



Climate Risks Pose Broad Impacts on Financial Security Systems

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Executive Summary

The actuarial profession is considering climate risks and their effect across all practice areas.

Assumptions and models will need more explicit considerations of how data reflects experience, assumptions, and methods to incorporate climate change. Both frequency and severity of climate-related events are accelerating, which affects both short-term and long-term financial modeling. As a result, awareness that climate change and climate risks will impact actuarial work across practice areas is important because these physical risks and the potential subsequent impacts of the transition risks will result in historical data having decreasing credibility to inform actuarial assumptions in the short, medium, and long term.

In addition, investment strategies will need to reflect considerations of how companies are adjusting to climate change impacts.

This paper provides actuaries with a practical guide for considering a broad range of impacts that climate change may have on their work.



Introduction

Climate risk and climate change involve physical risks that impact all forms of financial security systems for which actuaries aim to identify and manage risks. Financial security systems, embodied by insurance products, whether property/casualty, life, or health and, more indirectly, pensions and retirement products, are touched by climate risks.

The actuarial profession is continuously involved in considering the climate risks, currently most obviously related to property and casualty exposures as it most closely aligns. In addition, climate risk and change will have a growing impact on public health and may well impact retirement security. These risks will be felt differently among those who have the resources to adjust their lives to the impact versus those who have no choice but to suffer the consequences.

Actuarial models and analyses incorporate climate change through information imbedded in the data being used, but the incorporation of any more explicit recognitions related to prospective change will bring with it significant levels of uncertainty. Actuaries are being called upon to consider the implications of this uncertainty. The directions and orders of magnitude of both the changes and the levels of uncertainty vary by lines of business or different work products. Assumptions and models are part of setting premium rates and reserves and of evaluating investment returns and will need more explicit considerations of how the data reflects experience, assumptions, and methods to incorporate climate change. Both frequency and severity of climate-related events are accelerating, which affects both short-term and long-term financial modeling.

As a result, awareness that climate change and climate risks will impact actuarial work across practice areas is important because these physical risks and the potential subsequent impacts of the transition risks¹ will result in historical data having decreasing credibility to inform actuarial assumptions in the short, medium, and long term. The two terms, “physical risks” and “transition risks,” are used extensively in discussions related to the impacts of climate. Physical risks, with the more obvious definition, in the climate space refers to the climatic events such as wildfires, storms, and floods. The term transition risks when related to climate impacts refers to the risks that result from policies and actions to transition the economy away from fossil fuels to a more climate-friendly future. These risks can include policy and regulatory risks, technological risks, market risks, reputational risks, and legal risks. In addition, the variation in geography, severity, and frequency of the physical risk of climate-change-related events increase the uncertainty of the impact.

¹ See, for example, “[New Tools Needed to Assess Climate-Related Financial Risk](#)”; Council of Economic Advisers Issue Brief; Nov. 3, 2021; and [Report on Climate-Related Financial Risk](#); Financial Stability Oversight Council; 2021.

Immediate climate impacts for property/casualty insurance are being seen in an increase in severity of storm-related activities: in warmer weather, hurricanes, rain events, and tornados; in colder weather, southern winter storms and Nor'easters. At the other extreme, are the more intense droughts and wildfires. The impacts vary greatly by geography.

For life and health insurance, the impact of rising temperatures on health is being widely discussed. Health status (personal health conditions and age), income level, and geography are important factors in determining the ability of an individual to cope with increasing temperatures and extreme weather.

Insurance companies are being asked by multiple stakeholders—shareholders, investors, consumers, regulators to directly help mitigate climate impacts for their customers, demonstrate prudent financial preparation for the effects of climate change, and document steps they are taking to reduce their carbon footprints and adhere to environmental, social, and governance (ESG) frameworks in a sustainable investment approach.²

To accomplish this, investment strategies will need to reflect considerations of how companies are adjusting to climate change impacts and consider new trends such as changes in migration patterns, impact of climate on the underlying assets supporting retirement financing, and transformations in the fossil fuel industry. Regulators of financial statements such as the Securities and Exchange Commission (SEC) and regulators of insurer solvency such as the National Association of Insurance Commissioners (NAIC) are in the process of studying and establishing more uniform methods for climate-related disclosures in financial statements for their own use as regulators as well as by the investment community. Comparable disclosures will inform decisions related to the long-term adaptability, profitability, and solvency of the disclosing entities. Regulators of retirement systems such as the U.S. Department of Labor's Employment Benefits Security Administration (EBSA) are studying how to make sure that the administrators of assets underlying retirement programs are also considering the impact of climate on assets.

This paper describes some of the basic impacts that changes in climate are having that may influence actuarial work by practice area which focuses in part on the varying types of impact, then describes how the impacts over time may cross different practice areas. The paper enumerates exposures subject to both direct and indirect impacts. Over time, the significance of the impacts may change from this current view.

² Forms of sustainable finance have grown rapidly in recent years, as a growing number of institutional investors and funds now incorporate various environmental, social and governance (ESG) factors into their investment strategies. The growth of sustainable finance, including the increasing array of financial products, has attracted the attention of investors, policy makers, and civil society stakeholders because of its potential to deliver long-term enterprise value, align with societal values, and contribute to sustainability and climate-related objectives. [Policy guidance on market practices to strengthen ESG investing and finance a climate transition](#); OECD Business and Finance Policy Papers; OECD Publishing; 2022.

Intended Audience

This paper explores considerations for actuaries, including an introduction to the range of climate impacts and the variations of these impacts on core actuarial practice areas, as well as providing a cross-practice view of climate impacts.

In addition, this paper may be used by non-actuaries interested in how climate change will affect individuals and society in the casualty, life, health, financial markets, and retirement arenas. Policymakers and regulators can use information contained in this paper about the common impacts and the variation in impacts of climate change to produce more effective regulations and policies.

