RECOMMENDATIONS TO BETTER INTEGRATE NATURE-BASED SOLUTIONS INTO THE MODELS AND PRICING USED BY THE NATIONAL FLOOD INSURANCE PROGRAM

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Talley Burley
Environmental Defense Fund

Kelly Suttles
Environmental Defense Fund

Environmental Defense Fund

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Remaining errors are our own.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Flooding is becoming more frequent, more costly, and harder for communities to manage. In the United States, flood damages have averaged about $46 billion a year over the last decade, and climate change could increase those damages by as much as one-third by 2050. Recent disasters have shown how quickly floods can overwhelm communities, including places not traditionally seen as high-risk.

Wetlands, mangroves, forests and other natural systems absorb water, slow runoff, reduce storm surge and limit flooding, while also supporting healthier ecosystems. For communities to protect and restore these systems at scale, their value should be acknowledged within insurance and in the programs that guide flood mitigation decisions.

The National Flood Insurance Program (NFIP) provides most residential flood insurance in the United States and shapes how communities understand risk, where they build, which mitigation strategies they prioritize and which investments are rewarded. But NFIP pricing does not clearly or consistently recognize the full value of nature in reducing flood impacts. As a result, communities may have less incentive to protect and restore natural systems that can reduce flood losses and lower long-term costs. Ensuring that NFIP risk modeling and pricing better reflect the value of nature can help drive deeper investment in nature-based solutions for flood mitigation.

This report examines how the models and pricing in the NFIP can better recognize flood-risk reduction benefits from nature-based solutions and use that recognition to incentivize more nature-focused mitigation investments.

Over the last year, EDF undertook work to understand what actions are needed to integrate nature-based solutions into the NFIP in a practical and meaningful way. Based on a review of the science, and engagement with specialists across flood insurance, modeling, engineering, conservation and local government, this report identifies key considerations and opportunities.

Nature does not fit neatly into the structure of NFIP's current systems, meaning integrating nature-based solutions into models and pricing requires several approaches. But, focusing where the science is the strongest will build a pathway for other nature-based solutions. Four recommendations emerged:

- Improve how existing natural assets and nature-based solutions are recognized in catastrophe models.
- Create a post-model adjustment to acknowledge the flood-risk reduction benefits of nature-based projects.
- Strengthen the NFIP's Community Rating System by expanding the eligibility of nature-based solutions and addressing existing program barriers that can limit participation and advancement.
- Modernize FEMA flood maps and floodplain management standards to better guide mitigation and land use decision-making; and reduce the potential for development that drives nature loss and degradation of natural systems.

These approaches will require reforms to the NFIP, improved datasets, cross-sector collaboration, pilots and analysis to test how nature can be reflected in insurance rating, and clearer communication about how flood mitigation affects premiums. Communities need every credible tool available to manage rising flood risk. When nature helps protect people and property, the NFIP should recognize that value.

I. INTRODUCTION

The increasing frequency and intensity of floods is leading to more tidal flooding in low-lying areas, larger storms that reach further inland and flash flooding from heavier precipitation. In the United States, flooding is the most common and most expensive natural hazard. The Congressional Budget Office (CBO) estimates that during the last 10 years flood damages averaged about $46 billion per year, with climate change likely to increase damages by as much a third by 2050 (CBO 2024). According to FEMA 1 inch of water can cause buildings damages of more than $25,000, these costs can have significant financial impacts for households and communities (FEMA 2023).

Post-disaster financial resources are often limited and flood damage is not included in homeowners' insurance policies. Instead, in the United States, the vast majority of flood insurance is provided through the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP), rather than through private insurers. Yet, based on research from the CBO, in 2024 only 8% of households nationwide had an NFIP policy, including only 18% of households in areas where NFIP coverage is required (CBO 2024). Low-income and marginalized communities are particularly vulnerable to the impacts of increasing flood risk but often lack access to and are unable to afford financial resources, like flood insurance, that help households and communities recover from disasters and build financial resilience.

Flood mitigation can reduce flood risk and lower insurance costs, but NFIP pricing does not consistently reflect the full range of effective strategies. NFIP's Risk Rating 2.0 pricing methodology uses proprietary catastrophe models and standardized discounts for certain measures, such as home elevation and FEMA-certified levees. Many other approaches—including nature-based solutions, storm sewer upgrades and backwater valves—are not clearly or reliably reflected in flood insurance pricing. This gap can discourage layered mitigation across buildings, blocks, neighborhoods and watersheds, even as climate change increases the need for broader, innovative adaptation.

Communities and states have been pursuing approaches that utilize nature-based solutions to better manage flood risk, while also leveraging the co-benefits of these projects such as recreation, improved air quality, improved water quality and biodiversity. Nature-based solutions are defined as: **actions that leverage natural processes to protect, restore and sustainably manage natural and modified ecosystems to reduce risk, promote resilience and provide co-benefits for people and nature, including biodiversity, recreation and well-being (UNEP).** [1]

The co-benefits of nature-based solutions can help build community support and motivate local investment (WHO 2025). Research also increasingly points to nature-based-solutions—wetlands, mangroves, sea-grass beds and forests —as important to reducing flood impacts. Coastal wetlands, for example, can reduce flood inundation and the extent, depth and duration of floods (van Zelst, 2025). Recent research by the SwissRe Institute found that natural habitats helped to reduce the frequency of insurance losses from floods in coastal Florida by half (SwissRe 2025). The UC Santa Cruz Center for Coastal Climate Resilience (CCCR) and East Carolina University (ECU), in collaboration with Moody's RMS and the Nature Conservancy, indicates the important role mangroves played in significantly reducing storm surges and property damages during Hurricanes Irma in 2017 and Ian in 2022 (Narayan et al., 2025).

