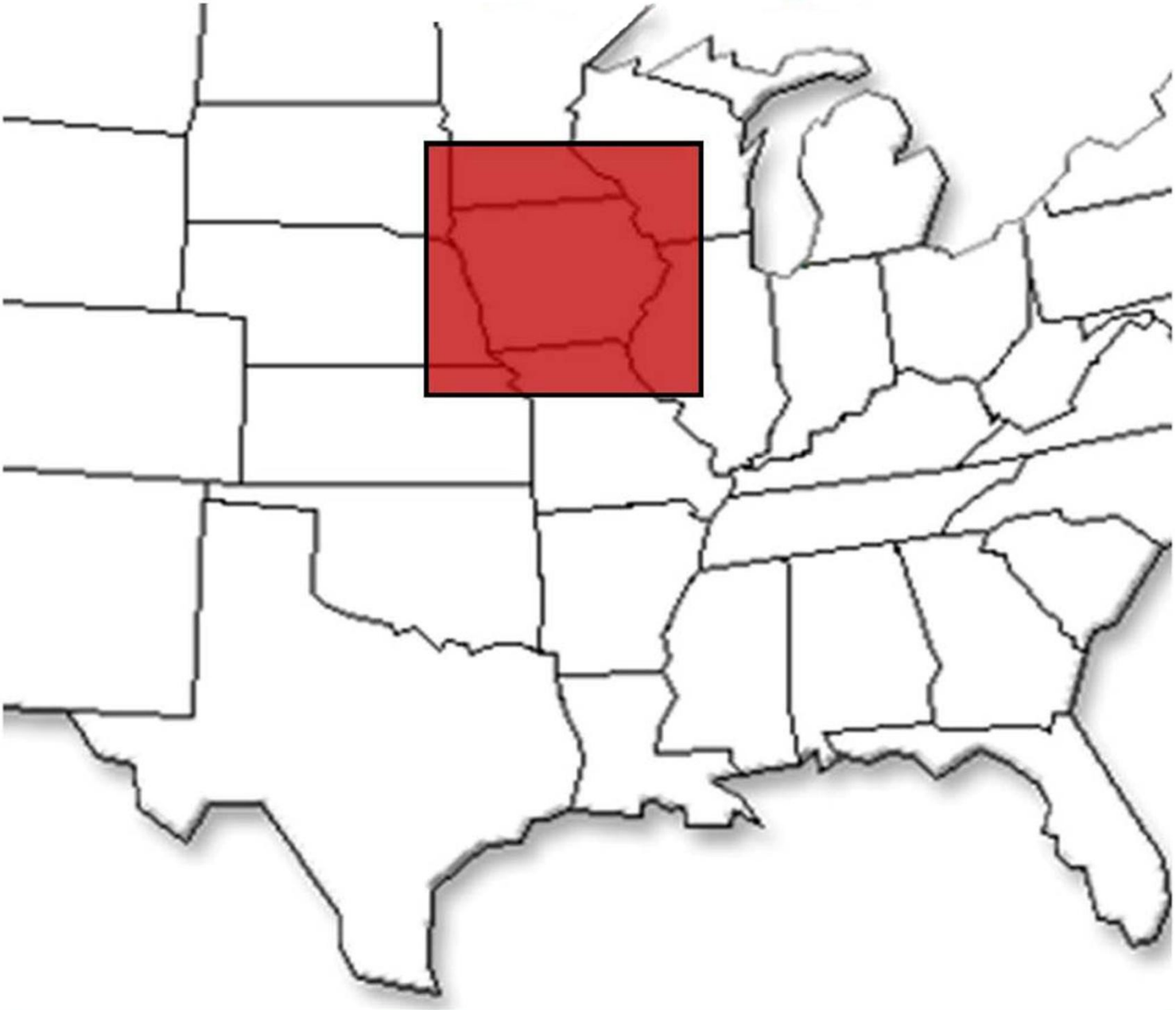
PSR

PHYSICIANS FOR SOCIAL RESPONSIBILITY

DEATH BY DEGREES

HEALTH THREATS OF CLIMATE CHANGE IN IOWA



IOWA REPORT 2016

A REPORT BY THE IOWA CHAPTER OF PHYSICIANS FOR SOCIAL RESPONSIBILITY

This report was prepared by the Iowa Chapter of Physicians for Social Responsibility (PSR/Iowa) to alert Iowans to the unfolding health effects of climate change in Iowa and to encourage all Iowans and elected leaders to make the changes needed to help halt and eventually reverse global warming's deadly course.

Physicians for Social Responsibility (PSR) works to protect life and health from the gravest threats to health and survival including climate change, environmental degradation and nuclear weapons.

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About Physicians for Social Responsibility

PSR has a long and respected history of physician-led activism to protect the public's health. Founded in 1961 by a group of physicians concerned about the impact of nuclear proliferation, PSR shared the 1985 Nobel Peace Prize with International Physicians for the Prevention of Nuclear War for building public pressure to end the nuclear arms race. Today, PSR's members, staff, and state and local chapters form a nationwide network of key contacts and trained medical spokespeople who can effectively target significant threats to global survival. Since 1991, when PSR formally expanded its work by creating its environment and health program, PSR has addressed the issues of global warming and the toxic degradation of our environment. PSR presses for policies to curb global warming, ensure clean air, generate a sustainable energy future, prevent human exposures to toxic substances, and minimize toxic pollution of air, food, and drinking water. Iowa PSR is a proud member of this esteemed family of physician and health professional activists.

Acknowledgements

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Proud member since 2005

Dedication

To Iowans, friends, families & neighbors all around the globe seeking health and security in our rapidly changing world.

Time to Pay Attention

Climate Change is not a new concern, rather one that just keeps growing.

In 1995 Dr. Eric Chivian wrote:

Over the last several years, we have been deluged with reports from scientists worldwide, detailing the accumulation of greenhouse gases in the atmosphere, and warning us that unless we are able to reduce our emissions of these gases, we are likely to experience major changes in the world's climate, with consequences that could prove disastrous for human beings. . . it is essential that health be at the center of the global environmental debate, and that physicians and other health professionals take the lead in educating the public and informing policy-makers about the human dimensions of global environmental change.

Eric Chivian, MD
Director, Center For Health and the Global Environment
Harvard Medical School

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Executive Summary

GLOBAL WARMING IS UNEQUIVOCAL

> ***Climate change is one of the greatest health threats facing humanity in the 21st century. As worldwide patterns of temperature, precipitation and weather events change, the delicate balance of climate and life is disrupted, with serious impacts on food and agriculture, water sources, and health.***
>
> -- PSR Climate Change, Environment Health Statement

The world, including Iowa, is warming at an unprecedented rate. The global temperature, including that of the world's oceans, has been increasing over the past 50 years due to emissions of heat trapping gases, primarily CO_2 released by burning fossil fuels, and the loss of natural carbon sinks. By April 2015, CO_2 in the atmosphere hit the highest level ever recorded: 409.44 ppm, and Arctic ice reached a record low. Fifteen of the warmest years on record have occurred since 2001. The year 2015 shattered all previous records by a wide margin. December 2015 was both record warmest and record wettest, the only month ever to break both records. The year 2016, at this writing appears to be on course to continue the trend. In the face of scientific evidence of a warming planet, public perceptions and responses remain minimal relative to the growing threats to health and other related dangers.

Accelerating climate change in a warming world is a complex process that does not manifest simultaneously and uniformly everywhere around the globe but largely in a pattern of intermittent local weather events. Public perception is confounded by intermittency and local variations. Still, the global trend is now unmistakable and as a doctor might put it, "clinically significant." While warming can be seen by some as a benefit, the long-term trend will become devastating for agriculture. In fact, Iowa's lengthening growing season can be recognized as the proverbial "lull before the storm." But the situation for Iowa's farmers today is only part of the Iowa climate story.

CLIMATE CHANGE AS THREAT MAGNIFIER

Climate change works in many ways to threaten Iowa's health and well-being. Consequences of climate change challenge social, environmental and economic health by exploiting existing weaknesses in infrastructure, air and water quality, and social cohesion.

Regardless of the relative invisibility of unfolding climate change, Iowa already faces challenges not only to the environment and economy, but also to health and human rights. Scientific consensus indicates that within years, not decades, higher temperatures and more violent storms with heavy precipitation will intensify. Intensified weather extremes will worsen Iowa's agriculture, water quality, food production, health, and economy. Iowa is challenged to change now, or pay dearly later.

This report reviews recent climate science, especially on associated health risks, in an effort to make recognition of climate change risks real, local and accessible. The elements addressed in this report are designed especially to encourage action from Iowa's decision makers, leaders in the health and business professions, and compel communities to accelerate the pace of climate mitigation and adaptation.

IOWA'S ALTERED ENVIRONMENT AND CHANGING CLIMATE

IOWA IS GETTING WARMER AND WETTER

Warmer air holds more moisture. Most Iowans already feel the impact of the changing climate through the evolving changes in precipitation cycles. Extreme precipitation events with attendant tornadoes, downpours, and floods, interspersed by severe drought, are expected to intensify in the coming years.

Iowans are accustomed to four-season weather with widely varying cycles of temperature, humidity, rain, and wind. While severe storms can occur in any season as the globe warms, Iowa can expect more chaotic, dangerously unpredictable weather with more severe or persistent extremes that have corresponding health impacts.

Iowa has experienced a sustained rise in number, range and severity of floods and storms. Precipitation across the U.S. has increased about five percent over the past 50 years. In Iowa, precipitation has increased over eight percent even as southern and western areas of the state become drier. Climate scientists predict the warming climate will produce flooding of the intensity of the 1993 & 2008 floods every 3 - 20 years.

Very little of Iowa's native protective natural environment remains intact. Most of Iowa's original wetlands, prairies and cooling forests are gone. Consequently, Iowa has lost its organic, nutrient and microbially rich topsoil at an unsustainable rate. Finally, due to the effect of Iowa's intensive agricultural industry, especially the extensive tiling system, many of Iowa's surface waters have been degraded. Iowa's water resources are imperiled by pesticides, fertilizer and manure that wash off the land during downpours. Heavier precipitation and flooding can be expected to progressively worsen these problems.

CLIMATE AND IOWA'S HEALTH

When determining health risks of climate change for Iowa, factors to consider include the state's aging water infrastructure and widespread water pollution; aging population; inadequate mental health resources; increasing intensity and duration of allergen producing plants; and the ever-present risk of animal to human transmission of difficult to contain microbial contaminants associated with confined livestock. Each of these risks grow in a warmer, wetter Iowa.

Over recent years, Iowa's growing season has lengthened, Iowa cities have become at least 1.0° F. warmer on average. More heat and heat waves are associated with degraded urban air quality; worsening urban heat islands; a wider array and penetrance of disease-carrying vectors; and rapid growth and spread of the infectious organisms that grow in food and imperiled water sources.

The most serious challenges to health associated with Iowa's changing climate include worsened respiratory and cardiovascular diseases; injuries; altered infectious diseases; allergies; and death as a direct consequence of extreme storms and heat waves. Additionally, Iowans can expect to experience worsening mental health in the aftermath of increasingly extreme weather events.

Every Iowan is at some risk, but not all are at equal risk. Similar to health threats, climate change amplifies stress on social, physical infrastructure, and environment frailties. Vulnerability varies across age, gender, economic and occupational status, geographic residence, chronic illness, diability. and racial and ethnic status of individual Iowans.

Heat Waves and Droughts

Higher precipitation will be interspersed with more intense periods of desiccating heat that neither animals nor humans tolerate. In urban centers it creates dangerous "heat islands" because of building density, heat trapping surfaces (concrete and asphalt), roadways, and traffic congestion. Heat islands concentrate air pollutants like particulates, smog and ozone. Unrelieved extreme high temperatures contribute to neurologic impairment; respiratory distress; cardiovascular collapse and death, especially among infants, elders, those with pre-existing disease; and those who labor outdoors.

Allergens

Allergenic flora such as poison ivy, and trees, grass and weed pollens are already increased due to longer, warmer, and wetter growing seasons in Iowa. Allergies cause misery, lost productivity at work or school, and need for costly medications. For those who experience allergy-induced breathing problems like asthma, these powerful allergens become life threatening, especially in concert with prolonged heat and air pollutants.

Vectors on the Move

"…human-caused micro-perturbations in ecologic balance can cause innumerable slumbering infectious agents to emerge unexpectedly."

-- Dr. Anthony Fauci

The number and variety of vector-borne diseases will increase. Infectious organisms constantly adapt and the vectors that carry them are on the move. Rising temperatures with movement northward of disease-carrying birds, bugs, and rodents increase the spread of vector-borne diseases. Lyme disease, West Nile virus, and Rocky Mountain spotted fever, are rapidly emerging vector-borne infectious diseases in Iowa.

Avian Influenza and Climate Change

The role of the changing climate and related environmental damage has altered the habits of wild birds. To date, avian influenza virus strains do not easily infect humans. Because of the lethality of the disease in birds and extensive damage done in 2015 to Iowa's poultry industry, epidemiologists are closely tracking human/avian interactions.

Mental Health

In 2016 Iowans face a severe shortage of mental health providers and mental health facilities. As flooding, tornadoes, and prolonged heat waves worsen in intensity and duration, symptoms such as anxiety, depression, social withdrawal, and incidence of post traumatic stress disorder and will all rise to further burden the weak mental health care system in Iowa.

Iowa's Vulnerable Populations

Iowans and Iowa's economy are healthier than many other areas in the U.S. Measures of inequality indicate a more equal distribution of income in Iowa relative to 45 other states. Yet, Iowa is home to significant vulnerable and impoverished populations.

Of Iowa's total population of just over 3 million, there are 560,000 elderly, disabled and low-income Iowans who rely on Medicaid—one out of six Iowans. And this statistic does not include the working poor who desperately struggle to survive catastrophic climate events and often lack the resiliency to ever completely recover.

Iowans are aging, and elders do not tolerate heat. Meeting elders' needs in a changing climate is of high priority but will strain existing social and health services in Iowa. For Iowa's African American and other minority communities, high unemployment and incarceration rates, worsening population health indicators, and a widening wealth gap combine to impair resiliency in the face of weather disasters.

Iowa's demographic mix is rapidly changing in part due to hosting increasing numbers of refugees who have escaped climate and environment related challenges in their native countries. Iowa also receives domestic U.S. "climate" refugees from coastal weather catastrophes.

Not to be overlooked, some of the nation's most dangerous and climate sensitive occupational settings are concentrated in Iowa including farming, confined animal feeding operations (CAFOs) and packing plants. All these demographic factors will become even more challenging to Iowa's vulnerable populations as heat waves and extreme weather increase in frequency and intensity.

Toward Solutions

Thermal Lag, Thresholds & Tipping Points

Thermal lag, reflecting the long half-life of GHGs, means despite what is done today temperature increases are expected well into the next few decades. Continuing to allow levels of GHGs to rise, primarily from the burning of fossil fuels, will inevitably lead to points-of-no-return with irreversible and massive sea level rise with inundation of the world's coastal areas; more powerful and damaging super storms from which recovery is unlikely; dislocation of hundreds of millions of people; and massive loss of agricultural productivity and famine. Such a tipping point could arrive sooner than expected. The track record of climate science and modeling predictions have consistently underestimated the subsequently observed rate of temperature and sea level rise. In the simplest terms, future climate conditions will be determined by policies made and actions taken today to reduce current and future GHG emissions.

Climate Reality and Call to Action

Climate realities and predictable health risks call for enhanced, coordinated, preventive and adaptive action on the part of all Iowans, especially healthcare, business and elected leaders. To minimize adverse health impacts, individuals, businesses, communities, and the State must work together to improve infrastructure and resilience within medical and public health sectors, including heightened surveillance, rapid response protocols, and upgraded mental health services. Iowa also needs to advance preventive and mitigation efforts in city planning; green building; structural design for improved survivability in storms; emergency response to heat waves; and energy efficiency in air conditioning. Infrastructure improvement is critically needed in water and sanitation, transportation, roads, and bridges. Farmers must continue to institute improved proven tilling practices; fertilizer management; and watershed catchment developments including restoring wetlands and riparian environments. Restoration of tree cover in both rural and urban areas will help mitigate climate change with co-benefits of improved air, water, and soil quality.

Climate Change as Opportunity

Mitigating climate change can be both cost-effective and a boon for healthy people, communities, economies, and quality of life. Many Iowans already consider their personal carbon footprint and health and act accordingly. With looming global warming, several individual Iowa cities have already begun mitigation and adaptation. Elsewhere in Iowa, cities and counties have worked together, driven by economic reality in transitioning to locally produced wind and solar energy sources with the added benefit of critically reducing dependence on greenhouse gas emitting fossil fuels. Other cities have improved their tree cover, made their commercial centers more walkable, and improved energy efficiency of their buildings. Iowa's GHG emissions have, in fact, been decreasing. Iowa leads the country in wind energy production per capita, yet only exploits a fraction of this abundant Iowa resource. Solar electricity is now an economic sleeping giant with a solid potential in Iowa.

Nevertheless, there is still a big improvement gap if Iowa is to remain a leader.

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Glossary of Terms & Acronyms

Adaptation: Actions to change how a community or society acts to prevent adverse outcomes. Mechanisms for preparation, threat reduction, and coping with unavoidable changes in the weather and environment as weather extremes, natural disasters, and other climate change related effects increase; efforts

Aero Allergens: Medical term used to describe pollen, spores, and other types of allergens that are transmitted through the air. Aero allergen concentrations will increase as the globe continues to warm.

BAU: Business As Usual. Shorthand term used in may climate reports when talking about what might be expected if no serious changes are made to reduce global fossil fuel energy use, carbon sink removal, or current consumption and trade practices.

CAFO: Confined Animla Feeding Opperation.

CDC: Centers for Disease Control and Prevention.

CEIP: Clean Energy Incentive Program. Companion to the U.S. EPA Clean Power Plan (CPP). Rewards states that act early to bring more renewable energy and energy efficiency to their communities.

CO_{2e}: Equivalent carbon dioxide, sometimes expressed as CO_{2eq}. The concentration of CO_2 that would cause the same greenhouse effect (radiative forcing) for a given concentration of other greenhouse gases, such as methane or nitrous oxide. This can be confused with the Carbon Dioxide Equivalent (CDE) that would represent the concentration of CO_2 that would cause the same greenhouse gas effect as a mixture of different greenhouse gases.

