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AN ESSAY ADAPTED FROM A PRESENTATION ENTITLED, "ADAPTATION TO CLIMATE CHANGE"

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I. THE SCIENTIFIC CONSENSUS

Humans are changing the Earth's climate. The physics behind this statement is not only well-understood, but has stood the test of time, dating back to the 19th century, when Svante Arrhenius projected that adding carbon dioxide (CO_2) to the atmosphere through anthropogenic, or human-caused, sources, such as burning carbon-based coal, oil, and gas, would increase the temperature of the planet. Over one hundred years later, Arrhenius's initial projections still hold true.

Fortunately, there is a natural greenhouse effect that makes life possible on Earth and that keeps it about 60° Fahrenheit (F) warmer than it would be otherwise. Greenhouse gases (GHGs) in the atmosphere, such as CO_2 and water vapor, form a "blanket" around the earth. Energy enters the atmosphere in the form of solar radiation. Some of this energy is absorbed, warming the earth's surface, and some is reflected off of surfaces such as clouds, ice, and snow. The energy that is absorbed is then re-emitted as heat energy. Some of this heat is not absorbed and leaves the earth's atmosphere. The rest of the energy, however, is absorbed by GHGs in the atmosphere, and then re-emitted in all directions, keeping heat in the earth system. The critical element of a greenhouse gas is this ability to both absorb infrared heat and to also re-radiate it.

If the greenhouse effect is a good thing, why are we concerned

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about GHGs increasing in the atmosphere? The problem is that through human influence, such as deforestation and the burning of carbon-based fuels, we have added many more of these GHGs to the atmosphere and much more heat is being trapped, shown as the large red arrows in Figure 1. Currently, anthropogenic carbon emissions total more than nine billion tons per year,[1] in addition to significant emissions of other greenhouse gases such as nitrous oxide and methane.[2] This is causing the Earth to warm.

The science behind climate change has only become stronger over time, particularly in the past twenty or more years. We have many tools to decipher past climate; for example, a key process in being able to understand future climate is through proxies such as growth rings in trees, air bubbles in ice cores, distribution of pollen grains and fossils in soil and rock, and coral growth rates. In addition to these proxy measurements that tell us about climate in the distant past, the scientific community now takes millions of measurements each year of temperature, precipitation, sea level, and shifts in species and ecosystems, which build an observed, empirical basis to examine climate change in real-time. These are taken from both Earth and space. These long-term records show that historically, CO_2 in the atmosphere has ranged from 180 parts per million (ppm) up to 280 ppm as the Earth moved in and out of ice ages over millennia, as shown in Figure 2. In 2013, the atmospheric concentration hit 400 ppm. This rate of increase occurred in a geologic "blink of an eye," meaning over little more than a century – not millennia.

Model projections of future changes have also improved in the last 20 or more years. The scientific community has developed models that both project future climate and hindcast past climate. Models today can reproduce the observed temperatures over the past 150 years, suggesting that scientists have been able to incorporate the main chemistry and physics at play into the models, as well as the solar cycles and episodic events such as volcanic eruptions and El Niños, etc.

Since 1988, the Intergovernmental Panel on Climate Change (IPCC) has been summarizing and synthesizing the state of consensus science on climate change every 5-7 years. The IPCC was created by the United Nations and the World Meteorological Organization and includes about 150 countries and 2,000 scientists in the overall process. Increasing scientific confidence can be seen in the summary concluding sentences of subsequent

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1. CARBON DIOXIDE INFORMATION ANALYSIS CENTER, *2013 Global Carbon Project, Global Carbon Dioxide Emissions to Reach 36 Billion Tonnes in 2013*, http://cdiac.ornl.gov/GCP/carbonbudget/2013/ (last visited Mar. 10, 2014).

2. C. Le Quéré, et al., *Global Carbon Budget 2013, doi: 10.5194/essdd-6-689-2013*, EARTH SYSTEM SCIENCE DATA DISCUSSION, *available at* ftp://cdiac.ornl.gov/pub/Global_Carbon_Project/Global_Carbon_Budget_2013_v 1.1.xlsx (last visited Mar. 13, 2014).

IPCC reports. For example, in 1995, the IPCC stated that "the balance of evidence suggests the discernable human influence on global climate" – noting that the scientists see a human fingerprint in the climate record.[3] The 2001 IPCC report increased the strength of this statement, saying that "most of the warming observed over the last 50 years was attributable to human activities".[4] By 2007, the IPCC stated that the science behind climate change was "unequivocal," a rare un-caveated sentence in the world of science.[5] In the same report, IPCC scientists determined that there was a greater than 90% probability that the current observed warming was due to the increase in anthropogenic greenhouse gas emissions. In the new 2013 report, this probability was upped to 95%.[6]

Our world runs on fossil fuels. World energy sources are currently dominated by carbon-based fuels, such as coal, oil, and gas, as shown in Figure 3. The non-carbon sources of energy such as nuclear and hydro-power sources are only a small part of the overall energy picture. Most of the nine billion tons of carbon that we add annually to the atmosphere are due to the combustion of carbon-based fuels, with about 15% due to deforestation and land-use-change. The other greenhouse gases, such as methane, nitrous oxide, and black carbon cause about 25% of the heat-trapping. Both deforestation and non-CO_2 greenhouse gases are important pieces of the global warming puzzle, but it is clear that it is impossible to confront climate change in a serious way without tackling energy-related CO_2.

II. THE IMPACT OF CLIMATE CHANGE

There is direct observational evidence of global changes. Over the industrial era, CO_2 concentrations have increased from about 275 parts per million (ppm) to about 400 ppm today. Put in different terms, each molecule of air today has about 40% more CO_2 than it did in 1850. Global temperatures have also been

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3. *Second Assessment Report: The Science of Climate Change, 1995,* INT'L PANEL ON CLIMATE CHANGE, *available at* https://www.ipcc.ch/ipccreports/sar/wg_I/ipcc_sar_wg_I_full_report.pdf (last visited Mar. 10, 2014).