1 This definition of nature-based solutions is used by EDF and adapted from the UN Environment Programme (UNEP)

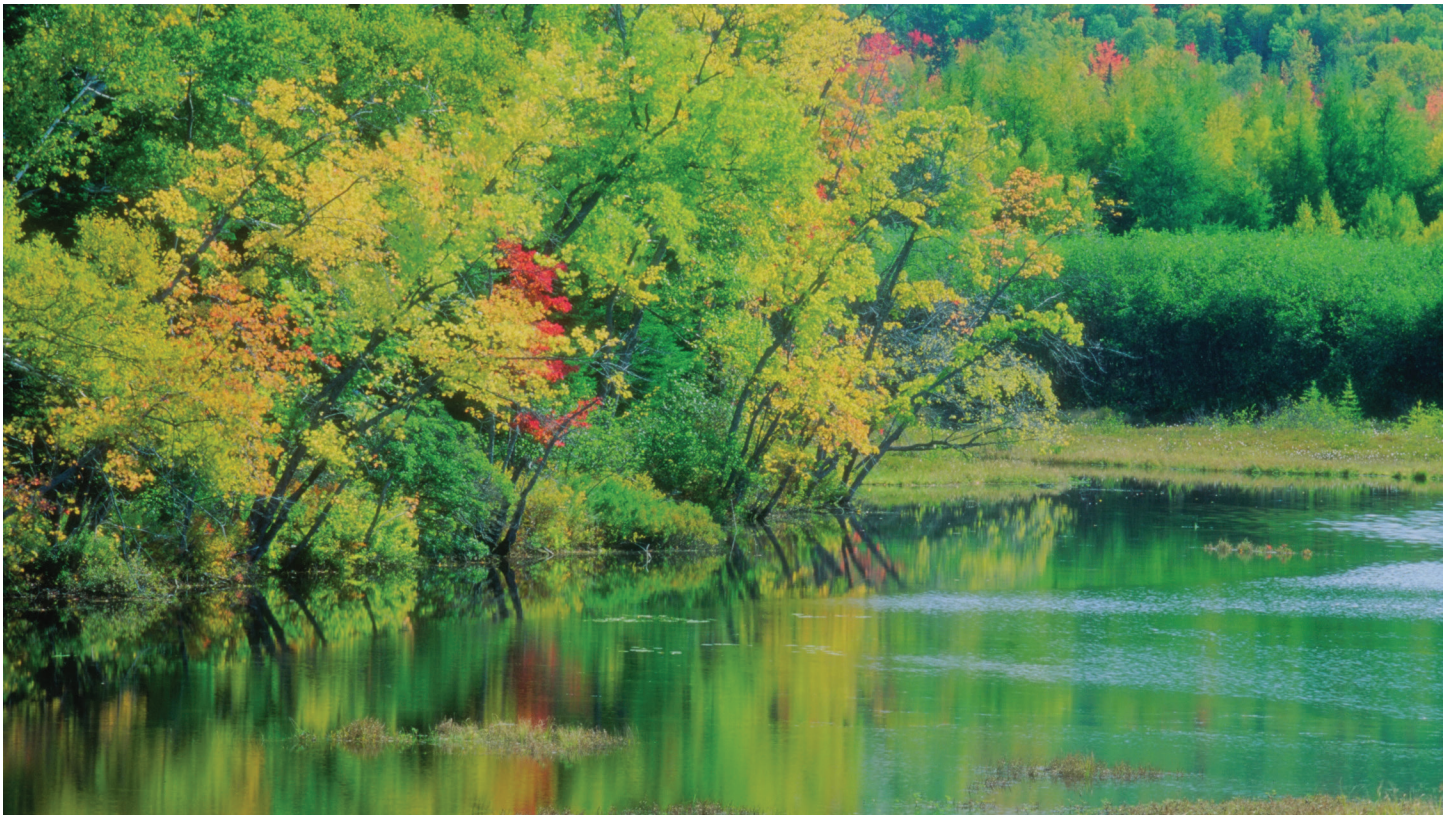
Despite the mounting evidence, nature-based solutions are not well acknowledged or valued within the pricing and models used by the NFIP. The Environmental Defense Fund (EDF), with a select group of expert stakeholders, undertook a one-year effort to identify practical ways to incorporate nature-based solutions into the NFIP and strengthen incentives for nature-friendly flood mitigation. This work builds on EDF's report Nature for Insurance and Insurance for Nature, which highlighted gaps in how the NFIP recognizes the flood-risk reduction benefits of nature-based solutions and the need for pathways that drive meaningful change (Kousky & Burley 2025).

Building on a convening of multidisciplinary experts, a state-of-the-science literature review and 16 interviews with experts in modeling, insurance, engineering and local flood mitigation, this report identifies key considerations, recommendations and next steps for integrating nature-based solutions into NFIP pricing.

A note on the focus of this report

Our report narrowly focuses on nature-based solutions and the NFIP, however, policymakers may find lessons that can be applied more broadly across flood mitigation approaches and to private sector insurance. Flood mitigation often requires layered gray and nature-based approaches and many other non-NbS flood mitigation strategies are also not well reflected in NFIP pricing. Where possible, we acknowledge when solutions and challenges have broader application.