This paper is not intended to be all-inclusive of the areas that will impact actuarial assumptions in short-, medium-, or long-term time horizons. Instead, it provides actuaries with a practical guide for considering a broad range of impacts that climate change may have on their work. The paper should not be read to imply that the risks and uncertainties described are currently embedded or need to currently be addressed directly in actuarial work outside of what may be reflected in experience and trend. However, these considerations may be contemplated in the future. Finally, this paper does not set forth actuarial standards of practice or guidance.

Prelude—Physical Science

The evidence of climate change and a warming planet are firmly established.

“Recent changes are rapid, intensifying, and unprecedented over centuries to thousands of years.”³

³ Source: “[Recent changes are rapid, intensifying, and unprecedented over centuries to thousands of years](#),” (IPCC, 2021: “Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.” Cambridge University Press, Foreword, p5, 2021.)

The temperature of the Earth has increased by 1 degree Celsius (about 1.8 degrees Fahrenheit) in the past 100 years.⁴ Accompanying this increase in temperature is sea level rise after nearly a 3,000-year stable ocean level. Most of that increase has been in the last 30 years. Increased levels of carbon dioxide and methane have caused significant changes in the temperature levels around the earth with impacts on ocean levels.⁵

- The sea levels in the ocean have risen at the fastest rate in 3,000 years. Sea surface temperatures have risen at the fastest rate in 11,000 years. And the ocean heat content is unprecedented in at least 18,000 years. The rise in sea level is caused by melting of the Antarctic ice and worldwide glaciers.
- The warming of the air is unprecedented in over 2,000 years. While this is very significant, we should note that the effects are not uniform around the globe. The temperature changes are much more significant in higher latitudes.
- Arctic sea ice levels are the lowest in at least 1,000 years. The melting of the glaciers is unprecedented in over 2,000 years. This is certainly caused by the very significant temperature changes at high latitudes.

The effects of these changes have evidenced themselves in several drivers of severe weather events.

- Extreme heat has shown increases in both frequency and severity.
- Heavy rainfall has also shown increases in both frequency and severity.
- Drought conditions have increased in some regions.
- Fire weather has shown an increase in frequency.
- Oceans have been warming and acidifying, thereby impacting the food web, while losing oxygen.

The severe weather events that result have grown in intensity.

- Non-storm flooding along the coast and higher storm surge levels during storms are caused by the rise in sea levels.
- The severity of tropical storms is caused by the increases in ocean water temperature. This is particularly shown by dramatic strengthening as storms approach landfall.
- Wildfires are spreading over larger areas, infringing on many populated areas.
- More damaging flooding is occurring throughout the world caused by increased rainfall.
- Crops are at significant risk as drought conditions expand in growing areas.
- Damage from winter storms and tornadoes is increasing as climate change causes more severe weather.

⁴ [“How long have sea levels been rising? How does recent sea-level rise compare to that over the previous centuries?”](#) NASA; undated.
⁵ [Global Warming from “Causes of Climate Change”](#); Environmental Protection Agency; April 25, 2023.

Impacts of Climate by Actuarial Practice Area

Climate change may have significant impacts on actuarial assumptions and models, but the impacts may be gradual and vary based on the time horizon of the work at hand.

The physical changes in temperature extremes, rain and drought, winds, and sea level are occurring and have been documented in the [Actuaries Climate Index](#). The impacts, while still gradual, are most noticeable and immediate today as described in the property and casualty practice area. When looking at the impacts of heat (one of the physical aspects of climate change) in the health practice area, the potential areas that will be impacted are likely to occur not so much immediately but in the medium term. For retirement planning, the impact of climate, while seemingly more on a long-term horizon, may be a risk to consider in current plans' investment strategy.

Climate change impacts many other areas such as governmental entities, corporations, and individuals. For example, changes in heat may influence the availability of quality water sources due to drought or algal bloom, which in turn can have significant potential health and business impacts.

Property and Casualty Issues

There are several natural hazards that are being affected by climate change. These are having significant impacts on insurance entities today, especially property insurance. A number of those hazards are shown below, including how they are affected, and which geographic areas are especially at risk. The impact of climate change on each of these hazards varies based upon geography as well as the particular portfolio (e.g., type of business, geographic distribution) of an insurer.

Property Insurance

Hurricanes (Tropical Cyclone)

Table 1 below, based on data from the federal agency National Oceanic and Atmospheric Administration's [National Centers for Environmental Information](#) (NCEI), shows that the number and cost of disasters have materially grown over the decades. In the past decade, there has been a significant increase in the number of major hurricanes, especially those that strengthen significantly shortly before landfall. Because climate change is causing an increase in the water temperature, especially in the Gulf of Mexico, there has been more fuel for hurricane intensification as the storms near land.

Table 1

U.S. Billion-Dollar Tropical Cyclone Disasters

Decade	Billion-Dollar Disasters	Cost in Billions (CPI adj'd to 2022)	Avg Disaster Cost (\$Billions)	Deaths
1982-1991	7	44.3	6.32	214
1992-2001	12	127.1	10.59	324
2002-2011	16	410.8	25.68	2,466
2012-2021	21	610.1	29.05	3,691
Totals:	56	1,192.3	21.29	6,695

Source: NOAA National Centers for Environmental Information (NCEI), [U.S. Billion-Dollar Weather and Climate Disasters](#), 2023.

The Panhandle of Florida and the area between Houston and New Orleans have been notably impacted. Prime examples are: Hurricane Harvey (2017), which came ashore and then stalled, causing torrential rains and major flooding; Hurricane Michael (2018), which intensified before landfall, becoming the first Category 4 storm to hit that area of the Florida Panhandle; and a number of 2021 hurricanes that struck near the Texas-Louisiana border.