4. *Third Assessment Report, Climate Change 2001: Working Group I: The Scientific Basis,* "Summary for Policymakers," INT'L PANEL ON CLIMATE CHANGE, *available at* http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg1/007.htm (last visited Mar. 10, 2014).

5. *Fourth Assessment Report: The Physical Science Basis, 2007,* INT'L PANEL ON CLIMATE CHANGE, *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4_wg1_full_report.pdf (last visited Mar. 10, 2014).

6. *Fifth Assessment Report: The Physical Science Basis, 2013,* INT'L PANEL ON CLIMATE CHANGE, *available at* http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf, p. 15 (last visited Mar. 30, 2014).

increasing; we are currently nearly 1° Celsius (C) or about 1.5° F warmer compared to one hundred years ago, as shown in Figure 4. While there are "bumps and wiggles" in the record reflecting seasonal, annual, and decadal variability, the trend of the data set shows a clear increase in temperature, which is especially dominant over the last fifty or so years. Each of the last three decades was warmer than any other decade since widespread thermometer measurements were introduced in the 1850s.[7]

The emerging scientific consensus is that many of the predicted negative impacts of climate change are beginning to appear with the present increase in CO_2 and global temperature. The general consensus used found in many reports and now embodied in the Copenhagen agreements of the United Nations Framework Conventions of Climate Change (UNFCCC) is that warming the world 2° C, or about 3.6° F above pre-industrial levels is a point at which we will increasingly see "dangerous"[8] consequences. At over 2° C of warming, ecologists conclude that about 20% to 30% of the world's species will likely be at risk of extinction, and an extra one billion people will experience water stress.[9] There will likely be a complete loss of tropical glaciers, many of which supply water to major cities around the world. There will also be a great loss of coral reefs and increased coastal inundation from sea level rise, affecting many hundreds of millions of people. Unfortunately, if the current emissions trajectory is not dramatically altered, we are well on our way past a 2° C world.

There are ten commonly referenced, easily observed signs we would expect to see under a warming climate, as shown in Figure 5. All of these ten indicators are occurring in the manner expected; seven of the indicators are going up, and three are going down. As climate changes, temperatures are expected to increase – at the sea surface, in the deep ocean, over the sea, over land, and in the air. Humidity will increase as warming speeds up the water cycle. Sea levels will rise mostly due to thermal expansion of the oceans,

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7. NAT.'L ACAD. OF SCIENCES & THE ROYAL SOCIETY, *Climate Change: Evidence & Causes: An Overview from the Royal Society and the U.S. National Academy of Sciences,* 3 *available at,* http://dels.nas.edu/resources/static-assets/exec-office-other/climate-change-full.pdf (last visited Mar. 10, 2014).

8. "Dangerous" is a term that comes from THE FRAMEWORK CONVENTION ON CLIMATE CHANGE. UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, art. 2, "Objective", *available at* http://unfccc.int/essential_background/convention/background/items/1353.php (last visited Mar. 10, 2014). In the Copenhagen negotiations in 2009, this term was equated with keeping temperature increases to less than 2° C above pre-industrial levels. UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, *Draft Decision CP.15,* (Dec. 18, 2009), *available at* http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf.

9. Jacob Schewe, et al., *Multimodel assessment of water scarcity under climate change, available at* http://www.pnas.org/content/early/2013/12/12/1222460110.full.pdf (last visited Mar. 10, 2014).

but also due to land-based ice melting.

Under a warming climate, we also expect glaciers to melt, and snow cover and sea ice extent to decrease. The earth is currently losing the parts of the massive Greenland ice sheet *faster* than models actually predict. Glacier National Park might need a new name, as it now contains only twenty-six glaciers from the original 150, and these will likely all be gone in a few decades.

Sea level rise in the last thirty years has almost doubled, from 1.7 mm/year to 3.2 mm/year,[10] some of which now appears attributable to the rapid melt of Greenland. Last year in July, for the first time, the entire surface of Greenland was observed to be melting, not just the edges of the ice sheet.[11] If all of Greenland were to eventually melt, this would translate into twenty-one feet of sea level rise.

Though melting of floating arctic sea ice does not contribute to sea level rise, it too has a role to play in the climate system. Ice, whether arctic sea ice, glaciers, or snow, provides a very bright surface, which reflects rather than absorbs a lot of incoming solar radiation. When that bright, reflective ice melts into dark, open ocean, however, its reflectivity is lessened and it absorbs more heat, leading to more warming and, in turn, more melting. Last summer, cargo ships passed through both the Northwest and Northeast passages,[12] perhaps a harbinger of new trade routes and new national security issues.

We have more independent proof that climate is changing. For example, spring is coming one to two weeks earlier, using evidence from seventy-five botanical gardens around the world that use satellite measurements to keep track of bud burst or "greening" of the planet. The ideal range to grow crops is shifting latitudinally toward the poles, or altitudinally up mountains. Warmer, wetter weather helps pests and invasive species such as mosquitos, ants, ticks, molds, avian flu, kudzu, fire ants, and West Nile virus to increase their range.

We are also seeing an increase in record high heats around the world, and extreme heat events have actually doubled in the last few decades.[13] There were recent record temperatures set in

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10. *Climate Change 2013: The Physical* Basis, Summary for Policymakers, INT'L PANEL ON CLIMATE CHANGE, *available at* http://www.ipcc.ch/report/ar5/wg1/docs/WGIAR5_SPM_brochure_en.pdf (last visited Mar. 10, 2014).

11. NASA Press release, *Satellites see unprecedented Greenland ice sheet surface melt,* (July 24, 2012), http://science.nasa.gov/science-news/science-at-nasa/2012/24jul_greenland/.

12. ARIA PHILLIPS, THE FIRST-EVER BULK FREIGHTER TO PASS THROUGH THE ARCTIC WAS CARRYING COAL, *www.climateprogress.com,* (Sept. 26, 2013, 1:44 PM), http://thinkprogress.org/climate/2013/09/26/2683481/northwest-passage-passable-climate-change-arctic/#.