COP21: 21st Conference of the Parties to the United Nations Framework Convention on Climate Change, held in Paris, December 2015

COPD: Chronic Obstructive Pulmonary Disease. Primarily caused by cigarette smoking but also by long term exposure to irritants, dust and fumes, or neonatal factors. COPD is exacerbated by air pollutants.

CPP: Clean Power Plan. U.S. EPA regulations in 2015 promulgated to cut carbon pollution from power plants. The CPP provides incentives, flexibility and opportunity for States working to meet important, public health safeguards by reducing the industrial carbon pollution that triggers asthma attacks, heart attacks and premature deaths.

CSA: Community-Supported Agriculture. Locally grown food network cared for and used by the community of farmers and consumers to access fresher, healthier foods, reduce transportation costs, improve local economies, and mitigate climate change.

°C: Degrees Celsius. Scale of temperature in which water freezes at 0° and boils at 100° under standard conditions—unless indicated otherwise temperatures in this report refer to degrees Celsius since that is the international convention used by climate scientists.

Energy Storage: A variety of means to store energy when energy production exceeds that needed to provide electricity demand, The stored energy can be later used to generate electricity for the grid when demand is high. Examples include: chemical batteries, hot molten metal, pumped water, and compressed air.

EPA. U.S. Environmental Protection Agency established in 1970 under the Nixon Administration.

Extreme Energy. Term used to describe the mining of fossil fuel by destructive and energy intensive extractive mechanisms. Examples include: tar sands oil, deep sea drilling, mountaintop removal, and hydraulic fracturing.

Fossil Fuels. The fuels produced over millions of years from decay and compaction under the earth's surface and include oil, natural gas, and coal.

GHG: Greenhouse Gas. Any of the heat-trapping gases in the atmosphere that include carbon dioxide, methane, nitrous oxide, ozone and synthetic hydrofluorocarbons. GHGs promote retention of solar radiation in the atmosphere, land, and ocean thus creating the greenhouse effect. Rising concentrations of GHG in the atmosphere is the key driver of global warming.

Heat Island Effect: Refers to disproportionate high temperature that arises in densely populated urban/metropolitan areas due to the concentration of concrete, steel, vehicle exhaust, and lack of greenery relative to natural rural areas with green spaces and trees.

HSI: Heat Stress Illness

IPCC: Intergovernmental Panel on Climate Change. The leading international body for the study of climate change. Established by the World Meteorological Association and the United Nations Environment Program (UNEP) in 1988. Thousands of international climate scientists from 195 countries and territories are members of the IPCC and contribute to its work

World Meteorological Organization: WMO. Established in 1950 in the United Nations Development Group as the United Nations specialized agency for meteorology, hydrology, and geophysical sciences.

LEED: Leadership in Energy and Environmental Design. Third party rating and certification system for green buildings established by the U.S. Green Building Council for all new building and renovations to promote efficient energy and water use, reduce GHG emissions, and ensure materials are safe for human health and the environment.

Methane (CH_4): Naturally occurring GHG, also known as "natural" gas, but far more potent than CO_2. Methane is found both below ground and under the sea floor and is used as a fuel and in industrial chemical processes. Methane is produced in the environment by fermentation of organic matter such as manure and in the guts of herbivores. Methane as a global warming potential of 78 and 34 times that of CO_2 over a20-year period and 72 over a 100-year period, respectively.

Mitigation: Measures to reduce the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere.

NAAQS: National Ambient Air Quality Standards for fine particulate matter, SO_2, ozone and others.

Nitrous Oxide (N_2O): Toxic air pollutant and powerful GHG produced by vehicle emissions, gives rise to Nitric Oxide which contributes to ground level ozone. Compared to CO_2, N_2O has 298 times the ability per molecule of gas to trap heat in the atmosphere. Also used as anesthetic and analgesic in surgery.

NOAA: National Oceanic and Atmospheric Administration.

Ozone (O_3), Tropospheric: Ground and lower atmospheric ozone has prominent health effects as a respiratory irritant formed when man-made VOC pollutants combine with heat and humidity. Health effects occur at relatively low ozone levels, especially in the chronically ill, elderly, children and infants.

Ozone (O_3), Stratospheric: Atmospheric layer ozone 10 to 30 miles above the Earth protects terrestrial humans, flora and fauna by preventing the harsh UV rays and radiation from entering the atmosphere. This layer allows for breathable oxygen levels at the surface.

Passive Design: Method of building design that accounts for solar exposure according to the seasonal position of the sun to minimize use of artificial energy by maximizing natural heating, cooling, and lighting.

ppm: Parts per million. Common units to indicate concentration of trace toxic pollutants in the atmosphere.

Solar Energy: Radiant energy emitted by the sun that can be harnessed to meet energy demands: passively as in rooftop water heaters, solar hot air heaters and clothes lines for drying, or converted to electricity when energy is collected by photovoltaic panels.

STAR City: Sustainability Tools for Assessing and Rating communities. STAR is toolbox developed for community leaders to assess the sustainability of their community, set targets for the future, measure progress along the way; includes economic, environmental and social aspects of sustainability, and consists of a number of goals, objectives, and evaluation measures.

Thermal Lag: Also Thermal Latency. Given the long half-life of greenhouse gases, primarily CO_2 currently in the atmosphere, global temperature will continue to rise accumulating past emissions.

Tiling: Network of buried drainage tubes used by farmers to drain excess water off land into near-by streams. When the water table is near the soil surface, without tiling, water ponds in surface depressions hampering agricultural productive. Iowa has ~3,000 drainage districts covering 12 million acres. Tiling contributes to increased runoff of agrichemicals into public waters.

Tipping Point: Threshold for abrupt and irreversible change. With global warming a threshold is foreseen when several accelerating drivers (methane release from thawing of the permafrost, loss of polar ice reflectivity, and "thawing" of deep ocean methane crystals melt) will lead to irreversible acceleration of global warming. Precise levels of climate change sufficient to trigger a tipping point remain uncertain but the risk or reaching a tipping point increases with rising global temperature.

Topographic Change: Altering the shape and features of the surface of earth as in mountain top removal mining or melting of the glaciers.

Troposphere: The lowest region of the atmosphere, extending from the earth's surface to a height of about 3.7–6.2 miles (6–10 km), which is the lower boundary of the Stratosphere.

Vulnerability: Characteristics and situations of some population groups resulting in a disproportionately lower capacity to anticipate, cope, resist, and recover from the impact of a natural disaster. Multi-dimensional construct simply synonymous with poverty but involving socioeconomic status, age, race and ethnicity, gender, functional needs, home ownership, health, and language proficiency.

Vector-borne disease: Diseases such as malaria, dengue, West Nile, Lyme and now Zika caused by a microorganism (vector) such as a virus, bacteria or protozoa that is transmitted to humans by an vector such as a rodent, an insect or a tick.

VOC: Volatile Organic Compound. VOCs are chemical compounds containing carbon plus other elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulfur and/or nitrogen. VOCs easily evaporate and are emitted by thousands of products and by burning fuels such as gasoline, wood, coal, or natural gas. When combined with nitrogen oxides VOCs react to form ground-level ozone.

Wind Energy: Non-polluting, renewable electrical generating resource. The electrical power generated windmill turbines driven by the wind created by the sun heating the earth unevenly. Iowa has excellent wind resources and in 2016 35.7% of electricity generated in the state was from wind. The intermittencies of wind energy and solar energy are complementary.

WHO: World Health Organization. Public health arm of the United Nations, working to improve the health of the world's people and prevent or control communicable diseases globally. Monitors disease outbreaks and advises on responses; assesses the performance of health systems around the globe; and manages global health research, technical projects, programs, and data.

Introduction

Climate change represents an inevitable, massive threat to global health that will likely eclipse the major known pandemics as the leading cause of death and disease in the 21st century ... The health of the world population must be elevated in this discussion from an afterthought to a central theme around which decision-makers construct rational, well informed action-orientated climate change strategies.

— Dr. Dana Hanson President, World Medical Association

CLIMATE SCIENCE

This report highlights the status, trends and future direction of climate change as it evolves around the world and impacts Iowa in particular. Climate change is not an event but a complex process with many manifestations. The overall enormity of potential devastation occurring as a consequence of a changing climate is almost incomprehensible, especially if we do nothing to reduce the activities driving the changes. Already coastal cities from Miami to Baltimore are threatened by rising seas. California and the West are suffering through years of deadly drought and deadly wildfires. Alaska is burdened by subsidence and buckled roads due to loss of the permafrost. New York and the East coast have been battered by super storms, and Louisiana and Texas swamped by flash floods.

Climate change means much more of what the world is already experiencing: more extreme heat, drought, fires, storms, and floods. It means melting glaciers release ever more water into the oceans and rising sea levels contributing to dangerously higher storm surges. Ecosystems on land and in the oceans are deteriorating and species are experiencing unusual migration patterns and extinction at unprecedented rates. Coincidently medical data clearly show that mining, processing, transporting, and burning of all fossil fuel energy sources, coal, natural gas and oil, have an immediate adverse impact on human health even as the fuels accelerate changes to the global climate.

GLOBAL WARMING IS ACCELERATING.

CO_2 is rising and the world is getting warmer at an alarming rate. The global temperature, including the world's oceans, has been increasing, albeit unevenly, over the past 50 years due to human induced emissions of heat trapping gases, primarily CO_2, and the loss of natural carbon sinks. By March 2016, Arctic ice reached a record low and in April carbon dioxide hit the highest daily level ever recorded: 409.44 ppm (NASA 2016; NOAA 2016). Such levels have not occurred for hundreds of thousands of years. Fifteen of the 16 warmest years on record have occurred since 2001, with 2015 and then Feb. 2016 shattering all previous records by a wide margin. December 2015 was both record warm and record wet. This was the only month to break both records. (NOAA 2015). 2016 appears to be on course to continue the trend with each month this year breaking all prior records for the month.

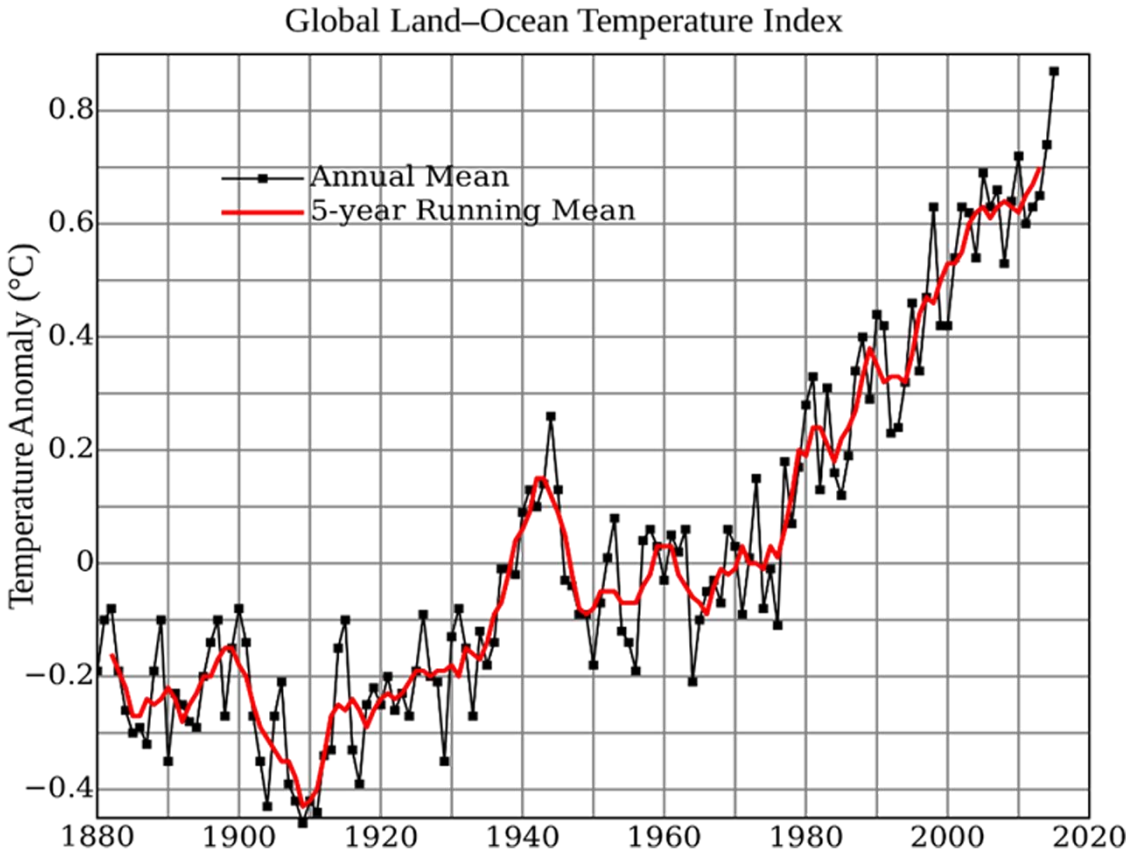

Figure 1. Global Land-Ocean Temperature Index.
Source: NASA GISS 2016

Some might assert that the warm Feb. 2016 can be seen as a "one off" event, but it "represents an increase of 1.35 °C above the average temperature level for the period 1951-80 and 1.63 °C above pre-industrial levels. In fact, it took global temperature for the month above the 1.5 °C rise that the 2015 Paris Climate Agreement was supposed to prevent (European Commission 2015; McKie 2016). It is one more bench mark in a series of increasingly troubling events.

An even more troubling fact is that the ***rate*** of temperature increase has nearly doubled in the last 50 years and is projected to increase further in the future. (NASA 2016a). Finally, the newest glacial melting data demonstrate that parts of the West Antarctic may soon reach a irreversible level of melting which would contribute to sea levels not seen since prehistoric times. Some authors predict 4-5 feet of sea level rise, others even more if levels of atmospheric pollution are not quickly decreased (Upton 2016).

The entire globe is warming, major disasters are increasingly frequent and costly, even though the rate of warming and related effects vary by latitude, longitude, and altitude as well as locations of rivers, glaciers and bodies of water, and preexisting intensity of regional congestion and industrialization. For some examples, see selected significant climate anomalies and events complied by NOAA in their *Billion-Dollar Weather and Climate Disasters* Series (NOAA 2016a) and their *State of the Climate* Reports for July 2016.

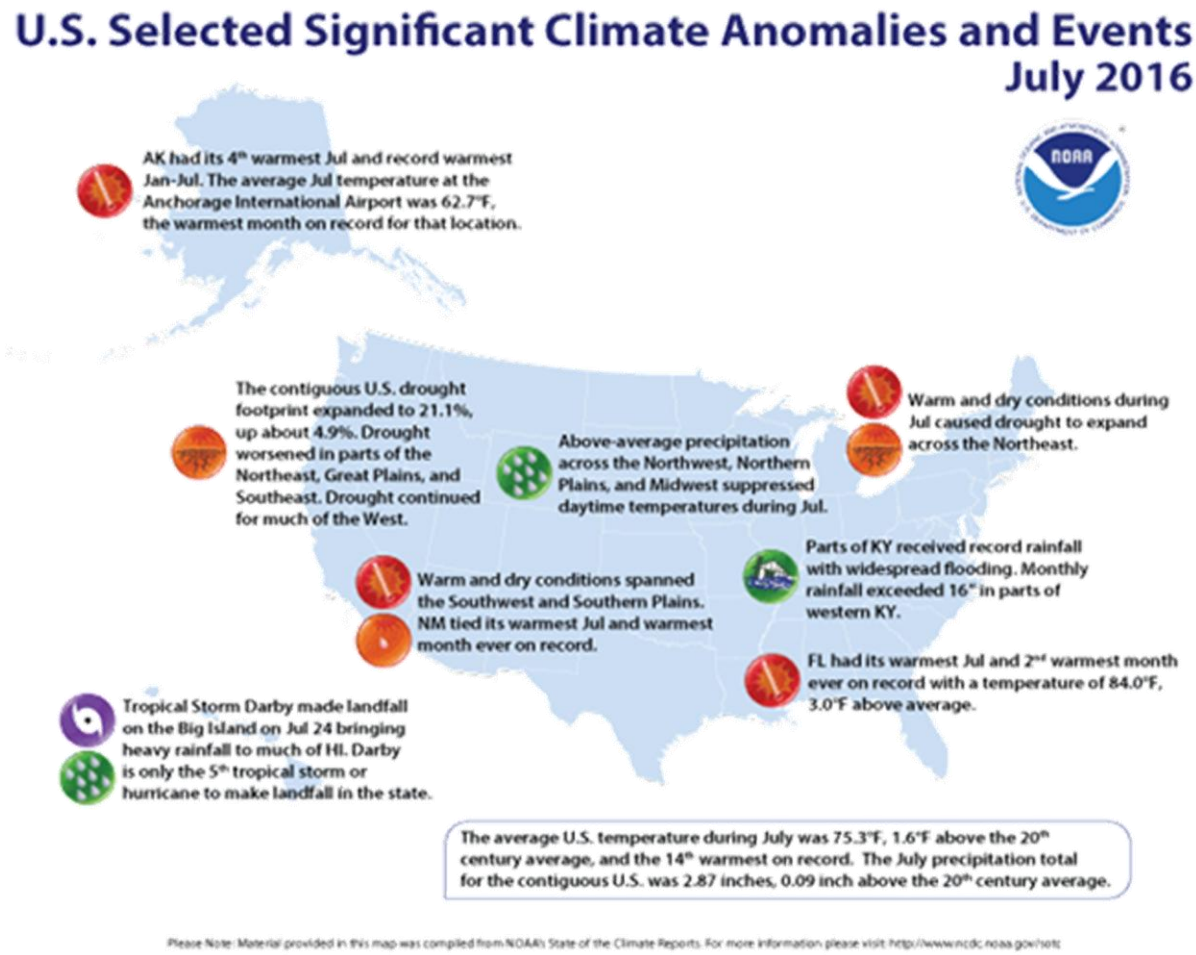

Figure 2. U.S. Selected Significant Climate Anomalies and Events, July 2016. *Source NOAA 2016a*

WATER IS LIFE—AND DEATH

Water quality and availability is an absolute necessity for survival and well-being anywhere on the planet. It is through evolving changes in global precipitation cycles that most people will feel the impacts of the changing climate. The consequences of droughts and floods, vary greatly depending on their location, duration, depth and speed, as well as the vulnerability and value of the affected natural and constructed environments—any significant variation in average rainfall has serious implications for local health and wellbeing. As our atmosphere warms and holds more moisture widespread impacts include increases in heavy downpours, rising sea levels, and ice-free seasons in the ocean, on lakes and rivers, earlier snowmelt, with alterations in river flows, thawing permafrost and rapidly retreating glaciers. The Arctic sea ice that formed over winters of 2014-15 and 2015-16 was about a million square km less than the 1981-2008 average and the lowest two extents on record

Sea level rise: Flooding in Miami

(NSIDC 2016). Already such changes in the climate affect global water availability and quality, energy systems, transportation, agriculture, ecosystems, population migration and health.