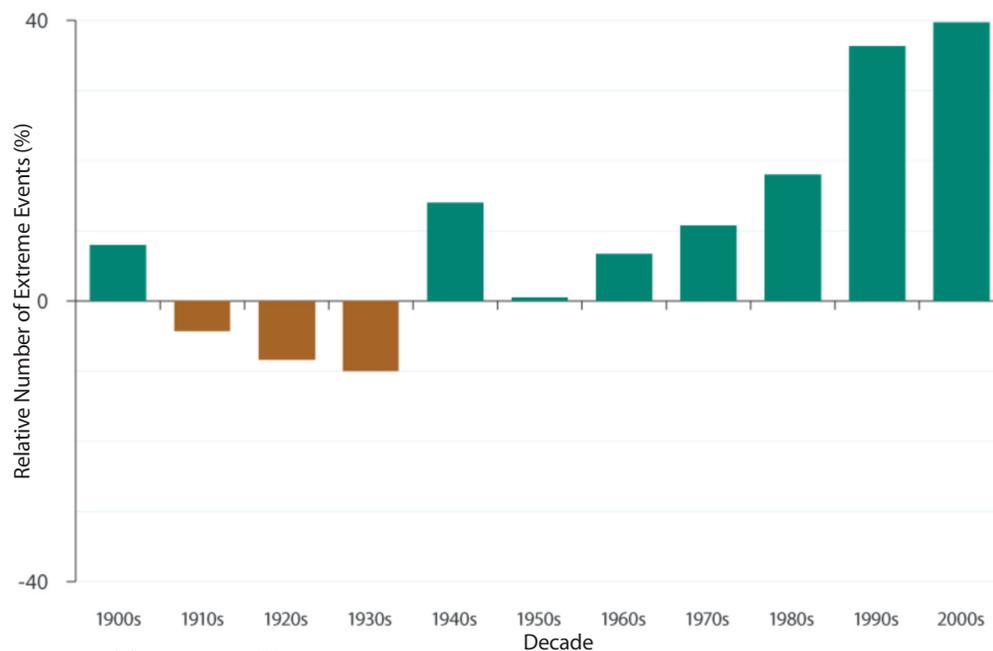
This increased intensity is expected to further threaten the Northeast (e.g., Superstorm Sandy, 2012). This is due to the increased water temperature in the eastern Atlantic Ocean, leading to more northern hurricane formation, which then increases the probability of strong storms making landfalls in the northern U.S.

Severe Rainstorms

One of the results of climate change has been more extreme weather, such as the increase in the intensity of rainstorms. Some of these are the result of more heavy rain as part of hurricane systems, but there are other storm patterns that have shown this effect. Chart 1 below shows the increase in heavy precipitation totals, defined as a *two-day precipitation total* that is exceeded on average only once in a five-year period compared to a 1901-1960 reference period. The chart shows an increasing amount of severe rain.

Chart 1

Observed U.S. Trends in Heavy Precipitation



The Pacific Coast, while suffering severe drought for the past few years, was hit with severe rain caused by an “atmospheric river” of moisture, particularly during 2021 and again in late 2022 and early 2023. This caused flooding and landslides throughout the region. As with hurricanes and other hazards, there is a rating scale (category 1 through 5) for atmospheric rivers based both on their physical characteristics (quantity of water vapor) and on the level of destruction they cause.

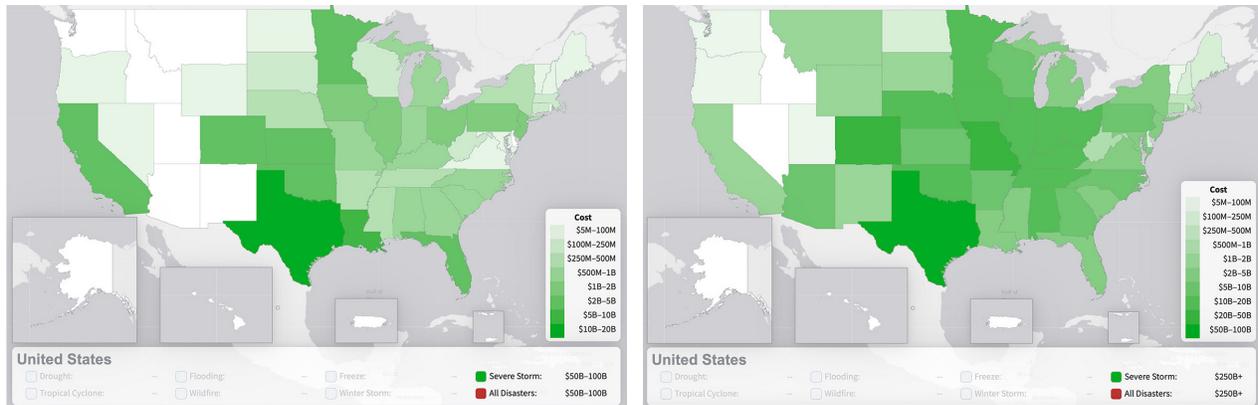
There also have been significant severe rainstorms that are not hurricanes in the Midwest and Eastern regions of the U.S., causing unprecedented flooding.

Severe Tornadoes

In the last few years, there has been a significant increase in tornado activity as well as an increase in the destructive impact of tornado activity. While the evidence is inconclusive whether the impacts are solely due to change or amplified by increased urbanization, the activity is notable.

The tornado frequency has shifted from the “tornado alley” of Texas, Oklahoma, Kansas, and Missouri, to the east, hitting Arkansas, Alabama, Mississippi, and Tennessee more frequently than in the traditional tornado alley. Chart 2 below uses Severe Storm data, which heavily incorporates tornado data and shows how the costs of these storms have been shifting by geography.

Chart 2 Billion-Dollar Severe Storm Disaster Cost (CPI-Adjusted)
1980-2000 2001-2022



Source: National Centers for Environmental Information; [Disaster and Risk Mapping](#); 2023.

