DRAFT REPORT of the Climate Insurance Working Group

EXECUTIVE SUMMARY

California, the United States, and the planet are facing increasingly extreme and compounding consequences of climate change. Without financial resilience and risk reduction, communities are likely to enter a damaging feedback loop where escalating risks lead to increased losses, then financial backsliding, fewer insurance options, and diminished capacity for future resilience. To prevent the worst outcomes and ensure a more climate resilient future, California needs to act quickly to close existing gaps in risk assessment, risk communication, risk reduction, and risk transfer. Closing these specific gaps will build a stronger and more equitable resilience to climate-intensified disasters. Insurance is an underappreciated cornerstone of that resilience. It not only improves recovery to climate disasters, but can also provide incentives for climate adaptation, averting some future impacts.

Without early action, climate change impacts will exacerbate existing inequities. Amidst accelerating climate risks, California needs to envision policies that build capacity for strong and equitable recoveries, especially in low-income communities and communities of color, which experience higher rates of heat-related exposure and deaths[1,2], and greater damages from flooding.[3] If only some communities in California bounce back from climate impacts, the entire state will struggle moving forward. Innovative approaches to risk assessment and risk communication are needed for further resilience. Such approaches would enable communities to better prepare, focus risk reduction investment where it will be needed most, and establish risk transfer solutions to buffer damages and broaden resilience.

At the core of this report are recommended actions for California to expand insurance protection and strengthen the insurance sector's role in reducing mounting climate risks. It provides a forward-looking approach to closing coverage gaps and achieving sustainable insurance markets aimed at preserving the role of insurance in disaster recovery. Innovative insurance strategies for responding to climate impacts in this report include harnessing insurance mechanisms, developing new public sector tools and partnerships, thus creating a more climate resilient future.

This report focuses exclusively on the physical and health impacts of climate change to individuals and communities, exploring the role of risk transfer tools in managing these risks to health, structures, and properties, as well as to the related financial stability of local governments and businesses. The report does not address transition risks related to investments or litigation risks associated with climate change, nor does it address some of the existing California laws that apply in the immediate aftermath of disasters, including short-term moratoria and claims handling.

The problem: California is facing multiple accelerating climate impacts, has existing insurance gaps and inequity among communities, and an unclear pathway to resilience

California faces multiple growing risks, including from climate-worsened wildfires, extreme heat, and flooding. Yet insurance for each of these perils is inadequate in the state. With climate-fueled wildfires scorching hundreds of thousands of acres, causing the loss of life and property, wildfire insurance availability has shrunk while the premiums charged have increased. Uptake of flood insurance—typically through the National Flood Insurance Program—is low, although the risk of flooding remains high. Meanwhile, the disruptive impacts of heat waves on health, energy systems, local economies, and other sectors are not commonly measured during or after the events, and largely lack any insurance coverage at all, leaving people vulnerable to such disruptions. In short, California has a widening protection gap—the gap in insurance coverage between insured and uninsured losses. A widening gap leaves communities more exposed to financial costs and less able to recover. This report targets three primary threats:

Wildfires
In only the last few years records have been set in number of acres burned, structures destroyed, people evacuated, and overall costs. With recent and likely future development in the wildland urban interface—areas in which development occurs within or adjacent to wildlands— increased heat and drought, and the legacy from decades of severe fire suppression in forested areas, the Fourth Climate Assessment projects that high severity wildfires will occur more frequently.

A large percentage of homeowners and businesses have insurance coverage for wildfires through standard property insurance. But the wildfires of 2017-2020 revealed growing challenges in this market. Many homeowners and businesses have received insufficient payouts, straining their own financial security and raising concerns about underinsurance and uninsured losses. Simultaneously, insurers have made record payouts, raising concerns about the long-term sustainability of both homeowners and commercial insurance amid climate-intensified wildfires. In the face of such damage, and without effective risk mitigation, insurers may withdraw from offering insurance or raise premiums to levels that make policies unaffordable to those in high-risk areas throughout the state. This phenomenon is already observable in certain parts of California, where non-renewals of homeowners policies are increasing and premiums are rising, sometimes with over 100% increases, in areas vulnerable to wildfire while premiums have remained stable in urban areas.

Many states have a publicly authorized insurance program that guarantees access to insurance for homeowners whose properties face so much risk that coverage is otherwise unavailable in the insurance market. Homeowners have increasingly turned to California's high risk pool, the expensive but available California FAIR Plan (Fair Access to Insurance Requirements) in high wildfire-risk areas, with the number of policies jumping from 120,000 to nearly 200,000 between 2014 and 2019. While the

FAIR plan is a useful backstop for homeowners, it does not address the underlying problem—the ballooning risks from the growing impacts of climate change.

Extreme heat
In 2020, California experienced unprecedented temperatures and duration of heat waves across the state, and the aptly named Death Valley recorded a temperature of 130 degrees Fahrenheit, reportedly the highest temperature ever measured on the planet. Such an expansive heat wave foreshadows the extreme heat, especially urban-heat-island, projections of the Fourth Climate Assessment: higher peaks, longer durations, and high night-time temperatures that prevent daily recovery for communities, worsening health impacts. Heat waves can worsen air quality and put communities at further public health risk, including asthma and other respiratory illnesses, particularly in communities that are already living in areas with poor air quality. The power grid was disrupted, thwarting cooling strategies and economic resilience. Going forward, the state is projected to experience even greater extremes of temperature that will stress impoverished communities and communities of color, agriculture, urban and rural workers, water availability, electric-grid performance, and transportation systems, among other things. Yet the economic disruptions and costs caused by heatwaves are very rarely insured. Without available insurance, unmet costs fall to communities and individuals.

Flooding
The Fourth Climate Assessment projects escalating intensity of high precipitation storms, putting people and properties at risk of growing damages. The combined or successive impacts from pulses of heavy rainfall, faster snowmelt and rising rivers, and sea-level rise, put more communities, especially low-income communities, at increased risk of flooding. Low-income households are often concentrated in flood-prone areas.[4] Coastal communities are particularly vulnerable to sea-level rise, high tides, and coastal storms, and this trend is expected to continue. Yet the uptake of flood insurance has been low: Of the 1.1 million homes with a relatively high risk of flooding (a 1% chance or higher per year), less than half have flood insurance policies. Areas with more moderate flood risks have even lower flood insurance uptake rates, indicating major gaps in insurance for flood risks. Without an increase in flood insurance update, the costs of flooding damages and rebuilding will continue to accumulate.

This report: Climate Insurance Working Group

Pursuant to Section 12922.5 of the California Insurance Code (Chapter 614, Statutes of 2018), the California Insurance Commissioner established a working group to examine issues related to climate change, resilience, and insurance. As a first step, the working group agreed upon the following mission for its work:

The mission of this working group is to identify, assess, and recommend risk transfer approaches to reduce the risks of climate change impacts including, but not limited to, insurance incentives that promote nature-based solutions.

The working group chose to focus on climate impacts from wildfire, extreme heat, and flooding because these are three of the largest threats facing the state, and responding to

these perils has great potential to build resilience in the state. It focused on finding ways to bolster insurance's role in building a resilient California. The working group met publicly eight times from 2019 to 2021 to develop the recommendations contained in this report.

Insurance as a tool for more equitable recovery

Closing the insurance protection gap will be essential to supporting more equitable recoveries when future disasters strike. Climate-intensified disasters will repeatedly stress the state, and have the potential to exacerbate existing inequity. Extreme heat is particularly demonstrative. A study from neighborhoods that were subject to historic redlining in the US including over 100 cities show patterns of higher land surface temperatures in formerly redlined areas, indicating racial inequities, especially for Black communities, in extreme heat exposure. In California, exposure to urban-heat-island impacts is higher in Black and Latino neighborhoods than white neighborhoods, as is exposure to air pollution. Fewer Black and Latino households have access to air conditioning or local urban forests, both of which can mitigate the expected future temperature shocks during heat waves. Many low-income communities already pay a disproportionate percentage of their income for energy, and may not be able to afford using air conditioning, or pay for water to cope with hot weather. Moreover, examples from past natural catastrophes show disparate impacts in mortalities and damages. Black communities saw disproportionate mortality rates in the 1995 heat waves in Chicago. During the summer heat waves in France in 2019, elderly individuals made up more than half of deaths, and in Quebec in 2018, heat-wave deaths were disproportionate towards isolated, older individuals. Flooding has had a disproportionate impact on low-income communities and communities of color. And for climate impacts where evacuation is essential, socially isolated individuals and those with disabilities may face additional barriers.

Insurance uptake can promote equity in financial capacity to recover from disasters, but existing insurance coverages need to expand to support strong, equitable recoveries. For example, even though roughly half of California households rent their home, renters insurance is far less common than homeowners insurance, putting renters at risk to losing their possessions and not being able to rebuild their lives after a wildfire or flood or other climate-intensified event. In California, similar to many areas in the US, homeownership is less common for Black and Latino households. In data from 2014, over 60% of white and over 50% of Asian Californians owned their homes, while 35% of Black households and 42% of Hispanic households were homeowners. Moreover, uptake of certain insurance coverages, such as flood insurance, demonstrate racial differences, and households without insurance are less likely to rebuild at all. Black homeowners were less likely than white homeowners to have homeowners insurance in the aftermath of Hurricane Andrew in Florida (1992). Therefore, in the face of accelerating climate impacts, closing the protection gap for insurance will strengthen the equity of recoveries in the face of future climate impacts by providing more households with the resilience of recovery funds when disasters occur.

Recommended Solutions

To survive and flourish in a future being altered by climate change, California must become more resilient: making risks clearly visible, accelerating risk reduction where people live, and building more thoughtfully moving forward. The initial climb will be steep. Making climate risks more visible and building the necessary resilience will take new investments and early actions. It will require overcoming the myopia and other behavioral biases that have served as hurdles to past disaster preparedness.[5] This report describes possible pathways to achieving greater resilience through insurance and focuses on these cross-cutting, fundamental themes:

HAZARD MAPPING AND DISCLOSURE

Widely-available risk information supports resilience. Decision-makers, including elected officials, home buyers, renters, and insurers, need access to information about climate risks and how they are changing. Therefore, building public understanding of risk and how to de-risk is fundamental. Access to hazard mapping, models that project future catastrophic events, and other tools to better understand the risks of flooding, extreme heat, and wildfires will empower individuals, businesses, and communities to better prepare for and recover from catastrophic events. Although multiple public and private sector groups are providing weather and climate information, that information is often difficult for individuals to find and not easy for the public to understand.

For California to become more resilient, the state needs to expand access to easy-to-understand information as well as linking it to resilience-enhancing actions. California is fortunate to have significant in-state research capacity for providing this vital information in its prominent public and private universities, in conjunction with research organizations and government labs. In particular, publicly accessible and detailed information about the threats faced at specific locations, such as individual communities or small regions, will be especially valuable for enabling local governments, businesses, and individuals to make smart decisions about the future. Lack of clear risk information leads to risky land use decisions and the establishment of developments that will be unprepared financially and structurally for the physical climate risks that are unfolding. Comprehensive risk information will also enable the state to oversee a sustainable insurance marketplace.

LAND-USE AND BUILDING PRACTICES

Where and how we build and rebuild matters. The clearest path to reducing future losses—which also leads to lower insurance costs—is building better. For too long, development has moved more people and homes into areas at higher risks in the absence of strong building and zoning codes and accurate hazard mapping; this will not solve the state's long-term affordable and equitable housing challenges. Climate impacts can put a family's largest asset at risk. Insurance premiums in those areas can climb to unaffordable levels as risks accelerate. Some homeowners may find themselves with only one option, the FAIR Plan, as insurance companies stop offering certain coverages.

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Solving these problems will require lasting partnerships across the public and private sectors and require multiple tools. We need stronger building codes for new construction, in moderate and high-risk areas. In addition, each time a home or community is rebuilt after disaster, there is an opportunity to design and build a more insurable property and in aggregate, a more climate-resilient community. When disasters are severe, local governments have substantial unmet costs and uncertainty in future tax revenues.

Given the magnitude of this challenge, risk reduction should be incentivized by the state through an overarching state resilience strategy, by local governments through adoption of a broader and stronger building code—including through the incorporation of risk reduction measures in permitting and planning of developments and programs for relocation post-disaster—and by insurance companies through insurance pricing systems that reflect risk reduction measures.

The state's role is vital, since deferring decisions to local governments when the risks are statewide creates patchworks of risk mitigation and local building practices that increase exposure to adjoining communities, as well as volatility in emergency response costs, which wreaks havoc with budgeting. This report recommends actions that the state can take to achieve better land use decision-making, including actions to require more effective recovery planning and risk reduction moving forward.

NATURE-BASED SOLUTIONS

Nature can reduce harm. Nature is already deemed important in climate adaptation, but its role in stabilizing insurance availability or opportunities to link insurance and mitigation is underappreciated, and therefore policies are underdeveloped. Wetlands can buffer floodwaters to reduce flooding, dunes can absorb storm surges, and green spaces in cities can reduce urban heat islands. Prescribed burn programs and other proactive management of forests can better protect forested communities against the long-term threat of high-severity wildfire. Avoided future losses are an important economic benefit.

In addition, the benefits from enhancing natural systems to provide protection go far beyond just the risk reduction. Those benefits include better wildlife habitats, more recreation opportunities, increased carbon sequestration, cleaner air and water, protection of biodiversity, and improved aesthetics. For all of these reasons, a number of recent reports advocate a major increase in financing ecosystem restoration[6] and increased action to adapt to climate impacts,[7] as well as in making investments in nature-based solutions.[8]

One study showed that the coastal wetlands in the northeastern US avoided as much as $625 million in direct flood damages from Superstorm Sandy.[9] The study also showed an estimated average reduction of 16% in annual flood losses by salt marshes; areas at lower elevations showed higher reductions. The challenge, though, is that nature-based investments require additional funding on top of existing state and local budgets. Risk transfer mechanisms, such as insurance or risk pooling, can supplement existing

insurance policies and increase investments in nature-based solutions by shifting the abrupt burden of future financial losses away from governments or communities making these investments. Nature-based solutions can also secure funding for restoring natural infrastructure after a disaster without the local government needing to find unexpected additional funding. Among several recommendations to address the funding shortfall, this report recommends establishing new climate hazard abatement districts and developing pilot projects that focus on nature-based solutions at the community scale. Public-private partnerships can leverage local and state dollars and diversify the risks to both communities and natural assets.

CLOSING THE PROTECTION GAP

Insurance protection is essential for disaster resilience and equity. Those with insurance tend to recover faster from wildfires, floods, and other disasters.[10] A review of disaster recovery case studies indicates that insurance uptake speeds economic and social recovery of communities.[11] Government financial responses, while important, have historically been slow and incomplete. As a result, if households, businesses, and communities are uninsured or underinsured and reliant on federal relief, then the rebuilding process can be slow and challenging, exacerbating existing inequalities. If California does not become more resilient, the potential for significant disruption and backsliding from climate goals exists in the aftermath of every disaster. One key reason is that uninsured disasters have significant opportunity costs as well as physical costs, because large amounts of public dollars need to be spent on evacuations, debris removal, emergency responses, temporary housing, and other immediate responses. With disaster losses continuing to accumulate, it will be difficult to maintain public funding for pre-disaster risk reduction and abatement of emissions, and to maintain sustained support for nature-based projects that reduce long-term risks.

Insurance helps solve these problems. If a high percentage of the total costs are insured, and funds are quickly distributed to claimants, a community can move forward to rebuild rapidly, easing the pain and limiting the devastation of climate-related catastrophes. Unfortunately, too few California residents are fully insured against extreme climate events. Insufficient insurance coverage means that residents must turn to private individual savings or to credit to pay for damage, or rely on community or state-sponsored safety nets, which typically provide assistance with immediate needs but not long-term recovery expenses. The protection gap is usually largest in communities with lower incomes and fewer resources. As the destruction from climate-related disasters mounts, the lack of strong insurance coverage will make it increasingly difficult for communities to rebuild stronger, or even at all, touching off a vicious cycle of economic vulnerability and decline. Hardest hit will be the most vulnerable, exacerbating already-growing social and financial inequalities. Therefore, to improve the financial resilience necessary for coping with climate change, California should make a priority of closing the disaster insurance gap.

Accelerating climate risks threaten insurance affordability. While disaster insurance reduces financial vulnerability, those who need the financial support of insurance the

most are often those least able to afford coverage. Moreover, the expected higher losses from climate change impacts are causing insurance costs to rise, making the affordability challenge even greater. As a result, certain homes in California may be initially affordable to purchase, but are unaffordable to insure.

One strategy for making insurance more affordable is to reduce the risks that homeowners, renters, and communities face. Investments in resilience can avert at least some future losses, lowering rebuilding costs for both individuals and insurance companies, creating a positive feedback loop towards more affordable insurance and greater resiliency. If California can reduce vulnerabilities by retrofitting homes, fortifying communities, and reducing landscape-scale threats, those actions could reduce insurance costs and thus help close the protection gap. Subsidies like loans, tax incentives, or insurance-pricing incentives can encourage and support risk reduction. This report also recommends that California should consider how to implement a basic level of disaster insurance coverage for lower-income residents, which would help to make every individual more resilient and serve as an instrument to build the strength of entire communities.

INNOVATION

Innovative risk transfer concepts can expand insurance access. Even with stronger buildings and investments in resilience, threats to structures, businesses, and governments remain and will impact communities. *Parametric insurance policies* are one innovative option.[12] While not a replacement for indemnity-based homeowners coverage, they can improve resilience by providing funds for unexpected disaster costs, such as evacuation, and by helping state and local governments fund their own recoveries, including disrupted tax revenues and infrastructure rebuilding. Another innovative option is to insure *entire communities* for a particular peril to guarantee that all residents have some degree of coverage.[13] Community-level insurance not only pools the shared risks of the community, but can also be used to provide financial incentives for community-wide investments in risk reduction, especially nature-based solutions. *Nature-based solutions* are a third theme of innovation, taking a communally owned asset, identifying insurable value, and using parametric insurance to increase its resilience. Insurance mechanisms that act earlier, providing incentives or even anticipatory funds to reduce the ultimate impact of a disaster, could strengthen resilience and encourage early investments in resilience across public and private actors.