Additionally, this report focuses on the NFIP, but some findings may also be relevant to private flood insurance. Despite the unique characteristics and political landscape related to NFIP as a federal program, Risk Rating 2.0 has moved NFIP pricing closer to private-market approaches, particularly through the use of catastrophe models. As the private flood insurance market grows, some lessons could be transferable.



Box 1: Defining Nature-Based Solutions and Grey Infrastructure

Nature-Based Solutions (NbS) - Actions that leverage natural processes to protect, restore and sustainably manage natural and modified ecosystems that can address socio-environmental challenges to reduce risks, promote resilience and provide co-benefits, such as biodiversity, recreation and well-being, for both people and nature. This definition is used by EDF and adapted from the UN Environment Programme (UNEP).

Sub-types of NbS include:

- **Natural Infrastructure (NI)** - Natural Infrastructure is a nature-based solution that relies on the protection, restoration, enhancement or management of natural or modified ecosystems to provide services and reduce risks at a landscape, watershed, coastal or regional scale. Natural infrastructure works through ecological processes and includes features such as wetlands, floodplains, forests, dunes, aquifers and coral or oyster reefs that support hazard resilience, climate adaptation, water management and other benefits to people and ecosystems.
- **Green Infrastructure (GI)** - Green Infrastructure is a nature-based solution that uses intentionally designed, constructed or engineered features to mimic, restore or harness natural processes, typically within developed or urban environments. Green infrastructure is often implemented at the site, neighborhood or community scale to manage stormwater, reduce flooding, improve water quality and provide other environmental and community benefits. Examples include bioswales, rain gardens, green roofs, permeable pavement and constructed wetlands.

Natural infrastructure and green infrastructure are different from one another and should not be used interchangeably, but each are considered a nature-based solution.

Gray Infrastructure - Engineered, human-made physical structures and systems that support urban development and manage natural resources. Often, they are constructed from materials like concrete, steel and asphalt and are designed to control or manage environmental processes.

Hybrid Infrastructure - An integrated approach that combines natural and/or green infrastructure with grey infrastructure like seawalls. By integrating two or more approaches, hybrid solutions can deliver enhanced benefits such as flood control, improved water management and increased climate resilience.

II. BACKGROUND

2.1 The National Flood Insurance Program

The National Flood Insurance Program (NFIP), managed by the Federal Emergency Management Agency (FEMA), has been providing households and businesses with flood insurance coverage for more than fifty years. Following several widespread and costly floods along the Mississippi River during the first half of the twentieth–century including a flood in 1927 that caused over $236 million (equivalent to over $5 billion today) of damage and displaced more than 700,000 people—private insurers began limiting flood coverage (FEMA Floodsmart 2023; NOAA, n.d.). NFIP was created by an act of Congress in 1968 to fill the gap left by the private market which made flood insurance unaffordable and difficult to find.

Today, about 90% of residential flood insurance coverage in the United States is provided by the NFIP, with flood-damages excluded from most standard homeowner's or renter's insurance policies (Chang & Saleh 2026). The NFIP provides over $1.28 trillion in coverage for more than 4.6 million policyholders in more than 22,000 communities across the United States and its territories, with annual premiums over $4.2 billion (CRS 2024). The program has seen consistent declines in enrollment over the last 15 years.

The federal program functions as a partnership: communities voluntarily join the NFIP by agreeing to adopt and enforce minimum floodplain management regulations; in turn all residents in participating communities are eligible to purchase flood insurance coverage through the program.

Though FEMA contracts with private insurers to help administer the NFIP, insurance rates and coverage limits are set by FEMA and all risk is held by FEMA. Federal regulation mandates certain properties carry flood insurance: those located in the FEMA-mapped 100-year floodplain, also known as the Special Flood Hazard Area (SFHA), who have a federally backed mortgage or have received federal disaster assistance. The Mandatory Purchase Requirement (MPR) was established by Congress in 1973 to address low uptake (Shabman et al., 2019).[2]

To enforce the MPR and establish minimum floodplain management regulations, FEMA develops flood insurance rate maps (FIRMs) for participating NFIP communities. The FIRMs, also referred to as FEMA Flood Maps, depict the floodplain, with a focus on the SFHA for coastal and riverine areas. Minimum floodplain management standards include building and land use provisions that can reduce damages and loss of life within the SFHA.

Despite their role communicating risk and identifying areas where flood insurance is required, the FIRMs have several limitations due to the inaccurate and outdated depiction of flood risk. Though FEMA is required to update the FIRMs every five years, maps can often take years to be produced or updated, with many communities relying on products that are decades old (NRDC 2017). Even the most up-to-date maps go into effect based on data that reflects a moment in time many years prior. Rising risks due to climate change and changes to the built environment, such as new development in and around the floodplain, can influence a community's flood risk in the years between mapping updates.

2 Failure to comply with the MPR can impact eligibility for future disaster assistance.

Additionally, FEMA maps fail to communicate flood risks associated with heavy rainfall or how flood risks are projected to change over time as sea levels rise and storms become more intense due to climate change. Instead, the FIRMs depict flood risk as binary rather than graduated, creating false understanding of risk and false security for those living outside of the SFHA (Kousky 2018). More than 30% of NFIP claims occur outside of the SFHA, but given floodplain management regulations rely on the FIRMS, standards adopted by communities often fail to account for risk outside of the SFHA.

2.1.1 NFIP Pricing & Risk Rating 2.0.

In 2021 FEMA began implementation of a new insurance pricing system ("Risk Rating 2.0."). Prior to this change, flood insurance rates were based on a property's elevation and flood zone according to the FIRMs. The previous rating methodology did not accurately price risk, with some policyholders being charged artificially lower insurance premiums, while other policyholders saw premiums that were too high. This was driven by some distinct differences between NFIP and the private sector, including the presence in the NFIP of discounts and subsidies for policyholders living in buildings constructed before FEMA established maps and the SFHA (Kousky & Shabman, 2014).