13. Potsdam Inst. for Climate Impact Research and Climate Analytics, *4°:*

the last few years in Europe, India, Russia, and Japan, and 2012 was the warmest year ever recorded for the United States. In concert warmer temperatures, evaporation of water is increasing, leading to more droughts, especially in the interior of continents. In the United States, droughts tend to cost about $65 billion a year; in 2012, it was double that amount, with 60% of the country suffering drought.[14] As a result, food prices in various parts of the world increased, demonstrating how fragile and interconnected our global food distribution systems are.

Extreme rainfall events have also been increasing in the last century, as shown in Figure 6. In the Midwest region, there has been a 45% increase in rainfall that now comes from the most extreme rainfall events, or erosive rains. Other extreme events, such as heat waves, tropical storms, flooding, wildfires, severe storms, are also increasing. The Midwest region has experienced all of these, except for fires. This translates to real money for our region – from 1980 until present, we had about thirty disasters total, each costing a billion dollars. Globally, natural disasters have also been increasing, in all regions, but what is particularly noteworthy is that the weather-related disasters that had hovered around 400 events in the 1980s now occurred about 800 times a year in the last decade, as shown in Figure 7. The United States is not immune; in 2012, the five costliest events for the insurance industry were all in the US.[15]

The future greenhouse gas emission paths would have us on trajectories that will take the earth to somewhere between 2° C to 5° C (about 3.6° F to 9° F) above pre-industrial levels; without significant changes to the world's energy systems and consumption patterns, we will most likely exceed the 2° C guardrail, as shown in Figure 8, beyond which climate experts project some unmanageable impacts, such as species extinction, or significant populations at severe water stress. In the high emissions scenario, by 2100 parts of the United States could have on average about a

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Turn Down the Heat, Why a 4° C Warmer World Must Be Avoided, WORLDBANK.ORG, xvi (Nov. 2012), http://climatechange.worldbank.org/sites/default/files/Turn_Down_the_heat_Why_a_4_degree_centrigrade_warmer_world_must_be_avoided.pdf.

14. Natil Harnik, *Worst US Drought in decades deepens to cover 60 percent of lower 48 states*, U.S. DROUGHT MONITOR, (Nov. 22, 2012), http://usnews.nbcnews.com/_news/2012/11/22/15354660-worst-us-drought-in-decades-deepens-to-cover-60-percent-of-lower-48-states?lite.

15. Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE, *available at* http://www.munichre.com/site/corporate/get/documents_E732398503/mr/assetpool.shared/Documents/0_Corporate%20Website/6_Media%20Relations/Press%20Releases/2013/2013_01_03_munich_re_natural-catastrophes-2012_en.pdf (last visited Mar. 10, 2014); *Natural catastrophe statistics for 2012 dominated by weather extremes in the USA*, MUNICHRE, Reinsurance Press Release, http://www.munichre.com/en/media-relations/publications/press-releases/2013/2013-01-03-press-release/index.html (last visited Mar. 10, 2014).

month of 100° F days.[16] To put this into context, Illinois summers will feel more like Arkansas at the end of the century than its current climate.

To summarize the climate science, we know that the climate is changing. The associated impacts are already affecting our built social, natural, economic, and cultural assets. We know there will be future impacts, and more frequent and severe extreme events no matter what path might be taken to reduce emissions. In response to this future, proactive preparedness and preventative actions will be more cost effective than reactive action. This constitutes a very clear case for adaptation measures and initiatives in the United States.

III. DEVELOPMENTS IN ADAPTATION TO CLIMATE SCIENCE

In the United States, adaptation measures are nascent, but they are growing. Substantial adaptation planning is occurring in the public and private sector, as well as at all levels of government. However, very few planning measures have been implemented, and those that have appear to be quite incremental.[17] The Federal Government is taking action on both the mitigation and adaptation fronts.[18] The States are becoming important in climate efforts and in adaptation, though there is more room for action, as shown in Figure 9. In the Midwest region, only Wisconsin has a state-level climate adaptation plan. Many of the states, however, have mitigation plans or are thinking about adaptation plans.

Two interesting case studies of state-level adaptation initiatives can be found in New York and California. New York has a climate-smart communities program, which is a unique state-local partnership to advance community goals for health, safety, and improved quality of life, as well as mitigating measures to reduce greenhouse gases and move towards energy independence and resilience.[19] In New York, six state agencies jointly sponsor the program.

The Cal-Adapt[20] program in California is another example of

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16. ENVIRONMENTAL PROTECTION AGENCY, *Climate Impacts on Human Health*, http://www.epa.gov/climatechange/impacts-adaptation/health.html#impactsheat (last visited Mar. 10, 2014).

17. *See* Rosina Bierbaum, et al., *A comprehensive review of climate adaptation in the United States: more than before, but less than needed*, MITIG ADAPT STRATEGIES GLOB CHANGE 18:361-406 (2012).

18. *President Obama's Plan to Fight Climate Change*, WHITEHOUSE.GOV, (June 25, 2013), *available at* http://www.whitehouse.gov/share/climate-action-plan.

19. *Climate Change*, NEW YORK STATE DEP'T. OF ENVIRONMENTAL CONSERVATION, http://www.dec.ny.gov/energy/44992.html (last visited Mar. 10, 2014).

20. *See* CAL-ADAPT, http://cal-adapt.org/ (last visited Mar. 10, 2014) (offering research and information on California's climate change).

an innovative state-scale adaptation effort. California has a climate action team (CAT) that works to coordinate statewide efforts on both mitigation and adaptation, and issues a biennial report. California's CAT has just developed near-term implementation plans for fifty different mitigation and adaptation strategies within the states.

