A REPORT BY THE CALIFORNIA DEPARTMENT OF INSURANCE

# TRIAL BY FIRE

## Managing Climate Risks Facing Insurers in the Golden State

**Trial By Fire: Managing Climate Risks Facing Insurers in the Golden State**
California Department of Insurance | September 2018

Authorship: Evan Mills, Ted Lamm, Sadaf Sukhia, Ethan Elkind, and Aaron Ezroj
Production: UC Berkeley School of Law Center for Law, Energy & the Environment
Design: Emily Van Camp

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# Acknowledgments

Authors: Evan Mills, Ted Lamm, Sadaf Sukhia, Ethan Elkind, and Aaron Ezroj.

California Insurance Commissioner Dave Jones provided the vision and the initiative that made this report possible. Many California Department of Insurance staff members gave of their time and knowledge, including: Joel Laucher, Susan Bernard, Geoff Margolis, Ken Allen, Amorette Yang, Robert Herrell, George Yen, Lisa Strange, Melerie Michael, Amanda Bastidas, Durriya Syed, Sumeyye Tarhan, and Kelvin Chao.

We would like to thank Evan Mills for his leadership in preparing this report. We would also like to thank the colleagues who provided review comments and useful conceptual discussions on drafts of this report, particularly Lindene Patton (Earth & Water Law Group). Other valuable input was offered by Edward Baker (PRI), Ophir Bruck (PRI), Ben Caldecott (University of Oxford), Geert Van Calster (KU Leuven Law), Dan Farber (UC Berkeley School of Law), Alice Hill (Hoover Institute), Robert Muir-Wood (RMS), Claudia Polsky (UC Berkeley School of Law), and Kathleen Schaefer (UC Davis).

Lloyd Dixon (RAND) provided valuable data on California wildfire vulnerability under climate change and Petra Loew (Munich Re) provided comprehensive loss histories for the United States. Stan Dupre, Jakob Thoma, Tricia Jamison, Clare Murray, Tina Wang, Taylor Posey, Nils Blum-Oeste, Michael Hayne, and Klaus Hagedorn of 2 Degrees Investing Initiative performed the scenario analysis of insurer fossil-fuel investments. Alex Bernhardt, Karen Lockridge, Max Messervy, Hemant Kapoor, and Ashish Babbar of Mercer performed the threshold analysis of insurer fossil-fuel investments. Emily Van Camp managed the design for this report.

UC Berkeley School of Law's Center for Law, Energy & Environment (CLEE) hosted a day-long symposium on June 13, 2018 in support of this study that was attended by 60 individuals with relevant expertise. Information on the symposium can be found at https://www.law.berkeley.edu/research/clee/events/insuring-california. CLEE also managed the production of this report. Emily Van Camp managed the design for this report.

> Recommended citation: Evan Mills, Ted Lamm, Sadaf Sukhia, Ethan Elkind, and Aaron Ezroj. 2018. "Trial by Fire: Managing Climate Risks Facing Insurers in the Golden State." Sacramento, CA: California Department of Insurance.

Photographs in the report without captions are courtesy of Flickr's National Park Service (cover, p. 26), Unsplash's Jeremy Perkins (pp. iii and 41), Flickr's Bureau of Land Management California (pp. viii and 53), Unsplash's Dan Gold (p. 1), Flickr's U.S. Forest Service Pacific Northwest (p. 3), Unsplash's Tom Barrett (p. 8), Unsplash's Rodion Kutsaev (p. 9), Unsplash's Mourad Saadi (p. 20), Unsplash's Lucy Chian (pp. 22 and 57), Unsplash's Blaque X (p. 26), Unsplash's Connor Jalbert (p. 29), Unsplash's Jason Wong (p. 30), Unsplash's Guillaume Bourdages (p. 32), Flickr's Grizzlybear.se (pp. 35 and 88), Unsplash's Gerson Repreza (p. 37), Unsplash's Michal Mancewicz (p. 43), Flickr's Joshua Tree National Park and Cathy Bell (p. 45), Unsplash's Karsten Würth (pp. 50 and 66), Presidio of Monterrey (p. 51), Unsplash's Mark Doda (p. 52), Flickr's Rob Owens (p. 55), Unsplash's Sanjiv Nayak (p. 74), Unsplash's Dominik Lange (p. 77), Flickr's David Whelan (p. 80), Flickr's Moonjazz (pp. 83 and 86), Unsplash's Liv Bruce (p. 84), and Unsplash's Luke Bender (p. 87).




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# Foreword

Climate change presents risks for insurance policyholders, markets, and companies. This includes physical, transition, and liability risks, which may have consequences for insurers' underwriting and the investing of their reserves.

With regard to insurers' core underwriting business, the physical impacts of climate change pose risks. Climate scientists say that rising global temperatures are contributing to severe weather events – fires, hurricanes, droughts, and floods – some of which are causing or may cause loss of life, injuries, property damage, and economic disruptions. Insurers writing insurance for the people, property, and economies affected by severe weather events are already seeing increasing losses. For example, in 2017, California was hit with some of the most destructive wildfires in recorded history. Climate scientists have attributed the rise in destructive wildfires in part to climate change. Insured losses were $12.6 billion. The Caribbean and Gulf Coast were also pummeled by a series of Category 4 and 5 hurricanes whose severity was attributed to warmer ocean waters. And wildfires hit California again in 2018 – the Carr Fire caused an extremely rare "fire tornado" while the Mendocino Complex Fire became the largest in California history.

Insurers collectively hold and invest trillions of dollars in their reserves, and thus face climate-related financial transition risks to those investments. These risks manifest if markets, consumers, and governments transition away from reliance on fossil fuels and a carbon-based economy in order to reduce climate change causing greenhouse gas emissions, and the value of such investments declines in response.

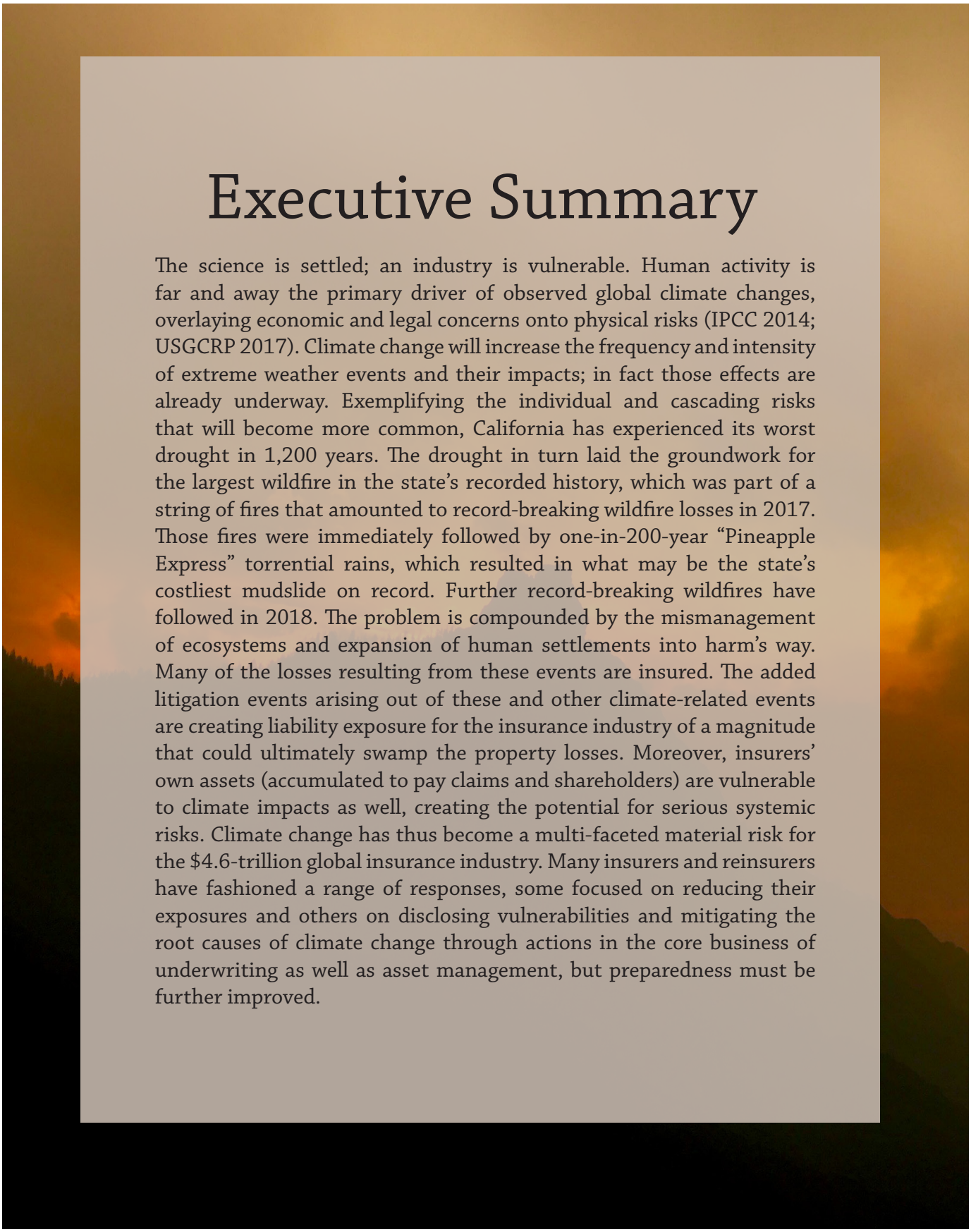
There are also climate-related liability risks. It is possible that the law will eventually provide that greenhouse gas emitters are liable for climate-related damages, which in turn insurers might be obligated to pay for.

As Insurance Commissioner, I am responsible for monitoring the financial condition of insurers, including both their assets and their liabilities and risks thereto, and helping maintain the availability, affordability, and adequacy of insurance for consumers. Given the climate-related risks faced by insurers, I have required insurers since 2011 to identify whether and how they are considering the impact of climate change in their business operations, underwriting, and reserving. In 2016, after concluding there are additional potential transition risks to insurer investments, I required insurers to disclose their investments in fossil fuel enterprises and utilities that rely on fossil fuels and asked that they divest from thermal coal investments because of the risk that such investments are or will become a stranded asset on the insurers' books. And, in 2018, I was the first United States financial regulator to undertake climate-related scenario stress testing of insurers' reserves.

Disclosure of climate-related risks to the financial sector is important for the sustainability of the global and United States financial systems generally, and the insurance sector in particular. In 2017, the G-20 Financial Stability Board's Task Force on Climate-related Financial Disclosures issued its recommendations for climate risk disclosures for each economic sector, including the insurance sector. Insurers, investors, policyholders, and regulators should all support and implement these recommendations.

I asked that this report be prepared in order to more fully identify climate risks and to discuss how insurers, regulators, and policymakers are responding. Thanks to Dr. Evan Mills, principal author, the climate policy experts at Berkeley Law's Center for Law, Energy & the Environment, and our staff in the Office of Climate Risk Initiatives, this report makes an important contribution to a better understanding of the challenges and opportunities associated with climate risk and climate change, and insurance.

**Dave Jones**
Insurance Commissioner
State of California



# Executive Summary

The science is settled; an industry is vulnerable. Human activity is far and away the primary driver of observed global climate changes, overlaying economic and legal concerns onto physical risks (IPCC 2014; USGCRP 2017). Climate change will increase the frequency and intensity of extreme weather events and their impacts; in fact those effects are already underway. Exemplifying the individual and cascading risks that will become more common, California has experienced its worst drought in 1,200 years. The drought in turn laid the groundwork for the largest wildfire in the state's recorded history, which was part of a string of fires that amounted to record-breaking wildfire losses in 2017. Those fires were immediately followed by one-in-200-year "Pineapple Express" torrential rains, which resulted in what may be the state's costliest mudslide on record. Further record-breaking wildfires have followed in 2018. The problem is compounded by the mismanagement of ecosystems and expansion of human settlements into harm's way. Many of the losses resulting from these events are insured. The added litigation events arising out of these and other climate-related events are creating liability exposure for the insurance industry of a magnitude that could ultimately swamp the property losses. Moreover, insurers' own assets (accumulated to pay claims and shareholders) are vulnerable to climate impacts as well, creating the potential for serious systemic risks. Climate change has thus become a multi-faceted material risk for the $4.6-trillion global insurance industry. Many insurers and reinsurers have fashioned a range of responses, some focused on reducing their exposures and others on disclosing vulnerabilities and mitigating the root causes of climate change through actions in the core business of underwriting as well as asset management, but preparedness must be further improved.

*"Whether one believes that it is caused primarily by humankind's collective actions, as I do, or not, the reality is that for insurers or insurance regulators to ignore climate change is to commit professional malpractice."*

California Insurance Commissioner Dave Jones

## The physical and business climates are changing

The Earth's natural environment is changing in ways that are less evident in our daily lives. For example, the Sahara desert has grown by 10% (Gabbatiss 2018) while we are losing nearly 150 cubic miles of land-based ice to the seas each year, which are consequently rising (NASA 2012). According to Pentagon-funded research, sea-level rise will make more than a thousand tropical islands uninhabitable in the next few decades, displacing civilian populations and swamping military infrastructure (Mooney and Dennis 2018; Storlazzi et al. 2018). The implications of sea-level rise are particularly worrisome for California's San Francisco Bay Area. These changes are rigorously attributed to human activities that overwhelm natural variability in the climate system. In fact, some natural phenomena such as sunspot cycles would actually be cooling the climate at this point in history were it not for human-caused greenhouse gas emissions.

As evidenced by analyses from the World Economic Forum, the business community has come to anticipate a warming world as well, placing climate change and the associated types of events befalling the world economy at the very top of their list of concerns on the global risk landscape. Climate change is usefully viewed by the scientific community and business leaders alike as a problem of risk management.

Indeed, in its core business, the insurance industry has long played a major role in helping society quantify and spread the risk of losses arising from climate and weather events. Yet major surprises continue to roil the industry as its customers continue to move into harm's way and as the risk landscape changes in sometimes unpredictable ways.

## California on the cusp

California – the world's fifth largest economy – sits at the edge of a continent and at a crossroads for slow- and fast-onset natural hazards that are already arising from climate change. With a GDP of $2.7 trillion and a population of nearly 40 million residents, much is at stake. Meanwhile, the Golden State is a pioneer in developing and bringing to scale technologies essential to reducing greenhouse gas emissions (and achieving climate adaptation) and a champion of forward-looking policies and programs to speed emission reduction and adaptation to otherwise unavoidable impacts.

California is the nation's largest insurance market, with over 1,300 insurance companies collecting $310 billion in premiums annually and holding $5 trillion in assets under management. Public insurers assuming most crop and flood risks collect an additional $500 million each year in premiums in the California marketplace alone.

The insurance market provides a clarion call for both registering the effects of climate change and shaping the responses. The industry is at once highly vulnerable to the losses that result from heightened weather- and climate-related events and to market dislocation caused by a changing economy yet also perfectly placed to play a key role in supporting innovative responses and

*"The headlines are naturally dominated by the escalation of tensions and conflicts, or high-level political events. But the truth is that the most systemic threat to humankind remains climate change...."*

UN Secretary General Antonio Guterres
Press conference, New York, March 29, 2018.

enhancing resilience to climate change.

In California, as in much of the world, insurance is part of the "DNA" of the broader economy. It serves an essential role of spreading risk, helping homeowners and businesses manage losses that would otherwise be crippling. This risk spreading in turn alleviates the exposures of the financing community, enabling it to provide capital knowing that the underlying collateral is reasonably secure. Insurance also fosters peace of mind on the part of homeowners and businesses, assuming that insurers honor their role in paying claims and remain solvent in the face of major loss events. Indeed, the availability of insurance in and of itself is part of society's capacity to adapt to climate change. That said, the disparity between total economic losses from weather and climate extremes and those covered by insurance is widening. This differential, commonly referred to as the "protection gap," may be compounded by new stresses that climate change imposes.

As an advanced economy, California hosts an insurance market that is well-developed and stands to be an innovator in efforts to analyze, underwrite, and mitigate the risks associated with certain climate impacts. Its customers want no less. Meanwhile, from an insurance regulator's perspective, the risks climate change poses to insurers must not threaten the solvency of individual companies or the availability, adequacy, and (to the degree possible) affordability of insurance to homes and businesses. The specter of climate change challenges both insurers and their regulators to take an increasingly expansive and proactive view of their missions and roles in the broader societal context in which many other stakeholders – including insurance consumers themselves – play essential parts.

Insurers face myriad risks in this warming world, and those doing business in California often assume climate risks in other markets as well (for reference, California represents about 7% of the global insurance market). These risks exist across the insurance enterprise, from underwriting, to functioning in the field post-event, to disputed claims, to asset management, to liability for insurers' own actions or inactions (e.g., approaches to safeguarding shareholder value). The challenges fall into four broad categories:

1. The physical risks of climate and weather extremes to insurance customers impact the built environment as well as health. Beyond these considerations are more complex systems-level risks such as those arising when power grids or supply chains are disrupted leading to business interruption insurance claims. Ecosystem disruptions such as fishery collapse or abrupt reductions in crop yields can rapidly manifest in systemic socioeconomic impacts.

2. A diverse set of considerations encompass what have come to be known as transition risks, which include the reverberation of physical losses into insurer assets and reserves (equities, bonds, and real estate) as well as new risks that may accompany efforts to address climate change (such as untested technologies and deliberate climate modifications that may backfire).

*"A + 4 °C world is not insurable."*

Thomas Buberl, CEO, AXA
Remarks, One Planet Summit, Paris, December 12, 2017.

More broadly, transition risks reflect the uncertainty of financial markets in a potentially carbon-constrained world.

3. Climate changes also precipitate a diversity of litigation risks, including claims for damages against producers of fossil fuels, other business interests found to be inadequately prepared to avert the impacts of climate change, or insurers themselves over disputed contractual obligations.

4. The broader reverberations of climate change impact the economy as a whole, with the potential for knock-on reductions in the availability of or demand for insurance, which in turn can erode property values or cities' credit ratings, along with other adverse consequences. Insurance markets can contract when consumers retreat or become less able to afford insurance or when insurers themselves deem risks uninsurable (as is evident in the U.S. government crop and flood insurance programs, residual insurance markets, and the evolution of the Florida market). These responses can be undesirable mal-adaptations to the climate problem, reducing consumers' peace of mind and failing to capture the socio-economic benefits of risk-spreading. Public insurance systems of last resort are vulnerable to political vagaries or insolvency, once again shifting risk back to individual consumers.

Cutting across these sources of risk are extensive potential correlations among risks, a top concern expressed by industry analysts (Moody's 2018). For example, a major hurricane striking a key financial center can simultaneously affect securities prices while triggering a wave of property/casualty and life/health insurance claims as well as litigation.

While technical uncertainties in projecting the timing and location of climate change impacts are at times held up as a rationale for inaction, uncertainty is in fact at the heart of the insurance industry's business. As observed by the International Actuarial Association:

> The enormous uncertainty associated with climate change is in and of itself an actuarial problem … it creates forecast risk. Since increased risk has an economic cost, uncertainty in future forecasts will likely increase the risk of errors and inevitably the cost of such programs…. [I]t is incumbent on the profession to lead the debate on the likely impacts … rather than let it passively emerge as an implicit "experience item" in annual reconciliations of actual versus expected experience (IAA 2017).

Global total and insured losses from weather-related catastrophes broke all records for total and insured losses in 2017: $330 billion and $136 billion, respectively (Munich Re). These losses mark a potential turning point in thinking – and acting – about climate change that may well surpass the momentum of prior moments following events such as Hurricanes Andrew (1992) and Katrina (2005). Yet headlines featuring abrupt, catastrophic events reflect only the tip of the iceberg in terms of climate risk. Many hazards are sufficiently small or localized (such as lightning and soil subsidence) but highly replicated, or sufficiently diffuse and slow-moving (such as drought, sea-level rise, or

*"We must, above all, shift from a culture of reaction to a culture of prevention. Prevention is not only more humane than cure; it is also much cheaper…. Above all, let us not forget that disaster prevention is a moral imperative, no less than reducing the risks of war."*

Daniel Stander, Managing Director, RMS
Keynote, RMS Exceedance Conference, Miami, April 28, 2015.

weather-related vehicle accidents) that they receive less attention. Further layers of risk that experts consider even less often include wide-ranging impacts such as ecosystem collapse, food-borne disease correlated with higher temperatures, or kidney disease correlated with dehydration.

Economists often bemoan the presence of "externalities" that result in societal costs (such as those from climate change), which are not reflected in the prices consumers pay for goods and services. With the potential to address one such set of externalities, insurance can be the messenger of climate risk, serving an important role in telegraphing the cost of that risk to buyers of insurance across all sectors, including housing, business, industry, and agriculture. This dynamic extends from property coverages to liabilities such as those facing polluters as well as entities responsible for foreseeing, disclosing, and proactively averting the adverse impacts of climate change. Conversely, as insurers refine their pricing to better reflect risks, they have an improved ability to participate in or reward consumers for improving their resilience. Moreover, as new technologies and practices emerge for combating climate change, insurers can participate in those markets through their core business by crafting related products and services or through their investment practices.

However, complications arise if the historical loss experience used to establish pricing fails to capture the actual cyclical nature of climate extremes:

> Insurance is an ex-ante finance instrument (pricing based on estimated expected future losses); however, the already challenging predictability of extreme weather events and related impact/loss profiles is now further confounded by climate change forecasts. This complicates an already tough question of how much money should be included in the charged rate today to pay for a well-defined future loss in a non-mandatory market where asset ownership may also change during the return period. Charging adequate rates to provide for expected ex-post outcomes in a manner consistent with an ex-ante finance instrument where the return period for the event/named peril loss cycle exceeds the instrument/policy period can drastically impact affordability.[1]

Ironically, and further complicating matters, by protecting consumers from the most significant economic impacts of climate change, insurance can unintentionally minimize the perceived need for resilience and mitigation and cause unintended mal-adaptations.

California is well positioned to build on its existing base of institutional and analytical preparedness. This report documents existing efforts on the part of Commissioner Jones and others and points the way to deepening their impact.

## California is a leader in insurance-focused climate risk management

California has a vibrant institutional and analytical ecosystem for mitigating climate risks and enhancing resilience. The state is particularly

1. Lindene Patton, Earth & Water Law Group, private communication on June 15, 2018, following June 13, 2018 symposium presentation.

vulnerable to the ravages of climate change and has become a hub for litigation against producers of products that ultimately result in greenhouse gas emissions. But it has also long been a leader in efforts to get in front of the problem. These efforts extend into the insurance sector.

**Applied research on risk:** California's universities, national laboratories, and non-governmental organizations have long been in the vanguard of assessing climate risk at the global and local levels and performing insurance-relevant assessments. As a case in point, the California-based think tank RAND Corporation has recently conducted a detailed assessment of climate change on insured wildfire risk (Dixon et al. 2018). The state's brain trust also includes deep legal scholarship on climate change litigation.

**Innovative insurers:** Insurers doing business in California have developed products and services aimed at reducing climate risks. Foremost among these are the first North American "green buildings" policies for homes and businesses, which reward the better risk profiles of these facilities with lower premiums and help rebuild damaged properties to a higher level of energy efficiency. In another example, eight companies have fielded mileage-based insurance products in California that reward reduced driving with lower premiums, consistent with reduced roadway risks incurred by these drivers.

**Insurance partnerships to leverage private investment:** Insurers cannot single-handedly address the risks of climate change, but they can exert considerable leverage and make meaningful progress through partnerships with other stakeholders. Identifying risk-reducing actions that policyholders can take is consistent with the commercial and social role insurance has played in the United States since the Great Chicago Fire and the advent of the steam boiler. In a more recent example, California is one of the few states where insurers have deemed that homes in compliance with the National Fire Protection Agency's "Firesafe" guidelines can receive premium credits, which can in turn inspire non-insurer investment in risk reduction.

**Forward-looking insurance regulation:** The California Department of Insurance (CDI), under the leadership of Commissioner Jones, has taken a number of forward-looking regulatory actions to focus insurers on the risks of climate change. CDI has led in the administration of a national survey by state insurance regulators of insurers regarding their responses to climate change. CDI has asked insurers to divest voluntarily their investments in thermal coal, in light of the risk that those investments will become "stranded assets" on the books of insurers as and if markets reduce demand for (and governments restrict use of) thermal coal as an energy source. More than 200 insurers in California's market have divested $4.1 billion in thermal coal and other fossil fuels and made commitments for further divestment. CDI has required insurers to disclose publicly their climate risks and fossil fuel and utility investments and undertaken first-in-the-nation "two degree scenario testing" of insurers' reserves to ascertain their potential exposure to a transition away from use of fossil fuels, consistent with keeping global temperature increases below two degrees Celsius.

CDI co-chairs the high-level National Association of Insurance Commissioners (NAIC) committee on climate change, which has led national-level efforts at climate risk disclosure among insurers. CDI has supported innovative efforts to develop insurance products that address emissions and has participated in climate change preparedness initiatives at the national and international level. Table 1 provides a more detailed listing of CDI's past and current activities.

**TABLE 1** | A decade of climate change activities at the California Department of Insurance.

| | |
|---|---|
| **2009** | Sponsored first-in-the-nation "green insurance" legislation allowing Californians to use their personal vehicles in car-sharing pools without invalidating their auto insurance (Assembly Bill 1871 [Jones, Chapter 454, Statutes of 2010]). |
| **2009** | Promulgated regulations allowing (but not requiring) insurers to offer mileage-based automobile insurance products in the California market; eight companies have brought products to the California market as of mid-2018. |
| **2010** | Helped develop the NAIC Insurer Climate Risk Disclosure Survey. California subsequently became one of only 20 states implementing a voluntary NAIC Insurer Climate Risk Disclosure Survey, and one of only four making it mandatory and requiring public dissemination of the responses in 2011. California broadened participation by lowering the threshold for participation from $300 million in annual premiums nationally to $100 million with nearly 1000 insurers responding to the survey in 2016. |
| **2011** | Reinvigorated a program crediting insurers for making investments in green infrastructure under the California Organized Investment Network (COIN) program, resulting in $7 billion in investment by 2016. |
| **2011** | Hosted the Green Insurance Summit, a forum led by California Insurance Commissioner Dave Jones to offer advice, insight, and recommendations on the impact of climate change on the insurance industry, the availability of green insurance products and investments, transparency and disclosure, and other issues where insurance and the environment intersect. |
| **2011-2018** | Commissioner Jones served as Vice Chair for the NAIC Climate Change Working Group, articulating the need to address climate change impacts. |
| **2012** | Signed an MOU with Cal Fire and began meeting bimonthly to coordinate efforts concerning wildfire. |
| **2015** | Joined California's Tree Mortality Task Force, working specifically with the Insurance Subgroup. |
| **2015** | Commissioner Jones attended the United Nations World Climate Conference (COP 21). |
| **2015** | Became a signatory of the United Nations Principles for Sustainable Insurance (PSI), positioning CDI for international collaborations to address climate change impacts. |
| **2016** | Launched the Climate Risk Carbon Initiative with the CDI Thermal Coal Divestment Request and CDI Fossil Fuel Data Call, resulting in $4.1 billion in divestment as of mid-2016. |
| **2016** | Co-hosted the inaugural meeting of the United Nations Sustainable Insurance Forum (SIF) with Commissioner Jones becoming the first Chair. |
| **2017** | Participated in Second Meeting of SIF, where workstreams were advanced and membership increased. |
| **2017** | Participated in Third Meeting of SIF, where membership decided to support the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD). |
| **2017** | Commissioner Jones wrote the Chair of the International Association of Insurance Supervisor (IAIS), asking that the IAIS formally support recommendations of the TCFD. |
| **2017** | Participated in a PSI and reinsurer symposium on the development of sustainable insurance products. |
| **2017** | After holding a claims workshop in an area impacted by severe wildfires, Commissioner Jones issued a notice asking insurers to simplify the claims process for California wildfire survivors who were overwhelmed with the task of navigating the claims process, provide relief from completing detailed home inventories, and follow the lead of insurers providing up to 100% of contents (personal property) coverage limits without a detailed inventory. |
| **2017-2018** | Participated in California's Fourth Climate Change Assessment, supporting RAND's research on the increased wildfire risks in the wildland-urban interface and providing guidance on the availability and affordability of insurance coverage in these areas. |
| **2018** | Commissioner Jones spoke at a Legislative Committee Hearing on Drought, Climate Change and Fire during which he asked the Legislature to take action so that consumers have available and affordable fire coverage. |
| **2018** | Shared strategies for addressing climate risk at the Climate Risk Conference for Supervisors. |
| **2018** | Conducted a first-in-the-nation stress test to determine climate-related risk to insurance industry investments, demonstrating that thermal coal still presents a great risk to insurers. |
| **2018** | Spoke on scenario analysis at the Fourth Meeting of SIF and a PSI conference. |
| **2018** | Participated in a symposium on insurance and climate risk, hosted by Berkeley Law's Center for Law, Energy & the Environment, identifying best practices within the insurance sector. |
| **2018** | Spoke on scenario analysis at United Nations-supported Principles for Responsible Investment (PRI) events, discussing the benefits of the analysis to supervisors and insurers. |

*"It is clear that a societal response is required – from legal and regulatory issues to corporate responsibility – to address the liabilities and the opportunities presented by climate change. Climate change will also require a more holistic or comprehensive risk management approach."*

Chubb (2016)

## Key findings

California insurers have diverse underwriting vulnerabilities to climate change, and CDI and insurers, together with other stakeholders, have achieved significant progress in identifying and responding to these risks. However, the full dimension of climate risks has yet to be quantified. Certainly much more can be done.

The physical risks facing insurers and the broader California economy have been starkly illustrated – with clear evidence that they can accumulate in a series of cascading perils – by the convergence of a multi-year drought deemed the worst in more than a millennium, ended by devastating rainfall and flooding, in turn followed by the largest wildfire in the state's history, immediately followed by landfall of a one-in-200-year pacific Pineapple Express storm upon the highest-valued settlement adjacent to that fire zone. The resulting combined insured wildfire losses were $12.6 billion, plus $658 million for the subsequent mudslides. One third of the structures lost in the fires were uninsured and the total societal costs are as yet un-tabulated. As this report goes to press in summer 2018, the Mendocino Complex fire has become the largest wildfire in records California history, a record previously held by the Tubb fire in Santa Rosa. Meanwhile, the also raging Carr Fire in Redding has destroyed 1,077 homes, 22 commerical structures, and 500 outbuildings have been destroyed and at least six people killed, an ominous development in keeping with the trend towards a "new normal" under climate change (Cal Fire 2018a). Segments of the California insurance market are currently under stress with respect to wildfire risks, and pressure on consumers will only increase under climate change. Encouragement can be taken from the fact that aggressive efforts to reduce greenhouse gas emissions can materially reduce the likelihood of such events in the future, benefitting insurers and their customers in particular.

A wide range of health risks occur in parallel with the better-known property risks. These risks range from extreme heat stress to a host of cardio-respiratory concerns and vector-borne diseases, which have been largely unassessed and unaddressed by the insurance community. The implications extend to disruptions in the delivery of healthcare following catastrophes.

Financial vulnerabilities extending beyond direct insurance losses include transition risks, which largely manifest in investments and the asset management side of the industry. Insurers operating in California have about $528 billion in fossil-fuel-related investments in various sectors and asset classes. Adverse impacts on the climate and resultant competitive risks from clean energy technologies in combination with an adverse economic and regulatory environment can present financial uncertainties for these investments (McHale and Spivey 2016).

While litigation against emitters of pollutants contributing to climate change has as yet been unsuccessful, a recent wave of challenges in California courts based primarily on tort and nuisance claims and the costs that climate change impacts are imposing on municipalities may

*"By increasing incentives for reduced driving, the building of 'green buildings,' investments in energy efficiency improvements and renewable energy projects, and the conservation of natural resources, the insurance industry can help reduce greenhouse gas emissions."*

California Assembly Bill 1011 (Jones, Chapter 418, Statutes of 2010)

result in extremely large insurance liabilities or settlements.

Society's responses to climate change also bring serious new risks, particularly concerning the last-ditch efforts being discussed to "engineer the climate" itself, for example by reducing sunlight reaching the Earth. The potentially serious insurance implications of this trend have not been examined. However, other strategies that focus on using energy more efficiently and decarbonizing the energy supply with renewable sources, often improve climate resilience or reduce insured risks in other ways.

The aforementioned risks can intersect and compound one another in ways that are rarely evaluated. Their combined and sometimes cascading effect in a given underwriting year represents the full impact of climate change on an insurer's business. Climate change – particularly with the many simultaneous and correlated risks it presents – is thus more daunting than traditional hazards.

A range of actions from insurers, regulators, lawmakers, and consumers will be necessary in order to preserve insurance availability, adequacy, and affordability as climate change worsens. While current legislative proposals seek to address the specific problems raised by recent wildfires, insurers will face even greater systemic barriers to offering affordable insurance statewide as risks grow and combine. Increased regulation will help residents obtain and maintain insurance coverage. Among the efforts to be proactive, many insurers have fielded a range of green insurance products and services. These appear to have had mixed market reception, with many agents as well as consumers unaware of their existence. In certain cases, however, uptake has been appreciable, although the current deficiencies in terms of product distribution are significant.

A key and largely untapped area for innovation is in enhancing resilience. For insurers to play a greater role requires better models and better loss data, which is made possible by recent advances in science, remote sensing, and "big data" analysis techniques. Science-based processes of identifying and quantifying climate risk (both in space and time) can support more sophisticated actuarial analyses and tailoring of insurance products and services to pinpointing risk and incentivizing risk reduction. A conceptual model for this may be obtained by borrowing a page from the "highly protected risk" side of the industry, where premium revenues are targeted towards loss prevention with the goal of drastically reducing the risk of future payouts. Third party stakeholders such as local governments, non-governmental organizations (NGOs), and the academic community also clearly have roles to play in such a process. Institutional arrangements for organizing and financing such ambitious undertakings are not currently in place. Insurers also lack incentives to engage in analysis or implementation of large-scale resilience measures.

The most effective approaches will embrace an enterprise-wide perspective, integrating the core underwriting business with asset management. The industry has already begun to respond in myriad innovative ways. Approximately 1,500 innovative activities have been pursued by over 500 insurers

*"I do not want to sit by and then discover in the near future that insurance companies' books are filled with stranded assets that have lost their value because of a shift away from the carbon-based economy, jeopardizing their financial stability and ability to meet their obligations, including paying claims to policyholders."*

California Insurance Commissioner Dave Jones
California Department of Insurance Press Release, Huntington Beach, January 25, 2016.

and associated entities across 50 countries, with significant market uptake in some cases (Mills and EA). These span a range of activities including innovative products and services (e.g., insurance for green buildings), leadership by example in "greening" their own operations, disclosing risks, promoting loss prevention, engaging in climate science and communications, direct investment or financing of climate-change solutions, and expressions in public policy fora. On the asset side, insurers' divestment of coal has been coupled with strong growth in investment in clean energy technologies and other climate change mitigation strategies. Over $60 billion in such investments have been identified globally. Meanwhile, following divestment decisions, some insurers have ceased to underwrite or finance coal-based companies and projects. While current levels of "climate-friendly" investment and divestment represent a vanishingly small proportion of total insurer assets, stated ambitions for further initiatives remain high.

## Recommendations

The CDI's goals regarding climate change are informed by its mission to protect insurers and consumers from this immense set of emerging risks. Over the past decade, CDI has championed green insurance initiatives, increased transparency regarding insurers' perception and response to climate risk, led climate-related disclosure efforts, worked with other agencies to advance resilience and loss-prevention, and participated in related industry dialogue on the national and international stage. Among the potential future directions that regulators can take to broaden as well deepen these efforts are:

- Continue to monitor the insurance-relevant climate situation and responses
- Refine insurance pricing and contract design to more precisely reflect climate risks and incentivize mitigation efforts
- Fortify consumer protections and resilience efforts
- Continue to champion and improve climate risk disclosure
- Support innovation in loss modeling, data science, and stress testing
- Identify and mitigate barriers to green insurance and risk reduction
- Participate in climate mitigation and adaptation research and inter-agency initiatives
- Enhance market awareness of disparate risks and insurance responses
- Increase engagement in broader public policy discussions

The evolution of society's ability to identify and respond to climate-change risks is essential to the ability of the insurance industry to reach its economic potential while maintaining its own solvency together with the availability, adequacy, and affordability of insurance for consumers. The effort is a collective one, involving all segments of the economy in partnership with regulators, the scientific community, and other stakeholders.

# Climate Change is Risky Business for Insurers

Weather-related events underlie approximately 90% of natural disasters and their costs in an average year (Munich Re). The year 2017 broke global cost records for such events: $320 billion globally, of which $133 billion (42%) were insured. The vast majority of these impacts (93% of total insured losses) were in North America, an atypically high proportion in the global context. Total economic losses caused by hurricanes were nearly five times the average of the prior 16 years, those for other types of severe storms were 60% higher, and those for wildfire were four times higher (Aon Benfield 2018). The United States endured 16 individual events each exceeding $1 billion in damages. Among these, the Tubbs Fire in the Napa Valley was the costliest wildfire in the global insurance industry's history (Aon Benfield 2018) and the largest urban conflagration since the fire following the 1906 San Francisco earthquake. These trends and loss events reflect an interaction between intensifying hazards and populations that continue to move into harm's way. The results are material for property insurers: global losses in 2017 shifted industry-estimated return on equity from a healthy 11% the year before to negative 4% (Swiss Re 2017).