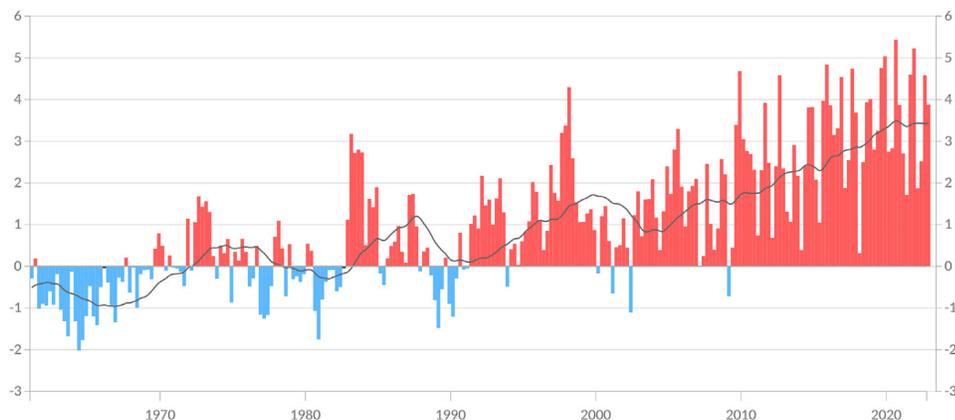
There also has been an increase in more severe tornadoes (EFT-3 and higher) that are causing more damage throughout Arkansas, Alabama, Mississippi, and Tennessee.

Sea Level Rise

Sea level rise is the most obvious and clear result of climate change. Easily measured, its steady rise is certain to continue, given the melting ice in Antarctica, Greenland, and the world's glaciers.

In the U.S., low-lying properties along coastal areas are facing an increasing risk of flooding from tropical storms, as well as “clear-sky” flooding during high tides. Sea level has risen to such a point that flooding results at high tide. Superstorm Sandy showed the vulnerability of New York City to storm-related flooding, as lower Manhattan saw basement and subway flooding. Miami Beach is one area subject to “clear-sky” flooding and is struggling to find a long-term solution to protect the valuable real estate along the coastline. Chart 3 below shows the Sea Level component of the Actuaries Climate Index.

Chart 3 Continental USA Sea Level Index



Source: [Actuaries Climate Index](#).

Wildfires

Recent years have shown a dramatic increase in property damage caused by wildfires.

Table 2

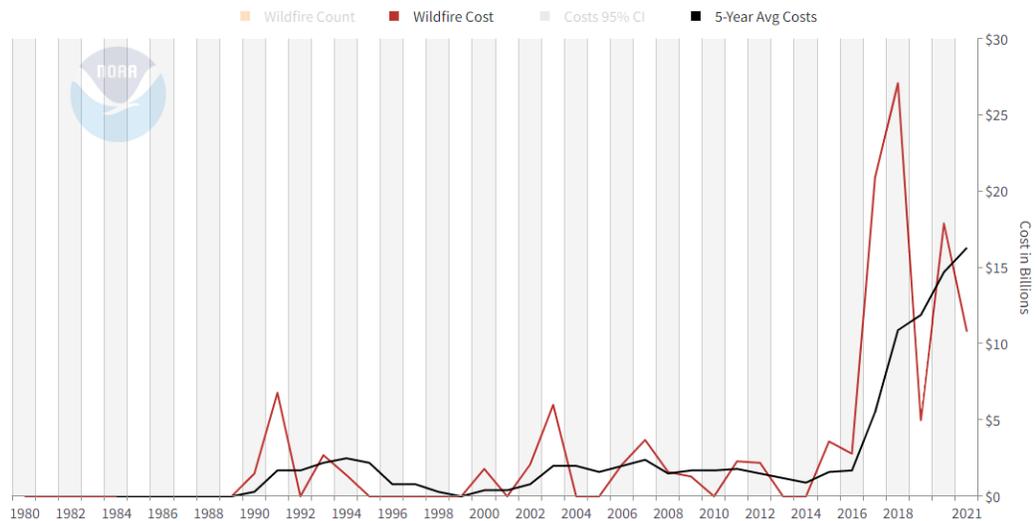
Billion-Dollar Wildfire Disasters

Decade	Billion-Dollar Disasters	Cost in Billions (CPI adj'd to 2022)	Avg Disaster Cost (\$Billions)	Deaths
1982-1991	2	8.6	4.31	42
1992-2001	3	6.0	2.01	4
2002-2011	7	19.6	2.81	114
2012-2021	8	92.9	11.61	258
Totals:	20	127.1	6.36	418

Source: NOAA National Centers for Environmental Information (NCEI), [U.S. Billion-Dollar Weather and Climate Disasters](#), 2023.

Chart 4

Billion-Dollar Disaster Events 1980-2021 (CPI-Adjusted)



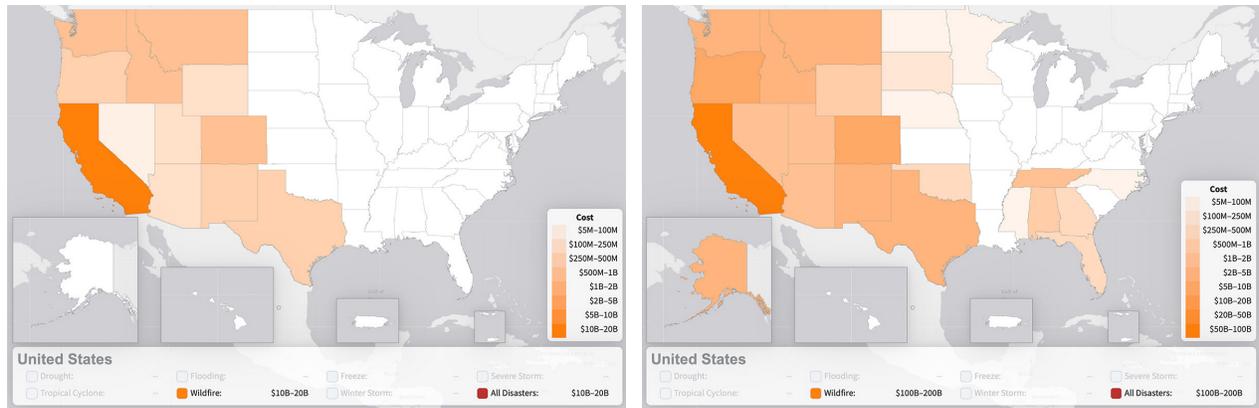
Source: NOAA National Centers for Environmental Information (NCEI) [U.S. Billion-Dollar Weather and Climate Disasters](#) (2023).

The volatile weather patterns driven by climate change have led to very dry and windy conditions that in turn have led to historic fires on the Pacific Coast and Mountain West.