This report recommends bolstering climate disaster financing by developing innovative insurance products and public-private partnerships, including expanded use of parametric insurance, community-level insurance, and other risk transfer tools. Innovative ideas for applying those strategies to impacts from extreme heat would test a new frontier for insurance. Advancing pilot projects could be a needed first step to speed policy development, especially for risks where insurance is uncommon. This report recommends a catalyst role for the Insurance Commissioner, including initiation of collaborative pilot projects to accelerate insurance policy development to match the acceleration of climate risk impacts.

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This report emphasizes cross-cutting recommendations to support broad resilience. Insurance products alone, however, will not solve the looming insurance crisis. This report recommends that California follow a multidimensional approach to the threat of climate impacts, an approach that considers actions that can be taken from the top down, through direct government leadership, and from the bottom up, fostering insurance uptake and risk reduction by communities and individuals. This report recommends that all parties, public and private, local or state government, need to take further action starting now. Where possible, the threats themselves, wildfire, extreme heat, and flooding, must be approached in a cross-cutting way, so as not to exacerbate one risk with actions on another. The threats addressed in this report are not the only threats California faces. Additional threats, such as drought, heavy snowfall, and extreme cold events, will require additional work but can build on the backbone provided in this report.

WORKING GROUP BACKGROUND

The Climate Insurance Working Group was convened by Insurance Commissioner Ricardo Lara, implementing Section 12922.5 of the California Insurance Code (Chapter 614, Statutes of 2018).[14] The Honorable Alice Hill and Dr. Carolyn Kousky were appointed Chair and Vice Chair, respectively. The first meeting took place on September 10, 2019, with subsequent daylong meetings in November 2019 and February, May, July, August, and December 2020, and April 2021. Meetings are accessible to the public, and meeting minutes and reference documents are posted to the Climate Insurance Working Group website after each meeting.[15]

After initial discussions, the Climate Insurance Working Group developed the following mission statement: The mission of this working group is to identify, assess, and recommend risk transfer approaches to reduce the risks of climate change impacts including, but not limited to insurance incentives that promote nature-based solutions. Further, the working group decided to split into three subgroups to concentrate their efforts on 1) wildfire, 2) extreme heat events, and 3) flooding, including storms and sea-level rise. In addition, the members developed a plan to provide recommendations in a report and identified core questions that each group should consider to link the groups together. Contributing members to each of the subgroups are listed in Appendix 2. The views expressed in the report and the recommendations represent the collaborative effort of the working group as a whole and do not necessarily present the views or recommendations of any individual working group member. The working group reached consensus on the recommendations.

At subsequent meetings, the working group examined and discussed existing examples of risk transfer mechanisms, California local government climate-risk-planning laws, and additional materials to develop proposals, recommendations, building codes, nature-based risk reduction solutions, and actions that align with the mission statement.

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INTRODUCTION

Many of the most vulnerable communities in California are projected to face the most destructive consequences of climate risk impacts.[16] If California does not make significant progress on risk management, climate change impacts will exacerbate existing inequities. When a disaster occurs, the magnitude and speed of financial response can be crucial to recovery.[17] Yet, disaster aid can often be limited and delayed. Such a gap hurts the most vulnerable, those without a robust financial backstop. Access to adequate insurance is critical but becoming more costly. Without insurance, the financial costs of climate impacts will fall hardest on vulnerable individuals and on local jurisdictions that struggle to preserve stable funding for recovery.

Building climate resilience requires both reducing risks and building the capacity to recover. The best long-term resilience strategy is a dramatic reduction in the emissions that cause climate change. Yet even if we are able to quickly move to a low-carbon economy, past emissions have already locked in rising temperatures for the foreseeable future, and we need to seize every opportunity to adapt to and bounce back from climate-intensified events. The insurance sector is central to both sides of resilience: it is a tool for incentives to reduce physical climate risks and drive behavioral change, and a contributor to economic recovery. The strength of insurance coverage is therefore crucial, especially for vulnerable communities. Households and communities with strong insurance uptake recover more quickly and more completely after facing catastrophes, helping to preserve economic health and stability.[18, 19]

The COVID-19 pandemic has provided a sobering backdrop for this report, tragically underscoring many of the existing vulnerabilities of people and communities. Similar to climate risks, COVID-19 has revealed that existing planning and programs are much more accustomed to respond to immediate, tangible local risks, and consistently struggle to anticipate and respond to global risks. This pandemic has also introduced factors that can compound the climate risks of storms, flooding, wildfires, and extreme heat. An ongoing pandemic that disrupts supply chains and the ability to gather safely complicates emergency responses, firefighting, evacuations, and medical care. It increases economic vulnerabilities and reduces rebuilding capacities. As we write this, the future consequences of the pandemic remain unknown.

Public and private opportunities to advance climate adaptation exist yet need stronger coordination and innovation. This report focuses on four key essential elements (*Figure 1*) of risk management—risk assessment, risk communication, risk reduction, and risk transfer–to arrive at an extensive set of recommendations, including roles for state and local governments, the insurance sector, and the Insurance Commissioner. State government is unlikely to be able to do this alone. It needs the complementary and reinforcing actions from federal and local counterparts, and from private sector players, including from the insurance and reinsurance industry. This is a report about how we empower all stakeholders with risk science, invest more on pre-disaster assessment and planning, and foster insurance markets that support a strong rebuilding process.

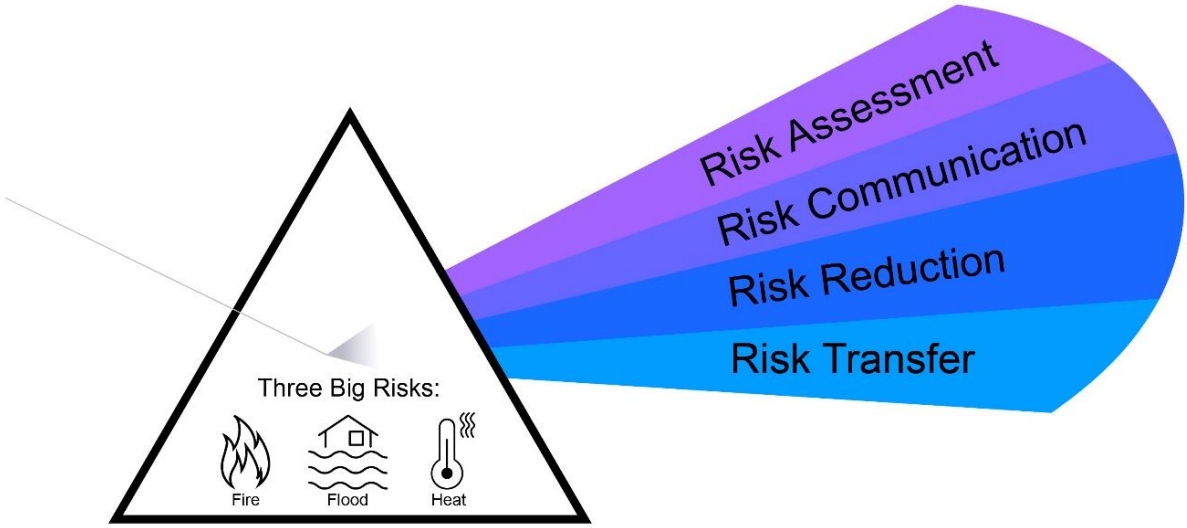


Figure 1. Four elements that provide a consistent framework throughout this report for considering risk and policy alternatives.

Assess risk

An understanding of climate threats, vulnerabilities, and impacts requires a robust foundation of risk assessments. This understanding can then guide decisions about risk reduction, as well as underpin the design and pricing of insurance and other risk transfer instruments. In the absence of robust risk assessments, determining which approaches to prioritize remains a challenge. Such risk assessments must include

forward-looking analyses of how hazards are evolving in light of climate change and where there are opportunities for nature-based risk reduction and to insure nature-based investments. Past experience is no longer a guide to future risk.

Improve risk communication

Once a strong risk assessment is in place, that information must be widely shared with all decision-makers. Markets are only efficient with full information, and individuals can only make optimal decisions when they are aware of the risks associated with their choices. Risk communication is necessary to support pre-disaster mitigation of risk. If communities can reduce or even avoid damage from future disaster events, then recovery costs become more manageable, much suffering is avoided, and future insurance costs are lowered. This is the positive feedback loop that, under the best cases, risk communication facilitates. Without accurate information about risk—including maps, robust and publicly available models, broadly available disclosure information, and collection of home-attribute data—understanding risk becomes much more difficult. Understanding the burdens of recovery is also an important component of risk communication, as individuals and local municipalities can make more resilient decisions if the opportunities and limitations of federal or state backstops are more clear.

Reduce risk

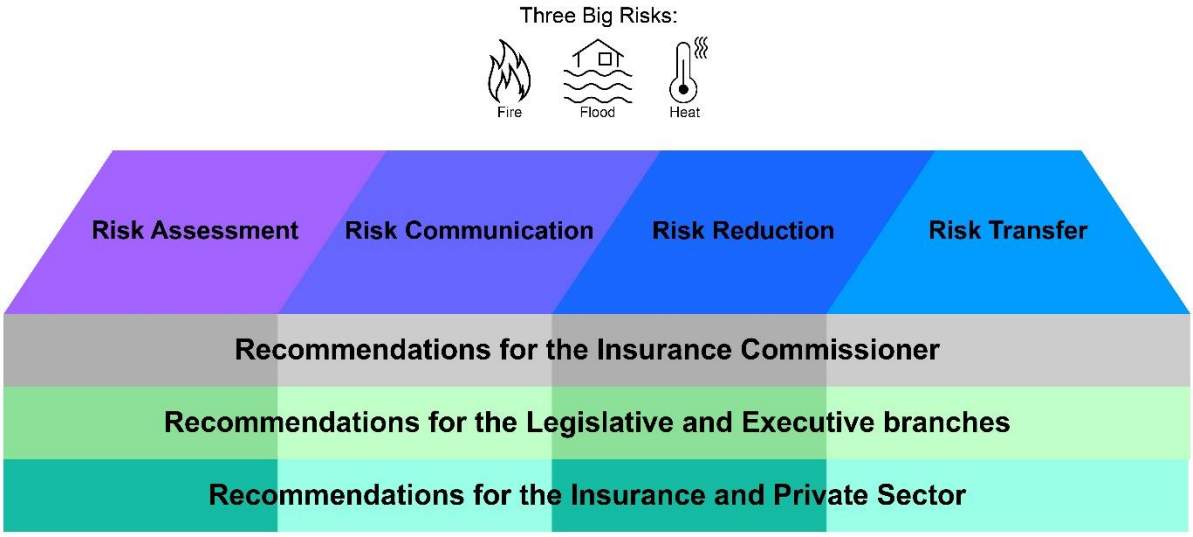
Pre-disaster risk mitigation can be cost-effective and avoids tragic losses. Public policy in the area of risk reduction, however, remains fragmented and misaligned. Risk reduction to address the growing threats from climate change requires large-scale adjustments that will provide systemic and effective incentives to (1) reduce risk for individual properties through improved building practices, (2) reduce risk at a community level through local to regional level mitigation investments, and (3) harness nature-based approaches where feasible to lower losses. To ensure a stable insurance market in the long term, communities must accelerate their investments in and their understanding of all three approaches. Public policy—including public investment priorities, building codes, regulations surrounding insurance pricing, and publicly created and distributed risk information–should reward and push homeowners and communities towards cost-effective approaches to lower risk. In addition, resiliency planning by local, state, and federal governments is crucial.

Transfer Risk

Resilience is not just about prevention but also about improving the ability to recover. Insurance availability and affordability is central to post-disaster financial resilience, since it guarantees funding for repairs and rebuilding. Closing the protection gap by increasing insurance coverage will spread the risk of disaster events. It has multiple benefits, including strengthening the backstops throughout society, reducing the exacerbation of inequality, accelerating repair and recovery, and preventing backsliding in restoring ecosystems. For example, after a wildfire, if insurance companies reimburse most costs, individuals and businesses have access to funds quickly and can begin to rebuild their lives. Fewer public funds are diverted to the disaster recovery, thus making it possible to support more long-term projects aimed at major public benefits, such as the restoration of local parks. As climate change impacts intensify, as they are projected

to do, risk transfer will likely become an even more important tool to protect communities.

How to read this report



As a guide to reading this report, this introduction is followed by four chapters of recommendations: recommendations that cut across all three of our examined perils, wildfire recommendations, extreme heat recommendations, and flooding recommendations. Each chapter is organized into the four essential elements (risk assessment, risk communication, risk reduction, and risk transfer), and provides specific recommendations for the Insurance Commissioner, for the legislative and executive branches in California, and for the private sector, including the insurance industry. Each individual recommendation includes both *the motivation* for the recommendation, and *the recommendation* itself. Finally, the report concludes with short- and long-term priorities for the Insurance Commissioner, state government, and the insurance sector.

Insurance related terms

This report uses the terms risk, hazard, exposure, and peril. **Risk** refers to the ultimate impact arising from multiple factors, including the intensity of a hazard, as well as the vulnerability and value of the structure or community. **Hazard** describes the probabilities of occurrence and severity of a particular **peril**, such as wildfire, flooding, or extreme heat, at a given time and place.

Part 1: CROSS CUTTING RECOMMENDATIONS

Assess the Risk

Even as the impacts of climate change grow, many local communities are unaware of the nature of the accelerating risks in their locality. Understandable climate risk information is therefore imperative for governments, communities, businesses, and individuals. That information can inform decisions critical to the future resilience of Californians, including decisions regarding land use, disaster risk reduction strategies, and the development of climate-resilient communities with access to the protection provided by insurance. Public and private sectors require strong and accessible risk science tools to guide investments in nature, homes, and infrastructure. Such tools are most useful when they are understandable to the public and insurers alike, and can identify where risks are greatest or more moderate, and what measures can reduce risks.

Ability to assess risk makes early warning systems more effective. The National Weather Service warns the public when possible in advance of extreme weather events. But by the time such an event is about to strike, mitigation measures and options are limited. That is why effective risk assessment far in advance of a catastrophe is essential, empowering individuals, governments, and insurance companies to plan ahead, and become more resilient.

Cross-cutting *Recommendation* 1 *Create publicly accessible models and risk assessment tools*

Motivation: Although California has a formidable Cal-Adapt tool for understanding future climate risks, the granularity of the tool has limited value for those interested in parcel-level risk assessment and reduction for wildfire, extreme heat, or flooding threats occurring today. [20] Increased understanding of property-level actions could accelerate mitigation at homes and in neighborhoods. One successful example can be found in Colorado, where a parcel-based risk model is used to inform homeowners about relative risk in different locations and about specific actions they can take to reduce wildfire risk and measure the impact of a home retrofit, defensible space, and other mitigation action.[21]

Recommendation: To identify and optimize mitigation priorities and community nature based investments, the Insurance Commissioner should convene a task force of public and private partners to establish a publicly available forward-looking model that identifies areas for optimal mitigation investments, including nature-based strategies, and recommends how the state can provide incentives or requirements for its use by local governments.

Cross-cutting 2 *Evaluate uses for catastrophe modeling*

Motivation: Effective risk assessment tools support sustainable insurance markets by providing a more accurate approximation of the risks being insured. However, there are nuances to the application of new tools to different perils; therefore, the use of such tools for insurance require thorough evaluation by the Insurance Commissioner.

Insurance pricing should continue to reflect the changing nature of risk so that Californians can make better-informed decisions about where to live, what measures to take to better protect themselves where they live, and how to financially plan for a future of climate-related risks. The use of modelling in risk assessment of wildfire and flooding could send clearer and more consistent price signals to the public in the form of insurance costs that are more reflective of risk. Furthermore, modeling can inform the public on ways to optimize risk reduction strategies, including nature-based solutions, thereby reinforcing an emphasis on building resilience and limiting insurance market disruptions.

Wildfire Catastrophe Models
Wildfire risk is one example of the broader challenge facing insurance companies and regulators when making policy choices. One factor that affects insurance pricing is whether there is an estimate of the costs that catastrophes will add, to smooth the impacts of those catastrophes over time. Currently, California employs a system of using the actual loss history, rather than using the projections from catastrophe models to determine a portion of rate filing applications. Catastrophe models for wildfire are not currently allowed by the California Department of Insurance for projecting future losses in the calculations that govern insurance rates. Although all policy choices have tradeoffs, such tools could be a better assessment of risk and allow for further integration of risk reduction actions with insurance pricing.

Recommendation: The Insurance Commissioner should consider allowing use of probabilistic modeling as a tool to more accurately price insurance policies for catastrophic perils that are increasing as the planet warms. Current requirements for using historical insurance losses to estimate future insurance losses from catastrophes should be re-evaluated and discussed. Historical losses do not directly account for the growing risk caused by climate change or changing exposures related to new developments in high risk areas, and only react to losses after they occur. This may make insurance for wildfire and for flooding difficult to accurately price. Catastrophe models should include the mitigating impact of nature-based solutions. Where the science does not exist to make this possible, the Insurance Commissioner should identify gaps and support research efforts to fill them. For example, the risk reduction power of wetland restoration, prescribed burns, and community wildfire mitigation should be included in models.