While average conditions seem to be changing only modestly, scientists have firmly established that climate change will increase the frequency and intensity of extreme weather events (USGCRP 2017) (Figure 1). The business community has come to accept this fact as well, as evidenced in the World Economic Forum's ranking of such events as the greatest risk on the global landscape – with potential impacts on par with those of weapons of mass destruction – yet the likelihood of extreme weather events is far higher (Figure 2). Climate change is deemed the largest driving trend influencing the

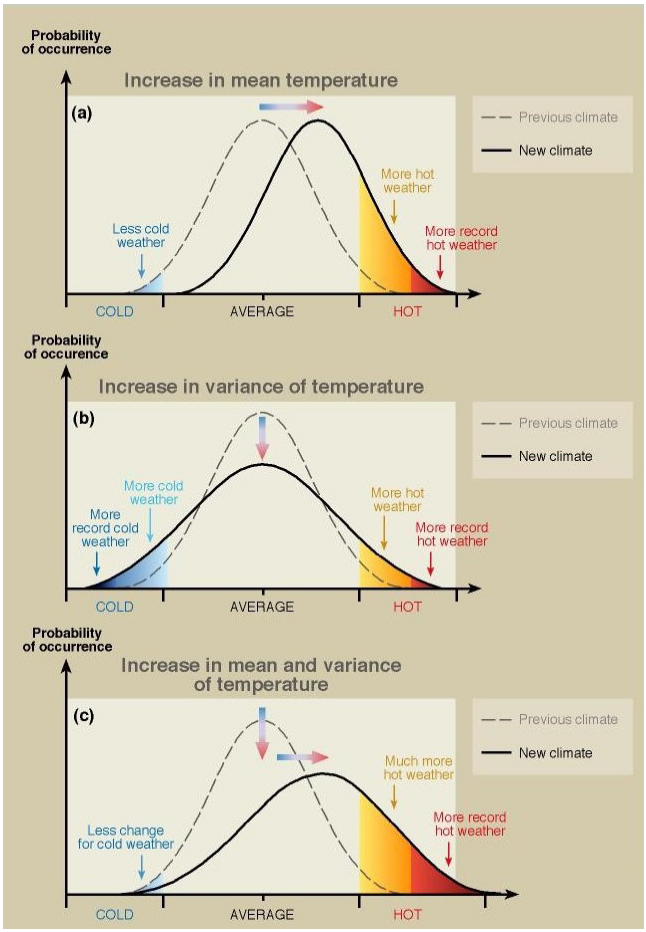
> *"Climate change creates significant challenges for the property and casualty (P&C) insurance and reinsurance sectors and has a net negative credit impact on the industry...."*
>
> Moody's (2018)

entire array of risks, some of which are very directly related to one another, such as food and water crises. In light of these findings, it is not surprising that the *failure* of climate change mitigation and adaptation is ranked the fifth highest risk by likelihood. Notably, the insurance industry (Marsh & McLennan Companies and Zurich Insurance Group) played leading roles in assembling this analysis (WEF 2018).

The risks of climate change are myriad. From an insurance vantage point, they can be broadly grouped into underwriting risks (property and casualty) and risks to the assets that insurers develop to fund losses and provide a return to investors. In the core business, weather- and climate-related losses can affect physical assets such as buildings, as well as vehicles, crops, life, and health. Risks to the values of assets constitute transition risks. The acts of those responsible for greenhouse-gas pollution are increasingly leading to litigation, which, in turn, can involve insurers. The significance of this latter trend is reinforced by the increasing ability to probabilistically attribute climate events to human activity (Marjanac and Patton 2018). Recent assessments have concluded that the multiplicity of simultaneous and correlated climate risks are expected to magnify current volatility levels and adversely impact credit within the industry, with smaller or more geographically concentrated insurers most at risk (Moody's 2018).

It is encouraging that reduced greenhouse-gas-emission trajectories hold the promise of material reductions in insurance risks. Emission reductions could have tangible benefits if they are substantial enough to move the planet to a lower-emissions

**FIGURE 1** | Extreme weather events become the new normal under climate change.




*Source: IPCC (2001).*

scenario. Examples of this include:

- The projected increase in acreage burned in some high-risk parts of California doubles by the end of the century under lower-emissions scenarios, while it quadruples for high-emissions scenarios (Dixon et al. 2018).
- There is a nearly four-fold variation in potential inundation around the San Francisco Bay Area under climate change, depending on emissions pathway (Shirzaei and Burgmann 2018).
- The frequency of conditions like those occurring in the most extreme insured crop-loss years (1988 and 1993) would double under anticipated climate change (Beach et al. 2010).

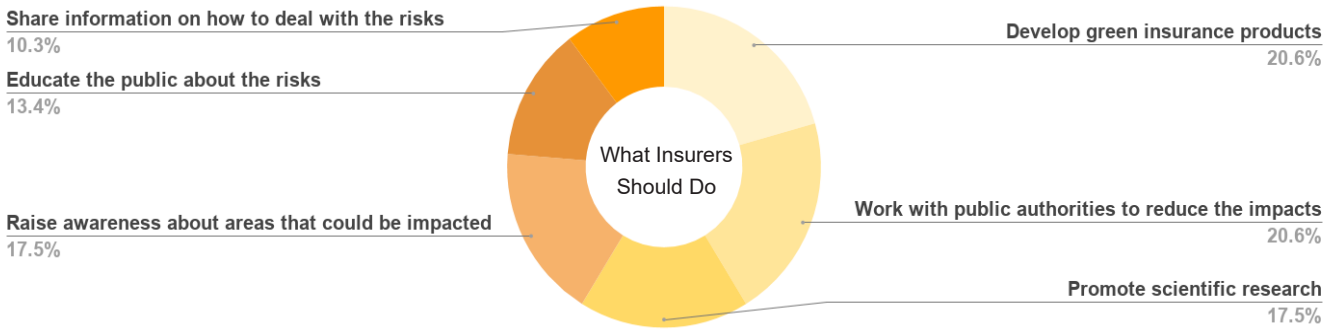
While these individual nodes of risk are serious in their own right, the very real correlations among them are perhaps the greatest threat to the vitality of the insurance industry as a whole (Mills 2005; Moody's 2018). Not only do individual physical risks often correlate with one another, but the underlying hazards can trigger losses in unexpected ways across multiple insurance lines that compose the broader core business. More significantly, weather and climate extremes also stand to simultaneously trigger losses in the asset side of the industry, while further adversely impacting the broader economy in which insurance consumers must function. At the level of individual events, a major hurricane striking one of the world's major financial centers is one example. In practice, a wide range of events occur in any given underwriting year and parallel major losses can prove more deeply destabilizing, particularly in an increasingly interconnected global economy.

It is important to consider global exposures even when focusing on insurance vulnerability in a specific market such as California. Most insurers operate in multiple markets and multiple countries. An insurer operating in California may face climate risks half a world away.

**FIGURE 2** | Extreme weather events are ranked as the number-one concern by the World Economic Forum, followed by natural disasters.


*Note: Survey respondents were asked to assess the likelihood of the individual global risk on a scale of 1 to 5, 1 representing a risk that is very unlikely to happen and 5 a risk that is very likely to occur. They also assess the impact on each global risk on a scale of 1 to 5 (1: minimal impact, 2: minor impact, 3: moderate impact, 4: severe impact, and 5: catastrophic impact). Label, symbol sizes, and color saturation are proportional to the combination of likelihood and impact. To ensure legibility, the names of the global risks are abbreviated. The survey was administered to over approximately 1,000 constituents from World Economic Forum (WEF)'s network in business, government, civil society, and experts. Source: WEF (2018).*

**FIGURE 3** | Almost two thirds of customers think their insurers should act on climate change.




*Source: AXA/Ipsos (2012). The survey was administered to over approximately 1,000 constituents from WEF's network in business, government, civil society, and experts. Source: WEF (2018).*

## The market expects insurers to understand and help manage climate risks

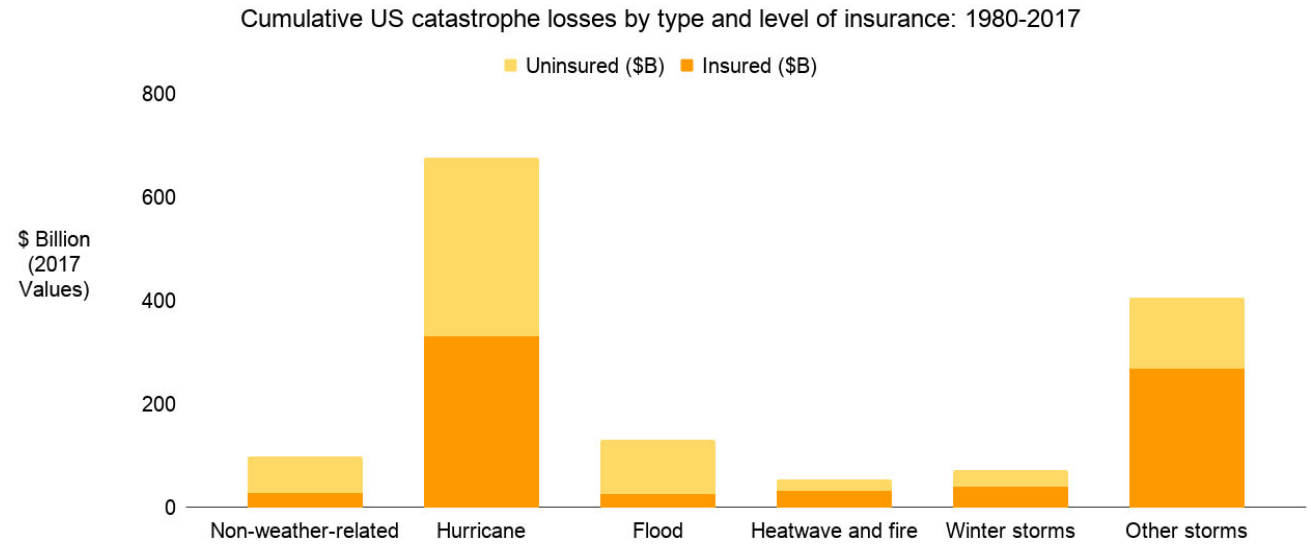
Vast swaths of the business community and general public see climate change as a palpable risk, and seek to participate in collective efforts to reduce greenhouse-gas emissions to the extent possible while preparing for otherwise unavoidable impacts. Investors see emerging risks in their portfolios, real-estate holdings, and other assets. They also see opportunity in clean energy investments. Non-insurer members of the financial services sector view insurance as protecting their collateral from risk that they choose not to or are not permitted by law to underwrite against, exclude, or price.

All parties see the value proposition of insurance as a source of peace of mind and loss prevention/recovery. With insurance premium volumes of about $300 billion each year in California alone, and $5 trillion in assets under management, insurers serving the California marketplace are capable of making a difference.

The specter of climate change is unsettling for an industry with a business model dependent on being able to identify, anticipate, and forecast risks, and quantify potential losses and the associated uncertainties. To make risk more visible, insureds as well as investors are increasingly focusing on the need for climate risk disclosure and risk management.

Insurance customers care about these issues as well. More than 90% of 13,000 surveyed insurance consumers in North America, Europe, and Asia believe the climate is changing and are concerned about how it will affect them (AXA/Ipsos 2012). Almost 80% of the respondents think their insurance coverage will be affected by climate change and 61% expect insurance to play a role in responding, beyond simply providing insurance products (Figure 3). They expect insurers to offer green products, provide climate-change information, promote relevant research, support environmentally conscious behaviors, and build partnerships with national and local authorities. Hiscox conducted a similar survey of 610 customers, with analogous findings (ClimateWise 2017a).

**FIGURE 4** | The degree of U.S. insurance coverage varies widely by type of catastrophe: 1980-2017.




*Source: Munich Reinsurance Company, Geo Risks Research, NatCatSERVICE. Note: most of the insured flood losses were paid through the publicly funded NFIP. Source: Munich Reinsurance Company, Geo Risks Research, NatCatSERVICE, used with permission.*

## The U.S. insurance industry absorbs half the costs of weather- and climate-related losses

Insurers are long-standing stakeholders in the broader economy, and consumers are encouraged to view them as agents of safety and peace of mind. Insurers have seen steadily rising claims globally, and California is no exception.

However, according to global statistics gathered and tracked by Munich Re for nearly four decades, only about half of total economic losses from weather- and climate-related events are insured (Munich Re). The uninsured portion of these events, which has come to be known as the protection gap, has averaged almost $100 billion per year in the past decade. In North America, the gap has averaged $15 billion per year, spiking to $42 billion in 2017 (excluding losses paid under the National Flood Insurance Program [NFIP]). Under climate change this gap will likely grow, both in absolute and percentage terms, unless insurers expand their coverages commensurately. Moreover, consumers have been observed to buy flood insurance following major loss events but then allow it to lapse after just a few years (a phenomenon termed the "flood memory half-life" by Pinter et al. [2017]). Uninsured losses are absorbed by governments and, ultimately, individual consumers and businesses.

In the United States, the vast majority (93%) of all catastrophe losses are weather-and climate-related. Insurance has absorbed about half of the total losses in the United States between 1980 and 2017 (Figure 4), ranging from 32% to 79%, somewhat higher than the rest of the world. In some areas, the protection gap is far larger, particularly for flood losses, 80% of which were uninsured between 1980 and 2017. The vast majority of the insured portion was paid by NFIP. Yet, even for large wildfire events in California, 20% to 40% of total historic economic losses are uninsured (Munich Re).

While insurers can generally count on steady and incremental changes in loss trends, one source of uncertainty with weather- and climate-related events is that loss patterns can change abruptly (Figure 5 A-F), unlike the far more steady loss patterns familiar to life insurers. This is illustrated by the fire and heat-event losses in 2017. Losses in that year (almost all of which were in California) were on par with total losses in the preceding four decades.

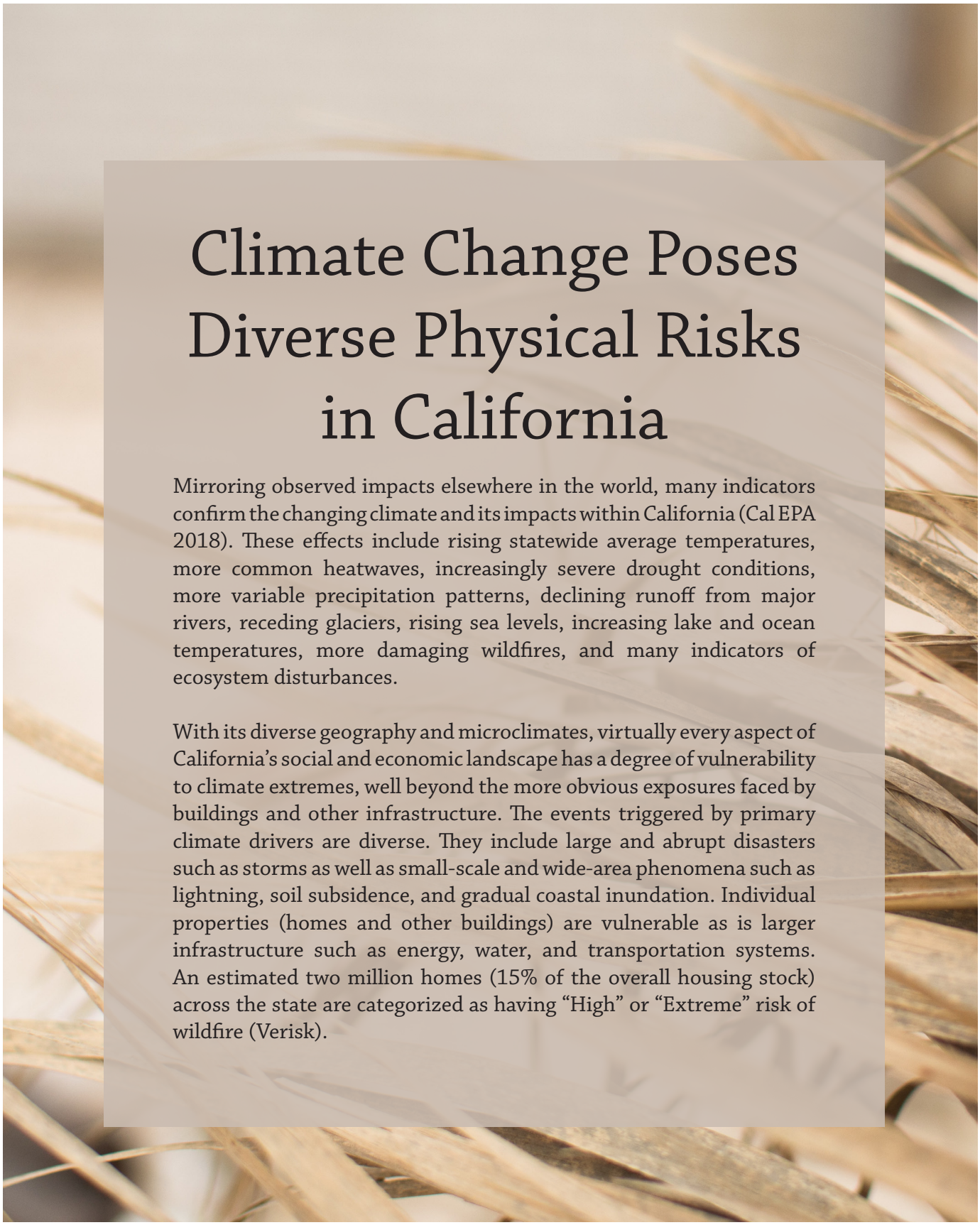
While it is important to analyze the direct property loss outcomes of individual perils such as wildfire, doing so misses a more pervasive pattern of risk and exposure evident when focusing on broader systems affected by these events. These include power grids, supply chains, communications networks, and transportation systems. Damages to these systems can in turn lead to cascading casualty insurance losses in the form of business interruption. Further, should loss events caused by extreme weather (e.g., a hazardous pollution release) be deemed to have occurred due to a failure to take adequate measures to protect against harm to others from foreseeable losses, then additional casualty/liability claims may arise

**FIGURE 5 A-F** | Volatile trends in U.S. natural catastrophe losses: 1980-2017.


*Note: most of the insured flood losses were paid through the publicly funded NFIP. Source: Munich Reinsurance Company, Geo Risks Research, NatCatSERVICE, used with permission.*

in volumes that swamp property claims. From this vantage point, the relevant geographic scale also enlarges significantly, typically stretching beyond state and even national borders. Among the many non-insured economic impacts are lost tax revenues (sales, income, and property), examples of which are noted for the 2017 and 2018 Santa Barbara floods and mudslides in the next section.

In a particularly California-relevant example of the complexity of impacts, warmer and drier winters will adversely affect the winter sports industry, which has an important role in the California economy. One estimate puts the costs of a warm winter for winter sports tourism at $1 billion for the country as a whole (Hagenstad et al. 2018). California ski resorts have litigated with their insurers over whether their business interruption insurance will cover disrupted ski seasons (Cronheim 2012).



# Climate Change Poses Diverse Physical Risks in California

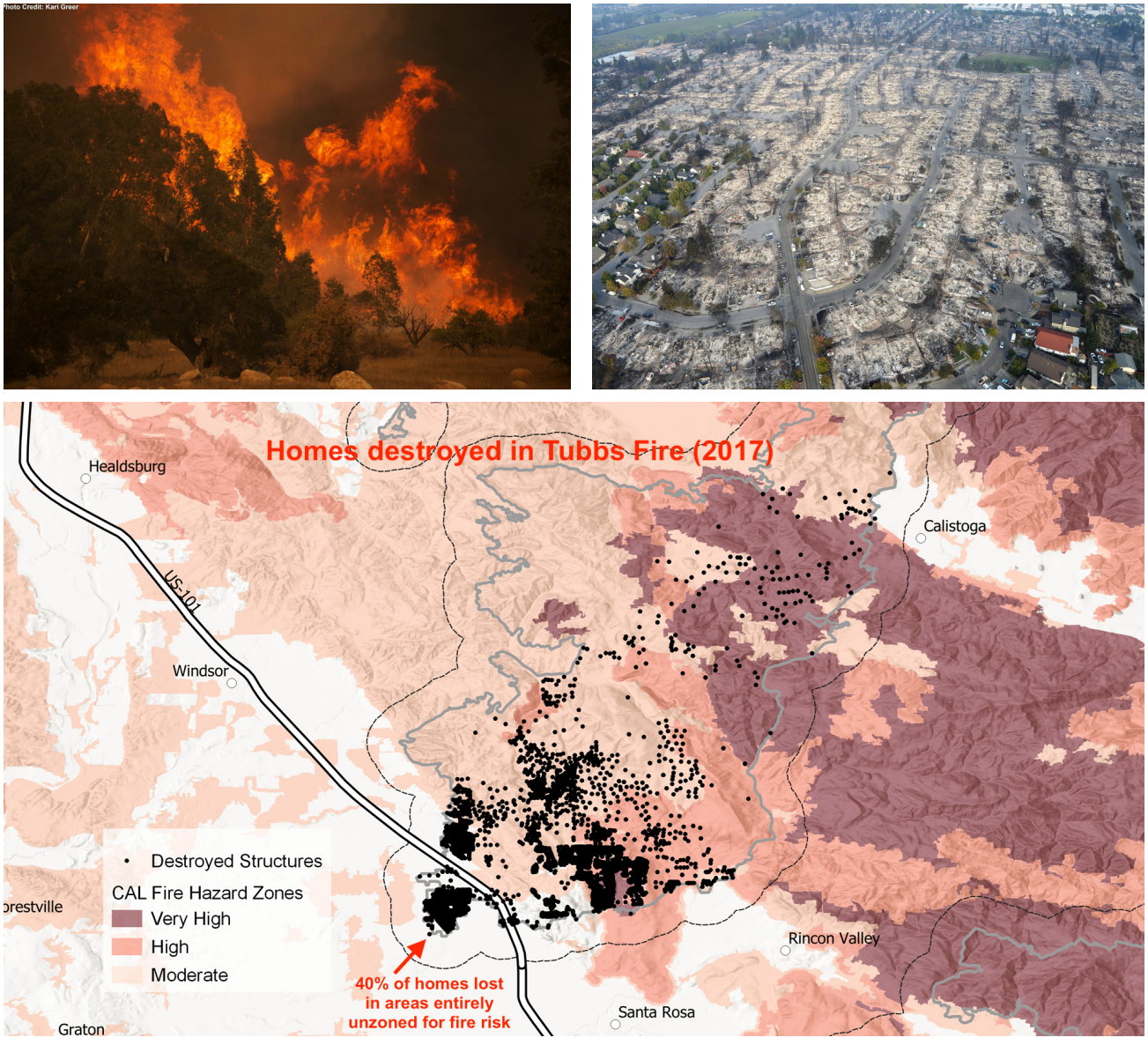
Mirroring observed impacts elsewhere in the world, many indicators confirm the changing climate and its impacts within California (Cal EPA 2018). These effects include rising statewide average temperatures, more common heatwaves, increasingly severe drought conditions, more variable precipitation patterns, declining runoff from major rivers, receding glaciers, rising sea levels, increasing lake and ocean temperatures, more damaging wildfires, and many indicators of ecosystem disturbances.

With its diverse geography and microclimates, virtually every aspect of California's social and economic landscape has a degree of vulnerability to climate extremes, well beyond the more obvious exposures faced by buildings and other infrastructure. The events triggered by primary climate drivers are diverse. They include large and abrupt disasters such as storms as well as small-scale and wide-area phenomena such as lightning, soil subsidence, and gradual coastal inundation. Individual properties (homes and other buildings) are vulnerable as is larger infrastructure such as energy, water, and transportation systems. An estimated two million homes (15% of the overall housing stock) across the state are categorized as having "High" or "Extreme" risk of wildfire (Verisk).

A more nuanced view of vulnerability must consider correlations among these hazards (e.g., drought paving the way for wildfire and wildfire paving the way for mudslides). And changing geographies together with the increasing scale of the events can drive impacts into new areas (e.g., wild fires penetrating deep into urban settlements, as seen in Santa Rosa in 2017, Figure 6 A-C). Moreover, at larger scales, degradation of ecosystems can pave the way for insured losses to infrastructure. Examples include loss of coral reefs due to ocean temperature increases and acidification, and the consequent loss of storm-surge protection for buildings near shorelines.

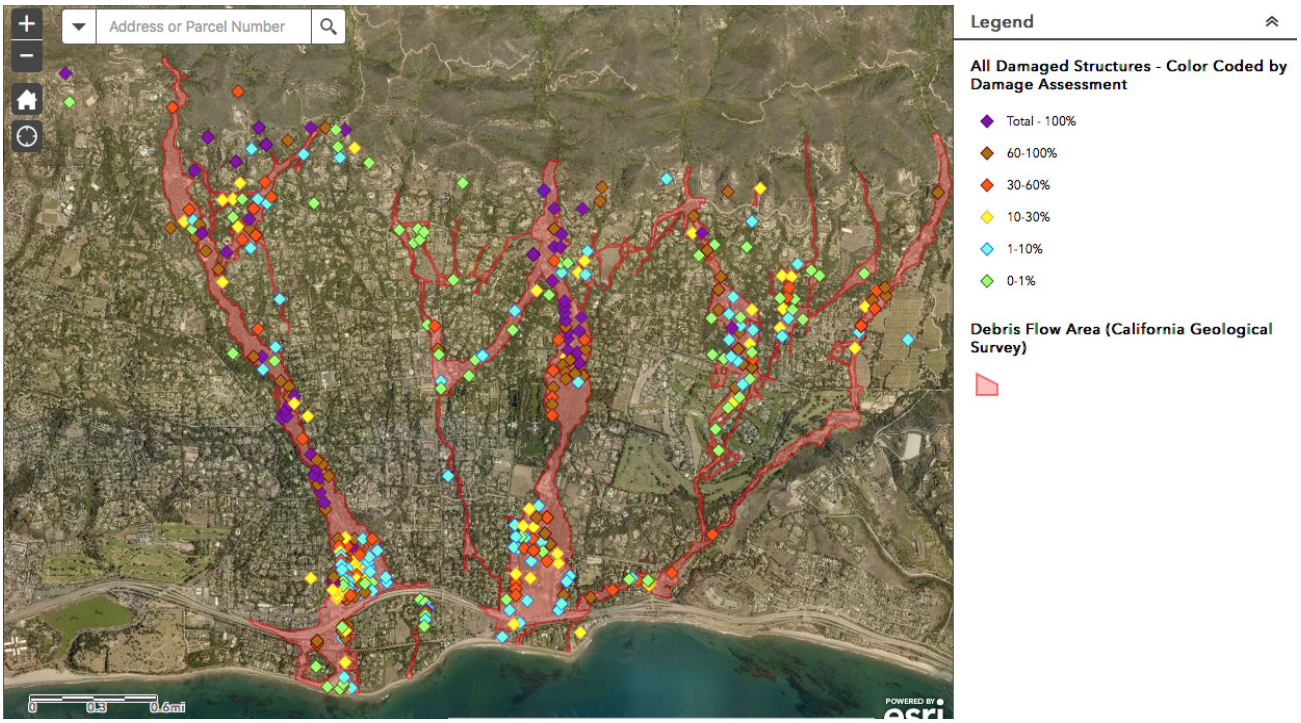
Events linked to climate change can conspire with non-weather-related ones to compound damages and economic losses. Examples of the latter

**FIGURE 6 A-C** | The year 2017 saw the then-largest wildfire in the state's history with other major fires extending outside of areas deemed to be risky.




*Credits: Coffey park in Santa Rosa Tubbs fire (upper right): California National Guard via Flickr; Thomas fire in Santa Barbara County (upper left): Pacific Southwest Region 5 via Flickr. Map showing Tubbs fire (Muir-Wood 2018).*

**FIGURE 7 A-E** | Multiple corridors of mudflow carrying boulders and debris inundated neighborhoods and roads in Montecito following the Thomas Fire.




(Before Image: Google Maps - After Image: Ventura County Aviation Unit)

(Before Image: Google Maps - After Image: Ventura County Aviation Unit)

(Before Image: Google Maps - After Image: Ventura County Aviation Unit)

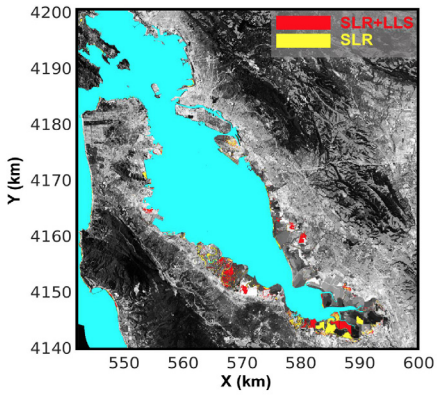
(Before Image: Google Maps - After Image: Ventura County Aviation Unit)

*Thomas Fire burn zone extends northward at top of frame, immediately adjacent to origin of mud flows. Sources: Top: Prepared by ESRI for Santa Barbara County (Mike Eliason and Santa Barbara County), used with permission. Bottom: before/after images from Google Maps.*

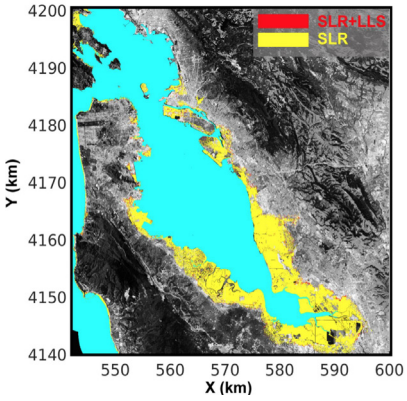
include wild fires increasing the risk of mudslides as occurred in California in 2018 (Figure 7 A-E) or soil subsidence caused by human activity compounding the inundation created by sea-level rise. The latter example is an important factor in the damages facing infrastructure inundated by sea-level rise around the San Francisco Bay Area in the coming decades (Figure 8 A-C). The latest assessments project 48 to 166 square miles of inundation along the San Francisco Bay alone, depending on the emissions scenario (Shirzaei and Burgmann 2018). This represents a large uncertainty with which insurers must cope. Superimposing earthquake events upon buildings already compromised by sea-level rise and subsidence could yield yet higher thresholds of damage. California's Pacific Institute estimates that $100 billion of California infrastructure is at risk from sea-level rise:

A wide range of critical infrastructure along California's coast is also at increased risk, including nearly 140 schools; 34 police and fire stations; 55 healthcare facilities; more than 330 U.S. Environmental Protection Agency regulated hazardous waste sites; 3,500 miles of roads and highways; 280 miles of railways; 30 coastal power plants, with a combined capacity of more than 10,000 megawatts; 28 wastewater treatment plants; and both the San Francisco and Oakland airports. Overall, nearly $100 billion worth of California property is at risk of flooding from a 100-year event with a 1.4 m sea-level rise if no adaptation actions are taken (Gleick 2017, citing Heberger et al. 2011).

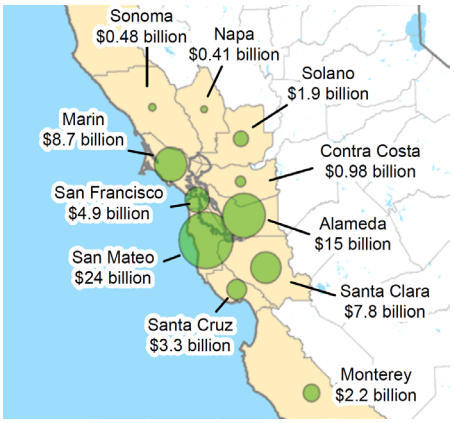
**FIGURE 8 A-C** | Range of scenarios for land inundation under sea-level rise together with soil subsidence by the year 2100 around the San Francisco Bay.




Inundation map at 2100 given the lower bound of the likely range of SLR projection under RCP 2.6 Scenario. An area of 98 km$^2$ will be vulnerable to inundatin considring both SLR and LLS as opposed to 51 km$^2$ considering SLR alone.




Inundation map at 2100 given the SLR projection under H++ scenario. An area of 429 km$^2$ will be vulnerable to inundation considering both SLR and LLS as opposed to 413 km$^2$ considering SLR alone.




*San Francisco Bay Area ocean inundation at (a) the lower bound of the likely range of lower-emissions scenario (emissions scenario RCP 2.6, representing attainment of the goals of United Nations Framework Convention on Climate Changes 2015 Paris agreement) resulting in 38 square miles of land area around the San Francisco Bay vulnerable to inundation versus (b) under the H++ emissions scenario, representing a high-emissions scenario resulting in 166 square miles of land area vulnerable to inundation. Attribution to sea-level rise (SLR) and local land subsidence (LLS) coloredseparately. The area pictured in panels a and b is 37 miles x 37 miles. Panel c shows replacement value of buildings and contents vulnerable to sea-level rise of 1.4 meters under a 100-year coastal flood event in year-2000 dollars across a somewhat broader area. Sources: Sea-level rise imaging (Shirzaei and Burgmann 2018); Values at risk (Pacific Institute 2009).*

*Climate-related losses "could materially and adversely affect our results of operations, our financial position and/or liquidity, and could adversely impact our ratings, our ability to raise capital and the availability and cost of reinsurance."*

Travelers Insurance
Annual Report (SEC Form 10-K) 2014.

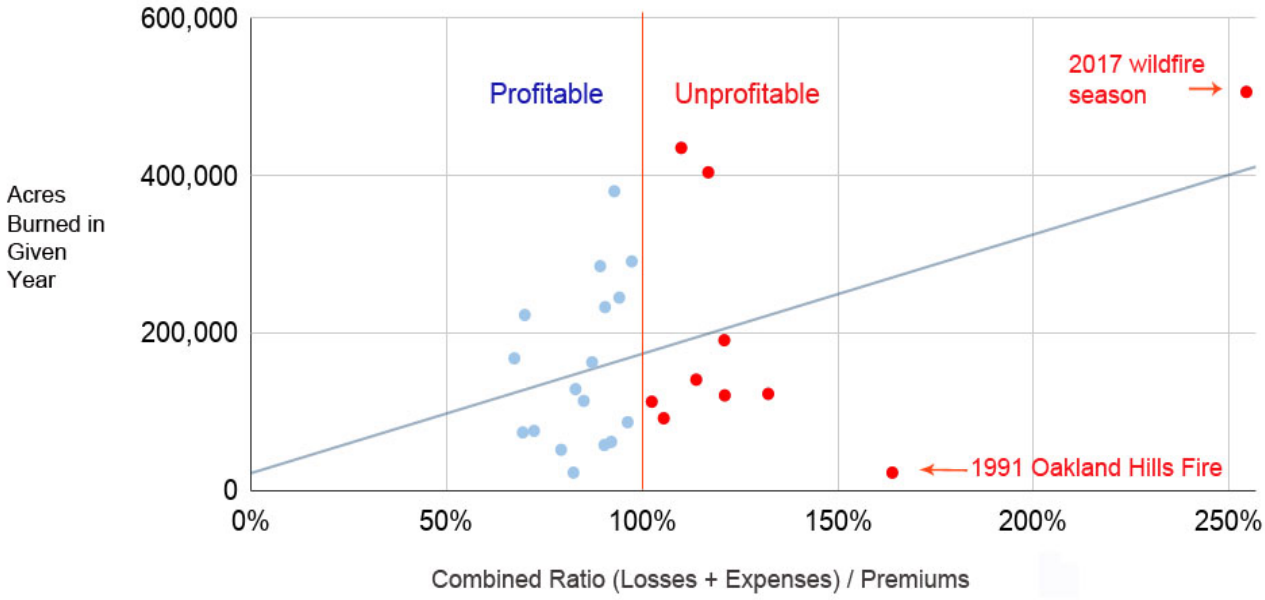
Roadway safety is strongly influenced by weather conditions, which impact visibility, pavement friction, and driving behavior. The Federal Highway Administration reports that 22% of roadway accidents (about 1.2 million per year) are weather-related, with approximately 6,000 people killed and 445,000 injured in these accidents in an average year (FHA). Climate change is widely expected to lead to increased precipitation, particularly torrential rain events, with one of the likely consequences being worsened roadway safety in a state with 400,000 miles of roads.

California produces over 400 agricultural commodities, including more than one third of the nation's vegetables and two-thirds of the nation's fruits and nuts, at a value of over $45 billion each year (Pathak et al. 2018), of which $20 billion is for export, the largest of any state (CDFA 2018). Key climate-related hazards for agriculture are summertime temperature extremes as well as reduction of wintertime "chill hours" necessary for fruit-setting; changes in precipitation, snowpack and stored water availability, and drought; extreme weather events; and changes in crop pests and diseases. Even modest and gradual changes in these conditions can lead to abrupt changes in yields (Beach et al. 2010). For example, researchers foresee reductions in yields ranging from 5% to over 40% for grapes, almonds, oranges, walnuts, and avocados in California by the year 2060 (Pathak et al. 2018). Predicted climate changes will result in disturbances outside those of even highly experienced farmers in the state.

As noted previously, specialized parts of the economy, such as California ski resorts, are also becoming quite vulnerable. The influence of climate change as a driver of losses in California is compounded by increasing values at risk and the tendency for people to move into high-risk areas (coastlines, the wildland-urban interface, and floodplains).

Leading insurers note that climate change is a risk to both the property/casualty and life/health sides of their business (Chubb 2016). The most apparent climate-related concerns arise from severe-weather disasters. Additional risk factors stem from air pollution, disease transmission, increasing allergens, extreme heat, food and water supply, water quality, and environmental degradation. The World Health Organization projects 250,000 extra deaths each year due to climate change between 2030 and 2050, increasing significantly thereafter (WHO 2014). Far more cases of non-fatal illness (morbidity) are expected as well, and some will affect insurers doing business in California. Of particular relevance in California are the consequences of heatwaves (CEHTP 2018; Guirguis et al. 2014), kidney disease related to increased temperatures and dehydration (Brikowski et al. 2008), and spiking hospital admissions related to respiratory health that often accompanies major wildfires (UC Irvine 2008; UCSF 2017).

**FIGURE 9** | California acreage burned in wildfires correlates with multiple peril homeowners insurance profitability: 1991-2017.