Risk Rating 2.0. updated flood insurance pricing to reflect improved data and a better understanding of flood risk. Through the licensing of private sector catastrophe models (for more information on catastrophe models see Section 2.2) and accounting for an array of variables that impact an individual property's flood risk (e.g., flood types, distance from a flooding source, frequency of flood, elevation and the cost to rebuild a property) NFIP pricing has become more reflective of property-level risk and the different sources of flooding.

One of the largest changes under Risk Rating 2.0. is the use of proprietary catastrophe models to estimate expected annual losses from across multiple sources of flooding (inland, storm surge, great lakes, tsunami), which are then integrated and applied to establish base rates. NFIP uses three models: AIR Touchstone version 5 ("Verisk model"), CoreLogic RQE v. 17.0 US Flood Model ("CoreLogic model"[3]) and KatRisk SpatialKat and SoloKat ("KatRisk model"). The specific models used by the NFIP could be modified in the future. Each model provides different inputs and insights to shape the understanding of a property's flood risk and are calibrated using historical NFIP claims data and other information on flood losses. FEMA worked with the actuarial consulting firm Milliman to carefully combine these models together with existing data from the NFIP about risk, such as insurance claims, to inform a property's flood insurance premium. Adjustments are then made to reflect flood mitigation or conditions that could impact the flood risk of a given property.

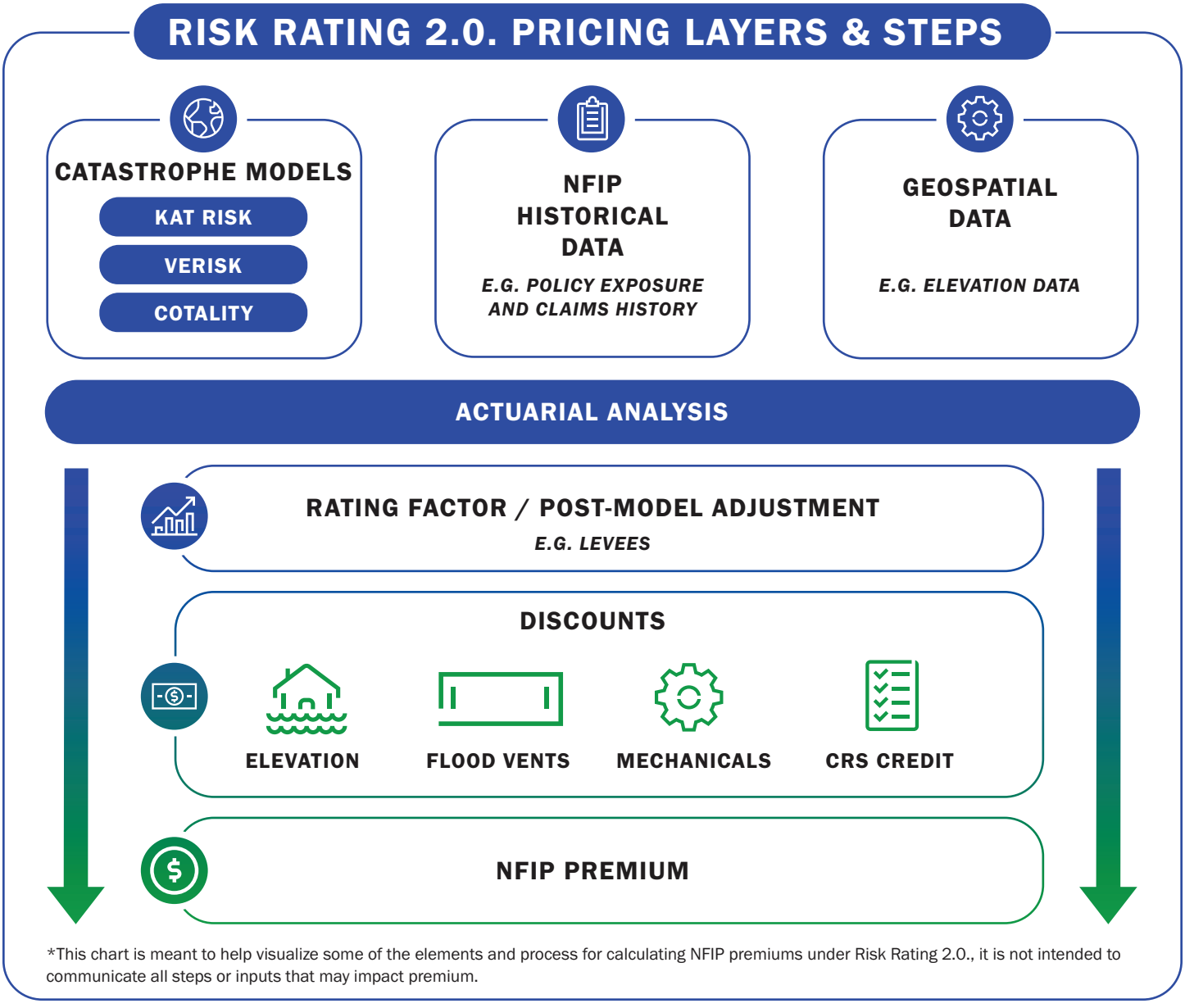
FEMA's publicly available documentation on the Risk Rating 2.0. pricing methodology does not provide direct insight on whether or how nature-based solutions are reflected in NFIP rates (NFIP 2022). The only form of flood hazard mitigation mentioned in the methodology documentation is levees. The catastrophe models underlying Risk Rating 2.0. are periodically updated, however the timing of these updates is not publicly available. This lag could weaken the price signal for investing in certain mitigation strategies, including NbS.