This issue is particularly acute in the area of wildfire (*see box*). The Commissioner should convene one or more public meetings or discussions, examining existing departmental approaches, and comparing those that rely on past loss experience to the potential application of catastrophic models, giving the Commissioner and the public an opportunity to discuss and assess this policy tool (*Additional details in Appendix 4*). In doing so, the Insurance Commissioner should evaluate how wildfire mitigation measures, including prescribed burns and forest management, community buffers, and home hardening, are integrated into catastrophe models.

Risk Communication

Hazard mapping and disclosure
Two cross-cutting themes of risk communication are hazard mapping and disclosure. California has state-developed wildfire hazard maps that delineate moderate, high, and very high-risk areas. There are flood maps for the state from the Federal Emergency Management Agency (FEMA) that depict areas with at least a 1% annual chance of flooding. Yet all these maps are incomplete and do not include future risk worsened by climate change and potential development patterns. Gaps in the existing hazard maps create loopholes in public policies, such as where building codes are required by state law or how local governments approve new developments.

Existing Flood Disclosures
A number of different entities disclose flood risk, resulting in a patchwork system that can confuse buyers, and no disclosure systematically alerts buyers to a home's full prior flood history. At the federal level, legislation requires lenders to inform those taking out a mortgage in a FEMA-mapped 100-year floodplain that they are in a so-called "Special Flood Hazard Area" (SFHA). The State of California has its own law requiring sellers to provide a Natural Hazard Disclosure, which includes whether a home is in a SFHA, whether the seller knows of prior flood damage, whether there are known flooding problems, or whether the property is in an area at risk of flooding if a dam fails. California law does not require disclosure of earlier flooding of the home when it was owned by prior owners. Flood disclosures must also include where to obtain more information and a notification that the owner's insurance does not cover flood damage to the tenant's possessions.

For many people, their greatest asset is their home. Yet individuals cannot make optimal decisions about where to live if they do not have information on risks to their property. Timely climate risk disclosure could drive more informed market-based decisions in the housing market, and this report makes recommendations for making disclosures more effective. California has disclosure laws for flood and wildfire, whereby sellers of property need to disclose to potential buyers information on the hazards facing the property if that property is in a high-risk zone for wildfires or floods. The state's disclosure laws also apply to all leases and rental agreements for residential property. While California thus has fairly comprehensive disclosure, there is room for improvement in providing information on prior flood events, and also risk outside the 100-year floodplain. In addition, risk information should be provided sufficiently early in the homebuying process to allow for reasonable decision-making.

The private sector has begun to address some of these issues. As of 2020, Realtor.com has listed flood risk information beyond the FEMA Special Flood Hazard Areas (SFHA) at the point of listing, which allows potential buyers to understand some aspects of their flood risk in advance of putting an offer on a home.

Cross Cutting 3 *Strengthen public access to risk tools more simple through a one-stop resource*

Motivation: Hazard maps, models of physical risk, and available disclosures should be easily accessible to decision-makers, and California can make these tools easier to use. The National Weather Service synthesizes vast information and provides actionable weather information, most notably for events with the potential to cause disasters, that is broadly available to the public. This information assists preparation but does not communicate underlying hazard information. In the same vein of public access, California should approach up-dating hazard maps, synthesizing those maps with other tools, and making them understandable to the public with similar urgency as forecasts of weather events. Without such an effort, effective climate hazard information will only be available to those who purchase private analyses. Pinellas County, Florida has a one-stop tool for information on flooding risks, including disclosures and certifications, as well as hazard maps.[22]

California has existing powerful tools (e.g., "*myhazard*" mapping tool, Cal-Adapt climate projection tool, and urban heat index) that could become the foundation for a user-friendly, one-stop shop of risk information for the public. The existing "*myhazard*" tool has an overlaid map with 100-year flood maps, earthquake maps, and very high wildfire hazard designations—all in one place. However, this tool is too narrow, because it considers only the highest risk zones and uses existing hazard maps, which are outdated, that do not effectively reflect the threats of climate change. The Cal-Adapt tool is more of a long-term tool, rather than an immediate decision-making tool, because it considers climate impacts for hundreds of years, but not a detailed projection for next year. Without a robust and integrated cross-peril approach, Californians may unintentionally move away from high wildfire risk and into moderately high flood risk or extreme heat areas. A one-stop shop for climate risk information can help homeowners optimize investments in retrofits and risk reduction measures and help communities get on a path to stronger resilience. Such a hub could also strengthen understanding between the public and insurance companies, which use probabilistic models for underwriting decisions, thereby encouraging decision-making that considers future insurability of communities.

Recommendation: The Insurance Commissioner should encourage a one-stop approach to hazard communication by working with other state agencies to create a publicly accessible, web-based repository for 1) publicly available hazard maps, whether generated by the state or a private entity, and 2) disclosures. With such a system, property owners, business owners, or renters could enter their addresses and find links to the most recent hazard maps, output from publicly available catastrophe or risk models, and climate hazard disclosures. The effort could leverage the research and development already done by California universities regarding state climate risk. In addition, the Governor's Office of Planning and Research should develop an overall resilience risk rating system based on wildfire, flooding, extreme heat, and earthquake risks to be included in the one-stop resource.

Cross-cutting 4 *Improve hazard maps to inform decisions*

Motivation: When hazard maps are incomplete, out-of-date, or insufficient to communicate risk, people do not have the information they need to make safer climate-

related decisions, and existing zoning and building codes will be misaligned with the level of risk. People need access to information to decide whether to live in an area and communities need to know whether to build in an area.

Recommendation: Existing wildfire and flooding maps need to be updated more frequently, include all areas of California, and be available in the one-stop shop described in **Cross-Cutting Recommendation 3**. These maps have to better reflect current and projected risks, especially in the areas of moderate to moderate-high risk for California to become more resilient. Additional details regarding the hazard maps for specific perils are found in the wildfire and flooding sections.

Cross-cutting 5 *Require climate risk education for professionals in real estate*

Motivation: Home buyers rely on realtors to highlight important information about prospective homes. California requires many disclosures, and wading through all of them likely diminishes the effectiveness of disclosures at the point of signing. Climate impact information will be better utilized if real estate agents, appraisers, assessors, and insurance brokers understand the information and can help their clients interpret the information and take action accordingly. Pinellas County in Florida is attempting something similar with flooding risks.[23] In the Pinellas County program, flooding information is located in an easy-to-access place for real estate agents, and a brochure is available for realtors to provide flood information to prospective buyers. Training classes are available for realtors to learn about flooding risks and tools, such as a GIS mapping app for the county.

Recommendation: The state legislature should establish a statewide requirement for continuing education in climate impacts for real estate agents, assessors, and insurance agents who interact with home buyers and sellers. Real estate agents should be further required to share the one-stop climate risk website in **Cross Cutting Recommendation 3** with prospective buyers of property prior to that buyer placing an offer.

Cross-cutting 6 *Promote earlier risk disclosures for homes*

Motivation: Disclosure information often comes too late in the process to effectively inform potential buyers of climate risks. The ideal risk communication for home buyers would be to understand climate-related risks by having access to publicly available maps and models, disclosures of prior wildfires or flooding, and disclosures of existing risk reduction strategies, as well as through insurance pricing that reflects current risks.

Recommendation: As part of the one-stop shop in **Cross Cutting Recommendation 3**, the state should store information regarding previous damage from wildfire and flooding in the single publicly accessible database so that potential home buyers can search for flooding and wildfire risk information for a specific property prior to making an offer. The state should also consider mandating that hazards disclosures be made

available at the time of listing, so that potential buyers can consider information before making an offer.

Risk Reduction

Land Use Decisions

The Wildland Urban Interface (WUI)
The wildland urban interface is defined by the US Forest Service as a place where humans and their development meet or intermix with wildland fuel, meaning trees and grasslands. A useful tool developed by academic researchers at the University of Wisconsin for visualizing the WUI can be found at:
http://silvis.forest.wisc.edu/data/wui-change/

Land use decisions in the past are one of the causes of insurability problems today. Where and how Californians build and rebuild has consequences for the severity of losses, the degree of economic and physical resilience, and the insurability of properties, both now and in the long term. Housing in risky areas can sometimes be less expensive; but housing that burns down or repeatedly floods is not an affordable or equitable option because it leaves vulnerable people exposed to danger and the destruction of their possessions. Furthermore, for the availability of insurance to flourish, risks need to be extensively assessed, communicated, and reduced at the point of approving development. Once developments are built, the risks of additional emergency, insurance, and rebuild costs are passed on to future homeowners, the community, and the state, and insurance options may be minimal for the homeowner.

Although the state government provides planning guidance related to climate risks, the authority to permit new development in California largely rests with cities and counties. In deciding whether to approve such development, it is important from a social point of view that local jurisdictions consider the full costs of development and future occupancy. If they do not, additional costs may be borne by state or federal taxpayers when disaster strikes, thus potentially creating a perverse incentive to approve development that is ill-advised.

Federal Flood Protection Standard
Under the Obama Administration, the National Flood Standard was established, requiring federally funded infrastructure, such as hospitals and water treatment facilities, built in high-risk areas to be elevated or built in accordance with the best available science to better prioritize the safety of the structure.

Local jurisdictions currently charge service and impact fees for single- and multi-family development to recoup the costs to the public sector associated with development. There are not systematically higher fees in areas at risk of natural disasters, however, to offset response costs. Service fees cover the costs of the jurisdiction's role in the development process, such as the costs of plan review and inspections. Impact fees offset the costs of new development, such as the need for new roads, schools, or other infrastructure. Some jurisdictions charge fire and public safety fees, which go toward the expansion of fire and public safety systems. A recent study found, however, that fire and

public safety fees were charged by only two of the seven California cities examined.[24] Even the fees that do exist likely do not consider the California Department of Forestry and Fire Protection (CAL FIRE) or the U.S. Forest Service response costs or the costs of evacuating and providing temporary housing to evacuated residents. While special districts, such as levee districts, may have fees to cover certain risk reduction actions or specific rebuild costs for infrastructure, there are not hazard-related fees associated with covering the costs of disaster recovery.

The National Flood Insurance Program

The National Flood Insurance Program (NFIP) was established in 1962 to provide an option for homeowners to insure against flood risks. The NFIP provides flood insurance to any homeowner who wishes to purchase it, although flood insurance is most commonly required by banks offering mortgages to homeowners only within Special Flood Hazard Zones, established by the Federal Government. The pricing of NFIP policies has been a very contentious issue and the program has been operating with substantial debt, currently in the tens of billions of dollars.

Cross-cutting 7 *Identify areas to invest in conservation rather than development*

Motivation: High-risk development can create significant public costs in the future, and therefore should be scrutinized with climate impacts in mind prior to approval. Through the Coastal Barrier Resources Act, federal spending is prohibited in designated lands to encourage conservation of hurricane-prone, biologically-rich coastal barriers. Most new or substantially improved residences, businesses, and other development in the Coastal Barrier Resources System (CBRS) are not eligible for certain federal funding and financial assistance, including insurance coverage under the National Flood Insurance Program (NFIP) and federal disaster-recovery funds. No CBRS areas exist in California because hurricanes do not impact the state. Atmospheric rivers (*see box*) and other high precipitation events, however, cause substantial damage. The CBRS approach to avoiding future vulnerability does not prevent development or impose restrictions on development conducted with nonfederal funds, but it does effectively contain public costs over time by removing incentives to build. Recent research indicates that the CBRS reduced federal coastal disaster expenditures by $9.5 billion (in 2016 dollars) between 1989 and 2013 and that future savings because of the CBRS approach would be between $11 billion and $108 billion by 2068.[25]

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Atmospheric Rivers
One important source of flooding risk in California is a meteorological phenomenon known as "atmospheric rivers." Atmospheric rivers are long, narrow regions of the atmosphere that transport water vapor, sometimes referred to as "rivers in the sky." While atmospheric rivers are a key component of the global water cycle and contribute significantly to California's water supply, they can also cause heavy precipitation and present serious flood risks. Extreme atmospheric rivers can disrupt travel, induce mudslides, and cause catastrophic damage to life and property.[1] Research has found that atmospheric rivers are responsible for the majority of flood damage in the West, with average damages at about $1 billion per year. Although hurricanes and tropical storms are well categorized, atmospheric rivers are not. Recent research by the state and federal government is now beginning to better understand and assess this risk. But an effective warning system has not yet been developed.

Recommendation: Local governments should reassess their land use element of their general plan to consider climate risks and approaches to better land use. Using the CBRS as a model, the state legislature should establish a multi-agency approach to designate lands where risk from climate disasters is too high for state dollars to be used to support new development and infrastructure. Furthermore, because state infrastructure is generally self-insured, the state legislature should require local jurisdictions to analyze and report climate risk when taking on new debt to build infrastructure, such as low-lying wastewater plants and water distribution systems.

The California FAIR Plan
Established in 1968, the California FAIR plan is not a state agency, but rather a non-profit state-mandated insurance program. It is backstopped by the insurance companies writing homeowners insurance in the state, acts as an insurer of last resort, and is increasingly providing wildfire coverage in high-risk areas.

Cross-cutting 8 *Limit insurance incentives for new high-risk developments*

Motivation: Avoiding future losses requires thoughtful building practices. Because insurance is required to obtain a homeowners mortgage, new developments in high-risk areas must be insurable to be practical. The California FAIR Plan ensures insurance availability, albeit often very expensive insurance, to all homeowners in the state. The NFIP plays a similar role for properties throughout the US. This is an important protection for existing developments because homeowners can lose their homes if their insurance disappears. However, when insurance availability is guaranteed to all new developments, then homes may be built in areas where no private insurer may be willing to write insurance, either now or in the future. Such insurance availability for new homes enables further developments in high-risk areas associated with fires and flooding, with risks and future costs borne by homeowners and the public.

The Flood Re Approach to Land Use
The Flood Re program in the United Kingdom is designed to assist insurance policy holders with flood insurance in the near term and to provide an incentive to limit state-subsidized insurance benefits to homes built pre-2008. The program sunsets in 2033 in an attempt to promote a phase out of high-risk residences over time.

Recommendation: Given the predictions of increased future climate impacts and damages, the more sustainable path forward is for the FAIR Plan to provide essential insurance access for existing homeowners, but not to provide incentives for building new high-risk developments that increase both public and private exposure to future losses. The state legislature should consider changing insurance rules of the state FAIR plan to promote more responsible land use. To reduce incentives for development in high-hazard areas, the state legislature should consult information from the Insurance Commissioner and the Governor's Office of Planning and Research, and consider whether future residential development built in defined high-hazard areas after a specific future date should be ineligible for the FAIR Plan, unless preconditions are met. The Insurance Commissioner should work with the Governor's Office of Planning and Research to develop the preconditions that are likely to address a portion of the risk in question. Preconditions could include: 1) commitments by local governments to fund future wildfire response costs in such new developments, 2) implementation of the full mitigation guidance of the Governor's Office of Planning and Research when designing new developments, and 3) locating all new developments in the high- and very high-hazard areas in spatial designs that are least vulnerable to wildlife.

Similarly, the US Congress should reform the NFIP so that it no longer provides incentives for new developments in high-flood risk areas. An appropriate phase in time for both California and the NFIP would be necessary, with 5-10 years of lead time. An example of this type of approach is the Flood Re program in the United Kingdom (*see box*).

Cross-cutting 9 *Create an iterative process for more effective building standards*

Motivation: Building codes are a powerful and often cost-effective tool to reduce disaster losses. Codes are no guarantee that homes will avoid damage or destruction, but homes built to stronger codes have a better chance of escaping with less damage. Indeed, with growing disaster losses, California needs to continue to adopt more resilient codes and more resilient community redevelopment strategies. The private sector and local governments may desire the certainty of a consistent code, but we need an iterative process with regular advancements because homes are rebuilt each year, and with each rebuild there is an opportunity to adopt the latest codes to bolster resilience.

Existing California building codes for wildfires, largely dating back to 2008, indeed have helped reduces losses. Experimental research by the Institute for Building Home Safety, modeling research coordinated by the National Association of Insurance Commissioners, and post-disaster assessments by the National Institute of Standards and Technology point to the value of building codes.[26] Additionally, a 2019 analysis by the Sacramento Bee found that of the homes in the path of the Camp Fire, one of the

most destructive in California history, 51% of those built after 2008 survived undamaged—compared to only 18% of those built before. The disparity shows the value of building codes, as well as the need for further improvements. Given the recent wildfire experiences, California would benefit from codes designed to reduce risks from ember-driven fires. Those codes would include requirements for the siting of homes in a neighborhood, the location of neighborhoods within a community, and the performance of designs.

Current building standards for floods are also a minimum requirement that applies in the 100-year floodplains for communities participating in the NFIP. As discussed further below, this minimum flood code may not be sufficient for the expected future increases in risk.

Recommendation: Given the accelerating risks, some areas will be unaware of the threat, and therefore, codes should be more broadly applied to not only the high risk areas, but moderate hazard areas as well. The legislature should require future code iterations to include neighborhood and community factors. Furthermore, the legislature should require that building codes related to climate resilience be revisited more frequently, especially for climate-worsened events including heat, landslides, wildfire, flood. Details for improvements on each peril can be included in the perils section.

Cross-cutting 10 *Create an overarching disaster resilience strategy that includes local and state actions and incorporates nature-based solutions*

Motivation: The importance of pre-disaster mitigation investments is accentuated when more impacts are expected. Although California has programs to reduce climate impacts, the state does not have an overarching disaster mitigation strategy or consistent pre-disaster risk reduction funding. Scaling up mitigation projects can become a cross-jurisdictional challenge. For example, nature-based solutions and land management can be most effective over large and contiguous areas of land. In California, the federal government owns and manages 45% of the land in California, including one-third of forested lands. Making pre-disaster mitigation more coordinated at the state level can help optimize public and private funds. FEMA's Building Resilient Infrastructure and Communities (BRIC) program aims to move money forward to pre-disaster mitigation, with the intent to reduce the overall losses from disasters, a goal that would align well with a coordinated risk mitigation effort by the state. Insurance expertise and data could help inform and improve BRIC applications from California.