*Sources: Wildfire acreage from Cal Fire (excludes other jurisdictions) (Cal Fire). Combined ratio is for homeowners multiple peril insurance line [(losses incurred + expenses)/premiums earned] from CDI. Loss development values for the late-2017 fires are as of May 2018. Potential future recoveries if utility liability is established may improve the net results for insurance companies. Source: CDI data.*

## Climate-related loss events are a material influence on consumer costs and insurer profitability

Wildfire has become a leading concern for California even prior to the events of 2017. Under a project for the California Natural Resources Agency (as a contribution to the state's major Fourth Climate Change Assessment), RAND researchers closely analyzed the wildfire-related challenges facing the state insurance market under projected climate change (Dixon et al. 2018). They have estimated that annual acreage burned by wildfires in the California Sierra Nevada region (most of Nevada, Placer, and El Dorado counties) will quadruple this century under a business-as-usual emissions scenario. RAND has found that these areas are already facing higher premiums and rates of non-renewal than elsewhere in the state. Under anticipated business-as-usual climate changes in these areas by the end of this century, technical residential premiums are projected to increase 51% for the highest structure risk category and higher-risk geographies. Aggressive emission-reduction efforts could stabilize the rate of wildfire acreage burned by the mid-century, but not sooner.

While many factors influence insurer losses and profitability in any given year, homeowner insurer profitability in California is consistently influenced by wildfire losses and severity (Figure 9). The 2017 season was (to date) an extreme outlier with insurers paying out more than twice their premium income for the homeowner segment of the insurance market. While smaller (by acreage), the 1991 Oakland Hills Fire burned large, high-value residential areas.

## A mosaic of climate risks underpinned the 2017 California wildfires

The ways in which changes to environmental and extreme weather conditions, triggered by climate change, create a web of interconnected impacts relevant to insurance are illustrated by a mosaic of

factors preceding and following the catastrophic California wildfires of 2017 (Figure 10). Climate drivers leading up to the fires included heat, wind, and rain and lightning storms. While not directly involving people and property, intermediate ecosystem impacts during the period preceding the fires created abnormally large fuel loads, the causes of which ranged from extreme temperatures and drying followed by excess rainfall creating particularly tall, and flammable grasses to temperature-related explosions of pine beetle populations that killed off large swaths of forest. Notably, there are now an estimated 100 million dead trees across the state due to drought and beetles (Stephens et al. 2018), and reduction of vegetation in some areas that retains soil on steep slopes. The drought that begins this story is estimated to be the worst facing the state in 1,200 years (WHO 2014), followed by torrential rains and ignition of wildfires by lightning. The fires were compounded by above-average heat and winds. When subsequent deluges of rain followed shortly after fires in areas with steep slopes, mudslides occurred. Lastly, smoke from larger fires created an array of health risks over and above the immediate risks to health and life presented by fires and mudslides themselves. Each of the hazards, in turn, triggered various types of insurance claims. In time it will be seen whether further knock-on insurance costs materialize through liability claims being levied against electric utilities for not adequately maintaining their transmission system (which possibly contributed to some fire ignitions). Some utility executives have even suggested that the cause of the downed wires is climate change (Chediak 2018).

More was at play than the unfortunate sequencing of these hazards. Extraordinarily rare events took place almost simultaneously. The initial drought was record-breaking in several respects. The storm system that finally broke the drought was known by climatologists as an "Atmospheric River" (AR) generated through an intensive period of evaporation from the oceans. Atmospheric rivers can transport as much water as the Amazon River

**FIGURE 10** | A mosaic of factors preceded and followed the California wildfires of 2017.

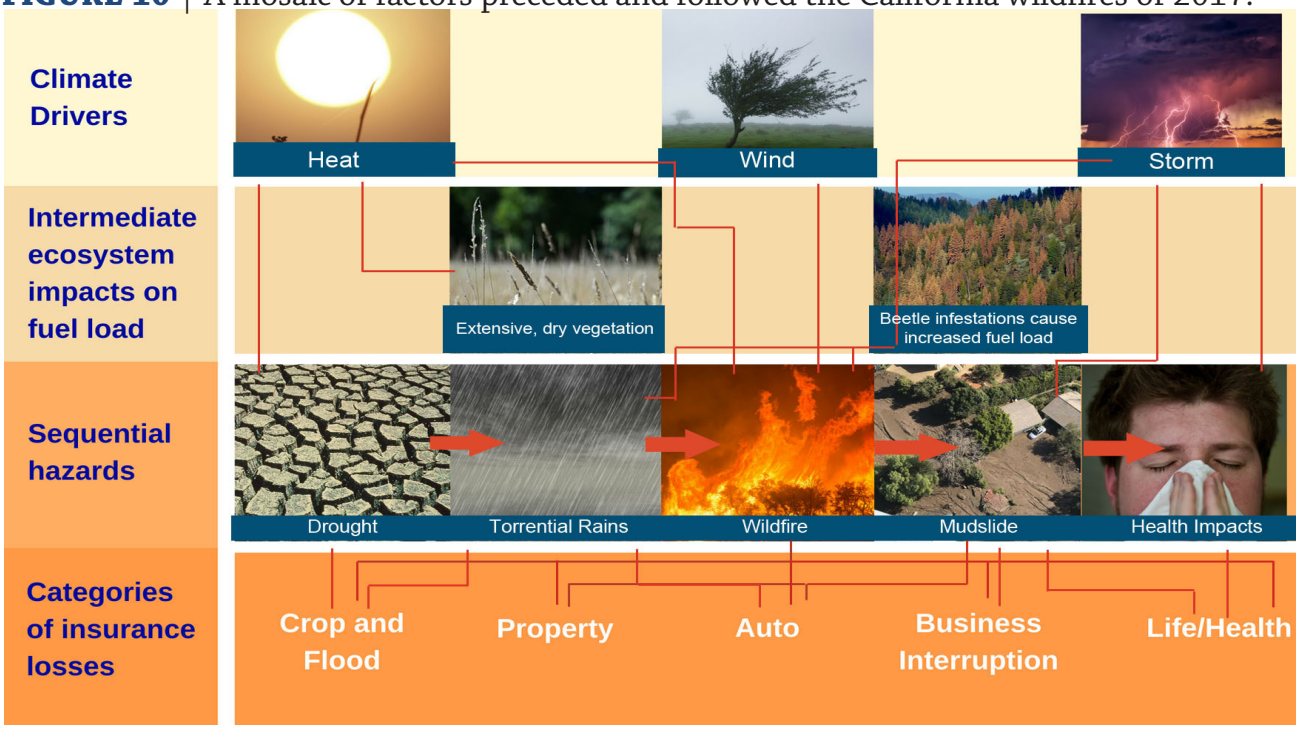
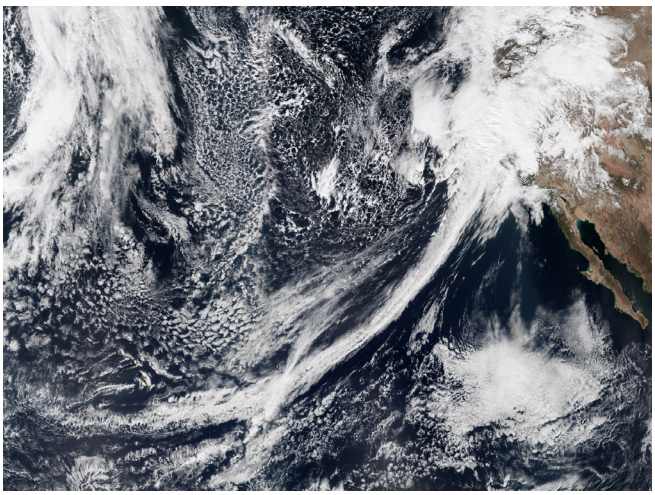



*Photo credits: Flickr (William Brawle, California National Guard, Mary Cernicek, Jenny Downing, Everglades NPS, Kari Greer), Unsplash (Mahkeo), Air National Guard (Sgt. Cristian Meyers), USGS (N. Stephenson), iStock.*

**FIGURE 11** | A 1-in-200-year Pineapple Express (atmospheric river) hit California in early 2018.



*Atmospheric rivers are relatively long, narrow regions in the atmosphere – like rivers in the sky – that transport most of the water vapor outside of the tropics. When an atmospheric river makes landfall, extreme precipitation and flooding can often result. The picture features a natural-color image of conditions over the northeastern Pacific of a similar storm to that hitting California in January 2018 which triggered highly destructive mudslides in Montecito, CA. The visualization was generated by Jesse Allen (NASA Earth Observatory) using data from the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi National Polar-orbiting Partnership (NPP) satellite. Source: NASA, used with permission.*

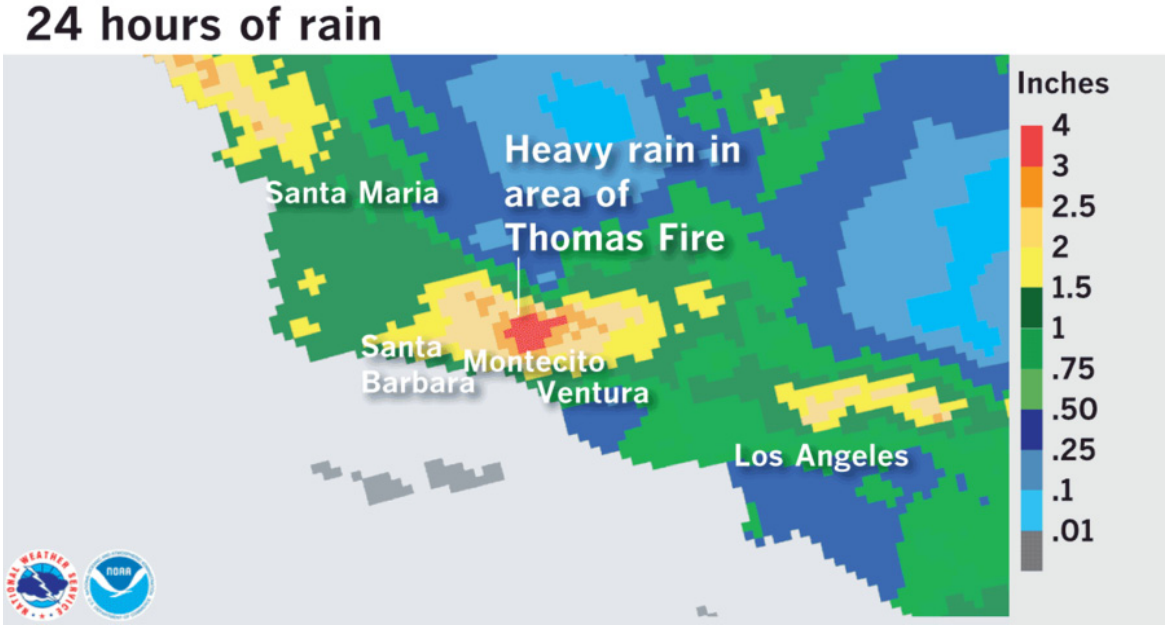
(USGCRP 2017). When they make landfall on the Pacific coast, such storms are more commonly called a Pineapple Express. The storm that brought massive rains to California in early 2018 (Figure 11) ended the drought (at least temporarily), but brought massive flooding, as parts of the state were stricken with as much rain in a single storm as they normally would receive in the preceding five-month period. This particular storm is said to have been a once-in-200-year event (Serna et al. 2018). Citing multiple prior peer-reviewed studies, the U.S. Global Change Research Program (USGCRP 2017) concluded that "studies have uniformly shown that ARs are likely to become more frequent and intense in the future," with increases of between 50% and six-fold in the number of days when ARs are present (Gao et al. 2015) and with high confidence that the frequency of these storms will increase.

The otherwise welcome precipitation resulted in increased fuel growth which dried as the following summer arrived and record-breaking temperatures set in. A variety of triggers both human and natural (such as lightning, itself expected to increase under climate change) triggered numerous fires across California (Mariani et al. 2018). Among these was the Thomas Fire in Ventura County, which burned for nearly six weeks, consumed more than a quarter of a million acres, and infamously became the largest fire in California recorded history.

A second Pineapple Express storm arrived shortly after the Thomas Fire had been extinguished, bringing as much as four inches of rain in a twenty-four-hour period. The storm made landfall directly on the epicenter of the affluent community of Montecito, California, immediately adjacent to the steep slopes where the Thomas Fire had burned (Figure 12). The fires laid to waste vast areas of steep terrain, which, by destabilizing the soils, set the stage for what are likely the worst mudflows and debris flows in California recorded history in terms of property damage and loss of life. Twelve-foot-deep flows also closed all six lanes of interstate Highway 101 for almost two weeks (Dolan 2018a).

These events resulted in abrupt loss of life, with 43 fatalities from the fires and 21 fatalities from the mudslides (Dolan 2018b). Experts compared the poor air quality during the 2017 wildfires to that in Beijing, vastly exceeding safety standards; in just one week of the California fires as much unhealthful particulate matter was lofted into the air as from a year of driving statewide (Santiago and Scutti 2017). No comprehensive information yet exists on long-term injuries or other health impacts. Previous large California wildfires have resulted in significant spikes in hospital admissions during wildfires (UC Irvine 2008). The fires in 2017 also affected healthcare services in many parts of the state, including hospital evacuations in some areas. The lone available detailed study focused on the 82,000-acre Detwiler fire in Mariposa County (CDPH and MCHD 2018), in which calls related

**FIGURE 12** | Epicenter of the January 2018 Pineapple Express storm in Montecito, CA, adjacent to the Thomas Fire burn area, with rainfall occurring in a 24-hour period.




*Source: NOAA/National Weather Service, used with permission.*

to respiratory conditions, anxiety, psychiatric emergency, and behavioral health were more frequent.

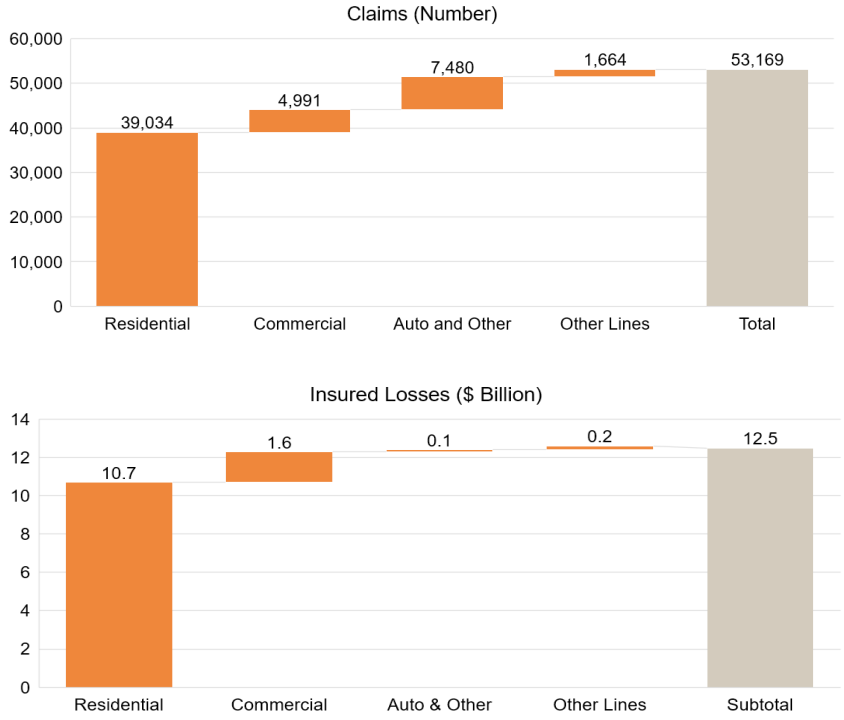
Taken together, the wildfires together with the massive mudslide and debris flow resulted in 56,000 insurance claims and $13.3 billion in losses, including 7,384 complete losses of insured structures, and 9,978 claims for vehicles and other miscellaneous damages.

Counting up the insured losses from the fires, $12.6 billion in claims were filed as of May 2018 (Figure 13 A-B). Over 39,000 insured homes were damaged, of which 6,885 were complete losses. About 5,000 insured non-residential buildings were damaged – of which 343 were complete losses – representing $1.6 billion in claims. In addition, claims for cars, boats, planes, and other miscellaneous equipment and structures amounted to about $350 million. In Santa Rosa alone, 3,000 homes (5% of the city's housing stock) were lost. To put these losses in perspective, cumulative underwriting profits to the homeowners insurance industry in California (Multiple Peril and Fire Lines) for the period of 2001-2017 were $4.1 billion (Dixon et al. 2018). An encouraging finding is that lower-emissions climate scenarios for California would materially reduce these kinds of impacts.

Mudslides are normally exempted from insurance coverage, but where the "efficient proximate cause" is an insured hazard (e.g., a wildfire), then the resulting losses are insured (CDI 2018). For the Montecito mudslide event, a total of 2,837 claims were made for a combined amount of $658 million as of May 2018 (Figure 14 A-B). As was the case for the fires, the majority of claims were for residences, but a remarkable 329 affected commercial properties were insured and filed $102 million in claims. About 144 homes were total losses, together with 12 commercial properties. There were over 750 personal automobile claims, with an insured loss of $8 million. An addition 80 miscellaneous claims amounted to $7 million.

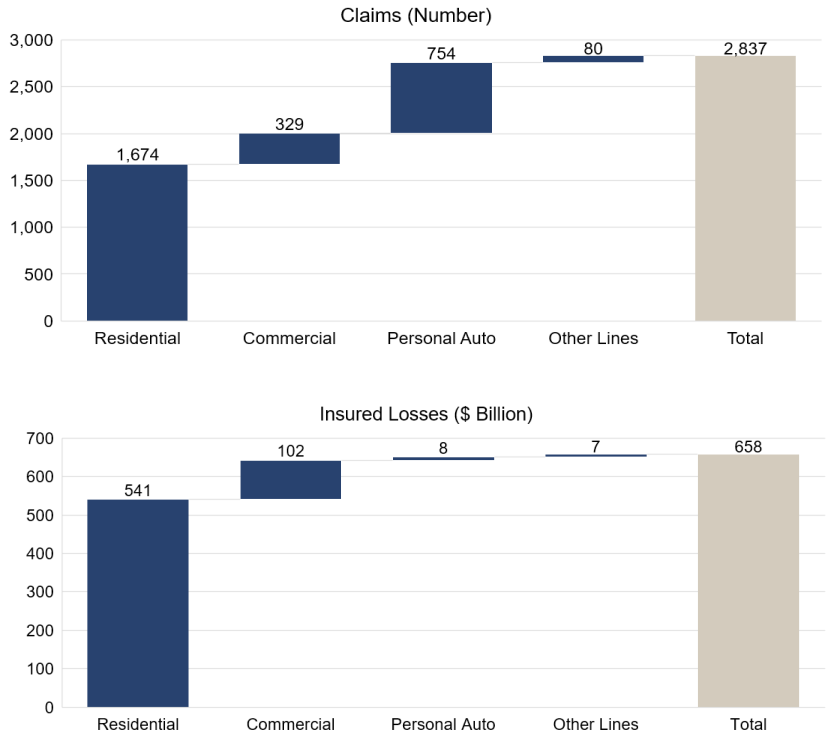
Certainly not all of the aforementioned fire- and mudslide-related losses are commercially

**FIGURE 13 A-B** | 2017 California wildfires: 53,000 insurance claims, amounting to $12.6 billion statewide.




*Source: CDI estimates as of May 21, 2018.*

**FIGURE 14 A-B** | 2017 mud and debris flow proximate to the Thomas fire: Nearly 2,900 insurance claims, amounting to $658 million in Montecito.

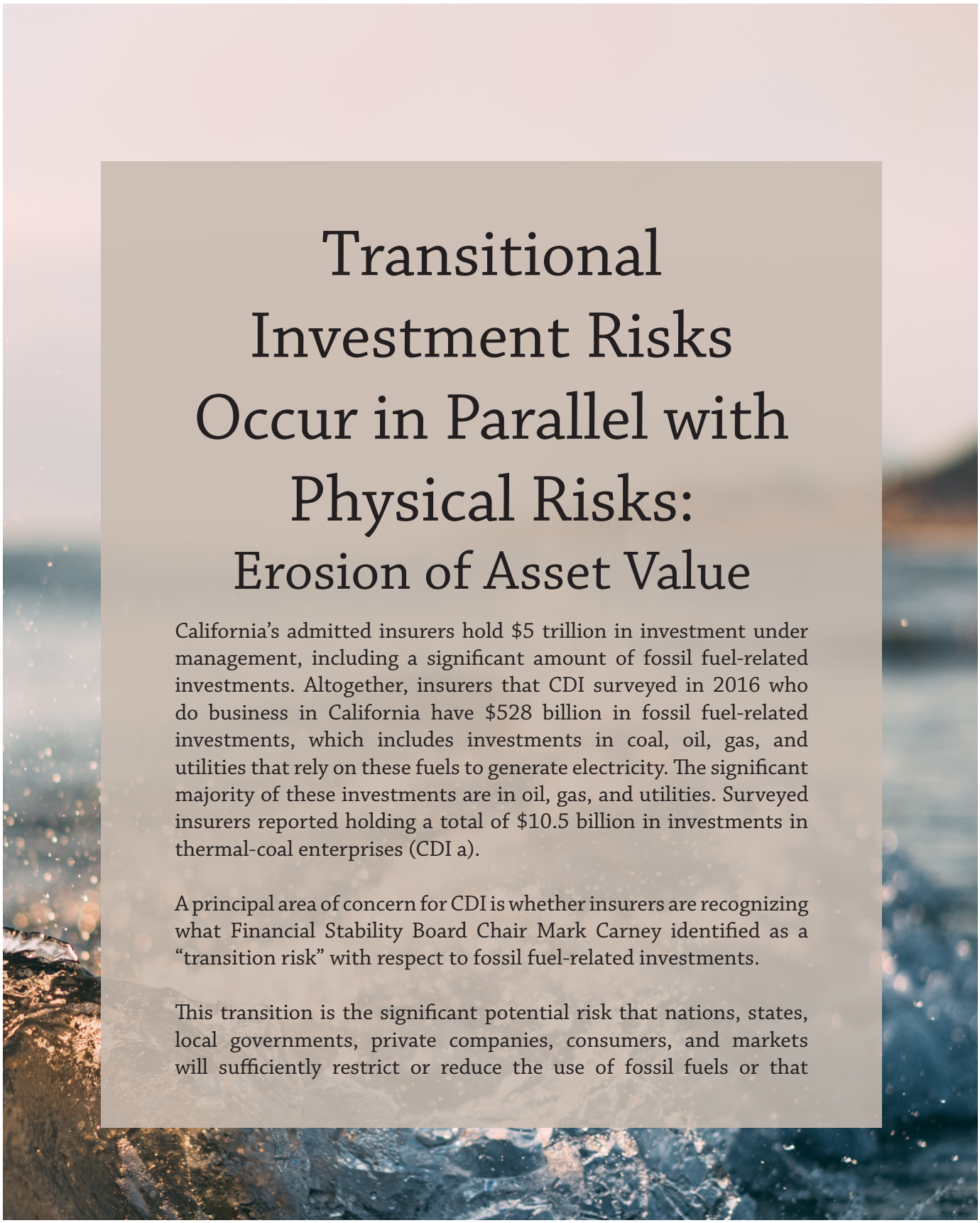



*Source: CDI estimates as of May 21, 2018.*

**FIGURE 15** | Oil wells at the foot of steep, eroding slopes at risk of future floods and mudflows, with recently burned vegetation in the drainage area.

*View across Amphitheater Canyon in San Miguelito Oil Field, with oil wells circled. Source: WERT 2018, used with permission.*

insured. Uninsured amounts include losses to homeowners and businesses lacking insurance, the deductibles and excess losses by those who are carrying insurance, damages to public facilities and infrastructure, publicly insured crop damages (at least 57 wineries in the state were affected [Hodgins 2017; Orlin and Steade 2017]), as well as firefighting and cleanup costs. The 2017 fires resulted in a total of more than 10,800 structures, a third of which were not insured (Tierney 2018). Among largely uninsured non-residential impacts were agricultural losses estimated at $189 million (Bloch 2018), and diverse damages to publicly owned (in some cases self-insured) infrastructure, together with response costs absorbed by public entities, and, ultimately the taxpayers. The county of Santa Barbara's initial estimate of their own costs was $55 million (Magnoli 2018). Other uninsured losses include $9 million to the City of Santa Barbara, $15 million in lost sales to businesses, and $25 to $30 million in lost wages due to transportation disruptions and reductions in tourism to this popular destination (RDN 2018). Clearing debris from Highway 101 cost the state $11 million (Aston 2018). Statewide firefighting costs topped $700 million (Cooper 2018), with those for the Thomas fire alone estimated at $177 million, and the U.S. Army Corps of Engineers spent $110 million on debris cleanup and removal following the Montecito mudslides (Rupert 2018). This complex cascading chain of losses may still be in process. Loss of groundcover and accumulation of debris in drainages increases the risks associated with future torrential rains. In-depth post event investigations have revealed significant oil production infrastructure (idle and active wells, pipelines, tanks, and processing facilities) within and near the fire and mudflow zones, which will be in harm's way if additional sloping areas succumb to future mudslides (Figure 15). The Watershed Emergency Response Team (WERT) report identified and classified 63 specific pieces of oil infrastructure in and around the Thomas Fire zone as vulnerable (WERT 2018). Such events would risk not only the loss of valuable infrastructure, and downslope residential and commercial structures, but also releases of flammable and otherwise hazardous oil onto the landscape and perhaps into the adjacent Pacific Ocean.



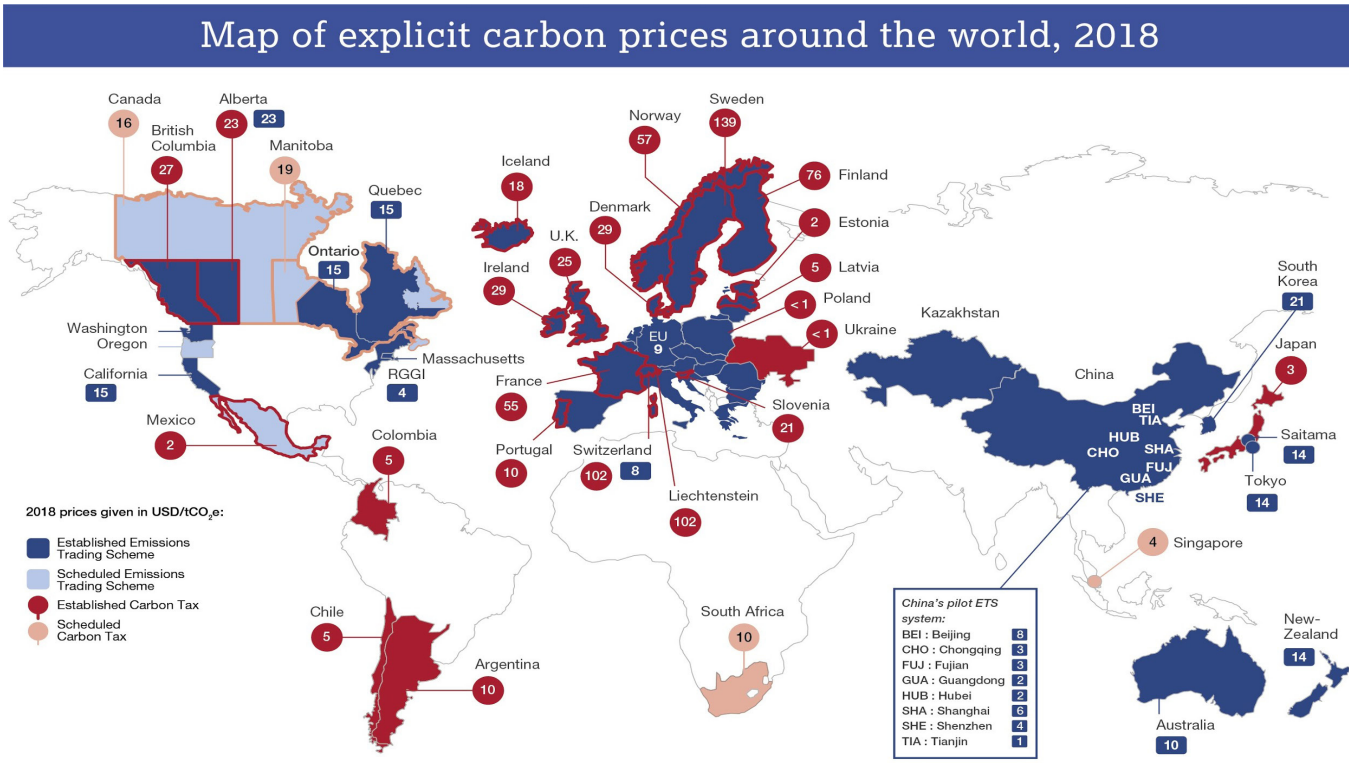
# Transitional Investment Risks Occur in Parallel with Physical Risks:
## Erosion of Asset Value

California's admitted insurers hold $5 trillion in investment under management, including a significant amount of fossil fuel-related investments. Altogether, insurers that CDI surveyed in 2016 who do business in California have $528 billion in fossil fuel-related investments, which includes investments in coal, oil, gas, and utilities that rely on these fuels to generate electricity. The significant majority of these investments are in oil, gas, and utilities. Surveyed insurers reported holding a total of $10.5 billion in investments in thermal-coal enterprises (CDI a).

A principal area of concern for CDI is whether insurers are recognizing what Financial Stability Board Chair Mark Carney identified as a "transition risk" with respect to fossil fuel-related investments.

This transition is the significant potential risk that nations, states, local governments, private companies, consumers, and markets will sufficiently restrict or reduce the use of fossil fuels or that

**FIGURE 16** | Growing number of cap-and-trade systems for greenhouse-gas emissions and carbon taxes.




*Source: I4CE – Institute for Climate Economics with data from ICAP, World Bank, government officials, and public information, used with permission.*

market forces alone will devalue these companies, which in turn presents a risk to linked insurer investments. Commissioner Jones believes that financial institutions, including insurance companies, should recognize and address potentially significant climate-related risks facing their investments in these vulnerable industries.

Significant national, state, and local government efforts are pushing a transition to a low-carbon-intensive economy. This effort includes the various commitments made by nearly all national governments as a part of the United Nations COP 21 Agreement and state and local commitments made in association with COP 21. It has been projected that in order for countries to meet the COP 21 targets for not exceeding a two degrees Celsius temperature rise, more than 80% of coal reserves, a third of oil reserves, and half of gas reserves cannot be used between 2010 and 2050 (McGlade and Ekins 2015).

Some ways that these entities are seeking to reach the COP 21 targets or achieve related objectives include the following, all of which reduce the demand for fossil fuels:

- Developing cap-and-trade systems, such as the European Union's Emission Trading System and California's cap-and-trade system which was recently renewed until 2030 (Assembly Bill 398 [E. Garcia, Chapter 135, Statutes of 2017]), and carbon taxes.

- Implementing clean air laws and regulations that have the effect of reducing the ability

> *"[Transition risks are] the financial risks which could result from the process of adjustment towards a lower-carbon economy. Changes in policy, technology and physical risks could prompt a reassessment of the value of a large range of assets as costs and opportunities become apparent."*
>
> Bank of England Governor Mark Carney
> Remarks, Lloyd's of London, September 29, 2015.

to burn carbon (e.g., the Clean Power Plan, which is now being reviewed by the U.S. Environmental Protection Agency (EPA), and the California Global Warming Solutions Act of 2006).

- Requiring utilities to rely less on carbon-based and more on renewable sources, such as California's renewable portfolio standard that requires utilities to derive 50% of their energy from renewables by 2030 (Senate Bill 350 [De Leon, Chapter 547, Statutes of 2015]).

- Building smart grid energy technologies that allow for further incorporation of intermittent renewable energy sources (e.g., the Energy Independence and Security Act of 2007, P.L. 110-140).

- Advancing voluntary and mandatory energy efficiency initiatives, such as increasing auto emissions and fuel efficiency standards to reduce demand for fossil fuels and even restricting the sale of vehicles with solely combustible engines.

Even without government efforts aimed at curbing carbon emissions or otherwise limiting the use of fossil fuels, the decreasing cost of renewable energy threatens the value of carbon investments. Renewable energy has become more competitive, with solar costs dropping 85% from 2008 to 2016 (Houser et al. 2018) and wind costs falling 36% in that same period (ClimateNexus 2017). Solar is already at least as cheap as coal

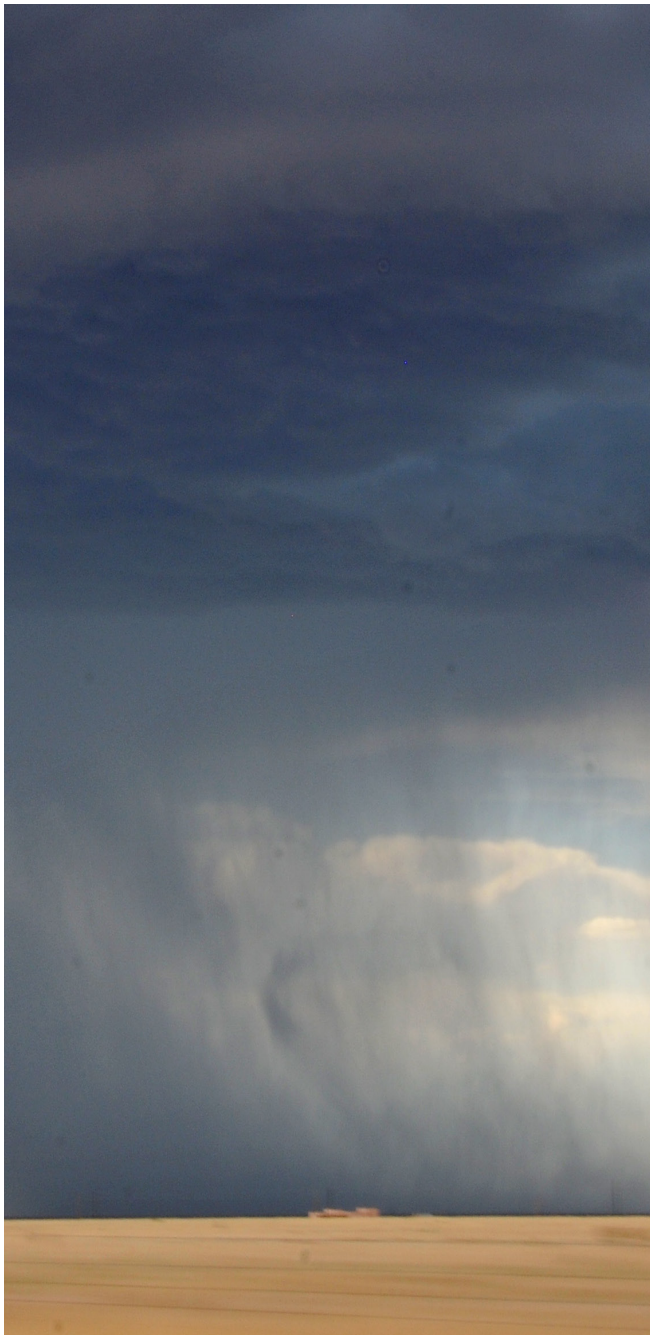


**Figure 17** | U.S. consumers waited in line for hours, some spending the night so that they could make a deposit on an electric vehicle.

*Source: Licensed from AP.*

in the United States, Germany, Australia, Spain, and Italy, and is expected to drop another 66% by 2040. By 2021, solar is projected to be cheaper than coal in China, India, Mexico, the U.K., and Brazil as well. The cost is expected to continue to decline as technology improves (BNEF 2017).

Consumer energy demand trends are also further motivating a transition to a low-carbon-intensity economy. Energy efficiency improvements between 2000 and 2016 reduced global coal consumption by an amount equivalent to all coal use in the United States (IEA 2017a), or about one-fifth of global coal use. While absolute numbers are still small, global sales of electric vehicles grew by 40% in 2016 (IEA 2017b). When Tesla made it possible to order an economy version of their electric vehicle, U.S. consumers lined up for hours, some spending the night in line (Figure 17) to be among the first to pay a deposit to purchase such a vehicle a year or more in the future (McFarland 2016). Recently, large car manufacturers have also announced their intention to accelerate the transition away from vehicles with solely combustible engines to vehicles with electric motors. For instance, Volvo announced that electric motors will be included in all cars that the manufacturer makes from 2019 moving forward (Pham 2017).