3 CoreLogic rebranded as Cotality in March 2025.

These changes align NFIP pricing with private industry standards, moving toward a more actuarially sound approach that provides a better risk signal. Pricing policies based on actuarial assessment has resulted in premium changes. When Risk Rating 2.0. went into effect, FEMA estimated that 23% of policyholders would see immediate decreases in their rates, but the remainder could see rate increases, regardless of flood zone (FEMA 2025). Year-over-year rate increases are possible until a property reaches the "full-risk rating" but are capped by federal statue at no more than 18% per year (GAO 2023).

Risk Rating 2.0. also standardized discounts for property-level measures: home elevation, flood vents and elevating mechanical systems. Other community-scale strategies may be captured through the licensed catastrophe models or the Community Rating System, but many measures—including green infrastructure, backwater valves and storm sewer improvements—do not have clear, reliable commensurate premium discounts. Because many variables affect premiums, following the implementation of Risk Rating 2.0., it is difficult to isolate how a single strategy (i.e. a bioswale) or portfolio of projects (i.e. the Louisiana Coastal Master Plan) affects insurance costs.

Figure 1 illustrates how the models are used to inform NFIP pricing.



*This chart is meant to help visualize some of the elements and process for calculating NFIP premiums under Risk Rating 2.0., it is not intended to communicate all steps or inputs that may impact premium.

2.1.2 The Community Rating System

Established in 1990, the Community Rating System (CRS) is a voluntary program that rewards communities for adopting flood mitigation standards that exceed FEMA minimums. Only about 1,500 of the more than 22,000 NFIP communities participate, but they represent more than 70% of NFIP policyholders (FEMA CRS 2021). Participating communities earn points for a range of eligible activities—public information, mapping and regulations, flood damage reduction and flood warnings —which translate into community-wide premium discounts.[4] The Program recognizes some community-scale mitigation that may not otherwise be captured in NFIP modeling or pricing, including certain nature-based activities such as open space preservation and natural shoreline protection.

As communities earn points and advance through the program, residents receive NFIP premium discounts ranging from 5% to 45%. CRS discounts are based on the accumulation of eligible points rather than actuarial estimates of risk reduction. Research has demonstrated that CRS participation can help to reduce future flood losses and build community resilience, including one study that found CRS-related damage reductions totaled $11.4 billion, compared with $12.1 billion in cumulative premium discounts from 1998 to 2020 (Gourevitch & Pinter 2023).

Additionally, the program is also designed to be revenue-neutral, meaning increased discounts for CRS communities can be offset by higher premiums for non-participating communities in the state. The CRS program has already raised equity issues because of the administrative burden to participate, causing communities that are not as well-resourced to be excluded. The offsetting can further increase inequities.

2.1.3 Flood Mitigation and the NFIP

Flood mitigation can be costly for individuals and communities. Elevating a home, for example, can cost as much as $130,000 (First Street 2025). To help address these costs, the National Flood Insurance Reform Act of 1994 established the Flood Mitigation Assistance (FMA) grant program, which provides financial assistance to states, territories, local governments and tribal nations to reduce flood risk for repeatedly flooded NFIP-insured properties (FEMA 2024). FEMA's Building Resilient Infrastructure and Communities program also supports hazard mitigation projects that strengthen community resilience, including through the use of nature-based solutions.

The NFIP is not just an insurance program, it is also a floodplain management program. In order for residents to be eligible for NFIP coverage, their local jurisdiction must adopt and enforce minimum building and land use standards that meet or exceed FEMA requirements. As noted above, these standards are based on the FIRMs. Although Risk Rating 2.0. transitioned NFIP pricing away from the FIRMs, floodplain management regulations and the MPR continue to depend on these maps. Because the FIRMs are typically outdated and do not capture all sources of flooding, minimum floodplain management standards do not fully address flood risks such as the risk associated with stormwater overflow. Stronger local standards can reduce losses, improve resilience and lower premiums, but not all floodplain management activities translate into premium discounts and **many risk-reducing strategies, including nature-based solutions, are not consistently reflected in NFIP models or pricing.**

4 CRS communities are ranked from Class 10 to Class 1, with Class 1 receiving the highest discount.

Box 2: An Overview of the Shifting Federal Landscape of the NFIP & FEMA over the last 15 years
Growing concerns about flood insurance affordability, the solvency of the NFIP and a recognition about the need for program modernization have driven a call for more substantial reforms to the NFIP. Continued operation of the program and most reforms require Congressional action. FEMA does have the ability to make some changes to the NFIP using its existing authority and has exercised that authority in some cases, including the development and implementation of Risk Rating 2.0.

Congressional Reforms: A combination of decreasing enrollment and increasingly frequent high-damage flood events, starting with Hurricane Katrina in 2005, have contributed to strains on the financial solvency of the NFIP. In response, in 2012 Congress passed the Biggert-Waters Flood Reform Act which among several reforms, rolled back some long-standing subsidies and led to rate increases. Concerns about affordability following Biggert-Waters drove further reforms in 2014 with the passage of the Homeowners Flood Insurance Affordability Act (HFIAA), which included capping premium increases at 18% per year.

