



RESEARCH INSTITUTE FOR HOUSING AMERICA

A Collection of Essays on Climate Risk and the Housing Market

VOLUME 1

Introduction

In September 2021, RIHA published a Special Report by Sean Beckett, *The Impact of Climate Change on Housing and Housing Finance*. This report underscored the need for the mortgage industry to better address the growing impacts of climate change and prepare for increased reporting to regulators and investors on the quantitative estimates of climate-related risks. The overwhelming feedback we received from industry participants showed there is a strong appetite for more information on various topics connected to climate risk. We thus engaged four leading companies to prepare essays for a collection that delves into some of the industry's pressing themes:

Ceres Accelerator for Sustainable Capital Markets prepared the opening essay for the compendium, *Housing Finance and Climate Risk: Taking Action in an Uncertain Future*, in which the challenges associated with climate-related risks, and the need for engagement and cooperation across sectors and amongst diverse shareholders to meet these challenges, are discussed.

RiskSpan, Inc. wrote the second essay, *A Practical Approach to Climate Risk Assessment for Mortgage Finance*, that lays out a pragmatic framework for assessing climate-related risks from the perspective of a mortgage company.

Milliman, Inc. prepared the third essay, *Climate Change: Challenges for Insurance and Housing Markets*, that reviews the emerging impacts of climate change on property insurance and how, in turn, the changes in property insurance will affect housing markets. The essay also discusses how the insurance industry can work with housing stakeholders to mitigate these impacts and increase climate resilience for the United States housing market.

Andrew Davidson & Co., Inc. authored the final essay for the compendium, *Conditioning Mortgage Credit Analysis on Climate Risk: General Approach & Florida Case Study*. This essay provides details on an approach to condition behavioral mortgage and house price models on variability in climate risk as represented economically by variability in rising insurance premiums.

Volume I of the compendium includes the first two essays by Ceres and RiskSpan. Volume II will include Milliman's and AD&Co's essays.



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Housing Finance and Climate Risk: Taking Action in an Uncertain Future

Steven Rothstein and Joe Weisbord

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About the Authors

Steven Rothstein is Managing Director, Ceres Accelerator for Sustainable Capital Markets.

Joe Weisbord is Principal, JRW Strategies and a consultant to Ceres.

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Overview

THREE LITTLE HOUSES¹

The unassuming frame homes on Freeborn Street in Staten Island's Midland Beach neighborhood offer a telling snapshot of the growing risks of climate change for housing finance. Ten years after the neighborhood was devastated by Hurricane Sandy, uncertainty about the future remains.

Homeowners have responded in dramatically different ways. Some rebuilt their homes exactly as they were before the storm, some were able to access government assistance to upgrade their homes to better withstand future weather events, and some relocated, taking advantage of a New York State buyout program that paid them for what their homes were worth before the storm in exchange for demolishing the house and creating a natural buffer against future storms.

The contradictory responses of these homeowners reflect the absence of clear market and policy signals. They spotlight the gaps in how we understand, quantify, analyze, and respond to the growing financial risks associated with climate change. In this essay we make the case for urgent action by the housing and mortgage industries to close these knowledge gaps and develop effective and consistent responses to climate risk and the transition to a net zero future.

MEETING THE MOMENT

The housing and mortgage industries have a central and outsized role in mitigating the risks of climate change and financing the transition to a sustainable future. The operation and construction of buildings accounts for almost 40% of global carbon emissions.² The aggregate outstanding balance of all U.S. residential mortgage debt stands at \$14.7 trillion, including \$12.8 trillion in one-to-four family mortgages and \$1.9 trillion in multifamily mortgage debt.³ The scale of mortgage finance and how critical it is to meeting the nation's housing needs makes the industry's leadership key to tackling the challenges posed by climate change.

Historically, the housing finance ecosystem distributes hazard and disaster risk across a range of industry participants with varied risk appetites and specialized risk management capabilities. Secondary market guarantors, mortgage insurance companies, primary hazard and flood insurers, reinsurance companies, servicers, credit risk investors, and individual homeowners all play a part. But the increasing frequency, intensity and financial impact of severe weather events and other climate-related disasters are driving a reassessment of the stability and capacity of this system.



Flood risk, the costliest weather-driven peril, offers a stark example of what is at stake. Recent analysis by Milliman and KatRisk found that "single-family residential properties in the United States may be overvalued by \$520 billion today by not fully accounting for the potential costs of flooding." They estimate that "3.5 million homeowners are exposed to major repricing due to unpriced flood costs, where "major" is defined as a decrease in property value greater than 10%." In more severe scenarios, as many as 4.2 million homeowners may be at risk of being exposed to a flooding event that could lead to a significant repricing of their homes.⁴

Housing is key to opportunity in America. Location, quality, and affordability affect health, education, employment, and long-term well-being. We continue to live in the shadow of a long and shameful history of racial bias and discrimination in industry practice and government

1. This case study is drawn from the excellent reporting of Samantha Maldonado. [Three Little Houses: A Staten Island Study in Rebounding Post-Sandy](#). *The City*. May 18, 2022.

2. Brodie Boland, Cindy Levy, Rob Palter, and Daniel Stephens. [Climate risk and the opportunity for real estate](#). Real Estate Insights, McKinsey & Company. February 4, 2022.

3. Federal Reserve. Financial Accounts of the United States. [Table L.218](#) and [Table L.219](#). 2022 Q1.

4. David D. Evans, Leighton Hunley, and Brandon Katz. [Unpriced costs of flooding: An emerging risk for homeowners and lenders](#). Milliman. January 28, 2022.



policy. The housing finance industry is taking on the work of addressing this legacy⁵ and tackling enduring problems like racial disparities in appraisal and valuation.⁶ Acting Comptroller of the Currency Michael Hsu has called attention to the risks of “climate redlining”⁷ as lenders and regulators grapple with reducing risk while maintaining access to credit in underserved communities that are often disproportionately exposed to climate-related risks. As we navigate the risks and opportunities of the transition to a net zero economy, we must ensure that our actions do not have the unintended consequences of magnifying and exacerbating existing disparities.

Managing climate-related risks, ensuring equitable access to credit, and meeting the nation’s pressing housing needs are linked to systemic challenges. They demand engagement and cooperation across sectors and amongst stakeholders with diverse interests. The sections that follow offer a high-level overview of the critical issues and actions that industry participants can take now — voluntarily at the firm level and collectively through engagement in public policy — to address the risks at hand and ahead as they continue to fulfill a vital role in financing America’s housing needs into a sustainable lower carbon future.

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5. See for example the [Special Purpose Credit Program Toolkit for Mortgage Lenders](#), a joint initiative of the National Fair Housing Alliance and the Mortgage Bankers Association.
 6. Jonathan Rothwell and Andre M. Perry, [Biased appraisals and the devaluation of housing in Black neighborhoods](#), Brookings, November 17, 2021.
 7. Matthew Bisanz, Andrew Olmem, and Jeffrey Taft, [Climate Risk Management and Community Reinvestment in the US: Competing or Complementary Priorities?](#) Perspectives, Mayer Brown, March 4, 2022.

Understanding the Climate Risk Framework

The acute and long-term consequences of climate change have particularly serious implications for the housing sector and all stakeholders it touches. The frequency of severe weather events, rising sea levels, and temperature extremes are affecting real property values and the availability and cost of insurance coverage today.

The Task Force on Climate-related Financial Disclosures (TCFD) describes two primary categories of risks related to climate change and global warming: physical risks and transition risks.⁸

Physical risks include the array of all-too-familiar climate-fueled extreme weather perils. Flooding, hurricanes, and other severe storms, wildfires, and heat waves are acute physical risks to real estate and residents. Property insurers have long provided owners and lenders with protection against losses related to these perils. Climate change will not change the nature of these *acute physical risks*, but will affect the geography, frequency, and intensity of such events.⁹

Climate change is a fact, but exactly how it will affect specific places and properties remains uncertain. These uncertainties, detailed in the Intergovernmental Panel on Climate Change (IPCC) reports, complicate the assessment of *chronic physical risks*, defined by the TCFD as changes in precipitation patterns and extreme variability in weather patterns, rising mean temperatures, and rising sea levels.¹⁰

Chronic physical risks involve gradual changes to the physical environment, and the responses of individual households, firms, and government to those changes. The most familiar chronic risk, rising sea levels, will affect property values, insurability, and premiums, likely leading to abandonment of some properties over time and significant relocation of households and businesses. Similarly, increasingly severe droughts are impairing fresh water

supplies, which will drive dislocation and movements of people and businesses.¹¹

Transition risks involve a broad set of complex, multi-dimensional economic, social, and policy changes driven by the major reductions in GHG emissions that are necessary to avoid catastrophic levels of atmospheric carbon dioxide. The TCFD describes four areas of transition risks:

- Policy, legal, and regulatory changes
- Technology changes, especially in building materials and system components
- Market disruptions, especially abrupt changes to energy costs
- Reputational risks

Transition poses unprecedented challenges for housing finance. Regions reliant on employment in fossil fuel-related industries may experience job losses, population loss, shrinking local tax bases, and reduced public services. Businesses will be forced to adapt to a rapidly evolving regulatory and policy environment. The possible adoption of a carbon tax regime, for example, would have significant implications for business strategies and models. Tremendous uncertainty still surrounds the transition to a low-carbon future and the attendant risks.

8. Task Force on Climate-related Financial Disclosures (TCFD). [Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures](#). 2017.

9. Basel Committee on Banking Supervision. [Climate-related risk drivers and their transmission channels](#). Bank for International Settlements. April 2021.

10. Basel Committee on Banking Supervision. April 2021.

11. See for example Bradley Udall and Jonathan Overpeck. [The twenty-first century Colorado River hot drought and implications for the future](#). Water Resources Research. 53, 2404-2418. 2017.

In September 2021, the Mortgage Bankers Association/ Research Institute for Housing America issued *The Impact of Climate Change on Housing and Housing Finance*, a landmark report by economist Sean Beckett. The report brings the implications of the scientific consensus on climate change into sharp focus for housing and mortgage finance.¹²



Beckett points out that risks unique to housing finance, such as mortgage default, changing prepayment speeds, and the potential for adverse selection among them, may not fit easily into the standard TCFD categories.¹³ Analysis of recent disaster events point to effects on delinquencies and prepayment speeds, which may not be accounted

for in existing models.¹⁴ Beckett also observes that geographic concentrations of loans at greater risk for delinquency due to disaster events may adversely affect the value of mortgage servicing rights.¹⁵

Courtney Sapp, Freddie Mac's Vice President for Enterprise Climate Risk, notes that climate risk is a transversal risk — meaning that it is a driver of risk across credit, market, operations, liquidity, and all other familiar mortgage risk categories.¹⁶ Climate change has serious ramifications for all industry stakeholders, regardless of the underlying long-term exposure to credit risk.