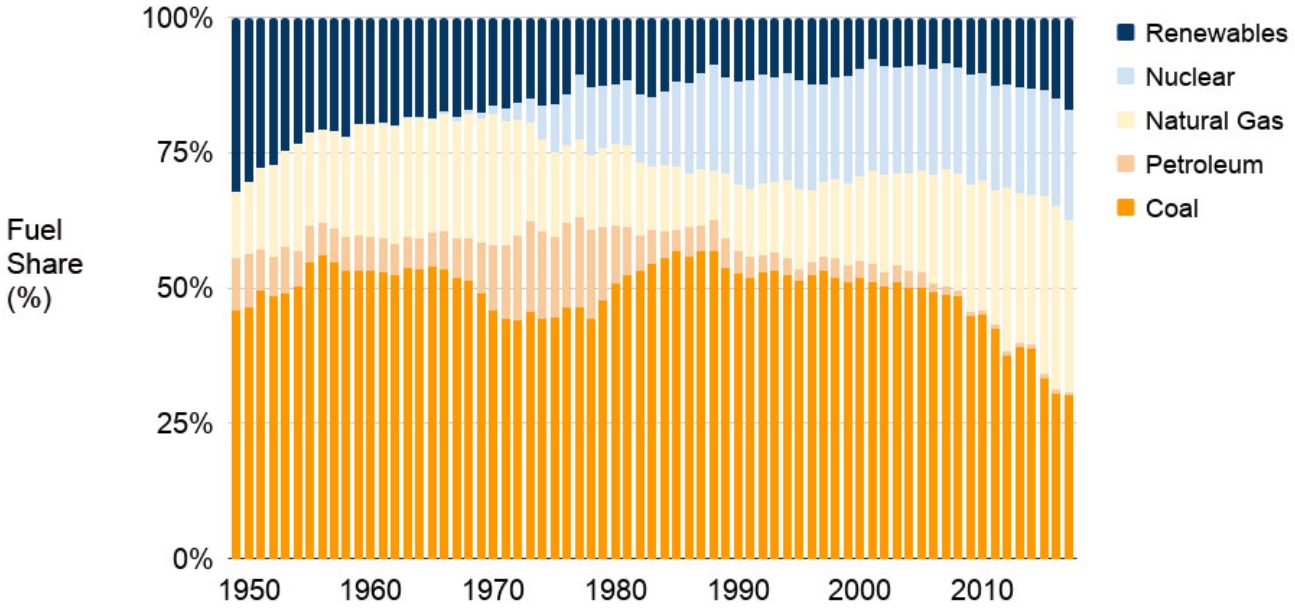
Coal industry losses are already a reality. Over the last decade, demand for coal has dropped dramatically. Coal has gone from generating nearly half of U.S. electricity to approximately 30%, a share that continues to decline (Figure 18). This downturn in demand has directly affected companies mining and selling coal. Three dozen U.S. coal companies went bankrupt in three years (SNL 2015). Utilities in the United States are shutting down thermal coal power plants before the end of their economic lifetimes, and none are building any new ones (although the current presidential administration has sought to reverse this trend through emergency orders). Major

banks have ceased or otherwise reduced lending to fund new coal infrastructure (e.g., Citigroup, Bank of America, Wells Fargo & Company, and Morgan Stanley) (Nussbaum 2015). Global insurers such as AXA, Allianz, Aegon, and Swiss Re announced that they are divesting or not making new investments in thermal coal (Ferguson 2017; Insurance Journal 2018). After the California State Teachers Retirement System and the California Public Employees' Retirement System, the largest pension funds in terms of assets in the United States, lost a combined $5.1 billion in oil, gas, and coal investments in 2014-2015 (Trillium 2015), the state Legislature directed them to consider divesting from thermal coal. Moreover, while there have been some recent short-term gains, the Dow Jones U.S. Coal Index decreased 92.9% from April 1, 2011 through June 20, 2017. These and other developments create risk that investments in coal and other fossil fuels may become "stranded assets" of diminishing value. It has been argued that life and annuity insurers have the largest exposures, given their "buy-and-hold" philosophies (Messervy and McHale 2016).

Some insurers have ceased to write policies for companies whose profits depend on coal. Allianz plans to no longer underwrite individual coal-fired power plants or coal mines, and plans to phase out all underwriting to coal interests by 2040 (Jergler 2018). The reinsurer Swiss Re no longer underwrites mining companies that derive more than 30% of revenues from thermal coal or utilities that generate 30% of their electricity from thermal coal (Insurance Journal 2018).

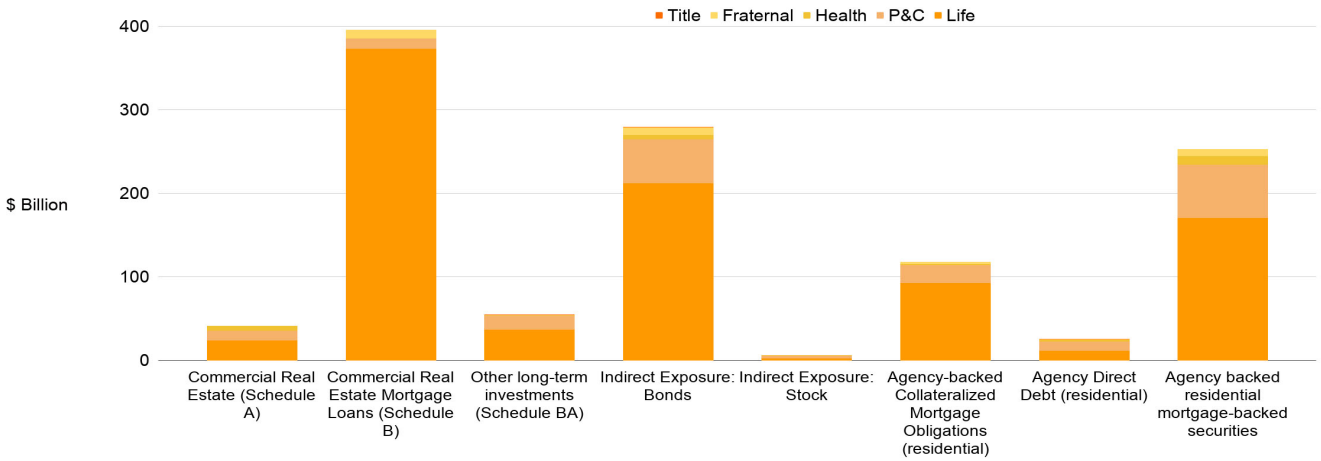
Also among insurer assets are $1.2 trillion in direct and indirect real estate investments (Figure 19) that could be vulnerable to the impacts of climate change. Life insurers hold about 80% of these investments. Uninsured hazard peril in residential mortgage-backed securities (22% of total real estate investments) could exemplify a systemic risk in the event of large real-estate losses (e.g., due to wildfire) in underinsured markets with corresponding investments owned by insurers.

**FIGURE 18** | Decreasing use of coal by U.S. electric utilities from one-half to one-third of total.




*Source: Data from USEIA (2018).*

**FIGURE 19** | U.S. insurer real-estate-related investment exposures.




*Commercial values as of 2015; residential values as of 2014. Source: NAIC (2017) and NAIC (2015).*

For all these reasons, it is important for insurance companies, insurance regulators, and the public to better understand the scope of insurer investments in fossil fuels and the scope of their associated transition risk.

## Insurance regulators have pioneered a diversity of effective strategies to evaluate transition risks

Following Hurricane Katrina in 2005, U.S. insurance regulators began to look more seriously at climate risks. In 2008, the NAIC developed a white paper entitled "The Potential Impact of Climate Change and Insurance Regulation" (NAIC 2008). This paper initiated a set of meetings and initiatives on the topic. Foremost among the follow-up activities was the development of a national climate change and risk disclosure efforts. In particular, it developed the original Insurer Climate Risk Disclosure Survey (NAIC survey), adopted in 2010.

A major cornerstone of CDI's efforts has been working to ensure transparency. CDI championed NAIC's development of the NAIC survey, modeled after a voluntary questionnaire that CDP, a non-profit organization comprised of the world's largest institutional investors, prepared and distributed globally to all industries. The NAIC survey consists of eight questions regarding insurance companies' responses to climate change, covering topics such as investment, mitigation, financial solvency, carbon footprint measurements, and consumer engagement. CDI, along with insurance regulators in New York, New Mexico, Connecticut, Minnesota, and Washington, has collaborated in administering the survey to insurers licensed in each of their states with over $100 million in annual premiums nationally. In 2016, the survey was sent to nearly 1,000 insurance companies whose combined premiums account for more than 70% of the total premium written in the U.S. insurance market. CDI posts survey responses on its survey web page which remains one of the world's most extensive datasets documenting how financial institutions are addressing climate risks (CDI b).

In-depth review of a large subset of these responses found improvement in disclosure practices compared to prior response cycles, yet the majority of respondents show "an overall lack of focus in addressing climate risks and related opportunities" (Messervy and McHale 2016).

*"Increasing transparency makes markets more efficient, and economies more stable and resilient."*

Michael Bloomberg

Final Report, Task Force on Climate-related Financial Disclosures, 2017

Only 16% of the respondents received "High Quality" ratings, while two-thirds received "Low Quality" or "Minimal" ratings. Quality responses were dominated by property and casualty insurers, with health insurers lagging noticeably. No health insurer earned a "High Quality" rating, with 89% earning "Low Quality" ratings. Based on survey responses, a principal area of concern for CDI is whether insurers are recognizing the significant potential risk that nations, states, local governments, private companies, consumers, and markets will further restrict or reduce use of fossil fuels, which in turn presents a risk to the value of oil, gas, coal, and utility investments.

CDI believes that insurers should recognize and address potentially significant climate-related risks facing their investments in coal, oil, gas, and utilities. In light of this concern, CDI launched the Climate Risk Carbon Initiative in 2016, with the aim of more deeply addressing the climate-related transition risk to insurer investments in these areas. When launched, this Initiative had two components: the Thermal Coal Divestment Request and the Fossil Fuel database.

Using metrics similar to those employed internally by AXA and Allianz, Commissioner Jones asked all insurers doing business in California to consider divesting from thermal coal investments, defined as investments in companies that generate 30% or more of their revenue from ownership, exploration, mining or refining of thermal coal, and from utilities that generate 30% or more of the energy they produce using thermal coal. "Thermal coal" was defined as lignite, bituminous coal with an ash percentage greater than 35%, as well as anthracite.

CDI collected information from insurers operating in California to document what insurers have already done to divest from fossil fuels and whether they planned to further divest of thermal coal holdings and refrain from making future investments. CDI learned that around 200 surveyed insurers doing business in California had already divested $4.1 billion dollars of fossil fuel investments by mid-2016. Sixty-seven insurers further pledged to divest from thermal coal which altogether would account for $944 million worth of coal divestment at the time pledged. Moreover,

> *"[A]ll organizations exposed to climate-related risks should consider (1) using scenario analysis to help inform their strategic and financial planning processes and (2) disclosing how resilient their strategies are to a range of plausible climate-related scenarios."*
>
> Task Force on Climate-related Financial Disclosures (2017)

325 insurers also pledged to refrain from making future investments in thermal coal (Figure 20).[2]

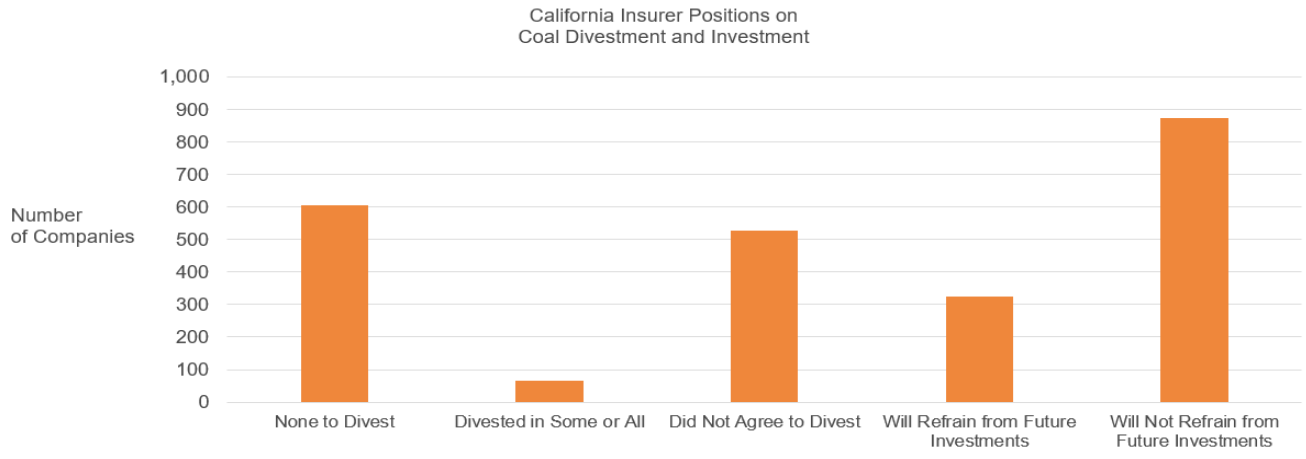
CDI also collected information on current fossil fuel holdings for insurers operating in California and the CDI website displays the coal, oil, gas, and power-generating utility investments. Using metrics similar to the threshold approach of the divestment request, CDI defined oil and gas investments as direct investments in enterprises that generate 50% or more of their revenues from oil and gas. Investments into utilities included investments that generate 30% or more of their electricity from thermal coal or utilities that generate 50% or more of their electricity from mixed fossil fuels, which included thermal coal, oil, and natural gas. As a reporting threshold, CDI used the amount of annual revenue a fossil fuel enterprise derived by fossil fuel type (revenue threshold) and the fossil fuel type used by energy utility companies to generate their electricity (power generation threshold). This ensured the use of practical metrics to measure and manage climate-related risks, and revenue-based thresholds as a consistent measurable basis to identify fossil fuel investments. Disclosed data was cross checked for accuracy and results were posted on a searchable database which, as with the NAIC survey database, is one of the world's most extensive data sets of its kind.

In 2018, CDI updated its methodology for evaluating fossil fuel investments by incorporating the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD). In particular, CDI has incorporated scenario analysis into its efforts.

CDI partnered with 2 Degrees Investing Initiative (2Dii) to conduct a scenario analysis on the investments of insurers operating in California

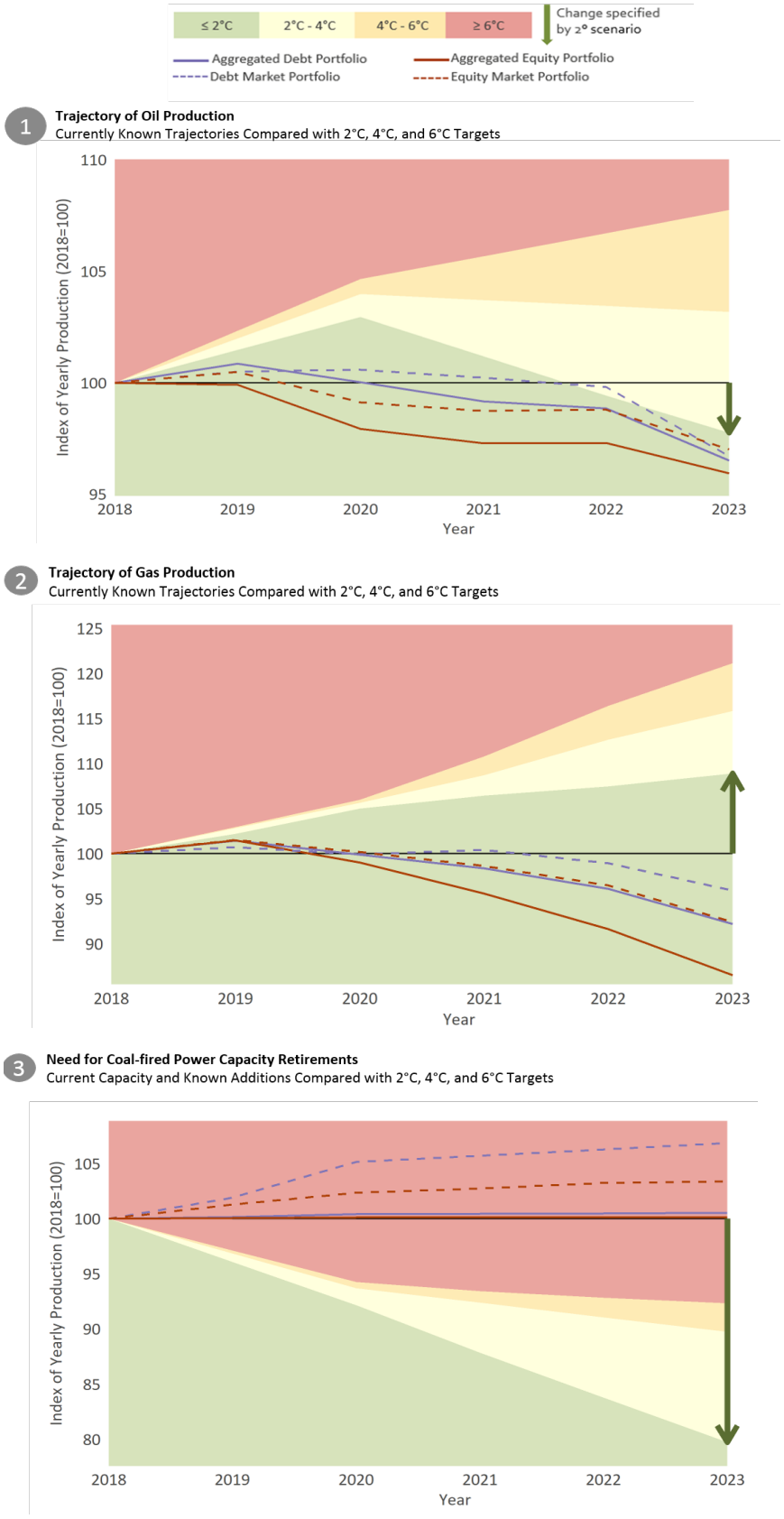
2. Other efforts along these lines globally are tracked at https://unfriendcoal.com/scorecard/.

**FIGURE 20** | Sixty-six insurers agreed to divest from thermal coal and 325 to refrain from future investment.




*Source: CDI.*

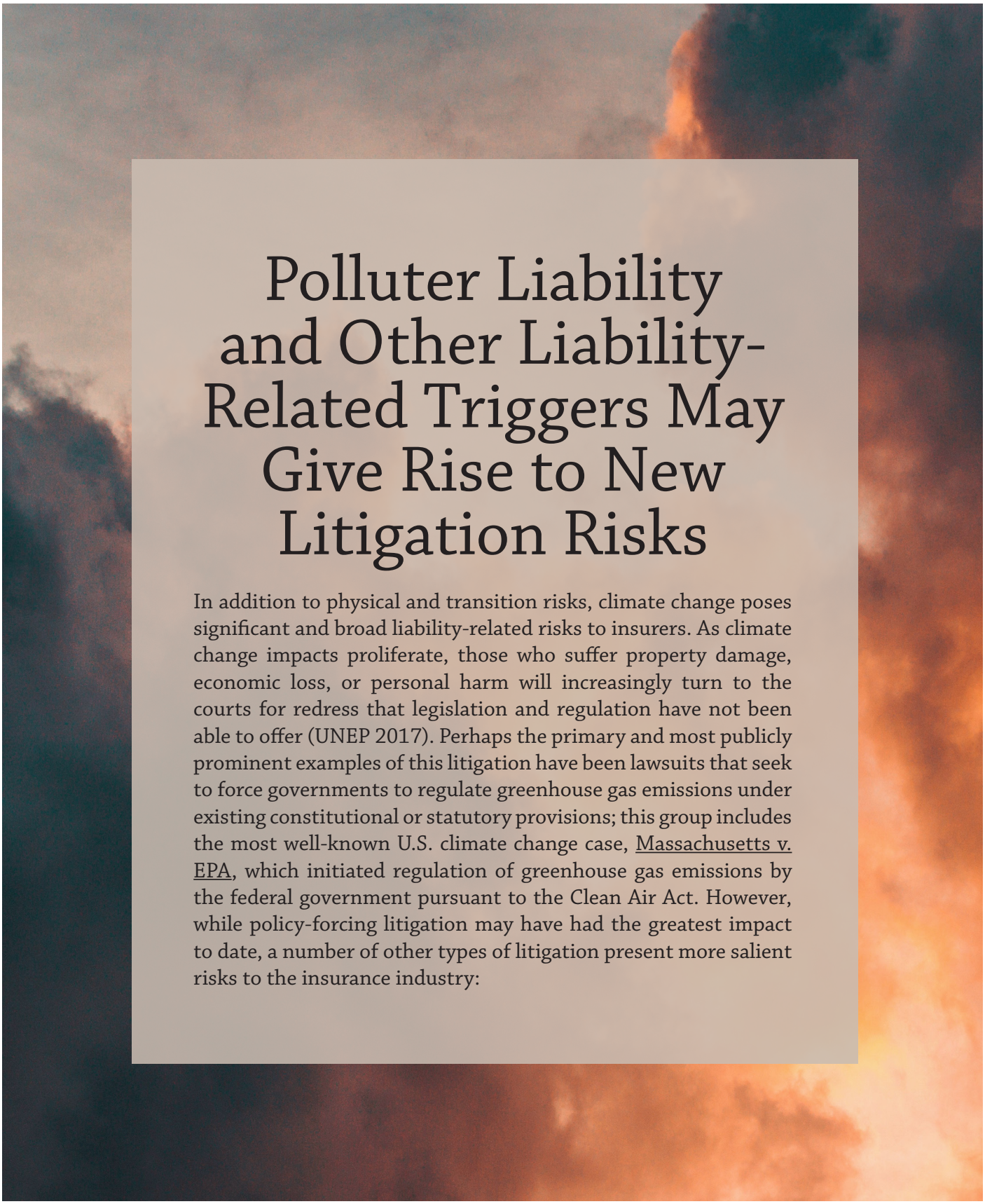
**FIGURE 21** | Forward-looking carbon intensity index of aggregate fossil-fuel investments for insurers operating in California with over 100 million in annual premiums.




*Left: Colored shadings indicate forward-looking trends in economy-wide carbon intensity needed to cap global temperature increases at various thresholds (per IEA scenarios), while the curves show actual trends for the debt and equity market portfolios held by insurers operating in California with over $100 million in annual premiums. 1. Oil. 2. Natural gas. 3. Locked-in coal capacity by utilities (excluding capacity forecasts). Solid lines represent aggregate portfolios of insurers operating in California; dotted lines represent broader market benchmarks. Source: CDI, 2Dii analysis, used with permission.*

with over $100 million in premiums nationally. CDI and 2Dii recently released aggregate findings which CDI posted on its website and have been shared at United Nations Principles for Sustainable Insurance (PSI) and Sustainable Insurance Forum (SIF) conferences. Of note, the aggregate data shows that in order for investments in utilities to be aligned with a scenario in which the global temperature does not exceed a two degrees Celsius increase from the baseline, there is significant need for coal-fired power plant retirements (Figure 21). This affirms the importance of the Commissioner Jones' request for divestment from thermal coal as further coal-fired power plant retirements would further decrease demand for thermal coal. The aggregate data also shows that the trajectory for oil and gas production investments is currently aligned with a two degrees scenario over the next five years (Figure 21), but not every insurer analyzed is necessarily aligned and some may face greater exposure to transition risks compared to their peers. Assumptions underlying the International Energy Agency results used to generate these scenarios will evolve with energy prices and other factors. Thus, exposure to transition risk will vary over time and such analyses should continue to be performed.

Commissioner Jones sent individual reports to the CEOs of the 100 analyzed insurers with the largest investment portfolios and analyzed insurers that are most exposed to thermal coal risk. The reports were accompanied by a letter from Commissioner Jones asking CEOs to incorporate scenario analysis into their decision making about investments. CDI expects insurers to use the forward-looking scenario analysis to evaluate and address the climate-related financial risks to their reserves and investments, including especially those risks to investments in fossil fuels and utilities. CDI also expects insurers to probe investments in other ways that they may find useful, such as running further scenario analyses with varying metrics and benchmarks. To this end, CDI participated in United Nations-supported Principles for Responsible Investment (PRI) events where PRI launched their and 2Dii's dynamic scenario analysis tool, which was created as an adaptation of the tool used for the CDI analysis.



# Polluter Liability and Other Liability-Related Triggers May Give Rise to New Litigation Risks

In addition to physical and transition risks, climate change poses significant and broad liability-related risks to insurers. As climate change impacts proliferate, those who suffer property damage, economic loss, or personal harm will increasingly turn to the courts for redress that legislation and regulation have not been able to offer (UNEP 2017). Perhaps the primary and most publicly prominent examples of this litigation have been lawsuits that seek to force governments to regulate greenhouse gas emissions under existing constitutional or statutory provisions; this group includes the most well-known U.S. climate change case, Massachusetts v. EPA, which initiated regulation of greenhouse gas emissions by the federal government pursuant to the Clean Air Act. However, while policy-forcing litigation may have had the greatest impact to date, a number of other types of litigation present more salient risks to the insurance industry:

*"Identifying the human influence in events once known as 'acts of God' is likely to inform litigation relating to claims and liability for damages.... [F]oreseeability of damage is an important requirement to establish a duty of care in many legal systems."*

Marjanac et al. (2017)

- **Damages and tort suits.** Individuals and local governments in the United States have sued fossil fuel companies, electricity generators, and automobile manufacturers seeking compensation for the damages caused by climate change-induced sea-level rise, extreme storms, and more that are linked to emissions they generate.

- **Utilities**. California's devastating 2017 wildfire season, which included major fires that are believed to potentially have been sparked by electrical utility infrastructure, has raised the specter of significant liability for the state's utilities as climate change exacerbates annual wildfire risks. Senate Bill 1088 (Dodd 2018) has been proposed to insulate utilities that follow certain standards, among a number of other bills seeking to protect utility viability in the future.

- **Directors and Officers.** Shareholder activism on climate change has increased significantly in recent years, with dozens of shareholder resolutions in 2018 alone pressing fossil fuel companies and electric utilities to disclose risk assessments and transition to cleaner energy sources (Hasemyer 2018) and over 20 Securities and Exchange Commission filings or other complaints (including suits initiated by the Massachusetts and New York attorneys general) in the past 10 years relating to climate disclosure (CLSSC). As these shareholder actions develop they may entail liabilities that are covered by directors and officers policies.

- **Professionals.** In common-law countries like the United States, professionals such as engineers and planners owe heightened legal duties to those who use, benefit from, or reasonably expect protection from their work. As climate change impacts threaten the viability and safety of construction designs and urban plans, these professionals may be held responsible for resulting personal or property damage if it can be shown that their designs were negligent in light of increasing scientific certainty about where and when those impacts will occur (Ross et al. 2007).

- **New mitigation and geoengineering and climate engineering technologies.** If mitigation becomes more difficult to achieve via standard emission reduction methods, companies and governments may turn increasingly to techniques such as atmospheric carbon removal and solar radiation interference. Employing these strategies on the global scale necessary to achieve the intended effect could result in significant liability if unintended consequences occur (Mills 2012a).

While damages and tort litigation, which are discussed in detail later in this section, have received substantial attention in California and may threaten the greatest potential losses, lawsuits implicating a heightened duty of care or legal obligation to consumers or the general public – such as those of corporate directors and officers, licensed professionals, and electrical utilities – are most likely to result in near-term liability that is or may be covered by existing policies. Directors

and officers liability presents perhaps the most widely discussed and potentially disruptive litigation risk for the insurance industry. Insurers and commentators have warned for over a decade that shareholders could initiate derivative actions and other major lawsuits if climate change-related incidents harm stock values and were not previously disclosed (Roberts 2006). Such suits have not developed in the intervening years, and climate change risk disclosure has increased significantly, but experts and some insurers still anticipate that shareholders will seek redress against directors and officers for climate impacts to profitability that were inadequately disclosed – and believe that these suits would be covered by directors and officers policies (Messervy et al. 2014; Greenwald 2017). Similarly, a leading legal opinion in Australia, a fellow common-law country, has found that corporate directors may be required to consider climate change risks as part of their duties of care and diligence in the future (Hutley and Hartford-Davis 2016). While the opinion does not have the effect of law or court precedent, legal experts view it as a potential indication of how liability standards may evolve due to the author's expertise and status as a Senior Counsel of the Australian Bar (Barker 2018). However, respondents to the 2016 NAIC survey, when asked whether their companies have considered potential climate change exposure through directors and officers policies, almost uniformly did not identify these policies as potential sources of risk.[3]

Nonetheless, industry actors have begun to encourage proactive measures around corporate climate-related responsibility and disclosure that may address shareholder concerns and limit exposure under directors and officers policies. Some insurers have publicly adopted the recommendations of the G-20 Financial Stability

Board (FSB)'s industry-led TCFD (Swiss Re 2016; SIF 2017). The FSB was established in the wake of the 2007-2008 financial crises in order to prevent future instability to the financial sector. The FSB has determined climate change to be a risk that threatens the global financial sector. The TCFD was established to develop recommendations for the financial sector and all economic sectors with regard to disclosing and addressing climate-related financial risks. The recommendations include disclosure of risk management measures, corporate metrics and targets used to measure climate change-related risks and opportunities, actual and potential impacts on operations and strategy, and governance and oversight (TCFD 2017). Such disclosure could satisfy board obligations to shareholders under existing securities regulatory regimes, but the nature and extent of those obligations are still unclear (Gelles 2016).

These issues are still in the earliest stages of development and have not been tried in court. As a result, it is nearly impossible to predict how they may be resolved and what the impact of that resolution may be on insurers. A threshold issue, yet to be tested in court, is whether pollution exclusions – originally introduced to cover traditional soil and water contamination by toxic and hazardous substances – will apply to

3. Survey results are available at http://www.insurance.ca.gov/0250-insurers/0300-insurers/0100-applications/ClimateSurvey/.

greenhouse gas emissions, which are classified as a pollutant under the Clean Air Act (Marsh 2016). Further development of attribution science, which is already highly robust but relatively untested in the legal sphere, will be necessary for the development of causal links adequate to support liability, whether in the tort, professional, or shareholder context (Marjanac and Patton 2018). Where the defendants are licensed professionals or corporate officers with distinct duties of care under existing law, and plaintiffs sue over not emissions generated but the failure to account for or disclose known climate risks in violation of these duties, such barriers to establishing liability could be far less significant. But climate change is clearly driving a new crop of litigation risks that insurers will be forced to confront in the near future.

## Climate change litigation is growing but has focused on regulation and mitigation policies

According to most comprehensive estimates, nearly 1,000 climate change-related claims have been brought in the United States, including claims under federal statutory law, federal constitutional law, state statutory and common law, public trust doctrine, securities regulations and more (CLSSC). According to United Nations estimates, over 230 cases have been filed in an additional 24 countries and the European Union (UNEP 2017). Of these, many have been brought in fellow common-law countries: over 100 in Australia and New Zealand, nearly 50 in the United Kingdom, and at least 10 in Canada.

While the total number of lawsuits involving climate change-related claims is quite high, only a small subset are immediately relevant in the insurance context. Most climate change cases are filed against state and national governments and focus on mitigation and adaptation policies (UNEP 2017). For example, Massachusetts v. EPA, which involved claims against the federal government seeking regulation of greenhouse gases under the Clean Air Act, ultimately prompted statutory compliance but not legal liability for emissions. In some countries, plaintiffs have begun to challenge federal constitutional provisions, project approvals and lease sales related to resource extraction on the basis of harm to the climate. But to date, no court has yet issued a clear decision in plaintiffs' favor in these cases (UNEP 2017). Governments could also be held liable for wetland and waterway management actions that may exacerbate flooding and other climate change-related impacts, as has been unsuccessfully alleged in St. Bernard Parish Government v. United States (2018) and In re Katrina Canal Breaches Litigation (2015); or for failure to regulate emissions so as to internalize their negative externalities, such as the public trust doctrine claims made in the current case of Juliana v. United States; but no such claim has yet been successful (Van Calster 2016). Within the relatively small number of cases seeking to impose liability on private actors and entities, only a subset of those will result in claims under existing insurance policies, while others may be expressly excluded or may be brought against self-insured entities. Nonetheless, this growing field of litigation will present an increasing threat as the range of defendants and legal theories employed grows.

## Climate change tort litigation threatens insurers' balance sheets

Litigation based on the impacts of climate change poses multiple risks to insurers. In particular, lawsuits seeking to impose damages on fossil fuel companies and major greenhouse gas emitters for sea-level rise, flood, wildfire, extreme weather, and other events could result in hundreds of billions

of dollars in liabilities. For example, in their 2017 nuisance and trespass claims filed against five top fossil fuel producers, the cities of San Francisco and Oakland estimate potential real property losses due to sea-level rise of approximately $50 billion and $40 billion respectively, along with billions of dollars in seawall improvements, hundreds of millions in infrastructure upgrades and protection, and other significant costs for which they seek recovery (People of the State of California v. BP p.l.c). Any entities found liable in such litigation could face catastrophic losses that could materially affect any insurance company investments. Entities defending against such litigation could invoke existing commercial general liability policies or advocate for litigation-specific policies to insulate themselves from liability (Davis and Paul 2017). While the largest fossil fuel companies (which are the primary defendants in current cases) may be largely self-insured, smaller companies without the capacity to self-insure, and entities in other industries, could be equally vulnerable to the development of liability for emissions, with the same risk of major losses implicating insurance policies. Moreover, insurers' duty to defend under existing policies – broader than the duty to indemnify – may be implicated long before liability for emissions or a failure to meet a professional or corporate duty of care is firmly established, with many suits likely to involve multiple defendants and competing cross-claims, long timelines and counsel lists, and attendant costs (similar, for example, to Superfund litigation).

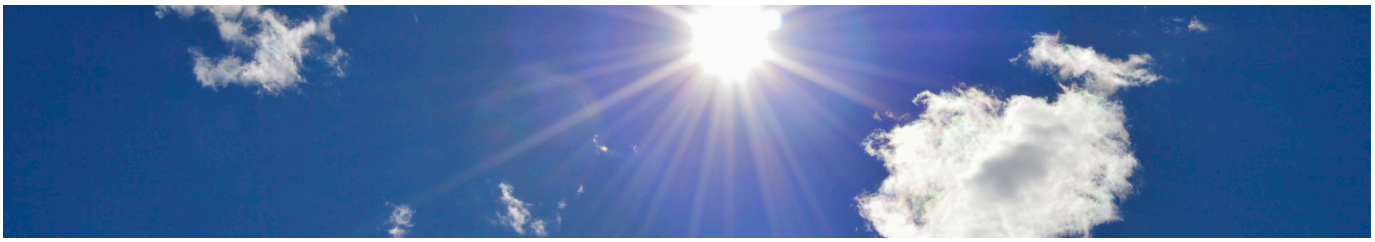
To be sure, this field of climate-change-related litigation is in its infancy, and significant questions remain open as to whether any court will impose liability. Current damages litigation for generation of emissions focuses on fossil fuel companies, while prior cases have involved electricity generators and automobile manufacturers. Entities responsible for agricultural, industrial, deforestation, or other emissions have not been named as defendants thus far. And even if any entities are ultimately deemed liable, the insurance industry lacks clarity on whether their policies would have to cover climate damages. But these lawsuits ultimately represent one of the greatest potential threats to the insurance industry in California and beyond. A number of noteworthy focal points have already emerged:

- **Climate change damages suits are on the rise**. Governments in California and multiple other states have recently sued fossil fuel producers for damages associated with sea-level rise, flooding, wildfires, and other events associated with climate change. These suits are likely to increase in the future, particularly if regulatory solutions continue to falter in the United States.

- **Liability may revolve around whether climate change-related harms were foreseeable and whether defendants' actions were unreasonable.** As a result, the growing certainty of climate science and viability of non-emitting energy sources may increase the likelihood of successful climate litigation, which otherwise falls outside existing legal models.

- **Tobacco and asbestos litigation provide some historical guidance.** Public pressure, the development of alternatives, and the direct involvement of governments in litigation helped lead to liability or mass settlement. But causation of individual health harms is simpler to prove than climate change-related damages.

The litigation that could have the most immediate and significant implications for the insurance industry are cases that involve claims for damages, such as common-law nuisance, trespass, and negligence, that might form a basis for monetary liability for the impacts of climate change. Such liability may be covered by



commercial general liability policies, and could also materially affect the value of fossil fuel-related assets held by insurers to the extent share prices are affected by legal outcomes.

## Past climate change damages suits in the United States have not resulted in liability

To date, there have been no successful claims in the United States alleging that greenhouse gas emitters are responsible for climate change-related damages or common-law claims (UNEP 2017). This record mirrors international experience to date, with claims in Germany, Peru, and the Philippines also unsuccessful (a landmark 2015 ruling in Urgenda Foundation v. Kingdom of the Netherlands ordered the national government to reduce emissions 25% by 2020 to mitigate climate impacts, but did not find liability for those emissions). In the United States, courts have typically not allowed cases to proceed to the merits, finding them to be preempted by legislation or political questions not appropriate for court rulings. The primary barriers to success for these claims have been preemption and plaintiffs' inability to prove legal causation sufficient to establish liability.

According to the Sabin Center for Climate Change Law at Columbia Law School, of the hundreds of climate change claims filed in the United States, approximately 20 have been common-law claims. Common-law claims involve damages, as opposed to those seeking enforcement of statutory requirements, revocation of permits, or constitutional remedies. The leading common-law cases against greenhouse emitters, all unsuccessful, have been:

- **American Electric Power v. Connecticut**, 564 U.S. 410 (2011). Eight states sued a group of electricity generators seeking a cap on emissions, based on a common-law nuisance claim that the emissions from their facilities contributed to climate change. The United States Supreme Court rejected the claim, holding that the federal Clean Air Act preempted federal common-law claims, since under the Court's ruling in Massachusetts v. EPA the act expressly delegated to EPA complete authority to regulate carbon dioxide emissions.

- **Kivalina v. ExxonMobil**, 696 F.3d 849 (9th Cir. 2012). Residents of a coastal Alaska town sued fossil fuel companies and electricity generators for damages due to the companies' contribution to climate change, which causes sea-level rise that was destroying the town and required plaintiffs to move. The case was dismissed as a political question not capable of resolution in federal court.

- **Comer v. Murphy Oil**, 607 F.3d 1049 (5th Cir. 2010). Mississippi residents sued fossil fuel companies for property damage caused by Hurricane Katrina, which was exacerbated by climate change caused by defendants' emissions. The claim was ultimately dismissed for a lack of standing (i.e., the legal right to bring a claim based on having suffered a harm that may be redressed by a court), as the court held that plaintiffs

could not establish a connection between the emissions and the harm they suffered.

- **California v. General Motors**, No. C06-05755 (N.D. Cal. 2007). The state sued a group of automakers on basis that they were responsible for greenhouse emissions that caused a public nuisance in the form of environmental impacts such as reduced snowpack, sea-level rise, and longer heat waves. The claim was dismissed as a political question.