While state and federal actors are taking many actions, either in planning or preparing for climate change, the majority of the work is taking place on local and regional levels of government. The primary mechanisms that local governments use are planning to protect infrastructure, developing regulations for the design and construction of buildings, roads, and bridges, or improving extreme events response and recovery.[21] On an optimistic note, 59% of U.S. local governments report that they are engaged in some form of adaptation planning. A prominent city at the forefront of climate adaptation is Chicago,[22] which has a citywide adaptation plan that covers everything from green infrastructure design to combatting heat stress to enhancing forest cover.

Non-governmental actors are helping to facilitate climate adaptation planning, mostly through publically available tools and information. Three good examples are the National Wildlife Federation site, ICLEI (the climate resilience cities program), and the Georgetown Climate Adaptation Clearinghouse.[23] Parts of the private sector are beginning to prepare for climate change as well. A number of adaptation actions are being taken by concerned industry and companies, principally with regard to insuring reliability of agricultural feed stocks, water supply, continuance of core operations, and developing contingencies if extreme events disrupt their global supply chains.

Barriers to adaptation certainly exist. Examples include lack of funding, policy and legal impediments at the local, regional, state, and national scales, and difficulty in actually anticipating climate-related changes. For example, how could Joplin, Missouri really prepare for the tornado that hit it in 2011? Or Cedar Rapids for the 2008 flood? Or, Colorado, for their recent storms? An

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21. *See generally* Bierbaum, et al., *A comprehensive review of climate adaptation in the United States: more than before, but less than needed, supra* note 18.

22. Adaption, CHICAGO CLIMATE ACTION PLAN, *available at* http://www.chicagoclimateaction.org/pages/adaptation/11.php (last visited Mar. 10, 2014).

23. *Climate Smart Communities* NAT'L WILDLIFE FOUNDATION, *available at* http://www.nwf.org/What-We-Do/Energy-and-Climate/Climate-Smart-Conservation/Climate-Smart-Communities.aspx (last visited Apr. 1, 2014); Adaptation Database and Planning Tool (ADAPT), *available at* http://www.icleiusa.org/tools/adapt (last visited Apr. 1, 2014); and *Adaptation Clearinghouse,* GEORGETOWN L. CLIMATE CENTER, *available at* http://www.georgetownclimate.org/adaptation/clearinghouse (Last visited March 30, 2014).

important implication is that adaptation cannot just be incremental changes made it real time—it must involve the process of actively preparing for a future that is very different from today.

In adaptation, there is no one-size-fits-all solution. However, similar kinds of information are needed in each locality. Communities require reliable and regularly updated data on climate trends and likely impacts, and in a form that is usable and accessible. There is a key role for Federal agencies to supply such "climate services." The actual process of adaptation involves some common steps, beginning with the full complement of stakeholders at the table to identify the problems and the solutions that are being discussed. Any adaptation plan starts with first characterizing what is at risk. Second, options to cope with the impacts are chosen. Third, actions are implemented. Fourth, the results should be monitored and evaluated. Finally, the results should then inform any revision to the adaptation plan, as shown in Figure 10. Few projects in the U.S. have gotten even to stage three, the implementation phase.

It is clear that vulnerability to climate change is exacerbated by many other stresses, such as pollution, habitat fragmentation, invasive species, and biodiversity loss. Solutions to the risks posed by climate change must be thought about in the composite context of these other stressors, to avoid creating new problems or exacerbating old ones. However, efforts to reduce vulnerability to climate change can often fulfill other societal goals such as disaster risk reduction, or improvements health outcomes, and therefore could be incorporated into ongoing decision-making. Examples of such efforts and options to enhance resilience can include institutional options, such as zoning for increased flooding or mitigation of the heat island effects through white or green roofs (such as Chicago has embraced), which help with current problems as well as climate change. However, to date, the effectiveness of climate change adaptation has seldom been evaluated, likely because actions have only recently been initiated, and very few have actually been implemented. Monitoring, verification, and evaluation are important tasks for the adaptation community.

IV. WHAT'S NEXT AND WHAT STILL NEEDS TO BE DONE

The mantra of current adaptation efforts is "more than before, but less than needed." To move towards concerted and widespread adaptation action, we need to embrace the idea that "stationarity is dead,'[24] and that there will be a new normal in this constantly

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24. Stationarity is the idea that natural systems fluctuate within and unchanging envelope of variability. MILLY, P. C. D., ET AL. *Stationarity is dead*, GROUND WATER NEWS & VIEWS 4.1 (2007): 6-8.

shifting mode. We need to mitigate or reduce emissions as much as possible to avoid getting into unmanageable territory, but we also need to prepare, adapt, and cope with unavoidable changes already underway.[25] This requires stakeholders to understand risks, to develop feasible and acceptable options, and to monitor efforts once implemented, and use this knowledge to revise the strategy.

We are not dealing with extreme events well enough today. Specific examples of what we can do to further our adaptability abound. We need to think about infrastructure that can withstand the new hundred-year flood. We need to identify and invest in crops that perform well in hotter, drier summers, as well as wetter, cooler ones. We need to better protect people, infrastructure, and livestock from extreme events by improving both our preparedness and responses to floods, droughts, and extreme storms. We can do this by rapidly sharing "best practices" and "lessons learned" from communities that have grappled with these issues. On a larger scale, meaning on the national level, we need better monitoring and periodic assessments of adaptation options and efforts to understand what we know, what we do not know, what we need to know, what is knowable in what time frame, and then conduct the research and disseminate information to managers and policy makers to inform wise decisions.

In all cases, we need to move beyond incremental adaptation options, and we need to think about what sort of transformational options might be needed in agriculture, forestry, water systems, urban design, protection of parks, and more for the next century. We need to be thinking about this proactively. A world we can aspire to is one where individuals and communities are well-prepared to cope with climate impacts, and where national leadership on climate action and resilience exists, with community-led resilience efforts receiving appropriate support. In this scenario, a set of best practices from adaptation efforts around the nation is readily available. Site-specific risk information would be available, transparent, and effectively communicated. We want a vibrant and diverse economy and a safer, healthier, and better-educated citizenry than we had in previous generations. This is only possible if we tackle climate change. We are responsible for our own future, more so than any prior generation.