Roof replacement, Big Bear, California
The risks from wildfires can likely be reduced through retrofits of suburban and rural homes in the Wildland Urban Interface. For example, the Big Bear Fire Department's Mountain Area Safety Taskforce implemented a Wood Shake/Shingle Roof Replacement Grant Program from 2008 to 2019 for the San Bernardino County Mountains in southern California. The program, funded by more than $5 million in grants from CalOES, FEMA, and CAL FIRE, replaced more than 600 wood shake or wood shingle roofs with more fire resistant alternatives, out of a total of about 3,000 homes in the area.

Recommendation: The Insurance Commissioner should collaborate with other state agencies to develop a multi-agency Climate Pre-Disaster Mitigation Vision. This vision should include accelerating large-scale natural and working lands projects. A good initial step is for California departments and agencies to expand agreements with the US National Forest Service and FEMA to increase large-scale risk reduction projects, including wetland restoration, urban greening, ecological forestry, prescribed burn projects, and drought management projects. In addition, the Insurance Commissioner should work with CalOES to develop robust applications for BRIC funding, and with insurers to identify opportunities for public-private partnerships, including nature-based risk reduction and improved community design and redevelopment over time.

Cross-cutting 11: *Optimize risk reduction programs for homeowners and businesses*

Motivation: Since insurance pricing responds to the level of risk, encouraging home retrofits that reduce risks could be a pathway to more affordable insurance in the future. However, homeowners need guidance for best practices and also in some cases cannot afford the recommended retrofits without financial support. South Carolina offers grants, Colorado offers tax write-offs, and Connecticut offered low-interest loans to provide funds to homeowners for risk reduction actions.

Recommendation: The Insurance Commissioner should consult with the National Association of Insurance Commissioners (NAIC) and contract for a study that examines which of these state-level approaches is best for providing financial incentives to reduce risks to homes and structures in California.

Closing the Protection Gap

One vital step for improving resilience to the impacts of climate change is closing the protection gap, the difference between the total amount of property damage and the amount of damage that is insured. Some perils, such as erosion or flooding, are not covered at all in standard property policies. For wildfire, a peril that is included in standard policies, there is still a large community protection gap due to underinsured homeowners and renters and the many non-property costs wildfires impose, such as evacuations. For example, the overall losses from wildfires in 2017 and 2018 exceeded $45 billion, but only $35 billion of those losses were actually insured.[27] Moreover, in addition to property losses, individuals and governments have incurred expenses and lost tax or other revenue. This leaves substantial costs for households and businesses, and the public sector.

To optimize insurance solutions, risk transfer tools and products should also promote investments in risk reduction—both improving the building of individual structures and investing in community-level risk reduction. These should also include nature-based solutions. Healthy forests, wetlands, dunes, reefs, and other natural ecosystems can reduce the effects of climate threats, and can at times be remarkably cost-effective. Insurance industry-based models have shown that every $1 spent on restoring marshes and oyster reefs on the American Gulf Coast reduces storm damages by $7, for example.[28]

Cross-cutting 12 *Encourage increased uptake of renters insurance through outreach and disclosure*

Motivation: Renters insurance has less uptake than homeowners insurance because it is not required in many cases and renters generally have a much smaller pool of assets to insure. In California, approximately 2.2 million renters insurance policies were written in 2019, a number that is less than some estimates of the number of renters in Los Angeles alone. However, renters face significant economic vulnerability. If renters lose all their possessions in a wildfire or flood, they are more likely to face financial challenges to recovery. This means that every urban or rural flood or wildfire that damages structures and possessions is more likely than not uninsured for people who rent. In addition, renters face the challenge of finding affordable housing after disasters.

Recommendation: The Insurance Commissioner and the state of California should prioritize increasing the uptake of renters insurance throughout the state. To this end, the Insurance Commissioner should launch an analysis of renters insurance uptake in the state and use that data to develop a public outreach program for renters vulnerable to moderate to high flooding and wildfire risks. Insurance companies should consider the costs and payment requirements associated with including a limited amount of funding for evacuation or post-disaster rental costs in renters policies. In addition, programs that aim to enhance community resilience, such as the Transformative Climate Communities program in California, should consider how to incentivize greater uptake of renters insurance.

Cross-cutting 13 *Support basic protection for disasters*

Motivation: Federal governments can use public funds or public-private risk sharing to promote insurance coverage. For example, Morocco recently passed a law providing natural disaster risk insurance to those who are economically disadvantaged, funded by a tax on all insurance policies.[29,30,31] The law establishes a Solidarity Fund against Catastrophic Events (*Fonds de Solidarité contre les Evénements Catastrophiques* (FSEC)) to provide partial compensation to uninsured households for personal injuries and losses of principal residences from catastrophic events. New Zealand approaches earthquake insurance using a public-private approach, with the state covering the first $150,000 of damages. Such a policy reduces the financial risk to insurers, encouraging increased insurance availability for damages beyond the $150,000 threshold. Mexico has established a disaster resilience fund, known as FONDEN, which has been used to appropriate regular funding for disaster response and mitigation.[32]

Recommendation: The state legislature should consider establishing a solidarity fund for assisting the lowest-income homeowners and renters with insurance premium payments for a basic level of personal disaster risk coverage. The Insurance Commissioner should establish a task force to study, develop, and propose such coverage. In addition to coverage for property loss, the task force should consider coverage that addresses the costs of disruption to renters and homeowners from natural hazards, including business disruption, income disruption, and evacuation costs.

Cross-cutting 14 *Support proof of concepts for parametric and community insurance*

Community Insurance
In a community insurance program, a public entity, such as a municipality or a special purpose district, purchases insurance for a group of properties in its jurisdiction. The concept of community insurance is being actively explored by researchers and practitioners as a way of closing the disaster insurance gap, securing affordable coverage, and better linking risk reduction and risk transfer.[1] There is enormous flexibility in how a community insurance program could be designed and in the role it plays in the financial recovery of residents.

Parametric Insurance
Typical property insurance in the United States is what is referred to as indemnity coverage; this means it reimburses the insured for the amount of damage sustained. For instance, if you have homeowners insurance and a tree falls on your house, your insurance company will send an insurance adjuster to estimate the cost of repairs and that will be the amount of funds (subject to deductibles and coverage caps) that you receive. Parametric insurance, in contrast, is event based and pays a set amount of money to the insured based on a pre-agreed and objective measure of the disaster itself—called the trigger.[1] For instance, a parametric insurance product for hurricanes might pay a certain amount when a given category of storm crosses within so many miles of the insured's home. The benefits of parametric insurance for disasters are that they can provide funds much faster and the payouts can be used flexibly for any needed and unanticipated expenditures, deductibles, or lost revenue, which are typically insurance gaps. The downside is that the actual payout may be more or less than the damages sustained.

Motivation: As the impacts of climate change intensify, the protection gap will likely widen. To reduce financial stress, risk transfer policies and public-private partnerships need to be developed now in order to be in place to meet the future demands of surging costs. New tools, including parametric and community insurance concepts, could reduce the impacts of such costs and close the protection gap (see boxes). One value of innovative parametric policies would be to protect against threats where insurance is uncommon, such as extreme heat impacts or flooding. They also can be targeted to assist vulnerable populations, for example through microinsurance policies, or to stabilize local government tax revenues in the aftermath of disasters. Parametric earthquake coverage is currently being explored in California. Community insurance, moreover, is likely the ideal scale for nature-based solutions, and therefore would provide opportunities and incentives for community-wide mitigation investments.

Recommendation: The Insurance Commissioner should consult with outside experts and the NAIC to develop parametric and community insurance pilot projects in multiple parts of the state. Such products should be used as models of insurance solutions for other risks, such as parametric drought protection or a risk transfer to protect against economic disruptions caused by strong snowstorms or high rainfall events. Specific

examples of innovative insurance product concepts are detailed in the individual peril sections.

Cross-cutting 15 *Initiate policy development for nature-based solutions*

Motivation: Ecosystem restoration projects in California are not currently viewed as part of a state-wide risk reduction strategy. As a result, opportunities to align the goals of restoring ecosystems services for the full lifetime benefits to carbon storage and restoring ecosystems for risk reduction may be missed.

Existing nature-based solutions linked to the insurance sector are few. Perhaps the most well established are focused on reducing flooding impacts and the consequences of storm surges from waves (*see box*), although concepts exist for wildfire and heat. Canada is pursuing a top-down, nature-based solutions strategy, with coordination among individual provinces. This strategy includes pilot projects on seagrass and sand dunes, as part of a substantial effort to reduce flood risks and increase flood insurance availability in large portions of the country. The pilot projects will to explore county and municipality level solutions, provide long-term risk reduction, and create opportunities for public-private partnerships. In a similar fashion, California can leverage existing federal and state programs to develop potential risk transfer policies that include nature-based solutions.

Restoration Insurance Services Company (RISCO)
Funded initially by the Climate Innovation Lab, RISCO will be the first enterprise to assess and monetize the coastal asset risk reduction value and carbon storage benefits of mangroves. Jumpstarted by grants, equity, and loans, RISCO aims to become self-financing by using insurance and blue carbon revenue streams. RISCO will contract directly with insurance companies or insurance associations and will secure an annual payment for continued, verified conservation and/or restoration of mangroves. The annual payment will be linked to a site-specific calculation of the flood reduction benefits provided by the mangroves.

Figure 2. The combination of nature-based solutions and risk transfer mechanisms can strengthen resilience across the state.

Recommendation: To increase the development of nature-based investments that reduce insured losses, the Insurance Commissioner should identify projects that can serve as opportunities to develop risk reduction concepts and increase the data that can be used to incorporate nature-based solutions into catastrophe models. Furthermore, the Insurance Commissioner should consider creating options that allow the insurance sector to contribute to long-term resilience through its own investments or through relatively small fees on insurance policies to reduce long-term flooding and wildfire risks before losses occur. Finally, the Insurance Commissioner should establish a working group to formalize design criteria for nature-based solutions and use these criteria to pursue a statewide strategy.

Cross-cutting 16 *Catalyze new Climate Hazard Abatement Districts*

Motivation: The optimal scale for nature-based solutions and risk transfer mechanisms may be different than city or county boundaries, and may be at a watershed scale.. A similar problem was faced because of geologic hazards, and to address those risks, California developed Geologic Hazard Abatement Districts (GHAD) in order to prevent, mitigate, and abate geologic hazards and fund the rebuilding of areas after a geologic event. [33] GHADs are one type of special district that impacts land management, along with Resource Conservation Districts and Park Districts. Similarly in part, communities recognized as "Firewise" by the National Fire Protection Association have self-determined boundaries for their communities and the risk reduction actions they will pursue.[34] Such boundaries can stretch beyond one government jurisdiction. Firewise communities have wildfire risk mitigation plans and invest money towards meeting the goals in those plans.

Recommendation: The state legislature should establish Climate Hazard Abatement Districts (CHAD) as an extension of the existing system of GHADs that have already been established in California. This report recommends that the state support both CHADs and local jurisdictions to pursue pilot projects for community insurance solutions that blend risk transfer and risk mitigation at the community and landscape levels.

The reasons why CHADs have potential to increase the effectiveness of climate adaptation versus the existing system of local and state governments are that CHADs would operate at an ideal scale and would focus holistically on climate risks. They also would have taxing authority to fund projects at this scale. At such a scale, CHADs are well positioned to link avoided future losses to early investments in risk reduction, especially nature-based solutions at the watershed scale.

To jumpstart the CHAD approach, the Governor's Office of Planning and Research and Insurance Commissioner should identify three FireWise communities, and three communities selected to improve flood resilience, in the state to encourage and provide technical assistance to become CHADs. FireWise communities are already spending $2 per person per year on wildfire mitigation projects, and becoming a CHAD would likely expand their opportunities to receive grants and consider risk transfer. Converting to a

CHAD will leverage the existing organization and also take a more holistic approach, with the tools to levy taxes and plan for not only risk mitigation but recovery as well. These three CHADs would serve as a proof of concept and, if successful, as a template for other areas of the state.

Cross-cutting 17 *Establish business investments in nature-based community resilience*

Motivation: Nature-based solutions benefit more than just homeowners and local governments; businesses and insurance companies also have an interest in investments that make communities more resilient and sustainable. Local businesses, especially corporations headquartered in certain communities, have a vested interest in the resilience of those communities, because it affects both the resilience of their workforce and the sustainability of their business. These businesses want their employees to be safe, whether at work or at home, and to be productive. In the face of wildfires, heat waves, and flooding, ensuring the safety of the workforce is a growing challenge. Nature-based solutions and resilient public infrastructure safeguard against climate disruptions for businesses because they allow workers to get to work, customers to access goods, and supply chains to remain intact.

Recommendation: Local governments and the state should consider commercial tax rebates for investments in resilience bonds, risk transfer products, and restoration projects to encourage the private sector to invest more in nature-based approaches. The insurance industry should be an important leader by considering opportunities to invest some their surplus in investments that strengthen risk reduction and sustainability.

Cross-cutting 18 *Include nature-based solutions in local planning*

Motivation: While gray infrastructure depreciates in value over time due to age and wear and tear, green infrastructure often appreciates. A riparian buffer that reduces flooding performs better as it matures, for example, while urban trees are better able to reduce the urban heat-island effect as they grow.[35] Living shorelines, which last longer and do not require as intensive repairs as concrete bulkheads, on average cost about one-third as much as concrete bulkheads, $361 per linear foot of living shorelines versus $1,022 per linear foot for concrete bulkheads.[36] In the face of accelerating risks of flooding, designing adaptation pathways can assist planning and can help spread costs over time. One study has analyzed potential adaptation pathways to address the flood risks in the coastal zone of Los Angeles County.[37] The pathways were predicated on maintaining beaches and dunes, recognizing their value for flood protection. If nature-based solutions like sand dunes can eliminate a portion of anticipated risks, insurers will be more likely to write policies.

Recommendation: Local government plans should be required, by the state legislature, to consider nature-based solutions for increasing resilience to fire, flooding (including from sea level rise), or heat. Where the state offers incentives or matching funds for investments in resilience, the contribution and priority should be higher for nature-

based solutions. Furthermore, state agencies that address risk reduction should explicitly encourage greater use of nature-based solutions and insurance products that can help communities invest in these solutions.[38] Finally, local governments should specifically scrutinize their recovery plans for public assets, whether insurance or reserves are to be utilized, and pre-disaster mitigation.

Cross-cutting 19 *Develop a public resource for cross-pollinating community risk transfer solutions*

Motivation: California currently has a clearinghouse of state planning documents related to climate change but no such clearinghouse of information on public-sector insurance policies.[39] Insurance approaches are rare in state climate daptation guidance documents or in large-scale agency action plans. Yet risk transfer products could assist local jurisdictions or the state for insuring infrastructure, ecosystems, or communities. Although at present there are few products of this kind, a resource for local leaders could galvanize interest and provide assistance to planners.

Recommendation: The Insurance Commissioner should produce a database for public-private risk transfer policies that are proposed or in use. This clearinghouse of community and state-level risk transfer programs, including international examples, will help communicate basic principles of such policies. Access to such a database could encourage consideration by local governments and special districts to develop new risk transfer approaches.

PART 2: RECOMMENDATIONS FOR SPECIFIC PERILS

WILDFIRE

The damage from California's recent wildfires has been exacerbated by land use, forest management, and climate change. The costs associated with recent wildfires have been staggering, with$25 billion of insured losses in 2017 and 2018 combined. Moreover, the total losses go beyond the destruction of structures and the disruptions and declines in local economies. Catastrophic wildfires also have high evacuation and firefighting costs, and cause air pollution that has negative impacts on human health, particularly among the more vulnerable. The cumulative costs strain financial planning for households, local governments, and the state.

In response to the recent severe wildfire years, California has enacted several new laws aimed at better managing wildfire risk: 1) a state fund to provide financial assistance to homeowners making home hardening retrofits (Chapter 391, Stats. of 2019), 2) enhancements to California's prescribed fire capacity and goals (Chapter 624, Stats. of 2018), and 3) a new requirement on utilities to prepare wildfire mitigation plans to prevent, combat, and respond to wildfires in their service territories (Chapter 626, Stats. of 2018). In addition to these new laws, the state has prepared a range of reference materials to guide wildfire preparedness, available through the California Department of

Forestry and Fire Protection (CAL FIRE). These include outreach materials on adoption of mitigation measures, such as defensible space, home hardening, and fire-resistant landscaping.

Meanwhile, the state's growing population and an urgent housing shortage are contributing to the demand for housing in the wildland urban interface (WUI), where support for development can be easier to obtain. Redevelopment in existing urbanized areas is often more expensive than development into areas of the state without existing infrastructure, making new housing in the WUI often more affordable.

California has established building codes and defensible space requirements to reduce wildfire risks. Most of the building codes, however, apply exclusively to new construction, and not in all moderate or high fire risk areas. Nor have all homes built to these wildfire codes actually withstood fire. Furthermore, inspections of properties have significant gaps. The state inspects for defensible space compliance, and local governments enforce a patchwork of ordinances.

But most homes in California already exist. Making those existing homes safer is thus essential to a more resilient future. Retrofits to address risks from wildfire range from relatively economical to very costly. For example, replacing vent coverings and clearing brush is far more affordable than replacing a roof or removing large trees. The collective decisions of a community influence wildfire risk as well. If you establish defensible space and your next-door neighbor does not, you will still be at higher risk. That's why community-scale risk reduction measures are often the most effective.

Risk Assessment

Recommendations related to risk assessment for the threat of wildfires are included in the cross-cutting section.