As these key cases demonstrate, U.S. courts (and federal courts in particular) have not been receptive to date to large-scale climate change damages suits against major sources of emissions, identifying statutory preemption, political considerations, and causation issues as barriers to a finding of liability. Beginning over a decade ago, they have set a provisional but consistent precedent disfavoring claims for damages against a range of defendants, including fossil fuel producers, electricity generators, and automobile manufacturers. (Importantly, these holdings in favor of defendants have not meant that insurers were unaffected; a number of insurers were initially named as defendants in Comer v. Murphy Oil, and defendants in the other cases surely involved their insurers where possible throughout the costly litigation process.) As a result, they likely limited the number of suits filed over that same period. In particular, the Supreme Court's unanimous 2011 decision in AEP v. Connecticut may have had a strong dampening effect on common-law claims. That case followed the Court's ruling in Massachusetts v. EPA requiring the EPA to regulate greenhouse gas emissions and was issued at a time when the EPA under President Obama had finalized initial greenhouse gas emission limitations for automobiles. In addition, the EPA was crafting regulations for new and existing power plants. In that context, AEP v. Connecticut appeared to firmly establish that the Clean Air Act displaced these claims against greenhouse gas emitters. However, as aggressive EPA action has become less likely and as the physical impacts of climate change in the United States have become more tangible, plaintiffs have begun to seek new avenues for redress.

## Recent climate change damages suits in the United States present new avenues for liability

A number of new common-law cases have been filed in the United States between 2017 and mid-2018. In this new crop of litigation, the plaintiffs are all local governments, while the defendants are all fossil fuel companies. While not uniform in underlying facts or legal theories, these cases share a common thread of public-scale property and infrastructure damages and claims made under state law. Please note that each of these cases was in progress as of the date of publication of this report, and dismissal, removal, appeal, or other developments may have taken place.

- **People of State of California v. BP** (N.D. Cal., Docket No. 3:17-cv-06011). The cities of San Francisco and Oakland sued five oil and gas companies based on state nuisance law. The federal district court dismissed the suit in late June 2018, on grounds that the plaintiffs' claims were displaced by the Clean Air Act as well as separation-of-powers and foreign policy concerns.

- **County of Santa Cruz v. Chevron** (N.D. Cal., Docket No. 5:18-cv-00450). The City and County of Santa Cruz sued 29 fossil fuel companies for damages related to nuisance, trespass, failure to warn, and negligence.

- **County of San Mateo v. Chevron** (N.D. Cal., Docket No. 3:17-cv-04929-MEJ).

The counties of San Mateo and Marin and the City of Imperial Beach sued fossil fuel companies under nuisance, negligence, strict liability, and trespass standards.

- **City of New York v. BP** (S.D.N.Y., Docket No. 1:18-cv-00182). The city sued the five largest fossil fuel companies claiming that the production, marketing, and sale of their products caused public and private nuisance and trespass damages. The case was dismissed in July 2018 on political question and similar grounds.

- **City of Richmond v. Chevron** (Cal. Super. Ct., Docket No. C18-00055). The city sued 29 fossil fuel companies for damages related to nuisance, trespass, failure to warn, and negligence.

- **Board of County Commissioners of Boulder County v. Suncor Energy** (Colo. Dist. Ct., Docket No. 2018CV030349). Two counties and the City of Boulder sued Exxon and Suncor for nuisance, trespass, and violations of state consumer protection law.

- **King County v. BP** (Wash. Super. Ct., Docket No.18-2-11859-0). The county sued five major fossil fuel companies in a complaint similar to that filed in California v. BP, also highlighting the risks that climate change-driven ocean acidification poses to the region's shellfish industry.

- **Rhode Island v. Chevron** (R.I. Super. Ct., Docket No. PC-2018-4716). The state sued a group of fossil fuel companies for damages to state-owned facilities and real estate.

While none of these cases has been fully resolved, (those that have been dismissed are subject to further appeal) two trends have emerged. The first is the common traits of the claims. Primarily coastal jurisdictions are bringing comprehensive

common-law claims for damages against large groups of major fossil fuel companies, but not electricity generators or automakers. The claims allege a full suite of tort claims including nuisance, negligence, trespass, failure to warn, and strict liability, and they reach the production, sale, and marketing of the fuels, including concealment of climate change science. The claims seek damages for a broad range of applicable climate change-related harms, including sea-level rise, heat waves, wildfires, extreme weather events, flooding, spread of invasive species and drought, which the plaintiffs allege have caused and will cause them to incur costs to protect public and private property, upgrade infrastructure, preserve public health, and conduct scientific analyses. The second trend is that defendants are attempting to remove these claims from state court to federal court, in order to argue that the AEP v. Connecticut decision will be applied and the Clean Air Act will preempt the suits. To date the defendants have been mostly successful in this strategy, earning a dismissal of the claims in California v. BP as noted above, but appeal is likely and some removal actions are still pending (appeal is also likely in New York v. BP).

The claims by the cities of San Francisco and Oakland in California v. BP were limited solely to public nuisance and seek no punitive damages, requesting billions of dollars solely to fund climate adaptation projects and not to compensate for past harm (Drugmand 2017). This strategy was

designed to keep the case in state court based on recent lead paint litigation, People of State of California v. ConAgra (Santa Clara Co. Super. Ct. 2017, No. H040880), that employed a similar strategy in winning an award against a group of manufacturers who were required to pay $1 billion into an abatement fund. The decision was seen as an expansion of the public nuisance doctrine under California law as the court found liability for actions dating back many decades, which may have driven the increase in public nuisance-based climate claims filed in late 2017 and early 2018 (Coppinger et al. 2017). This strategy was obviated in California v. BP when the defendants were successful in removing the case to federal court (where the California court precedent may not apply), but one or more of the other suits may remain in state court. Keeping claims in state court may also ease the burden of standing, which can be easier to establish under California law than under federal law.

Given the similarities across these common-law cases, the global nature of the impacts of climate change (with some regional variation affecting the precise list of damages claimed), and the fact that the cases were filed within a very narrow timeframe, more coastal jurisdictions in California, the Pacific Northwest, and the Northeast will likely file similar state common-law claims against the same defendants. As the Boulder County case demonstrates, however, non-coastal jurisdictions may also begin to file their own claims as climate change impacts become more diverse and directly affect more geographies. And adjacent legal developments, such as that in California v. ConAgra, may shape innovative approaches or drive yet more jurisdictions to file similar suits.

## Historical mass tort examples offer insight into the development of liability

While the field of climate change damages litigation is still relatively young and has not yet resulted in any decisions on the merits of liability, two examples provide perhaps the clearest guidance for how tort liability might emerge in this context. United States courts have previously developed mass tort liability regimes in the context of tobacco and asbestos, in each case decades after the first links of harm were identified and scientific attribution was robust and well understood. Tort liability for climate change may similarly rely on the development of attribution science and public acknowledgment of direct links between greenhouse gas emissions and specific harms to life or property.

### Tobacco

The decades-long litigation over the health effects of tobacco use may offer the most valuable parallel to climate change claims. Science identifying the harms of tobacco smoke was established by the 1950s, and lawsuits seeking damages against tobacco companies began at the same time. Yet the industry was able to shield itself from liability on the basis that the science was not conclusively established. Similar to the climate change context, it was later learned that industry leaders had far more conclusive understanding of that science than they publicly divulged. After the 1964 Surgeon General's report definitively linked smoking to cancer risk (USDHEW 1964), the defendants were initially able to shift blame to plaintiffs based on the doctrine of assumption of risk. Only in the 1990s did the liability risk become so significant that the tobacco companies eventually agreed to enter into a $200 billion mass settlement with 46 state governments (Meier 1998).

Three key factors drove this development. First, the public had understood smoking as a public health risk for over 30 years, with the agreement and support of federal and state governments that sponsored some of the leading medical research and sponsored public health and education programs. Second, states, rather than individual plaintiffs, sought recovery for public health care costs related to smoking, reducing the difficulty of proving causation and other factors that exist in individual cases and increasing the political power and litigation capacity of the plaintiffs (Olszynski et al. 2018). Finally, evidence grew regarding the tobacco companies' knowledge of harmful effects and deceptive efforts to hide them from the public, allowing claims under unfair trade practices laws.

Each of these factors – the progress of climate science, the rise of government-level plaintiffs, and evidence of public misinformation – are apparent in the climate change context. However, the cases have a number of key distinctions. First, the damages caused by tobacco consumption are individual, not global. Tort law was not initially well suited to smokers' claims for evidentiary reasons, but the nature of the harm suffered was amenable to resolution under traditional tort principles. By contrast, climate change impacts are not directly related to the end-user of the emitting products and services. Second, damages to particular plaintiffs could generally be traced to particular defendants (i.e., the type of cigarettes smoked) and even when aggregated, state-level claims could reasonably address all liable parties. But climate change is the result of global emissions. Finally, political consensus around the harms of climate change has not yet matched the scientific consensus. Each of these differences, while surmountable, presents a barrier to liability. (In plaintiffs' favor, the doctrine of assumption of risk – which long barred smokers' claims – likely would not apply in the climate change context).

## Asbestos

The development of liability in the asbestos context provides another example that may be relevant to climate change litigants. From the 1930s to the 1960s, scientists developed clear links between asbestos and health harms. Then in the early 1970s, the Occupational Safety and Health Administration officially recognized the link and issued protective regulations, leading to a rapid reduction in production and use of the material. Between the 1980s and 2000s, hundreds of thousands of individual plaintiffs sued for billions of dollars in damages, with the vast majority settling in an aggregate amount exceeding $50 billion. These settlements and the prospect of total liability drove the industry into mass bankruptcy.

Two key factors influenced the findings of liability. The development of science and the decades-long incubation period of disease meant that after the initial discovery of risks in the 1930s, the scientific community took decades to identify the link between exposure, asbestosis, mesothelioma, and lung cancer, in large part as a result of the progressive aging of a significant population of workers who had been exposed to the substance. And since primary exposure to harmful levels of asbestos took place in the workplace, which is subject to heightened regulation, oversight, and record-keeping regarding substances and quantities used, plaintiffs could more easily establish causation.

As with the tobacco analogy, some key distinctions exist when compared to climate change liability. First, like tobacco, asbestos created an individual health harm that scientists could trace to specific products and behaviors. Second, the industry developed alternatives to asbestos that possessed its fire and heat resistance without its harmful side effects. Such alternatives also exist in the context of energy production, but not all of the

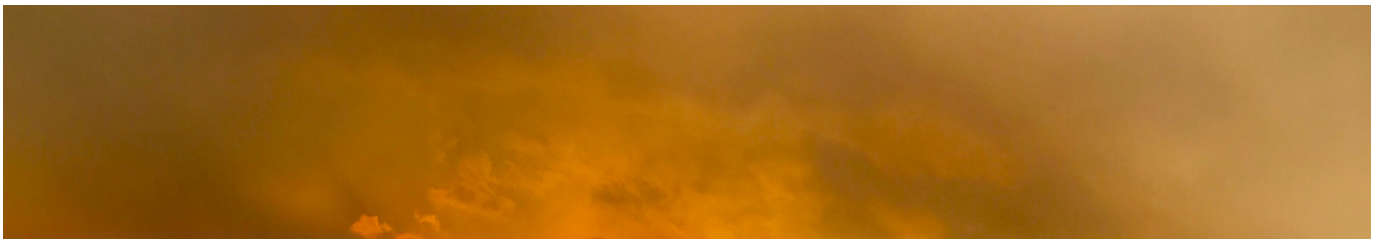
technology is yet at market scale, which may affect an analysis of whether defendants' actions are reasonable: so long as fossil fuels remain necessary to provide much of the world's power, courts may hesitate to deem their production unreasonable merely because some quantity of an emissions-free alternative exists.

Within both tobacco and asbestos cases, the development and public acceptance of scientific conclusions regarding causation of harm was essential to the establishment of tort liability sufficient to motivate settlements. In addition, experts could link each substance in question directly to individual human health damages. These analogies present a challenging picture for climate change liability, as scientists cannot link greenhouse gas emissions definitively to any individual impacts, and because large segments of the public and various governments do not accept the established science regarding impacts. In order for tort liability to emerge with respect to climate change-driven harms, the scientific and political communities may need to more frequently and conclusively establish the ability to link an individual destructive event or set of events to greenhouse gas emissions. But alternative forms of liability, such as those related to fossil fuel companies' public information and marketing campaigns under unfair trade practices laws, could persist even if traditional tort liability is not established.

One potentially instructive concept is the principle of market share liability, which was introduced in California pharmaceuticals litigation. In Sindell v. Abbott Laboratories (1980), the California Supreme Court held that where a plaintiff could prove that a product manufactured by a group of defendants (but not definitively linked to any individual one of them) had caused her actual damages, those defendants could each be held liable to the plaintiff in proportion to their market share for the product, provided that 1) the product was fungible and 2) a substantial share of the manufacturers were named as defendants. The nature of the problem that gave rise to the market share theory – the plaintiff's inability to prove which manufacturer produced the drugs in question – aligns with the inability of climate change litigants to link specific harms to any individual emitter. Similarly, the concept of fungibility – the essentially interchangeable nature of a commodity – overlaps with the common measurement of climate impacts in carbon-dioxide-equivalent units regardless of greenhouse gas emitted (although this deals with fungibility of outputs, rather than the initial fossil fuels). While the market share liability concept has rarely, if ever, been extended beyond the narrow context of pharmaceuticals, and it would require expanded interpretation to apply to the climate change context, its principles may provide a framework for future litigants.

## Fellow common-law countries have not developed climate liability

The national governments of other common-law countries do not appear to be expressing any anticipation of or plans for liability for greenhouse gas emissions. Leading government reports and the websites of government environment and climate agencies, including the UK Committee on Climate Change's 2017 Report to Parliament, the Pan-Canadian Framework on Clean Growth and Climate Change, the Australian Department of Environment and Energy's 2017 Review of Climate Change Policies, and the New Zealand Government's Action on Climate Change report all focus on carbon pricing, emission reduction, adaptation and resilience, and clean technology innovation, with no mention of proposed or anticipated liability schemes or litigation. Available legal analyses indicate skepticism that liability might be imposed in these countries under current



legal standards, and no other countries appear to have enacted statutory law imposing liability for damages caused by greenhouse gas emissions (Pepper 2017; Williams 2017; Day 2017).

In addition to the lack of government action on climate liability, damages litigation in other common-law countries has been far less robust even than in the United States. Only one case appears to have been tried: In a 2011 Australian case, Macquerie Generation v. Hodgson, the court rejected a claim that an electricity generator's permit contained an implied condition limiting carbon emissions to a level exercising reasonable care for the environment. The court also indicated skepticism regarding common-law nuisance claims in the same context (UNEP 2017). Of the other climate change-related cases identified in Australia, Canada, New Zealand, and the United Kingdom, none apparently involved a claim for damages against an emitting entity (CLSSC). However, as noted earlier, Australia may be on the path to recognizing liability in connection with corporate directors and officers duties toward shareholders.

## Legal academic commentary and theory suggest additional barriers to liability

Legal scholars have been discussing and predicting the development of climate change-based tort litigation risks for more than a decade, including scenarios both good and bad for plaintiffs. For example, on the favorable side, they have argued that climate change tort liability would likely not be preempted by the Clean Air Act and could survive on the merits based on nuisance (Grossman 2003). In addition, they have reasoned that a nuisance-based climate claim does not represent a political question that cannot be resolved in court and that the issue of proof of damages will be resolved over time as the science develops (Farber 2008). On the negative side for plaintiffs, they have argued that a climate change litigant in the general population likely lacks common-law basis for standing (Mank 2005). They also have predicted that climate tort claims will continue to fail on the merits, until damages become so significant and widespread that courts are forced to fundamentally alter the tort system (Kysar 2011).

These arguments represent only a small cross-section of the extensive legal academic literature, but they demonstrate the extent to which scholars have long predicted the rise of tort litigation based on damages caused by climate change, but failed to predict the direction that the United States Supreme Court – from Massachusetts v. EPA to AEP v. Connecticut – and other courts would take in decisions regarding the bases for liability. The recent group of local government-initiated cases described earlier is the first significant attempt at establishing liability since AEP v. Connecticut, and the interim period was filled largely by the Obama Administration's now-stalled effort to regulate greenhouse gases under the Clean Air Act. As a result, scholarship on the topic has slowed somewhat since 2011.

However, an analysis of the basic elements of tort liability that must be established in a successful claim of damages against an emitter reveals two key insights for a prospective view

of the risk faced by fossil fuel companies (or other large-scale emitters, such as power generators, that have been involved in past suits):

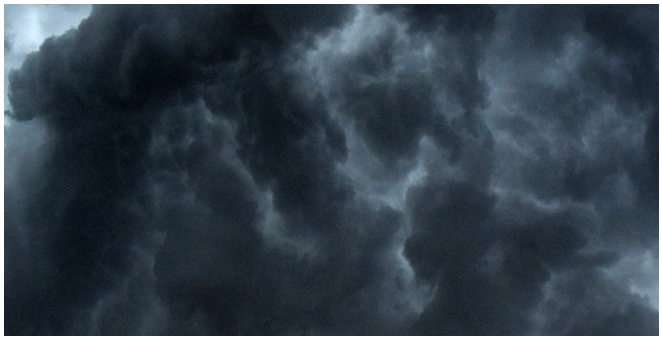
- A claim for damages will likely not succeed without showing that the defendant emitters' actions presented an unreasonable risk of foreseeable injury. This need, in turn, will require showing that the emitters were aware of climate science and the harm caused by their products (a claim the recent cases all make, and which is fairly well established). But litigants may also need to prove that alternative means are available and affordable – i.e., that non-emitting technologies are a cost-effective choice for the defendants. These alternatives are now, increasingly, becoming viable for generators of electricity with renewable energy but not yet for automakers or oil companies with mass-market, ubiquitous zero-emission vehicles and fuels (or equivalents that are sufficiently low-emitting as to not contribute to harmful warming).

- In claims for mass damages, courts often apply an industry standard approach. Thus, suits against comprehensive groups of emitters – the current norm – may yield to suits against companies who continue to lag behind the field as the emitting industries begin to shift away from fossil fuel-reliant technologies (Hunter and Salzman 2007).

These two additional factors – the need for a viable, non-emitting alternatives to current energy production methods, and the vulnerability of worst-performing actors – go beyond attribution science and regulatory schemes to a basic proposition that courts will resist imposing liability that could force industry transformation on too broad a scale. Even if and as barriers relating to political question, statutory preemption and scientific proof of causation fall, these two factors could determine the nature of climate change-related tort liability going forward. At the same time, cases against professional builders or engineers and corporate directors and officers, alleging losses related to violations of their duties to protect and inform consumers and shareholders, could begin to form the basis of tort liability as the field progresses.

## Implications for the insurance industry are significant but details continue to emerge

The field of climate change-based litigation is relatively young, and few of the claims filed to date have sought damages under common-law theories. But these common-law claims could present a major threat to the insurance industry, since liability for even a small portion of the sea-level rise, flooding, wildfires, extreme weather events, and other impacts of climate change could be immense. The National Oceanic and Atmospheric Administration estimated that the 2017 California wildfires alone caused nearly $20 billion in damage, while hurricanes Harvey, Irma, and Maria totaled over $250 billion throughout the Southeast and Caribbean (NOAA). These events have been linked to climate change – by one estimate Hurricane Harvey's rainfall was 38% greater due to anthropogenic warming – and even a small apportionment of liability for similar past and future events, given increasing severity and frequency, could result in unsupportable costs to insurers (Risser and Wehner 2017). As attribution science develops, the likelihood of liability and certainty of apportionment will increase as well. In particular, advances in attribution science will address the threshold legal question of causation, both by establishing conclusively that climate change is a factual or "but-for" cause of extreme weather events, sea-level rise, and other harms, and by demonstrating that climate change is a legal



or "proximate" cause of those harms, foreseeable to fossil fuel emitters and extractors (Marjanac and Patton 2018).

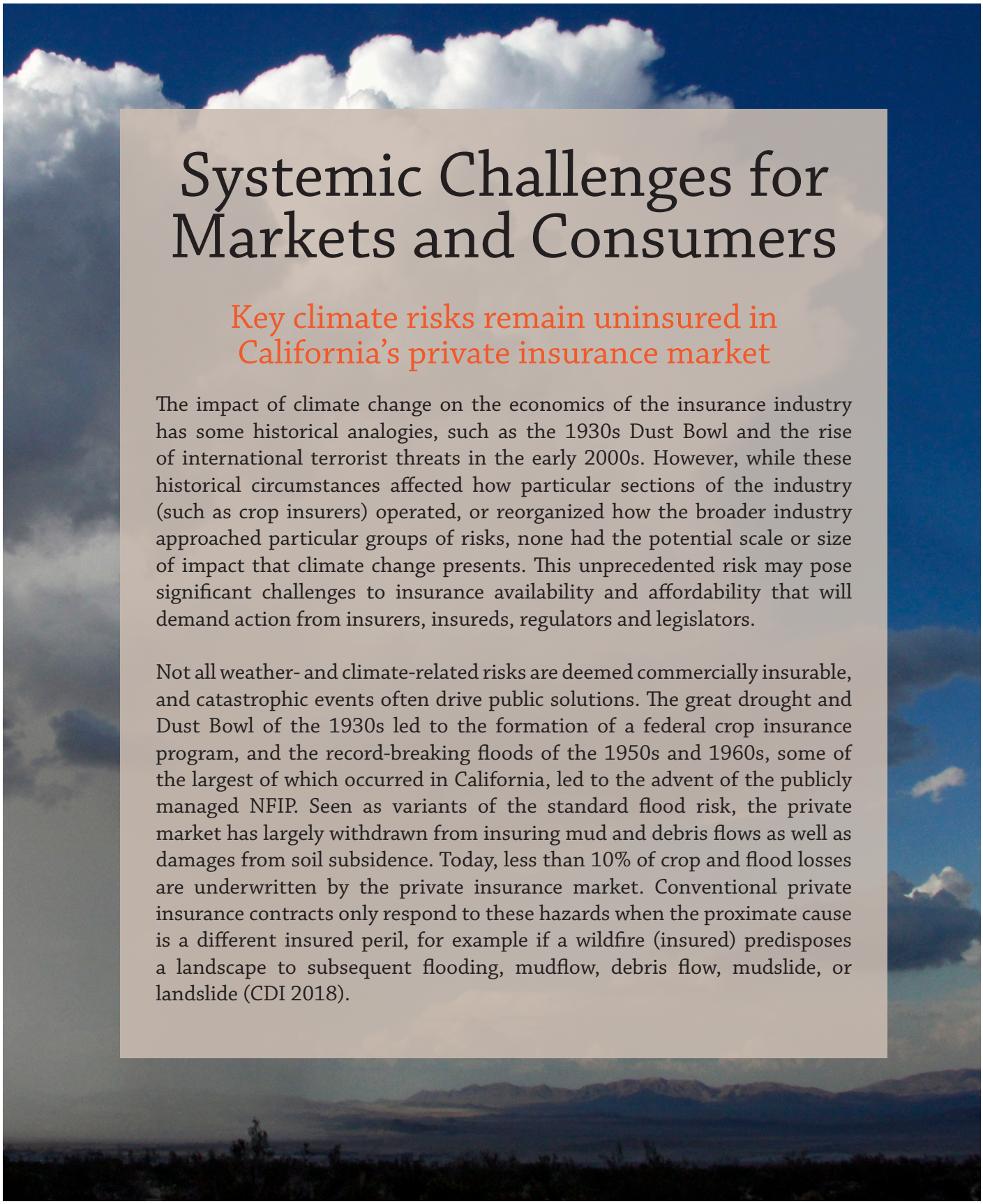
While each of the common-law theories underlying the current California, Colorado, New York, Rhode Island, and Washington cases – such as private and public nuisance, trespass, and negligence – requires a different set of factors to establish liability, a common standard of reasonableness outlines them. For example, in a public nuisance claim, the plaintiff must establish an unreasonable interference with a right common to the public, while in a private nuisance claim the plaintiff must show a substantial and unreasonable interference with the use and enjoyment of land: in either case, the defendant need not have behaved negligently or been "at fault," but simply have taken actions of insufficient social utility to justify the infringement of public or property rights. In a negligence claim, the plaintiff must establish four traditional factors: a duty of care owed by the defendant to the plaintiff, a breach of that duty, causation (both factual and legal/proximate), and harm to the plaintiff. The issue of breach is often evaluated by weighing the likelihood and severity of harm against the burden of avoiding it (i.e., the utility and reasonableness of the behavior in question) (Hodas 1999; Hunter and Salzman 2007). Courts employ differing interpretations of reasonableness, and their analysis will be tailored to the specific common-law theory in question. But they typically evaluate similar factors: the likelihood and severity of harm; the social utility of the action in question; the degree of certainty of causation; the relationship between the parties; and, in some cases, whether insurance is available (Hunter and Salzman 2007).

Each of these factors could be a major barrier for individuals or local governments seeking to hold fossil fuel companies or major greenhouse gas emitters or governments liable for climate change-induced harms: apportionment of harm may be distinctly challenging in the climate change context, fossil fuel activities continue to drive much of the global economy (and their consumption continues to hold social utility), extractors and emitters may owe a minimal duty of care to the public, and the links between specific plaintiffs and defendants are difficult to establish. Plaintiffs may be able to recast their claims to make the implications of liability less radical – for example, by seeking only damages for emissions that were unreasonably high due to the marketing of SUVs over other cars – and thus more likely to survive in court. More broadly, climate science will continue to develop and sharpen, and the social utility of fossil fuels will likely diminish as non-emitting alternatives become more viable. But it is unclear whether liability is a significant likelihood in the near term.

However, should liability arise, the defendants – currently multinational fossil fuel companies, but potentially including automotive and energy generation companies, other commercial generators of greenhouse gas emissions such as airlines and industrial facilities, corporate directors and officers, and licensed professionals – certainly hold extensive and diverse forms of insurance. The defendants would likely seek to recover to the maximum extent possible under their existing policies. Most companies' commercial general liability policies cover judgments for personal injury and property damage, which would likely include climate

change-related tort damages based on sea-level rise, flooding, wildfires, and public health costs like those sought in the cases recently filed in California and elsewhere (Davis and Paul 2017). As discussed earlier, corporate directors and officers policies and professional license-related policies are also likely to be implicated in future litigation. However, just as numerous hurdles to establishing liability for climate change damages exist, so do hurdles to establishing coverage obligations. Most insurance policies include policy exclusions for damages expected to result from intentional conduct. In this case, the conduct of extracting and burning fossil fuels is certainly intentional and general climate effects foreseeable, while the extent to which specific, litigable climate change-related harms can be anticipated is a matter of ongoing scientific and legal inquiry. Similarly, some issuers may be able to exclude liabilities of which the policyholder knew or should have known at the time the policy was purchased. While extensive evidence exists that fossil fuel companies have understood climate change for decades, the link between that understanding and specific harms is much less clear. Many commercial general liability policies also contain exclusions for pollution liabilities, although it is unclear if both greenhouse gas emissions and core business operations (such as resource extraction or power generation, as opposed to an accidental spill) can fall within those exclusions (Marsh 2016).

This additional layer of questions further complicates the picture of potential liability in climate change lawsuits. But insurers will likely be heavily involved in this growing field of litigation, particularly as advances in attribution science and an increasing diversity of climate change-related harms make the causal links between insureds' activities and plaintiffs' damages ever clearer. Furthermore, if a plaintiff ever is successful, the cohort of defendants may expand to incorporate the full panoply of major emitting activities worldwide, as well as professionals and others responsible for interpreting or managing their impacts. And as more companies begin to engage in thorough climate change risk disclosure, an industry standard may develop against which deficient disclosure could be readily apparent. Proactive measures such as adopting (Swiss Re 2016) or guiding policyholders through the implementation of (Aon 2017) climate risk disclosure recommendations may limit exposure to directors' and officers' liability, and independent organizations such as the Sustainability Accounting Standards Board and others provide additional frameworks that can further build institutional standards. Other concepts such as an insurance levy on fossil fuel producers to fund adaptation programs and reduce litigation risk by building goodwill may be less appealing and feasible, but they indicate the type of measures the industry may need to contemplate in a future of climate litigation (Webster and Clarke 2017). As claims proliferate and the total amount of damages sought becomes more apparent, insurers may respond to new risks by withdrawing from market segments, and regulators may be called upon to assist in the formation of new coverage arrangements. The evolution of legal theories implicating sources of emissions, directors of corporations affected by physical and transition risks, utilities involved in large wildfires, and engineers and planners responsible for building resilient homes and communities may force the industry to confront – and, ideally, engage constructively with – the possibility of significant liability losses alongside the physical losses and investment risks that are likely to occur.



# Systemic Challenges for Markets and Consumers

## Key climate risks remain uninsured in California's private insurance market

The impact of climate change on the economics of the insurance industry has some historical analogies, such as the 1930s Dust Bowl and the rise of international terrorist threats in the early 2000s. However, while these historical circumstances affected how particular sections of the industry (such as crop insurers) operated, or reorganized how the broader industry approached particular groups of risks, none had the potential scale or size of impact that climate change presents. This unprecedented risk may pose significant challenges to insurance availability and affordability that will demand action from insurers, insureds, regulators and legislators.

Not all weather- and climate-related risks are deemed commercially insurable, and catastrophic events often drive public solutions. The great drought and Dust Bowl of the 1930s led to the formation of a federal crop insurance program, and the record-breaking floods of the 1950s and 1960s, some of the largest of which occurred in California, led to the advent of the publicly managed NFIP. Seen as variants of the standard flood risk, the private market has largely withdrawn from insuring mud and debris flows as well as damages from soil subsidence. Today, less than 10% of crop and flood losses are underwritten by the private insurance market. Conventional private insurance contracts only respond to these hazards when the proximate cause is a different insured peril, for example if a wildfire (insured) predisposes a landscape to subsequent flooding, mudflow, debris flow, mudslide, or landslide (CDI 2018).

Private crop insurance claims in California over the years 2014 to 2017 were $60 million, or 3% of the $1.8 billion in federal crop insurance payouts in California over the same period (Figure 22 A). The total value of insured and uninsured crop losses in California is not available, and so the protection gap in unknown.

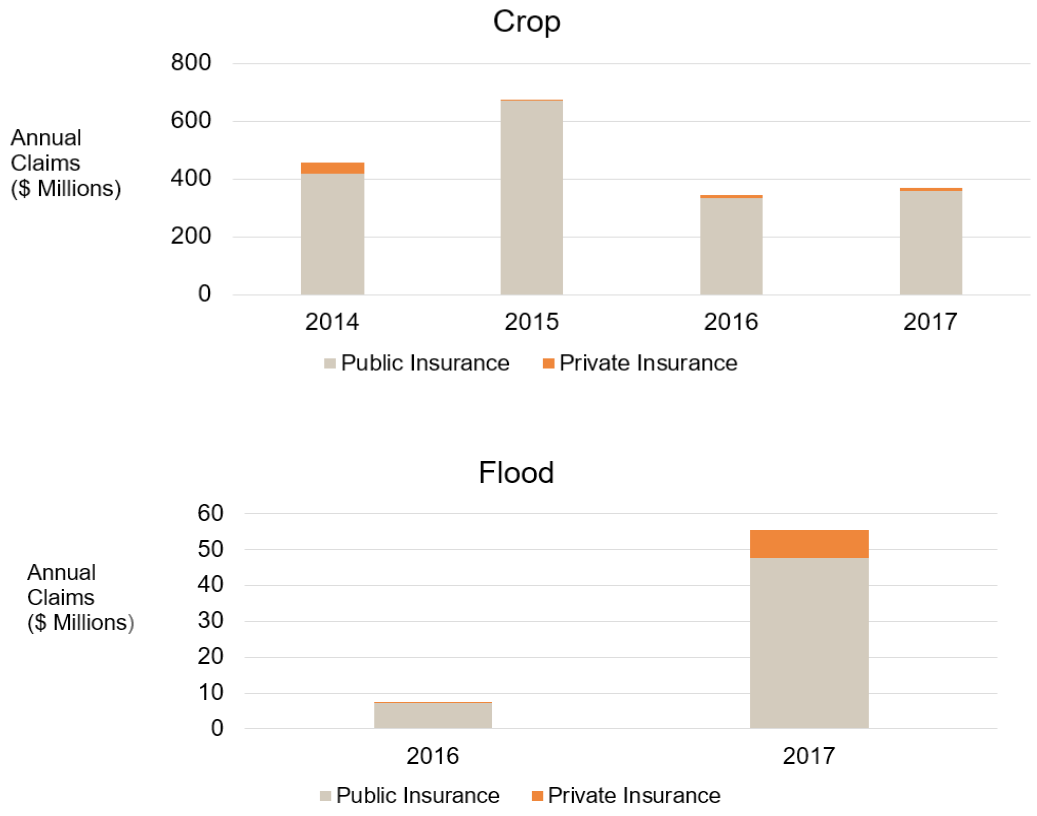
In an example of the allocation of loss burden and risk-spreading for flooding, the California floods of February 2017 are estimated by National Oceanic and Atmospheric Administration (NOAA) to have an aggregate cost of $1.5 billion, of which only $47 million (3%) was insured under the NFIP, and $7.6 million (0.5%) via private insurance (Figure 22b) (NOAA).

Sea-level rise poses one of the costliest potential risks to the California property and infrastructure, yet resulting losses for homeowners will tend to fall under the rubric of federal flood insurance. Many commercial properties either purchase flood insurance or have coverage under their general property policies, but total market penetration is unclear.

## Climate change reduces insurance availability, adequacy, and affordability

As the physical risks of climate change become more apparent and more severe, insurers may respond by increasing the cost of coverage for

**FIGURE 22 A-B** | Public vs. private payouts for crop and flood insurance: California.




*Source: CDI, and federal insurance program data. Private and NFIP values provided by CDI. Prior years' data not available.*

those risks or removing coverage from the marketplace altogether. Observers have long anticipated that the impacts of climate change will drive up insurance claims and costs, potentially leading to higher premiums and deductibles, lower policy limits and restrictions of coverage (Mills et al. 2006). These concerns have already begun to materialize. In response to devastating wildfire seasons in recent years, major insurers in California have begun to withdraw from covering properties and significantly increase premiums in the wildland-urban interface area where destructive wildfires are most prevalent (CDI 2017; Dixon et al. 2018). Insurers have also sought to increase deductibles, with the CDI recently approving "split" deductibles that are higher for wildfire damage than for other damage (CDI 2016a). In other parts of the country, premiums have increased radically following major unanticipated windstorm losses. Some analysts doubt the ability of existing public and private flood insurance regimes to offer affordable policies in light of the anticipated increased frequency and severity of major storm and flood events, which the United States may be already experiencing (Lamond and Penning-Rowsell 2014, Van Marter et al. 2018; UCS 2014). In May 2018, a "1-in-1,000-year" flood hit the same Maryland town twice in two years (Bacon 2018).

Reforms both within the insurance industry and beyond – including building, land-use, and policyholder measures – will be necessary in order to preserve availability and affordability as climate change worsens (Cremades et al. 2018). These reforms may take many shapes. Planning and building code improvements can reduce policyholders' vulnerability to climate risks, while action to reduce greenhouse gas emissions can help reduce the underlying insured perils. Meanwhile, insurers and their regulators could work with local flood control agencies to increase climate-related data collection and improve risk modeling and together to incentivize increased cross-subsidization and bundling of products and resilience measures to dampen the cost of catastrophes for insurers and insureds alike. Finally, legislators could enact new laws addressing coverage withdrawals and price increases (or strengthening regulators' existing ability to do so) and promoting resilient development practices to help maintain actuarial validity of lower rates. Elements of this approach have been applied for decades in Florida, beginning in the wake of Hurricane Andrew.

## Climate change threatens the basic functioning of insurance markets

Extreme weather events have been correlated with the reduction in availability, adequacy, and affordability of commercial insurance in many markets around the world. These reductions are market responses that climate analysts would refer to as "mal-adaptations," simply replacing one problem with another rather than addressing root causes (Cremades et al. 2018). As a result, insurers are experiencing a declining role in helping society manage climate risk. A growing amount of weather- and climate-related losses are not covered by insurers. Today this protection gap represents approximately 50% of losses from weather- and climate-related events globally (ClimateWise 2016). Emerging risks such as those arising from climate engineering and geo-engineering are unlikely to be accepted by the private insurance market.

In California, the effects of climate change on the availability and affordability of insurance are on display in the aftermath of the 2017 wildfire season. Over four million California homes are located in the wildland-urban interface, and over one million of those are considered high- or very high-risk for wildfire (Martinuzzi et al. 2010; CDI 2017). As the state's population continues to grow, these numbers are expected to increase significantly (Mann et al. 2014). CDI reviewed availability and affordability following the record-setting 2017 wildfires and identified a number of problematic trends in the wildland-urban interface, including:

*"For Chubb to continue to offer coverage under climate change conditions, pricing must always be set at sound actuarial rates...."*

Chubb (2016)

- Reduction in the issuance of new policies and renewal of existing policies;
- Significant increases in premiums and wildfire surcharges;
- Failure to account for homeowners' mitigation measures;
- Insufficient data and use of best-available models; and
- Insufficient regulatory authority over insurers' wildfire risk models and non-renewals (CDI 2017).

Not only did homeowners insurance non-renewals increase in nearly every high-risk California county between 2015 and 2016, but consumer complaints regarding insurer renewals and premium hikes increased over 200% between 2010 and 2016, demonstrating the long-term nature of these trends (CDI 2017). For one leading insurer, total catastrophe losses worldwide (including but not limited to wildfire, flood, drought, and severe weather, occurring largely in the United States) have increased by over 5% more than inflation since 2000, a trend which necessarily will be reflected in commensurate premium increases in order to protect solvency, and which is likely to grow as climate change progresses (Aon Benfield 2018). Premiums and deductibles are projected to increase and the market share of admitted insurers in many areas of California is expected to decline under a business-as-usual climate change scenario (Dixon et al. 2018).

In California, more than $500 billion of buildings and public infrastructure are at risk from flood damage, and more than half of Major Disaster Declarations over the past 65 years in the state have involved flood events (CDWR 2013; Pinter et al. 2017). The NFIP, operated under the Federal Emergency Management Agency, provides highly limited homeowners coverage capped at $250,000 per claim for a structure and $100,000 for personal possessions. Commercial coverages are also limited to small businesses, with caps at $500,000 each for a structure and the same for contents (FEMA 2017).