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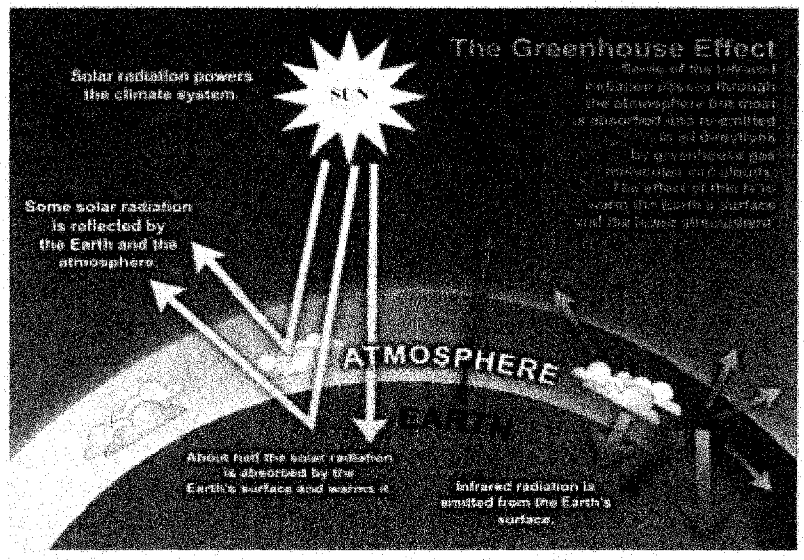
25. R. M. Bierbaum, et. al, *Confronting Climate Change: Avoiding the Unmanageable and Managing the Unavoidable* (eds.) Scientific Expert Group on Climate Change (SEG), 2007 *available at* http://www.globalproblems-globalsolutions-files.org/unf_website/PDF/climate%20_change_avoid_unmanagable_manage_unavoidable.pdf (last visited Apr. 1, 2014) (report prepared for the United Nations Commission on Sustainable Development)

FIGURES

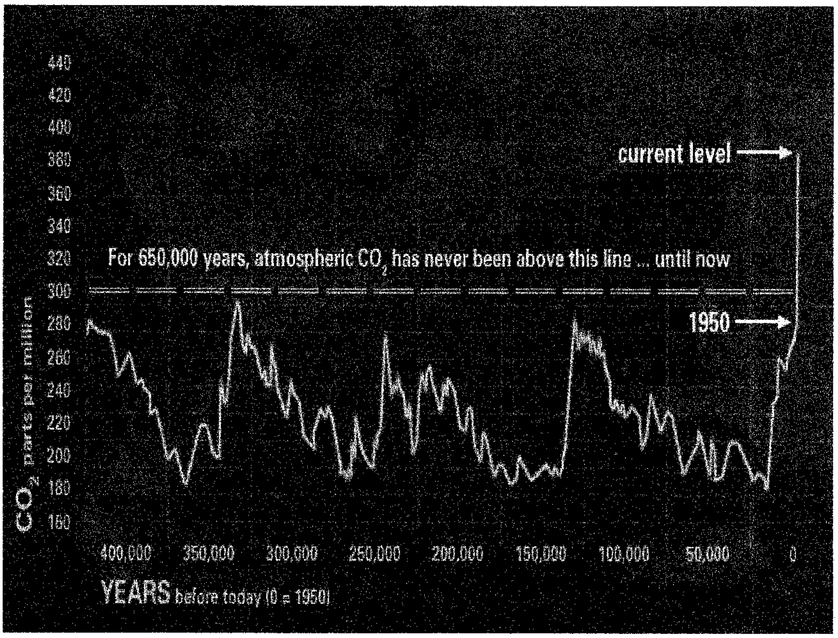
Figure 1. The Greenhouse Effect



A depiction of the role of the greenhouse effect in Earth's energy budget.

Source: MANAGING CLIMATE VARIABILITY INITIATIVE (AUSTRALIA), *Climate change: the scientific basis for concern*, *available at* http://www.managingclimate.gov.au/publications/climate-change-the-scientific-basis-for-concern/ (last visited Mar.13, 2014).