Risk Communication

State law currently directs CAL FIRE to map areas of fire hazard based on fuels, terrain, weather, and other relevant factors.[40] Those areas, called Fire Hazard Severity Zones (FHSZ), show the likelihood that an area will burn over a 30 to 50 year period based on current conditions. Local governments then have discretion in adopting these maps from CAL FIRE. Once they do, the maps are used as a basis for building standards for new construction and property development standards for roads and water supplies, and provide the basis for disclosure of risk when properties are sold. In California, the financial responsibility for fire prevention and suppression depends on geography, with areas mapped as state responsibility areas (SRA) or local responsibility areas (LRA).

Significant areas of California are not currently included in the FHSZ maps because the maps were intended to guide the building of new homes, primarily in the SRAs. As a result, the maps have geographic gaps, especially in LRAs, where there is no established hazard rating. Therefore, not being in an official hazard zone does not mean that no fire hazard exists. Wildfire building codes are required in all Very High Hazard Severity

Zones, whether in SRAs or LRAs. However, this misses moderate and high severity zones in the LRAs where hazard maps have gaps, and wildfire building codes are not required.

Wildfire 1 *Develop wildfire hazard maps that include moderate, high, and very high distinctions for the entire state, rather than only for the State Responsibility Areas*

Motivation: As discussed above, California maintains its own wildfire hazard maps, known as Fire Hazard Severity Zones (FHSZ), which have not been updated in over 10 years. In addition, some areas do not have publicly available ratings for moderate or high risks because they fall in local responsibility areas, and some local jurisdictions do not adopt the state FHSZ maps. The consequence of these gaps is that some areas with moderate risk are not currently required to build to the wildfire risk building codes. This problem is most visible when areas that were recently burned in wildfires are being rebuilt to less than the current wildfire building codes. Building or rebuilding without applying wildfire building codes is a missed opportunity to reduce risk.

Recommendation: The state legislature should specify that CAL FIRE update Fire Hazard maps no less than every eight years to align with updates to local planning documents. The state legislature should specify that all areas of the state should be assessed and mapped for fire hazard, including the areas that are omitted from the existing maps. All the maps should identify the level of risk as being "moderate," "high," or "very high," as is currently done for all SRAs. Furthermore, the legislature should direct that CAL FIRE designations trigger automatic adoption of wildfire related building codes. The most up-to-date map should be available in the one-stop resource from **Cross Cutting Recommendation 3**.

Risk Reduction

Reducing wildfire risk cannot be done with one approach on its own; all opportunities at the parcel, community, and landscape level should be evaluated. Community actions are essential and many communities are already approaching wildfire risk reduction through FireWise Communities—areas where residents have agreed to develop and follow a wildfire mitigation plan recognized by the National Fire Protection Association (NFPA)—or through local ordinances enforced by local governments.

Building codes typically only apply to new construction, or perhaps during rebuilding, leaving existing homes more vulnerable. So while these stricter building codes have made progress toward preventing fire damage for buildings built after 2008, buildings constructed beforehand are still at great risk. As the Sacramento Bee outlines, while the initial proposed 2020 budget included $101 million to help retrofit older homes, the pandemic and its resulting financial crunch quickly extinguished this idea—and the owners of older buildings have thus never received any funding to mitigate their fire risk. Furthermore, owners of older buildings in high fire severity zones—which are usually more rural—are often not financially able to do these retrofits on their own. These retrofits do make financial sense, however. A recent report from the International Code Council explains that the National Institute of Building Sciences (NIBS) found that

retrofitting structures in Wildland-Urban Interface Fire Areas to provisions of the 2018 IWUIC (International Wildland Urban Interface Code)—a code largely similar to that required of new buildings in CA fire zones—provides a "conservative benefit of $2 for every $1 invested but could yield as much as an $8 benefit."

Requiring additional fireproofing for new buildings would also not necessarily impose large costs. In a November 2018 study, Headwater Economics, a consulting firm, found that "a new home built to wildfire-resistant codes can be constructed for roughly the same cost as a typical home," and that "some of these materials have added benefits such as longer lifespan and reduced maintenance." While they acknowledge that state and local governments must "weigh many issues" when considering new regulations, their findings suggest that "the cost of constructing to comply with wildfire-resistant building codes" should not be one of these issues.

Wildfire 2 *Increase and optimize open space to reduce wildfire risks*

Motivation: Increasing open space to create buffers between neighborhoods, reducing home to home transmission. Redevelopment of communities in wildfire risk areas, however, can be challenging because buildings are already sited and constructed. Governments have opportunities to promote risk reduction through redevelopment when properties are not rebuilt after loss and available to be purchased at reduced cost. In the aftermath of wildfire losses, certain homeowners may not return, leaving properties undeveloped amidst a rebuilding development. In addition, some agricultural properties are retired to meet water management requirements. These lands could be purchased by the state or local governments or by non-profit organizations and used as open space to increase wildfire resilience for existing developments.

Recommendations: The two overriding goals to strategically plan buffers to reduce wildfire risk should be: 1) utilizing existing open space and newly available former working lands, such as ranches, farms, and parks, and 2) purchasing vacated lots to provide additional open space for strategic wildfire buffers. The Insurance Commissioner should convene public policy experts to initiate a process that would enable both non-governmental organizations and government agencies to identify vacated properties, including nature-based and natural working land options, to be acquired and restored as natural risk reduction buffers. The Insurance Commissioner could work with insurers and local governments to identify properties that are not being rebuilt, and with planners to develop strategies for reducing risks.

Wildfire 3 *Ensure that building codes are improved*

Motivation: In the fire footprint of recent northern California wildfires, homes are not being rebuilt to the current state wildfire building codes.[41] While these homes are in areas with moderate or higher wildfire risk, building codes were not required. This points to the need to expand the geographic scope of areas that fall under California's wildfire code and to update the code to stricter standards.

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Recommendation: This recommendation is in two parts. 1) The legislature should require fire resistant building codes for all new and rebuilt homes in all moderate and higher wildfire risk areas in the state. Anticipating that risks are increasing, the rebuilding process after tragic wildfires should result in a more resilient home, built to the most up-to-date standards. 2) At the next revision of the California wildfire building codes, the state legislature should specify that codes consider existing research[42] on the siting and spacing of structures to reduce wildfire vulnerability. Finally, the Insurance Commissioner should work with insurance companies to develop better data collection on the loss experience of homes that have employed risk reduction measures to accelerate the development of forward-looking performance-based standards. The state can leverage this process to develop better data collection and analysis tools to inform the planning of new and rebuilt structures. Given the increasing and changing nature of climate impacts and the need to consider both the structures themselves and the surrounding areas, the legislature should consider establishing a specific independent Commission to recommend additional measures on how to reduce wildfire losses in the Wildland-Urban Interface.

Wildfire 4 *Rebuild stronger homes and design existing communities to be safer*

Motivation: Wildfires can be tragic and destructive. Avoiding repeat devastation is in the best interests of communities. In addition, community redevelopment to reduce future risks is often most achievable when rebuilding is occurring. In the aftermath of wildfires, local governments have an opportunity to provide the incentives and rules to encourage the strongest possible rebuilding process. In particular, a local government can rebuild in a way that adds additional buffers and defensible space.

Recommendation: The state legislature should establish an independent wildland urban interface commission to advise on community rebuilding plans. After a wildfire that results in large losses, local governments should re-evaluate their general plans, local ordinances, and the codes that govern rebuilding. Furthermore, the state legislature should revise state law to provide a process for land easements for the specific purpose of wildfire risk reduction to be recognized by land trusts and tax laws, providing further incentives for rethinking community risk reduction during the rebuilding process.

Risk Transfer

Although the number of homes with wildfire coverage is relatively high and insurance availability is largely guaranteed by the California FAIR Plan, there are reasons to expect that many homeowners have insurance coverage that will not fully cover the costs to rebuild. In the aftermath of recent wildfires, the Department of Insurance has received numerous communications from consumers frustrated by the costs to rebuild outpacing their insurance coverage. This problem is not unique to California. A recent research article estimated that the majority of homeowners in the US have less insurance coverage than it would take to rebuild their homes.[43]

As a supplement to current insurance options, coupling a community insurance concept with nature-based solutions could provide broad benefits in addressing wildfire risks.

California, and the western US more broadly, has a history of fire suppression that has increased the risk of high severity wildfires. In addition, designing communities with managed buffer areas of forest or open space can decrease wildfire losses.

Wildfire 5 *Develop proof of concept project to establish a community insurance solution*

Motivation: Community insurance solutions could be a complementary strategy to indemnity insurance for decreasing the protection gap. California currently does not have community insurance solutions for wildfire, and initiating pilot projects would provide proof of concept for this strategy.

Recommendation: The Insurance Commissioner should convene insurance experts and stakeholders, and support the development of a pilot project for a community insurance policy in an area of high wildfire risk to assist in closing the protection gap. Such a policy could cover a portion of the initial wildfire costs, including evacuation costs and up to $100,000 in homeowners coverage for participating residents. The pilot would include the following elements:

- The community will set up a risk pool for wildfire insurance for households who will pay into the pool that will be insured by the insurance and re-insurance companies.

- The risk pool will provide a predetermined primary portion of coverage limits for homeowners living within the identified community.

- The community will identify, over the course of time, risk mitigation measures that can further reduce the wildfire risk for the region. As studies quantify the benefits of the risk mitigation, the risk transfer mechanisms can incorporate the credits, thus reducing the premiums over time.

Wildfire 6 *Develop proof of concept for a nature-based solution combined with community insurance*

Motivation: Even though evidence supports the argument that pre-hazard mitigation is cost-effective, both the public and private sector struggle to finance resilience projects. Risk transfer and risk reduction have often been treated as two separate mechanisms for disaster risk management. California currently does not have community insurance solutions, and initiating pilot projects would provide proof of concept for this strategy.

Recommendation: The Insurance Commissioner should convene insurance experts and stakeholders to develop a proof of concept project to combine risk mitigation with a community insurance solution in multiple high wildfire risk areas of California, with the following components:

- Identify the region and the natural infrastructure needed to reduce the risk for the region.

- Set mitigation benchmarks in collaboration with IBHS and use those as a standard for all new construction in the region.

- Invite insurers and reinsurers to participate in providing multi-year risk transfer solutions with the above mitigation aspects in place.

- Amortize the reduction in premium associated with the implementation of the regional and localized mitigation into the initial investment.

Wildfire 7 *Make rebuilding costs more visible to reduce the frequency of underinsurance*

Motivation: In the aftermath of recent wildfires, some insured homeowners whose homes were destroyed had insufficient coverage limits for meeting the rebuilding costs of their homes. Insufficient coverage contributes to a wider protection gap and is likely to become a more visible problem if insurance continues to become less affordable.[44] A wider protection gap impedes recovery and hampers California's resilience to wildfires. Given that a small increase in coverage limit could make a significant difference to resilience, this problem needs to be better understood and remedies identified.

Recommendation: The Insurance Commissioner should convene insurance companies in the state and determine how best to compare coverage limits with the rebuilding costs for homes damaged or destroyed in the 2017-2020 wildfires. In addition, the Insurance Commissioner should prioritize outreach and education of consumers on coverage limits, helping consumers evaluate whether coverage limits are adequate to cover the cost of rebuilding or relocation in the wake of wildfire.

EXTREME HEAT

Each year, extreme heat is the largest cause of weather-related deaths, and the Fourth Climate Assessment projects that extreme heat events are increasing in frequency, intensity, and duration.[45] Many low-income communities of color in California are located in areas of higher risk, exacerbated by the repercussions of historic redlining, which resulted in racial segregation in housing.[46,47] Construction practices that lack insulation, a lack of infrastructure and investments in urban forestry or greenspaces, limited ventilation, and inability to afford high cost of temperature control during extreme heat events contribute to greater suffering. This report puts particular focus on urban areas, where more than 87% of Californians live, and where urban-heat-island effects escalate peak temperatures, limit night-time cooling, and can produce localized temperatures several degrees higher in communities of color. Vulnerable, low-income families also commonly lack the resources to reduce their exposure to heat, including a lack of resources to cool their homes, according to a recent study of Los Angeles by researchers at the University of Southern California. A forthcoming assessment in Los Angeles County shows that not only is high heat exposure impacting communities, but

that many communities have limited capacity to adapt to such conditions, resulting in vulnerability to extreme heat.

Vulnerability to Extreme Heat
In California, vulnerability to climate impacts, and especially extreme heat events is exacerbated by existing inequalities. Research on ten heat events in the U.S. 2001-2010 indicate that costs for heat-related in hospitalized were greater among Black, Hispanic, and Asian and Pacific Islander communities. Individuals hospitalized for heat-related illnesses were more likely to reside in the lowest zip-code income quartile, not have insurance, and be hospitalized in rural areas.[44] Furthermore, a study that analyzed maps of redlined vs. non-redlined neighborhoods, which were used beginning in the 1930s and outlawed in 1968, with maps of recent temperatures demonstrates that 94% of studied areas from over 100 cities show patterns of higher land surface temperatures in formerly redlined areas, indicating racial inequities, especially for Black communities, in extreme heat exposure.[45]

The anticipated health impacts are projected to be substantial: increased hospitalizations due to heat-related illnesses and significant increases in kidney and other renal problems to be treated.[48] Kidney disease is expected to increase more than 10% by 2050, resulting in over 500,000 additional cases. Without risk reduction, hospital capacity could be insufficient, businesses risk lost revenue due to disruptions, and local government costs will likely spike. A study by the Natural Resources Defense Council in 2011 found that a 2006 heat wave in California resulted in nearly $179 million in costs due to hospitalizations, out-patient visits, and emergency room visits.[49]

In addition to public health impacts and costs, heat also increases the strain on energy grids, decreases labor productivity, and threatens to disrupt the agricultural industry.[50] Without further planning, such impacts will create costs and disruptions that will lead to further inequity. Therefore, reducing risks to heat impacts will help safeguard health and the long-term sustainability of local economies.[51]

Heat-related Illnesses
Mitigating extreme heat events will save lives and reduce hospitalizations. An assessment of hospitalizations related to heat exposure in California found that every 10°F increase above the mean ambient temperature is accompanied by a 393% increase in hospitalization for heat exposure, a 3% increase in hospitalization for ischemic stroke, and a 15% increase in acute renal failure hospitalizations.[45]

Insurance solutions for heat waves exist in part for crops and under the umbrella of health insurance, but are lacking to address other heat-related problems. Crop insurance exists through the Federal government, but incomplete in coverage. For example, the federal program does not cover some specialty crops, which are important parts of local and state economies in California. Furthermore, the combination of deductibles and coverage limits, and the lack of insurance for downstream economies, such as the transport and processing of crops, leaves a concerning protection gap for

individuals and local economies. In addition, despite the fact that at this time health insurance is widely held by Californians, the costs to individuals in lost income and long-term chronic health impacts, and the anticipated costs to health systems and the economy from repeated extreme heat waves could be overwhelming.

Assess the Risk

A more comprehensive assessment on the impacts of extreme heat is needed to build a consciousness around the risks of extreme heat exposure and to develop better solutions for the future. California has multiple assessment tools of the heat *threat*, including the Cal-Adapt tool and the Urban Heat Index. Yet, assessments of the *impacts* of heat events are far less common. Particular to California, one study that estimated health impact costs of a 2006 statewide, ten-day heat wave event found the direct health costs to be approximately $179 million U.S. dollars based on hospitalizations, emergency department visits, and outpatient visits[52]. In addition, a 2014 study estimated that the worker productivity of individual days declines roughly 1.7% for each 1.8°F increase in daily average temperature above 59°F, and that a weekday above 86°F costs an average county $20 per person.[53] Better assessments of the financial and health costs from extreme heat events are essential for designing and funding public programs to reduce the climate impacts from heat waves in California.

Extreme Heat 1 *Perform extreme heat public sector cost analysis*

Motivation: In recent years, the ability of researchers to more accurately calculate the diffuse effects of extreme heat has improved as economic and climate modeling techniques have advanced, and larger amounts of data have become available on specific economic sectors and regions.[54] These developments all provide an opportunity to increase the understanding of extreme heat costs–a critical step in preparing for and developing financial resilience to extreme heat and risk transfer instruments. An economic analysis that delves deeply into the costs of extreme heat events to cities, counties, and the state would inform the needed size and adaptability of specific local funds or potential insurance coverages to consider in planning decisions by local and state authorities.

Recommendation: The Commissioner should convene with university researchers and other public agencies to develop a method for backcasting extreme heat costs and apply it in multiple California cities or counties. The analytic method should also include the capability to use the backcasting finding to forecast future costs from an extreme heat event to allow decision makers to compare future heat-related costs with the costs of mitigation efforts.

- First, reliable meteorological data encompassing a past heat event and data representing associated outcomes in a sector (e.g., hospitalizations, reduced productivity, financial market trends) must be identified.

- By analyzing outcomes (financial, health-related, government and business interruption) over time, cost impacts and implications of extreme heat events can be isolated.

- Data from multiple communities and cities can be examined and compared among locations to identify discrepancies due to extreme heat.[55] The cost of a specific indicator (e.g., a single emergency room visit) can be established based on information from local authorities or existing research on the subject. Recently, the New York Department of Health partnered with NASA Earth Science to study past heat events for identifying thresholds, and the results of the study led to New York changing its heat advisory threshold from 100ºF to 95ºF.[56]

The result of this work would not only be an understanding of total extreme heat cost, but also the development of a clear methodology and identified best practices to do this analysis in any location or municipality, which will enable improved decisions leading to greater financial and physical resilience.