Analysis of the NFIP suggests significant economic inefficiency and muted progress toward the program's original goal of reducing flood risk (Pinter et al. 2017). Nationally, the NFIP takes in $3.3 billion in premiums each year to provide over $1.25 trillion in flood insurance coverage. As a result of cumulative losses exceeding premiums, the program was $25 billion in debt by the end of 2016 with an uncertain future. Remarkably, 19% of claims made to NFIP are outside even the 500-year floodplain, which is consistent with long-standing concerns that flood-risk mapping is seriously outdated and not reflective of current science.

The program has arguably fostered mal-adaptations, with over 10% of payments ($5.5 billion) having been made to properties with multiple sequential losses (i.e., four or more claims of $5,000 more or two claims equal to or exceeding the entire structure's value). The worst case on record was 40 claims for a single structure. That a third of premiums are taken as fees by private insurers administering the program further compounds the inefficiencies. The federal government continues to subsidize flood insurance more heavily than loss prevention.

California has 240,000 NFIP policies in force,

**FIGURE 23 A** | Between 1994 and 2015, only one California county received flood payouts in excess of insurance premiums.

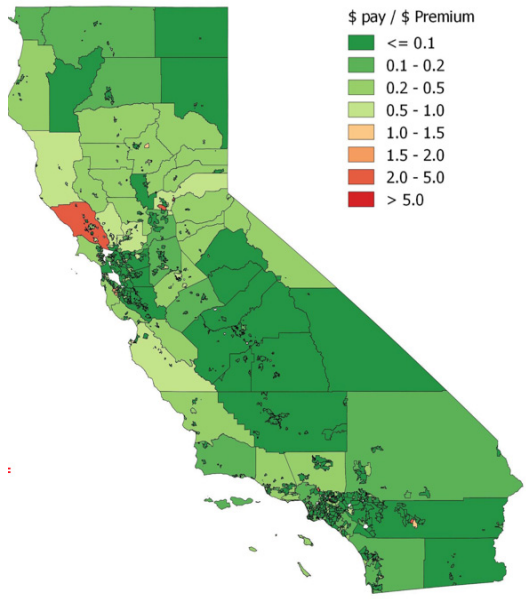
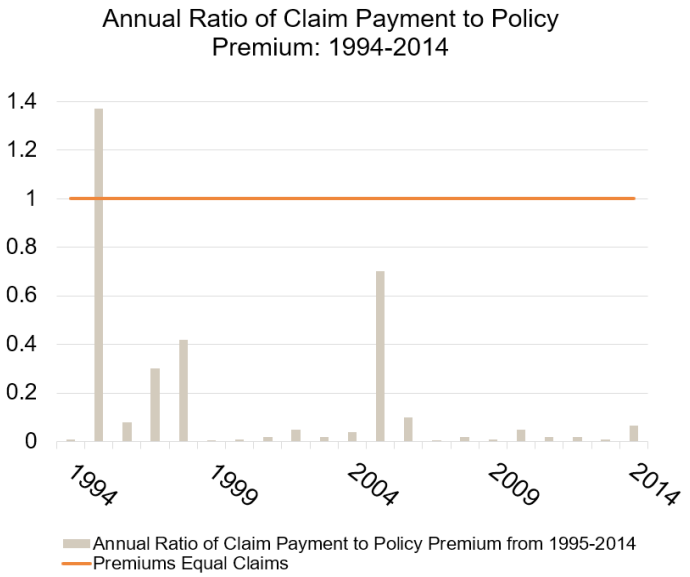



**FIGURE 23 B** | Aggregate premiums exceeded payouts by over $3.5 billion during this period.




*Source: Pinter et al. (2017), with permission.*

corresponding to about $190 million each year in premiums, providing coverage for $83 billion in assets. These values represent around 5% of NFIP policies, assets, and premiums nationally. Between 1994 and 2015, NFIP damage payouts in the state amounted to only 14% of premiums collected (Figure 23 A), corresponding to over $3 billion paid in excess of claims. In only one year (1995) during this period did payouts exceed premiums. In aggregate, only Sonoma County has exhibited payouts exceeding premiums (Figure 23 B). While California has thus historically subsidized flood risk in other parts of the country, rare catastrophic events in the state could result in unprecedented claims. In any case, given fiscal challenges, the future of NFIP is uncertain, resulting in risk for state policymakers reliant on federal support for financing these losses. The additive stress of climate change – which is predicted to increase the frequency of torrential rain events together with storm-surges due to sea-level rise – will further challenge NFIP's viability.

## Climate change presents a chronic challenge to insurability

In a functioning voluntary insurance market, three factors define the availability and affordability of insurance: an insurable risk that is quantifiable and distributed, an insurable population that is aware of the risk and is willing to insure, and a solvent insurer that is willing to insure and can afford to pay claims (Mills et al. 2006; Lamond and Penning-Rowsell 2014). Climate change threatens all three of these conditions. First, it presents physical risks that may combine or accelerate in unprecedented ways. Second, political division and long time horizons may cloud consumers' understanding of risk. Finally, potentially massive and sustained losses may stretch insurers' capacity to cover. And as climate change increases the need to maintain insurance coverage, for example by increasing the range of wildfires (Cal Fire 2018b), it also increases the cost of that coverage (Mills et al. 2006). In a separate but related phenomenon,

climate change not only directly increases cost and need, but it also complicates insurers' ability to model and predict aggregate losses from multiple perils over longer time horizons and their practices for distributing those losses across parties and time. Climate impacts can shorten the time between loss events, change the geography of catastrophic events, and multiply the correlated consequences of individual events (Mills et al. 2006). As a result, the increasing exogenous risk to the insurance business model necessarily drives insurers to reduce risk through other means.

## Regulators, insurers, and insureds can take actions to protect themselves and the marketplace

Insurance regulators are concerned about the availability, adequacy, and affordability of insurance as the effects of climate change materialize on an increasingly regular basis. Even as California and other governments take bold action to reduce greenhouse gas emissions and increase the adaptability and resilience of cities and communities, millions of residents and businesses will need to be able to purchase insurance policies that can insulate them from both traditional losses and the unprecedented risks posed by climate change. The regulatory, information, and market-based reforms that sustain the insurance market must support policyholders while protecting the long-term solvency of the industry.

As a primary and ongoing means for achieving these goals, governments and insurers can take action to improve data collection and modeling (in support of more precise risk-based pricing, and to better understand economic losses and risks to uninsured assets) and increase risk management. These efforts will intersect with broader efforts occurring throughout government and markets to understand and limit the impacts of climate change. Such actions would include more thorough analysis of loss data in the aftermath of climate change-driven disasters (such as the ongoing claims process following the 2017 wildfires) and linking of more routine weather events to second-order impacts, such as vehicle accidents. They could also include improved land-use planning and building codes to reduce vulnerability and greenhouse gas emissions, thereby limiting increases in frequency and severity of harm (Mills et al. 2006). Existing insurance models for highly protected risks such as energy generation facilities and large manufacturing plants, which can obtain increased policy limits in exchange for instituting industry-standard protective measures, may provide an example of how to address increased climate change-related risks. While these measures may call on actors beyond the insurance industry and its regulators, improving the physical and locational resilience of structures and communities will be essential to preventing the risks of climate change from becoming altogether uninsurable.

A separate and more directly applicable set of solutions for insurance regulators involves requiring or incentivizing increased cross-subsidization and spreading of climate risks. Because increased threats will often concentrate in particular areas, sharing risk across low- and high-risk regions could be employed to moderate the most drastic price increases. Better integrating

flood and fire insurance coverages with other insurance products, or developing community-scale insurance programs may help address issues of availability, adequacy, and affordability (Lamond and Penning-Rowsell 2014). Any such measures, however, could lead to market failure by artificially lowering the cost of building structures in high-risk areas, inadvertently resulting in more high-risk development to the detriment of the state and the insurance industry. Thus, any cross-subsidization or bundling measures would need to be limited to the extent necessary to preserve availability, adequacy, and affordability for current residents without promoting additional undesirable development. Concepts such as the "split" deductible, which allows consumers to obtain affordable coverage without sending counterproductive price signals on fire risk, are instructive in this regard.

## Legislative solutions may be needed to preserve availability, adequacy, and affordability

The California Fair Access to Insurance Requirements (FAIR) Plan, created by the Legislature in 1968, is a private "insurer of last resort" for Californians who are unable to obtain property insurance in the private market due to factors beyond their control (Cal Ins. Code § 10091 et seq.). The FAIR Plan is comprised of all property insurers in the state – which are required by statute to participate – but is subject to regulation by CDI. Similar FAIR Plans have proliferated around the country as states seek means to ensure that private insurance is available to all residents. While they provide a key backstop, experts often characterize them as having high premiums reflective of higher risk. As a result, they effectively solve for availability but not affordability (Mills et al. 2006). Between 2014 and 2017 the number of FAIR Plan policies in California increased by 36% (Laucher 2018). As wildfire risk increases in scope and severity in

coming years, the FAIR Plan model may become an even more essential component of the private insurance system to the extent that marketplace reforms are unable to close the gap between consumers' needs and insurers' bottom lines. To that end, Senate Bill 1032 (McGuire, Chapter 543, Statutes of 2016) requires insurers to direct holders of cancelled and non-renewed policies to the FAIR Plan, and CDI has acted to require the FAIR Plan to continue issuing policies through recent wildfire events. However, since the FAIR Plan is backed by the potential for assessments on private insurers based on their share of the voluntary market, increasing reliance on the part of underserved consumers can have the same net impact on insurers' solvency, although with the added benefit of pooling risk across all carriers. As with all forms of insurance, if premiums do not reflect risk, mal-adaptations can result.

In response to the devastating 2017 wildfire season in California, and anticipated increased risk of property losses due to climate change impacts in coming years, a number of legislative proposals have been sponsored by CDI to further protect consumers in the insurance claims process, which as of summer 2018 include:

- **Senate Bill 894** (Dodd 2018) would require insurers to a) offer to renew policies for at least

24 months after a total property loss; b) offer at least 36 months to recover living expenses that are subject to a dollar limit within a policy; and c) allow insureds who have suffered losses from declared disasters to combine their policy limits for primary dwellings, other structures, contents, and living possessions and use the combined amount for any covered purposes

- **Senate Bill 897** (McGuire 2018) would require insurers to offer a payment of at least 80% of the policy limit for personal belongings without demanding an itemized claim for insureds who have suffered losses from declared disasters

- **Senate Bill 1291** (Dodd 2018) would require California to implement exam, fingerprint-based background check, and continuing education requirements for insurance adjusters, addressing consumer complaints about insurer misrepresentations of the law in the months following the 2017 wildfires.

- **Assembly Bill 1772** (Aguiar-Curry 2018) would require insurers to offer at least 36 months to recover the full replacement cost of a loss caused by a declared disaster.

- **Assembly Bill 1797** (Levine 2018) would require insurers to provide an updated building replacement cost estimate when a property insurance policy renewal offer is issued.

- **Assembly Bill 1799** (Levine 2018, Chapter 69, Statutes of 2018), signed into law in July 2018) requires insurers to provide a copy of complete policy documents to insureds upon request.

- **Assembly Bill 1800** (Levine 2018) would require insurers to cover replacement costs for a destroyed home even if the policyholder decides to buy or build the new home in a different location from the one originally covered by the policy.

- **Assembly Bill 1875** (Wood 2018) would require an insurer that does not provide at least 50% extended replacement cost coverage to help direct the consumer to an insurer that does.

- **Assembly Bill 1923** (Limon 2018) would require insurers to facilitate participation in a consolidated debris removal program after a declared disaster.

- **Assembly Bill 2594** (Friedman 2018) would increase the statute of limitations for policyholder claims against insurers from 12 months to 24 months following a declared disasters.

- **Assembly Bill 2611** (Obernolte 2018) would establish a consumer appeal process for insurer determinations made pursuant to a wildfire risk model.

In addition, Senate Bill 824 (Lara 2018), which CDI supports, would prohibit insurers from canceling or refusing to renew property insurance policies within 12 months after a declared disaster based on the location of the property in an area struck by the disaster, except if the insurer faces insolvency. CDI has also proposed a set of legislative reforms designed to improve the availability and adequacy of insurance in high risk fire areas, including:

- Requiring insurers to issue or renew property insurance policies for residents in state-identified high-fire risk zones "if the property meets specific mitigation and defensible-space criteria and any other underwriting guidelines" which would be issued by CDI;
- Offering insurance premium credits to policyholders who face significant premium increases due to wildfire risk and who meet mitigation and defensible-space criteria; and
- Approving insurers' wildfire-risk models (used to determine availability and premium levels) only if they properly account for property-area factors like fuel density, ground slope, accessibility to emergency responders, and mitigation efforts (CDI 2017).

As these numerous proposals demonstrate, no single solution exists to address the issue of availability, adequacy, and affordability in the context of climate change. Rather, a suite of approaches will likely be necessary, including the non-cancellation and renewal policies of SB 824 and SB 894, the location-shifting concept of AB 1800, and the required renewal and premium credits proposed by CDI. A key common trait among these proposals is that they not only protect consumers but also drive risk-reducing behavior through incentives to meet mitigation criteria and the easing of insurance-based restrictions on homeowners moving away from the most vulnerable areas. As the state continues to experience increased

wildfire and other impacts of climate change, some combination of these proposed reforms will be necessary to ensure that all residents and businesses have access to affordable insurance.

## Climate-response strategies have new and widely varying risk profiles

Most experts agree that the greatest risk associated with climate change is procrastination or pretending that the problem does not exist. But efforts to secure a transition to a world with less risk from climate change also necessarily entail adoption of new technologies and strategies. This transition includes both measures to reduce greenhouse gas emissions and measures to manipulate the climate itself. The prospective availability, adequacy, or affordability of insurance for the latter set of measures is unknown.

The options are not equal in terms of the balance of potential risks and benefits they entail (Mills 2012a), an issue that has received little consideration from the insurance community. Public discourse tends to focus on the most optimistic scenarios for implementing new technologies and to downplay not only the potential downsides but also the non-climate-related benefits associated with some approaches. A more cohesive analysis framework is attainable.

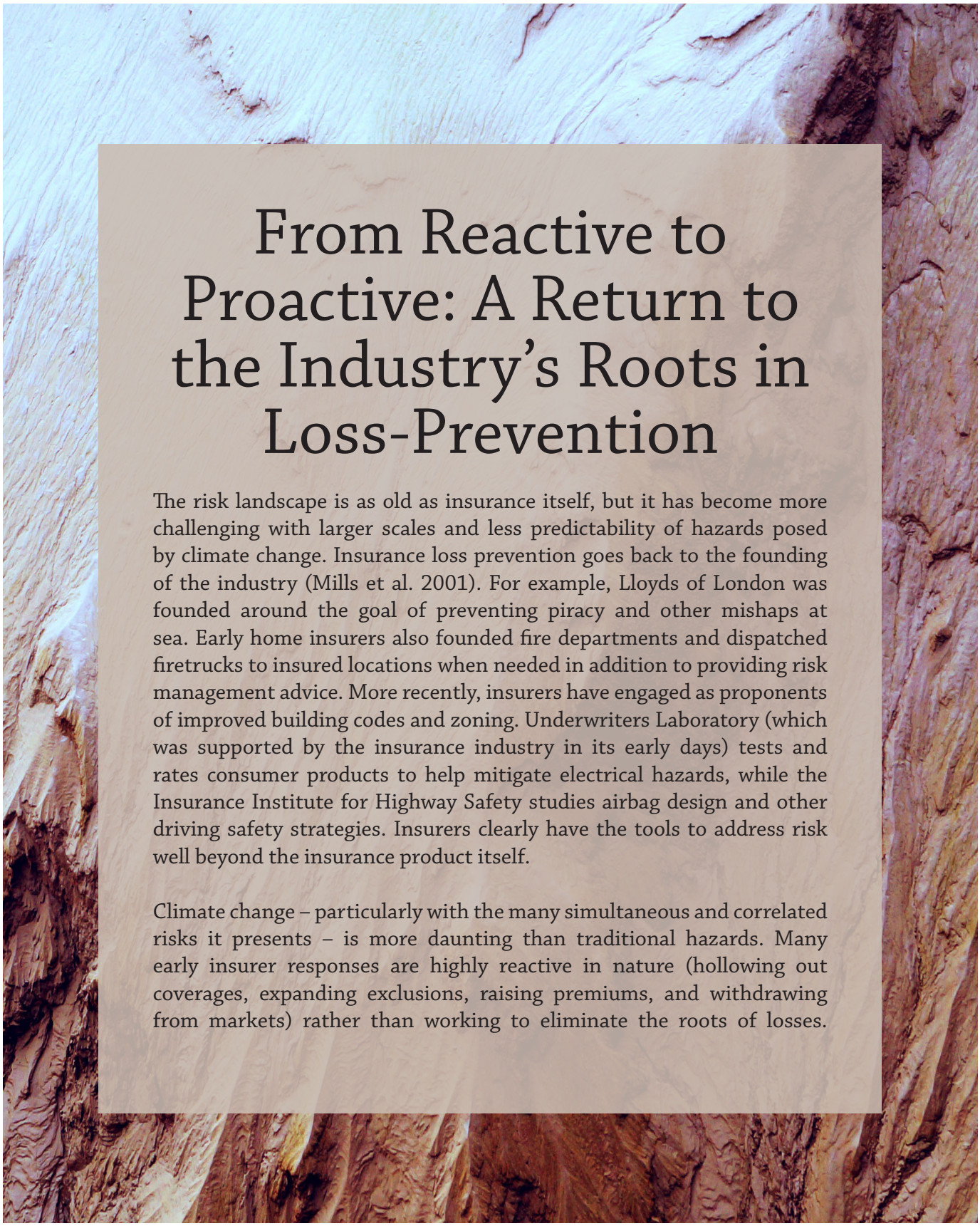
> *"The traditional insurance model – to evaluate risks and pay-out following a disaster – may no longer be sustainable in a climate-changed world. Exposure to climate risk could simply render large customer segments uninsurable without adaptation."*
>
> ClimateWise (2017a)

Climate mitigation strategies currently undergo economic and engineering analyses, but they are not consistently subjected to rigorous risk assessment and risk management. Assessments by the insurance industry are critically important in this process because insurers can provide a dispassionate view and internalize the costs of risk through pricing. Insurer engagement is also desirable, as the public sector may be forced to assume many of the risks associated with emerging technologies if insurers opt out. After all, a century of dangerously blending technological enthusiasm with lack of care in assessing the comparative risks of energy and land-use choices ushered in today's climate crisis. Continued inattention threatens to saddle society with new risks from poorly prioritized efforts to solve the climate problem.

A strong industry has emerged to deploy emission-reduction efforts on the energy demand side, focusing on everything from energy efficient technologies to solar panels. Hundreds of billions of dollars are already being spent and invested annually in these pursuits. While specific new risks introduced in this process are broadly deemed insurable (and indeed create new market opportunities for insurers), it is prudent to heed unintended adverse outcomes such as moisture problems created by improperly applied insulation or air-sealing strategies. Meanwhile, there is a large body of evidence that many green technologies in fact enhance resilience (Mills 2012a). Examples include battery-backed solar systems keeping power on during grid outages, occupants of efficient buildings being less susceptible to urban heat mortality or morbidity, and certain efficient building envelope technologies improving resilience to wind and fire hazards.

Other "upstream" approaches to climate change mitigation involve removing greenhouse gases at the point of release or extracting them from the air. One of the geoengineering strategies that some leaders advocate involves dumping massive quantities of iron filings into the oceans so as to "fertilize" algae blooms that would in turn absorb carbon dioxide and sink with it to the bottom of the sea. The practice of capturing carbon dioxide when it is created at power plants and injecting it into the earth for long-term storage has been under development for decades and deployed at scale in some cases. Insurers have cautiously assessed the many risks associated with drinking water contamination or accidental release in connection with this process and have guardedly proposed criteria under which the practice can and cannot be insured. It is not yet clear that the market will respond.

The most herculean approaches – broadly termed "Solar Radiation Management" – seek to cool the climate by, for example, continuously injecting large amounts of particles high in the atmosphere to dim the Sun's energy. The risks are numerous and significant, such as curtailing the yields of American agriculture or disrupting the Asian monsoon and drying out water supplies for hundreds of millions of people. While insurers are unlikely to deem the risks insurable, they will be saddled with the downstream losses and broader market disruptions that could ensue, which, in turn could trigger property, professional liability, or directors and officers liability claims.



# From Reactive to Proactive: A Return to the Industry's Roots in Loss-Prevention

The risk landscape is as old as insurance itself, but it has become more challenging with larger scales and less predictability of hazards posed by climate change. Insurance loss prevention goes back to the founding of the industry (Mills et al. 2001). For example, Lloyds of London was founded around the goal of preventing piracy and other mishaps at sea. Early home insurers also founded fire departments and dispatched firetrucks to insured locations when needed in addition to providing risk management advice. More recently, insurers have engaged as proponents of improved building codes and zoning. Underwriters Laboratory (which was supported by the insurance industry in its early days) tests and rates consumer products to help mitigate electrical hazards, while the Insurance Institute for Highway Safety studies airbag design and other driving safety strategies. Insurers clearly have the tools to address risk well beyond the insurance product itself.

Climate change – particularly with the many simultaneous and correlated risks it presents – is more daunting than traditional hazards. Many early insurer responses are highly reactive in nature (hollowing out coverages, expanding exclusions, raising premiums, and withdrawing from markets) rather than working to eliminate the roots of losses.

*"With increased resilience fewer assets are likely to become uninsurable, thereby helping to maintain or improve overall insurance penetration…."*

CISL (2016)

Proactive efforts being taken by the most forward-looking insurers and insurance organizations focus more on anticipating these risks and proactively implementing physical (as distinct from financial) upstream loss prevention, primarily in the case of commercial risks.

The broad categories of potential insurer response begin with engaging in fundamental and applied climate science and modeling to better define climate risks and pathways to adaptation. This informs the process of identifying and making more transparent the risks themselves as well as efforts to address them through a formal disclosure processes. These are increasingly followed by efforts to "decarbonize" insurer investment portfolios and other assets, which some insurers believe brings the dual benefits of accelerating the clean energy revolution while lowering the risk of assets becoming "stranded." Insurers and their regulators are slowly working to integrate risk analysis into financial stress testing to, in turn, help quantify the imperative for loss prevention. With this information in hand, insurers are returning to their roots and embarking on efforts in their core business to proactively improve climate resilience. Many insurers have also introduced "green" approaches into their core products and services. Most of the promising efforts involve partnerships with other stakeholders. European and Asian insurers are the primary centers of innovation, as well as U.S. subsidiaries to offshore insurers. Addressing investment portfolios is arguably easier within the insurance business model, as they are a "shared service" across the enterprise with more centralized decision-making. Innovation in underwriting is more decentralized and more institutionally challenging.

## Enhancing climate resilience will reduce future losses

While the roles insurers might play in addressing the causes of climate change by reducing greenhouse gas emissions have long been discussed, only relatively recently has the focus expanded to include large-scale improvements in resilience to impacts that will not be avoidable (CISL 2017). Insurers are well aware that resilience is highly relevant to their core business and that, indeed, it is critical to maintaining insurability in the face of increasing hazards and uncertainty due to climate change. Industry thought leaders based largely in Europe have produced assessments of resilience and the opportunities for enhancing it (CISL 2016).

Acting alone, insurers are constrained when it comes to enhancing resilience. They do not build infrastructure or make proactive day-to-day operational decisions regarding hazard management. Nor do they have responsibility for promulgating building codes or land-use planning or constructing defenses against hazards. Nonetheless, insurers are major stakeholders, and have many skills and resources that could be brought to bear together with their significant influence in the marketplace through their core business and central role in global asset management.

Insurers are taking progressive steps to help better assess and enhance resilience, typically triggered by unexpectedly large loss events (Cremades et al. 2018). These begin with efforts such as more precisely mapping risk; identifying resilience

strategies that can help minimize impacts on insurance availability, adequacy, and affordability; and collaborating with public and private stakeholders to develop innovative responses. An important caveat is that complacency can follow these steps as a false sense of security creeps in, leading to a repeat of the cycle.

The diversity of resilience vulnerabilities (and corresponding opportunities for fortification) is overwhelming, ranging from the scale of individual buildings to entire urban landscapes, to communications systems, to ecosystems from which economic (and often insured) resources or services are obtained. Often those impacted are not those who were in a position to avoid the hazard in the first place. Benefits of resilience improvements accrue to policyholders and non-policyholders, creating a sort of "tragedy of the commons" dynamic that has undermined many other environmentally and public health- and safety-oriented initiatives. There can be a misperception that insurers face an economic tension between the lower losses that resilience may achieve and the correspondingly lower premiums that reduced risk invites (CISL 2016), when in fact loss-prevention is a core principle in insurance and risk management practice and pricing. Particularly in the face of climate change, risks are rising and prices cannot necessarily remain in step without erosion of market penetration and thus profitability for insurers. Thus, investments in resilience can maintain market size and scope for insurers as much as they manage physical risk for insureds. In addition to mitigating losses and averting potential market contraction, resilient investments stand to diversify an insurer's portfolio and build good will in the marketplace.

The issue has not gone unnoticed by the real estate appraisal industry, which has begun to recognize that hazard exposure coupled with poor resilience can erode property values (Curry et al. 2016, Finlay et al. 2018). As remote sensing

and other technical capabilities improve, practical applications are emerging for differentiating risk at the level of individual properties. Credit rating agencies are signaling similar concerns at the city scale, as they take climate change vulnerability into account (Moody's 2017).

At the same time, individuals and institutions face similar barriers to building resilience as they do energy efficiency. These include large upfront investment for uncertain gain, lack of financing, dual-agent issues such as owners and occupants of properties having conflicting objectives, and the general hazards of complacency and the invisibility of risk.

Through the Cambridge Institute for Sustainability Leadership (CISL), forward-looking insurers have proposed a combination of augmenting existing know-how and expertise with resilience-enhancing service delivery (CISL 2016). They propose leveraging existing industry expertise to provide novel resilience services, such as:

**Core business**

- Appraisals to identify issues upfront and reward improved valuation, for example via premium credits which induce insureds to invest directly in enhancing the resilience of their own properties
- Rebuilding to a higher level of resilience following loss (fortifying and/or relocating), rewarded with risk-adjusted premiums
- Mutual insurance pools where members share both profits and losses, allowing multi-year financing and confidence that premiums reflect losses

**Asset management**

- Screening security and bond investments for vulnerability/resilience attributes, investing/divesting as appropriate
- Directly investing in resilience enhancements to human settlements
- Developing and/or investing in green bonds to finance resilience

**Customer interaction**

- Customer education
- Developing a definitive resilience rating system with multiple applications
- Providing data and services to assess vulnerability/resilience

While these proposals offer the potential to improve the market environment, fundamental questions of funding and finance, risk assumption, and regulation remain.

Insurers are pursuing a variety of climate-adaptation areas that focus on research and analysis. A long-standing example is Swiss Re's "Economic Analysis of Climate Adaptation" activity (Swiss Re 2009) which models location-specific options for individual firms or regions and ranks them by cost-effectiveness. In another example, Canadian insurer Intact Financial (the largest property and casualty insurer in the country) opened the Intact Centre on Climate Adaptation in 2015 as a collaboration with the University of Waterloo. Intact describes the initiative's focus as "de-risking Canada from the financial, physical, and social impacts of climate change by providing cost effective guidance to Canadians on how to adapt to extreme weather" (Intact). Specific activities include on-site assessments to help homeowners identify and mitigate basement flooding risks, developing a national wetlands retention and restoration program to reduce community-level flood risk, and a program to engage businesses in identifying climate risks and associated loss-prevention strategies (with a primary focus on electricity sector as a common risk to virtually every type of business). An analogous U.S.-based example is the RainReady program offered by the Center for Neighborhood Technology to address flood and drought risks at a community scale. To have material impact, such initiatives must be highly scalable.

There is also evidence of this thinking within the public insurance programs and by outside observers (Pinter et al. 2017). The NFIP has demonstrated an ability to utilize premium reductions to reward loss-prevention efforts. The community of Avalon, New Jersey was awarded a 25% average reduction in flood insurance premiums in recognition of extensive efforts to improve resilience recognized by NFIP's Community Rating System (CRS), which are expected to translate to over about $1,500 per year per household (ABN 2013). Roseville, California was the first jurisdiction to receive a CRS Class-1 rating – the highest rating possible, corresponding to nearly $1,000 per year per household in average premium reductions – while Sacramento County achieved a Class-2 rating and $400 per household per year reductions (FEMA 2017). These ratings were achieved in part because the state adopted the International Building Codes.

Insurers' asset management practices have traditionally been decoupled from goals of the core business (other than avoiding correlated risks). The most innovative insurer climate risk-reduction strategies focus on finance, not underwriting. Significant capital is required to enhance resilience, both at the individual customer level as well as at much larger scales. One proposal involves "Forest Resilience Impact Bonds," which would fund restoration and management of forests in the western United States with the goal of minimizing wildfire risk and improving watershed management (Madsbjerg and Connaker 2015). Under the proposal, the U.S. Forest Service

*"[T]he Company's catastrophe models may be less reliable due to the increased unpredictability, frequency and severity of severe weather events or a delay in the recognition of recent changes in climate conditions."*

Travelers Insurance

Annual Report (SEC Form 10-K) 2014.

would pay a fee based on the projected savings in firefighting costs and water and electric utilities would pay fees based on benefits accrued to them. Unfortunately, these types of projects may have excessive correlated risks for property insurers across the underwriting and asset-management sides of the companies. However, the risks for life insurers should be sufficiently independent from those in their core business to allow investment with risk spreading to the property and casualty business. Insurers could engage as designers, issuers, and investors in such instruments.

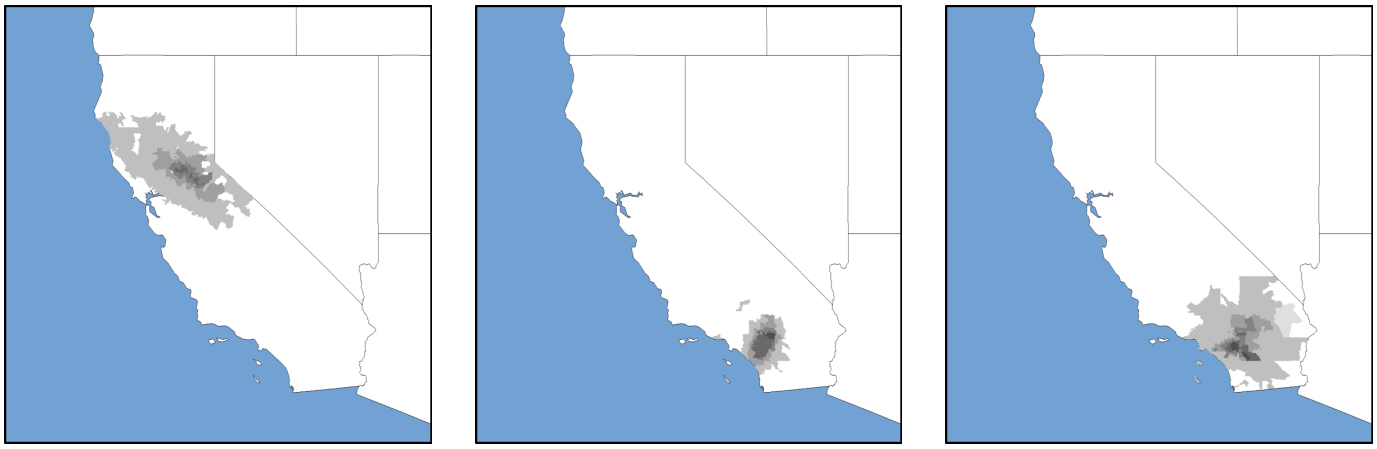
One example of a coastal resilience project focuses on storm surge risk reduction via coral reef protection and restoration. Coral reefs provide important "ecosystem services" by protecting beaches and land-based infrastructure from storm surges, estimated to avoid $4 billion in flood damages each year globally, while also providing a base for tourism in many areas (Beck et al. 2018). Public and private interests along a 60-km stretch of the Yucatán Peninsula of Mexico, which includes the major resort city of Cancún, established the Coastal Zone Management Trust to fund projects to protect coral reefs and others to help restore them after damaging storms. Tourism brings $10 billion per year into the area. Some of the funds will be used to buy a new parametric insurance product designed by Swiss Re, with payouts triggered by storm events exceeding specified wind speeds (around Category 4) in designated areas. Participants include local hotel owners and other segments of the tourism industry, The Nature Conservancy, scientific experts, and state government. Restoration will reduce beach erosion during future storms and protect coastal infrastructure as well (TNC 2018).

One of the greatest climate risks faced in California and many other parts of the world is torrential rain followed by flood. Combining risk reduction (as in the Yucatán example) with insurance could reduce risk in the California context. Researchers point to a body of thinking that, when unified, could link modeling with in-field sensor networks in support of parametric insurance products placed at the community scale (with claims paid when measurable event trigger levels are surpassed) together with proactive finance of resilience enhancements that could provide enhanced flood risk management at lower cost than today (Schaefer 2017). Such enhancements could include wetlands protection and restoration, forest management to reduce runoff, or flood defenses. Resilience bonds – coupled with reduced insurance premiums thanks to the loss reduction potential of investments made with the bonds – could be placed to fund loss-prevention investments at the community scale, helping to achieve insurability at a cost-effective level (Vajjhala and Rhodes 2015).[4]

In California, mudflows and landslides are sometimes insured through publicly managed geologic hazard abatement districts (GHADs), 35 of which have been created across the state in response to the lack of conventional insurance availability. GHADs place strong emphasis on pre-event risk mitigation, funded through special property-tax assessments.

4. It has been proposed that resilience bonds be used in tandem with catastrophe (CAT) bonds such that the CAT bond holds funds in a collateral account in the event of a major loss event, paying interest and coupons to the owner and being returned to the owner if no such event occurs. When coupled with a resilience bond, the CAT bond payments made by the potential beneficiary are reduced (a "resilience rebate") and that amount redirected to resiliency investments.

FIGURE 24 A-C. | Three scenarios of California grid disruption due to thunderstorm.



1:100 event -
609k people without power

1:200 event -
935k people without power

1:200 event -
935k people without power

*Shading density represents the fraction of a given ZIP code without power in the model results.*
*Source: Hartford Steam Boiler / Munich Re.*

An important precedent in the industry for these sorts of proactive loss-prevention approaches is commonly referred to as a "highly protected risk" business model, in which the insurer provides detailed and customized loss-prevention advisory services to the insured, together with preferential rates for implementing approved best practices. Expanding this approach to a larger scale, in which property-level as well as community-level resilience enhancements are made in partnership with insurers, may be an opportunity for insurers and insureds to increase resilience. In any case, appropriate reserves would need to be maintained for rare, catastrophic loss events.

## Climate science, hazard modeling, and risk assessment can be usefully integrated

Over the past few decades, private modeling firms and actuarial departments of the insurance industry have developed powerful catastrophe (CAT) models. Peril-specific models have been created over time – from hurricane, to electrical blackout, to pandemic – thanks to improvements in computing power, event-based databases, and more. Insurers and policymakers use the results of these increasingly robust models to better understand underwriting risks. However, leading insurers still perceive "non-modeled" gaps in climate-change-related risk assessment (e.g., concerning perils such as flooding, sovereign credit risk, shared infrastructure failure, and business interruption [Chubb 2016]). Climate change only adds uncertainty to the modeling process.

Power outages have been shown to produce high insured losses, both for homeowner and commercial lines policies (Mills and Jones 2016). Hartford Steam Boiler Inspection and Insurance Company has developed special-purpose models that simulate the impacts of extreme weather on grid reliability at the zip-code level. Results for California show the potential for over a million people without power from events such as thunderstorms (Figure 24 A-C). This type of analysis is notable in that it characterizes risk at scales useful to planners and policymakers. Applications for insurers occur when a specific book of business is assessed within

*"Climate change represents a long-term peril to our planet…. A pragmatic current message for actuaries is for them to recognize that climate change represents an additional source of uncertainty in future mortality rates and to consider its implications for the assumptions they make and communication of the associated uncertainty to their clients."*

International Actuarial Association (2017)

the overall risk landscape and evaluated with respect to the type of impacts and nature of losses (e.g., property versus business interruption).

Leading modelers have engaged with the climate science community and are striving to incorporate emerging research in their models. However, regulators generally do not allow forward-looking projections to be used in ratemaking, thus limiting the perceived utility of forward-looking modeling to insurers. Other stakeholders with longer time horizons, such as urban planners and emergency relief organizations, have clear use for such analyses.

The scientific community continues to find deficiencies in models. For example, researchers have shown how the failure to include soil subsidence in sea-level rise modeling severely underestimates the risk (Shirzaei and Burgmann 2018). Following Superstorm Sandy in 2012, analysis showed that some of the greatest health and welfare impacts were caused by factors that officials had not modeled, such as the vulnerability of electricity generators that were below sea level (IAA 2017).

Over-reliance on imperfect models can create blind spots. In the California context, this is particularly important with respect to wildfire and its consequential impacts. The 1991 Oakland Hills and 2017 Coffey Park fires were not only outliers (Figure 9) in terms of insured losses, they were also not anticipated in the wildfire models prevailing at the time (Daniels 2018; Muir-Wood 2018), likely a reflection that windblown embers were not well characterized in the prevailing models (Muir-Wood 2018). Examination of the wildfire models used by insurers in the California context revealed a number of specific concerns (CDI 2017). Among these, the models did not accurately characterize vulnerability of the building stock and the extent of mitigation around given properties or broader community-scale efforts to manage risk. Thus, underwriting and rate-setting may be done with inadequate levels of precision, which can prompt overly conservative decisions on the part of insurers about whether or not to retain a given customer. There are no mechanisms in place to ensure wildfire model quality. Further complicating matters, that individual insurers issue limited numbers of policies in some at-risk areas erodes their ability to accurately quantify risks based on loss experience.