The world has been experiencing a sustained rise in the numbers of floods and storms. According to the Brussels Center on Epidemiology of Disasters, flooding alone accounted for 47% of all weather-related disasters affecting 2.3 billion (CRED 2016). Storms have killed more than 242,000, most of which were in lower income countries. Natural disasters alone are now costing the world nearly $200 billion annually, and that cost is likely to continue to rise with a changing climate (World Bank 2013).

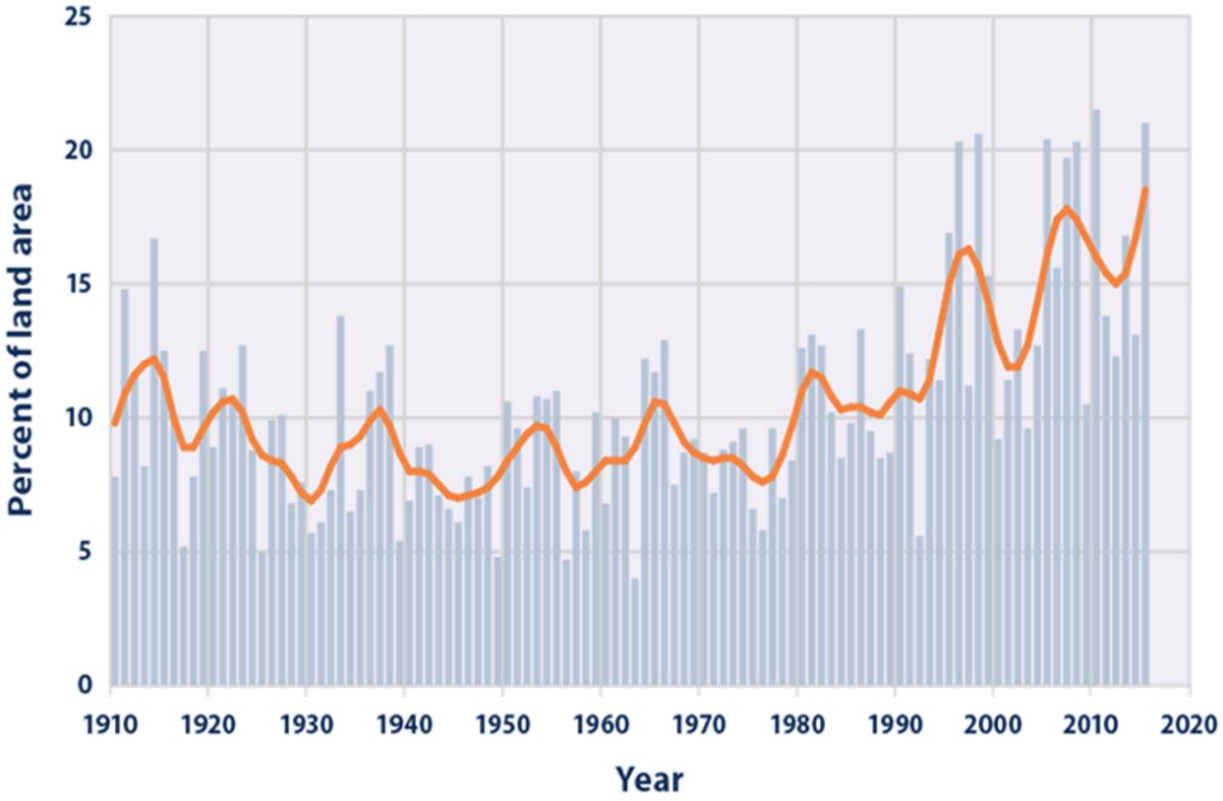

Figure 3. Extreme One-Day Precipitation Events in the Contiguous 48 States, 1910-2015.
(NOAA 2016a)

The U.S. has not been spared. During the decade 2005-2015 extreme weather and wildfire events occurred in all 50 states; 93 natural disasters cost the US $586 billion. Most significant are increasing trends for floods in the Midwest and Northeast, and a decreasing trend in the Southwest. Even given this wide range, precipitation in the U.S., has increased about 5 percent over the past 50 years, especially the number of days of heavy downpours over short time periods. The extreme precipitation in West Virginia earlier this year killed at least 22 people and caused widespread property damage, as did flooding in Texas just months before. The flooding in Louisiana again this year and that experienced most recently in North Carolina constitute major catastrophes. While these changes and impacts vary by location and local history, they are all expected to grow.

While U.S. northern areas are projected to continue to become wetter, southern and western areas are projected to become drier. Reduced precipitation, increased heat and evaporation, and increased water loss from plants will become progressively challenging in the West. Intensity, frequency and extent of wildfires blowing through dried forests and brush are anticipated to increase (EPAe 2016).

Coastal Areas

Sea level has been rising at the rate of about 0.6 inches per decade since 1900 and the rate of rise is increasing (NOAA 2016b). Coastal areas and low lying island states are at increasing risk from sea-level rise and storm surge combined. A higher intensity of extreme weather is particularly likely along coastal waters. A 2014 NOAA study predicted that by 2050, a majority of U.S. coastal areas are likely to be threatened by 30 or more days of flooding each year due to dramatically accelerating impacts from sea level rise (Sweet 2014).

These phenomena place U.S. coastal areas, their economic activity and populations at increased risk of erosion and flooding especially along the Atlantic and Gulf Coasts, Pacific Islands and parts of Alaska. This will adversely affect energy, transportation infrastructure, property as well as health in these areas. Flooding in local areas can be affected by multiple factors, including land-use changes, dams, and diversions of water for a variety of uses.

While precision about future levels of total precipitation due to human induced warming are hard to predict, regions like the Midwest can expect more floods with corresponding challenges to water quality. For example, Alaska and other mountain states that rely on snowpack for year round water will experience decreasing water storage. Simultaneously Global food production will be challenged.
Livestock and food crops take time to adapt to water and temperature changes. Diets, food production methods and supports all evolved within the stable climate humans experienced over many thousand years, not the one that is evolving.

Global warming is primarily human induced

> ***"… scientists now say that they cannot explain this unusual warmth without including the effects of both human-generated greenhouse gases and aerosols. "***
>
> - D. James Baker, Administrator, U.S. National Oceanic & Atmospheric Administration, **1999**.

The human role in the loss of forests and topsoil, the reduction of carbon sinks, and reliance on fossil fuels (coal, oil and gas), their mining, refining, transport, burning and then managing their waste constitute the greatest contribution to the rise in greenhouse gases and the consequent global warming that is changing the climate. At the same time such activities contribute directly to air and water pollution and poor health in the U.S and around the world. The risks of burning fossil fuels are becoming clearer each day, even as the supply of readily accessible fossil fuels is declining.

Using fossil energy sources for transport, heat, electricity, and countless consumer goods requires more and more energy along with ever more environmental devastation. Global energy extraction today requires using "extreme energy" (deep sea drilling, hydraulic fracturing, mountain top removal). More intensive energy inputs and environmental destruction are required to retrieve ever smaller volumes of useable fuels. These practices worsen and accelerate the threats of the changing climate.

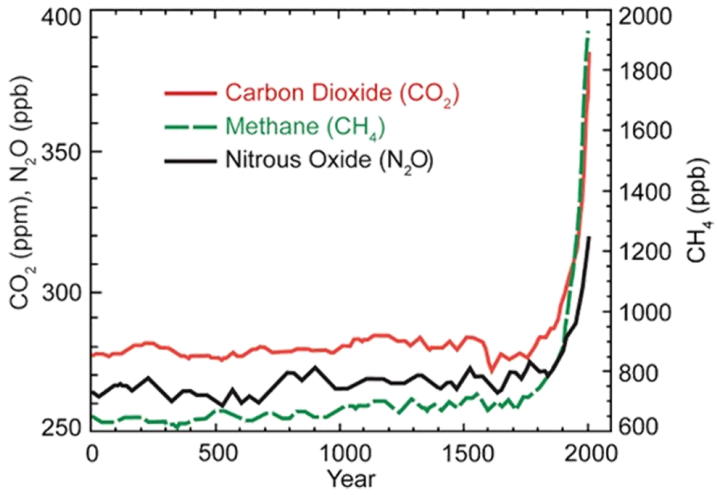

Figure 4. Atmospheric Greenhouse Gases over 2000 years.
Source: NOAA Earth Observatory.

Humans have been releasing greenhouse gases at an increasing rate over the last 250 years by burning fossil fuels, removing important carbon sinks like forests, and most recently, increasingly releasing large amounts of other more powerful greenhouse gases like methane and nitrous oxide. In terms of warming effects both methane and nitrous oxide are far more powerful greenhouse gases than CO_2. Since 2009 methane levels have increased 148 percent.

Beyond burning fossil fuels, the principle human activities releasing GHG emissions come from modern industrial agriculture, transportation infrastructure and fossil fuel extraction, especially for natural gas extraction with its associated leakage of methane. Together these three processes emit millions of tons of CO_{2e} annual.

Food is produced, stored, processed, packaged, transported, prepared, and served. At every stage, from production to consumption to waste, today's food releases greenhouse gases. Beyond the heavy equipment used, trees and top soil lost for row crops and livestock, farming releases the two powerful greenhouse gases, methane and nitrous oxide. Methane is produced by livestock during digestion due to enteric fermentation and released in belches. Methane also escapes from stored manure & organic waste in landfills. Nitrous oxide emissions are an indirect product of organic and mineral nitrogen fertilizers.

The industrialized food production system (depending on the source and factors included in the analysis), contributes at least 20% of current GHG emissions. When including the pesticides, fertilizers and large agricultural equipment used, all of which are dependent on heavy fossil fuel inputs, agriculture's contribution rises to 30% or even more.

THRESHOLDS & TIPPING POINTS

There are points at which irreversible changes will occur are difficult to predict. Given the recent acceleration in arctic melting, frequency and intensity of wildfires, floods, and extreme weather, evidence is accumulating that such points are rapidly approaching. Despite the mounting scientific evidence and warnings about increasing

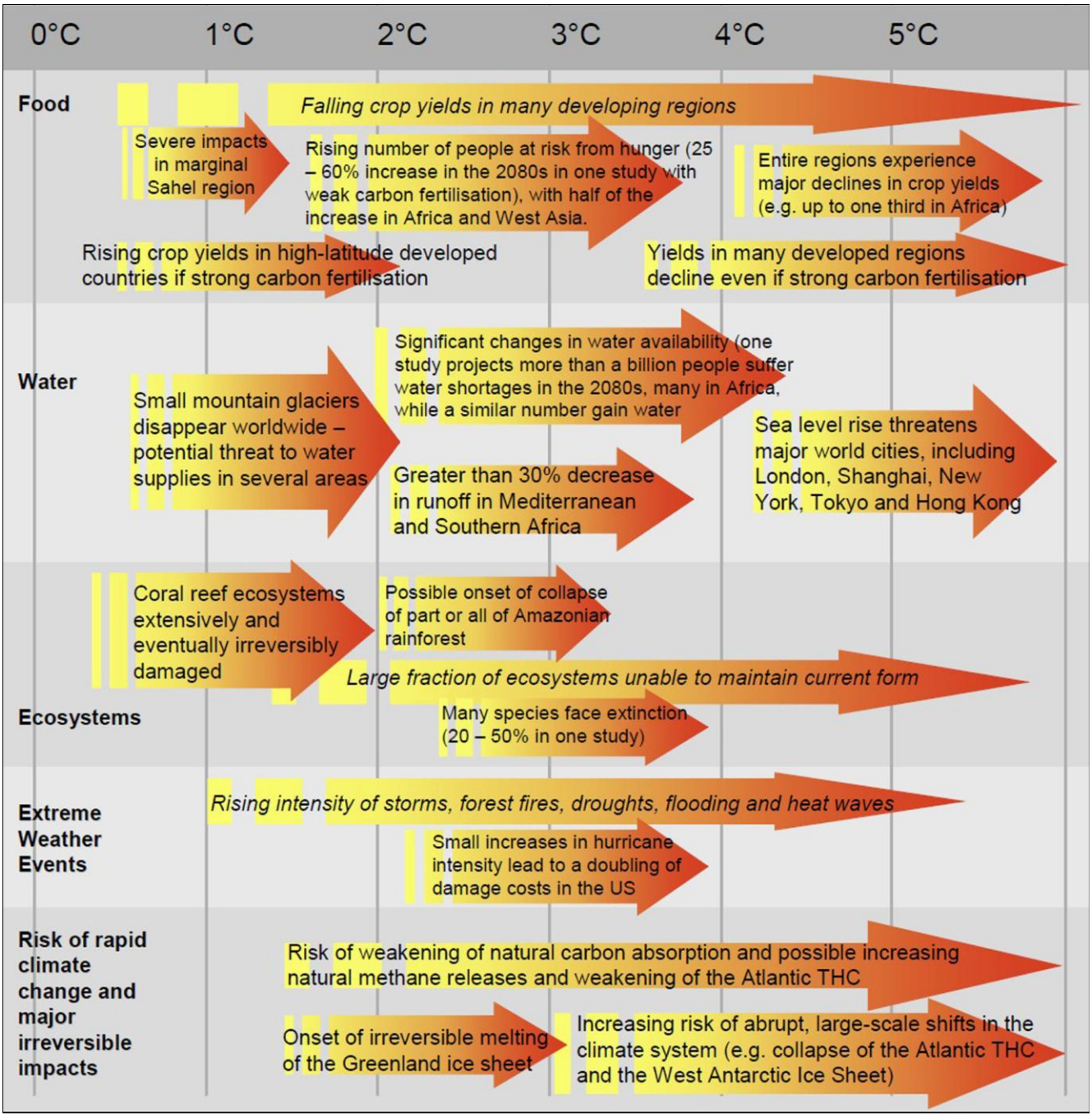

Figure 5. Projected Impacts of Climate Change.
Source: Stern Review 2006. The Economics of Climate Change

difficulties, public perceptions of, or responses to the health and many other consequences remains minimal relative to the growing danger (Leiserowitz 2014; Maibach 2015). Uncertainty has likely contributed to some of the world's complacency in responding to climate threats.

Climate change in the wake of a warming world is difficult to comprehend in its enormity. It is a complex gradual process, not a straight forward event. Its pattern is intermittent, discontinuous, often distant, and perceived as slow in terms of individual experiences and life spans. The lack of unique signs and symptoms are made all the more confusing given the many ways the climate interacts with other challenges. Understandably, public awareness and response is incomplete when urgency to act becomes lost in the cacophony and urgency of competing day to day demands.

Complacency is further normalized by the phenomenon of thermal lag. Due to the long life of GHGs in the atmosphere, thermal lag means the increased temperatures experienced today occur primarily as the result of past

> ***" Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. "***
>
> *IPCC Synthesis Report 2014*

emissions. Regardless of what is done today to halt climate change, temperature increases are expected well into the next several decades.

Despite the conceptual challenges, complexities, uncertainties, variability and intermittency, if nothing is done to change course, ensuing decades will experience even more intense and higher warming as a result of current and future emissions. Without concerted efforts today, a BAU (business as usual) scenario could mean that by the century's end the average U.S temperature could increase by 5° or even up to 11°F (EPA 2016e). Such changes will seriously challenge the global environment and economy, health and human rights.

THE GOOD NEWS

Global warming can be solved by humans—at least slowed, and eventually halted, if action is taken in time. Future climate change and impacts depend on choices made today. Climate's eventual impact can be lessened through mitigation efforts now while simultaneously developing protective adaptation measures. Given the known catastrophic risks, and availability of alternatives to GHG gas emitting fossil fuels, humans have a responsibility to work to halt and eventually reverse climate change. Possible solutions are almost more than can be listed. Solutions are already available on the shelf and useful at all levels of social organization—most can save money, increase jobs and improve health. Society can cut back on fossil fuel use, work on energy efficiency, walkable and bike-able cities, green buildings. Low carbon healthy diets contain less meat. Taken together these changes create less waste and more good. What is needed most is understanding and political will. To limit future warming impacts, sensible responses involve rapidly adapting our cities, businesses, and life styles to withstand the changes that are unavoidable.

CLIMATE CHANGE THREATENS HEALTH

As climate change unfolds, everyone is threatened with increased risks of serious illnesses, injuries, and diseases. Given the current warming trajectory, *Lancet* scientists found that by the end of this century, there will be 2 billion more people exposed annually to extreme rainfall events, 3 billion more elders exposed to heat waves, and 1.4 billion more people exposed every year to drought (Lancet 2015). The WHO adds that between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year, from malnutrition, malaria, diarrhea and heat stress. (WHO 2016a)

Over the past 2 decades (1995-2015) weather related disasters claimed 606,000 lives (CRED 2016). However, the numbers of people adversely affected by these events is much larger, in the billions. Due to the changing climate, extreme weather events are predicted to increase in frequency and intensity; correspondingly, so too will global morbidity and mortality. Prolonged heat waves, deteriorating air quality, rising sea levels, extreme precipitation and violent weather events are all expected to grow, as will the associated incidence of waterborne, food borne, and vector borne diseases, and mental health challenges in response to each of these.