Chart 5 U.S. Billion-Dollar Wildfire Disaster Cost (CPI-Adjusted)

1980-2000

2001-2022



Source: National Centers for Environmental Information; [Disaster and Risk Mapping](#); 2023.

Fires in California have burned properties at an unprecedented rate. Also notable are fires in Colorado and Utah, especially the Marshall fire at the end of 2021. Wildfire damage includes subsequent landslides and flash flooding.

A discussion of the wildfire problem is given in *Wildfire: An Issue Paper—Lessons Learned from the 2017-2021 Events*,⁶ published by the American Academy of Actuaries Extreme Events and Property Lines Committee. This paper describes both the increased frequency and severity of wildfires as well as the increased exposure to financial loss from wildfires with the expansion of building in areas prone to wildfire.

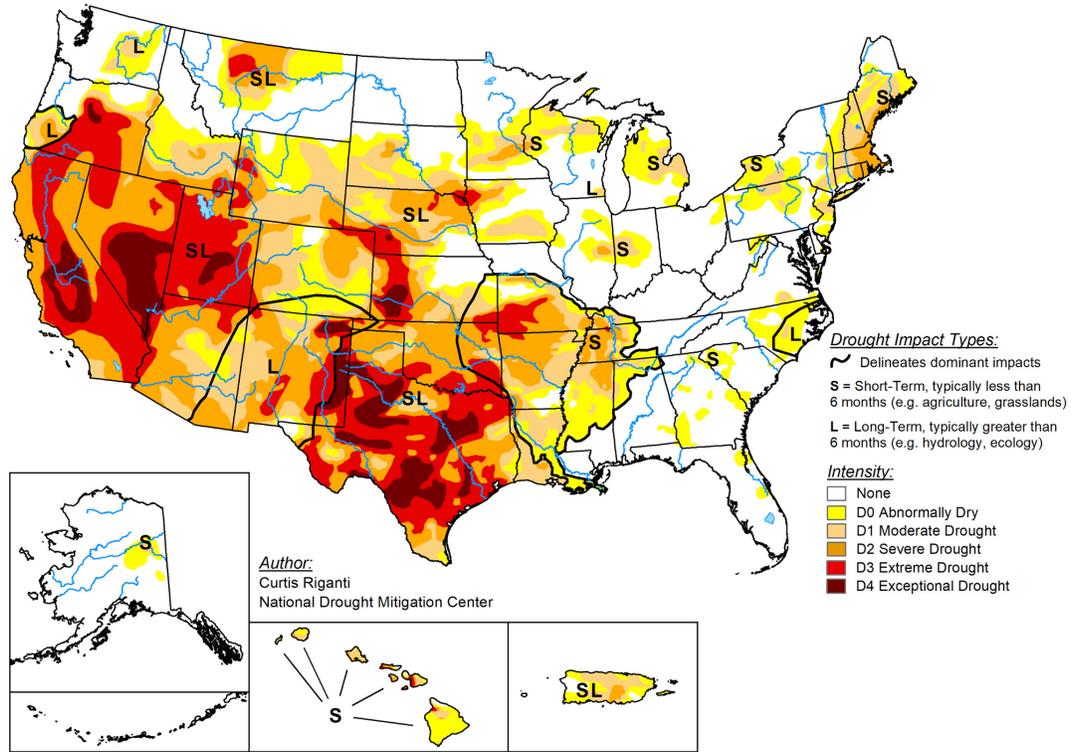
Drought

Drought has been widespread throughout the country, but particularly west of the Mississippi. Climate change has exacerbated the severe swings of weather causing long stretches of dry weather in those areas.

⁶ *Wildfire: An Issue Paper—Lessons Learned from the 2017-2021 Events*; American Academy of Actuaries; 2022.

Chart 6

U.S. Drought Summary for August 2, 2022



Source: [U.S. Drought Monitor](#), a joint project of the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture and the National Oceanic and Atmospheric Administration. Accessed August 4, 2022.

The principal economic impact is a large loss of crops and livestock, leading to increased payments from crop insurers.

Winter Storms

In recent years, there has been an increase in the number of damaging winter storms. This is primarily an issue in the South, where the infrastructure is not built to withstand freezing temperatures, heavy snow, and strong winds. In addition, there has been an increase in the severity of Nor'easters, which often cause significant damage to the mid-Atlantic and New England coastal states.

Workers' Compensation

For workers' compensation (an insurance coverage some property/casualty actuaries work on) climate impacts and transition risks⁷ can be significant. If an insurance carrier decides to stop writing coverage for coal or other energy sector-related employers, there may be a drop in premium or a shift to the residual market. An insurer may make this decision to reduce its own carbon footprint as measured by the downstream carbon footprint of its customers and/or insureds. If coal and other energy sector exposures disappear, the insurance industry will face a drop in premium or a shift of premium to alternative businesses. The potential variation in future expected premium could become an emerging industry risk.

Directors and Officers (D&O) Liability

For D&O liability (also within property/casualty actuarial practice), there may be transition risks related to whether or not a corporate entity embraces mitigation of climate risks and how the underwriting is handled. Shareholder suits may allege a particular company's board of directors did not appropriately mitigate against climate risks and therefore the profitability and solvency of the business suffered. Costs associated with such suits may be covered by D&O liability coverage, impacting losses and pricing in the short term.

Health and Life Issues: Impact of Heat

Extreme shock heat events, experienced in the Pacific Northwest region during the summer of 2021, are a precursor to a long-term heat impact. The world is warming—eight of the past 10 years have produced all-time high temperature records. Health impacts are not confined to high temperature alone. Wildfire, wind events, and flood have an acute impact. Drought and higher heat (in general) have a more cumulative impact on health. Mental health issues are becoming more common, and persistent. The focus in this section of the paper is on the impacts of heat due to its current widespread impact.

The impact is global but affects populations in different magnitudes and ways. Much research has been conducted on the impact of heat on health, and the conclusions are summarized here in three key areas: personal health condition, income level, and geography.