Efforts to improve these models are ongoing. More transparency and independent peer review can improve models, as has been pursued for hurricane models in Florida and South Carolina (SCDOI). Florida has gone a step further to create a public hurricane model (FLOIR b). Swiss Re has noted that it currently depends on U.S. flood models that are not sufficiently maintained and updated (Ball 2015). It has since developed a higher resolution model and with it is offering private insurance and reinsurance (Swiss Re). Chubb is developing flood risk management tools (Chubb 2016).

It is important to note that non-insurers also develop powerful natural hazard models. For example, the State of California, through the Central Valley Flood Evaluation and Delineation Program (CVFED), has invested millions dollars in modeling the flood risk associated with the State Plan of Flood Control levees.

> *"What we will need are forward-looking stress tests assessing the comprehensive interaction between climate change and assets and liabilities."*
>
> Bank of France Governor Villeroy de Galhau
> Interview, *Financial Times*, April 8, 2018

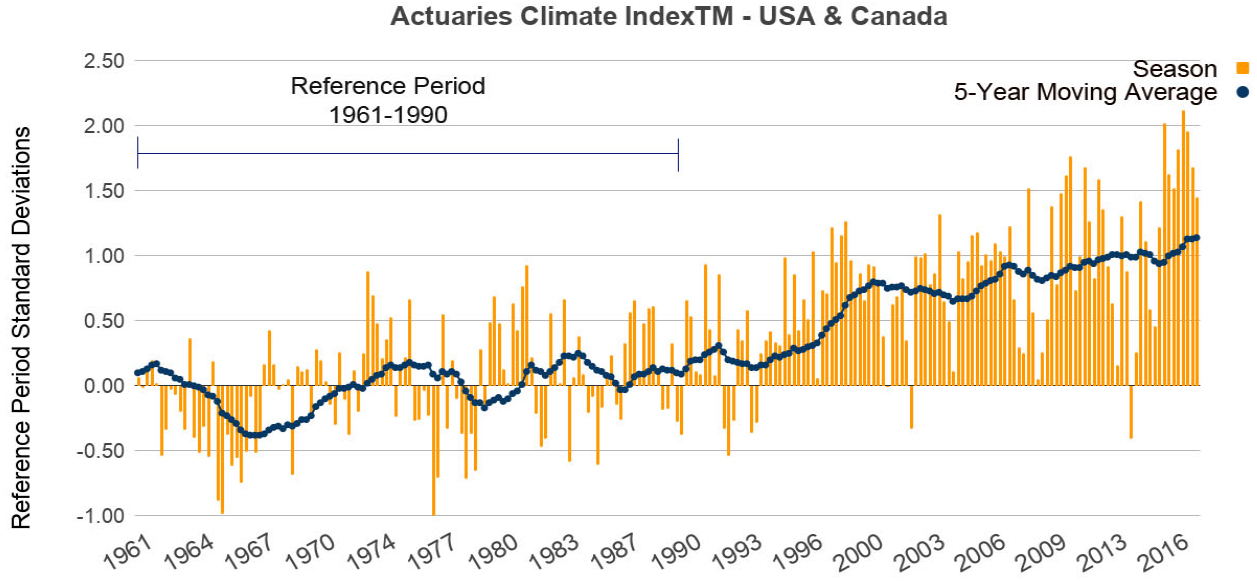
## Insurers and their actuarial societies are contributing expertise

Insurers have also engaged directly in climate science and analysis. For example, Munich Re has for decades amassed and made publicly available unique data on regional and global insured and uninsured losses from climate and weather extremes (examples are seen in Figures 4 and 5). The U.S.-based Insurance Services Office provides similar data for the United States on a proprietary basis. Some insurers have conducted or funded climate-related research and have participated in the work of the Intergovernmental Panel on Climate Change (Vellinga et al. 2001), and helped gather data and case studies on climate change impacts and mitigations.

Four North American actuarial societies have developed a climate index which they update quarterly (Figure 25). This is based on a methodology that combines indicators for temperatures, rainfall, soil moisture, wind, and sea levels (AmAA et al. 2018). The group is now developing a second index relating extreme events to impacts with insurance relevance.

Other actuarial organizations have examined the implications of climate change for the life/health side of the insurance industry (IAA 2017).

**FIGURE 25** | Insurance-relevant climate index developed by actuarial societies for the United States and Canada.




*Source: Actuaries Climate Index (http://actuariesclimateindex.org), sponsored by the American Academy of Actuaries, Canadian Institute of Actuaries, Casualty Actuarial Society and Society of Actuaries, used with permission.*

*"We believe that the annual probability of a U.S. mega-catastrophe causing $400 billion or more of insured losses is about 2%..... much – indeed, perhaps most – of the p/c world would be out of business."*

Warren Buffett

Berkshire Hathaway Annual Letter to Shareholders, February 24, 2018.

## Bringing it all together: Stress testing and enterprise risk management

Stress testing is essential to understanding risk, particularly when underlying hazards are in flux. Underwriting and modeling are used by insurance regulators and insurance companies to identify and quantify current and prospective risks and to develop mitigation practices. Stress testing compares expected losses to collected and reserved premium funds and investment practices in order to ensure that adequate funds are sufficient in both amount and liquidity to pay losses at the point in time when they are forecast to manifest. Designing an effective stress-testing methodology and implementing it requires scenario analysis, stress modeling, investigating and developing clear definitions of risks, recording and reporting data, and open discussion with internal and external parties.

Ideally, stress tests reflect all simultaneous stresses across the insurance enterprise and the multiple geographies in which they operate, including broader market conditions influencing the insurance business environment. A hypothetical example would be one or more consecutive years with record-breaking wildfires in the West, coupled with an occurrence such as multiple hurricanes making landfall in major cities along the Gulf Coast, large losses associated with climate change litigation decisions, the introduction of new carbon taxes, or a major downward stock market correction. Rare years of extreme weather events could also coincide with major non-climate-related loss events such as earthquakes or pandemics imposing large healthcare costs.

While the magnitude of probable worst-case losses has progressively been revised upwards over time, the industry has not always been fast to support greater analysis. A report commissioned in 1986 by the All-Insurance Research Advisory Council (AIRAC, now the Insurance Research Council) to estimate the industry-wide effect of two $7 billion hurricanes (AIRAC 1986) was considered by some to be a frivolous exercise (Mills et al. 2001). Today such storms are regarded as relatively standard events, although it is remarkable that subsequent publicly available industry-wide studies like AIRAC's have not been conducted over the ensuing 30 years.

The types of risks that need to be taken into consideration in stress tests are underwriting risks; catastrophic risks related to exposure and resulting claims; externalities including but not limited to market risks in terms of price shifts and economic downturns; credit risks of all types; liquidity risks of all types; operational risks if systems fail or procedures in place are not adequate; and finally group risks associated with membership of certain parties resulting in liabilities and obligations being unfulfilled (IAIS 2003). A drought stress-test model applied to nineteen industry sectors in the United States and other countries found erosion of creditworthiness of bank loans and increased default risks (NCFA 2017). Affected industries included water supply,

agriculture, power generation, food and beverage production, and petroleum refining. Insurance industry modeler Risk Management Solutions (RMS) participated in the work.

In 2013 the North American Chief Risk Officer (CRO) Council, the CRO Forum and the International Actuarial Association published a volume on stress testing (PwC 2016). According to PwC, "[f]rom a regulatory perspective, the NAIC Own Risk and Solvency Assessment (ORSA) calls for a prospective solvency assessment to ascertain that an insurer has the necessary available capital to meet current and projected risk capital requirements under both normal and stressed environments." PwC conducted a survey with 55 U.S. insurers and concluded that stress testing would greatly benefit from additional efforts. One recommendation is a more robust stress testing platform (PwC 2016).

In North America, stress testing practices remain somewhat opaque. Only a handful of insurers responding to the NAIC survey offered substantive insights into their stress-testing practices with respect to climate change. None were robustly responsive to the spirit of the questions. There may exist real or perceived conflicts of interest in disclosing in-house stress modeling details to regulators, which in turn may affect the availability and transparency of data in making informed decisions by other parties such as investors. However, in many ways the practice is no different than that followed by accountants to certify financials for the purpose of reporting to shareholders and regulators.

Some health insurance companies consider themselves least likely to be affected by climate changes, although some insurers may be starting to model or test the risks. According to the 2016 NAIC survey, HealthNow has implemented an incident triage team as part of the business continuity program, and can invoke established disaster recovery plans and tactics. Also, through the annual ORSA modeling process, HealthNow performs stress testing on the company's top enterprise risks, but does not count climate change among these. Another company, HealthPartners, has identified three specific risks that climate changes could pose to its business.

- The proliferation of pandemic pathogens that could result in additional member claims and employees becoming too ill to process claims.
- A large influx in claims arising from tornados or other catastrophic weather events.
- An growth in cases of asthma or other chronic illnesses (NAIC survey results 2016, Q.6, Row 1175).

This response suggests that the company monitors changing health patterns of its members and takes these patterns into account during underwriting and product development, but no computer modeling or actual stress testing appears to be involved.

A number of other insurers' responses to the 2016 NAIC survey offer insight into the range of stress testing activities currently in practice. The Hartford Insurance Company of Illinois established a committee to assess and manage the company's risks at multiple levels (NAIC survey results 2016, Q.6, Row 1052).

A good example of the use of computer modeling with respect to stress testing is Utica First Insurance Company. It uses catastrophe modeling to evaluate risk aggregation using distance from the coast as criteria. For stress testing, the company specifically assesses the overall impact of two, 1-in-100 year hurricanes taking place in the same year as the company's largest climate-related loss exposure.

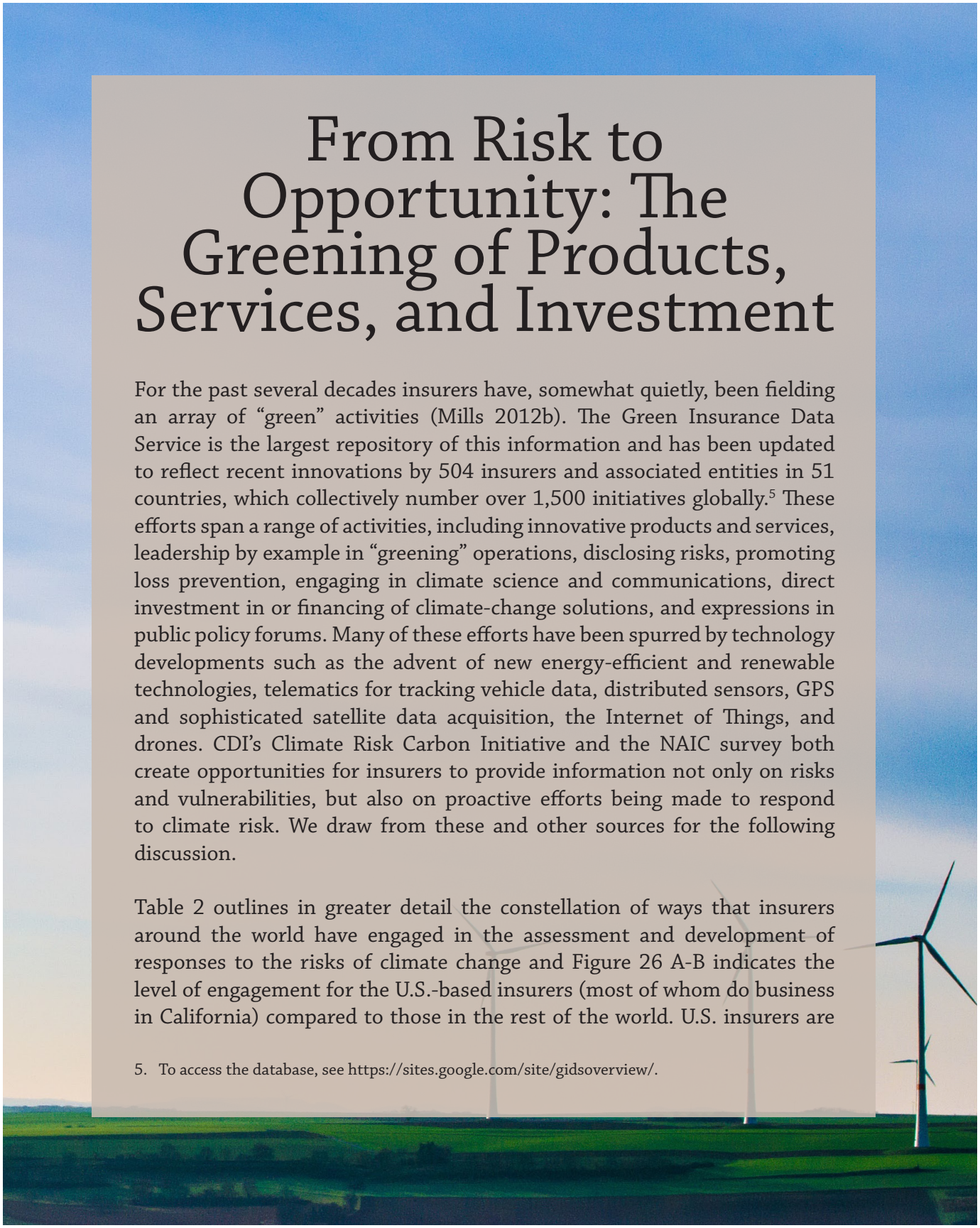
An elaborate stress testing model was developed by Metropolitan Life Insurance Company (MetLife). MetLife uses three independent

catastrophic models. To begin with, the company uses precise property locations, with geo-coding to street locations in nearly all circumstances. The company reviews both historical and anticipated near-term hurricanes with and without demand surge and storm surge. All three models generate results for five distinct hurricane regions. The company reviews results for deterministic events and stochastic events for high return periods ranging from 1-in-100-year to 1-in-2000-year probabilities. These events typically produce higher losses than losses that have previously resulted from storms. With this in mind, the company manages with the assumption of conservative return periods and obtains property catastrophe reinsurance based on near-term expected losses (NAIC survey results 2016, Q.6, Row 384).

Riverport Insurance Company investigates the possibility of "model miss" within vendor catastrophe models. For instance, the company compares modeled industry losses to revalued historic losses. The company investigates separate sub-components in the model. It also evaluates stress testing components related to the frequency and severity of occurances (NAIC survey results 2016, Q.6, Row 382). This is a very constructive use of the stress testing paradigm.

The potential devaluation of assets (i.e., transition risk) is not mentioned in NAIC disclosure responses regarding stress testing. Similarly, minimal indication is provided of health impacts being assessed.

The Florida Office of Insurance Regulation issued a data call for catastrophe stress test analysis in 2015 which evaluated insurance companies' ability to absorb specified hurricane scenarios. The participating insurance companies were required to provide data showing how their surplus position would be affected by one or more historical storm scenarios in terms of a company's capital and surplus (FLOIR a). If more state regulators follow the example set by California and Florida, insurers may begin to engage in more consistent stress testing and related analyses.



# From Risk to Opportunity: The Greening of Products, Services, and Investment

For the past several decades insurers have, somewhat quietly, been fielding an array of "green" activities (Mills 2012b). The Green Insurance Data Service is the largest repository of this information and has been updated to reflect recent innovations by 504 insurers and associated entities in 51 countries, which collectively number over 1,500 initiatives globally.[5] These efforts span a range of activities, including innovative products and services, leadership by example in "greening" operations, disclosing risks, promoting loss prevention, engaging in climate science and communications, direct investment in or financing of climate-change solutions, and expressions in public policy forums. Many of these efforts have been spurred by technology developments such as the advent of new energy-efficient and renewable technologies, telematics for tracking vehicle data, distributed sensors, GPS and sophisticated satellite data acquisition, the Internet of Things, and drones. CDI's Climate Risk Carbon Initiative and the NAIC survey both create opportunities for insurers to provide information not only on risks and vulnerabilities, but also on proactive efforts being made to respond to climate risk. We draw from these and other sources for the following discussion.

Table 2 outlines in greater detail the constellation of ways that insurers around the world have engaged in the assessment and development of responses to the risks of climate change and Figure 26 A-B indicates the level of engagement for the U.S.-based insurers (most of whom do business in California) compared to those in the rest of the world. U.S. insurers are

5. To access the database, see https://sites.google.com/site/gidsoverview/.

reasonably well represented among those crafting innovative insurance products and in-house energy savings programs and have far outnumbered global insurers in the divestment of fossil fuel investments. They have been under-represented in areas such as public commitments to substantive goals, voluntary climate risk disclosure,[6] engaging in climate science, investing in climate-change solutions, and providing finance for customer-side emission-reduction projects.

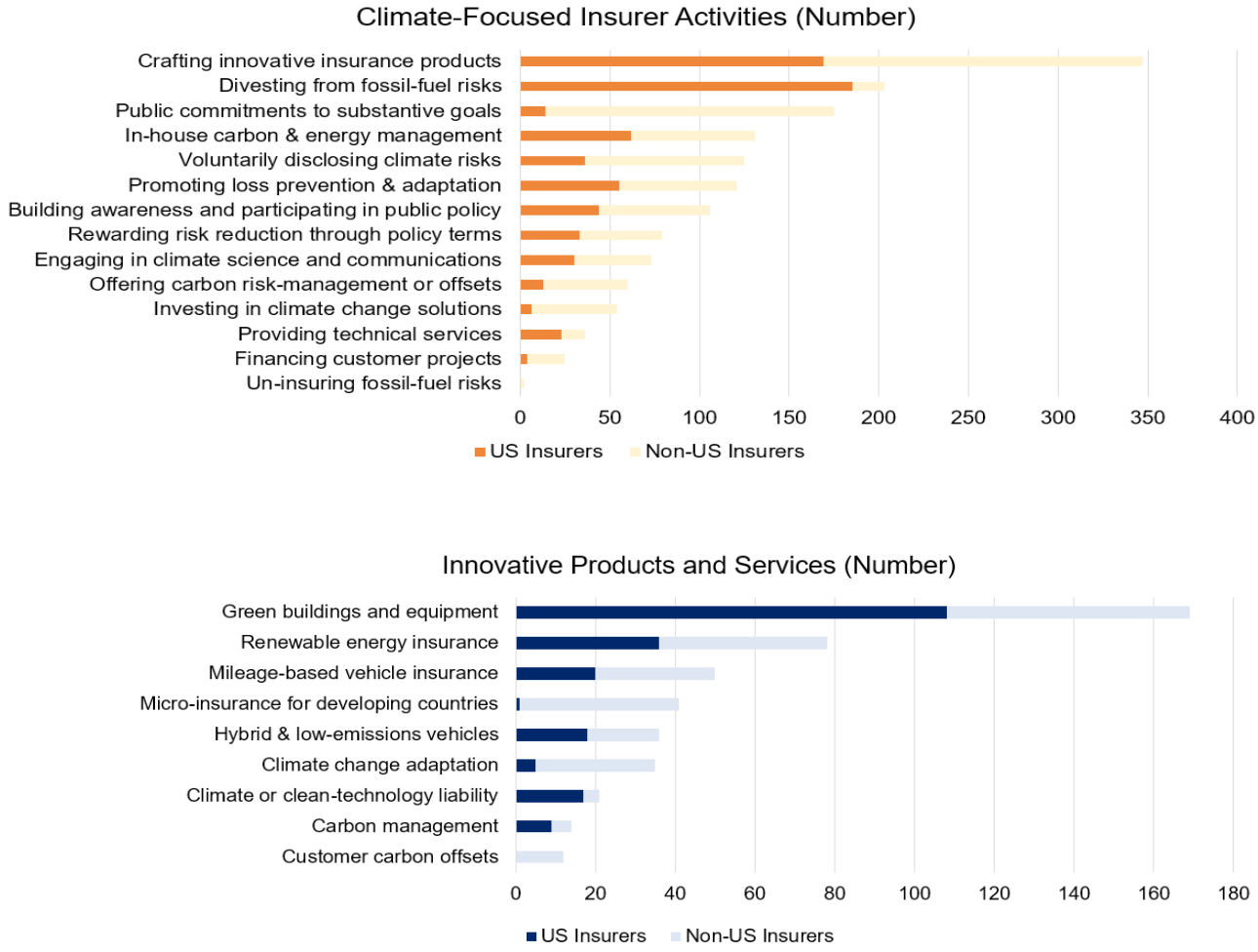
**TABLE 2** | Categorization of insurer climate-response strategies.

| | |
|---|---|
| **Public Commitments to Substantive Goals** | • An increase in chronic illness such as asthma (NAIC survey results 2016, Q.6, Row 1175)<br>• Cross-cutting corporate initiatives<br>• Institution of an enterprise risk management approach to climate change mitigation and adaptation<br>• Participation in industry consortia to advance best practices<br>• Corporate Social Responsibility (CSR) and Environmental, Social and Governance (ESG) reporting |
| **Engaging in Climate Science and Communications** | • Analyzing loss trends and assessing vulnerabilities to future climate change<br>• Integrating climate change into traditional catastrophe modeling<br>• Performing technical or market research on green technologies and climate change solutions |
| **Promoting Loss Prevention and Adaption** | • Traditional risk management approaches to reducing climate risks, like improved building codes<br>• Improving land-use planning vis-a-vis changing climate risks<br>• Integrating energy management and risk management perspectives<br>• Better management of forestry, agriculture, and wetlands<br>• "Rebuilding right" following losses<br>• Technology development |
| **Rewarding Risk-Reduction Through Policy Terms** | • Mileage-based vehicle insurance<br>• Incentivizing use of public transportation<br>• Assigning directors and officers liability with respect to climate risk<br>• Recognizing and rewarding correlations between sustainable building practices and a low risk profiles |
| **Crafting Innovative Insurance Products** | • New insurance products for energy service providers<br>• Energy-savings insurance<br>• Innovative renewable energy project insurance<br>• Green-buildings insurance<br>• Preferential terms for low-emission vehicles<br>• Insurance for the developing world (e.g., micro-insurance)<br>• Sustainable energy system technology warranties |
| **Providing Technical Services** | • Energy audits or carbon-footprinting services<br>• Engineering services for project development<br>• Performance benchmarking and rating |
| **Offering Carbon Risk Management or Offsets** | • Climate risk management services<br>• Carbon trading risk management<br>• Managing risk for Clean Development Mechanism (CDM) and carbon-offset projects<br>• Enabling customers to purchase carbon offsets |
| **Enhanced Customer Projects** | • Targeted lending for carbon-reducing projects or resilience enhancement<br>• Targeted lending for resilience enhancements |
| **Investments in Climate Change Solutions** | • Investment in capital projects that reduce greenhouse gas emissions<br>• Investment in bonds or equities that are screened to include climate change solutions<br>• Divesting from polluting industries<br>• Green buildings development |
| **Disinvesting from Fossil-Fuel Investments** | |
| **Un-Insuring Fossil-Fuel Risks** | |
| **Building Awareness and Participating in Public Policy** | • Providing climate change information and education<br>• Participating in the formulation of public policy<br>• Endorsing voluntary energy-saving policies<br>• Promoting energy-efficiency codes and standards |
| **Leading by Example: In-House Carbon and Energy Management** | • In-house energy/carbon management<br>• Sustainable operations |
| **Disclosing Climate Risks** | • Disclosure to regulatory agencies: CDI and the U.S. Securities and Exchange Commission (SEC)<br>• Disclosure to investors: CDP, ShareAction, PRI, and more |

*Source: Mills and EA*

6. These refer to the global CDP and other similar surveys. Mandatory disclosure has subsequently been required in California and several other states.

**FIGURE 26 A-B** | Insurer activities in assessing and responding to climate change risk (top) and detail on innovative products and services (bottom).




*Source: Mills and EA.*

Green products and services create business opportunities and emission reductions. Among these, U.S.-based insurers have engaged in more than half of green buildings activities globally, and are relatively well represented when it comes to mileage-based insurance products and specialized insurance for renewable energy projects. Conversely, they are virtually unrepresented in offering finance of customer-side climate mitigation improvements and in micro-insurance for emerging markets. While their level of direct investment in climate solutions is low by count, they represent a very substantial portion (approximately one-third) of the overall dollar value of such investments (Mills 2012b, with updates for this report).

The global insurance industry's relative emphasis on these types of products and services is indicated in Figure 26 B, which also shows the focus of U.S.-based insurers, indicating a strong focus on technology and energy, with less on climate change adaptation. A cross-cutting theme that can be observed is a trend toward the provision of services as distinct from isolated products or changes to insurance terms and conditions.

*"I believe there is an urgent need to address the current mismatch between the need for sustainable investment activities on the one hand, and a limiting regulatory environment on the other."*

Stephen Catlin, Special Advisor to XL's Chief Executive Officer, XL Group plc

ClimateWise Insurance Advisory Council website.

Some broad categories of green products and services that have been brought to market include:

- **Rebuilding to a higher level of energy performance following loss:** Through the payment of claims, insurers in effect finance hundreds of billions of dollars each year in restoring damaged property, much of which can be improved and made more energy efficient upon reconstruction. The former Fireman's Fund (absorbed into Allianz), Chubb (owned by ACE), The Hartford, Travelers, Farmers (owned by Zurich Financial), and many other carriers have offered "green reinstatement" coverages, which can include green building elements as well as ancillary costs such as those for design or certification of green features.

- **Energy and carbon risk management services:** Insurers have fielded a variety of services to provide support for climate change mitigation and adaptation. Broad categories of such efforts include clean energy system opportunity assessment, design, carbon footprinting, risk assessment, and financing. Among U.S.-based insurers, Allstate offers an online home energy calculator, ACE offers green building certification and carbon footprint calculation, Hartford Steam Boiler/Solomon offers energy benchmarking for oil refineries, Chubb offers infrared camera scans to find energy loss and fire hazards, Marsh offers geothermal energy exploration risk advisory, Chubb offers biofuel project risk assessment, and Chartis offers wind turbine loss-prevention services.

- **Insuring performance of clean energy systems:** A major barrier to the market penetration of solutions for reducing greenhouse gas emissions is uncertainty about the energy output of renewable energy systems (such as wind, solar, and geothermal) or energy savings achieved by major energy retrofits in buildings and industry. Hartford Steam Boiler and Allianz are among the insurers who have brought products to market that indemnify for losses related to output, delivery, or performance failure in energy markets. Performance insurance can improve credit ratings for project developers, thus reducing borrowing costs.

- **Aligning terms and conditions with reduced risk:** Green practices can be less prone to loss. Mileage-based insurance (also known as pay-as-you-drive insurance or PAYD) and premium credits for using public transportation are two examples in which driving risk aligns with environmental benefits. Companies offering mileage-based insurance in California include: AAA, Allstate, CSE Safeguard, Esurance, Metromile, Pacific Property and Casualty, Sequoia, and State Farm. Vehicle monitoring technology ("telematics") can also enable more precision pricing as a function of day versus night driving, patterns of braking and accelerating, and speed. Estimates of the potential for national gasoline savings due to mileage-based insurance programs range from 8% to 20%, which could achieve 140 to 257 million metric tons of carbon dioxide emission reductions annually in the United States depending on the scale of policy

implementation (Greenberg and Evans 2017).

- **Climate resilience services and financing:** Scaling up traditional localized loss-prevention practices such as safety inspections, leading insurers are developing offerings at the city and regional scales. Their roles can range from modeling and risk assessment to advice on adaptation measures to financing through instruments such as catastrophe bonds formally linked to resilience investments. A case in point is Santam Insurance's partnership with various NGOs to address rising fire, flood, and coastal risks by providing community-level education and awareness programs across multiple municipalities, donating firefighting equipment, and supporting improved flood-risk mapping in South Africa (ClimateWise 2017b).

- **Protection and repair of ecosystems damaged by climate change:** Swiss Re is working with public and private stakeholders to craft insurance products to rebuild coral reefs after major storms, which in turn protect coastal settlements and the tourism industry. It remains to be seen whether these types of projects will be scaled and replicated.

AIG's summary of their current offerings (per their response to Question 6 of the 2016 NAIC survey) illustrates the breadth of ways in which a single insurer can engage:

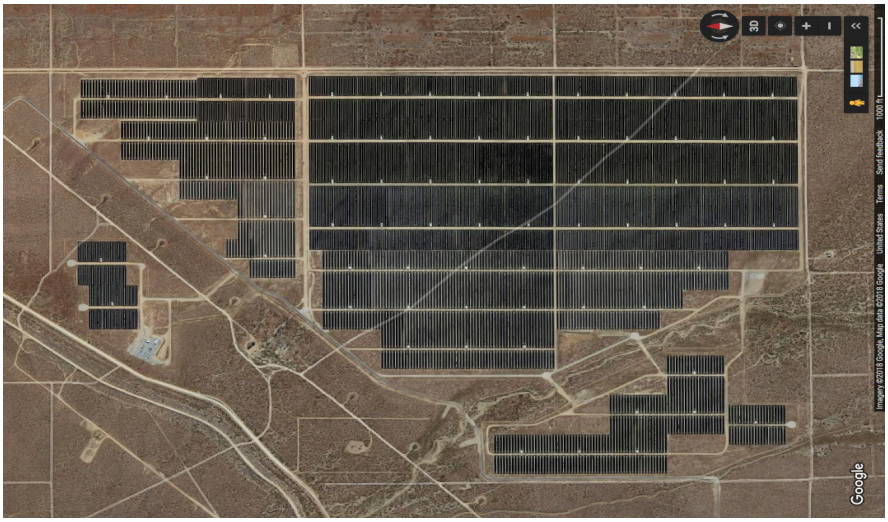
> As part of AIG's vision to contribute to the growth of sustainable, prosperous communities, one of its initiatives is to increase social resilience against extreme weather events by developing and implementing insurance solutions.... AIG provides a range of products and services across all lines of insurance that help clients respond to the "greening" of the economy, expand natural disaster resilience, reduce greenhouse gas emissions and support proactive action against the threat of climate change. For example, coverages are available to individuals and businesses that: replace ENERGY STAR or equivalent energy efficient materials; provide rebuilding costs for Leadership in Energy and Environmental Design (LEED®) certified and non LEED certified buildings and mobile energy properties; address the unique risks faced by homeowners who generate their own power and feed surplus energy back into the local power grid – including lost income generated from selling surplus energy back to the grid; and, compensate for direct physical loss or damage of a physical asset that is collected to create carbon offset credits. Additionally, professional liability coverages are available for registries that track, confirm, and verify carbon offset credits as well as for claims which may arise from greenhouse gas consulting services or emission reduction verification services.

## Some insurers believe investment in climate solutions diversifies assets and supports emission reductions

While significant focus has been placed upon assessing climate risk in the asset side of insurance companies, some insurers have also elected to invest in activities and industries poised to help address climate change. This practice began among European insurers in the mid-1990s and gradually spread to Asia and North America. With the global industry's $30 trillion under management, there is enormous potential for aligning asset management with risk management in the core business (CISL 2016).

An early example was AXA's CleanTech fund, which invested in companies developing technologies, products, or services having a positive impact on global warming, the environment, and linked concerns such as pollution, overpopulation, desertification, deforestation, and diminishing natural resources. One criterion for inclusion in

**FIGURE 27** | TIAA-CREF is an investor in the Catalina Solar Plant in the Mojave Desert, California.




*This 143-megawatt facility is a mile in length and contains over one million solar panels, providing enough power for 35,000 homes and offsetting 250,000 metric tons of greenhouse gas emissions each year. Source: CDI (2016b) and Google Maps.*

the fund was that the companies be active in renewable energy, water treatment, pollution control, waste treatment, or energy efficiency.

Green investment has been a focus in California as well. In 2010, California Assembly Bill 1011, written by now-Commissioner Jones, increased the ability of insurers to make green investments. The bill expanded the COIN program to provide tax credits to insurers who invest in qualifying green community development investments:[7]

- The Data Call Program (now concluded) evaluated investments that provide a benefit to low-to-moderate-income populations, focus on rural areas, or achieve environmental benefits. Seventeen insurers self-identified as having made investments in renewable energy projects in 2012 (the last year of the data call).

- The Bulletin Program analyzes insurer investments that will provide some type of social or environmental benefit. COIN-qualified green investment (in renewable energy, transit oriented development, economic development, and affordable housing focused on infill sites so as to reduce automobile dependency) among insurers earning over $100M in premium increased seven-fold to $8 billion after the program began in 2011 (CDI 2016b).[8]

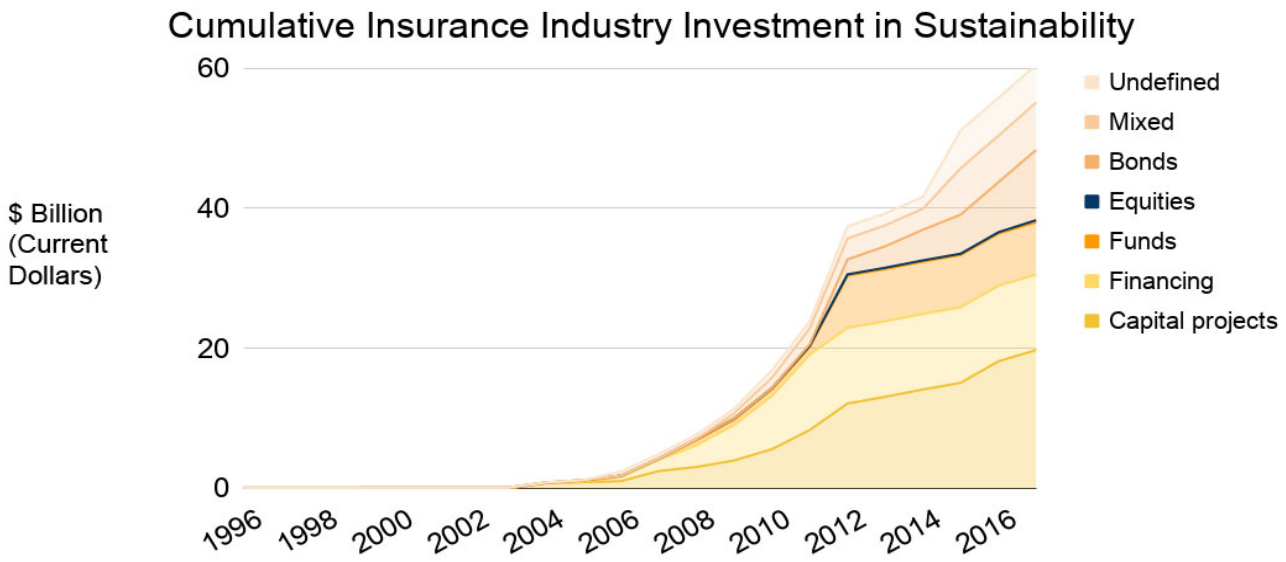
- The Tax Credit Program (now concluded) offered institutional and individual investors a 20% tax credit if they invested through a Community Development Finance Institution that would provide some type of social or environmental benefit.

One investment performed under COIN is the Catalina Solar plant in California's Mojave Desert (Figure 27).

7. Cal. Ins. Code §§ 926.1, 926.2, 12939. "Green investments" are defined as "investments that emphasize renewable energy projects, economic development, and affordable housing focused on infill sites so as to reduce the degree of automobile dependency and promote the use and reuse of existing urbanized lands supplied with infrastructure for the purpose of accommodating new growth and jobs. 'Green investments' also means investments that can help communities grow through new capital investment in the maintenance and rehabilitation of existing infrastructure so that the reuse and reinvention of city centers and existing transportation corridors and community space, including projects offering energy efficiency improvements and renewable energy generation, including, but not limited to, solar and wind power, mixed-use development, affordable housing opportunities, multimodal transportation systems, and transit-oriented development, can advance economic development, jobs, and housing." § 926.1(e).

8. Overall investment was $21 billion in the low-income and rural area investment categories.

**FIGURE 28** | Growth of ESG and climate-friendly investing by the world's insurance industry.




*Values are posted as of the year of investment or reported valuation, with no effort made to further track the funds as they may increase or decline in value over time. Sources are company announcements, disclosure reports, and third-party reports. Source: Mills and EA.*

An emerging instrument is green bonds, which support a diversity of projects ranging from greenhouse gas emission reductions to improving resilience to natural hazards. The scope is illustrated by the World Bank's $300 million "Kangaroo Green Bond," which finances projects in Australia such as:

- Rehabilitation of power plants to lower their greenhouse gas emissions;
- Solar and wind installations;
- Funding for development of new low-emission technologies;
- Building greater efficiency into transportation (fuel-switching and mass transport);
- Reduction of methane emissions from waste-disposal sites;
- Construction of energy efficient buildings;
- Reforestation and avoided deforestation; and,
- Resilience projects including protection against flooding and stress-resilient agriculture systems (World Bank 2014).

Twenty percent of the investors in this particular instrument were insurers (Insurance Journal 2014). One of these was QBE insurance, which has also created a program for customers in various markets (including North America) to direct a portion of their premiums to green investments: $453 million had been thus mobilized as of 2017 (QBE 2018). Figure 28 tabulates 73 such investments on the part of 30 insurers around the world, valued at $66 billion in 2018 dollars. U.S.-based insurance companies have made $19 billion of this total direct investment, substantially more than the $7.2 billion in renewable energy investment by U.S. insurers tabulated in earlier studies (McHale and Spivey 2016). Two broad categories of investment are represented in this compilation: those targeted to energy and climate change issues (approximately 85% of the total) and those more broadly defined as supporting ESG purposes (which include but are not limited to environmental issues such related to climate change). Direct investments include capital allocations for large renewable energy projects such as wind farms or industrial energy efficiency projects. Prominent examples among those included in Figure 28 and involving U.S. insurers include:

*"There's mass confusion in the industry… a lot are not aware that these types of [green] coverage really exist…. If insurance companies could help in that education the results would be better…."*

Travis Pearson, Head, Real Estate Practice,
CMR Risk & Insurance Services Inc. (Wells 2013)

- **AIG**: $2 billion for renewable energy projects including 15 wind projects totaling 5,100 MW, seven solar projects totaling 2500 MW;
- **Allstate**: $300 million for renewable energy projects;
- **Chartis**: $600 million for debt financing for green projects;
- **Hartford**: $475 million for solar, wind, and hydro projects;
- **Manulife – John Hancock**: $3 billion for renewable energy projects and finance;
- **MetLife**: $2.6 billion for 37 wind and solar farms and 56 LEED-certified properties;
- **New York Life:** $1 billion for renewable energy projects;
- **Prudential**: $3.8 billion for wind, solar, hydro, geothermal, and biofuels projects; and,
- **Voya Financial:** $1.15 billion for wind, solar, hydro, and geothermal projects.