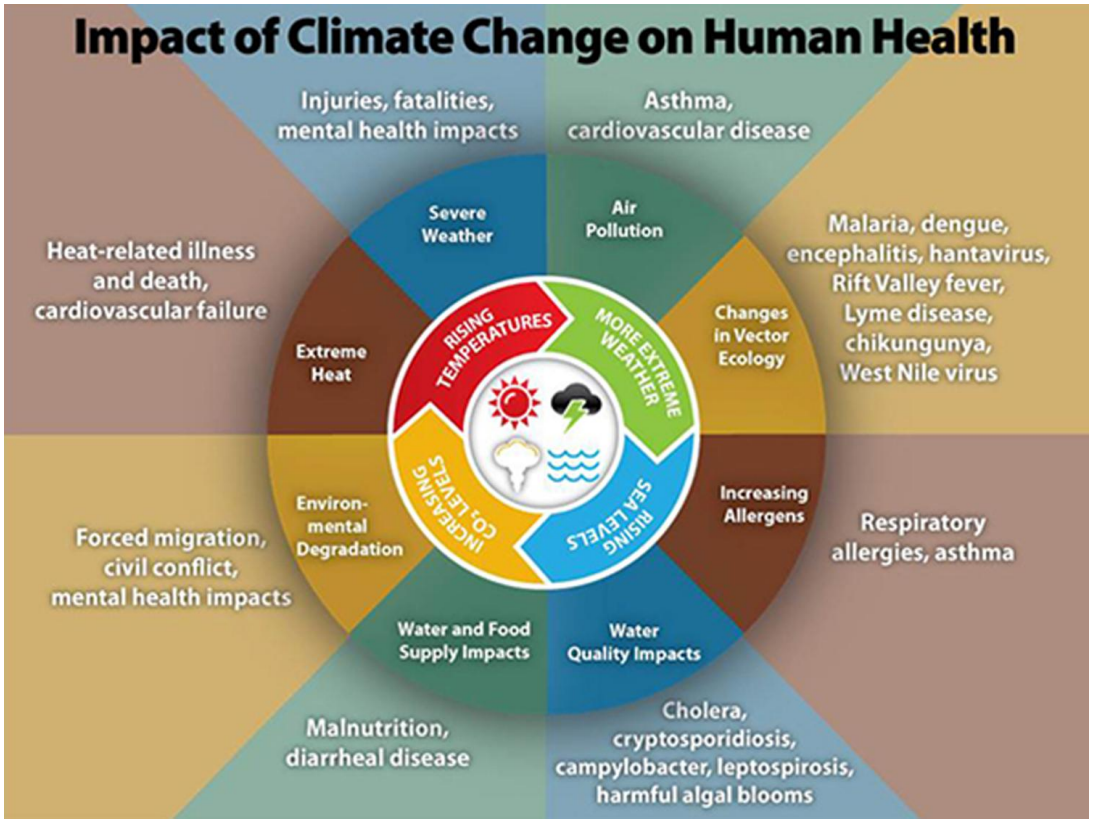

Figure 6. Impact of Climate Change on Human Health.
Source: Center for Disease Control

While the impoverished are likely to suffer and die in greater numbers, extreme weather related disasters affect vast numbers of both rich and poor, all of whom live on and share the same planet. Health risks due to climatic changes will differ between countries not only because of climate changes themselves but because of differences in the resilience, quality and accessibility of local disaster response, health and public health infrastructures.

It should be noted that over the past 40 years temperatures have risen faster in winter than any other season (Tebaldi 2013). While reduced frost and days of extreme cold will reduce the numbers of cold related deaths and

injuries, such a change will have minimal impact on the growing global health risks of the changing climate across the seasons and around the world.

HEAT

Heat waves are deadly, especially when minimal cooling occurs during nighttime. Heat related illnesses occur when the body's temperature regulatory system is overwhelmed. When sweating no longer serves as a viable method of cooling, the danger of suffering from a heat related illness or death increases. Extreme high temperatures contribute directly to death from cardiovascular and respiratory disease especially among infants, elders and those with pre-existing disease. Extreme heat caused 7,415 heat-related deaths in the United States from 1999 to 2010. According to the CDC and National Weather Service, extreme heat kills more than hurricanes, tornados, lightning, floods and earthquakes combined (CDC 2015a).

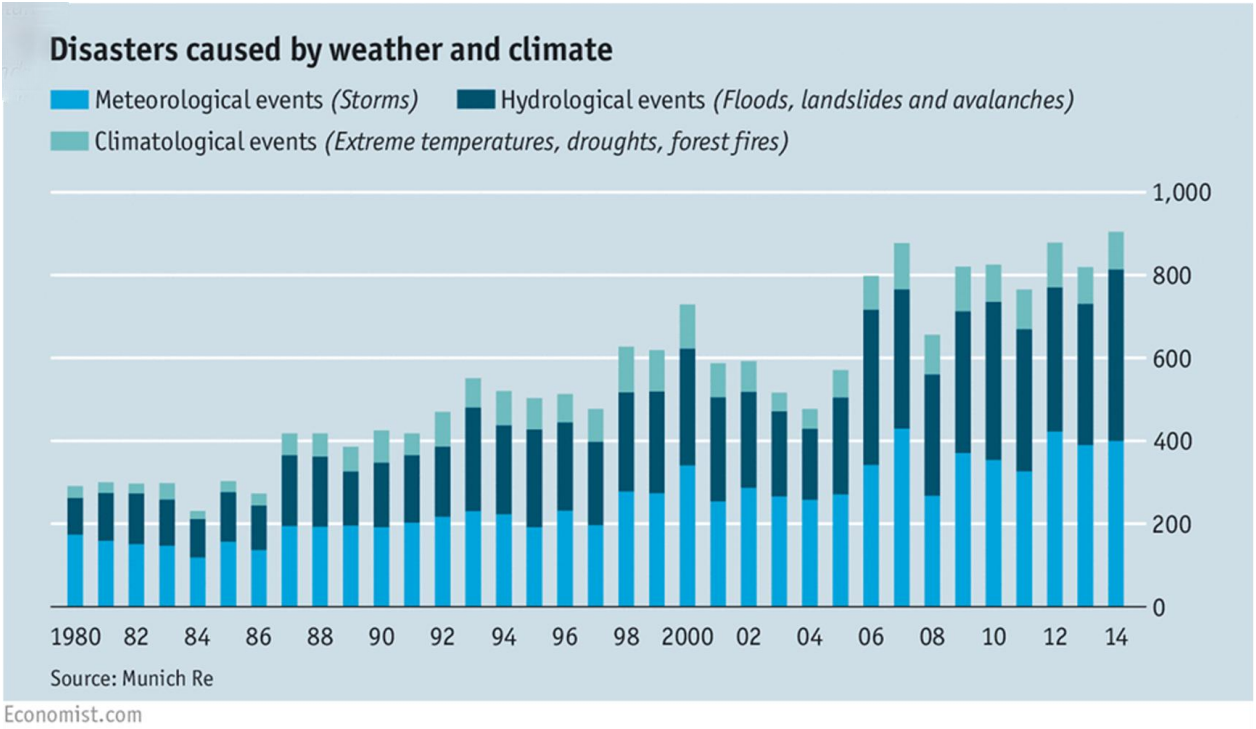

Figure 7. Disaster Caused by Weather and Climate.
Source: The Economist, June 2015.

If nothing is done to reverse course, by 2100 it is estimated that average global temperatures will have risen an additional 1.0–3.5 °C (beyond the increases already experienced) with an increasing frequency of stronger and longer heat waves. Summer temperatures in the future are projected to exceed the hottest on record during 1920–2014 at all land locations as global warming progresses (Lerner 2016). Counts of heat related deaths to date are inexact depending on specific inclusion and exclusion factors considered, but according to figures from the Brussels Center for Research on the Epidemiology of Disasters (CRED 2016), the global heat mortality toll over the past two decades is approaching 140,000 people.

Children, the elderly, outdoor workers, athletes, and people with chronic medical conditions are particularly vulnerable to the rising temperatures brought on by climate change. Additionally, poor people and ethnic or racial minorities are typically at a greater risk of suffering from heat exhaustion since their socioeconomic status may preclude access to air conditioning making their functioning in extreme weather events more difficult (Hanson 2013).

Ambient heat is made worse in urban areas because cities are inherently hotter than the surrounding rural area due to the urban heat island effect making it worse for people living and working there. Humidity effects, included in the heat index, exacerbate warming effects. People exposed to these simultaneously suffer more severely.

Aeroallergens, Smog, Ozone and Particulate Matter

Resource extraction, refinement, transportation, burning, and waste disposal make up the fossil fuel energy cycle, the major driver of global warming and the changing climate. Throughout the fossil fuel, cycle, toxic elements, compounds, and sub-microscopic particles are released into the air, water, and soil degrading air and water quality and the health of humans, animals, and vegetation. Urban air pollution kills over 3 million people worldwide per year (WHO 2016a). With continued reliance on fossil fuels and increasing urban congestion in the world's megacities, driven by climate change, these numbers are projected to increase.

Urban air pollution kills over 3 million people worldwide per year.
WHO 2016

Pollen counts are rising in the U.S. Wet, mild winter weather results in stronger, longer allergy seasons. The warming world and rising carbon dioxide concentration leads plants to produce more pollen with higher allergen potency **(CDC 2016)** as well as prolonging the ragweed pollen season. Over the last few decades the spring allergy season has inched up on the calendar -- in some parts of the country up to 13 and even to 27 days. More than 50 million Americans are living with seasonal nasal allergies, and the numbers are increasing, presenting additional risks for asthma and allergy sufferers. High temperatures combined with high humidity also raise the levels of molds in the environment—another respiratory irritant.

Ozone is more readily formed on humid, warm, sunny days when the air is stagnant. Cities with higher levels of industrial activity, congestion and motor vehicles will all see increasing levels of air pollution, especially ozone and particulate matter. Ozone is created when VOCs combine with nitrous oxides (released at ground level by cars, factories, and power plants) humidity and increasing temperatures (EPA 2016c).

Global warming will increase levels of ozone and smog in the same regions where it is increasing sneeze-inducing pollen counts. Either singly or in combination ozone and smog exacerbate cardiovascular and respiratory disease, especially asthma and COPD. Asthma is a chronic disease of the lungs that affects adults and children of all ages is characterized by repeated episodes of wheezing, breathlessness, chest tightness, and nighttime or early morning coughing. The WHO estimates that around the world there are at least 300 million asthma sufferers. The number of those suffering from either asthma or COPD around the world is rising according to both the WHO and the U.S. CDC (CDC 2014a).

Ozone is a direct irritant to lungs and particularly toxic to young children whose lungs are still growing, and to elders. Both these populations are at risk playing, working, or walking out doors in the heat and humidity especially because when heat and high humidity combine with industrial and vehicle exhaust they create ozone and exacerbate the impact of other toxic air pollutants.

Across much of the U.S. the Clean Air Act has improved air quality, but the expected higher temperatures and stagnant air masses that often occur over cities are expected to make it all the more challenging to meet health supporting air quality standards. In 2015, despite significant improvements in air quality, approximately 127 million people lived in counties that exceeded the revised national ground-level ozone standards (EPA 2016c).

Smog and increased allergens are two important factors contributing to soaring rates of asthma and negative impacts on lung and heart health. The CDC estimates that asthma prevalence within the U.S. population went from 3.1% in 1980 to 8.4% in 2010 and now affects some 25.7 million, including 7 million children under 18 years. Children, especially between the ages of 5-14, females and people living in poverty, in the Northeast or the Midwest are more likely to have asthma. Overall, Blacks are more likely to have asthma than Whites or Hispanics. (CDC 2014a)

Major Air Pollution Sources:
Vehicle Exhaust, Industry, Coal, Oil & Natural Gas Energy

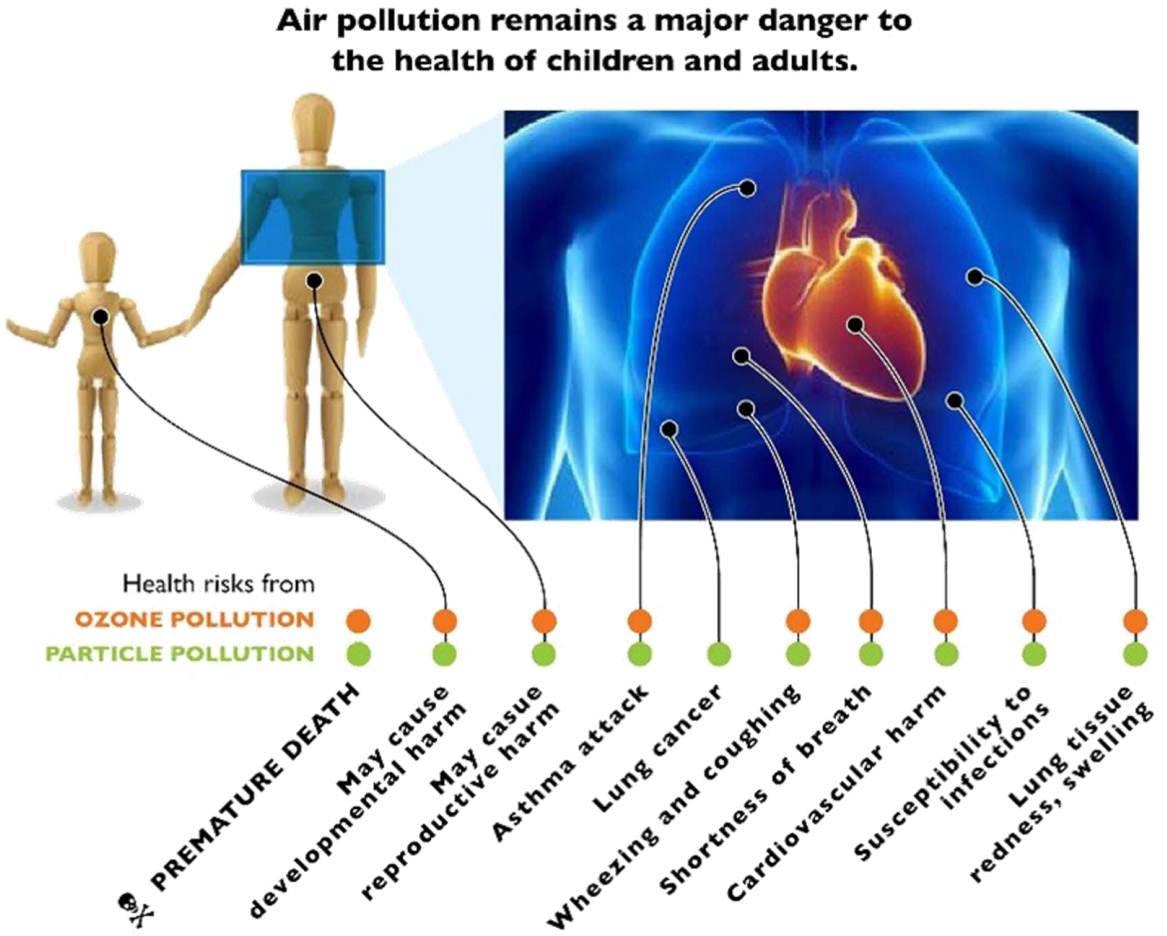

Figure 8. Major Air Pollution Sources.
Source: American Lung Association

In 2008, the National Center for Health Statistics in the U.S., noted that approximately 13.6 million adults had been diagnosed with chronic obstructive pulmonary disease (COPD) (Pleis 2009). An approximately equal number suffer but had not yet been diagnosed (Mannino 2002). These numbers have also been increasing in the meantime (ALA 2016)—up to 24 million older adults may now suffer from the debilitating shortness of breath and chronic cough.

Wildfires around the world are increasing due to warming especially in the U.S. West. Given heat and drought, fires break out with greater frequency, extent and duration. Expanded wildfire seasons not only increase the direct risks of injury and adverse mental health effects, but also the release of fine particulates that irritate the respiratory systems of countless people living downwind free of direct risk of the fire itself.

While the sources and nature of specific air pollutants and aero allergens are widely variable, human anatomy and physiology have only a few ways of responding. People can cough and sneeze to eliminate the offending entity if it is large enough to be trapped in the upper air way. However, if the offending agent is a gas or exceedingly tiny particles, they are likely to be inhaled and settle further down in the airways, or even cross respiratory barriers into the wider circulation.

The burden of these respiratory diseases affects individuals and their families, schools, workplaces, neighborhoods, cities, and states. Because of the cost to the health care system, the burden of respiratory diseases also falls on society; it is paid for with higher health insurance rates, lost productivity, and tax dollars. Annual health care expenditures in the U.S. for asthma alone are estimated at $20.7 billion (Kamble 2009).

Heat Islands

The ambient temperature experienced anywhere depends on location, population density and the aggregate of dark surfaces compared to available shade and trees in any given area. Urban environments can be many degrees hotter relative to surrounding green spaces and rural environments. During hot, sunny summer days, roofs and pavement surface temperatures can be fully 50-90 °F hotter than the air itself because pavement and building surfaces trap more heat than natural surfaces. The increased urban temperatures - up to 22°F hotter than surrounding areas - can persist into night hours as heated surfaces reradiate their heat if there are no breezes and ambient temperatures remain elevated.

Elevated temperatures on urban surfaces can also affect initial rainwater runoff temperature with downstream impacts on local aquatic life. Additionally, the widespread production and use of cement and concrete in heat islands contribute to atmospheric warming, elevated levels of air pollution and smog. Finally, heat islands secondarily lead to increased energy demand for cooling, and over exposure to deadly heat for outdoor workers, children at play, elders, chronically ill, homeless and impoverished minorities (EPA 2016d).

Transportation is a major contributor to global climate change accounting for almost 23% of the world's total CO_2 emissions as well as contributing to ozone and fine particulate matter from fossil fuel combustion. It's also important to note that inactivity itself in car-based cities is estimated to kill 3.2 million annually by contributing to obesity, diabetes and cardiovascular disease (WHO 2002). Rebuilding Cities for optimal health focused on reducing car miles, could save $4 billion in hospital costs while switching to bikes saves another $4 billion in hospital costs (Grabow 2012).

Altered Precipitation Patterns

Wet places are expected to become wetter over time even as dry places become drier, bringing multiple increased health risks. Globally extreme weather disasters result in over 60,000 deaths annually, mainly in developing countries according to the WHO. Extreme weather events, such as floods, cause injuries, increase contact with infectious and allergenic organisms, and disrupt infrastructure (damage roads, bridges, or utilities). Such increased health risks simultaneously prevent access to existing health care facilities.

Powerful and fast flowing flood waters potentially damage everything along their way, multiplying their deadly impacts. Water treatment plants and electric power plants (nuclear and coal), which rely on flowing water can be impacted both directly and indirectly. Flood waters contain a toxic stew of pesticides, heavy metals, nitrogen and phosphorus, VOCs and fuel residue, as well as fecal material (human and animal) composed of pathogenic bacteria, parasites and viruses. When city sewage and municipal drain systems are overloaded during intense rainstorms, raw sewage overflow can result, impacting nearby water supplies and clean water availability and human health.

Lung Association 2016

By the late 21st century, climate change is also likely to increase the frequency and intensity of drought at regional and global scales. Prolonged heat and drought too can prove deadly in a number of ways but most especially by affecting the supply of fresh water and food production. These in turn, compromise hygiene and increase the risk of diarrheal disease, which already kills approximately 760,000 children aged under 5, every year (WHO 2016a). In the U.S., drought in association with sand storms in the West is increasing the frequency of Valley Fever, coccidioidomycosis, a fungal respiratory disease (CDC 2014b). Drought can also increase the presence of aflatoxins in grain grown in the Midwest. Both forms of fungal diseases can be deadly.

