weather and hold Earth's temperature increase to 3.6°F, the United States and other nations around the world must stabilize total carbon dioxide emissions in the 350 ppm to 400 ppm range. Most climate scientists agree that it will be necessary to stabilize at 450 ppm to avoid the worst problems from climate change, but debate rages on about the economic and political feasibility of the marker. The window of opportunity is closing rapidly and it might no longer be possible to reach the crucial reduction goals set for 2020 and 2050.

Americans understand the recent extreme weather is due to a changing climate and not divine intervention. The Public Religion Research Institute recently conducted a poll that found 58 percent of Americans believe floods and other such natural disasters are evidence of climate change.

Indeed, the 1,000-year flood in Tennessee last year was not a biblical event. It's a foreshadowing of floods to come. Rising carbon dioxide pollution caused by human activities will turn up the dial on extreme weather. We need to make serious changes or prepare for the worst. The costs of climate disasters show us the vulnerabilities of the status quo, from pollution standards to the poor infrastructure planning evidenced by building up along shorelines and floodplains.

As Dr. Heidi Cullen, CEO and director of communications for Climate Central, testified before the Senate Subcommittee on Energy and Environment in November 2010:

> *Until now, we've been able to view extreme weather like ooding as an act of God. But the science tells us that due to climate change these oods will happen more o en and we need to be prepared for them. I say that a climate forecast is an "anti-forecast" because it is in our power to prevent it om happening. It represents only a possible future, if we continue to burn fossil fuels business as usual. e future is ultimately in our hands.*

But not for much longer.

Sources and methodology

The data in the tables and graphs of this report come from the National Climatic Data Center's Storm Database, which allows the user to search for information by state, time period, event type, and many other criteria. Using this database in conjunction with FEMA incident reports and preliminary damage assessments allowed us to compile information about fatalities, injuries, and economic damage in the absence of comprehensive annual reports.

The National Weather Service, Insurance Information Institute, Swiss Re, National Agricultural Statistics Service, and NOAA produce annual reports that provide more accurate data on property losses, crop damage, and other effects of severe weather events.

Information pertaining to the science of climate change, observed trends from the 20th century, climate models, and projections for the 21st century under different emissions scenarios was derived from several reports, most notably the U.S. Global Change Research Program's 2010 report "Global Climate Change Impacts in the United States," and the U.S. Climate Change Program's 2009 report "Extreme Weather in a Changing Climate: Regional Focus on North America, Hawaii, Caribbean and U.S. Pacific Islands." The findings from these independent publications build on those of the Intergovernmental Panel on Climate Change's Fourth Assessment Report of 2007.

This report also uses information from Joseph Romm's Climate Progress, Yale University's e360, Jeff Master's Wunderblog, and several other blogs that are well-respected within the scientific community.

About the authors

Daniel J. Weiss is a Senior Fellow and the Director of Climate Strategy at American Progress, where he leads the Center's clean energy and climate advocacy campaign. Before coming to American Progress, he spent 25 years working with environmental advocacy organizations and political campaigns. Weiss is an expert in energy and environmental policy; legislative strategy and tactics; and advocacy communications. Most recently, he was a senior vice president with M+R Strategic Services, where he oversaw collaborative campaign efforts by 15 major national environmental organizations working to oppose anti-environmental legislation. A graduate of the University of Michigan with both a Bachelor of Arts and Master of Public Policy degrees, Weiss has been involved with presidential, Senate, and House campaigns across the country since he was old enough to vote.

Valeri Vasquez is a Special Assistant for Energy Policy at the Center for American Progress, where she works with CAP's clean energy and climate advocacy campaign. She joined CAP after working as a field organizer in Colorado's fourth congressional district. As an intern at the White House Council on Environmental Quality, Valeri assisted with executive office policy outreach addressing the BP oil spill in the Gulf of Mexico. Previously, she produced and edited online learning programs for a training and development firm. Valeri studied in Spain and South Africa before graduating from the College of William and Mary in 2008.

Ben Kaldunski is a former intern with the Energy Team at American Progress.

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Any errors in this analysis are the responsibility of the authors.

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1333 H STREET, NW, 10TH FLOOR, WASHINGTON, DC 20005 • TEL: 202-682-1611 • FAX: 202-682-1867 • WWW.AMERICANPROGRESS.ORG