Extreme Heat 2 *Strengthen insurance coverage to account for costs of extreme heat events*

Motivation: Extreme heat spikes can cause both acute and cumulative economic stress. In California in 2020, extreme heat events and forecasts prompted the Governor to make an emergency declaration, the first of its kind. The events disrupted the energy supply, businesses, and supply chains.[57] Many businesses carry supply chain or business interruption insurance coverages, but it remains unknown if common policies cover heat-related events. Heat is also correlated with decreased economic productivity and increased workers compensation claims.[58] Looking forward, the increased prevalence of extreme heat events may have measurable impacts on payouts from existing insurance policies. The inclusion or exclusion of such costs in existing policies should be a consideration by the businesses purchasing these policies, and also by the local jurisdictions planning for extreme heat events because heat has economic impacts. If extreme heat events have unmet costs to local businesses, energy systems, tax revenues, government operations or health care, they could threaten fiscal sustainability of local governments.

Recommendation: The Insurance Commissioner should work with state agencies, scientists, and international organizations to consider the implications of extreme heat for existing insurance lines that may be vulnerable to a surge of claims or periodic disruption by extreme heat events, such as insurance products related to health, energy outages, workers compensation, or supply chain disruptions. The Commissioner should also consider existing risk transfer solutions available in the market to reduce risks of supply chain disruptions or to alleviate the drain on past workers compensation to focus on newer risks.

Risk Communication

Even with existing data, risk communication for heat must be urgently expanded. The Fourth Climate Assessment found that, in California from 1999 to 2009, 19 heat-related events occurred that had significant impacts on human health, resulting in about 11,000 excess hospitalizations. However, the National Weather Service issued Heat Advisories for only six of the events. Heat-Health Events (HHEs), defined using an existing California tool.[59] In addition, California has developed several tools, including the Urban Heat Island Index and the Office of Emergency Services (CalOES) online resources that link to National Weather Service advisories, those resources are not commonly used by state or local governments for action plans.

Extreme Heat 3 *Improve communication of heat threats and potential impacts*

Motivation: Although public education programs for extreme heat exist, further coordination and collaboration is needed to reach people and avoid health impacts. For local governments and the state to reduce heat impacts, communicating the threat and ways to reduce impacts, whether to human health or the economy, requires a coordinated policy response and adequate resources. Even though the state has tools, it is unclear whether they are being used. In particular, federal and state agencies have spent years producing warning systems and communication plans for emergency flooding, fires, tornadoes, and earthquakes, among others. California needs successful communication of risk with communities for the state's programs to have a positive impact.

Recommendation: The Insurance Commissioner should liaison with California Public Health, the Office of Environmental Health Hazard Assessment, CalOES, and other relevant state agencies to launch an Extreme Heat Risk Communication Campaign with state and local partners (*see Appendix 3)*. Information like emergency warnings should be shared in multiple languages to ensure critical information reaches linguistically isolated communities. Strategies should consider how people with poor or no broadband will be able to access the information in addition to people who are hearing and seeing impaired. Cooling centers and other emergency shelters should also be accessible to communities that need them most, particularly for residents without access to reliable transportation.

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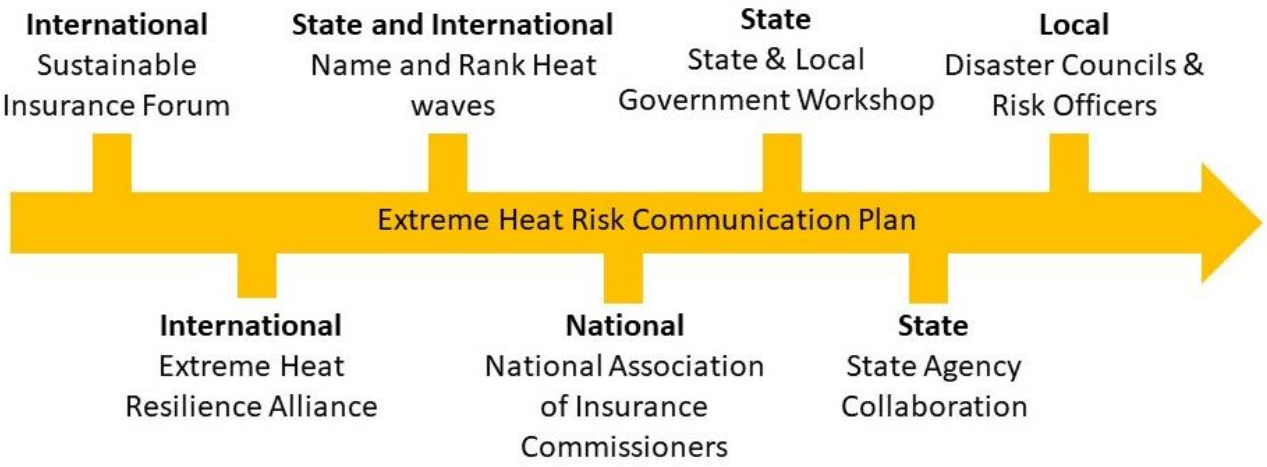

Figure 3. Communicating the threat of heat requires a multi-jurisdictional effort, including local, state, national, and international partners. Partnerships among insurance regulators, such as the Sustainable Insurance Forum, and among public policy experts, such as the Extreme Heat Resilience Alliance, can produce a more effective warning system and communication strategy.

Extreme Heat 4 *Improve warning systems*

Motivation: Advance warning of disasters save lives and provide a window of opportunity for protecting property or avoiding harm.[60] Such systems have historically been critical assets for facilitating evacuations and risk reduction measures. California's "red flag" warnings for wildfire conditions, the Environmental Protection Agency Air Quality App, and the naming system for tropical storms and hurricanes by NOAA could serve as templates for naming and ranking heat waves. For example, early warning of an approaching hurricane often prompts boarding up windows and placing sandbags. Even though weather forecasting from the National Weather Service provides advance information, California's early warning systems for extreme heat are not demonstrably effective, in part because extreme heat is not often viewed as an event for which to prepare and react. California has existing tools, including an urban heat index and Heat Health Event calculator, but no coordinated warning system. At multiple levels of government, extreme heat events appear to surprise policy makers. In a very recent example, even with advance warning, the heat waves of 2020 in California caused disruptions to the state's highly sophisticated electricity grid.

Recommendation: The Insurance Commissioner should work with state agencies and legislators to establish a state system to identify and rank heat waves, and to provide information to the public about the projected impacts of each. Clear categorization of heat waves could enable public policy makers to craft prevention strategies, risk reduction measures, and response strategies to specific thresholds. Such a system could allow the state to track the impacts of specific events more easily and communicate the

results to the public more effectively. A heat wave categorization system should include the following elements:

- The heat wave name should include categories of magnitude, and communications about the event should include details related to geographic location, measures of severity, and potential duration to make it easier to track.

- The different categories should be accompanied by recommended precautions for the public to take based on the intensity of the heat event, with additional precautions described for vulnerable populations. For example, for a Category 2 heat wave warning, the public should limit time outdoors and wear loose, cool clothing and a hat and sunglasses. Vulnerable populations like the elderly and others that are especially susceptible may need to take additional measures.

Risk Reduction

One of the recommendations from the Global Commission on Adaptation Report is to expand green space in and around cities to reduce heat risks.[61] Increasing urban forests, changing materials used to build streets, and providing incentives for cool roofs can all moderate the temperatures experienced by communities and can be integrated into state and local planning and spending priorities. Such measures can reduce the risks to communities and reduce the unmet costs to both the public and private sector, stabilizing budgets for businesses and local governments alike. California has existing programs but no overarching statewide strategy or benchmarks.

Extreme Heat 5

Motivation: The burden of addressing extreme heat falls heavily on local governments, and in response, many are developing heat action plans. Yet implementing a comprehensive approach carries costs and risks to local governments, which require supplemental, ongoing funding. Bonds can move money forward in time, which is critical for extreme heat impacts that are projected to grow. A Social Investment Bond is a finance tool that could help a city improve health outcomes in a vulnerable community by reducing peak day and night temperatures, while providing data on the efficacy of implementing a heat action plan. Such data will help clarify insurance opportunities for local governments while reducing impacts.

Pay for Performance Bond Concept
In Washington D.C., the Water and Sewer Authority has created a municipal bond with an innovative structure that invests in green infrastructure to reduce the incidence and volume of sewer overflows, and covers the potential unexpected downsides. The performance risks of the green investments are shared among The DC Water and Sewer Authority and the investors (*See* writeup on concept by NRDC).

Recommendation: The Insurance Commissioner should propose a Climate Resilience Bond Financing Concept for Local Heat Action Plans. A model pilot project, in which a comprehensive heat action plan would be implemented in a vulnerable or disadvantaged community, could provide valuable lessons in reducing heat risks. The project would be financed through an innovative Climate Resilience bond with a risk transfer mechanism based on the "Pay for Performance" construct. Such an approach has been recently used to promote green infrastructure in Washington D.C. (*see box)*[62] The bond would be paid for by a combination of local and state funds. The bond would be structured as follows:

- If the reduction in temperature or other relevant metric in the pilot area compared to the city at large falls within the estimated range, the city pays back the investors per the terms of the bond without a contingency fee.

- If the temperature reduction is greater by a predetermined amount, the government pays the contingency fee to the bond purchaser for assuming the risk.

- If the project underperforms and the reduction in temperature falls below the estimated range, the purchaser pays an additional risk payment—the contingency fee—to the City.

If successful, the pilot project would provide a proof of concept, demonstrating that a comprehensive heat action plan can reduce public health risks during extreme heat events, while also showing the potential benefits of transferring a portion of their risk from extreme heat through an innovative parametric insurance instrument. A successful pilot may motivate the local government use such a parametric insurance instrument.

Risk Transfer

California likely faces a financial gap in meeting the anticipated increase in hospitalizations, disruptions to business, the need for additional cooling centers, and the electricity to power those centers. Insurance is a financial planning tool that can address some, but not all, of the specific heat-related risks. The proposed framework (*Figure 4, below*) offers an approach to identifying points of stress or shock and designing interventions, and is meant to demonstrate concepts that can be tailored to state or local government needs. At each point in the curve, the local jurisdiction could develop risk transfer policies or employ intense risk reduction to alleviate the escalating impacts.

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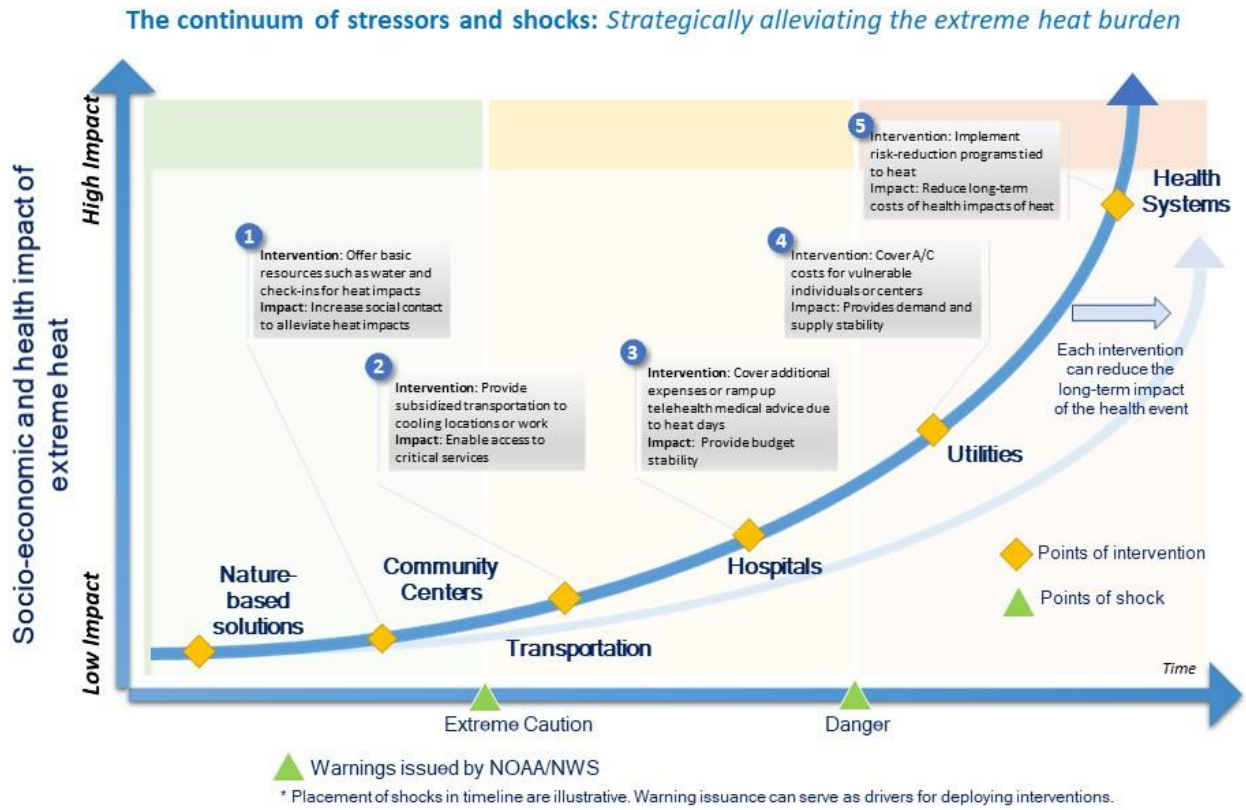

Figure 4. For extreme heat events, the magnitude and duration of the episode increase moving up the X-axis and the socio-economic and health impacts increase moving up the Y-axis. The curve indicates the escalating impact of the heat episode with increasing time and severity; this impact can be curbed through interventions, such as a public outreach campaign and mitigation actions. However, each point requires additional costs, which could be paid through fund reserves or a risk transfer product. Local jurisdictions or the state would identify points where risk reduction and risk transfer could be effective and design a solution. Such a framework can be adapted to the needs of each jurisdiction.

Extreme Heat 6 *Develop pilot projects for extreme heat*

Motivation: California should initiate an overarching pilot project approach to insurance product development now so that the types of policies that can provide financial protection could be in place as climate impacts on health accelerate. Without insurance policy development and risk mitigation, unplanned costs will fall on overwhelmed local governments and their individual constituents. Furthermore, proactive risk mitigation and intervention through insurance products is necessary to reduce the impact of these events; indemnifying for catastrophic impacts after the fact misses the opportunity to reduce individual suffering and community cost.

Many extreme heat costs fall to local governments, health systems, and individuals. Timely funding is needed to support intervention services when extreme heat waves

occur. Jurisdictions with the mandate to provide needed public services during heat waves can incur unanticipated and unmet costs. In the short term, counties and cities might have to deploy healthcare staff to check on vulnerable individuals and provide cooling centers for people to find shelter, or run transportation services at a higher cost. In the medium term, hospital emergency rooms may be overwhelmed by individuals seeking care. Because many vulnerable individuals lack air conditioning, or the ability to pay to run air conditioning, it may be unsafe to send them home. Greater hospital admissions and longer hospital stays, in turn, escalate expenses to counties and cities that own and manage public hospitals. In the long term, the cumulative impact of illnesses exacerbated by heat conditions, such as diabetes and kidney disease, can be tragic for communities and create significant costs for local jurisdictions in social services. If counties, cities, hospitals, and utilities are not able to reduce climate impacts, then repeated economic disruptions and long-term damage to health will ensue.

Recommendation: The Insurance Commissioner should convene potential partners and put out a Request for Proposals to conduct a proof of concept for an extreme-heat-risk transfer and risk-mitigation strategy. The effort should identify 1 – 3 potential urban locations to implement and test risk mitigation and risk transfer solutions. The effort should consider insurance solutions at the individual level to incentivize early intervention as well as at the jurisdiction level to reduce the financial and health impact to a community.

Although a risk transfer product for hospitals should be considered, the overall goal should be to develop the strategies that could be considered to preserve stability for health systems, energy systems, cooling systems, and public sector budgets in the face of successive heat waves. *Please see Appendix 3 for specific proposals.*

Extreme Heat *7 Establish a California extreme heat risk pool*

Motivation: Developing effective strategies for reducing risks from heat events offers an opportunity to open a new frontier in resilience planning—the establishment of risk pools. During each heat wave, while health costs may be covered by individual health insurance, the cost to a city or county in reduced tax revenue from lost economic activity, in electricity outages, and in the need for interventions, such as cooling centers and proactive medical outreach, can be abrupt and disruptive to budgets.

Recommendation: In order to reduce the health and financial risks of extreme heat, we recommend that the Insurance Commissioner develop a proposal to establish an extreme heat risk pool, which would transfer aggregated risk from counties or cities to the state, and subsequently to reinsurance markets. The Insurance Commissioner should review existing captives and risk pools, and identify the appropriate stakeholders and experts to convene for policy development.

This type of solution costs money, which would come from taxpayers. The public sector would need to pay more money upfront, but gain the capacity to better react to future heat waves, potentially preserving health and saving money in the long term. Risk pools for natural disasters have been tested around the world (e.g., African Risk Capacity) as a

method of quickly and consistently delivering funding to local and national governments when disasters strike.[63]

FONDEN
As part of the country's disaster finance strategy, Mexico established a fund for natural disasters, known as FONDEN. When funded, after a disaster, the fund can be used for the rehabilitation and reconstruction of: 1) public infrastructure (federal, state, and municipal); 2) low-income housing; and 3) specified actions to restore the natural environment. A portion of the FONDEN fund supports disaster risk reduction.