Last, but certainly not least, prolonged heat and drought are associated with rising numbers of wild fires around the world. These carry obvious threats to those living in the vicinity. Often overlooked however are the particulates released by the fires and wafted on winds to sites many miles away. They add to existing air pollution and can contribute to respiratory difficulties.

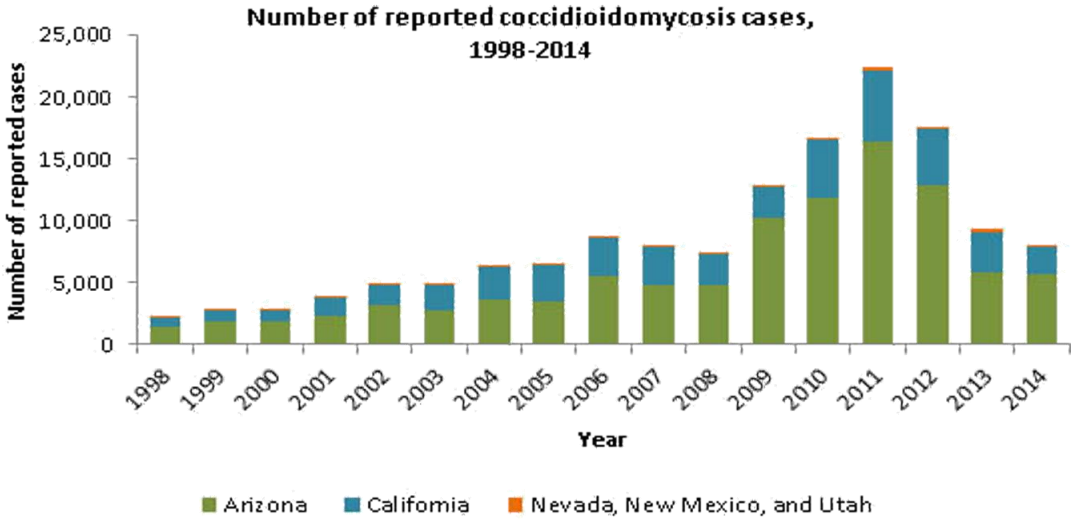

Figure 9. Reported Number of Coccidioidoidomycosis Cases 1998-2014.
Source: CDC.

INFECTIOUS & VECTOR BORNE DISEASE RISKS

Epidemics disrupt health security and cause wider socioeconomic impacts around the world. Climate related infections are contracted in many ways: from contaminated water, insects and other vectors, droughts, heat, and warming surface & ocean waters (WHO 2016c). Increasing temperatures and more variable weather threaten to undermine recent global progress against both infectious and vector borne disease outbreaks in the U. S. and elsewhere over the past several decades. (Campbell-Lendrum 2015).

> ***" …human-caused micro-perturbations in ecologic balance can cause innumerable slumbering infectious agents to emerge unexpectedly."***
>
> Dr. Anthony Fauci

Vector-borne diseases contribute significantly to the global burden of disease. Due to the increase in heat, humidity, altered air, and water quality/quantity, insects, birds, rodents and other disease vectors, old & new, are all on the move (Githeko 2000, Ginty 2015). Humans face increasing risks of diseases carried to new sites by this diversity of actors. Diseases transmitted by food, water, insects, and sand are all likely to increase particularly due to increased precipitation, but at times also in conjunction with droughts (as described previously).

Table 1. Changing Weather, Altered Environments & Changing Diseases

Disease	Change	Mechanism
Malaria Dengue Chikungunya West Nile Virus	Heat, Humidity & Standing Water	Mosquitoes, Increased Breeding, Biting, & Expand Range
Water Borne Diarrheal Disease Cholera	Increased Precipitation & Flooding	Water Contamination & Altered Sanitation
Food Borne Diarrheal Disease	Extreme Storms	Loss of Refrigeration
Valley Fever	Drought	Dry Hot Winds
Ciguatera (fish poisoning)	Warming Waterways & Oceans	Toxic Algae Blooms: Red Tides
Helmenthiasis	Moist Soil	Contact
Lyme Dx Rocky Mountain Spotted Fever	Altered Forest Ecology	Animals & Ticks Sharing Human Environments
Hanta Virus	Altered Vegetation	Increased Rodent Contact
EMERGING TBA	Warming	Melting Ice Caps

Table by Kit Gaulden and Maureen McCue

In the eastern half of the United States and Europe, Lyme disease is currently the most common type of vector borne disease (CDC 2015b). Encephalitis is also becoming a public health concern (WHOa). Addressing vector borne diseases will be further complicated by our inability to limit the spread of the vectors geographically as global temperatures continue to increase.

Changing environmental conditions help accelerate outbreaks of mosquito borne illnesses because temperature affects biting frequency, survival and reproductive rates of the vectors, and the survival and development rates of pathogens they carry or are found in the environment. By 2100 it is estimated that average global temperature rise will increase the likelihood of many vector-borne diseases moving into new areas. Malaria and dengue fever are among the most important vector-borne diseases in the tropics and subtropics, but as we're currently experiencing, Zika is increasingly threatening to warm and humid parts of the U.S. While it is not yet in the Midwest, Zika is just the latest mosquito-borne virus to reach the Western Hemisphere in the past 20 years, following the path of dengue fever, West Nile virus and chikungunya. This latest epidemic,

> ***" …forces us to confront a potential new disease-emergence phenomenon: pandemic expansion of multiple, heretofore relatively unimportant [mosquito-borne] viruses previously restricted to remote ecologic niches,"* because *"human-caused micro-perturbations in ecologic balance can cause innumerable slumbering infectious agents to emerge unexpectedly. "***
>
> -- Dr. Anthony Fauci (Fauci 2016)

Finally, new diseases may potentially emerge as ice caps and permafrost melt and release long frozen and well-preserved viable viruses and other pathogenic organisms. The northern reaches of Russia and all the peri-arctic regions are experiencing the globe's fastest warming. The recent outbreak of Anthrax in Russia may simply be the tip of the iceberg (ABC News 2016).

MENTAL HEALTH

> ***" It will be "difficult to calculate the psycho-economic costs associated with climate change, but untold billions or trillions of dollars in human capital will be lost as people are displaced; family groups, jobs, and infrastructure are damaged or destroyed; and people contend with their painful psychological responses to all of climate change's harm. The result could be severe, lasting tears in the fabric of our society. "***
>
> --Psychologists for Social Responsibility

A more hostile climate will bring a substantial rise in post traumatic stress disorder, anxiety & major depression. Flooding, tornadoes, and prolonged heat waves constitute traumatic events—all of which are expected to increase in intensity and duration. Symptoms of post-traumatic stress disorder, and social withdrawal can all be anticipated to manifest in the aftermath of extreme weather events. In general, all-cause mortality, but especially suicides, drug & alcohol abuse, violence, family dissolution all increase after disasters. Millions of people are likely to exhibit some of the following symptoms in response to climate change's stressors: anxiety, traumatization & post-traumatic stress, depression, interpersonal conflict & societal conflict, family stress, persistent grief, child behavioral and developmental problems; academic decline, eco-anxiety, hopelessness; and avoidance from the awareness of climate change. Following a severe weather event, as many as one in five suffer extreme stress, emotional injury & despair. The emotional toll lingers months to years, affecting families, the ability to work, and entire communities (Dodgen 2016).

Unfortunately, the nation, and the world remain woefully unprepared to address the needs of today's mental illness sufferers much less those anticipated to develop in concert with evolving climate crises. According to a recent report by the Treatment Advocacy Center, the number of state hospital beds available all across the country to serve the nation's most ill and potentially dangerous psychiatric patients has fallen to its lowest level ever on record. As is increasingly evident in many cities across the country and around the world, "when there are no beds for them, people with mental health problems who can't be adequately treated cycle through other institutions or live on the streets…." (Fuller 2016). As homeless and untreated they crowd into emergency

rooms and/or become violent and languish behind bars. More often, they become victims of violence. They grow sicker and die. The personal and public costs of untreated mental illness are incalculable.

Vulnerable Populations

Children, the elderly, outdoor workers, athletes, and people with various medical conditions are particularly sensitive or vulnerable to rising temperatures. Additionally, poor people and ethnic or racial minorities are typically at a greater risk of suffering from heat exhaustion since their socioeconomic status often makes adapting to extreme weather events very difficult (Hanson 2013). Heat waves for wealthier populations are mitigated by the availability of air conditioning and health services for dehydration, heat stroke and underlying conditions including excess heart attacks. These costly mitigating measures are unavailable for many around the world and across the country.

U.S. and global inequality have never been greater. With future scenarios predicting a climate-change-driven increase in the frequency, intensity, and duration of heat waves, extreme storms and other risks, there is an increased need to recognize and protect vulnerable sub-groups. Those most at risk require adaptation and prevention strategies to boost their resilience.

Social and economic disparities, living conditions, language barriers, and occupational exposure are among the many factors contributing to heat and air pollution susceptibility among minority ethnic groups around the world and in the United States, including in Iowa. The burden of climate-sensitive illness and diseases is greatest for the poorest populations anywhere for a number of reasons. In general to be poor means even if employed, it is often in long hours of back-breaking labor, living in unsafe, low-quality housing situated close to industrial sources of pollution, highways, vector-breeding sites, along with a lack of access to preventive and curative health interventions and services.

Aggregate data based on regions often misses the situation at local neighborhood levels. While national data has shown consistent improvement in air quality, the urban poor and racial and ethnic minorities are often disproportionately exposed to air pollutants due to their proximity to industrial sites and traffic-heavy freeways (Geer, 2013). As recently as 2009, it was noted that half of all Americans, 158 million people, live in counties where air pollution exceeds national health standards (Karl 2009). Researchers with the American Thoracic Society assert that even tighter air pollution standards would save thousands of lives across the U.S. (Cromar 2016).

Climate, Violent Conflict & Security

Changed water cycles and ever higher temperatures stress both plants and animals. On a planet whose population is still growing and almost 1 billion people are hungry, adequate nutritious food and accessible high quality potable water is critical to global health and security.

As extreme weather and storms become stronger or more frequent, loss of arable land, reduction in food and water quality and availability is leading those in at-risk communities to relocate. As we are witnessing with the flood of Syrian refugees, climate forced conflict and relocations in numerous parts of the world are devolving into international crises, complex violent conflict and large population migrations. If nothing significant is done to change course, acts of terrorism, destruction of built environments, and crowding in refugee camps, are all expected to escalate as desperate populations confront the coming changes. Combined, these factors challenge efforts to protect global peace, food production, economies, & human health.

CLIMATE CHANGE AS THREAT MULTIPLIER

No single event is the perfect example of, nor provides conclusive proof of evolving climate changes. It's the trends and totality of many smaller changes acting together that provide the evidence. Similarly, to focus on a specific temperature target and the reduction in greenhouse gas emissions required to achieve that target is a handy, unifying strategy, but it overlooks many interrelated health challenges and their underlying, economic, social, and political determinants.

> ***" Global climate change will aggravate problems such as poverty, social tensions, environmental degradation, ineffectual leadership and weak political institutions that threaten stability in a number of countries… "***
>
> Defense Department Report. July 23, 2015 (DOD 2015)

Complicating our perception and understanding of the inherent threats of a changing climate are the preexisting global problems with which the climate interacts. The ways climate change is a threat multiplier are difficult to model, measure and predict quantitatively. Climate doesn't act alone to affect life and health, but rather in conjunction with other modern phenomena like intensive industrial farming, large dams, extensive irrigation, deforestation, population growth and movements, rapid unplanned urbanization, air and water pollution, and phenomenal increases in international travel and trade. These environmental and social factors often reinforce climate effects even as they themselves are affected by the climate.

Climate is superimposed on and interacts with many serious global threats and challenges especially rapid population growth and our consumption based global economy associated with overuse of limited resources and environmental degradation. While the rate of population growth has slowed, according to the United Nations and others, the world continues to add 227,000 people to the planet *every day,* or, almost 80 million per year. The world's population, which now stands at more than 7.4 billion has doubled since 1970. This growth in the human population and the consumption that comes with it – takes up an incredible amount of space and resources that simultaneously degrade the environment and crowd untold numbers of other species off the planet. Taken together these interacting factors create larger impacts than any of these factors taken alone including the changing climate—at least at this point in time.

A serious concern regarding the exacerbating and interacting effect of climate change on extant challenges concerns the rapid rate of ecosystem destruction, habitat loss and species extinctions. Deforestation is a major obstacle accounting for the destruction of carbon dioxide reservoirs worldwide, but in conjunction with the changing climate contributes to uncoordinated species migrations, and changing patterns of animal, insect, and plant interactions.

Global water and sanitation pose significant challenges for billions of impoverished people, both urban and rural. Half the world's hospital beds are filled with people suffering water related diseases (Corcoran 2010). Flooding by its basic nature and intrinsic power not only causes damage and injuries to all in its path, it adversely affects water quality and challenges health because of what else lays along the water's path. Flood waters include the excessive and extensively used toxic pesticides, fertilizers and animal manure that flush from farm fields, the sewage released by overburdened urban drainage systems, and the leached petroleum products of affected roadways, garages, gas stations, and parking lots, to name just a few of the health threatening contaminants of flooding events.

The web of dangerous interconnections features only some of the known ecosystem and social services under threat. Everything caught in this web is made worse by global warming and climate chaos.

Figure 10. A Dangerous Web.
Graphic by Channon Green & Maureen McCue

Climate Change Affects Iowa Agriculture & Economy

The prosperity and well-being of Iowans and the Iowa economy is critically dependent on the weather. Iowa leads the nation in corn and soy bean production and ranks second for agricultural income in the U.S., behind only California (USDA 2014; USDA 2016; Eller 2016b). Bordered by two major rivers, the Mississippi and the Missouri, Iowa is rich in water resources. While Iowa is naturally subject to great weather variability from the movement, meeting and intersection of cold air masses from the far north, and warm, humid air masses from the Gulf of Mexico, Iowa farmers rely on predictable precipitation patterns and the use of waterways for shipping and trade.

IOWA FORECAST: COSTLY WEATHER CHAOS

IOWA IS GETTING WARMER AND WETTER

Iowans already feel the impacts of climate change. Iowa, especially Iowa's cities, have become at least 1.0° F (~0.55°C) warmer on average over the last few decades. At the same time Iowa's growing season has lengthened,

Table 2. Iowa, Warmer & Wetter in 2015.

City	Temp. (° F) Above Average[a]	Pricip. (Inches) From Average[a]	Number Record Rains[b]
Algona	3.5°	2.3"	-
Cedar Rapids	1.5°	7.3"	10
Centerville	1.4°	-6.6"	-
Council Bluffs	2.0°	5.5"	0
Des Moines	2.7°	8.5"	14
Dubuque	1.1°	2.9"	9
Iowa Falls	2.7°	-6.8"	-
Muscatine	0.5°	-9.4"	-
Sioux City	2.5°	7.4"	5

Data Sources: a. (Lai 2016); b. (NOAA 2016)

its weather become more chaotic, and flooding more frequent (Iowa Flood Center, Pryor 2014, & NOAA 2013a). Numerous trends in climate change have significant relevance to Iowa's built environment and to its agriculture economy. Altered rainfall, heat stress, pests, ozone levels, and extremes like drought, late spring or early fall

freezes, severe storms and flooding can seriously affect people and increase costs of production across the state, and the entire Midwest.

Some of the early climate changes like the longer growing season related to earlier spring thaws have been favorable to farmers, as has the increased CO_2 in the troposphere. Longer growing seasons have allowed farmers to increase their crop yields by planting earlier (Rogovska 2011; Porter 2014). However, while such changes are beneficial in the short term, most changes like heavier downpours and extreme storms and the phenomena that follow in their wake will be detrimental to agriculture. Susceptibility to the movement of pests and invasive species is expected. Iowa is among the top 10 states with the greatest increases in heavy downpours, and Des Moines is in the top 20 U.S. cities with heavy downpours in recent years compared to the period between 1950-1959 (Climate Central 2015).

MORE FREQUENT EXTREME RAINFALL EVENTS

Since 1980, Iowa has had 26 flood disasters with damages exceeding $1 billion. Average temperatures and level of precipitation recorded by Accuweather and reported in the New York Times as an interactive database (Lai 2016) for thousands of cities around the globe for 2015 suggests the rate of temperatures rise is accelerating. This database compares average temperature and precipitation for 2015 to average for the period 1981-2010 for numerous Iowa cities. Only Iowa City, of those reviewed, showed a minimally less than average temperature in 2015: 0.4°F below average that year.

The state has had an 8% increase in annual average precipitation over the 136-year period from 1873-2008 (Takle 2011). These findings were confirmed in the *Times* review, and other studies, where most Iowa cities had been experiencing increased (5-14) record rains over the year. Heavy downpours are over twice as frequent as they were a century ago. Rainfall of more than 1.25 inches in a single day are increasingly frequent (Takle 2011). Current data from the Iowa flood center indicates even greater changes. Heavy rainfall precludes water's ability to percolate into the ground. Floods further degrade already degraded ecosystems. Removal of vegetation in and around rivers, increased channel size, levee bank and catchment clearing as has been done all across Iowa, in combination with heavy downpours, work to degrade hill-slopes, rivers and floodplains, increase top soil erosion, transfer of sediment and loss of nutrients (Global Change 2009).