Recent Program Lapses: Since 2017 there have been 35 short-term authorizations of the NFIP without substantial reform (CBO 2025). This period of uncertainty has included several program lapses during federal government shutdowns, including a six-week lapse in Fall 2025. Program lapses impact the ability of Americans to purchase flood insurance and renew their policies.

Growing Private Market: Though the NFIP continues to underwrite the majority of residential flood insurance coverage, there is a growing private flood insurance market. Steps have been taken by both FEMA and Congress to further incentivize private market growth. The 2012 Biggert-Waters legislation, for example, required lenders to accept private flood insurance for properties with mandatory purchase requirements, so long as the coverage meets or exceeds the NFIP. Private flood insurance, however, still accounts for a relatively small portion of the market, covering only about 10% of residential policies nationwide (Amacher 2026).

FEMA Review Council: The FEMA Review Council, established by Executive Order No. 14239 in January 2025, was tasked with evaluating FEMA's structure, effectiveness and long-term role in disaster management. The Council's final report, released on May 7, 2026, contains a suite of recommendations for reforming FEMA. Several themes are present throughout the report, but the one of the largest sections focuses on the NFIP. In addition to identifying several long-standing reform suggestions (e.g., the need for mapping modernization, addressing affordability challenges and smarter land use planning), the report recommends a gradual transition of NFIP policies to the private market. The report has generated significant policy discussions about the future of the NFIP and the role of the federal government in flood risk management, however most of the recommendations require Congressional action.

2.2 Overview of Flood & Catastrophe Models

2.2.1 Flood Models

The flood models that inform the NFIP are process-based hydrologic and hydraulic models. These models simulate the physical processes of water movement across landscapes, including rainfall and where the water flows across the land, absorbs into soil, moves through rivers and floodplains and interacts with terrain and vegetation (*see Figure 2)*. These simulations are developed using mathematical equations that describe water movement through the built and natural environments.

Many studies have used process-based flood models to estimate the benefits of NbS in reducing flooding (Amelie and Creed, 2019; Gay et al, 2023; Tang et al., 2020; Taylor-Burns et al., 2025). These studies estimate the flood reduction benefits of NbS by adding or removing representations of NbS within a model and comparing results to "baseline" conditions without the NbS. Typically, this is done by modifying flood model parameters that control for:

Infiltration — how quickly rainfall is absorbed into soils
Surface roughness — how much friction a landscape provides, through vegetation or land cover, to slow water movement
Storage capacity — how much water can be temporarily stored across landscapes

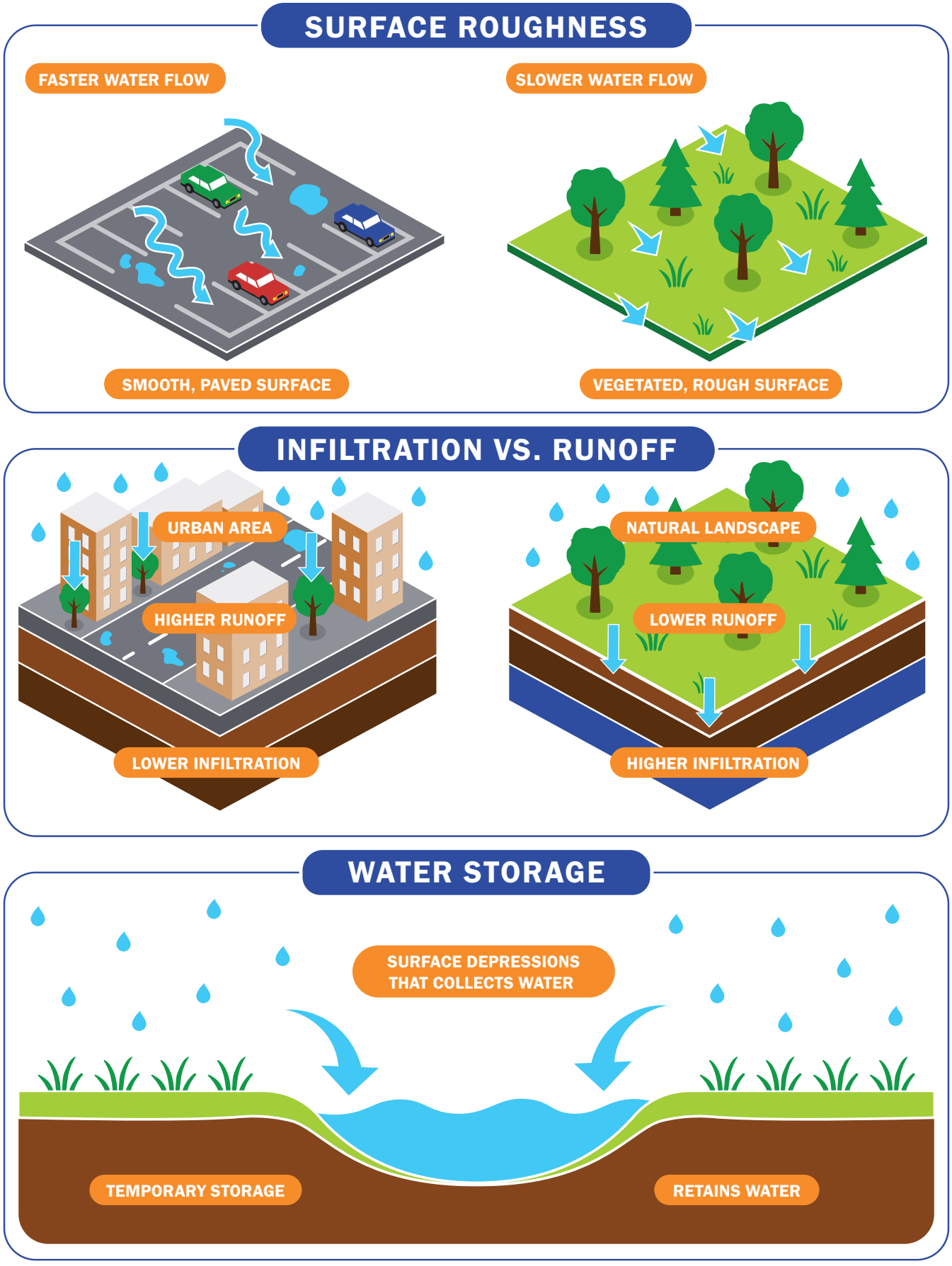
These models are typically calibrated against observed flood depths, streamflow records or inundation data under baseline conditions and validated based on historical data. Validation becomes significantly more difficult when evaluating hypothetical interventions. The lack of validation data and challenges with national-scale modeling, spatial resolution limitations and other uncertainties currently limit the use of process-based flood models to inform NFIP pricing decisions related to mitigation strategies, such as NbS. Research that pairs observed changes in NbS and hydrology with modeled NbS changes would be needed to ensure changes in NbS are well-represented in flood models.