CCRIF
The Caribbean Catastrophe Risk Insurance Facility was formed as the first multi-country risk pool in the world. The CCRIF is backed by a parametric policy that limits the financial impacts of tropical cyclones, earthquakes, excess rainfall, and the fisheries sector to Caribbean and Central American governments

A California statewide financial risk pool would enable a timely and forward-looking response to extreme heat, by 1) granting access to critical and immediate capital directly before or immediately after an extreme heat event, and 2) preventing the need to drain existing budget allocations or accrue debt from bank loans to finance extreme heat response. A parametric insurance model would increase the speed at which disbursements reach governments by relying on a set "trigger" based on reliable data to quickly release payments. The case of the Caribbean Catastrophe Risk Insurance Facility (CCRIF)[64] illustrates the value of parametric insurance—since 2007, all of the facility's payouts to member governments have been made within two weeks of the triggering events (*see box*). Such timeliness is critical. Mexico's FONDEN,[65] a fund for natural disasters, demonstrates the effectiveness of a risk pool coordinated across multiple levels within a single country (*see box*). FONDEN has been previously funded by the federal government and created an incentive at the federal, state, and local level to jointly manage risks and transfer risks. In the case of CCRIF and FONDEN, payments are made to insured governments by the facility or program. In the context of California, payments could go directly to counties or cities.

To provide liquidity for heat event preparation, public interventions and lifesaving activities, payouts could also be shifted to pre-event actions by relying on increasingly accurate forecasting, as the Red Cross has done in Vietnam (*see box*). Though the Red Cross delivers philanthropic—not insurance—money, its work demonstrates the value of pre-event financing for evidence-based preparation measures, such as setting up cooling stations and initiating community outreach programs. Partnerships should be formed with research and academic institutions that monitor relevant data to develop a robust trigger protocol.

Vietnam and the Red Cross
In Hanoi, the Red Cross partnered with the Institute of Meteorology, Hydrology, and Environment (IMHEN) to develop a trigger protocol for delivering philanthropic dollars for extreme heat impacts. The trigger protocol requires that the Heat Index reaches its 99th percentile value for two consecutive days, and that the maximum temperature forecast is higher or equal to 37 °C both six and three days before the forecasted extreme heat event.

A trigger protocol could be developed in California in partnership with meteorologists, climatologists and others, building on the Urban Heat Island Index for California developed by the Office of Environmental Health Hazard Assessment at the California Environmental Protection Agency.[66] Based on this tool, a trigger would be set for when payment from the risk pool's parametric policy would be made to the local government jurisdiction a few days prior to, during, or immediately after the heat wave. The local jurisdiction would decide how to use the funds.

FLOODING

Flooding is responsible for the most damage from all natural hazards in the United States. California faces threats from a number of different types of flooding, depending on the region. Those types include river (or fluvial) flooding, coastal tidal and storm surge flooding, rainfall (or pluvial) flooding, and flooding from the failure of protective infrastructure such as dams and levees. The risks from all these sources is increasing, due to a combination of climate changes, increased development, and infrastructure in need of repairs and upgrades. According to the Fourth Climate Assessment, for example, there will be more frequent flooding and inundation in certain regions, as well as increased cliff, bluff, dune, and beach erosion.[67] Higher precipitation-related flood risk is also driving increases in landslide and mudslide risks, particularly post-fire when the vegetation on the slopes has been burned and reduced. The risks are not just to homes, but to all types of infrastructure as well, such as roads and railways, harbors and airports, power plants and wastewater treatment facilities, and thousands of businesses and homes.[68]

Even aggressive reductions in greenhouse gas emissions will not eliminate the risk to California of extreme sea-level rise from Antarctic or Greenland ice loss, particularly if glaciological processes reach tipping points.[69] The Fourth Climate Assessment estimates that close to $18 billion in residential and commercial structures could be inundated from sea-level rise by 2050. Many inland communities that may not consider themselves vulnerable to sea-level rise can also expect to see inundation, saltwater intrusion, and disruptions to supply chains and to access to goods and services.[70] Sea-level rise will interfere with California's $44 billion ocean economy, including coastal recreation and tourism, as well as ports and shipping.[71] California's coastline has concentrated areas of economic activity and assets, including ports and cold storage, tourism, and fishing.

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Not only will California face greater risks of flooding because of climate-intensified rainfall and snowmelt, the state also may suffer greater effects and damage from floods because the nature-based "sponge" capacity of the state's landscape has been largely diminished over the course of the state's history. California's major rivers were once flanked by miles of floodplains, which allowed floodwaters to spread, meander, and pool. Land use conversion and development has eliminated many of those protective floodplains, and the hardening of banks and levees has fundamentally altered how water flows through the state, exacerbating flood risks. In addition, the United States Geological Survey estimates that California has lost approximately 95% of its historical wetlands, further reducing the natural water retention capacity of the landscape.

The State of California has tried to reverse these negative trends by improving floodplain management,[72,73] and made some progress restoring nature-based floodways and flood bypasses.[74] Large-scale preservation of floodplains requires acquiring and connecting large tracts of land and maintaining land uses compatible with flood management.[75] While expensive, these practices are already implemented in California through various programs, including state and federal laws protecting wetlands, local zoning, government-funded incentive programs, and acquisition of land by governmental entities, nonprofit organizations, or partnerships dedicated to land preservation.[76] There have also been federal-local partnerships on these types of nature-based solutions, such as the Napa "living river" project.[77] Acquired lands may generate revenue by continuing in agricultural production or by taking advantage of emerging markets for carbon sequestration or groundwater recharge.[78]

Assess the Risk

At the state level, the Department of Water Resources conducts risk assessment, primarily related to snowmelt, precipitation, and atmospheric rivers as a means to manage water supply and flood control from gray infrastructure. Localized risks have historically been managed by local governments, many of which work with FEMA and state agencies to produce hazard mitigation plans. One exception lies in the Central Valley, where flooding from rivers and examples of failed flood prevention infrastructure prompted the legislature to mandate a regionally focused risk assessment. Starting in 2012 and updated every five years subsequently, the Central Valley region develops a flood protection plan for each of six major rivers. This plan establishes zoning requirements for new development based on flooding risks. However, other jurisdictions in the state do not establish such plans and residents may not have access to insightful maps or models. Looking forward, federal risk assessment tools will be critical for assessing the various risks of flooding in California. Some of the most sophisticated risk assessment is focused on coastal flooding, the United States Geological Survey (USGS) has published the Coastal Storm Modeling System (CoSMoS), which makes detailed predictions of storm-induced coastal flooding, erosion, and cliff failures over large geographic scales.

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Flooding 1 *Conduct high rainfall event vulnerability analysis*

Motivation: The vulnerability of a home to flooding from large storms, such as those caused by atmospheric rivers, is a fundamental piece of information for homeowners, communities, and the state, in order for appropriate risk reduction actions to be adopted. Currently, there is poor understanding about the risk of structures to these types of catastrophic flood events.

Recommendation: The Insurance Commissioner should initiate a Request for Proposals for a vulnerability analysis of possible impacts from major atmospheric rivers. The analysis could draw upon historical data from the Great California Flood of 1861 and 1862 and couple it to forward looking modeling to anticipate the impacts of similar, or even greater, atmospheric rivers in the future. The report should also examine available mitigation strategies. The vulnerability analysis could be instrumental in setting building standards for new construction and in guiding community disaster resilience planning. This vulnerability analysis should be used to prioritize local flood mapping and modeling efforts.

Risk Communication

Much flood risk communication is done through the Federal Emergency Management Agency (FEMA), since it is the home for the National Flood Insurance Program (NFIP). FEMA produces flood hazard maps that depict various flood zones. Property located in a FEMA-mapped 1% annual chance floodplain, also referred to as a Special Flood Hazard Area (SFHA), with a federally-backed loan or a loan from a federally-backed lender must purchase flood insurance. As part of the program, lenders must disclose when a property is located in the SFHA. Many states, including California, also require sellers to disclose when a home is located in a SFHA.

Unfortunately, the existing FEMA maps for flood risk in California are outdated and incomplete. They typically fail to include the flood risks from extreme rainfall flooding (pluvial flood risk) as opposed to river flooding, and also create a false sense that flood risk is binary, depending on whether one is “in” or “out” of the SFHA. Those people who live in areas with out-of-date maps, or outside the coverage area of the FEMA maps, may have moderate or substantial risk, but may not know about that risk. Local development, changing hydrology, and stream maintenance may result in the existing maps being poor reflections of true risk.

Flooding 2 *Make risk reduction information more accessible*

Motivation: Risk reduction is often the key to averting some future losses, yet information on flood risk reduction is difficult for the public to obtain. Even when lists of possible mitigation actions are available, it is challenging for homeowners to know how to identify which mitigation options are best for them, and then to prioritize these actions, obtain cost estimates, secure funding, and find a trustworthy firm to do the work.

Recommendation: The Insurance Commissioner should develop consumer-focused tools that can assist in risk communication and in encouraging homeowners to understand their mitigation alternatives. This could be an online tool that provides information on flood risk, as well as possible mitigation and insurance options, their cost, and certified professionals to assist in the work. An example of this type of tool is https://www.floodhelpny.org, which helps people understand possible flood retrofits, certification systems for elevating a home to reduce flooding risks, and flood insurance. Furthermore, the Insurance Commissioner should work with FEMA to do outreach to those people living in areas where landslides and mudslides could occur in the aftermath of wildfires.

Flooding 3 *Make NFIP pricing more visible*

Motivation: The overwhelming majority of flood insurance is provided through the NFIP. While different insurance firms will write a NFIP policy, the price is the same across firms as it is set by FEMA. It is incredibly difficult for a potential buyer of a new home to get an estimate of the cost of flood insurance *before* making an offer on a property. This is problematic as it is a key component of the cost of ownership, and price is a communication point for homebuyers.

Recommendation: The Insurance Commissioner should create a NFIP flood insurance premium calculator, perhaps in partnership with FEMA, where individuals can enter property addresses or information about their property and immediately get a price quote. This should be done in conjunction with an expansion of the current *Insurance Finder* Tool, now focused on homeowners insurance, including flood insurance options from the NFIP and the private insurance market.

Flooding 4 *Synthesize existing maps and clarifying risks for the public*

Motivation: Flooding risks are more pervasive than is commonly acknowledged in existing planning by individuals or communities. The federal government provides flood hazard maps, but these do not show the full gradation of risk, focusing primarily on designating just the 100-year floodplain, or the area of at least a 1% annual chance of flooding. Furthermore, these maps have been criticized as being out of date and not including all sources of flood risk—notably, they often do not include rainfall-related flooding, sea-level rise, or groundwater flooding, nor risk of mudflows and landslides. Finally, the maps are inherently backward looking and provide no comprehensive information on future flood risk. To fill in gaps in information, several non-governmental organizations, private sector firms, and academics have provided more comprehensive flood risk information and projections of future flood risk. Many possible users, however, are unaware of all the information available or unsure how to compare and evaluate the different models to meet their needs. A private organization, the First Street Foundation, has created comprehensive flood risk information for all properties in the U.S., as well as projections of flood risk over the next thirty years, and now made that risk information available through their own website and Realtor.com.

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Recommendation: To support the one-stop approach for climate risk information in **Cross-Cutting Recommendation 3**, the Insurance Commissioner and the Department of Water Resources (DWR) should work together to make flood mapping resources more comprehensive. In particular, DWR should consider the flood mapping information that currently exists and endorse high quality public (e.g., FEMA) and private options (e.g., First Street Foundation), and report these endorsements to the state legislature and other state agencies. Because flooding can have multiple sources and cause multiple threats, the Insurance Commissioner and DWR should work with federal partners to make hazard maps more extensive, bringing together the existing maps of high flood risk areas, high erosion risk areas, and sea-level rise zones, and areas critical to mitigating the effects of climate change. In particular, the Insurance Commissioner should work with FEMA to ensure that areas where landslides and mudflows are high risk, especially after wildfire, are incorporated into future maps. The most up-to-date maps endorsed by DWR should be included in the one-stop-shop resource in **Cross-Cutting Recommendation 3**.

Risk Reduction

Local zoning, building standards, and natural infrastructure all play roles in California's approach to risk reduction for flooding. California has specific zoning rules for homes in the 100-year floodplain in the Central Valley area, which is where large rivers and water infrastructure collide. Starting in 2009, specific building codes and zoning rules were developed to reduce the risk of flooding to homes. But these development rules do not extend outside of the Central Valley area. All communities that participate in the NFIP must adopt minimum floodplain management regulations. These require that new development in floodways not be allowed if it increases flood heights and that all new construction (or substantially improved or damaged structures) in the FEMA-mapped 100-year floodplain be built above the base flood elevation (or the estimated height of waters in a 100-year flood). There are further requirements in areas subject to storm surge. Some stakeholders have argued that in the face of increasing flood risk, these minimum regulations should be strengthened.

Flooding 5 *Create a market for natural infrastructure investment to reduce flooding risks*

Motivation: Supplemental investment in nature-based solutions is needed to reduce risks and to meet the land conservation and biodiversity protection goals as stated by multiple governments, including by the California Governor. Such restoration investments produce a number of additional co-benefits, including habitat, recreational opportunities, and carbon sequestration. One way to increase the provision of nature-based solutions to flood risk is through a market for natural infrastructure that more effectively values wetlands and floodplains, allows for greater cross-jurisdictional pooling of investments, and could provide a mechanism for including blue carbon accounting in decision-making. Such markets are created through public policy, which requires "credits" that can then be traded, and contribute to the creation of a supply of nature-based solutions for flood risk reduction.

Recommendation: The state legislature should consider creating a market in natural infrastructure credits to finance proven climate-resilience measures. The legislature would need to require developers or others to secure a certain amount of these credits as a condition of new construction. This creates the demand for others to invest in restoration. In one recent example, North Carolina passed legislation to create a first-of-its-kind marketplace to create and sell flood reduction credits.[79] The program builds on the state's existing stream and wetland mitigation program as a way to provide further incentives to reduce flooding risks with investments in nature-based solutions. The new market-based program has three important components, which would apply to a potential California market as well:

- Measurable currency: Both the private sector and public sector must have a shared metric to quantify value and performance. The North Carolina program uses acre-feet of flood water storage capacity as a common currency. The Insurance Commissioner should determine if the state has the data and modeling capability to establish such a currency, including the capacity of existing nature-based solutions to slow and store water.

- Clear demand signal: North Carolina is using hydrologic models developed by the Army Corps of Engineers, with community input, and is setting flood reduction targets for achieving river basin and priority watershed goals.

- Efficient purchasing mechanism: A reverse auction will build on existing state contracting authority to efficiently solicit bids from private sector ecological restoration companies to deliver quantified units of flood reduction capacity.

Risk Transfer

California faces a sizeable flood insurance gap—this refers to the difference between total economic losses and the share of those losses that are insured. More simply, many people at risk of flooding in the state do not have flood insurance. FEMA maps show that approximately 500,000 California properties are in Special Flood Hazard Areas (SFHAs), with a 1% chance of being flooded in any given year. (The private flood insurance market, while growing, still represents less than 10% of the overall policies in force in California.) Yet Californians are severely under-protected for even those flood risks. As of Sept 2019, only 227,000 homes in the state were insured for flood by the National Flood Insurance Program (NFIP). With about 12 million housing units in California, that means less than 5% of all California homes have flood insurance. As discussed above, these maps are often outdated and limited; a recent extensive study by the First Street Foundation estimates that the actual number of properties at a 1% risk is much greater, at 1.1 million, and that an additional 150,000 properties will meet that threshold in the next 30 years, mainly because of rising seas. Absent widespread insurance to provide financial protection post-flood, large atmospheric rivers, coastal storms combined with storm surges and sea-level rise, or rain-on-snow events can be expected to cause further economic damage and pose major threats to household, local, and state fiscal stability.[80]

Flooding 6 *Map distribution of low flood insurance uptake*

Motivation: Low insurance take-up rates for flooding risks in California may have multiple causes—price, lack of information about flood risks, failure to understand the role and importance of insurance in recovery, and a range of behavioral biases in decision-making that lead people to be overly optimistic and dismissive of low-probability risks. Detailed information about flood insurance take-up rates could inform how to best approach reducing the protection gap.

Recommendation: The Insurance Commissioner should undertake a detailed and granular analysis of take-up rates for flood insurance to better identify flood insurance gaps in the state and make the results available to all stakeholders. The Commissioner should also promote flood insurance, even among those outside the SFHA or inside the SFHA but without a mortgage and not subject to the federal mandatory purchase requirement.

***Flooding** 7 Develop proof of concept for a wetlands nature-based solution and risk transfer*

Motivation: For community insurance policies to be fully evaluated, pilot projects must be conducted to develop the science and policy elements needed to conduct thorough analysis of costs and benefits. Recent research has explored combining risk mitigation and risk transfer for coral reefs.[81] California does not have coral reefs but has approximately 2.9–3.8 million acres of wetlands, some of which may be well suited for being incorporated into risk transfer mechanisms for either the community or the wetland (*for example, see* this recent study).[82] Wetlands can be both a mitigator of flooding damages to homes, businesses, and infrastructure, and also a natural asset in need of protection. Risk transfer policies for communities in areas of flooding risk or natural assets at risk of degradation are not likely to become available without further pilot projects co-designed by the state and insurance experts to test proof of concepts and determine costs and benefits.

Recommendation: The Insurance Commissioner should convene insurers and reinsurers and co-develop four nature-based solution risk transfer mechanisms. The focus of the convening should be to identify the asset, mitigator, level of damage, and threat for each innovative pilot project. The concept of these pilot projects would be to make an investment in natural infrastructure so that risks are reduced over time, and concurrently the community pays for insurance to maintain some financial protection (*Figure 5*).

Each pilot project would have three core elements:

1) blend risk mitigation and risk transfer,
2) serve as a template for further policy development, and
3) incorporate hydrologic modeling and scientific monitoring to measure the results.

Under this approach, public or private structures within a community would be the most likely insured assets. The project would identify a location where: 1) a determination is made that a wetland restoration project would reduce the threat of flooding, and 2) flooding maps exist to support the planning. After such a location is identified, a Public-Private Partnership with insurers and reinsurers that incorporates the benefits of risk mitigation from the wetland restoration project would be developed. The state should further allocate an amount equal to the risk premium reduction from the above project towards the next project, and provide the framework for insurance companies writing in that area and local corporates to contribute.