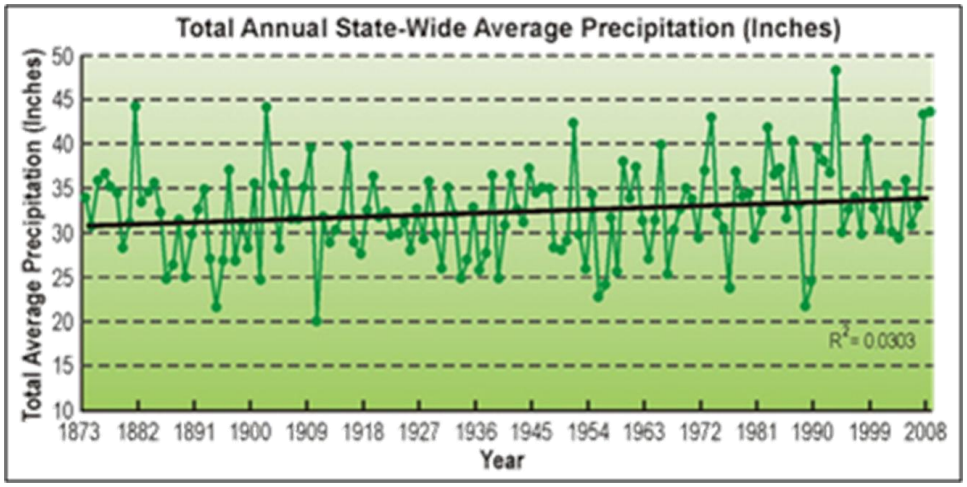

Figure 11. Total Iowa Annual State-Wide Average Precipitation 1873-2008.
Source. Accuweather

Very little of Iowa's protective natural carbon reservoirs remain intact. Approximately 85% of Iowa's land is dedicated to farming which has brought about widespread alteration of natural ecosystems. Most of Iowa's original carbon capturing prairies, wetlands, and cooling forest cover are gone. After achieving stable tree cover for a period in the late 20th and early 21st century, Iowa again lost a net of 97,000 acres of forested land between the years from 2008 to 2013 (Nelson 2016). This extensive deforestation contributes to the warming climate and compounds the risks of flooding.

Iowa has been losing its carbon rich top soil at a rapid rate. In 2014 alone, total cropland erosion was estimated at 15,029,723 tons costing Iowa farmers billions in yield and polluting waterways with fertilizers, other chemicals and sediment (Rundquist 2014). Erosion and sediment runoff may clog reservoirs and reduce storage capacity requiring Iowa farmers to adopt additional conservation practices to preserve soil and water quality (Rogovska 2011). Finally, due to the impacts of Iowa's extensive tiling system, many of Iowa's surface waters are already degraded and imperiled by the pesticides, fertilizer and manure that wash off the land during downpours (Eller 2016a). More heavy precipitation and flooding can be expected to progressively worsen these problems impairing future food crops.

Iowa agriculture alone has not been responsible for Iowa's environmental stress. Unplanned development and suburban expansion have contributed to surface warming as still more trees and carbon sinks are removed while more dark impermeable surfaces are added to make roads and buildings. The five largest population centers in Iowa (Des Moines, Cedar Rapids, Davenport, Sioux City, and Iowa City) are all located on river ways increasingly prone to flooding. These communities have been heavily impacted by record floods in the recent past. In 1993 and in 2008, flooding deemed to be in the 500 year flood range was highly destructive to Iowa.

The 1993 Great Midwest flood was one of the most extensive and damaging natural disasters to hit the United States and Iowa to that point. It was devastating economically and socially. Damages totaled $15-20 billion, at least 50 people died, hundreds of levees failed, and thousands of people were evacuated, some for months, some never to return home. At least 10,000 homes were totally destroyed. (Larson 1996)

Then only 15 years later, the Iowa Flood of 2008 forced authorities to evacuate over 8,000 people from their homes throughout Iowa City and Cedar Rapids. For Iowa, the flood of 2008 was considerably worse, especially

Figure 12. Flooding in Iowa, 2008.
Source: National Weather Service

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for relatively unprepared Iowa City and Cedar Rapids which remained above flood stage for several weeks. The flood safety report from the National Oceanic and Atmospheric Administration indicates that residents of over 5,200 homes were affected. Recovery has been prolonged, problematic and costly for the state to this day. The

University of Iowa sustained $862.5 million in damages to educational facilities per a retrospective legislative report (Iowa LSA 2012). In the years since, several other floods in the near 500 year range struck other parts of the state.

Precise predictions of future precipitation amounts and frequency due to human induced warming are hard to predict, but regions like the Midwest and Iowa can expect more floods (Mallakpour 2015; National Climate Assessment 2014). Precipitation in much of Iowa, especially the eastern half of the state is expected to become more intense, leading to increased flood damage, strained storm and sewage drainage systems, and corresponding challenges to water quality and reduced drinking water availability. Surface runoff in cities with impervious infrastructure is also problematic.

Toxic waste storage like the manure ponds seen around Iowa's many CAFOs (Concentrated Animal Feeding Operations), and the coal ash ponds and coal piles around Iowa's coal fired power plants are vulnerable to overflow retaining walls during flooding events. Such overflows threaten to destroy man-made structures in their wake, and can be extremely damaging to near-by ecosystems.

More Frequent and Extreme Heat Waves and Droughts

Alternating with the floods have been major heat waves and droughts which like the heavy precipitation events have been occurring more frequently across this region since the 1980s. More frequent, more severe, and longer lasting heat waves are predicted for the area in the coming years. Expected increases in summer drought frequency and evaporation rates, especially in the western half of the state could reduce water levels in nearby lakes and wetlands, as well as in important commercial waterways—as was seen in the 2012 drought when disruptions in barge traffic along the Missouri and Mississippi Rivers occurred.

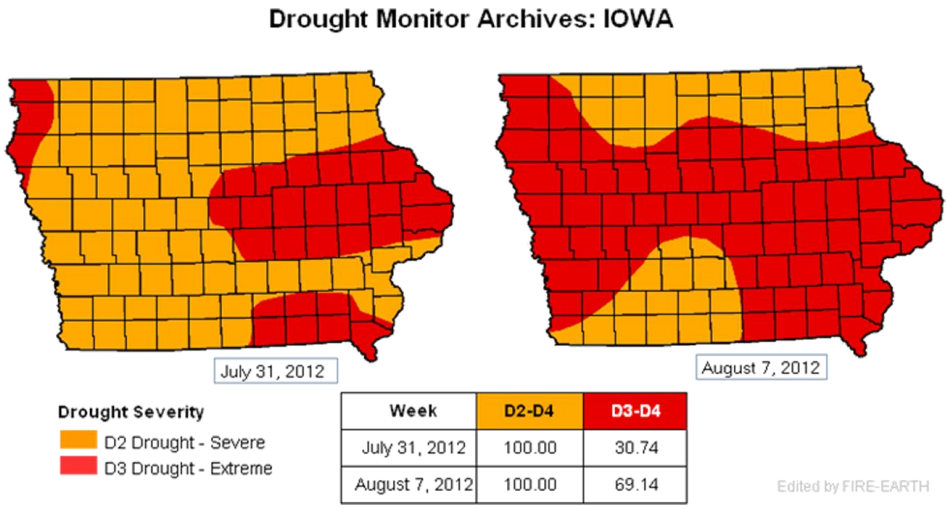


Figure 13. Drought Monitor Archives: Iowa.

Weather Affects Iowa Agriculture

Iowa farmers will likely see the higher yields resulting from the current earlier warmer, longer growing season for a limited time only. Extreme weather, especially Iowa's increasingly frequent flooding challenges food production. Livestock and food crops take time to adapt to water and temperature changes. While some crops show positive responses to elevated carbon dioxide and warming, changing water cycles and ever higher temperatures stress both plants and animals. Increasingly warmer temperatures and other stressors of a more

chaotic climate are expected to decrease corn and soybean yields with obvious impacts on the Iowa economy (National Climate Assessment 2014). When overheated, corn itself, contributes to local humid hot spots, an effect known as "corn sweat." (Eller 2016b)

Figure 14. Climate Change in Iowa: Interactions and Exacerbations.
Graphic: Channon Greer

Extremes reduce livestock & crop productivity and nutritional value, weaken growth and defenses, making them, like humans, vulnerable to pests, insects & diseases. Heat waves in Iowa are especially costly for livestock

producers who experienced some of the deadly impacts of heat and drought in 2011 (Rogovska 2011), 2012 and 2016 with significant crop and livestock losses.

Other factors complicate the agriculture picture. Global climate change and landscape alteration has led to the disappearance of 50 percent of Midwestern native bee species. In the last 20 years, four North American bumblebee species declined by 96 percent, and three of these pollinator species may already be extinct, according to the Xerces Society for Invertebrate Conservation. The historic plant pollinator network showed flexibility in response to early disturbances; but these networks will be less resilient to future changes (Burkle 2013).

Extreme weather assaults trees along with everything else in its path. A particularly intense wind and rain storm or an atypical early snow storm on still leafed out mature trees means over-burdened, heavy boughs and trees in the path of the storm come down. Nothing in nature is safe from a severe storm, whether straight line wind, tornado, or heavy downpours—all of which have been increasing and are expected to continue to increase in frequency and intensity over the coming years.

During droughts, water level decline can force reductions in the weight of cargo shipments and diminish the usability of waterway infrastructure, such as docks, locks and piers needed to move Iowa farm commodities to markets. Taken together, these weather predictions involve serious economic threats to agriculture, general trade, as well as destruction of natural resources and the built environment.

Heat adversely affects aircraft performance -- high heat makes it more difficult for airplanes to get off the ground.

Business Insider 2013

WEATHER AFFECTS IOWA ECONOMY

As noted, temperatures for most cities across Iowa have increased in recent years above established averages. Temperature increases and heat waves not only affect agricultural productivity but adversely impact urban centers due to their many heat trapping surfaces (roofs, concrete, asphalt parking lots), population and building density, road ways and traffic congestion. On average, summer temperatures in Iowa's urban centers are 2.9 °F hotter than surrounding rural areas. Summer heat in Des Moines has already soared to up to 24 °F hotter than in nearby rural areas (Climate Central 2014). In fact, Des Moines has 10 more days above 90 degrees than nearby rural areas.

Did you know?

The economic impact and number of jobs created by Iowa's beer and wine industry has exploded in recent years.

(McKay 2015)

But,

Climate affects the flavors and types of hops available for the favorite beers and the grapes for the best wines!

Environmental Defense Fund

While better in general than other parts of the country and the world, Iowa's air quality is already reduced during hot humid days in industrial centers. Air pollution is projected to worsen with rising temperatures due to the chemical interaction of emitted VOCs, heat and humidity forming ozone.

Heat island effects increase demand for energy intensive air conditioning and risk inducing electricity disruptions, and/or increasing economic stresses for those least able to afford increased energy use. At the same time, approximately 95% of the electrical generating infrastructure in the Midwest is susceptible to decreased efficiency when operating in higher temperatures. By mid-century the infrastructure investments needed to combat rising temperatures in the Midwest are predicted to require more than $6 billion (Pryor 2014).

Climate Change and Health in Iowa

Iowa's current health risks and emergencies will be exacerbated as extreme weather patterns evolve in many of the same ways as that of other states. However, given Iowa's topography, agriculture and industrial economic base, Iowa's health care and public health infrastructures, arrangements, and priorities, Iowans face several unique health risks while avoiding others.

Factors to keep in mind when determining health risks of climate change for Iowa include, among others: the state's aging water infrastructure and extensive water pollution; rapidly expanding elderly population; weak mental health resources; increasing intensity and duration of allergen producing plants; and ever present risk of animal to human transmission of microbial contaminants associated with confined livestock. Each of these risks grows in a warmer, wetter Iowa.

As a rural, land locked state, Iowa does not face the threats of rising sea levels or intense hurricanes. Similarly, despite the invasion of powerful tree pests like the emerald ash borer, with so little forest cover to burn, Iowa avoids wildfire associated threats. Most of Iowa's significant health challenges will be driven by heat waves with their exacerbation of air pollution, and precipitation extremes including both heavy rainfall and flooding, and drought. Threats of infectious diseases are always a concomitant of Iowa's heavy livestock agriculture, but they may accelerate as climate driven migration patterns for disease vectors (especially birds, insects, arthropods) are altered by changing climatic conditions.

HEAT SICKENS AND KILLS

Heat stress is likely to increase as a result of continued rises in temperatures and humidity (EPA 2016b; US Global Change 2009).

Heat stress illness (HSI) ranges from mild heat edema, heat syncope, heat cramps, to heat exhaustion, the most common type of HSI, and heat stroke, the most severe type of HSI. Iowans at both ends of the age range can expect more heat-related illnesses and death during heat events. Periods of high heat are especially challenging for those with chronic diseases (diabetes, heart and respiratory diseases, and mental illness), elders, and very young infants who are especially susceptible to Sudden Infant Death syndrome in the heat (Auger 2015). These populations are most sensitive to the heat itself, as well as to associated air pollution, vector borne diseases, and aeroallergens. They are also often unable to move themselves away from these risks.

Depending on living circumstances and resources of vulnerable populations, even a 1.8 °F increase in temperature during the summer can increase mortality for elders, especially those who have chronic health conditions (Zanobetti 2011). The CDC tracked heat stress illness (HSI) in Iowa and 19 other states from 2001-2010 and found an overall 2%–5% increase in the rate of HSI hospitalizations compared with the 2001 rate. Males over 65 years, infants and the oldest old with chronic diseases are at highest risk (Choudhary 2014). Outdoor workers, especially those in construction and farm labor, are also at risk of heat stress in high heat situations.

Air Pollution: Fine Particulates, Ozone, Smog

Heat exacerbates health threats for those vulnerable to a range of cardiovascular and respiratory diseases triggered by air pollution. Emissions from vehicle exhaust, industry, coal and gas based energy plants combine with climate driven high levels of pollens and air borne allergens, and infectious agents like molds and fungi to add to distress.

The state of Iowa is less heavily impacted by severe air pollution when compared to more populous states. However, since data has not been collected on most Iowa counties it is difficult to ascertain the extent of its effects. A handful of counties monitored for Tropospheric ozone pollution and particle pollution received grades ranging from passing to failing while a few others have been recognized for exceeding standards put forth by the EPA, achieving A's and B's (EPA 2016c). Regardless, the lack of monitoring in place throughout much of Iowa does not indicate that air pollution is of no threat to health locally.

Iowans, living in some rural areas and impoverished and industrialized urban areas that have difficulty complying with national air quality standards (NAAQS) share with those living in poorer neighborhoods all across the U.S., an increasing prevalence of asthma and respiratory disease. Depending on the sources cited, 8.2% - 10.3% of adult Iowans reported they have asthma (IDPH, 2010; Ositelu 2014).

Like all urban areas with major interstate traffic, Iowans living and working in Cedar Rapids, Des Moines, Waterloo, Davenport, Dubuque, Council Bluff, Marshalltown and other busy industrial centers can expect to encounter increasing ground level ozone on hot and humid days. Heat and humidity, CO_2, and the volatile organic chemicals (VOCs) emitted by tail pipes and industry, all combine to form ozone, a powerful respiratory irritant. While Iowa is generally in compliance with national air quality standards, some vulnerable Iowans may still suffer from the levels encountered today. The American Thoracic Society for instance predicts that over 20,000 Iowans are likely to be affected or become symptomatic because of existing concentrations of "allowable" pollution (Cromar 2016). With increasing heat, the numbers affected can also be expected to increase.

Pollen and Fungal Spores



For those who suffer from allergic rhinitis (sneezing, itching, dripping, sinus-clogging misery) and the more dangerous allergic asthma, the rising temperatures and CO_2 levels are leading to prolonged, higher levels of allergenic pollens (Albertine 2014). The plants that demonstrate the strongest response to the lengthened growing season and increased atmospheric CO_2 are also those spring flowering trees, grasses, weeds, and fall ragweed, associated with allergenicity.

During the spring, fall and summer months Iowa frequently experiences medium to high (relative to other states) levels of pollens and air borne allergy risks. Iowa's long growing season allows for bigger ragweed plants that produce more pollen later into the fall. Additionally, as the warming season grows longer and new allergenic plants continue to move northward into Iowa, the duration, intensity and range of exposure is amplified. These allergens then interact with existing air pollution, ambient levels of molds, temperature, wind, humidity and precipitation to produce difficult breathing conditions, increasing the severity of allergic rhinitis and asthma. Childhood and adult asthma have dramatically increased since the 1980s, despite significant declines in deaths from asthma attacks (CDC 2014a).

While ragweed and other pollen allergies are not life threatening for most sufferers, they cost time and money for symptom relief. On the worst days heavy pollen production leads to work and school absenteeism and lost economic productivity. The growth of poison ivy is also accelerated in Iowa's changing environment. Increased CO_2 is associated with more prolific and powerful poison ivy. Faster growth rates for toxic plants bring about more contact dermatitis misery for gardeners and hikers unfortunate enough to tangle with this and other increasingly wide spread noxious weeds!

INCREASED INFECTIOUS DISEASES RISK

Earlier and longer growing seasons mean expanded opportunities for the growth of a variety of disease carriers. Mosquitoes, ticks, changed bird populations and rodents are moving into and doing well in Iowa's longer warm season and altered ecology. Epidemics of vector-borne disease have the capacity to overwhelm health systems, and impact other sectors, such as tourism—even in Iowa. The "complex feedbacks" between climate and mosquito-borne illness is highly "location-specific" (Morin 2013).

Rapid Lyme Disease Spread

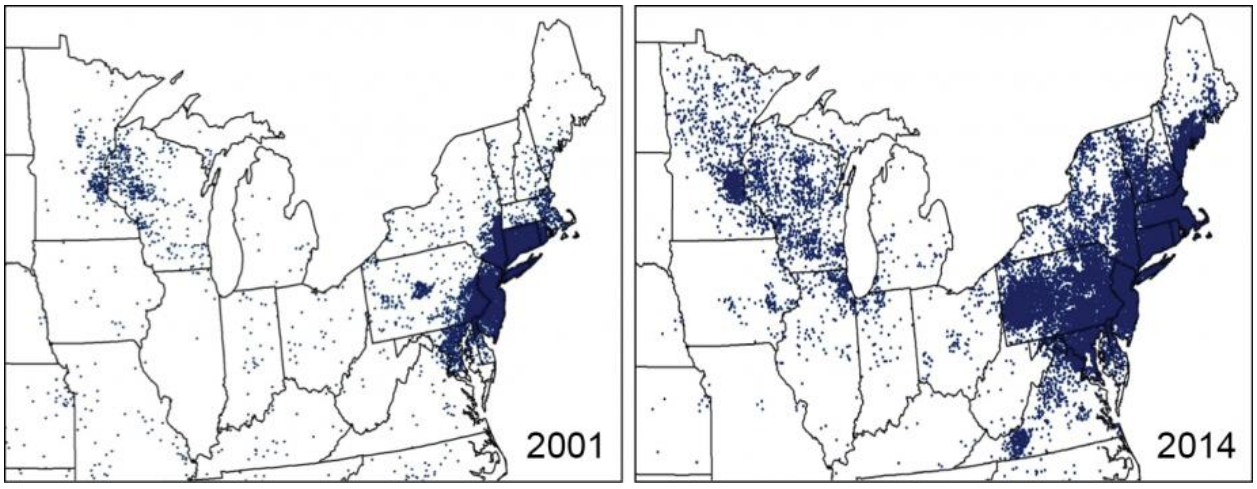


Figure 15. Rapid Lyme Disease Spread.
Source: (Global Change 2016)

With longer warmer weather insects have longer seasonal activity. West Nile Virus carried by mosquitoes and Lyme disease carried by ticks have both been increasing in Iowa over the past decade. Earlier warm weather means ticks emerge earlier in the season. Wetter summers are especially conducive to increased growth, biting, and reproduction of all mosquitoes.