Scenarios that model future physical risks and transition risks highlight the broad implications that significant population movements, market changes, new technologies, and new government policies could have for all aspects of mortgage finance and housing. Such climate-related impacts would exacerbate existing housing market disparities, with their underlying roots in systemic racism and discrimination. Concerns about racial and economic equity will undoubtedly be important drivers of public policy.¹⁷

Climate risks cannot be addressed by either government or the private sector alone, both must work together toward bold and innovative solutions. There is much that can and must be done now by individual companies and collectively in the policy arena. The sections that follow address these two domains of action in turn.

12. Sean Beckett. [The Impact of Climate Change on Housing and Housing Finance](#). Research Institute for Housing America/Mortgage Bankers Association. 2021.

13. Beckett. 2021. See also Michael Lacour-Little, Andrey Pavlov, and Susan Wachter. [Adverse Selection and Climate Risk](#). Fannie Mae Working Paper. March 30, 2021

14. Carolyn Kousky, Mark Palim, and Ying Pan. [Flood Damage and Mortgage Credit Risk: A Case Study of Hurricane Harvey](#). Journal of Housing Research. 2020, Vol. 29, No. Sup1, S86-S120.

15. Sean Beckett panelist comments during Industry Virtual Roundtable: [The Intersection of Climate Risk Management with Mortgage Loan & MSR Investing](#). RiskSpan and Housing Finance Strategies. April 14, 2022.

16. Interview with Courtney Sapp, Freddie Mac. August 26, 2022.

17. U.S. Environmental Protection Agency (EPA). [Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts](#). EPA 430-R-21-003. 2021.

Taking Action

The Sixth Assessment Report of the IPCC, issued in February 2022, plainly stated that the window for acting on climate change is rapidly closing. IPCC Chair Hoesung Lee is emphatic on the dire consequences of inaction.

The report shows that climate change is a grave and mounting threat to our wellbeing and a healthy planet. It emphasizes the urgency of immediate and more ambitious action to address climate risks. Half measures are no longer an option.¹⁸

REGULATORS RESPOND

U.S. financial regulators are starting to share this sense of urgency and are now moving forward to address the systemic challenges of integrating climate risk into the housing finance system. Ceres' 2022 [Climate Risk Scorecard](#), which tracks actions on climate risk by the nine federal financial regulators, including the Federal Housing Finance Agency (FHFA), outlined over 230 actions that federal regulators are taking and their priorities going forward. Two recent actions are particularly important for housing finance:

- In October 2021, the Financial Stability Oversight Council (FSOC) issued its "Report on Climate-Related Financial Risk," calling climate change an "emerging threat to the financial system of the United States."¹⁹ The FSOC report has injected new urgency for action on financial climate risk by U.S. financial regulators, who are far behind their peers in much of the world.
- In March 2022, the Securities and Exchange Commission (SEC) issued its proposed rule for "The Enhancement and Standardization of Climate-Related Disclosures for Investors."²⁰ The proposed rule, while narrower in scope than disclosure requirements adopted by the European Union, is intended to address investor demand for greater transparency and standardization of ESG disclosures.²¹ A final rule, not expected until 2023, will be a critical component

of the emerging global regulatory framework that will shape the capital markets of the future.

Housing finance is an important concern for all U.S. financial regulators, but it is the core mission of the FHFA. In early 2021, FHFA issued an extensive request for information on Climate and Natural Disaster Risk Management at the Regulated Entities and received dozens of comments from industry stakeholders, technical experts, and advocates. Ceres provided specific recommendations to FHFA that spanned the six categories evaluated in our 2022 scorecard, including proactively engaging with other regulators to ensure harmonization of relevant regulatory actions, providing public access to information on its data collection and research, and taking interagency action to coordinate assessment of risk to financially vulnerable communities and related policy actions.²² Since the RFI was issued, FHFA has established an internal team to develop and advance its climate risk strategy. The agency has incorporated action on resiliency to climate risks into the most recent Conservatorship Scorecard for Fannie Mae and Freddie Mac.²³ For the first time, both GSEs issued Sustainability Accounting Standards Board (SASB) reports.²⁴

Government policy will play a central role in shaping how the market responds to future events, and how the financial costs are borne. But the political process is often slow and unpredictable. Waiting for legislative and regulatory action alone in the face of climate risk is a disservice to customers, investors, shareholders, and all who depend on the housing industry to meet the essential need for home and shelter.

18. Intergovernmental Panel on Climate Change (IPCC). [Press Release on the IPCC's Sixth Assessment Report](#). February 28, 2022.

19. Financial Stability Oversight Council. [Report on Climate Related Financial Risk](#). October 2021.

20. Securities and Exchange Commission. [The Enhancement and Standardization of Climate-Related Disclosures for Investors](#). 17 CFR 210, 229, 232, 239, and 249. March 21, 2022.

21. Addisu Lashitew. The coming of age of sustainability disclosure: How do rules differ between the US and the EU? Brookings. June 6, 2022.

22. See Ceres comment letter in response to the FHFA RFI on Climate and Natural Disaster Risk Management at the Regulated Entities. Also see Addressing Climate as a Systemic Risk: A Call to Action for U.S. Financial Regulators, Ceres, 2020 and Turning Up the Heat: The Need for Urgent Action by U.S. Financial Regulators. Ceres. 2021.

23. Federal Housing Finance Agency (FHFA). Acting Director Sandra L. Thompson's Statement on Climate Change. December 27, 2021.

24. See Fannie Mae Sustainability Accounting Standards Board (SASB) Report 2020 and Freddie Mac Sustainability Disclosure — Report under the Sustainability Accounting Standards Board ("SASB") Standards and Management Criteria



WHAT COMPANIES CAN DO NOW

Regulatory initiatives have increased awareness and spurred action by industry participants, however, housing finance is yet in the early stages of integrating climate-related risks into strategic business priorities and day-to-day operations and decision making. In early 2021, Moody's surveyed U.S. companies and found that nearly 80% of banks reported no climate-related disclosure activity. This was far behind companies in the rest of the world, and even lagged behind U.S. non-financial companies.²⁵

Over the past 18 months, mortgage lenders, servicers, technology providers, and other industry participants have taken action to assess and mitigate the risks associated with climate change and to prepare for the transition to a low-carbon future. More and more are building the internal infrastructure and capacity to incorporate climate risk in their decision-making and strategic priorities. Some are farther along linking climate risk strategies to broader sustainability goals, developing business strategies and loan products aimed at strengthening existing housing in vulnerable locations and reducing the carbon footprint of the nation's housing stock.

More of the world's largest national economies have begun to incorporate climate considerations into supervisory expectations for banks.²⁶ In response, the largest

bank mortgage lenders operating in global markets are allocating greater resources and are ahead of the curve. U.S.-based Global Systemically Important Banks (G-SIBs) began issuing annual TCFD reports several years ago with larger super-regional banks following suit. But the housing and mortgage industries remain in the early stages of addressing climate-related risks, with most non-bank mortgage businesses yet to provide public disclosures related to climate risk or integrate the TCFD framework.

Some industry participants are holding off and waiting to see what happens with regulatory policy before starting the work. Beckett also notes concerns about the lack of standardized data and the need for more robust predictive analytics. Nonetheless, all industry participants can act now to begin to address climate risk. Here are three broad areas for everyone to consider.

Governance and organizational capacity: The risks and opportunities associated with climate change must be incorporated in corporate governance structures and human capital strategies. New types of specialized technical expertise are needed at all levels, but hiring people with the necessary skills and experience, is not a substitute for engagement by corporate boards and top executives. Blackrock's Michelle Edkins notes that "in the United States, there is still a debate in board circles about whether sustainability even does rest in the boardroom or whether it's solely a management issue. Our view is if it's

25. Michael Denton and Jeffery Perrella. [How US Banks Are Addressing Climate Risk and Sustainability](#). Issue Alert, Moody's Analytics. February 2021.

26. [Sustainable Financial Regulations and Central Bank Activities \('SUSREG'\) Tracker](#). Indicator 1.6.7. See also Task Force on Climate-related Financial Disclosures. 2021 Status Report. October 2021.

a significant or material driver of value or risk, then it rests in the board room.”²⁷

This view is rapidly becoming the norm as reflected in recent public reports on climate risk and opportunity. The largest financial institutions are explicit that their full board has oversight of climate-related risks, with primary responsibility often falling to their risk management and governance committees. To drive management accountability, these companies are incorporating progress on climate change strategy and risk management goals into performance goals for CEOs, senior executives, and managers throughout the organization.



Assessment of exposure to climate risk: Assessing risk requires quality data and proven models. Management of housing finance risk is built on a foundation of historic loan origination and performance data. There is, however, no historic precedent for climate change. It requires consideration of new data and information, which in many cases is not collected in existing loan underwriting and production processes and systems.

While climate change is a certainty, its precise impact over time remains unclear. In the most recent IPCC report, future climate change is simulated in *shared socio-economic pathways*, which are built on different forecasts of the timing and magnitude of reductions in carbon emissions.²⁸ This type of scenario analysis can be used to link various possible climate change trajectories to asset-level economic impacts.

Estimating physical risks to real estate assets is based on existing catastrophe models used by the insurance industry to assess natural disaster risk. Variations in the possible severity and frequency of acute events, combined with the effects of chronic events over time, are based on climate models developed through the scientific processes of the IPCC. Finally, the economic impacts must be mapped to specific risks for individual businesses and various financial instruments.

Again, the largest banks have begun to incorporate their quantitative scenario analysis into public disclosures, a supervisory expectation in the E.U., U.K., and Australia.²⁹ Most others, if they are providing climate risk disclosures at all, are limited to qualitative description of process. Those large institutions are integrating the results of their baseline risk assessments into enterprise risk management policies and processes.

Regardless of where a company is in the process of building out climate risk management infrastructure, the fundamentals still apply. The initial assessment of current exposure to climate-related risks establishes a baseline for continuous monitoring and reassessment: Starting with near-term acute physical risks that have the greatest potential loss severities and then working toward capturing chronic risks and longer-term transition risks.³⁰

In chapter two of this volume, Suhud Dagli, Janet Jozwik, and Jason Huang of RiskSpan delve into detail on housing market dynamics and impacts, and in chapter four, Eknath Belbase, and Alex Levin of Andrew Davidson & Co. go deep on the implications for mortgage models.