While current levels of "climate-friendly" investment are a vanishingly small proportion of total insurer assets, ambitions for further investment remain high. For example, in its 2016 NAIC survey disclosure, AXA committed to a total investment in renewables of $15 billion by 2020, a nearly four-fold increase from their total investment as of 2017. In one of the more prominent examples of rising ambition, Swiss Re recently announced its plan to realign its entire $130 billion portfolio with ESG principles (WEF 2017).

In a particularly large investment by a U.S. insurer, John Hancock Life purchased a 49% stake ($400 million) in a portfolio of 30 different wind and solar projects spanning 13 states. The 1,300-megawatt electrical capacity of these facilities matches that of about two typical fossil fuel power plants (Surran 2017). Non-U.S. insurers have also readily invested in clean-energy projects in the United States. Notable among these are a 324-megawatt wind farm along the New Mexico-Texas border, which is one of five U.S. wind farms that Allianz has invested in thus far out of a total of 76 wind farms and seven solar facilities around the world (Allianz 2017).

Notably, this compilation does not attempt to value the significant insurer investments in green buildings. For example, as of 2016, Prudential's real estate arm managed 34.9 million square feet of LEED-certified building space, which was valued at $17.7 billion (Prudential).

Insurers have also taken initiative via their participation in coalitions of institutional investors seeking to develop investment practices aligned with sustainability principles. Ceres' Investor Network on Climate Risk and Sustainability (INCRS) is one example, which currently comprises 161 institutional investors with $25 trillion under management. Sixty-one insurance industry entitites are PRI signatories, some of which are U.S.-based (PRI).

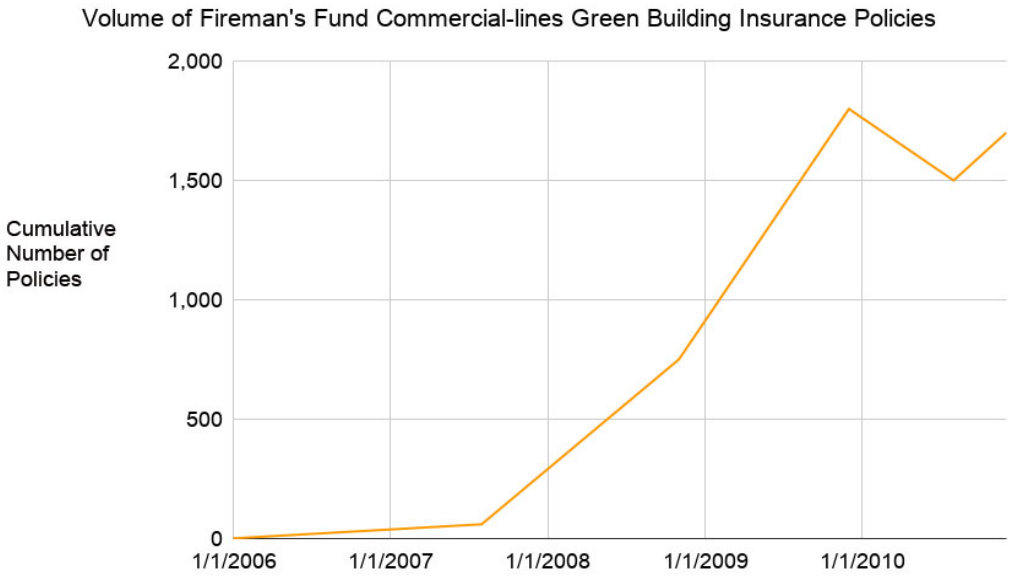
# Market uptake of "green" products and services

Ensuring that insurance markets function well and that consumers are equipped with adequate information about their insurance options and coverages is a key role of insurance regulators. Consumers can benefit from increased availability and awareness of green products and services. On the other hand, the offerings should have veracity and be represented clearly. CDI's long-standing support of transparency and disclosure is fully aligned with these goals. However, the distribution and regulatory structure of the insurance industry itself and the 2008 financial crash have thus far impaired the actual uptake of sustainable and resilient insurance products.

A U.S. insurance trade magazine polled 200 insurance agents and brokers with the question: "Has the green insurance revolution been oversold?" (Toops 2011). The answers were split evenly. Only a quarter of the respondents confirmed that their agencies were even writing green products or services. A full 15% were unsure, while 60% answered in the negative and only 13% were looking to this as an area for future growth. Types of products represented included new and existing green buildings property risks, carbon capture or carbon sequestration, executive liability and political risk, professional liability, and automotive. Less than one in five had experienced increased demand for the products in the 2010 to 2011 timeframe. Reasons given for less-than-ideal uptake ranged widely, including pricing, skepticism about greenwashing, broader economic downturn, lack of demand, owner-tenant split incentives, outmoded products, lack of sync with the latest green practices, and lack of broker, agent, and client education.

What these numbers do not illuminate is actual market uptake, which reflects a diverse combination of factors including insurer-side product design and the effectiveness of marketing efforts, together with how customers perceive value. It is problematic that no independent system exists for tracking the market uptake of green insurance products. However, there are isolated indications that these initiatives can gain market traction. For example, as of 2015, Munich Re's Green Tech Solutions group reported $100 million in premiums from green-oriented products (Ball 2015). Allianz reports its 151 "Green Solutions" (products and services) in 29 countries are generating $1.4 billion per year as of 2015 (Allianz). However, the allocation of these activities is not disclosed, and is presumably dominated by insurance for large-scale renewable energy projects. It is appropriate for regulators to track – and indeed to recognize – these accomplishments, while also being interested in initiatives that do not meet with success, particularly if barriers to adoption exist that are possible and appropriate for regulators to address. There is currently no requirement or format for insurers to report the impact of their green products, services, or other initiatives.

**FIGURE 29** | Fireman's Fund green-buildings insurance saw considerable uptake in the U.S. market between 2006 and 2010 (Fireman's Fund green policies).




*Source: Steve Bushnell/Fireman's Fund, used with permission.*

Significant information is available on green buildings insurance. Fireman's Fund founded the original green buildings insurance products in North America and shared data on uptake over the initial 2006 to 2010 period of sale. The original two products for commercial buildings featured premium discounts for green-rated buildings and "upgrade-to-green" and payouts to cover rebuilding to a higher level of performance following loss. Figure 29 shows that Fireman's Fund placed nearly 2,000 large commercial policies and premium volume peaking at approximately $160 million per year. This represented a sizeable 60% uptake among its commercial lines customers. Similar coverages were extended to all residential customers, nearly 46,000 policies in 36 states totaling $87 million in premiums. Notably, both products resulted in higher profits to the insurer than the comparable traditional products, with loss ratios for certified green buildings of about 20 points lower and those with green-upgrade coverage between 10 and 40 points lower. With the sale of Fireman's Fund, the visibility of its green product line diminished and market penetration is likely lower today (Bushnell 2018). Some information on uptake of energy performance insurance products is also available from Hartford Steam Boiler. Energy Efficiency Insurance (EEI), which makes building owners and investors whole if energy savings fall short of agreed targets, has been discussed for over a decade but only recently has demonstrated traction in the market. The key has been the economy of scale achieved when applying the offering to large portfolios of projects rather than to individual buildings. Since launch in 2015, Hartford Steam Boiler's EEI product has been applied to 220,000 square feet of residential buildings, 1.2 million square feet of commercial buildings, and 736,000 square feet of industrial buildings in six states, including California. Hartford Steam Boiler's Solar Shortfall product, brought to market in 2013, has been applied to 1.25 gigawatts of projects – the equivalent of five large conventional electric power plants – in 13 states (including California) and Ontario, Canada (Jones 2018).

Affordable telematics have become a highly

*"You can't have sustainability without resiliency."*

Chubb
Chubb Green Buildings Website

impactful technology development for vehicle insurance, able to track vehicle travel distance and an array of other driving behaviors. This development, in turn, has made it possible to rate individual drivers for insurance premium-setting purposes. Where climate change is concerned, telematics make it possible to tailor insurance premiums to distance driven, and this mileage-based insurance can incentivize energy savings while making the premium more accurately risk-based. The NAIC has gathered national data on market uptake (Karapiperis et al. 2015). It found that by mid-2014, 8.5% of U.S. consumers had telematics-based vehicle insurance (which may or may not measure distance driven among a variety of usage-based activities deemed relevant to insurance), nearly double that from 18 months earlier, and cite predictions that this will grow to 36% by 2020 (with 70% of insurers offering such products). As of 2015, Progressive, the largest provider of expressly mileage-based insurance at the time, reported $2 billion in premiums from two million customers nationwide. NAIC reports that more than half of U.S. insurers offered a telematics-based insurance product as of 2015 (an undefined proportion of which use distance driven as an underwriting factor). These data are not collected at the state level.

Barriers exist to further creation of innovative insurance products linked to emerging green practices and technologies. Some examples, and corresponding solutions, include:

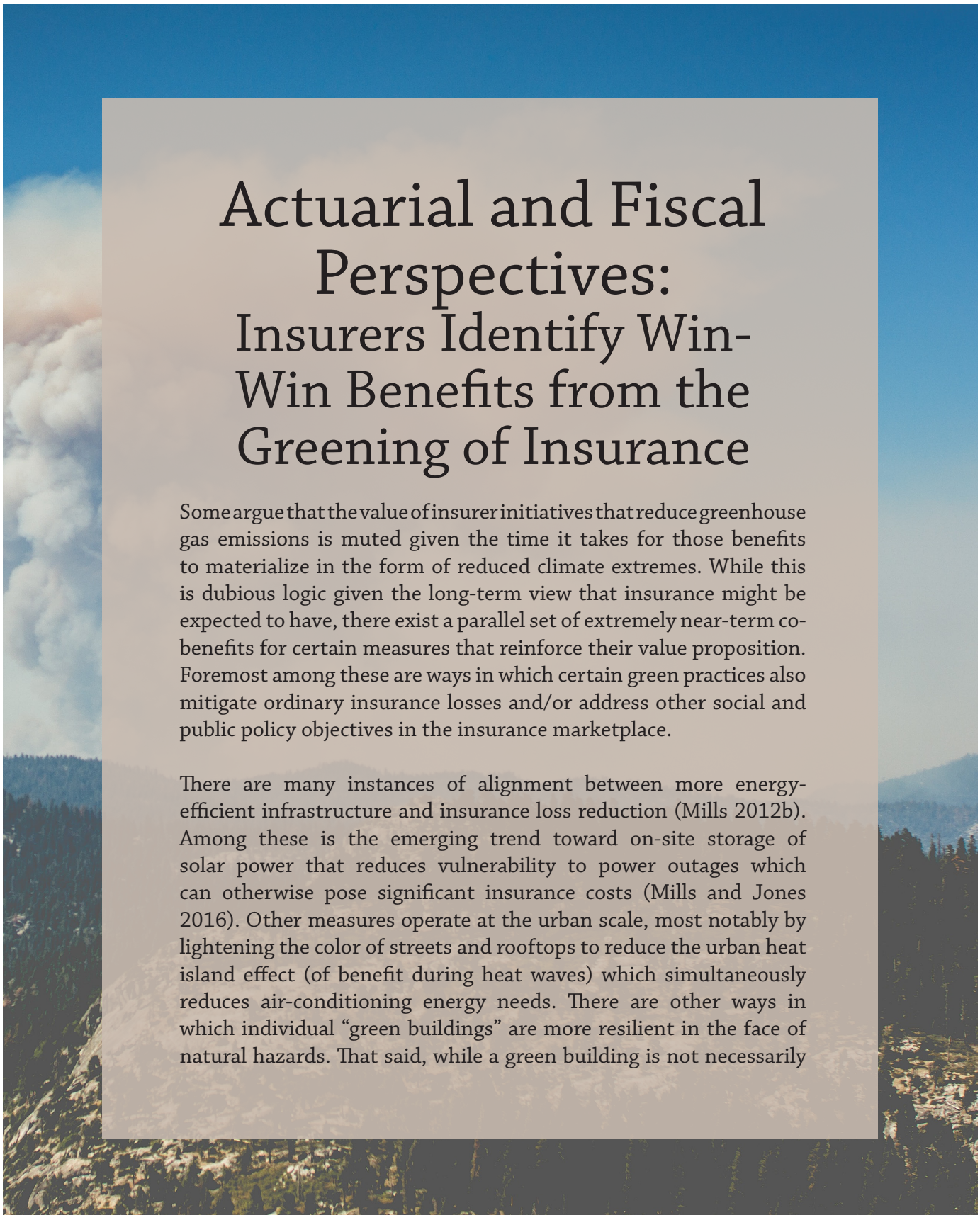
- By definition, innovations have no loss history, a problem that is compounded by lack of subsequent data collection or public availability of such data for academic analysis. Insurers' unwillingness to transfer data to other providers could pose a barrier, echoing much broader current societal discussions about personal data ownership. Engineering analyses can on occasion substitute for loss-experience data.

- Some consumer protection groups have opposed usage-based insurance on the basis that it invades privacy, although at least a third of surveyed consumers say they would join such a program if there were cost savings (Karapiperis et al. 2015).

- While questions have been raised as to whether costs for mileage-based insurance would rise for low-income consumers who must drive long distances to work, data actually show that current net subsidies flow from lower-income drivers to higher-income drivers.

- In an example of lifting barriers, CDI was first insurance regulator in the nation to allow Californians to share their personal vehicles in car-sharing pools without invalidating their auto insurance (Assembly Bill 1871 [Jones, Chapter 454, Statutes of 2010]).

As seen in the previous section, green investments are relatively well characterized, although the existing disclosure processes are relatively unstructured and results are time-consuming to retrieve. The European Commission is trying to specifically ensure the transparency and quality of green investment documentation by developing a taxonomy through the European Union Action Plan on sustainable finance.



# Actuarial and Fiscal Perspectives: Insurers Identify Win-Win Benefits from the Greening of Insurance

Some argue that the value of insurer initiatives that reduce greenhouse gas emissions is muted given the time it takes for those benefits to materialize in the form of reduced climate extremes. While this is dubious logic given the long-term view that insurance might be expected to have, there exist a parallel set of extremely near-term co-benefits for certain measures that reinforce their value proposition. Foremost among these are ways in which certain green practices also mitigate ordinary insurance losses and/or address other social and public policy objectives in the insurance marketplace.

There are many instances of alignment between more energy-efficient infrastructure and insurance loss reduction (Mills 2012b). Among these is the emerging trend toward on-site storage of solar power that reduces vulnerability to power outages which can otherwise pose significant insurance costs (Mills and Jones 2016). Other measures operate at the urban scale, most notably by lightening the color of streets and rooftops to reduce the urban heat island effect (of benefit during heat waves) which simultaneously reduces air-conditioning energy needs. There are other ways in which individual "green buildings" are more resilient in the face of natural hazards. That said, while a green building is not necessarily

a disaster-resilient one (Figure 30), neither is a disaster-resilient building necessarily green or fully "sustainable." Insurers are in a position to advance a more sophisticated notion of sustainability where both of these principles are considered and integrated.

This thinking extends beyond property protection to life and health. The combustion of fossil fuels in vehicles, buildings, and industry creates significant airborne emissions in addition to greenhouse gases. These pollutants, in turn, are tied to multiple health effects, often involving respiratory ailments (Hayes and Kubes 2018). In particular, much of the unhealthy air pollution to which 125 million Americans (American Lung Association 2017) are exposed comes from electric power plants. Energy efficiency thus results in quantifiable health benefits while reducing greenhouse gas emissions.

In another prominent example of insurance-climate co-benefits, the telematics-based PAYD insurance pricing approach for vehicles is far more actuarially accurate than "bulk pricing." Driving risk is strongly related to the amount of driving, meaning PAYD approaches can identify the most appropriate rate for each individual driver, while other risk factors like driving history can also be incorporated in pricing, as can risks of vandalism or theft (separate risk pools such as urban and rural groups can also be defined). Pricing insurance based on mileage also eliminates regressive cross-subsidies from populations that drive less than average to those who drive more (Bordoff and Noel 2008; Hymel 2014). Low-mileage drivers

**FIGURE 30** | A home with solar panels crushed in the early-2018 Montecito mudslides.

*Source: (Photo: Marcio Jose Sanchez, AP. Licensed from AP).*

**FIGURE 31** | Mangrove forests.

*Source: (Photo: dronepicr via flickr).*

tend to be in lower income groups as well, so the mileage-based approach enhances insurance affordability and is economically progressive. If insurance becomes more affordable as a result, the proportion of uninsured drivers should decline, which is societally desirable. Additional benefits of telematics include the elimination of errors in self-reporting mileage. With proper consideration given to privacy issues, this technology can also provide benefits such as tracking stolen vehicles, supporting navigation, and providing feedback on driving behavior. Additional social benefits include reduced congestion and accidents/injuries (VTPI 2018), which are in turn of value in the life and health insurance sector.

Co-benefits also accrue from larger-scale insurer initiatives. One of the earliest and longest-running efforts to improve resilience is the restoration of coastal mangrove forests by the large Japanese insurer Tokio Marine Group. Mangrove forests have dual benefits with respect to climate change. First, they remove carbon-dioxide from the atmosphere as they grow, thereby offsetting a proportionate amount of emissions (Figure 31). Second, they reduce the risk of storm surge and coastal erosion in areas where they grow, as Tokio Marine observed along the Thailand coastline following the 2004 Indian Ocean Earthquake and Tsunami. Tokio Marine began its mangrove planting project in 1999 and as of March 2017 had established 25,000 acres (about 40 square miles) of these forests across nine countries, primarily in Asia (Tokio Marine 2017). The company describes this as a 100-year program.

# New Best Practices are Emerging

This report concludes by taking stock of emerging strategies worth consideration by insurance regulators. Each merits further assessment and consideration of its relevance and applicability in specific markets.

## More closely monitor the insurance-relevant climate situation and responses

Climate change is one of the most dynamic risks facing the insurance marketplace. It behooves regulators to continually monitor loss trends and their drivers. Basic data on climate- and weather-related losses are not always readily available (particularly for events that are not regarded as catastrophic but rather are chronic or slow-onset and yet have large losses in the aggregate) or are proprietary. For example, while winter and non-convective storms (i.e., those other than hurricanes) are one of the largest categories of insurance losses year over year nationally (Figure 5), and are most clearly rising, no comprehensive California-specific data is available in the public domain. Despite their aggregate losses, the relatively small size and distributed nature of these events results in less attention than headline-grabbing catastrophes. Another example of data gaps are multiple-peril flood-related losses for commercial buildings outside the NFIP. Regulators should examine new initiatives to gather and mobilize such basic data in the public domain for the benefit of policymakers and consumers.

> *"[T]here is an increasing risk that pricing trends could consistently lag actual loss experience, which may force the industry to play 'catch up' in raising premiums to match increasing losses."*
>
> Moody's (2018)

Insurers currently have little incentive to fund original climate research and deep analysis. While there is a vibrant ongoing stream of climate science and research, it is not typically organized with insurers in mind. Effort is needed to continuously translate the latest research into a form that is understandable and applicable to insurers and their regulators.

It is also important to monitor the progress of insurance innovations (green products, services, and investments). Considerable innovation is underway in this arena but is not systematically tracked or analyzed by regulators, and the loss-experience associated with these technologies and practices are not always known.

The give-and-take between public and private insurance is continually in play. In the United States, the NFIP is in flux and faces increasing solvency challenges. It is timely for regulators and commercial insurers to continue looking for market-based solutions to manage these risks.

## Refine insurance pricing and contract design to more precisely reflect climate risks and incentivize mitigation efforts

Imprecise underwriting may lead to considerable unintended cross-subsidization of risk in some parts of the market, and can reduce the impetus to invest in mitigation. Consider the specificity of the way drivers and their cars are rated in comparison to that of homes. Unintended cross-subsidies are not only inequitable but can also reduce incentives to write insurance in higher-risk areas, impede insurers' ability to give mitigation discounts, and reduce the incentive of homeowners to invest in loss-prevention (Dixon et al. 2018).

Overseas insurers such as Aviva have brought state-of-the art "big data" to bear in more precisely pricing homeowners' insurance, which has the potential to improve market function by providing an economic incentive to mitigate risk. U.S.-based USAA Insurance is among the insurers providing premium credits for wildfire mitigation per National Fire Protection Association guidelines in California and several other states (NFPA). However, in cases of powerful, fast-moving fires it is the larger-area vulnerability as opposed to that in the immediate vicinity of a given property that most strongly determine outcomes.

Rates based on averaged multi-decade loss histories dampen recent signals that climate change may be providing. To the extent that rates are based on historical loss experience, it is important that recent trends are detected and considered in setting premiums. To the extent that premiums can reflect the outlook on future loss expectations, they will send a price signal consistent with improving resilience. The California prior approval process allows for variances which include using a very recent loss trend in projecting future rates. Loss-prevention efforts are poorly reflected in ratemaking, which dilutes the economic incentive for insureds to enhance the resilience of their properties. Conversely, however, potential changes in losses under climate change should not be used to "game" the system by seeking unjustified rate increases.

*"We believe strongly to address the rising risks of climate related natural disasters, and to close the insurance protection gap, governments, regulators, academics, private sector firms and other leaders must collaborate."*

Steve Weinstein, Group General Counsel and Chair,
RenaissanceRe Risk Sciences Foundation, RenaissanceRe
ClimateWise Insurance Advisory Council website

## Fortify consumer protections and resilience efforts to ensure insurance availability, adequacy, and affordability

As climate change progresses, consumer protection will become even more challenging for insurance regulators. It is thus incumbent on regulators to track and mitigate insurance availability, adequacy, and affordability issues together with any specific equity issues that arise for particular segments of the market such as low-income consumers. More exhaustive data should be readily available. The means for doing this at times lay outside the formal insurance sector, as illustrated by the roles of building code officials, city- and land-use planners, lenders, disaster preparedness agencies, and academics. Insurance regulators will need to increasingly engage with these other decision-makers, seeking areas of aligned goals. Consumers are the ultimate stakeholders.

In 2018, Commissioner Jones spoke at a Legislative Committee Hearing on Drought, Climate Change, and Fire. He stressed several recommendations for legislative reform that would address all or most of the issues that have come to light with CDI's work in addressing climate-related wildfire risks. First, CDI wants legislation that requires insurers to provide coverage if homeowners make appropriate improvements or that requires insurers to at least offer a minimum of differences and conditions coverages when such improvements are made. Second, CDI wants a mitigation premium credit for communities and homeowners that make property more defensible. Third, CDI wants an appeals process for homeowners to appeal non-renewals. Fourth, CDI wants insurers to file underwriting criteria for wildfires and allow CDI an opportunity to review this criteria. Fifth, CDI wants to be authorized to collect industry-wide loss data because some insurers do not have access to good loss data and are instead forced to rely on third-party data that is from outside California or from dissimilar events.

## Continue to champion and improve climate risk disclosure

Disclosure has proven to be feasible and highly informative, although many disclosure efforts thus far have focused on predominantly open-ended questions about climate risk and on the carbon-intensity of certain invested financial assets. More comprehensive disclosure processes must also look at assets vulnerable to climate change. These include real estate as well as investment sectors that are particularly vulnerable to climate change, such as agriculture, water, and tourism.

Within existing disclosure surveys, further pointed questions may elicit more substantive and usable responses (Leurig 2011). If adding questions to the NAIC survey is infeasible, regulators implementing the survey could instead update guidelines to indicate that such information is being sought (CDI 2016c). Furthermore, surveys

could allow for discrete inputs to facilitate truer database functionality. For instance, insurer responses to the NAIC survey include the reporting of many billions of dollars in gross market value of "green real estate," rather than the more relevant incremental investment made to achieve this goal. Other insurers appropriately exclude real estate from their tallies of green investments.

Disclosure need not focus only on downside risks. For example, insurer responses to the NAIC survey appear to include very few responses discussing stress testing or green insurance products and related innovations. Additional questions on these topics could elicit information on best practices in these areas.

Commissioner Jones has recommended that the TCFD, the FSB, and the G-20 take concrete steps toward mandatory insurer disclosure of portfolio risks. Outreach efforts should involve major mainstream financial filings agencies, such as the U.S. Securities and Exchange Commission (SEC), and encouraging them to incorporate by rulemaking or other mechanisms the TCFD recommendations (the SEC has previously recognized standards by an outside organization in an interpretive release). The TCFD rates the 80 largest global insurers on their approach to climate-related risks and opportunities. In the 2018 ratings, no U.S. insurers fell in the categories B to AAA band, three fell in the categories C to CC band, 18 fell in the "D" band, and three fell in the "X" (lowest) band (AODP 2018).

## Support innovation in loss modeling, data science, and stress testing

Insurance loss modeling has been improving for decades, and this process will no doubt continue. A changing climate and associated risk landscape present constant challenges to modelers. Further

convergence of earth-science and economic-impacts modeling is essential for improved accuracy and relevance. More emphasis could be placed on maximum probable aggregate annual losses (in addition to narrow per-event modeling), in both the property and casualty and the life and health lines. Enterprise-wide risks range from property, to liability, to health, to assets.

In light of issues regarding the conflict between data ownership and IP on the one hand and model transparency and peer review on the other, some states have discussed creating public models that are more open for peer review. Considerable scope exists for doing so, particularly by building off of the already enormous ongoing public investment in climate model development together with that by state and federal agencies for issues such as agricultural and fire risks. The industry's own non-profit Oasis Loss Modelling Framework is attempting something similar for emerging market applications.[9] Integration of earth-science modeling practices with economic analysis can yield models that better pinpoint potential industry stresses as well as prudent resilience investments.

9. For more information, see https://oasislmf.org.

Stress testing can become more nuanced in its ability to incorporate climate stresses across the insurance enterprise (underwriting and asset management). Techniques should be standardized. As most insurers have exposures in multiple markets, it is essential that regulators coordinate efforts, such as through the "International Colleges" wherein regulators from multiple countries collaborate in assessing cross-cutting issues.

Insurance regulators could have more input into the setting of publicly funded climate research agendas to inform stress testing and otherwise ensure relevance and usability of the results. Among the important frontiers are better modeling the benefits of adaptation investments, improved spatial and temporal resolution on the costs of climate change, and more developed risk profiles of the disparate strategies for reducing climate change.

## Identify and mitigate barriers to green insurance and risk reduction

While the desirability of mitigating climate change is uncontroversial, the process of transition can be costly or otherwise socially and politically difficult. New practices also bear risks for insurers.

Regulators must be aware of these challenges and seek to minimize barriers and provide inducements where appropriate. An example of the latter (noted previously) were CDI's COIN tax credits for green-infrastructure investment that was awarded for a period of time to insurers. Another illustration of the possibilities is the appropriate state agencies awarding carpool lane access for mileage-based insurance policy holders. On the other hand, regulations can also form barriers. As observed by the NAIC in the case of mileage-based insurance offerings:

> Many states require insurers to obtain approval for the use of new rating plans. Rate filings usually must include statistical data that supports the proposed new rating structure. Although there are general studies demonstrating the link between mileage and risk, individual driving data and UBI [usage-based insurance] plan specifics are considered proprietary information of the insurer. This can make it difficult for an insurer who does not have past UBI experience. Other requirements that could prevent certain UBI programs include the need for continuous insurance coverage, upfront statement of premium charge, set expiration date, and guaranteed renewability (NAIC 2018).

These issues were overcome in the case of California's admission of usage-based insurance products.

Even where insurers may be inclined to innovate, the business case may be lacking. Decades ago, utility regulators (initially through their national organization) effectively addressed the problem of underinvestment in customer-side energy efficiency improvements that were less expensive than building new energy production capacity and thus socially desirable. They did so by incorporating utility investments in customer-side energy efficiency into rates and their return on investment. This unleashed billions of dollars in such investment each year, which continues to this day.

## Participate in climate mitigation and adaptation research and inter-agency initiatives

Many California agencies and programs would benefit from engagement by the insurance industry and its regulators. Note that the California Climate Action Team's board is populated by heads of a wide range of agencies, without formal representation from the insurance community. These include expected units such as the California Energy Commission, the California Air Resources Board, the California EPA, Caltrans, the Governor's Office of Planning and Research, the California Natural Resources Agency, Cal Fire, and the California Department of Water Resources, but also a much broader coalition including the Governor's Office of Business and Economic Development, the California Business, Consumer Services and Housing Agency, the California Department of Food and Agriculture, the California Health and Human Services Agency, the California Government Operations Agency, and the Strategic Growth Council.

Illustrative questions that the broader research community is well-equipped to take up, but which are not necessarily within the mandate of other agencies include:

- How can climate modeling be made more relevant to insurance community?
- What are the long-term health insurance impacts of wildfire smoke?
- What will be the effect of changing weather conditions on vehicle accidents?
- What is the optimal pay-as-you-drive price structure to maximize market uptake and driving response, and does the practice decrease the numbers of uninsured drivers?
- What are the risk profiles and associated loss experience of "green technologies" compared to conventional ones?
- Can a resilience rating system be developed to help standardize assessment and underwriting?
- What is the elasticity of demand for resilience investments to the cost of insurance?
- How will climate change differentially impact the availability, adequacy, and affordability of insurance for disadvantaged groups?

A key challenge is that institutional arrangements for organizing and financing such ambitious research needs are not currently in place.

## Enhance market awareness of disparate risks and insurance responses

Markets cannot function properly without information and education, much of which is presently lacking in the climate-insurance nexus. Many stakeholders, including consumers, insurers, brokers and agents, and even regulators are often not well enough equipped to make the best decisions. One useful trend is that real estate appraisal practices are evolving to better incorporate consideration of climate risk in the property valuation process, thus standing to send better market signals of the cost of vulnerability and value of resilience.

Most consumers are unaware of the diversity of climate-related exposures that they face (physical and health), options for enhanced resilience, or the range of solutions available to them. Among these needs, the International Actuarial Association strongly argues for the need for insurer involvement in better communication of climate-change health hazards (IAA 2017).

Improved risk awareness may also be called for among professionals. For example, standards of care may be evolving such that it will become incumbent on designers and builders of structures, to ensure rethinking of siting and resilience to changing climate- and weather-related hazards. Indeed, there is precedent in California, under the doctrine of strict liability, for builders of tract homes to be held accountable for defective construction (e.g., Oliver v. Superior Court [Regis Builders, Inc.] [Cal. App. 4th 1989]).

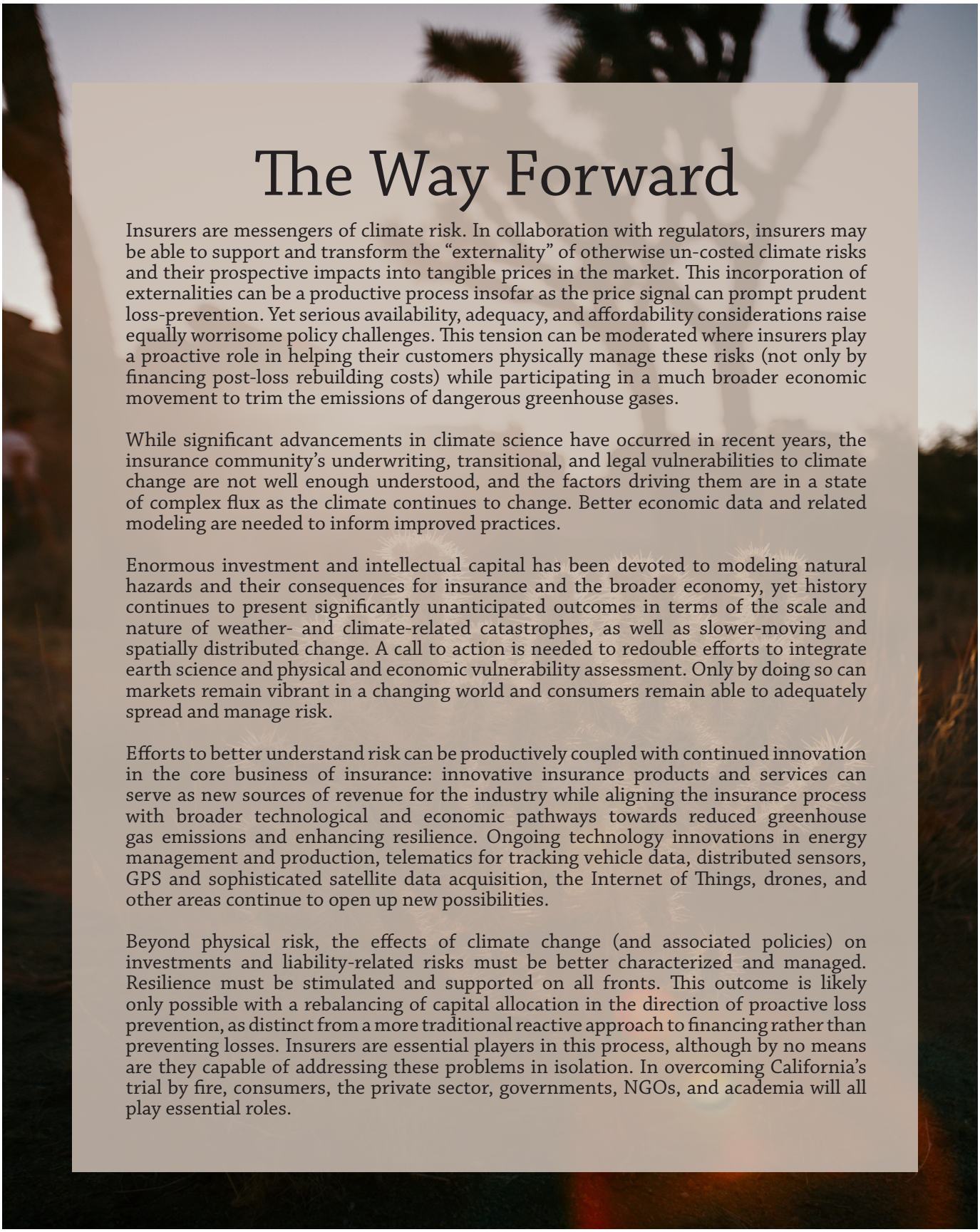
Existing disclosure systems (with improvements, as discussed previously) can serve the valuable function of gathering raw information, but further work is needed to analyze and make that information available to various constituencies that stand to benefit from it.

Consumers are also poorly equipped to identify or to judge the caliber of green insurance products and services, or the potential efficacy of resiliency enhancement strategies offered to them. Insurance regulators, in their role of consumer protection, are

in the position to moderate this process through non-proprietary commercial consumer education.

## Increase engagement in broader public policy discussions

Insurers have for decades been engaged in public policy discussions on climate change, particularly in Europe and Asia. Prior to the recent formation of the SIF, insurance regulators have been far less engaged. There is ample room for insurance regulators at the table. Among the very key issues today are the relative roles of public and private insurance and risk-sharing. Under climate change, public insurance systems will come under increased solvency stress, and the data, skills, and risk management insights of private insurers (and their regulators) may be called upon.



# The Way Forward

Insurers are messengers of climate risk. In collaboration with regulators, insurers may be able to support and transform the "externality" of otherwise un-costed climate risks and their prospective impacts into tangible prices in the market. This incorporation of externalities can be a productive process insofar as the price signal can prompt prudent loss-prevention. Yet serious availability, adequacy, and affordability considerations raise equally worrisome policy challenges. This tension can be moderated where insurers play a proactive role in helping their customers physically manage these risks (not only by financing post-loss rebuilding costs) while participating in a much broader economic movement to trim the emissions of dangerous greenhouse gases.

While significant advancements in climate science have occurred in recent years, the insurance community's underwriting, transitional, and legal vulnerabilities to climate change are not well enough understood, and the factors driving them are in a state of complex flux as the climate continues to change. Better economic data and related modeling are needed to inform improved practices.

Enormous investment and intellectual capital has been devoted to modeling natural hazards and their consequences for insurance and the broader economy, yet history continues to present significantly unanticipated outcomes in terms of the scale and nature of weather- and climate-related catastrophes, as well as slower-moving and spatially distributed change. A call to action is needed to redouble efforts to integrate earth science and physical and economic vulnerability assessment. Only by doing so can markets remain vibrant in a changing world and consumers remain able to adequately spread and manage risk.

Efforts to better understand risk can be productively coupled with continued innovation in the core business of insurance: innovative insurance products and services can serve as new sources of revenue for the industry while aligning the insurance process with broader technological and economic pathways towards reduced greenhouse gas emissions and enhancing resilience. Ongoing technology innovations in energy management and production, telematics for tracking vehicle data, distributed sensors, GPS and sophisticated satellite data acquisition, the Internet of Things, drones, and other areas continue to open up new possibilities.

Beyond physical risk, the effects of climate change (and associated policies) on investments and liability-related risks must be better characterized and managed. Resilience must be stimulated and supported on all fronts. This outcome is likely only possible with a rebalancing of capital allocation in the direction of proactive loss prevention, as distinct from a more traditional reactive approach to financing rather than preventing losses. Insurers are essential players in this process, although by no means are they capable of addressing these problems in isolation. In overcoming California's trial by fire, consumers, the private sector, governments, NGOs, and academia will all play essential roles.

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