Relatively recently both Lyme disease and West Nile Virus were rare in Iowa. The first case of Lyme disease in Iowa was reported in 1999. The trajectory since then has been rapidly increasing. From 2005 through 2014 Iowa reported 966 cases of Lyme disease. Similarly, West Nile Virus was first detected in Iowa in 2002. From 2002-2015 Iowa had 461 cases of West Nile virus (CDC 2015a; CDC 2015b). The course of both diseases has grown as temperature and precipitation patterns have been changing. Now common in the Midwest, Lyme disease infections are expected to continue to increase. And as with the recent emergence and spread of Chikungunya and Zika, yet other infectious agents can be expected in Iowa as land use and weather patterns continue to change.

Avian Influenza and Climate Change

For several years researchers have noted changing influenza interactions in the wild. Many questions remain unanswered about the role of the changing climate and the habits of wild birds that carry, alter, and magnify disease associated threats. The changing climate appears to be contributing to changed migration patterns, persistence of the virus, and potential interaction with other factors. To date, avian flu viruses do not easily infect humans – beyond the sporadic 600 cases and 300 deaths that have been reported worldwide (Mu 2014). However, given the lethality of the disease and Iowa's expansive poultry business and specific history with Avian Influenza, epidemiologists are watching these interactions closely.

Iowa lost about $1.2 billion stemming from the death of more than 30 million hens and 1.5 million turkeys because of avian flu in 2015. The avian flu outbreaks around the state—mostly caused by H5N2—resulted in 8,444 lost jobs, many of which will not be recovered (Decision 2015). Human cases of a related strain, H7N9 influenza, first emerged in China in February 2013, with the majority of reported infections occurring in the spring. As of Aug. 2013, 135 confirmed human cases, including 44 deaths, have been reported by WHO. Most of these cases involved people who came into direct contact with infected poultry. Although no H7N9 influenza cases have been reported outside of China and the virus has not demonstrated sustained person-to-person transmission, there is concern that it could mutate to pose a much greater public health threat, especially here in Iowa (NIH 2013 b).

Altered Precipitation Patterns

Severe storms, extreme rainfall events, floods, and intermittent drought all bring displacement and a myriad of health risks to Iowans. As described above, extreme weather events, floods and natural disasters force thousands to flee from their homes, while thousands of others are left stranded without access to clean water, food, or electricity. Increased respiratory illness from molds that form following heavy precipitation or flood events.

Beyond the impact of disasters, year round water quality is of serious concern as a public health issue in Iowa, one that will be exacerbated by the impacts of climate change altered precipitation. Heavy rains increase the presence of harmful substances such as nitrogen, phosphorous, pesticides and herbicides, manure-derived infectious pathogens, and antibiotics into nearby water ways (Rogovska 2011). As climate change superimposes itself upon this already longstanding threat to public health, higher levels of precipitation will lead to the increased discharge of these harmful chemicals.

Heavy rainfall in Iowa farming regions washes vast volumes of agricultural nitrogen and phosphorus pollution into rivers and lakes, which when combined with warmed surface waters fuels harmful algal blooms in many Iowa lakes. These poisonous Cyanobacteria blooms sicken and disgust residents & summer tourists. Exposure to associated microcystin levels can cause breathing problems with asthma like symptoms, upset stomach, skin reactions, and in extreme cases, even liver damage. The smell alone causes headaches, eye irritation, sore throats, chest pain & respiratory distress (Samples 2016; IDPH 2016).

Cyanobacteria bloom in Iowa Lake.
Source: Iowa Department of Health

MENTAL HEALTH AND SEVERE WEATHER

Disrupted lives, loss of community, cultural, environmental and, ecosystem resources during flooding, tornadoes, and prolonged heat waves constitute traumatic events. Threats to or loss of livelihood and/or home, especially the loss of life of friends or family members, can lead to post traumatic stress disorders, depression, anxiety and domestic violence in the months and years after extreme weather events (VA 2010). It has been recognized for decades that heat is correlated with violent behavior. A meta-analysis of 60 global studies (including several performed by Iowa State researchers) noted that for "every standard deviation of [temperature] change, levels of interpersonal violence, such as domestic violence or rape, rise by some 4 percent, while the frequency of intergroup conflict, from riots to civil wars, rise by 14 percent" (Hsiang 2013).

Families and communities are torn apart as some affected people cannot rebuild in their prior location and are forced to live elsewhere. The 2008 Iowa flood displaced more than 10,000 residents in Cedar Rapids alone (Fox News 2008). 1300 properties beyond repair and in harm's way were eventually acquired by the city (Tate 2016). The list of these non-monetary, but very tangible costs to people's mental health and well-being can be long and difficult to overcome.

> ***" Don't you find that disturbing that someone ends up in our jail just because somebody didn't take their meds? "***
>
> - Black Hawk County Sheriff Tony Thompson. 8/29/16

Iowans already face a severe shortage of mental health providers and quality mental health facilities. "Iowans often have long waits to get the mental health services they need," asserts Iowa State Senator Joe Bolkcom (Bolkcom 2016) and others (Fuller 2016). Iowa is at the bottom of the nation in the number of adult and child psychiatrists available per capita. In fact, Iowa ranked 49th in the 50 states when it comes to the state's ability to provide inpatient mental health treatment (Fuller 2016).

Sixty percent of Iowa's mental health beds available are in the correctional system. As evidence of Iowa's lack of attention to or support for mental health needs, Iowa currently has only 26 beds, or two beds for every 100,000 Iowans. Most of the limited mental health facilities available are being used by inmates.

In total, public and private, there are 731 mental health beds, considered not nearly enough to attend Iowa children and adults with serious mental illnesses. "…[T]he state is short-changing the mental health system"...we don't have enough capacity in the community based mental health network to meet the need we are facing right now," Mark Smith House Democratic leader from Marshalltown (Glover 2016). Despite current needs and growing future risks, funding mental health or growing an appropriate mental health infrastructure remains a very low priority for Iowa's law makers to date.

IOWA AND CLIMATE JUSTICE

Iowans and Iowa's economy are healthier than many other areas in the U.S. Measures of inequality indicate a more equal distribution of income in Iowa relative to 45 other states. Yet, Iowa is home to a significant number of vulnerable and impoverished populations (Munson 2015; Talk Poverty 2016). The impacts of climate change, fall disproportionately on low-income communities and marginalized people in all communities. Iowa is no exception.

Iowa's most vulnerable or climate sensitive citizens come in a variety of ages, ethnicities, occupations, and place of residence. Of Iowa's total population of just over 3 million, total enrollment in Medicaid was 613,386 elders, disabled and low-income Iowans—more than one out of six Iowans, many of whom are children (Norris 2016). And this statistic does not include the working poor who desperately struggle to survive catastrophic climate events and often lack the resiliency to ever completely recover.

Iowa's is an aging population; Iowa ranks fourth in the nation for those 75 and older. 491,349 Iowans were 65 and older in 2014 accounting for 15% of the Iowa's population. Almost a third of them have at least one type of disability. By 2050, almost 700,000 Iowans are projected to be 65 and older (Iowa Data Center 2016).

Chronic diseases like diabetes, heart disease and obesity make older Iowans susceptible to extreme heat or storm events. In 2014 almost 9% of Iowans were diabetic and over 26% of Iowans were obese (CDC 2016). This places a large number of Iowan's at risk of injury or disease when confronted by difficult weather situations.

At the other end of the age spectrum, Iowa's children too face important barriers to health. A survey done in 2010 identified significant health disparities for minority children in Iowa especially African American and Hispanic/Latino children as compared to White and Asian and Pacific Islanders children in the state (Damiano 2013).

It's also important to consider Iowa's outdoor workers and homeless population. Several sources indicate that even though homelessness has been on the decline over the years, as of this year Iowa is still considered to have over 12,000 homeless (Towne 2016). The homeless are at increased risk when exposed to any extreme weather, heat, cold or rain. Those most at risk require adaptation and prevention strategies to boost their resilience.

The rapidly changing climate isn't just a technologic or environmental concern that can be invented away by technology. The changing climate challenges our basic economic and social arrangements; our support for human rights. The challenges of the changing climate are made worse by increasing inequality and powerlessness especially for minority populations.

Source: Iowa Now, University of Iowa 2016

Iowa Accomplishments

CLEAN ENERGY

Iowa is first in the nation for percent of energy generated from wind and the number two state in total wind capacity. What's more this feat was accomplished with bi-partisan support. Furthermore, despite the lack of strong national leadership, many Iowa cities are nevertheless working hard to reduce their carbon footprints and become more sustainable for the climate future through strong local action.

MODEL CITIES

Many Iowa's cities work to build sustainability and resilience through a variety of important programs. The Mayors Climate Protection Agreement started in 2005 after the Kyoto Agreement has 34 Iowa cities of the 1,060 cities involved nationwide (US Mayors 2005). Eighty one Iowa cities also hold membership in Arbor Day's Tree City USA committed to improving urban environments by developing locally aesthetic and cooling tree canopies (Tree City). Iowa has nine cities enrolled in the relatively new and rigorous STAR Communities program. Most recently, Iowa City also became part of the Regenerative City framework to name a just a few of the applicable programs and initiatives.

Through these and yet other urban based initiatives, a myriad of indicator tools have been advanced and tested for effectiveness in cities wishing to improve social, economic and environmental sustainability. To varying degrees, they offer means to revitalize neighborhoods, spur economic development, and provide workable transportation options as needed to improve public health and protect natural resources. The various evaluative tools are available online for implementation by other communities, and include aspects of sustainable development well beyond environmental dimensions including ideas about governance, income, equity, and business opportunities. The Regenerative City framework being used by Iowa City specifically calls for a rethinking of urban designs in an age of climate change, restoration of native habitats, and a shift toward dramatically ramped-up urban agriculture, renewable energy and viable urban development, especially for the area's most vulnerable populations.

DUBUQUE

Dubuque is Iowa's highest rated 4-Star City and was also named a Climate Champion by the White House. Dubuque is working to incorporate sustainability into every sphere of daily life as it reduces its carbon footprint. Goal: 50% GHG emission reductions by 2030. Current initiatives include: a. local food systems to develop sustainable agricultural practices while fostering healthy lifestyles and economic development; b. improved air quality via tree-planting initiatives; c. "Reasonable Mobility" effectively decreasing reliance on cars, reducing GHG emissions and carbon footprint via improved and expanded transportation alternatives combining bicycling and making specific transit routes more accessible for all, promoting carpooling & public transit, improved bike/hiking trails as a part of a healthier lifestyle; d. high quality water supplies in compliance with all standards set forth by the EPA (EPA Partner). Finally, Dubuque has developed a Rack & Ride Program to make biking Dubuque's changing hills without the use of cars more feasible (City of Dubuque 2016).

Of special note, a 1.4 million dollar grant from the Iowa Office of Energy Independence supported a smarter electricity pilot study jointly conducted by Dubuque, Alliant Energy and IBM looking at real time energy use

Table 3. A Sampling of Iowa's Greening Cities.

City	Population	STAR Community Status[a]	Mayor's Climate Protection Agreement	Tree City[b] Since	Greening Landmarks
Ames	50,000	-	✓	1983	#39 of 300 Greenest Cities by Sperling.[c]
Davenport	102,157	4-STAR	✓	1980	STAR Pilot; Midwest's Largest 4-STAR City.[d]
Decorah	7,957	-	✓	2003	Luther College,[e] Decorah, IA reduced GHG 64% since 2004.
Des Moines	208,000	3-STAR	✓	1992	EPA State Capitals.[f]
Dubuque[g]	58,155	4-STAR	✓		Sustainable Cities Network.[h]
Fairfield[i]	9,500	-	✓		Abundance Ecovillage & Cypress Village.
Iowa City	71,600	4-STAR	✓	1980	Regenerative City.[j, k]
Waterloo	68,364	-	✓	1984	Americorps volunteers help green city.

Sources: a. (STAR City); b. (Tree City); c. (Sperling's Best Places); d. (Davenport 2014); e. (Luther College); f. (EPA Partner); g. Iowa's highest rated STAR Community (STAR City); h. (Sustainable City Network); i. Mayor Ed Malloy voted #4 of 15. (Greenest Mayors 2009); j. (Biggers 2016); k. (WFC).
Table by Kareem Butler, Maureen McCue and John Rachow

monitoring and feedback as a mechanism to motivate individual efforts to reduce energy use. Ultimately the city has a goal of achieving zero waste, via mechanisms of reuse, repair and recycle in order to drastically minimize and ultimately eliminate waste.

DES MOINES

Des Moines is one of only four locations in the US to host a meeting of the President's Task Force on Climate Preparedness and Resilience. The task force of governors, mayors, county officials and tribal leaders met in May 2014 to advance plans on identifying and responding to climate change related disasters for cities across the US. Des Moines' efforts to be a green, resilient, economically viable and livable city made it the perfect location for such a gathering, which having launched its STAR pilot project in 2010 has made great strides in the interim (Boose 2015). Des Moines has a sustainability team working in 10 City departments, operates four LEED rated buildings, had achieved 25% reduction in CO_2 emissions by 2015 (for 15 buildings). These efforts in departments as diverse as city libraries, transportation and fire saved the city over $1.2 million and emission of 11,542 metric tons CO_{2e} from 2008 to 2012, due to its energy efficiency improvements (Graham 2012).

Ongoing efforts by Des Moines include upgrading its system of city parks, trails (40 miles citywide) and tree planting programs, historic building upgrades and renovations, use of electronic motorcycles by the police department, solar hot water heaters for the fire departments, and restaurant grease and biogas reclamation, along with close affiliations with local businesses and entrepreneurships.

Iowa City

Iowa City is both a 4-STAR rated city and a Regenerative City within a joint Sustainability effort by Johnson County and the University of Iowa. The University of Iowa, itself, has incorporated a long list of sustainability initiatives. The three entities share a focus on local foods and food waste composting as a mechanism to reduce CO_{2e} release and contribute to healthier diets while simultaneously stabilizing and reducing soil runoff and improving local water quality. Each entity also prioritizes energy efficiency within its functional units and maintains active carpooling programs. They also work together to improve the bike-ability and walk-ability within their catchment areas. County 86 KW solar panel arrays, set up under the first Iowa Power Purchase Agreement generate, about 144,000 kWh of electric power per year and are set to be expanded in coming months (Johnson County 2016)..

Cities, Counties, Colleges and Universities

Many other Iowa cities, counties, and educational institutions are engaged in greening, sustainability, climate justice, climate adaptive and mitigative efforts focused on transportation, buildings, water quality, and local food production. Their efforts and results have been noticed. On Sperling's list of 100 Greenest U.S. Cities, Iowa City ranks at position #29, Ames at #39, Cedar Rapids at #84. Sperling's *Best Places* examines 24 data metrics in 5 major categories -- including air and watershed quality, mass transit usage, power usage, farmers markets, organic producers, and number of green-certified buildings to determine which metro areas are the best places to live a green life.

Building a Livable Iowa Future

To adapt to the unavoidable changes that are coming while taking mitigative measures to avoid catastrophic climate change, Iowa can and must do much more. Without ambitious, immediate action across all sectors of society to cut carbon and other greenhouse gases, climate impacts will be far worse in the future. Along with the rest of the country, Iowa needs to plan to be running almost entirely on clean energy by 2050. Although Iowa has made a good start in several important respects, especially in its support for and deployment of wind energy, there is so much more that can be done.

> …educational and policy programs are not enough. Networks and best practices are not enough. Software tools and consulting are not enough. Transformation requires a carefully coordinated, linked up system of political education, professional training and networking, technical support and civic education, and constant performance evaluation and feedback with each local government member over an extended time period. (ICLEI USA 2010)

Health improvements and lives to be saved as reliance on fossil fuels is diminished are also potentially dollars to be saved on health care and related costs even as sick days at work and in school are reduced. Across the U.S. switching to clean renewables, could save $4 billion in hospital costs (Meer 2015). Iowans can and have started to rebuild cities for optimal health by reducing car miles, and improving bike lanes and rapid transit. As the top ranked state in the nation for percent of energy generated from wind, Iowa is in great shape for continued progress building for a livable future.

Moving into a healthier, low carbon, clean energy future in time means picking up the pace of change. Acting now saves lives, expenses, and improves public health now and well into the future. Mitigating climate change can be a positive for health, farms, communities, and economies. Working to halt climate change provides an opportunity to rethink and reframe Iowa's values, not just about economic issues, but about definitions of community, the value of human lives, now and into the future.

There is something literally every Iowan can do to slow and reverse climate change and support the future by continuing to expand efforts in their homes, schools, and businesses, in the streets and at the ballot box. At all levels of government and throughout civil society, Iowans can work together to address global warming and its effects. Iowans can be leaders in the fight against climate change by taking bold steps to cut carbon pollution, protect clean air, and ensure no one is left out or left behind in the transition to a clean energy economy. As already noted, decarbonizing and working toward a clean energy future can be cost effective, create new jobs, save families and businesses money on their monthly energy bills all while providing multiple non-climate benefits for the health of Iowans.

Community cohesion requires support for development of community gardens, green spaces and tree plantings to revitalize blighted areas. Cohesion also requires expanding access to cost saving renewable energy by low-income households, and ensuring that good-paying clean energy jobs are available to residents in communities that struggle with energy poverty. This transition means opposing efforts by utilities to limit consumer choice or slow clean energy deployment.

Iowans and Iowa farmers can improve efforts to be responsible stewards of our natural resources, public lands and waters. Wildlife habitats and naturally wooded areas have to be protected rather than being turned into more farmland. Carbon sequestering native prairies can be reintroduced and expanded across the state.

Individual citizens and families, farmers, businesses, cities, states and the federal government need to continue expanding their efforts to devise and support clean energy policies, accelerate research, development and deployment of appropriate technology for a clean energy future. Cities can be redesigned and fortified, built up

not out in order to help protect land. Finally, given its large carbon footprint, there needs to be less reliance on concrete whenever possible.