Make a plan: It is increasingly clear that managing climate risk is intertwined with the pursuit of a net zero economy. In its most recent TCFD report, Citigroup explains that “climate risk and net zero work are related and reinforce each other... Our climate work focused on the integration of climate risk into Citi’s risk management governance, processes, and strategies while our net zero work focuses on Citi’s impact on the climate and achieving our net zero emissions targets.”³¹ The largest companies are devoting substantial resources and capacity to this work. But institutions of all sizes can begin to reduce climate-related risks for their business and their key stakeholders from customers to investors. Moreover, they can begin to seize the emerging opportunities to finance the transition to net zero. Here are elements of a housing climate risk plan that every lender should consider.

27. Interview with Michelle Edkins, Managing Director, Investor Stewardship, Blackrock in Chrissa Pagitsas. [Chief Sustainability Officers at Work](#). Apress. 2022.

28. Intergovernmental Panel on Climate Change. [Sixth Assessment Report — Fact Sheet](#). April 2022.

29. [Sustainable Financial Regulations and Central Bank Activities \(‘SUSREG’\) Tracker](#). Indicator 1.4.2.

30. See Jason Huang. [Incorporating Climate Risk into ERM: A Mortgage Risk Manager’s Guide](#). RiskSpan. March 21, 2022.

31. Citigroup. [Taskforce on Climate-Related Financial Disclosures Report 2021](#).



- **Prioritize resiliency.** Review existing product offerings with an eye toward loans that help increase the resiliency of the building to withstand likely hazards. Both Fannie Mae and Freddie Mac offer "green" mortgage products that finance improvements to enable homes to better withstand disasters and reduce GHG emissions. Rehab lending is more time consuming, costly, and operationally complex for lenders. The development of the single-family green MBS market is driving process improvements that are addressing these traditional challenges.³² There is potential to align product offerings with a growing array of financial incentives programs linked to voluntary resiliency standards. [The Fortified program](#), for example, an initiative of the Insurance Institute for Business and Home Safety (IBHS), provides tested construction standards that extend beyond local building codes to improve resistance to certain storm and wind hazards. In some parts of the country, insurers provide premium discounts on structures that certify compliance with Fortified standards, which offsets the additional cost. IBHS recently launched a [wildfire mitigation program](#) in California. More states and localities have implemented financial incentives linked to specific resiliency measures or standards.³³
- **Insurance is more critical than ever.** For mortgage lenders, servicers, and investors, adequate homeowner insurance from adequately capitalized providers has historically provided the first line of defense for collateral risk. But that foundation is starting to show signs of weakness in the face of rising losses from disasters worsened by climate change.³⁴ Even before the devastation of Hurricane Ian, the insurance industry was roiled by the threat of unprecedented rating downgrades.³⁵ This past summer, eight insurance companies doing business in Louisiana declared bankruptcy, affecting tens of thousands of customers and forcing the state to scramble to provide coverage.³⁶ At the same time, Florida's market was thrown into turmoil after ratings firm Demotech downgraded the financial stability ratings of three insurers doing business in the state and put 17 others on notice. The downgrades mean that policies written by these providers no longer meet the GSE's minimum requirements, leaving lenders, servicers, and homeowners in a quandary.³⁷ Starting November 2022, the National Association of Insurance Commissioners and 15 state insurance regulators will,

32. Rita Ballesteros, David Heslam, and Greg Hopkins, Build Back Better Homes: How to Unlock America's Single-Family Green Mortgage Market, RMI, 2021, <http://www.rmi.org/insight/build-back-better-homes>.

33. For a framework to evaluate and design resiliency incentive programs see [A Roadmap to Resilience Incentivization](#), National Institute of Building Sciences. 2020.

34. Umair Irfan. The \$5 trillion insurance industry faces a reckoning. Blame climate change. Vox. Oct 15, 2021.

35. Carol Pope. [Demotech downgrades and what they might mean for the Florida property insurance market](#), Bankrate. August 25, 2022.

36. Michael Finch II. [Eighth Louisiana homeowners insurer goes under, stranding 10,300 policyholders](#), nola.com. August 5, 2022.

37. Andrew Martinez. [Lenders wary of storm clouds in Florida's home insurance market](#), National Mortgage News. August 15, 2022.

for the first time, require large insurers (those with premiums of \$100 million or more, reflecting roughly 80% of the U.S. insurance market by size) to file TCFD reports.³⁸ Following Hurricane Ian, the stakes are even higher.³⁹ Monitoring rating agency actions and state policy developments will be critical. Andrew Pai and Leighton Hunley of Milliman review the climate challenges facing insurance markets and the current state of play in chapter three.



- **Increase awareness:** All mortgage originators have opportunities to raise borrowers' awareness of climate-related risks. For many borrowers, housing may become less affordable due to rising insurance premiums along with costs for uninsured property damage and property upgrades. Climate change will also affect property values.

While more states have adopted mandatory flood risk disclosure laws,⁴⁰ uniform consumer disclosures remain a work in progress. Still there are many resources that can help customers understand the risks and empower them to make more informed housing choices. Knowing if a potential property is in a FEMA designated flood zone is the bare minimum.

All borrowers in or near FEMA designated flood zones should be aware of FEMA's floodsmart.gov website. But customers should also know that many of the country's flood-prone areas are not identified in the updated FEMA maps. That's where [Risk Factor can help](#). Developed by First Street Foundation, the website can be used by anyone to enter an address and get an immediate assessment of potential flood, fire, and heat risks. Risk Factor is integrated into real estate websites, including Redfin and realtor.com. There are no comparable tools for assessing other types of risk at the property level, but the [FEMA National Risk Index](#) offers an estimate of the expected annual loss from a wide array of hazards, as well as indices of social vulnerability and community resilience at the neighborhood level (county and census tract views are available).

- **Develop business strategies for the transition to net zero:** The transition to a net zero economy is already affecting access to capital globally. Investors and central banks across Europe and Asia are adopting investment policies favoring financial products that increase resilience and adaptation. The recently passed Inflation Reduction Act is a major opportunity to align products with the incentives for climate risk mitigation and resilience. For depository institutions subject to the Community Reinvestment Act, the 2022 [proposed rules](#) offer credit for investments that improve climate preparedness, increase energy efficiency, and lower utility costs, as well as drive the build out of larger scale activities such as utility-scale renewable energy projects.⁴¹ Decarbonizing real estate will require enormous capital investments in the years ahead. Developers, homebuilders, and owners will have sustained needs for financing to reduce their carbon footprint. There are major opportunities for lenders able to adapt products and processes to these emerging needs.

38. [U.S. insurance commissioners endorse internationally-recognized climate risk disclosure standard for insurance companies](#). Press Release, California Department of Insurance. April 8, 2022.

39. [Florida's government subsidizes people living in hurricane zones](#). *The Economist*. October 6, 2022.

40. [How States Stack Up on Flood Disclosure](#). NRDC. 2022.

41. Board of Governors of the Federal Reserve System; Federal Deposit Insurance Corporation; and Office of the Comptroller of the Currency, Treasury. Community Reinvestment Act Proposed Rules. 12 CFR Part 25, Part 228, and Part 345. Federal Register, Vol 87, No 107, June 3, 2022.

Tackling Systemic Challenges

The Financial Stability Oversight Council's October 2021 *Report on Climate-Related Financial Risk* calling climate change an “emerging threat to the financial system of the United States” should be viewed as a watershed moment for federal policy action. Based on an analysis of potential physical and transition risks from climate change, the report found that:

[T]he financial sector may experience credit and market risks associated with loss of income, defaults, and changes in the values of assets, liquidity risks associated with changing demand for liquidity, operational risks associated with disruptions to infrastructure or other channels, or legal risks. Each of these dangers may lead financial institutions to pull back from credit provision or other financial services, potentially amplifying the initial climate-related shock and harming financial stability.⁴²

This final section of this paper highlights three major systemic policy issues that will be consequential for all housing finance stakeholders: uniform disclosures and data standards, the risks of disorderly transition, and the impact of climate change on the nation's worsening affordable housing challenge.

DISCLOSURES AND DATA

Climate financial risk is not well understood, and awareness is low. The homeowners of Staten Island's Freeman Street are hardly outliers. There are numerous examples of confusing market and policy signals rooted in information asymmetry that drive the disconnect between consumer behavior and exposure to climate risks:

- A recent survey of 3,500 homeowners and renters conducted by Fannie Mae found flood risk awareness remains low, even among those that live in FEMA designated high-risk zones. “[S]lightly under 40% of the survey respondents who are in a high-risk zone accurately identified themselves as living in that zone.” Further, the almost 40% of respondents actually living in high-risk zones do believe that they do and consequently, do not carry flood insurance, even

though it is required for homeowners with agency-backed mortgages.⁴³

- Real estate professionals in western states have sounded the alarm on long-term threats to the supply of fresh water. Still, many of the affected markets are “hotter than ever.” Home prices in Fort Collins, CO were up over 15% year over year, despite a tap moratorium that has halted issuance of building permits in the nearby town of Severance.⁴⁴
- Redfin provides a proprietary climate risk rating score with all single-family listings. Yet the company recently reported that during the pandemic “purchases of second homes with high flood, storm and/or heat risk surged roughly 40% over the past two years.”⁴⁵

It's more than anecdotal. Research suggests that flood and wildfire risks do affect home prices, and that any apparent discount is not likely to compensate for the added risks.⁴⁶ Uniform public climate risk disclosures are vital to providing all stakeholders with the information necessary to understand the costs and consequences of risk and to make decisions accordingly.

Uniform disclosures are also a critical step toward understanding and assessing longer term economic impacts and informing the public policies to mitigate disparate impacts and unintended consequences of transition, especially for at-risk lower income communities and communities of color. These communities are particularly vulnerable to the risk that disclosure itself could trigger adverse repric-

42. Financial Stability Oversight Council. [Report on Climate Related Financial Risk](#). October 2021. p 13-14.

43. Saiful Amin. [Fannie Mae Survey Underscores Opportunity to Raise Consumer Awareness About Flood Risk and Flood Insurance](#). Fannie Mae Perspectives Blog. February 16, 2022.

44. Brooklee Han. [These housing markets are hotter than ever. But water is running out](#). RealTrends. June 24, 2022.

45. Lily Katz and Sheharyar Bokhari. [Scores of Pandemic Homebuyers Purchased Vacation Homes with High Natural-Disaster Risk](#). Redfin Real Estate News. July 5, 2022.