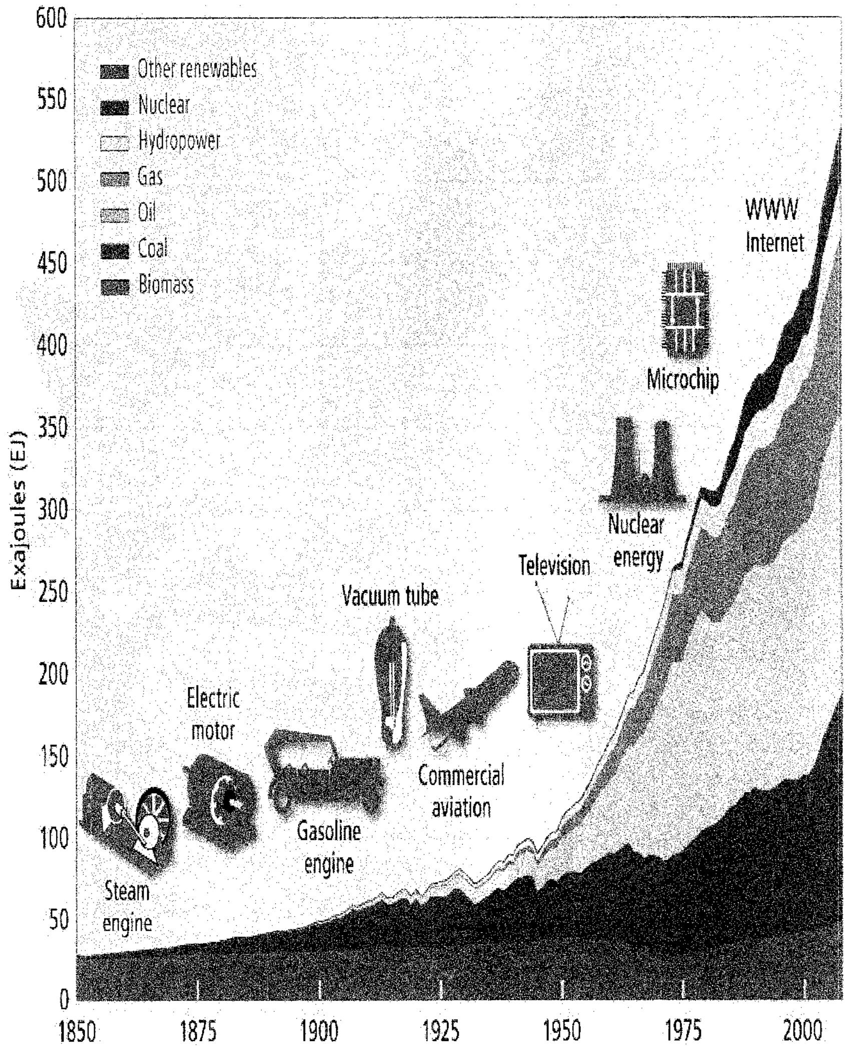
Figure 2. Historical Climate Record



Shows atmospheric CO_2 concentrations during the past half-million years.

Source: *Climate Experts Debate Strategies for Reducing Atmospheric Carbon and Future Warming*, PHYS.ORG, (Nov. 25, 2009), http://phys.org/news178392408.html.

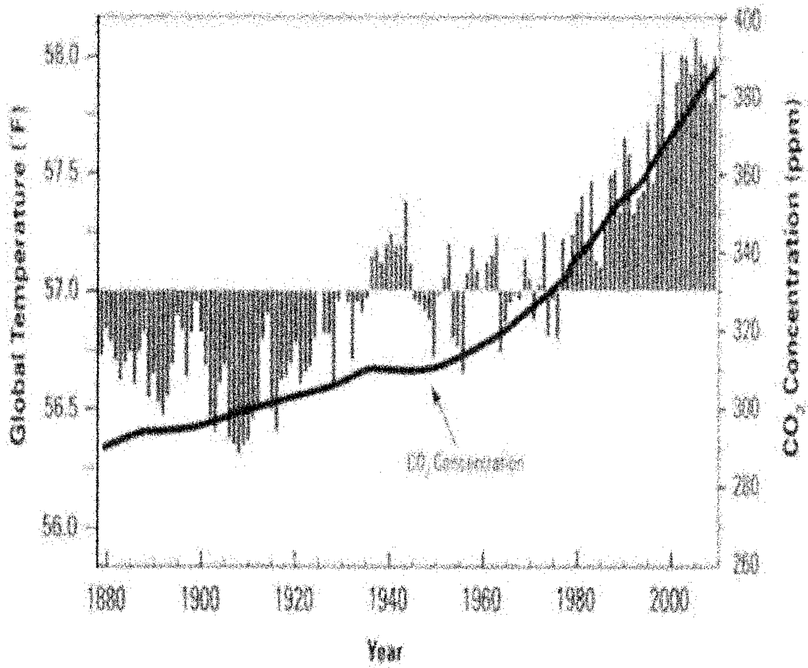
Figure 3. World Energy Sources



Shows the distribution of world energy sources and changes over time.

Source: ARNULF GRUBLER, ENERGY PRIMER. IN GLOBAL ENERGY ASSESSMENT—TOWARD A SUSTAINABLE FUTURE, Ch. 1 (IIASA, Vienna, Austria and Cambridge University Press, 2012).

Figure 4. Global Surface Temperature and Carbon Dioxide



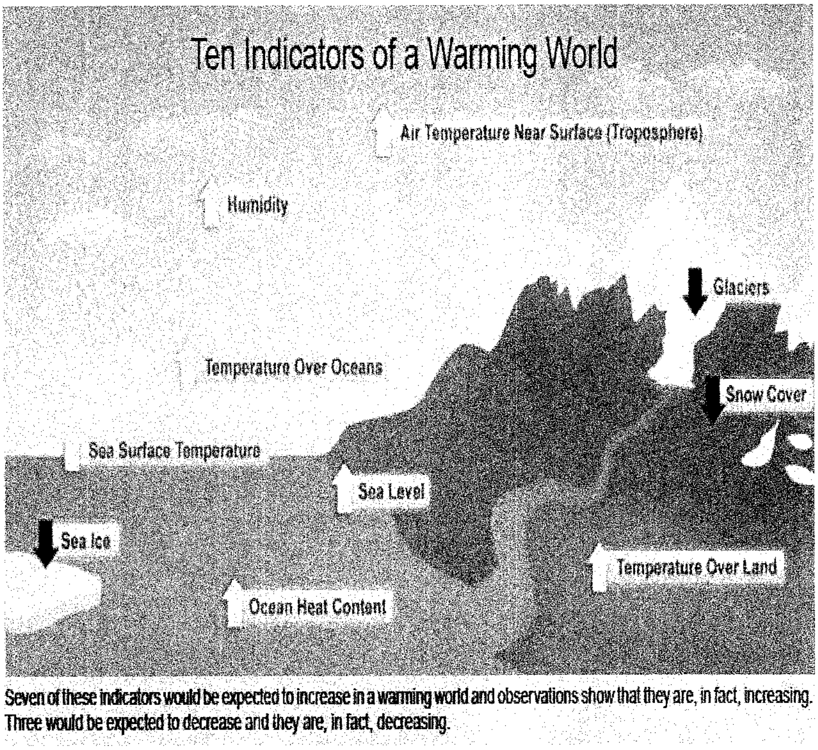
Global Surface Temperature and Carbon Dioxide

Surface records show global average temperature continuing to rise during the last half century. Natural warming and cooling cycles (of several years to a decade) are also evident. Red (above average) and blue (below average) bars show global temperature compared to the average from 1901-2000.
Source: NOAA/NCDC[1]

Shows how CO_2 and temp. have both been increasing.