The primary output of these models includes flood depth, inundation extent and flow velocity which can be translated into estimates of economic damage.

2.2.2 Catastrophe Models

Catastrophe models are used by the finance and insurance industries to estimate potential economic losses from extreme events like hurricanes, wildfires and earthquakes. Since extreme events by their nature are rare, catastrophe models allow insurers and reinsurers to estimate the probability of a financial loss to their portfolio. This is done by combining the physical characteristics of these events and then modeling them many times over. **Catastrophe models that focus on coastal flooding due to tropical cyclones are typically distinct from those models that estimate inland flood impacts.**

Figure 2 illustrates how process-based flood models generally depict water movement.



Catastrophe models are underpinned by four primary modules:

- **Hazard**: a catalog of simulated extreme events describing event frequency, location, intensity and physical characteristics. The event catalogue produced by this module is a core output of catastrophe models providing a range of event-specific information, such as flood depth, storm surge height, rainfall intensity and size.
- **Vulnerability**: relationships that estimate physical damage based on hazard intensity and asset characteristics
- **Exposure**: information about buildings, infrastructure and insured assets exposed to hazards
- **Financial**: calculations translating physical damage into insured and economic losses after policy conditions are applied

Results from these models are used to estimate potential financial losses across portfolios.

Catastrophe models from different vendors share the same overall framework, but each model uses different assumptions, input data and methodologies. The majority of private sector catastrophe models, including those currently used by the NFIP, are proprietary and the exact methodologies are not typically publicly available. Though the scientific foundations are documented and published, proprietary implementation means independent third-party validation is limited. Researchers who can pay for access are given limited details about the models, but modelers can't give all the details (Czajkowski et al, 2013) which can limit an understanding about how different models incorporate certain features, such as nature-based solutions.

Catastrophe models often use similar data inputs including, but not limited to: LiDAR derived elevation models, high resolution river networks and national land cover. Land cover and topography may indirectly represent landscape-scale NbS. However, the models do not differentiate between types of ecological systems or isolate the flood mitigation benefits associated with specific NbS. As a result, the models have a limited ability to quantify or evaluate the direct impact of NbS on flood risk and much about NbS may be missing or incomplete within the models. Instead the models more commonly and explicitly represent gray infrastructure such levees and dams. Varying resolution across the models may also impact their ability to easily capture localized flood mitigation projects.

III. FINDINGS

Many flood mitigation strategies, including nature-based solutions, are not well reflected in the catastrophe models or pricing methods used by the NFIP, despite growing evidence that NbS can reduce flood losses. To better understand this gap, EDF convened experts in policy, insurance, flood adaptation, modeling, engineering and nature-based solutions; conducted 16 anonymous informational interviews; and reviewed the current science. This research identified key opportunities and constraints for incorporating a broader range of flood mitigation strategies into the NFIP.

Four key findings emerged from our research:

- **Using catastrophe models to account for NbS has limitations**: Frequency of model updates, resolution limits, data constraints and uncertainty about whether existing natural assets are already represented in the models are barriers. And, without additional research or analysis it remains difficult to isolate within the models the role of NbS in reducing flood risks.
- **Catastrophe models are not the only option to integrate nature-based solutions, but alternatives must be designed**: Existing approaches to levees, property-level credits and CRS discounts provide precedents, but leveraging these for NbS would require developing new standards and metrics to easily assess NbS flood risk reduction benefits.
- **NbS has unique complexities**: NbS varies by type, scale, geography, maturity and condition; their benefits may occur downstream or off-site and may change over time. The dynamic nature of NbS complicates evaluation of these strategies for flood risk reduction and establishing NbS specific pricing factors.
- **Additional levers to incentivize NbS for flood risk reduction are needed**: Pricing reforms alone are unlikely to drive investment in NbS without modernized FEMA maps, stronger floodplain management standards, and clear and transparent communication about how mitigation affects premiums.

3.1 Using Catastrophe Models to Account for NbS has limitations

Risk Rating 2.0 made private catastrophe models a central input for NFIP pricing. Not all types of flood mitigation projects, however, are well-reflected in the models.

Three considerations emerged in our research related to integrating and reflecting NbS directly into the catastrophe models as a way to better recognize their value for flood risk reduction: **1)** infrequency of model updates; **2)** localized projects are not well reflected; and **3)** data availability and data accuracy underpin the models.