46. Matthew E. Kahn. [A new ratings industry is emerging to help homebuyers assess climate risks](#). PBS Science. December 8, 2021.

ing events. In the absence of effective buyout programs or other policy interventions, this could result in devastating loss of wealth, and displacement for the most vulnerable households.

Climate risk disclosures that are meaningful and decision-useful for owners, renters, lenders, and investors depend on establishing a shared data taxonomy and standards. There is not yet, however, a consensus on the availability and quality of the data necessary to fully assess climate risks at the asset level.



Data availability is limited in part because many critical data elements are not part of the existing mortgage industry data infrastructure. Fannie Mae Chief Climate Officer, Tim Judge, observes, “every tool we’ve ever built didn’t account for climate change. There’s still a ton of work to do.”⁴⁷

The Mortgage Industry Standards Maintenance Organization, a subsidiary of the MBA and known through the industry as “MISMO,” has developed data standards and definitions that are used across the industry and required by the GSEs and U.S. mortgage regulators. MISMO offers a unique forum to develop and implement a consensus approach to climate-risk data. No matter the origination channel, the servicer, the buyer, or the seller, virtually all single-family U.S. mortgage loans include the same standard data elements and specifications. The universal adoption of the MISMO standards makes uniform investor disclosures possible, a cornerstone of the deep and liquid market for U.S. mortgage-backed securities.

MISMO’s structure and processes enable the consistent addition of new data elements that may be needed to assess exposure to risk at the property level. To that end, MISMO recently released a new version of its residential reference model for public comment. It incorporates

numerous changes to property data elements in support of the GSEs’ Uniform Appraisal Dataset and Forms Redesign Initiative. MISMO recently launched an ESG Community of Practice which, according to MISMO Past President Seth Appleton, will “serve as a central forum for collaboration among the industry, the GSEs, and government housing agencies and regulators to identify and define necessary data elements and streamline the exchange of information in this rapidly evolving segment of the mortgage market.”

Judge further notes that there is a wealth of critical information in existing government data systems maintained by FEMA, NASA, NOAA, and other federal agencies, but much of that data is not easily accessed and none is integrated with existing origination and servicing data. The industry and its regulators together must develop a consensus view of what data are needed, their specifications, and how they can be sourced with acceptable quality.

RISK OF DISORDERLY TRANSITION

The FSOC reviews the framework for understanding the channels through which climate-related physical and transition risks are transmitted to financial risks. Financial risks will be amplified by a disorderly transition to a low-GHG economy. Delays in developing and implementing policies to reduce GHG emissions and the impacts of climate change increase the chances of larger and less predictable changes to asset values and market environments. Globally, piecemeal or contradictory policies implemented from country to country will increase uncertainty and confusion with the potential to increase financial stress. The FSOC’s report emphasizes the importance of “predictable and consistent policy actions that address climate risk and allow for economic adjustments to occur over time.”⁴⁸

The report also pointedly cautions that an orderly transition is far from certain. Individual firms and market actors must analyze and prepare for scenarios arising from lack of timely international or national agreement on transition policies. The European Union, the U.K., and countries in Asia and elsewhere are further along in developing systematic approaches to assessing, disclosing, and mitigating the climate-related risks faced by financial institutions.⁴⁹ Continued access to reliable flows of global capital will depend on alignment of U.S. national policy and standards with the rapidly evolving global framework.

47. Interview with Tim Judge, Fannie Mae. June 24, 2022.

48. Financial Stability Oversight Council. October 2021. p 20-21.

49. See [Financing a Net Zero Economy: The Consequences of Physical Climate Risk for Banks](#), Ceres. September 2021. See also [Portfolio Climate Risk Management: Case Studies on Evolving Best Practices](#), Ceres. July 2020 and Michael Denton and Jeffrey Perrella. [How US Banks Are Addressing Climate Risk and Sustainability](#), Moody’s Analytics. March 2021.

Alignment with the global context is further complicated by U.S. domestic challenges as individual state regulators are beginning to take aggressive, unilateral action. With much of the mortgage industry licensed and operating across multiple states, the lack of consistent, uniform national standards and requirements increases the risk of confusion and conflict detrimental to the interests of consumers and investors alike.⁵⁰

A sufficient, timely, and aligned policy response is just one element of an orderly transition. The Network for Greening the Financial System, a network of 116 central banks and financial regulators, has mapped multiple scenarios that include temperature goals, technology changes, and other dimensions of transition.⁵¹ Understanding and planning for disorderly transition scenarios cannot be ignored. But an orderly transition that creates new opportunities

- **Climate change will increase migration:** In her recent book, *Nomad Century*, Gaia Vince charts how climate migration will reshape our world, predicting that “[I]n the next fifty years hotter temperatures, combined with more intense humidity [,] are set to make large swaths of the globe lethal for 3.5 billion of us.”⁵² Millions of U.S. residents are already being displaced temporarily or permanently due to flooding, hurricanes, severe storms, wildfires, extreme heat, and related disasters. During the summer of 2021 nearly a third of all Americans lived in a county or state that was declared a disaster area by FEMA.⁵³
- **Development and settlement patterns will change:** It is widely known that a large percentage of the nation’s existing housing stock is exposed to disasters that are increasing in frequency and worsening in



and remediates persistent inequities can only be achieved with active engagement and cooperation across sectors and interests.

TRANSITION RISK AND AMERICA’S HOUSING NEEDS

Climate change is already beginning to shape development and planning decisions, settlement patterns, and population movements. The mortgage industry has a historic and essential role in addressing this challenge. Reducing exposure to future climate-related physical risks and transition risks may require new approaches to risk assessment, new products, and new partnerships. It also offers significant business opportunities.

severity due to climate change. Nonetheless, as Jenny Schutz comments in her recent book, *Fixer-Upper: How to Repair America’s Broken Housing Systems*, the country “continues to build — and rebuild — too many homes in the wrong places, environmentally speaking.”⁵⁴ Climate-driven changes in settlement and development patterns have the potential to further aggravate existing housing supply challenges.

- **Climate change will exacerbate existing race and income disparities:** The FSOC calls attention to the disproportionate exposure to, and impacts of, climate change on “financially vulnerable communities.” Black, Hispanic, and Native American households are more likely to live in places exposed to climate-related hazards and they are more likely to experience

50. Mortgage Bankers Association. [Comment Letter in Response to FHFA’s Climate and Natural Disaster Risk Management RFI](#), April 19, 2021.

51. Network for Greening the Financial System (NGFS). [NGFS Climate Scenarios for central banks and supervisors](#), June 2020.

52. Gaia Vince. *Nomad Century: How Climate Migration Will Reshape Our World*. MacMillan, 2022.

53. Sarah Kaplan and Andrew Ba Tran. [Nearly 1 in 3 Americans experienced a weather disaster this summer](#). *The Washington Post*. September 4, 2021.

54. See chapter 3 in Jenny Schuetz. [Fixer-Upper: How to Repair America’s Broken Housing Systems](#). Brookings Institution, 2022.

adverse long-term financial impacts of climate-related hazards and disasters.⁵⁵ Climate risk must be managed without the unintended consequence of limiting access to credit and amplifying inequities. Ceres has made recommendations on the proposed changes to the Community Reinvestment Act to provide additional incentives for lenders to invest in the resiliency and adaptation of the most vulnerable communities.⁵⁶ Engagement and collaboration across the housing sector will be critical to develop the products and policy tools necessary to ensure an equitable transition to a net zero world.

Climate-driven changes in migration, development, and settlement patterns will play out against the backdrop of existing housing supply and affordability challenges. The mortgage and housing finance industry is the life blood of American housing. And America desperately needs more housing.

Freddie Mac estimates that at end of 2020, the U.S. faced a shortage of 3.8 million units to meet long-term demand.⁵⁷ A 2021 analysis commissioned by the National Association of Realtors indicates the need for “at least 5.5 million housing units during the next 10 years” to make up for historically low rate of growth since 2000.⁵⁸ In recent testimony before the U.S. House Committee on Ways and Means, Chris Herbert, Managing Director of the Joint Center on Housing Studies at Harvard, noted that “record-setting increases in home prices and rents have exacerbated longstanding housing affordability challenges.”⁵⁹ Even as home prices have begun to moderate in the face of higher interest rates, affordability remains a significant challenge.

The affordability crisis faced by renters is longstanding and even more severe. The share of renter households paying more than 30% of their income toward housing costs has increased steadily for two decades.⁶⁰ In 2019, 7.77 million households *had worst case housing needs*, meaning households that had incomes at or below 50 percent of area median, did not receive government housing assistance, and paid more than half of their income toward rent; lived in severely inadequate conditions; or both.⁶¹ On nearly every measure, from homeownership to housing quality, cost burdens, and stability, households headed by people of color fare worse.⁶²

The lack of affordable housing has pushed home buyers and renters into areas more vulnerable to physical risks and disasters have reduced supply and increased costs. According to CoreLogic, 1 in 10 U.S. homes was damaged by disasters just in 2021.⁶³ Addressing climate change is critical to meeting the nation’s housing needs.

WHAT’S NEXT?

The housing and mortgage finance industries now face three interrelated challenges: the climate crisis, a persistent affordable housing shortage, and the enduring legacies of systemic racism and housing discrimination. If private and public sector industry participants can marshal their expertise and entrepreneurial energy and work together with commitment and urgency, we can make a significant difference on all these fronts. With 40% of carbon emissions generated by the real estate sector and millions of housing units needed, we have a unique opportunity and responsibility. Years from now, we will be asked what we did back in 2023 to address these issues. The time is now and there is so much more to be done.

55. Financial Stability Oversight Council. October 2021. p 20–21. p. 22.

56. Ceres. [Comment Letter in response to Notice of Proposed Rulemaking: Community Reinvestment Act](#). August 4, 2022

57. Sam Khater. [One of the Most Important Challenges our Industry will Face: The Significant Shortage of Starter Homes](#), Freddie Mac Perspectives. April 15, 2021.

58. Rosen Consulting Group. [Housing is Critical Infrastructure: Social and Economic Benefits of Building More Housing](#). National Association of Realtors. June 2021.

59. [Testimony of Dr. Christopher Herbert, Managing Director, Harvard Joint Center for Housing Studies before the U.S. House Committee on Ways and Means](#). July 13, 2022.