Source: NOAA NATIONAL CLIMATIC DATA CENTER, Source: U.S. National Climate Assessment 2013 Public Review Draft, *available at* http://ncadac.globalchange.gov/download/NCAJan11-2013-publicreviewdraft-chap2-climate.pdf (last visited Apr. 1, 2014).

Figure 5: Warming Indicators



Shows the indicators and direction of changes due to global warming

Source: *Ten Indicators of a Warming World*, NOAA.GOV, *available at* http://www.noaanews.noaa.gov/stories2010/images/warmingindicators.jpg (last visited Mar. 13, 2014).

Figure 6: Precipitation Increase During Extreme Events

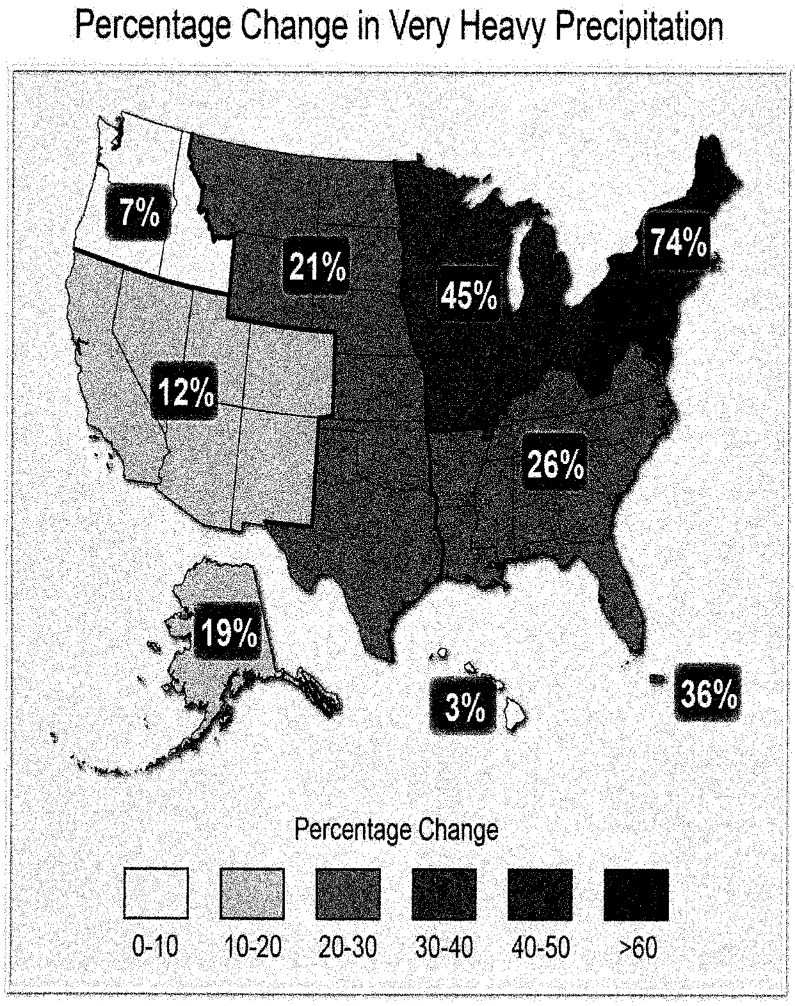


Figure 2.16: Percentage Change in Very Heavy Precipitation
Caption: The map shows percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2011 for each region. There are clear trends toward a greater amount of very heavy precipitation for the nation as a whole, and particularly in the Northeast and Midwest.
(Figure source: updated from (Karl et al. 2009) with data from NCDC)

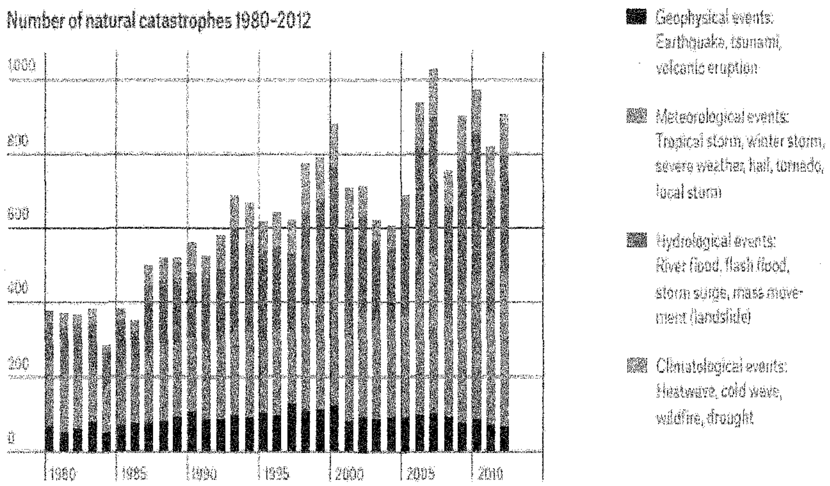
Source: National Climate Assessment Draft January 2013; http://ncadac.globalchange.gov/download/NCAJan11-2013-publicreviewdraft-chap2-climate.pdf

Shows how precipitation has increased during extreme events in different regions of the United States.