⁷ ["Impacts of Climate Change on Human Health in the United States: A Scientific Assessment"](#); U.S. Global Change Research Program; April 2016.

Personal Health Conditions

First, an individual's health condition is a critical factor in their ability to adapt to heat. Certain chronic health conditions significantly increase the health risks due to exposure to heat:

- **Respiratory**—The effect of warmer temperatures on lungs is similar to the effect of traffic pollution. Hot air holds more water vapor which leads to less oxygen and higher humidity. Denser air is more difficult to breathe in, especially for those with chronic lung problems. Heat leads to increased sweating, which leads to dehydration and potentially shortness of breath. Heat can also trigger a higher pollen count, which causes respiratory symptoms, especially for people who suffer from asthma, seasonal allergies, or chronic obstructive pulmonary disease (COPD).
- **Cardiovascular**—At higher temperatures, the heart beats faster and pumps harder. Sweating, the body's cooling mechanism, removes water and necessary minerals from the body which leads to more stress on the heart. Certain heart disease medications such as *angiotensin-converting-enzyme* (ACE) inhibitors can remove fluids from the body and exacerbate the heat risk.
- **Kidney**—The kidneys play an important role in protecting individuals from heat/dehydration with proper hydration, but are also vulnerable to dehydration. High temperatures increase the risk of dehydration, which leads to lower blood pressure and lower fluid balance and if not controlled, can lead to heat stroke or even kidney failure. Overuse of common over-the-counter painkillers and anti-inflammatory medications can be a catalyst for kidney failure when combining this with exercise in extreme heat. Even short-term use of these medications can cause dehydration, as they are designed to lower fever by dilating the blood vessels so that heat is lost through the skin, which triggers more sweating.
- **Behavioral Health**—Heat stresses the body and alters sleep patterns, which make existing behavioral health issues worse with higher rates of irritability, depression, suicide, aggression/violence, use of alcohol/drugs, and impairment of memory/attention/reaction. Dementia patients are especially vulnerable. Some antidepressants and anti-psychotics can affect the way the body regulates temperature (e.g., by causing excessive sweating and risk of dehydration), which makes the individuals taking these medications more vulnerable to higher temperatures.
- **Diabetes**—Diabetics are already more susceptible to dehydration as their kidneys work harder to expend excess sugars, which leads to more urination. More dehydration means higher blood sugar levels. Also, diabetics are especially vulnerable to heat exhaustion and heatstroke as often their blood vessels and nerves are already compromised, which impairs their ability to cool effectively.

- Pregnancy—Dehydration can cause a reduction of liquid in the amniotic sac, which can cause birth defects, miscarriage, and pre-term labor. Because a pregnant woman’s body is working harder with increased metabolism, increased blood volume, and weight gain, the body feels warmer than usual, which makes it more susceptible to heat exhaustion, heat stroke, and kidney damage. Extreme heat increases the risk of fainting and falling injuries to the mother and baby.
- Skin Exposure—Skin cancer incidence has tripled in the last few decades due to increased exposure to ultraviolet (UV) radiation from the sun. The combination of extreme heat with sun exposure increases the risk of skin cancer significantly.⁸

A common theme, as noted above, is that dehydration causes or exacerbates existing health problems, so hydration is a key remedy if done consistently and adequately and will be increasingly dependent on the adequacy of the water supply as discussed in the above *Drought* section. Also related to health is an individual’s age. Those at the extreme ends of the age spectrum are most vulnerable. The very young have more difficulties in regulating body temperature, are more susceptible to dehydration due to relatively higher water mass and higher metabolism, but are also vulnerable to asthma and allergies. The elderly struggle with heat as the body weakens with age and key cooling components such as blood circulation and sweat glands become less effective. An additional risk variable is an individual’s employment, with those working outdoors—e.g., in construction, farming, and delivery services—being particularly vulnerable to heat and dehydration. Given sufficient heat exposure, a person at any age or health status can be impacted.

Income Level

An individual’s income level is a second critical factor in adapting to heat. Lower-income families are most vulnerable because they lack resources such as air conditioning and mobility to relocate to get relief, either temporarily or permanently, to combat the heat. They spend a disproportionate amount of income on home energy cost (about 8% versus about 2% for other households).⁹ Lower-income families tend to live in less desirable locations that are more exposed to the impacts of climate change and be employed in professions that expose them to more heat (e.g., day laborers, farm workers, and in construction).

⁸ “Impacts of Climate Change on Human Health in the United States: A Scientific Assessment”; Op. cit.

⁹ “How High Are Household Energy Burdens?” American Council for an Energy Efficiency Economy; September 2020.

Geography

Geography is a third critical factor in the ability to adapt to increasing heat. Historically, people in hot climates are better acclimated to warmer weather. People in northern regions are more vulnerable to sudden increases in temperature. There is an annual seasonality to heat impacts—heat waves earlier in the warmer seasons have much more health impact than one that occur later when people are more acclimated to the heat. Urban areas tend to trap more heat due to the concentration of paved and dark surfaces on roads and buildings and a relative lack of parks and other green spaces. Historically, lower socio-economic neighborhoods in urban areas can experience temperatures of up to 20°F higher than surrounding green areas and up to 7°F higher than surrounding neighborhoods.¹⁰ Also, related to geography is where a person works or plays—those who do so outdoors are exposed to heat-related illnesses. Outdoor occupations and prolonged outdoor activities are becoming more dangerous.

Mortality Issues: Impact of Heat

The impact of extreme heat on mortality is related to the risk factors mentioned for health—certain health conditions, income, age, and geography. Precise measurement of heat-related death rates is still in development as it is fraught with inconsistent reporting and under-reporting. Heat is not typically listed as the cause of death on a death certificate, or it is only listed as a contributing factor. For example, the Chicago heat wave of 2006 resulted in 225 deaths according to some reports and up to 825 deaths according to other reports. Europe, with its older buildings and less prevalent air conditioning, has suffered more human loss. Two successive heat waves in France during the summer of 2019 led to a report of 1,435 deaths.¹¹ Education on how to handle the heat has proven to be effective in preventing deaths. At least 12,000 confirmed heat-related deaths have occurred in the U.S. in 2010-2020 and the number of deaths is projected to increase threefold under a moderate-warming scenario and eightfold under a high-warming scenario. Death rates spike once the heat-index reaches 130°F (55°C).