60. GAO. [Report to Congressional Requesters: Rental Housing](#). U.S. Government Accountability Office. May 2020.

61. Thyria Alvarez and Barry L. Steffen. [Worst Case Housing Needs 2021 Report to Congress](#). HUD Office of Policy Development and Research. July 2021.

62. Joint Center for Housing Studies. [The State of the Nation’s Housing 2022](#). Harvard University. June 2022.

63. Samantha Fu. [How Cities Can Tackle Both the Affordable Housing and Climate Crises](#). Housing Matters. November 2, 2022.



RESEARCH INSTITUTE FOR HOUSING AMERICA **SPECIAL REPORT**

A Practical Approach to Climate Risk Assessment for Mortgage Finance

Suhrud Dagli, Janet Jozwik, Jason Huang, and Timothy Willis

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Suhrud Dagli, Co-founder and CTO, RiskSpan

Janet Jozwik, Head of Climate Risk and ESG, RiskSpan

Jason Huang, Director, Climate Risk and ESG, RiskSpan

Timothy Willis, Managing Director, RiskSpan

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Abstract

Significant uncertainty exists about how climate change will occur, how all levels of government will intervene or react to chronic risks like sea level rise, and how households, companies, and financial markets will respond to various signals that will create movements in prices, demographics, and economic activity even before climate risk manifests. This paper lays out a pragmatic framework for assessing these risks from the perspective of a mortgage company. We evaluate available public and proprietary data sources and address data limitations, such as different sources providing a different view of risk for a particular property. We propose a sensitivity analysis approach to quantify risk and mitigate the uncertainties in measuring and responding to climate change.

Introduction

Global temperatures will continue to increase over the next 50 years regardless of the actions people and governments take. The impacts of that warming are expected to accumulate and become more severe and frequent over time, causing stress throughout our economy. Regulators are clearly signaling that climate risk analysis will need to become a regular part of risk management activities. But detailed, industry-specific guidance has not been defined. FHFA and the regulated entities have yet to release a climate risk framework. They clearly recognize the threat to the housing finance system, however, and are actively working towards accounting for these risks.

Most executives and boards have become conceptually familiar with the physical and transition risks of climate change. But significant questions remain around how these concepts translate into specific, quantifiable business, asset, regulatory, legal, and reputation risks in the housing finance industry. Further complicating matters, climate science continues to evolve and there is limited historical data to understand how the effects of climate change will trickle into the housing market.

Sean Beckett¹ describes the myriad ways climate change and natural hazard risk can permeate the housing and housing finance industries as well as some of the ways to mitigate its effects. However, quantifying these risks and inserting them into mortgage credit and prepayment models comes with significant challenges. No “best practices” have emerged for incorporating these into traditional model frameworks.

This paper puts forth a practical framework to incorporate climate risk into existing enterprise risk management practices for the housing finance industry. The framework incorporates suggestions to prepare for coming regulatory requirements on climate risk and, more importantly, proactively managing and mitigating this risk. Our approach is based on over two years of research and field work RiskSpan has conducted with its clients, and the resulting models RiskSpan has developed to deliver insights into these risks.



The paper is organized into two main sections:

1. Prescribed Climate Scenarios and Emerging Regulatory Requirements
2. A Practical Approach to Climate Risk Assessment for Mortgage Finance

Layering climate risk into enterprise risk management is likely to be a multiyear process. This paper focuses on steps to take in the initial one to two years after climate risk has been prioritized for investment of time and resources by corporate leadership. As explained in an MBA white paper from June 2022,² “Existing risk management practices, structures, and relationships are already capturing potential risks from climate change.” The aim of this paper is to investigate specific ways in which existing credit, operational, and market risk frameworks can be leveraged to address this challenge, rather than seeking to reinvent the wheel.

1. Beckett, Sean R. “The Impact of Climate Change on Housing and Mortgage Finance,” September 23, 2021. Available at <https://www.mba.org/news-and-research/research-and-economics/research-institute-for-housing-america>

2. Woodwell, Fratantoni, Seiler, “Who Owns Climate Risk in the U.S. Real Estate Market?,” June 2022

Prescribed Climate Scenarios and Emerging Regulatory Requirements

HIGH-LEVEL NATURE OF CLIMATE SCENARIOS AND FRAMEWORKS

The most cited climate scenarios are those published by the Intergovernmental Panel on Climate Change (IPCC), the International Energy Agency (IEA), and the Network of Central Banks and Supervisors for Greening the Financial System (NGFS). Scenarios are tied to specific CO2 emissions targets: 3 degrees (Celsius), 2 degrees, and 1.5 degrees of warming above pre-industrial levels. Scenario guidance typically layers in a notion of societal impact related to how the economy transitions away from fossil fuels.

Framework guidance boils down to a trade-off between physical and transition risk, and a worst vs. best vs. likely framing of potential future outcomes. Illustrative of this generalization, the NGFS released Phase 2 of its six-scenario regime. This approach captures low-risk and high-risk outcomes based on the level of physical and transition risks imposed on the financial system by “orderly,” “disorderly,” and “hot house” world scenarios.³



These frameworks all specify global-level scenarios and provide few details on how to translate to geographic or industry-specific impacts, leaving corporations to fill in the gaps themselves.

3. See <https://www.ngfs.net/en/communique-de-presse/ngfs-publishes-second-vintage-climate-scenarios-forward-looking-climate-risks-assessment>.

LIMITED GUIDANCE ON APPLYING CLIMATE SCENARIOS TO THE FINANCIAL SECTOR

We can look to guidance coming out of Europe, from the Task Force on Climate-related Financial Disclosures (TCFD), and the initial proposal from the SEC to get a sense for how to translate the global scenarios into something meaningful for the financial services industry.

The TCFD, created by the Financial Standards Board to improve and increase reporting of climate-related financial information, published its latest guidance in 2021. This guidance describes ways to assess and disclose financial impacts arising from climate-related risks and opportunities. The TCFD guidance calls for disclosure of an organization’s exposure to, and anticipated effects of, specific climate-related risks and opportunities. The guidance contains specific language⁴ around example metrics, including greenhouse gas emissions and carbon prices, as well as scenario analysis for plausible emissions pathways or setting climate targets that would inform an organization’s potential future business goals.

Echoing the TCFD, a proposed SEC rule would require firms to disclose the impacts of climate risk on financial statements. The proposed rule would also require disclosure of GHG emissions, material climate risks, and a plan for risk management.

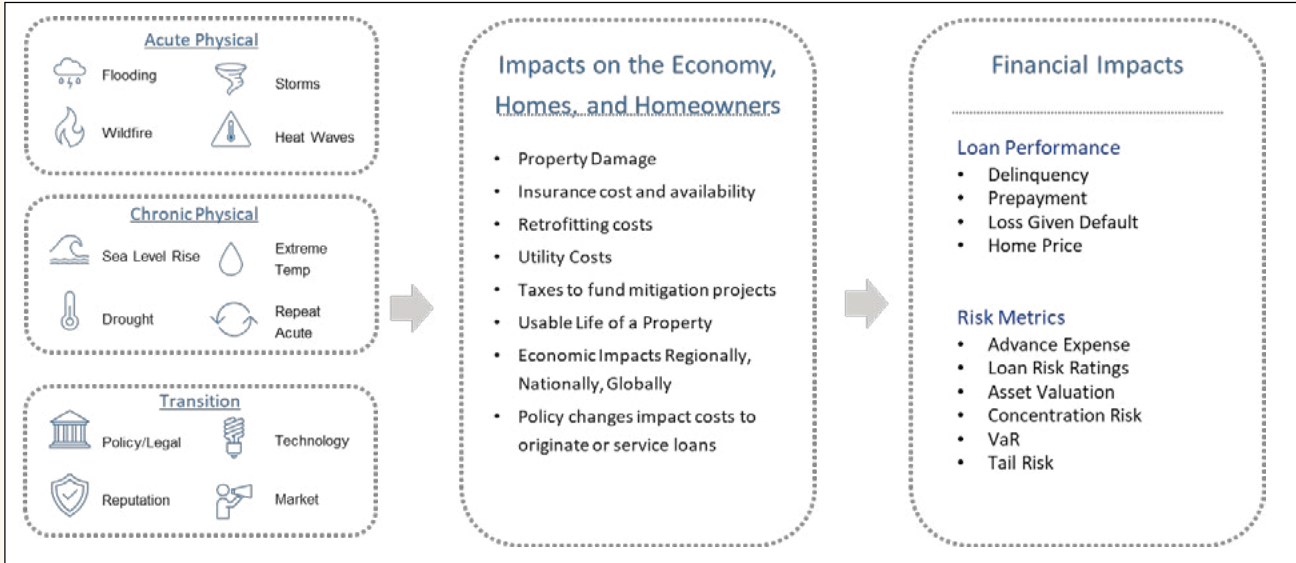
The Bank of England recently conducted a stress test to determine how the British financial system is likely to cope with climate change and transition to a net-zero economy.⁵ This test comprised three scenarios — early, late, and no action taken to combat climate change — and measured losses that would be incurred over the next 30 years. The Federal Reserve is conducting a climate scenario analysis pilot with six large US banking institutions, slated to start in early 2023. The pilot is intended to produce insight on how to measure and manage climate-related risks.⁶ The New York Department of Financial Services has issued

4. See [“Task Force on Climate-related Financial Disclosures Forward-looking Financial Sector Metrics Consultation”](#)

5. See [“Bank of England tells banks to take climate action now or face profit hit.”](#)

6. See https://www.dfs.ny.gov/industry_guidance/climate_change.

Exhibit 1: Climate Risk Impacts on Housing Finance



proposed guidance that would affect New York State-regulated banking and mortgage institutions of all sizes. The guidance emphasizes compliance with fair lending and taking a proportionate approach, tailored to the organization’s climate risk exposure.⁷

While this guidance specifically addresses the financial services industry, the housing market faces unique risks from natural hazards and climate risk due to the nature of the asset and the intricacies of risk sharing (property insurer, homeowner, GSE, servicer, and investor).

POTENTIAL IMPACTS ON HOUSING FINANCE ARE NUMEROUS AND COMPLEX

Before diving into a framework for how to measure this risk, let’s first revisit the mechanisms by which physical and transition risk could impact housing finance. Many of these items were first introduced in Beckett (2021). Exhibit 1 above highlights some of the ways acute, chronic, and transition risks impact our industry via homeowners, homes, or the economy.