Source: U.S. National Climate Assessment 2013 Public Review Draft, *available at*

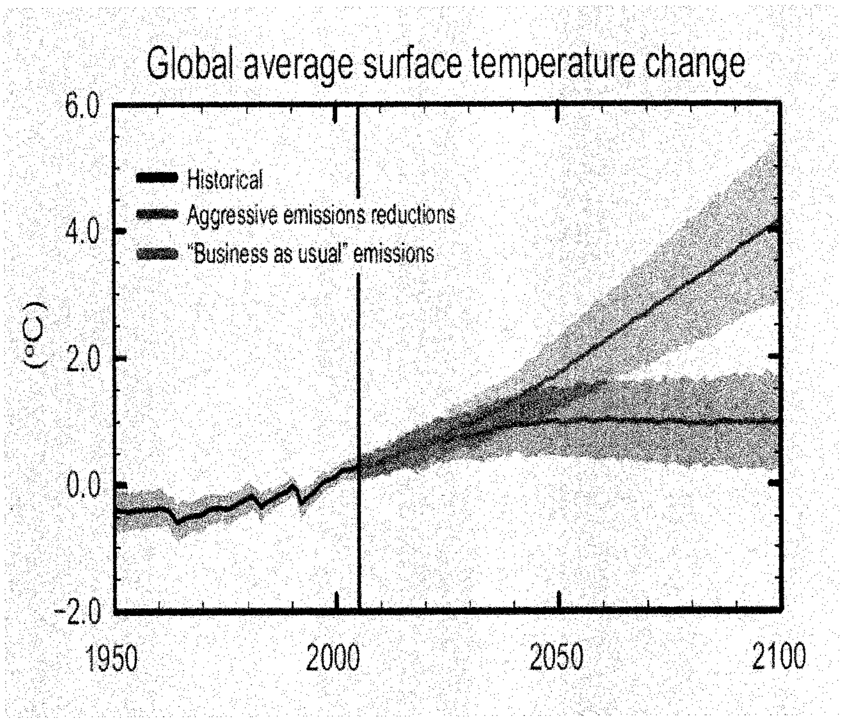
http://ncadac.globalchange.gov/download/NCAJan11-2013-publicreviewdraft-chap2-climate.pdf (last visited Apr. 1, 2014).

Figure 7: Natural Catastrophes



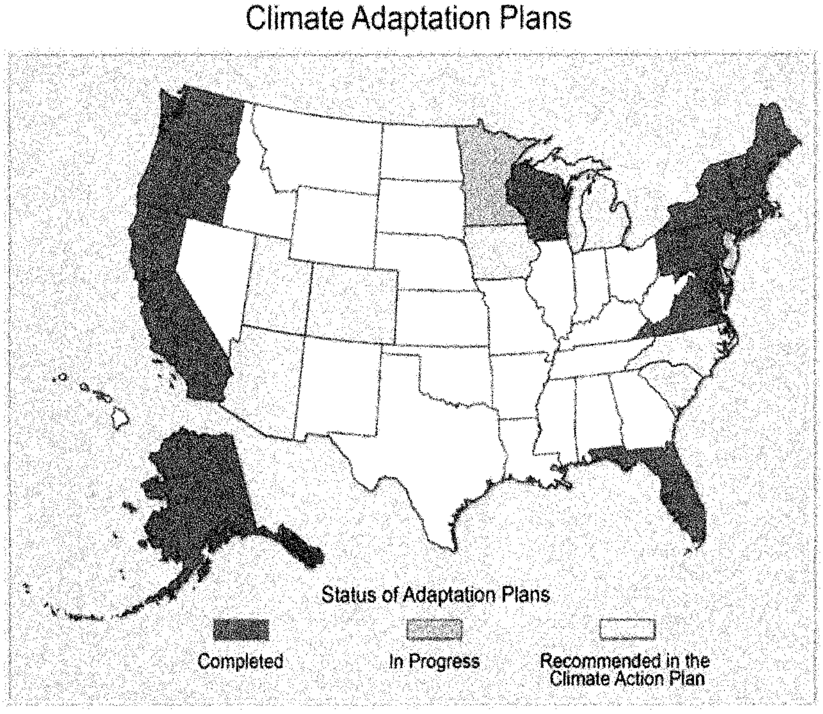
Source: Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE, *available at* http://www.munichre.com/en/media_relations/press_releases/2014/2014_01_07_press_release.aspx (last visited Mar. 10, 2014).

Figure 8: Climate Change 2014



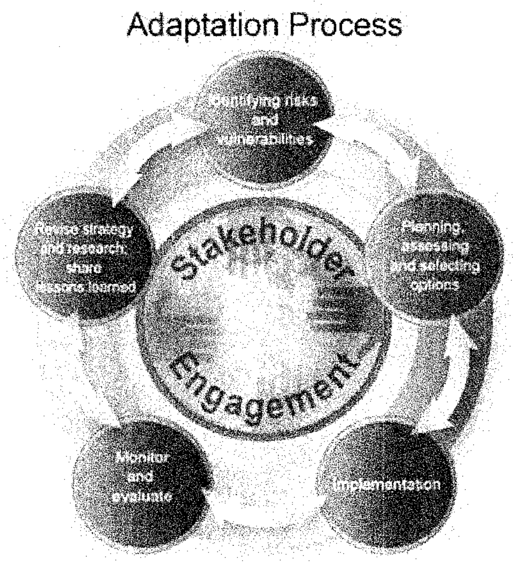
Source: NAT.'L ACAD. OF SCIENCES & THE ROYAL SOCIETY, *Climate Change: Evidence & Causes: An Overview from the Royal Society and the U.S. National Academy of Sciences, available at*, http://nas-sites.org/americasclimatechoices/more-resources-on-climate-change/climate-change-evidence-and-causes/climate-change-evidence-and-causes-figure-gallery/#jp-carousel-1318 (last visited Apr. 1, 2014).

Figure 9: Status of State-level Climate Adaptation Plans



Source: CENTER FOR CLIMATE AND ENERGY SOLUTIONS, "State and Local Climate Adaptation" *available at,* http://www.c2es.org/us-states-regions/policy-maps/adaptation (last visited Mar. 13, 2014).

Figure 10: Adaptation Cycle



Source: U.S. National Climate Assessment 2013 Public Review Draft, *available at*
http://ncadac.globalchange.gov/download/NCAJan11-2013-publicreviewdraft-chap28-adaptation.pdf (last visited Apr. 1, 2014).