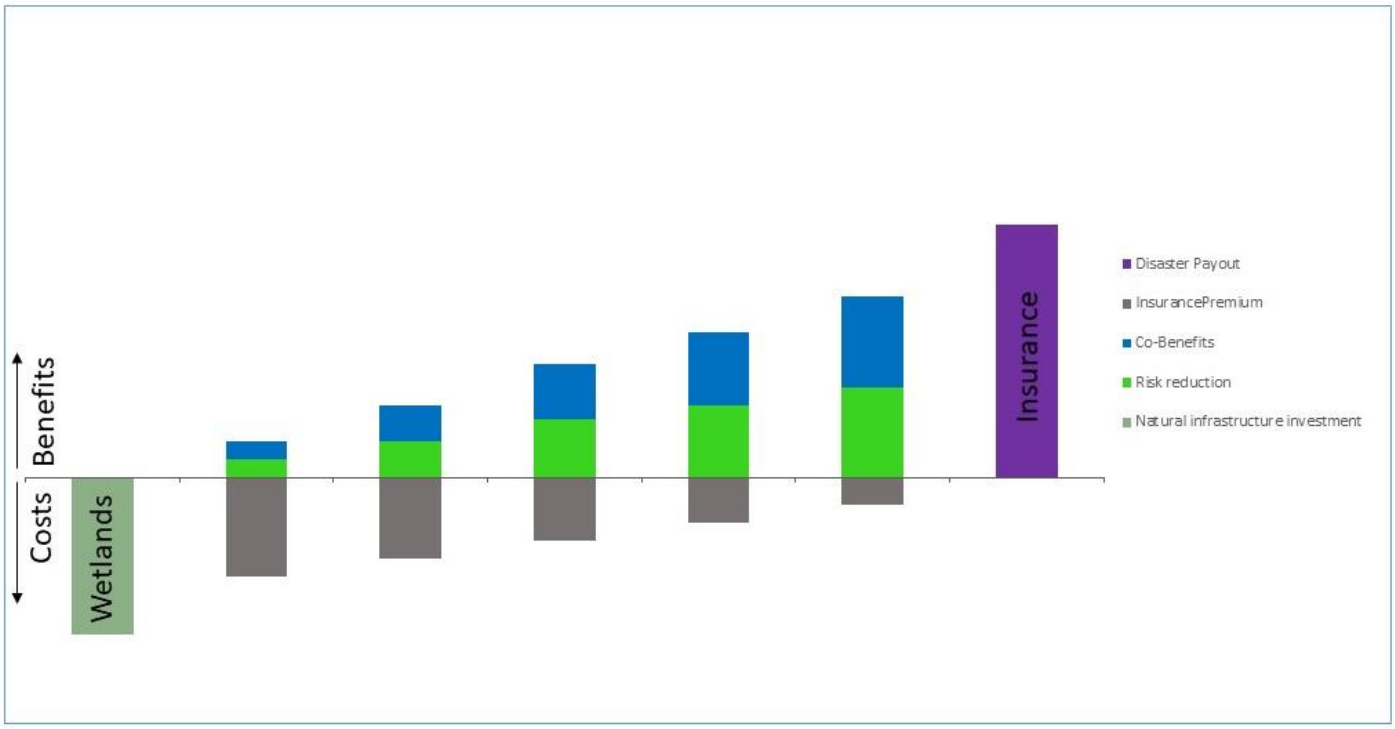

Figure 5. This figure demonstrates that a relatively small investment in a nature-based solution can have a significant multiplier effect by 1) protecting the specific asset in question; 2) lowering insurance premiums and providing savings that can help pay for the desired green infrastructure; and 3) creating new value by protecting health and safety at a community-wide level, encouraging new opportunities for tourism and recreation, increasing biodiversity, protecting and enhancing habitat, enabling carbon sequestration, and providing resilience against climate change. Because the asset continues to be insured, the owner can still receive an insurance payout in the event of a natural disaster (See example, Reguero et al. 2019).

Flooding 8 *Require purchase of flood insurance in specific areas*

Motivation: Although voluntary encouragement and better risk communication may increase the uptake of flood insurance in California, a strengthened mandate may be the

surest path to guaranteeing that all at-risk homeowners have the financial protection of insurance.

Recommendation: The state legislature should consider enacting a mandatory purchase of at least a low-coverage limit ($50,000-$150,000) of flood insurance for all properties within the 500-year floodplain. This would require mapping of the 500-year floodplain across the state.

Flooding 9 *Provide temporary assistance for purchasing flood insurance*

Motivation: As noted earlier, uptake of flood insurance is generally low in California. Barriers to increased uptake may be poor risk communication, lack of public understanding of flood insurance options, and cost. Moreover, human behavior can have systemic biases towards risk, and achieving greater uptake of flood insurance also likely requires addressing the role that inertia and herding play in human decision-making.[83]

Recommendation: In order to attract more households to purchase flood insurance, the state legislature should consider establishing a 3-year program to subsidize flood insurance premiums for low and middle income Californians who purchase flood insurance.

CONCLUSION

Although the insurability of homes and businesses has waxed and waned over time, climate change poses a unique threat. Early action to increase resilience is socially, fiscally, and ecologically imperative for California. Successive climate-intensified catastrophes are likely to increase financial volatility, further complicating action on greenhouse gas emissions, and likely leaving jurisdictions strained by financial costs. Cities and local jurisdictions need to act now to protect their people, economies, and workers from the projected impacts. Individuals will be reliant on the insurance that is available and affordable, and unmet costs will stress social safety nets.

The challenges from potentially overwhelming costs, vulnerable public and private infrastructure, and a multitude of risks can be met by stronger commitments from governments, communities, and the insurance and reinsurance sectors to accelerate investment in understanding, communicating, and planning for climate impacts. The insurance industry needs to strengthen investments in risk reduction and find more innovative solutions. The state needs to prioritize and coordinate efforts to close the gaps identified in this report, including in risk assessment, risk communication, risk reduction, and risk transfer. In addition, existing tools such as hazard maps and models need to be expanded and improved.

This report includes forty recommendations that could be implemented over different time horizons. Some recommendations require the state to fund policy development through proof of concept projects; others require changes to state law or regulation. To

prioritize next steps, this report concludes with short and long term bridges to a stronger, more resilient California.

Actions to take within the first year:

The Insurance Commissioner should rapidly:

- Implement tools to expand public access to risk information for all perils.
- Convene stakeholders to enhance communication of the risks of heat waves and the range of possible responses.
- Encourage flood insurance uptake through pilot projects and risk communication.
- Consider the advantages and disadvantages of the use of catastrophe models in insurance premiums and rates.

The Insurance Sector should rapidly:

- Develop innovative insurance products and risk transfer policies to reduce the protection gaps related to climate risk impacts.
- Support the development and wide application of resilient building codes.
- Collect data to inform risk-focused models, retrofit opportunities, and future building codes.
- Consider investments in resilience bonds to reduce future losses.

The State of California, through legislation or Executive Branch actions, should rapidly:

- Accelerate development of hazard maps for wildfire and flood.
- Incentivize risk mitigation through grants and loans.
- Provide matching funding for local government risk transfer pilot projects.
- Adopt land-use restrictions or requirements to enable local governments to understand the accelerating climate risks to new and existing developments.

Actions to start immediately and supplement in the future:

Actions include creating incentives for investment in natural infrastructure, developing nature-based solution pilot projects, and building more resiliently. These recommendations require sustained commitment, funding for policy development, and evaluation of performance. The recommendations need immediate attention to initiate the necessary pilot projects and concept development, but they also require long-term resolve to create lasting collaborations and sustained funding streams.

The combination of solutions fundamentally benefits from promoting a feedback loop where clear understanding of risks promotes risk reduction actions and risk transfer decisions that ultimately lead to reducing future risks. The challenges of insurance

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availability and affordability present difficult tradeoffs, exacerbated by the global risks we face today. At its core, the future insurability of homes, businesses, farms, ranches, and natural infrastructure depends on perceived levels of risk. Aligning diffuse incentives to achieve these goals will enhance climate resiliency.

Among the several dozen recommendations in this report, a notable common thread is that each peril is interwoven into the same basic themes: accessible risk information, policies to promote insurance availability and equity to reduce the protection gap, resilient building codes, resilient land use, and insurance approaches related to innovation and nature-based solutions. This enables state and local governments, private companies, and non-governmental organizations to set cross-cutting benchmarks and timelines. Because this is one of few--if not the first--report of this kind, the working group hopes that the cross-cutting themes lay the groundwork for future efforts on additional perils or in additional jurisdictions.

Appendix 1. Senate Bill No. 30, Chapter 614, Statutes of 2018, State of California.

An act to add Section 12922.5 to the Insurance Code, relating to insurance.

SECTION 1. The Legislature finds and declares all of the following:

(a) Much of California may have increasing exposure to climate-related events.

(b) California has environmental features that can mitigate damage from climate-related events.

(c) Innovative insurance and reinsurance businesses may provide opportunities to reduce the exposure of local communities and homeowners to these events.

(d) Reinsurance companies are already doing risk assessments and designing risk transfer products that incentivize investment in natural resources to mitigate against climate risks.

SEC. 2. Section 12922.5 is added to the Insurance Code, to read:

(a) The commissioner shall convene a working group to identify, assess, and recommend risk transfer market mechanisms that promote investment in natural infrastructure to reduce the risks of climate change related to catastrophic events and that:

(1) Create incentives for investment in natural infrastructure to reduce risks to communities.

(2) Provide mitigation incentives for private investment in natural lands to lessen exposure and reduce climate risks to public safety, property, utilities, and infrastructure.

(b) To the extent that the working group recommends risk transfer market mechanisms that would be provided by insurance and reinsurance companies, the working group shall recommend mechanisms that:

(1) Are profitable to insurance and reinsurance companies.

(2) If appropriate, apply to communities or regions, rather than individual land parcels.

(c) The policies recommended pursuant to subdivisions (a) and (b) shall include all of the following questions:

(1) What are the California analogies to examples in other countries for creating incentives for investment in natural infrastructure as part of insurance policies that mitigate elemental risks?

(2) Can we use insurance to create incentives for wetland restoration to help defend the coast against storm surge?

(3) Can we create incentives for forests to be managed to reduce the risk of major fires?

(4) Can we reduce the exposure of insurance companies to climate change-related losses through innovative state policies or insurance pricing mechanisms that reward good behavior and charge premiums for actions that increase public safety risks or losses of property or environmental attributes?

(5) Can we develop rating systems based on community risk factors to climate events, and use insurance incentives to make a community more resilient?

Appendix 2. Climate Insurance Working Group Members and Subgroups

Appendix 3. Extreme Heat Communication Plan

Synopsis: Heat is an international threat that needs to be planned for and communicated with communities in rural and urban settings. It is thus necessary to put together a specific plan to convene government and non-government organizations to elevate extreme heat as a climate impact and to build a communication strategy with vulnerable communities. The Insurance Commissioner should aggressively pursue an Extreme Heat Communication Plan that convenes groups at the international, national, state, and local levels.

International and National

1. The Insurance Commissioner should work with the Executive Climate Risk and Resilience Task Force at the National Association of Insurance Commissioners, the Sustainable Insurance Forum, and the Insurance Development Forum to learn how other Insurance Commissioners and insurance companies are thinking about

extreme heat in the context of insurance, and explore whether those strategies are applicable to California.

2. In partnership with the Extreme Heat Resilience Alliance, the Insurance Commissioner should promote legislation to determine the most effective way to achieve the identifying, ranking, and communication of extreme heat events to encourage preparation and efforts to mitigate the impacts on human health and the economy.

    - Informative models for consideration include California's "red flag" warnings, the Environmental Protection Agency Air Quality App, and the naming system for tropical storms and hurricanes by NOAA.

    - The heat event name should include categories, and communications about the event should include details related to geographic location and measures of severity and potential duration to make it easier to track.

    - The different categories should be accompanied by recommended precautions for the public to take based on the intensity of the heat event with additional precautions for vulnerable populations. For example, for a Category 2 heat event warning, the public should limit time outdoors and wear loose, cool clothing and a hat and sunglasses. Vulnerable populations like the elderly and others that are especially susceptible to the heat impacts may need to take additional measures.

    - Consider whether the declaration of a heat event can trigger any laws relating to insurance, such as a grace period for the public to pay insurance premiums or other implications associated with economic disruption.

State

3. The Insurance Commissioner should partner with the Governor's Office of Planning and Research through their Integrated Climate Adaptation and Resilience Program (ICARP) to co-host a workshop to (1) share key messaging on extreme heat risks developed in Recommendation #1; (2) learn of approaches local officials are currently undertaking to address extreme heat and what issues remain unaddressed; (3) get feedback and information from local officials about challenges that make it difficult to address extreme heat and where there may be interest in using insurance as part of an extreme heat mitigation strategy; and (4) develop strategies in collaboration with local governments to incorporate extreme heat into their local planning efforts, including those required in Government Code Section 65302.

4. The Insurance Commissioner should convene a meeting with key state agencies involved in extreme heat planning and response to coordinate messaging and benchmarks, and to determine how insurance concepts or approaches can be used to support those strategies and actions.

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5. The Insurance Commissioner should work with the California Office of Health Hazard Assessment and other agencies within the California Governor's administration to develop a public education campaign targeted to the general public on the impacts of extreme heat, similar to the public education campaign that California developed to promote statewide water conservation goals.

    - The campaign should include partnerships with community-based organizations serving communities that are most vulnerable to extreme heat, including low-income communities, communities of color, the elderly, disabled persons, farmworkers, and other vulnerable subpopulations.

Local

6. Promote *Heat Readiness* as an application of existing and future emergency preparedness planning.

    - For example, Phoenix, Arizona initiated a *HeatReady* program, the nation's first program of its kind. The program treats heat readiness like hurricane readiness and heat waves like temperature tsunamis, alerting residents with text notifications and offering emergency cooling centers.

    - California's existing and planned efforts to augment preparedness on wildfires can be adapted to pilot a heat readiness program.

7. The Insurance Commissioner should meet with the members of local Disaster Councils and the cities' risk managers to discuss opportunities to use insurance concepts or products.

Appendix 4. Catastrophe modeling

Insurers commonly employ probabilistic catastrophe models to estimate the range of damage and losses that can occur in a given year. Methods for estimating loss from wildfires continue to improve, such as incorporating factors associated with ember-driven wildfires, and offer additional insight beyond an individual insurer's historic loss experience. Because these models consider weather, fuels, and other physical characteristics as well as firefighting response, parcel-level defensible space, community mitigation efforts, and other mitigation measures, they could provide risk communication to homeowners, local governments, and the public. While not eliminating uncertainty, the models allow sensitivity testing, including taking into account changes in population growth, construction costs, or mitigation approaches.

The Commissioner should convene one or more public meetings or discussions, examining existing departmental approaches and comparing those that rely on past loss experience to those that apply catastrophic models, giving the Commissioner and the public an opportunity to discuss and assess relevant topics that could be important to

this consideration. The topics would include (but would not be limited to) the reliability of new scientific tools to model future wildfire losses, including probabilistic wildfire models that incorporate atmospheric and environmental science; vegetation, topography, and wind data; geographic location and proximity of structures to the Wildland Urban Interface; and the impact of parcel-level mitigation (including defensible space and home hardening) as well as community-based adaption.

This approach could provide an opportunity for Californians to discuss policy implications and for the Commissioner to assess and consider how to address practical regulatory questions, including but not limited to, data transparency, public understanding of catastrophic modeling approaches, consideration of trade secrets, and model evaluation by public expert panels, as well as questions related to model accuracy, precision, and validation. Moreover, such an approach could also consider possible modeling applications to evaluate insurance company financial health and an understanding of California's overall risk profile to foster stronger mitigation planning.

Public understanding of complex new tools will support decision-making about the application of such tools for insurance regulation, risk mitigation, or other public policy goals. Expert input and public discussion could foster understanding of how the Department currently approaches models used by insurance companies for certain risks, such as the fires that may result from an earthquake, and the use of catastrophic models for monitoring insurer solvency or use by the California FAIR Plan in projecting future losses, among other applications of predictive modeling.

Appendix 5. Options for Innovative Extreme Heat Risk Transfer

Two options for a potential pilot project are described here:

Option 1: Parametric Coverage for uninsured patients
Vulnerable populations may delay or limit seeking care until after the early onset of health impacts, which compounds the personal and systemic cost of treatment. Hospitals serve as critical intervention points to not just catch the early onset of heat health symptoms, but also to provide comprehensive care to rejuvenate these individuals sufficiently to avoid repeat emergency room visits. This type of risk transfer could offer a hospital or city the following benefits:

- Offering necessary services to uninsured patients without further straining hospital budgets
- Paying for lost revenue and uninsured expenses incurred during an extreme heat event
- Offering necessary services to patients to limit long-term impacts or repeat visits

Option 2: Supplemental coverage for public hospitals serving underinsured populations
When extreme heat events occur, it is crucial for the hospital to treat patients as long as necessary and not curtail their length of stay based on the patients' (lack of) insurance coverage. Hospitals incur operational costs to handle surges in hospitalization rates and

emergency room visits. Excess operational expenses, costs of underinsurance, and limitations of care posed through Medicaid can be insured. A local jurisdiction seeking to serve vulnerable populations in conjunction with the publicly-owned hospital can use such an insurance coverage. Such a coverage could provide the following benefits:

- Providing vulnerable populations with the care they need regardless of health insurance coverage
- Indemnifying hospitals for providing care and incurring expenses not covered within the patient's insurance coverage

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