Acute physical events, such as hurricanes, wildfires, and floods, can put stress on a borrower in several ways:

- Physical damage to the property that is not fully insured or where there is risk that an insurance counterparty cannot pay
- Borrower stress related to expenses even where some or all of the property damage is insured

- Regional economic impacts, potentially causing the borrower to lose income

These stresses lead to changes in borrower performance through increased probability of delinquency and increased probabilities of voluntary prepayment, especially when risk is insured. Property damage on defaulted loans will increase loss given default. Even properties with adequate insurance coverage can be subject to considerable climate risk. Acute climate events that seriously damage or destroy homes affect the timing of mortgage cash flows and can impact the overall performance of a mortgage portfolio, particularly when insurance proceeds are used to prepay loans. The specter of these events combined with concern over the future insurability of existing homes will almost certainly at some point lead to declining property values in high-risk areas. Doing business in these areas could also be the source of future reputational risk.⁸

Mortgage lenders, borrowers, and investors all take comfort in believing that the brunt of climate risk, as it pertains to housing, is borne by hazard insurers. Mounting evidence, however, indicates that property risk is often under-insured, especially in the case of flood risk. The question of whether insurance issuers can remain solvent in the aftermath of catastrophic events remains an open one.⁹ In the assessment of acute physical risks, specific events can put additional stress on the property insurance

7. https://www.dfs.ny.gov/industry_guidance/climate_change

8. See “[The Federal Government Sells Flood-Prone Homes To Often Unsuspecting Borrowers, NPR Finds.](#)”

9. See “[Louisiana’s insurance market is collapsing, just in time for hurricane season](#)” and “[Wildfire Risk in California Drives Insurers to Pull Policies for Pricey Homes,](#)” and “[Insurance Meltdown Leaves Homeowners Without Policies and at Risk.](#)”

industry, which may have knock-on impacts to unaffected properties, as we're seeing in Florida's insurance markets.¹⁰ Additionally, because insurance premiums are adjusted annually, the cost of insuring a property can increase dramatically over the life of a given mortgage loan. Insurers can also opt not to renew a policy. In a companion essay in Volume II of this set, Milliman will do a deeper dive on issues related to insurance markets.

In addition to the shocks of acute physical events, many of the other impacts of climate risk, whether physical or transition, lead to 1) increasing costs of homeownership and 2) decreasing demand for housing. These effects make it harder for a borrower to keep up with payments and can put downward pressure on home prices.

Increasing costs of homeownership are related not only to the looming threat of increased property insurance costs, but also increased costs of utilities, increased property taxes as exposed municipalities need to fund mitigation projects, and increased maintenance and home retrofitting costs.

Insurance rates will rise as insurance companies increasingly price in the actual risk of extreme events. To the extent that insurance companies opt to exit high-risk areas entirely, the resulting lack of competitive pressure among the remaining smaller group of insurers will likely push premiums higher as well.¹¹ Governments may elect to subsidize these costs to one degree or another, but that can only be accomplished by increasing the overall tax burden.

Utility costs for homeowners can increase both from increased demand for energy to cool homes and increased costs per unit. New risks of increasing frequency of shocks to electrical grids and other resources may result in higher operational costs for utilities if no action is taken to adapt or invest in climate resilient infrastructure. The transition to more resilient or greener infrastructure won't be as simple as turning on a switch — it may be a complicated process that further applies pressure on costs. In either event, increased operational expenses and the costs of capital infrastructure investments will likely be passed on in the form of higher utility bills.

Such costs, combined with concern over exposure to extreme climate events, have the potential to depress real estate demand in risk-prone areas while potentially pushing demand higher in regions believed to be more insulated from climate risk.



Chronic physical risks can be local or regional in scope. While sea level risk may threaten the livability of individual communities, drought and excessive heat can take a toll on entire regions. Both kinds of risk can potentially impact home prices by driving down demand in affected areas.

Beyond property and borrower performance considerations, potential regulatory action threatens to increase mortgage origination and servicing costs. Additionally, acute events have the potential to temporarily shock the loans and MSR asset market leading to asset valuation fluctuations and balance sheet issues.

CHALLENGES OF QUANTIFYING IMPACTS

To quantify these impacts, we need to understand not only what the physical and transition risks of climate change are, but also how those changes would impact the performance of mortgage assets.

Considerable evidence exists for quantifying the short-term impact of acute climate events on mortgage performance. Data gathered in the wake of the most devastating hurricanes of the past two decades suggest that while mortgage delinquencies and prepayments are impacted, most delinquencies cure within a relatively short period of time, sometimes (but by no means always) aided by forbearance, repayment plans, and other loss mitigation measures. These impacts are mitigated to some degree (but not entirely) by homeowners' insurance. Uninsured and underinsured properties obviously suffer more catastrophic losses. It is important to note the relatively limited history of robust mortgage performance data. Mortgage models used in production today are generally pulling from historical data going back only to about 2000. This limits the historical hazard events from which we can observe performance impacts. Hazard events that are costlier than those we've seen recently, such as Hurricane Katrina, are well within the realm of possibility.

10. <https://www.npr.org/2022/10/04/1126806832/floridas-insurance-market-was-already-on-the-edge-then-hurricane-ian-hit>

11. <https://www.npr.org/2022/10/06/1127083845/hurricane-ian-florida-property-insurance>



The longer-term impact of chronic climate risk on home prices is harder to pin down. Little evidence exists of home price declines attributable directly to climate risk. Some of this owes to artificially low homeowners' insurance premiums made possible by government-subsidized programs. Additionally, the impact of flood risk on home values in coastal areas is difficult to measure because these properties tend to have more amenities than non-coastal homes. The value of these amenities may offset climate-related value declines to an extent. This effect is likely to be temporary, however, as climate risk becomes increasingly salient to future buyers.

Home price impacts due to climate change will ultimately depend on the extent to which potential homebuyers believe that climate poses a substantial risk to a given community. As information becomes more readily available (and believed), climate risk will gradually get priced into home values. One source estimates only a seven percent discount on properties exposed to sea level risk relative to equivalent properties without such exposure.¹² Generalizing the complex impact of climate change on home prices poses a significant challenge to modelers. Take the unfortunate example of multiple houses on North Carolina's Outer Banks falling into the sea earlier this year.¹³ Are prices of nearby properties adjusting rationally to this risk? If not, when and how will this adjustment happen?

The uncertainties do not stop there. How will the government mitigate these impacts for homeowners? How well will local, state, and federal governments help communities prepare? How should insurance company counterparty risk be assessed? If this risk results in a mass migration from certain areas, where will these people live? How would such a migration impact housing in other parts of the country? How do other economic forces (housing supply, inflation, affordability) exacerbate the impact climate risk has in the near-term?

How will these risks impact residential housing prices, attractiveness of communities, building codes, insurance costs, and zoning laws? Relatedly, what will happen to mortgages and other financial instruments whose value derives from that of residential properties and the economic strength of communities? What will be the response from homeowners, insurers, builders, investors, and public policy of local, state, and federal governments that could impact asset valuation?

These questions make forecasting the financial impacts of future climate pathways extremely complicated and difficult. Thus, we need a practical approach to risk assessment and a manageable path that can move the industry forward.

12. Bernstein, A., Gustafson M., and Lewis R. 2018. Disaster on the horizon: The price effect of sea level rise. Working Paper, University of Boulder, Colorado

13. See ["Officials fear more Outer Banks homes may fall into ocean due to erosion"](#)

A Practical Approach to Climate Risk Assessment for Mortgage Finance

Given the uncertainties and historical data limitations we face in assessing the impacts of climate risk in housing finance, the best place to start is designing scenarios that augment traditional mortgage risk frameworks. These scenarios can help us understand a portfolio's sensitivity to climate-related shocks, similar to how macroeconomic scenarios and stress tests are used within risk management today.

The basic premise is to leverage available climate risk data and develop a framework for converting those data elements into inputs already used in the mortgage modeling process. The framework can be grounded in data, where available, but should also contemplate future performance that deviates from known history.

The framework should be sufficiently flexible to evolve as we learn more about regulatory requirements and, more importantly, how physical and transition risks manifest in housing finance. Incorporating climate risk into existing enterprise risk management practices is likely a multi-year process. Initial goals should be to make incremental progress that can be iterated and improved on over time.

This section walks through the practical steps for beginning the journey.¹⁴

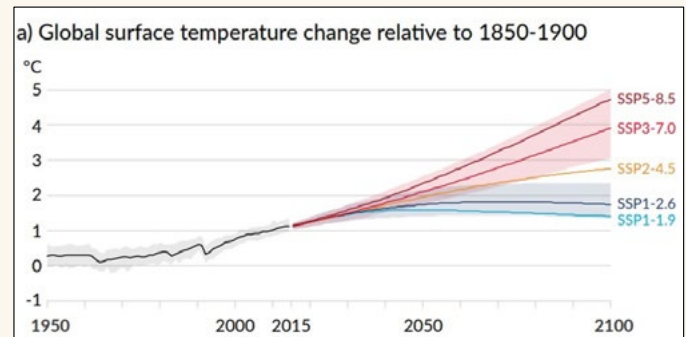
PRIORITIZE RISKS

Given the complexity and uncertainty involved, focusing initially on a few key elements makes assessing the financial impacts of climate risk a more tractable problem to solve. We prioritize risks that could result in substantial financial loss to a mortgage company. We narrow our focus to:

1. Acute events that impact borrower behavior
2. Home price and delinquency performance response to increasing costs of homeownership and decreasing housing demand
3. Insurance market issues that exacerbate effects of 1 and 2

Mortgage lenders, servicers, and investors may prioritize these risks differently. Servicers, for example, are more likely than investors to be concerned with the potential operational and liquidity challenges created when an acute climate event necessitates large-scale outlays for P&I and escrow advances.

Exhibit 2: IPCC Emissions Pathways



Source: IPCC

14. In a later essay, Eknath Belbase and Alex Levin from Andrew Davidson and Co will describe additional technical aspects of conditioning mortgage credit analysis on climate risk.

The other dimension to consider is the relevant time horizon. A logical place to start is by assessing financial risks that could occur over the next 5 to 10 years. This builds a foundation from which longer-term analysis can be layered in subsequently. An important note on current global surface mean temperature scenarios, as depicted in Exhibit 2, is that they do not meaningfully deviate from one another until about 2050 (they all get worse from now until then). Physical risks will be similar under each of these temperature scenarios for the near to mid-term.

Ultimately the financial impacts of these three risk drivers can be explored with mortgage model scenarios that stress loan performance and home price scenarios.

MEASURE EXPOSURE

Two types of data are needed to measure exposure to physical risks: 1) loan-level details needed for analysis and 2) geographically specific measures of climate risk.