The people who qualify for Medicaid and Medicare are those who are most vulnerable to the adverse impacts of heat on health. As noted earlier, the elderly and the young are particularly sensitive to heat and with about 50% of children in the U.S. being in Medicaid and the Children's Health Insurance Program (CHIP), this combination of vulnerable age and lower income financial status compound the risk. Children are particularly vulnerable due to the

¹⁰ "As Rising Heat Bakes US Cities, The Poor Often Feel It Most"; NPR; September 3, 2019.

¹¹ "Is it climate change? Coverage by online news sites of the 2019 European summer heatwaves in France, Germany, the Netherlands, and the UK"; *Climatic Change*; 2021.

lower ability of youth to manage body temperature.¹² However, heat can threaten the life of anyone who doesn't take the risk seriously. Governments and health insurers may be called upon to help mitigate these risks through education of the most vulnerable populations, self-preservation through heat crises, continued access to health care, potable water, and reliable power grids. Currently, several government agencies offer resources to help communities in this regard. For example, the Centers for Disease Control and Prevention (CDC) provides useful guidance through its Heat Response Plans (for emergency planning) and Heat and Health Tracker (for real-time heat-related ER visits). For individuals, the Occupational Safety and Health Administration (OSHA) provides a Heat Safety Tool with real-time heat indexes and hourly forecasts. Medicare provides heat-related support through its Special Supplemental Benefits for the Chronically Ill (SSBCI)¹³ program, while Medicare Advantage plans provide portable air conditioners to their chronically ill beneficiaries, among other benefits. The Department of Health and Human Services (HHS) emPOWER¹⁴ program provides state and local governments with lists of Medicare beneficiaries who are reliant on electricity-dependent durable medical and assistive equipment and devices or essential health care services in cases of power outages. While this paper discusses only the direct impact of heat on health, heat produces many residual impacts that further increase health risks, such as drought and floods, increased ozone, proliferation of parasites, more frequent wildfires, and poorer nutrition.

While the deaths from observed heat events may be minimal relative to overall mortality trends, the number may grow with greater impacts on group insurance than on individually underwritten policies.

Increasing Mortality and Severe Mortality Events Arising from Climate Change

Within a decade, climate change is expected to cause approximately 250,000 deaths per year globally arising from malnutrition, malaria, diarrhea, and heat stress.¹⁵ A disproportionate number of these deaths will occur in vulnerable populations including pregnant woman, children, racial/ethnic minorities, older adults, and the chronically ill, with low-income communities especially impacted. For pregnant women, climate change in some cases is linked to premature births.

Severe mortality events caused by climate change, while often difficult to forecast, can have large impacts on mortality over an extended period. Extreme heat, as described above, is

¹² "Warm Season and Emergency Department Visits to U.S. Children's Hospitals"; *Environmental Health Perspectives*; Vol. 130, No. 1.

¹³ SSBCI is the program offered by some Medicare Advantage plans. The optional program includes services such as non-medical transportation, meal support, home modifications, and other "general supports for living" to certain populations.

¹⁴ The [HHS emPOWER Program](#) is a mission-critical partnership between the Office of the Assistant Secretary for Preparedness and Response (ASPR) and the Centers for Medicare and Medicaid Services (CMS).

¹⁵ "Climate Change and Health"; World Health Organization; October 2021.

one of the deadliest climate impacts, causing deaths from a variety of heat related conditions such as heat stroke.¹⁶ After heat, the second highest number of climate event-related deaths is from flooding, mostly drowning.¹⁷

Collecting information on the frequency and cause of deaths arising from severe events caused by climate change over an extended period is needed to understand mortality experience more fully.

Pension Practice Issues

The implications of climate change in the pension practice area are more derivative with a longer time horizon rather than an immediate impact on retirement security systems. The key climate-derived issues with the most impact for pensions and retirement security include:

Economic downturns driven by climate change

- Social Security's ability to pay benefits is impacted by funding from wages of existing workforce;
- Multiemployer defined benefit plan failures create pressure on the Pension Benefit Guaranty Corporation (PBGC); and
- Retirees with defined contribution (DC) plan proceeds dedicated for retirement security may need to spend their savings to cover the cost impact of climate change either in immediate incidences of extreme loss or over time for higher insurance costs on property.

Climate change is pertinent to the projected returns of defined benefit (DB) pension plan portfolios

- The nature of DB plan obligations to participants and beneficiaries are subject to a long-term investment horizon;
- The effects of climate change are expected to continue to pose a threat to investments far into the future;
- Regulations and other policies incentivizing a shift from carbon-intensive investments to low-carbon investments could significantly impact the value of different categories of investments; and
- Effectively assessing investment risk for which government policies will impact performance and account for the risk of companies can have a beneficial effect on the ability of plans to pay promised obligations.

¹⁶ "Climate Implications—Extreme Heat and Health"; Indiana University, Environmental Resilience Institute; undated.
¹⁷ "Heat kills more in U.S. each year than any other extreme weather event"; NBC News; August 2, 2022.

Investment strategy impacts

- Change in investment strategies supporting retirement funding (institutional and individual) toward ESG¹⁸ options could cause a bubble in asset prices if based on the potential increased demand for limited investments or alternatively suppresses returns if ESG funds have lower expected returns.

Adequacy of funding of state and local defined benefit plans

- The additional need for capital to combat climate change may limit contributions to fund pensions. The causes of the decreased contributions are exacerbated by population migration caused by climate that impacts the tax base.
- Economic downturns that may be caused by climate impacts could increase unemployment and further the impact on the tax base and migration patterns.

Migration patterns may change

- Traditional migration patterns for retirees to warmer climates may change as destinations such as Florida and Arizona possibly become too risky to afford, while other retirees may have insufficient financial resources to have the choice of location and must retire-in-place regardless of the increasing impact of climate change.