For Law Makers

Cities

Local government actions will help move Iowa to increased sustainable clean energy and green cities. Cities represent 70% of potential cost-effective emissions reduction for the foreseeable future and clearly can be an important mover for climate mitigation around the world (IEA 2016). Cities can be made more adaptive, mitigative, economical and equitable. Ripe opportunities in food issues, housing, transportation, and city planning. For example, active transportation (walking and bicycling), has very little direct cost, can be made central to any city plan. Walking is conducive to lower-cost transportation and supports climate healthy options in both short and long terms. Air can be less polluted, health improved, lives and money saved if cities increasingly plan to reduce automobile-based traffic, increase buses, bikes and walkable neighborhoods and commercial areas.

Physical inactivity (lack of physical activity) has been identified as the fourth leading risk factor for global mortality (6% of deaths globally).

WHO 2016b

For those who live far away from where they work, public transportation can save cities significant emissions and people a significant amount of money over using a personal vehicle. Cities could do a better job of serving local transportation needs if public transportation were made free and extensive. This is very desirable from an equity perspective. Cycling is another low-cost option that cities can and should accommodate better, although it suffers from some of the same downsides as walking, at least in most cities as they are currently arranged (Cashman 2016; Levy 2015). Similarly, new buildings can be designed with climate change in mind. LEED certified and other green building approaches help with air flow and mitigate climate change by requiring far less energy to light, heat and cool. Older buildings can be refurbished for reduced energy needs with climate in mind.

State & County Policy Makers

State and local government can play large roles in designing Iowa's livable future. Local governments can invest in infrastructure and mechanisms to better protect water resources and prevent further contamination. Protection of our health requires concrete steps to reduce greenhouse gases. State and local health agencies can strengthen disease control efforts and plan for potential climate health risks, increasing resilience to long-term climate change (Campbell-Lendrum 2015). Assuring public health in a changing climate needs to begin with thinking

> ***" ...smart climate action goes hand-in-hand with future economic stability and growth. "***
>
> - Andrew Steer, President & CEO of the World Resources Institute

preventively and supporting improved surveillance, monitoring, control and response by public health entities to the many unfolding climate related health threats. Improvements are needed in areas such as robust mosquito control programs, sewage system upgrades, widespread availability of heat warnings and cooling centers for vulnerable heat sensitive Iowans. An improved, strengthened mental health system is essential.

Given that health care's first mission is to do no harm, hospitals and clinics can do much more to address their carbon footprint. The health industry, especially hospitals, is intensely dependent on electricity; U.S. Hospitals spend nearly $5 billion annually on energy and related costs (Meer 2015). Energy consumption in healthcare facilities is the second largest expense behind staff compensation. With hospital buildings aging and increasing energy demands with electronic medical records, intensive care, and other large energy demands, energy use improvements would reduce their bottom line, improve patient and community health, and reduce CO_2 emissions.

More energy efficient, greener buildings run on more local clean energy sources could save well over $100 million each year in power costs for hospitals (Meer 2015). The majority of hospitals have not yet undertaken steps necessary to achieve higher levels of efficiency or grid independence. Doing so requires conducting regular energy audits, developing a strategic master energy plan, monitoring baseline energy performance, and implementing on-site power systems where possible.

Federal Government

Iowa's Congressional delegation needs to support climate action for health, economic and climate reasons. For example, they have the power to promote and support one or more of the following policy initiatives illustrated in the next table.

Potential for significantly more wind expansion remains, even as our elected leaders can work to ensure that solar energy in Iowa experiences success similar to wind, with large amounts of solar to be installed with support from, and of benefit to a diverse set of Iowans. Iowa's distributed solar capacity grew from by 32% in 2014 and 2015 to 35 MW. Installation of another 20 MW is expected in 2016. Iowa's solar potential is 4,000 MW, enough to supply Iowa's electricity needs 150 time over (IEC 2016).

The Clean Power Plan is the U.S.'s most comprehensive effort to protect health and environment and slow climate change by establishing the first-ever federal limits on carbon pollution from power plants. Flexible and achievable, it is intended to cut roughly a third of CO_2 emissions from power plants by 2030. It gives states the opportunity to craft customized implementation plans to develop clean, renewable energy and deploying energy efficiency measures. Co-benefits include providing jobs, protecting public

Table 4. Cost Benefit Summary: Sampling of Possible Federal Clean Energy Policies.

Federal Policies	Initial Cost	Jobs Generated	Economic Potential
Wind Energy Tax Credit[a]	$1,506/kW = $3.76 million per turbine.	3.8 per 100 MW installed.	Landowner annual compensation rate $6,250 per installed turbine. Residential energy rates reduced.
Solar Energy Tax Credit[b]	$23,000 in 2013 for 5 KW system.[c] Homes need 3 - 8 KW.[b]	Nationwide jobs In 2015: 209,000 Projected 2016: 239,625.[d]	450 individual school districts could each save > $1,000,000 in 30 yrs by installing solar PV system.
Green Building Policy[e]	2009-2014 green building Cost $515 billion.	2009-2014 green building construction supported 8.33 million jobs.	Impact on GDP 2009-2014 $715 billion.
Fee and Dividend Plans To Reduce Fossil Fuel Use[f]	$10 per ton CO_2.	2.8 million jobs in 20 years nationwide.	$70-$80 billion increase in GDP from 2020 onward.
Implement EPA Clean Power Plan (CPP)[g]	Final State Plan Dependent.	Final State Plan Dependent	$55-$93 billion worth of health benefits by 2030.
Support Paris COP21 Agreement[h]	U.S. pledged $3 B to Green Climate Fund,[i] then all nations: ~1% GWP* x 30 years.[j]	Net increase in jobs, GDP continues to grow, while environment protected.[k]	Set all nations on a path to limit global warming. Averts world catastrophe.

Sources: a. (Swenson 2015); b. (Energy Informative 2015); c. (UCS 2014); d. (Solar Jobs 2015); e. (LEED); f. (CLL 2013); g. (EPA 2016f); h.(COP21 2015); i. (Green Climate Fund 2014); j. (Stern Review 2006); k. (WEF 2015).

* GWP - Gross World Product.

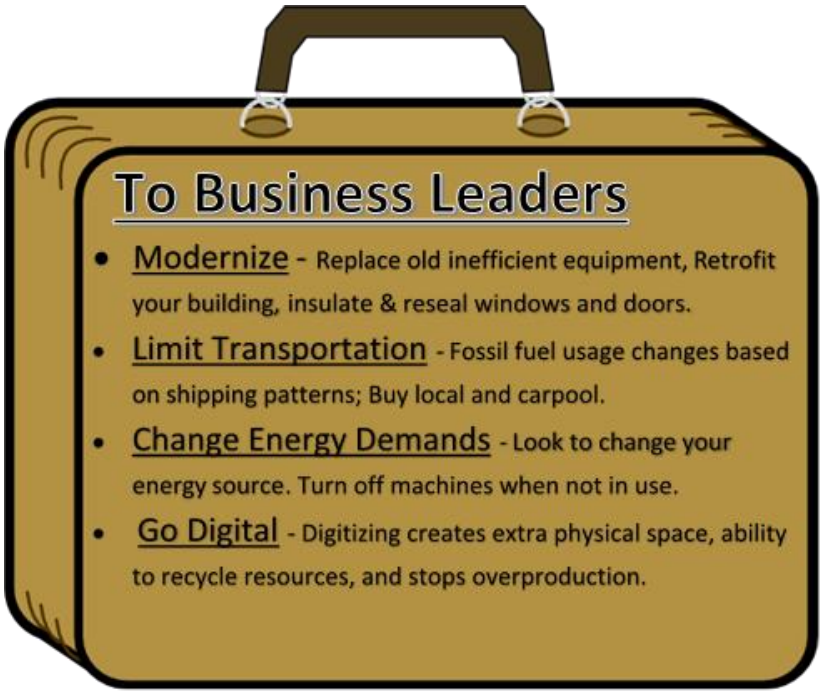
health from dangerous carbon pollution, and lowering electricity bills. It provides an opportunity for states working to meet needed public health safeguards by reducing the pollution that triggers asthma attacks, heart attacks and premature deaths. This plan is supported by leading businesses like Amazon, Apple, IKEA, 18 states, and 60 major cities, faith communities, leading public health associations, and U.S. Departments of The Interior, Energy, and Defense.

Many concerned with environmental justice are calling on lawmakers to price carbon dioxide, methane, and other greenhouse gases to reflect their negative externalities. Doing so could make fossil energy expensive enough to change both consumer and industry behavior making renewable energy much more cost-competitive. It could also potentially raise a lot of money as jurisdictions in Colorado, Maryland and California are already learning, money that can be returned to low income communities in a number of mechanisms to improve their resilience and health.

FOR BUSINESS LEADERS

Increasingly business owners are recognizing that climate pollution has a large cost and are increasingly tracking and reducing their carbon emissions. More businesses are realizing they can act to make a difference and a profit at the same time (Rosen 2016).

Iowa already has companies that support sustainability, energy efficiency, and water conservation, building and promoting the infrastructure for wind and solar energy, as well as using LEED principles as a measure of success. Iowa businesses like Medicap Pharmacy, a solar-powered business in Urbandale (IIPL 2015), and the Energy Group of Des Moines, provider of energy efficiency services for homes and businesses, can have by accelerating the adoption of clean energy and green building practices, technologies, policies, and standards.



Iowa's wind energy providers find that the more wind turbines are installed, the less variability there is in the amount of power they produce in contrast with periodic abrupt failures of conventional power plants & sudden loss of large amounts of power during extreme storms or other challenges. As a national leader in wind energy production Iowans have already learned supporting wind energy installations has meant over 30% of Iowa's electricity is generated with no pollutants once installed. $11.8 billion in capital investment in Iowa's existing wind industry by the end of 2015 resulted in 6,300 MW wind energy installed, offsetting 6.3 million metric tons of CO_2 per year which is equivalent to removing 1.2 million cars off the roads and saving 3.7 billion gallons of water per year. (AWEA 2016)

- There are 11 manufacturers of turbines/blades operating 75 wind-related companies
- 6,000-7,000 Iowans are employed in 2015 in all wind related activities
- Landowners lease payments are $10-20 million per year
- By July 2016 wind was generating 35.8% of all electricity generated in Iowa, equivalent to 1.6 million homes
- Iowa has much wind potential to supply 6.3 million homes by 2030 according to the U.S. Department of Energy
- Iowa's electric rates are lower than the national average

According to Stanford engineers, Iowa is the state third closest to going totally renewable (Solutions Project 2016). Beyond wind, Iowa's solar potential has barely been tapped. Even with about 40 MW of distributed solar installed, 52 solar companies and 349 jobs already in the industry, and nearly 125 businesses in the wind and solar supply chain, Iowa has much more potential. (SEIA 2015)

For Individuals and Farmers

Farming for Sustainability

Two important places for Iowa farms to begin cutting costs, improving health, and halting climate change is to reduce the release of the two powerful greenhouse gases Nitrous Oxide (N_20) and Methane (CH_4) from (1) Iowa's corn and soy fields where nitrogen fertilizers are too often too liberally applied, thus wasted, and (2) in Iowa's thousands of confined animal feeding operations where the volumes of methane produced are treated as waste instead of a resource.

N_2O is well known to be a powerful and long lived greenhouse gas and the primary stratospheric ozone depleting substance. While its deleterious effects on the environment (waterways, ocean dead zones, and climate impacts) have been recognized for years, scientists are increasingly concerned that the amount of N_2O entering the atmosphere may be under estimated. Consequently there are more appeals to regulate emissions from agriculture, which represents the primary anthropogenic source in the global N_2O budget. (Turner 2015)

Similarly, Methane produced in the guts of Iowa's livestock and in the decomposition of its manure constitute major sources of this powerful greenhouse gas. Like nitrogen, and soil management, there are mechanisms to reduce the level of methane emissions by attending to the quality and quantity of animal feed sources, and capturing the gas to be used as an energy source rather than a waste product.

Finally, soil management, no till practices, soil capture by turning to agroforestry practices such as managed shelterbelts and forested riparian zones can improve soil fertility, increase carbon sinks while improving stream quality and offsetting other carbon and greenhouse gas emissions of agriculture. Tree plantings also provide other wildlife and aesthetic benefits.

Healthy Iowans, Greener Households

At the household level the list of health and climate saving activities is almost endless. Getting engaged in climate action to halt and reverse the warming of the planet need not be onerous. Fortunately, there are choices which are also healthy: for example, transitioning to green transportation which results in less fuel consumption and saving money. Consider installing LED light bulbs and/or energy efficient appliances; initially costly (but good long term investment) is installation of solar panels, efficient windows, green roofs and use of passive designs whenever possible for new homes.

Green Transportation

Walking: involves zero emissions, free, healthy
Biking: faster than walking, low cost & healthy
Public Transit: affordable, easily accessible
Taxis: request green vehicles
Carpools: economical and eco-friendly

Choose a Healthy Low Carbon Diet

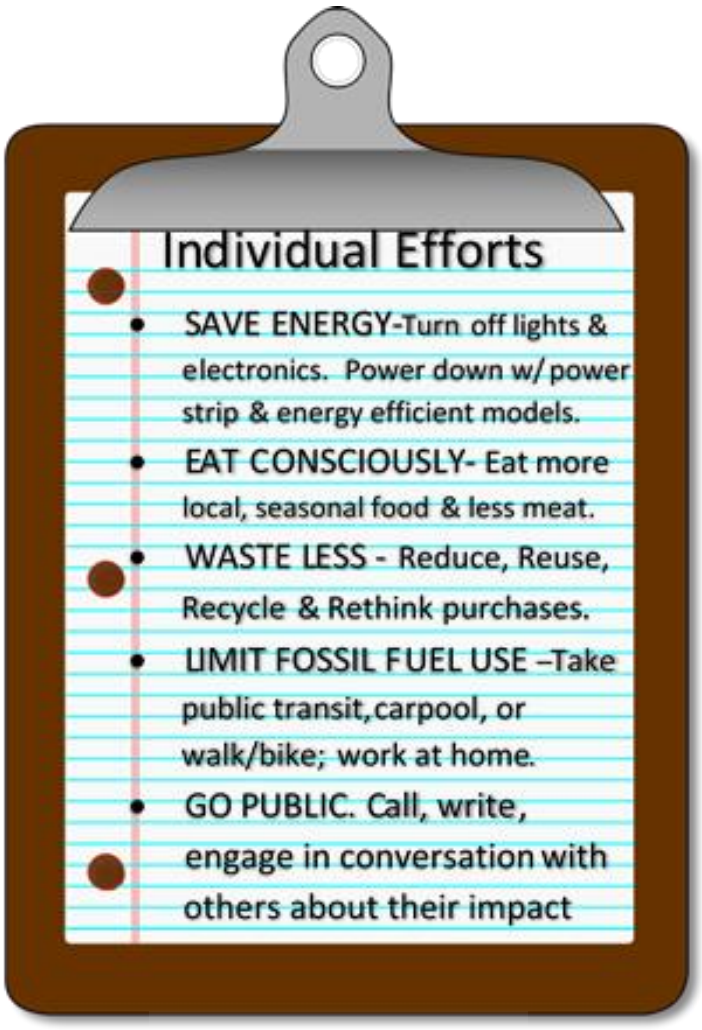
Raising animals for meat causes as much climate pollution as all the tailpipe emissions from the world's vehicles combined. Even small cutbacks in red meat consumption can have a positive impact on health and protect the planet at the same time. "If Americans ate 30 percent less beef, it would be like taking the tailpipe emissions from 10 million cars off the road each year," according to the USDA Economic Research Service, as reported by the NRDC—not to mention the improved health (NRDC 2016).

At the very least, every Iowan can:

1. Pursue educational opportunities to personally become better informed.
2. Make personal choices that reduce fossil fuel use and other greenhouse gas pollution.
3. Advocate for climate action with elected officials, candidates, and regulators.

Of these, the most important is advocacy, because the fight against climate change requires national Congressional action that is sustained over the coming decades. Small steps by all individuals are vitally important but insufficient. For a healthy climate future that maintains rewarding employment and supports a good economy, decisive action to prevent catastrophic global warming is needed beyond the household.

Increased research and development and funding are needed for expanding clean energy, for vehicle electrification, and fuel economy standards for automobiles, trucks, ships, and heavy duty vehicles, building codes and appliance standards. Such efforts take enabling legislation at the federal level. Similarly at the state and local level new investments in public transportation and bicycle and pedestrian infrastructure across urban and suburban areas are needed along with green building policies.



Graphic: Channon Greer

Conclusion

No one set out to create the climate problem. Fossil fuel driven energy sources have meant unprecedented relief of drudgery, provided multiple options for rapid transportation and communication to anywhere on the globe, and countless advancements in medicine and science. These benefits were enjoyed before people became aware of the dangers and dark side inherent to this form of energy. To ignore the risks of continued reliance on fossil fuels is to put all the benefits they've brought at risk as well.

We live in an increasingly interconnected world. The consumption and energy use patterns of the U.S. population, less than five percent of the world's total population has contributed a significant proportion of total greenhouse gases and supported other activities contributing to the changing climate. Given our interconnected world, attempts made here in Iowa to mitigate the wide ranging effects of climate change locally can be reflected worldwide.

The changing climate threatens the well-being and security of all we hold dear in Iowa, across the country and around the world. It's unfortunate that climate science has become politicized in a way that limits appropriate action by elected officials. The irony is that the effects of climate change are nonpartisan. There are some signs of hope, such as the COP21 Paris agreement, the bipartisan Climate Solutions Caucus in Congress, and the pending bipartisan house resolution introduced by Chris Gibson and signed by 14 Republicans stating that climate change is real, and that Congress needs to act on it. However, action has been glacially slow; and by the time meaningful legislation is introduced, it may be too late to prevent irreversible changes in health locally and globally.

Moving forward, the changing climate will be a major obstacle to the eradication of hunger and disease. We must work collectively to better understand that the changing climate presents a preventable threat to our health and future. Only by failing to work locally and globally, to live more sustainably, do we contribute to a changing climate that will make the challenges of the present, all the more difficult, if not impossible to overcome. We either strive to limit its impact or succumb to its effects.

It's vitally important to realize solutions to climate change already exist, waiting for us to embrace them. The more we innovate, conserve, invest and change now the less painful or costly the transition. People around the world in places as diverse as Indonesia, Kenya, China, Western Europe and California are developing new ways of living and benefiting from a long list of climate solutions. Iowa too can be a partner in this effort.

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