Beyond the typical loan-level features used in mortgage risk analysis, climate risk analysis is enhanced with:

- Property address (or the most granular geographic data available)
- Property insurance terms
- Home value (broken into land value and building value)¹⁵
- Any property-specific attributes that are available. These can be hard to find, but some items can be found in appraisal data or MLS listings (where available). Examples include property age, construction type, and elevation.

These data elements help paint a more accurate picture of loan-level exposure to climate risks. Property insurance terms help identify loans made to underinsured homeowners with substantial residual exposure. Absent insurance data, the property address can be used to determine whether a loan is in a FEMA-designated flood zone, giving insight into whether flood risk would be insured.

Free sources of data are a good place to start. These include information from government agencies, such as FEMA or NOAA, and academic sources, such as Notre Dame's Urban Adaptation Assessment. The largest limitation of open-source government or academic data is geographic granularity — these sources do not provide risk measures at the property-address level. Additionally, these sources are largely aimed at helping governments

15. Information on this may be found in appraisal information or from a (dated) source from FHFA that provides factors at a zip code level.

DATA OPTIONS

Open Source — A solid place to start:

- FEMA NRI, NOAA, and the new Climate Mapping for Resilience and Adaptation portal*
- Data is not reported at the address level and hard to roll up to the portfolio level in a meaningful way

Vendor Data — Make sure it's actionable:

- Scores can be tricky to relate to financial impact, so look for:
 - + Metrics that tie to property damage estimations
 - + Metrics that can be rolled up to the portfolio-level that incorporate geo-correlations of hazard risks
 - + Property-address specific assessments

Note: See <https://resilience.climate.gov/>

and municipalities prepare. Consequently, they do not provide detailed information on economic impact at the household level that would be useful in mortgage modeling. Lastly, in the case of the FEMA National Risk Index, scoring is based purely on historical data related to disasters that have occurred. This leaves potential gaps for geographies that happen to have avoided major events in the last century but may become more prone to them as the climate evolves.

Beyond these free sources lies a whole world of vendor data. New entrants seem to pop into the space daily and the myriad of choices can be overwhelming. Models that generate climate data generally fall into two camps: 1) Natural Catastrophe Models (Cat Models) and 2) Climate Models. Cat models are born out of the property insurance space and have been used to manage and price natural catastrophe risk for decades. They tend to be very geographically granular and can provide dollar estimates of physical damage to a property. Climate Models are based on General Circulation Models (GCMs).¹⁶ These models operate at a less geographically granular level but have a much longer projection time horizon and are natively able to reflect different warming scenarios.

Exhibit 3 summarizes some of the pros and cons of Cat Models vs. Climate Models. One critical element to look for in either data source is the ability to tie back to some tangible metric — property damage, frequency of events, or days of warming. Tangible metrics make it possible to

16. A short primer can be found at climate.gov.

Exhibit 3: Climate Model Types

	Natural Catastrophe Models	Climate Models
Pros	<ul style="list-style-type: none"> Used to price risk in the insurance markets — many users/regulators heavily invested in the model's accuracy Property specific geographic granularity Estimates damage in dollar terms Incorporates simulations that show how risks are geographically correlated Vendors have insight into insurance take-up rates and other key data inputs that could help plug loan data gaps 	<ul style="list-style-type: none"> Tied to the latest academic science on the future impacts of global temperature increases Contemplates longer time horizons and the various IPCC Representative Concentration Pathway (RCP) warming scenarios Captures increasing chronic risks
Cons	<ul style="list-style-type: none"> Missing chronic risks, such as heat, drought, and sea level rise Focused on near-term risks, models would need to be tuned for future risk under different warming scenarios 	<ul style="list-style-type: none"> Not as granular geographically, models must be 'down-scaled' to a local level Weak ties to economic losses, making the connection to mortgage modeling harder

establish financial impact in ways that scoring methodologies that provide no context for interpretation cannot.

Both approaches have value and provide insight into risk concentrations within a portfolio. In a perfect world with unlimited budgets and time for analysis, gathering data from multiple vendors with varying approaches to modeling would be ideal. In the scope of a multi-year, incremental approach to incorporating climate risk into enterprise risk management, a logical first step on vendor data would be to start with a Cat Model. Cat Models are tied to the economic realities of the near-term and will illuminate the most pressing risks. An analysis that starts with Cat Modeling may not show concentrations of chronic risks. Open-source, government, and academic data sources can help fill in those gaps.

Once climate data is gathered, it's time to start analyzing exposures to get a better understanding of where risks are concentrated in the portfolio. This will help point to the types of scenarios that should be contemplated when digging into potential financial impacts. Setting up ongoing tracking of these metrics will help show how risks change over time with portfolio shifts.

CATASTROPHIC MODELING METRICS PRIMER

Typically, Cat Models stochastically simulate natural hazard events and estimate physical damage to a specific property given the characteristics of the simulated event. This results in a distribution of property damage for an individual loan that can be rolled up to a portfolio-level distribution. Several important metrics can be extracted from the loss distribution for each property. These metrics can be evaluated for a specific peril (e.g., hurricanes) or all perils combined.

- **AAL:** Average Annual Loss is the average annual property damage. This can be broken down by the type of natural hazard (flood, hurricane, etc.) and can be viewed as either gross or net of property insurance.
- **TVaR:** Tail Value at Risk is the average value at and above a specific return period. A return period is a way to describe the estimated likelihood of losses of a certain magnitude for a given time period. TVaR at a return period will give a measure of the severity of losses at the extremes, or tail of the loss distribution.

AAL and TVaR can be expressed as dollars of loss or a rate, where the denominator can be the house value or the replacement value of the home. These estimates provide a tangible way to assign relative risk per loan or evaluate portfolio risk concentrations.

Important ways to track exposure include:

- Displaying properties color-coded by risk on a map
- Flagging underinsured loans, especially for flood risk
- Crossing climate risk with key mortgage risk layers, such as LTV and DTI

Climate Risk by Current LTV

Hazard Risk	(0,60]	(60,70]	(70,80]	(80,90]	(90,95]	(95,+]
5-V. High	6.1%	0.5%	0.2%	0.1%	0.0%	0.1%
4-High	14.5%	1.8%	0.7%	0.3%	0.1%	0.3%
3-Moderate	17.3%	2.5%	1.2%	0.6%	0.2%	0.6%
2-Low	17.8%	3.0%	2.0%	0.8%	0.3%	0.9%
1-V. Low	20.9%	3.3%	1.8%	0.9%	0.3%	1.0%

- Rolled-up views of key Cat Model metrics at the portfolio level that can demonstrate:
 - + The percentage of the portfolio's home value that is at risk in the tail, both gross and net of property insurance
 - + The types of hazards that drive major property losses to the portfolio
 - + Geographies that contribute disproportionately to portfolio AAL or TVaR. The example below highlights that Louisiana represents about 1% of the loan population, but it accounts for about 10% of the AAL or TVaR.

Before using scenario analysis to explore financial impacts, it's important to understand exposures and concentrations of property risk within the portfolio. Scenarios should be tailored to where a portfolio is most exposed.

DEVELOP SCENARIOS

In seeking to leverage existing mortgage models, the goal was to make use of existing inputs to mortgage models, thus avoiding costly re-engineering of existing modeling systems used throughout an organization. By layering climate risk into a framework that generates scenario inputs to a mortgage model, we can maintain 1) flexibility to evolve as new data and research are available, 2) transparency into the mechanisms that change loan performance, and 3) congruity by relying on existing models and inputs.

The other goal of the approach was to avoid a sense of false precision in the analysis. As described in the previous section, data demonstrating the impact of climate risk on either loan performance or home price is limited. If we embed the climate impact deep within the models with precise coefficients, that implies that these relationships are well understood and can be precisely quantified. The one thing we do know is that climate risks will have an impact on mortgage performance that is not yet observable in historical data.¹⁷

Exhibit 4 illustrates the high-level approach. Loan, insurance, climate, and macroeconomic data flow into a 'Climate Scenario Framework' that then generates inputs in the form of a loan tape, macroeconomic forecasts, and model tuners. This is how RiskSpan approaches it with its own models, but the framework relies on commonly used

17. See Beckett 2021

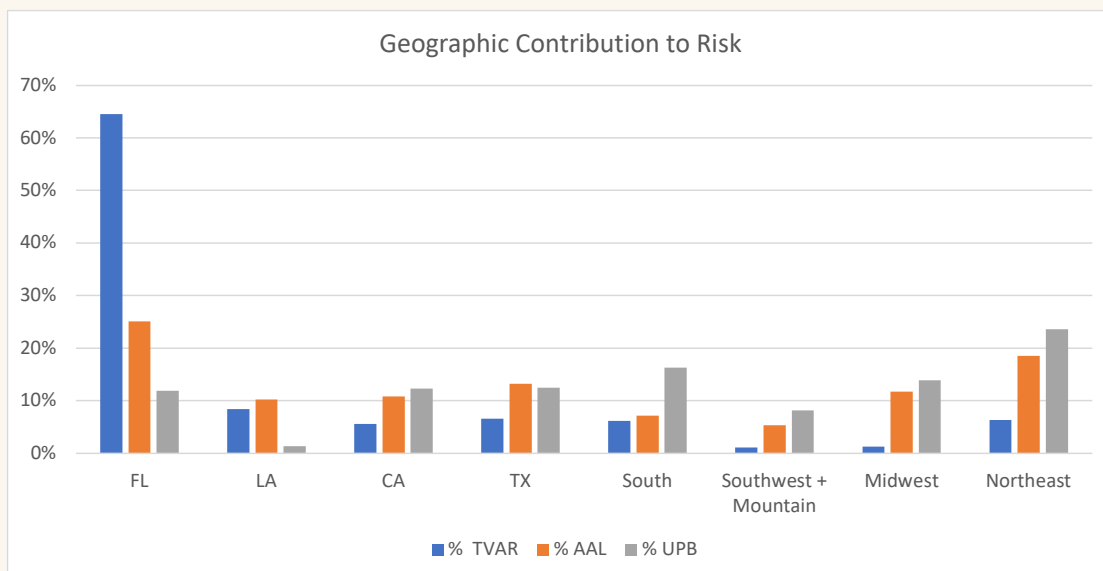
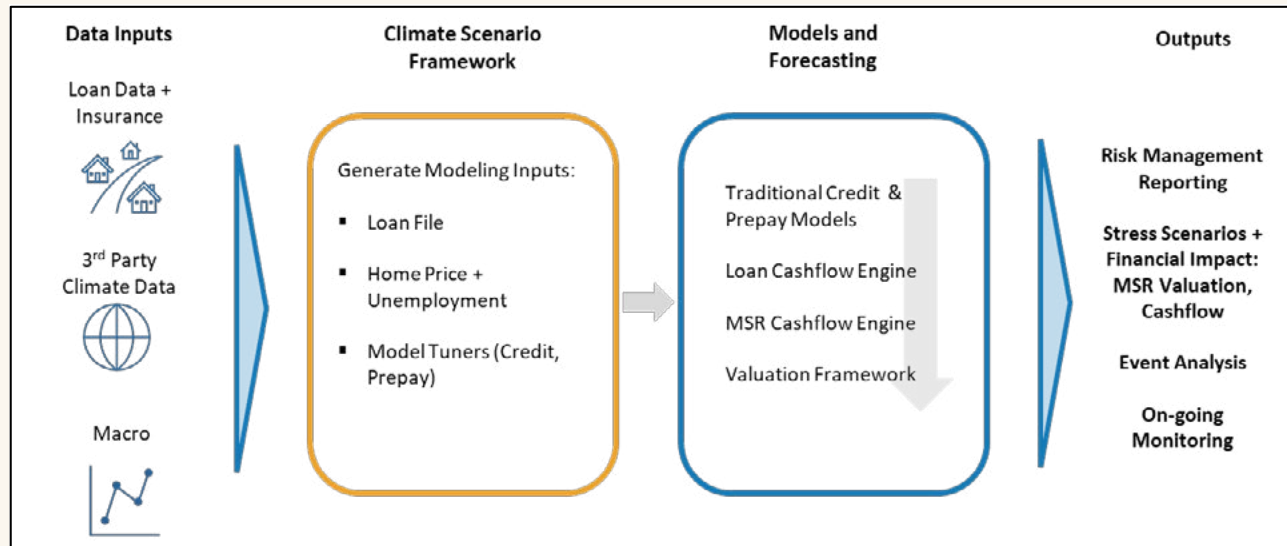