Plan fiduciary obligations

- Plan trustees are subject to a standard to act in a prudent manner;
- A decision to select ESG investments poses some challenges to plan trustees related to whether ESG investments meet the plan's investment criteria for optimal returns;
- Selecting investments that are more focused on the impact of climate change could end up providing smaller returns than investments by plans that do not reflect ESG considerations and could therefore create financial exposure for plan trustees;
- DC plans where plan participants are provided with investment choices that include ESG-friendly alternatives may need to provide plan participants with an objective way to assess the impact of climate change offered by such investments.

¹⁸ [“US Department of Labor announces final rule to remove barriers to considering environmental, social, governance factors in plan investments”](#); U.S. Department of Labor news release; November 22, 2022.

Funding of State and Local Defined Benefit Plans

State and locally funded infrastructure projects can mitigate the impacts of climate change in ways that will vary based on geography. These infrastructure needs, along with potential local economic downturns related to impacts from extreme climatic events, may strain the ability to fund existing DB plans. An additional factor in state and local government funding of retirement systems is changes in their revenue base as a result of retiree migrations.

Retirees often migrate to more temperate climates such as Florida, New Mexico, and Arizona. These states' economic structure is somewhat built around this migration trend. Each of these areas is subject to particular risks of severe weather events that may increase the cost of living, making such areas difficult to afford. However, some of the trends in weather events, such as tropical storms moving further north, may change the type and severity of the currently acknowledged risks. At the same time, combining these changing storm risks with rising sea levels could result in greater coastal flooding and the breakdown of infrastructures. While these risks are still unpredictable, their increase will impact the homeowner insurance markets and may cause retirees to be less likely to move from their current locations. This potential change could have impacts on public funds reliant on retiree income as well as other states' retention of retirement income when the retiree population remains in place. A further constraint on tax revenues are the property tax limits provided to senior citizens. In many states, counties, or cities, senior citizens may be eligible for property tax exemptions that reduce the amount of tax paid.¹⁹

Supporting Investment Trends

Besides the overall impact continued climate events could have on the capital markets that support retirement systems, certain investment classes and strategies under consideration could mitigate the impact of the oil and gas industry and fossil fuels on climate while also improving fiduciary transparency and compliance. This can be found in both direct investments in companies providing alternative energy sources to asset classes, in particular ESG-targeted funds.²⁰ These funds specifically consider actions and disclosures by corporations related to their approach toward mitigating their impacts on the environment and on improving social resilience. The question that is being studied is whether this class of investments will produce the level of investment growth that alternative investment strategies have provided for assets supporting the retirement benefits of participants.

The impact of ESG and specifically climate-related investment decisions may be market-

¹⁹ "How to Claim Your Senior Property Tax Exemption"; Mortgage Reports; April 15, 2020.

²⁰ "Environmental, Social and Governance (ESG) Funds—Investor Bulletin"; Securities and Exchange Commission; Feb. 26, 2021.

moving if the movements are sudden or large. Large pension funds as well as DC plans and Individual Retirement Arrangements (IRAs) may influence markets by investment decisions. More specifically, large-scale changes in investment decisions may result in bubbles in stock and fund prices.

As retirees and plan sponsors consider this potential increased volatility, they may place greater reliance on guaranteed insured annuities rather than on individualized investment portfolios. The insurers will also be facing the same volatility, leading to increased insolvency risk to insurers, as well as to the PBGC with similar solvency concerns related to plan sponsors.

Social Security Impacts

Climate change may impact Social Security in three major ways related to eligibility for benefits, the funding of the benefits, and the operation of the Social Security program itself.

- Increase in disability-related retirements due to health impairments as a result of climate change, without increases in mortality.
- Delivery of benefits and services: The Social Security Administration (SSA) has addressed the physical risks related to continued operations in the event of a variety of climate events on their website since 2014 with an action plan/sustainability report.²¹
- Economic downturns caused by climate impacts—either particular disasters or longer-term changes—could lead to increased unemployment which may impact Social Security’s ability to pay out promised benefits.

These three areas add uncertainty to longer-term retirement security systems stability.

Economic Downturns

The discussion of potential economic downturns has so far pointed to increases in unemployment with resulting impacts on funding state and local public sector retirement plans as well as on Social Security. The impact may also be felt on other pensions plans such as multiemployer plans, which in turn would put increasing pressure on the PBGC.

²¹ [2021 Climate Action Plan](#); Social Security Administration; August 25, 2021.

Pension Summary

Impacts on pension and public retirement plans are longer-range, and it is important to recognize that private retirement systems in the U.S. have been declining over the last 20 years. The combination of investment trends and migration changes add uncertainty to the future retirement security. The potential impact of retiree migration could have implications on state financial expectations long term, but changes in migration trends are not yet measurable. The implications for investment trends on retirement plans, both DB plans as well as other types of savings plans, variable. Workers covered under federal and public employer-sponsored retirement systems also have uncertainty related to funding and asset returns.

Conclusion

The financial security systems that actuaries attend to are subject to the impacts of climatic events and the increased frequency and severity of these events. Property/casualty actuaries are currently busy considering climate data linked to the increasing frequency from hurricanes, rainstorms, tornadoes, sea level rise, wildfire, drought, and winter storms. The other disciplines will need to incorporate climate data at some point, maybe sooner and more profoundly than might be obvious currently. The present and near-term impacts on health from various climatic changes as illustrated by just one dimension of climate change—heat—shows both short-term and longer-term adverse outcomes on various populations. The impacts on mortality of climatic events exist, but the longer-term impacts beyond individual events are uncertain. The interaction of climate risk and retirement security is more uncertain due to a wide range of interacting factors such as migration patterns, investment trends and employment trends.

Given these wide-ranging changes that are embedded to an increasing degree in the data that actuaries are currently using, actuaries are at an inflection point where there may be a need for actuarial disclosures on the uncertainties of using the current data, models, and assumptions. In addition, modeling scenarios that take current observations, data and trends and explicitly extrapolate climate change trends into the future may be considered by actuaries in describing the risk and uncertainty of current state results.



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