Exhibit 4: The Climate Scenario Framework



inputs and levers and thus can work with other mortgage models as well.

The climate scenario framework is where the translation of climate risks to mortgage risks happens. For example, uninsured property damage is translated into changes to a particular home's value or future regional impacts of chronic risks are translated into downward pressure on home prices. Focusing on the three key mechanisms of risk outlined in the section above, we target scenarios that toggle on:

- **Acute Risk:** Geared toward understanding event risk
- **Home Price + Delinquency:** Geared toward understanding increasing costs of homeownership and decreasing housing demand

Acute Risk Scenarios

- Reflect property damage and borrower stress from acute events
- Select scenarios based on portfolio-level tail risk
- Vary level of support from property insurance

Approaching the analysis from a variety of angles and scenarios provides a fuller view of potential outcomes. Types of scenarios to consider:

Specific Event Scenarios: One benefit of Cat models is that they can output results for a specific event, either replays of historical events or one of the simulated events. Types of events to explore:

- Replaying historical event scenarios, such as Hurricane Andrew, with the current portfolio and toggling on the impacts of property insurance (e.g., some percentage of insurance counterparties fail).
- Orienting to a historical event to help build intuition about other events pulled from the tail of simulated events from the Cat Model. Looking specifically at the impact of events pulled from a specific percentile of probability (1%, 2%, 5%, etc.) to reveal a range of possible but not experienced outcomes.

Future Path Climate Scenarios: Explore the tradeoff between physical and transition risks and the alternative versions of the future laid out in emerging guidance. As narratives for plausible futures come out (e.g., hot house world, disorderly transition), we can think about what risks to emphasize when developing scenarios to represent the future and adapt to new information. In exploring Future Path Climate Scenarios:

- Consider third-party macroeconomic forecasts that incorporate recommended scenarios into national or regional GDP and employment forecasts. These would generally cover the macro impacts of climate risk, especially many transition risks, but leave out housing-specific details.
- Consider loan-level home price projections that take a regional projection and adjust based on a specific property's exposure to chronic risks.
- Apply adjustments to delinquency or debt-to-income ratio to reflect a loan's exposure to increasing costs of home ownership.



It is important to remain focused on a time horizon that is relevant to the organization when exploring and evaluating future scenarios.

Sensitivity Testing: Stylized scenarios systematically shock key performance drivers based on regional or property-specific exposures. These scenarios can help highlight which loans or combination of loan features and climate exposures present the biggest risks. For example:

- Adjusting home prices in regions exposed to chronic or transition risk down X, Y, Z percent from the baseline forecast. An additional consideration may be coupling the downward HPI scenarios with home price increases in regions that are least exposed.
- Calibrating borrower delinquency performance for homes that are particularly exposed to increased acute and chronic risks. Delinquencies increasing X, Y, Z percent from a baseline level.
- Shocking prepayments to capture historically observed increases post catastrophic event, especially in the presence of insurance.
- Combining these possible paths to come up with a range of possible scenarios

Home Price + Delinquency Scenarios

- Regional home price impacts:
 - + Winners and losers due to climate risk
 - + Varying levels of government intervention
- Property-specific impacts driven by:
 - + Potential changes in property insurance
 - + Municipal resilience
 - + Usable life of the property
- Home prices can adjust to risk either gradually or suddenly if triggered by a specific event

Exhibit 5 on the following page outlines an approach to translating acute events. The same approach can be applied to a single event or over many simulated scenarios representing different future path climate scenarios.

Exhibit 5: Translating Acute Physical Events into Mortgage Model Scenarios

	Input File: LTV	Delinquency Adjustment	Turnover Adjustment	Macroeconomic Forecast
Designed to Capture	Change in borrower equity position	Borrower hardship	Increase in turnover, especially for insured loans	Wider regional economic impacts of the event
Historical Grounding	Assume that uninsured losses (from Cat model) are a direct hit to the building value component of home price	Observed spike in delinquency post event based on historical experience (Katrina + other hurricane events)	Observed spike in turnover post event based on historical experience (Katrina + other hurricane events)	Post-event economic behavior, including the Northridge Earthquake. Vary with stresses even more severe than history
Details	Adjust Building Value component of House Price by Uninsured Physical Losses, then recalculate the LTV	Apply delinquency multipliers as a monthly vector to loans with Damage > min threshold. Vary DQ spike by Insurance Coverage and Amount of Damage based on findings in: Kousky, Palim, Pan Paper and in the Du, Zhao paper ^{18, 19}	Apply turnover multipliers as a monthly vector to loans with Damage > min threshold. Vary turnover multiplier by insurance coverage based on Kousky, Palim, Pan paper	Adjust MSA-level baseline HPI forecast to create a 'Stress HPI' scenario for the entire region impacted

Mortgage servicers and MSR asset holders will need to take the analysis one step further by looking at how the changes in the loan cashflows impact the MSR cash flows. Scenarios should adjust factors for:

- **Servicing Costs:** Consider whether servicing a delinquent loan due to an acute physical event is even more expensive than servicing a 'normally' delinquent loan. For overall climate scenarios, consider a more general increase in the cost of servicing as the regulatory burden may increase.
- **Recapture Rate:** Prepayment rates spike after acute physical events. These loans likely experience a different recapture rate than normal.

Incorporating scenario analyses into existing risk management activities will help build intuition and understanding within the organization related to climate risk. It is important to understand the inherent limitations of what is being modeled, where the data may be imprecise or where proxies may be used. But this is a space that is quickly evolving, and the scenario framework proposed allows for pivoting as new data and methods are developed.



18. Carolyn Kousky, Mark Palim & Ying Pan (2020) Flood Damage and Mortgage Credit Risk: A Case Study of Hurricane Harvey, Journal of Housing Research, 29:sup1, S86-S120, DOI: 10.1080/10527001.2020.1840131

19. Ding Du, Xiaobing Zhao (2020) Hurricanes and Residential Mortgage Loan Performance, OCC and Northern Arizona University

PRACTICAL STEPS TOWARD MANAGING CLIMATE RISKS

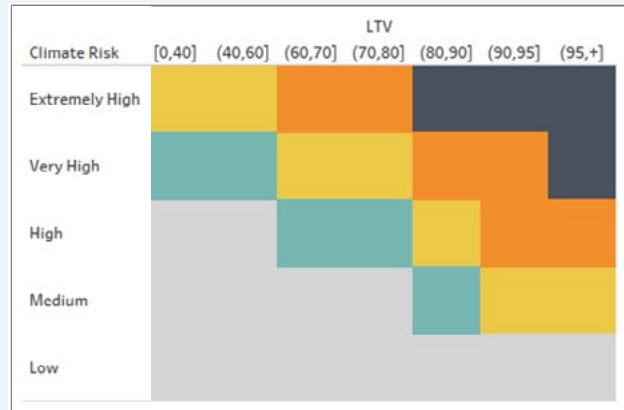
This paper focuses on practical steps to start measuring the financial impacts of climate risk. Once these risks start to be measured, the natural next step is to think about managing risk.

- Establish/understand the organization’s climate risk appetite
- Inventory potential remediation options, items would include:
 - + Additional reporting and monitoring (e.g., adverse selection monitoring)
 - + Changes to credit, underwriting, or pricing policies and strategies
 - + Insurance, reinsurance, and insurance-linked securities structures to offset risk
- Evaluate the costs and benefits of each approach
- Develop a roadmap for implementing (or re-evaluating) remediation strategies

FIRST STEP IN MITIGATION:

Establish exposure concentration limits by Risk, LTV, and Geography.

- Manages exposure
- Protects against adverse selection as others start to incorporate this risk



Portfolio Concentration Limits			
	FL	CA	Gulf Coast
Dark Blue	N/A		
Orange	2%	5%	2%
Yellow	None		
Teal	None		
Grey	None		

ITERATE AND UPDATE

We are at the very beginning of a long journey toward incorporating climate risk into mortgage risk modeling. The approach laid out here is meant to be a roadmap for how to start. By focusing on a streamlined list of impacts and starting with scenario analysis that leverages existing mortgage modeling capabilities, we create a more tractable problem for originators, servicers, and investors to tackle. The goal is to enhance the scenario framework through time with new data sources, new scenarios, and a better understanding of the impacts of climate change on housing. Today’s robust prepayment models did not arise all at once. Rather, they emerged from modest beginnings in the 1990s and gradually evolved in complexity. Incorporating climate risk into existing modeling regimes will follow a similar iterative process as we continue to gather data and get smarter about the interplay of these many factors on the dynamic and multifaceted world of mortgage finance.