Infrequency of model updates compared to pacing of flood mitigation
There is a disconnect between the frequency of catastrophe model updates, the frequency of new flood mitigation projects, and when mitigation projects are incorporated into insurance pricing.

Each year the more than 22,000 participating NFIP communities apply for available FEMA grant funding to support various flood mitigation projects, including infrastructure improvements, property-level mitigation or other community-scale interventions. As an example, in 2023 FEMA selected 149 projects across 28 states and the District of Columbia for Flood Mitigation Assistance grants (FEMA 2024b). Projects ranged in size but included some larger flood control systems that integrated NbS. These 149 projects represent only a portion of current flood mitigation activity; additional FEMA-funded projects are underway, and many states and localities are also funding projects directly. Awarding NbS in these grant projects indicates some acknowledgment that these solutions reduce flood risks, even if the benefits of these projects are not reflected in NFIP pricing. Despite the logical relationship of these FEMA-funded NbS projects to the reduce flood damages for participating communities, these projects are not automatically integrated into NFIP pricing or the underlying catastrophe models.

Updates to catastrophe models can be time, labor, and cost intensive. These capacity constraints often limit updates to between three to five years, on average. Outside of this typical cadence, modelers may perform updates if there is a known change in a region's underlying risk, such as a large flood mitigation project; or if a region experiences a severe flood event. Model updates are not common or easily provided, however, for individualized updates when local flood mitigation projects are completed.

The frequency and dispersed nature of flood mitigation mean projects are completed in the years between updates. This could create a lag between when a project is completed—and performing its flood mitigation purpose—and when the impact of a project is captured and translated into the cost of flood insurance. This also means that as natural assets are lost, such as when development encroaches on critical marsh or reduces permeable surfaces or when a fire destroys a forest, the reduction in flood protection associated with the loss of these natural features won't be immediately recognized in pricing because of the time lag of the models. Even if or when the flood risk reduction is captured through land cover layers or other mechanisms, the delay means it remains hidden from localities and thus not able to be an informational signal or financial incentive.

Localized projects are not well reflected in the models

Flood mitigation is often localized and project-specific, but catastrophe models vary in the scale and resolution they can capture. Large wetland restorations or other landscape-scale projects may be reflected in the models, but smaller or distributed interventions such as green roofs, pocket parks or interconnected green infrastructure are less likely to appear in model inputs.

Even for models that can more easily capture smaller projects, interviewees noted some other challenges related to integrating localized projects. In particular, there is no feedback loop or standardized process for modelers to gain insights about project information, such as the location of smaller projects, how projects are designed and the metrics for understanding how these projects reduced flood risk.

Data availability and accuracy underpin the models

The catastrophe models used by the NFIP rely on publicly available and verifiable datasets, such as the U.S. Army Corps of Engineers National Levee Database and the USGS National Land Cover Database. These datasets may implicitly capture some natural features through land cover, topography, or runoff assumptions, but they do not *explicitly* identify NbS projects or isolate the flood-risk reduction benefits of NbS.

Data quality and completeness across many of these data sets varies and could influence the degree to which flood mitigation projects are reflected in the models. For example, the National Levee Database, while the best source of information on levees in the United States, does not account for all levees or the maintenance and conditions of specified levees, which may impact a system's performance. The American Society of Civil Engineers notes considerable uncertainty about the total number and mileage of existing levees, with some estimates indicating 100,000 miles of non-federal levees not represented in existing data sets (ASCE 2025). Lack of comprehensive data on flood mitigation investments could mean that catastrophe models are not fully accounting for projects and their benefits.

Additionally, while some elements of nature-based solutions may be captured in existing data, there is no single data repository of nature-based solutions projects and much of the available data is not structured in a way that acknowledges or accounts for the risk-reduction benefits. Every project is very different, with different flood risk reduction goals and thus different performance monitoring and data collection needs. Modelers and actuaries need clear, uniform metrics to incorporate projects and evaluate the risk reduction benefits of projects.

Our interviews indicate that many models can integrate specific portfolio data from clients, such as individual claims and property-level mitigation, but these additional inputs are more challenging to incorporate in isolation, without fully re-running the model, which as noted above, is labor, time and cost intensive. Better integration of both existing and future projects into the models would likely require improving existing datasets, creating new datasets and setting up processes for data to be regularly updated.

Finally, natural assets may already influence model outputs through land cover and related datasets, but their specific effects are difficult to isolate. Additional analysis of how gains or losses in natural features affect flood risk could help establish clearer risk signals, inform minimum floodplain management standards and guide prioritization of NbS in hazard mitigation funding. Performing this analysis would require working with modelers to develop methodologies for assessing the specific impact of nature loss and would need to be performed across geographies and natural asset types.

3.2 Catastrophe Models Are Not the Only Option to Integrate Nature-Based Solutions but Alternatives Must be Designed Carefully

Integrating nature-based solutions into NFIP pricing may not require directly adjusting the catastrophe models. The NFIP already recognizes the value of some mitigation through carefully designed post-model adjustments and discounts. Our research highlights three key considerations: **1)** Clear standards and guidelines are needed, but do not yet exist for NbS; **2)** Discounts are scaled to flood risk reduction impacts which can varying significantly for NbS; and **3)** The Community Rating System could be leveraged with improvements.

Clear standards and guidelines need to be developed for NbS

Precedents exist that could inform the development of these post-model adjustments and discounts, but to do so would require a clear set of standards and guidelines designed in a way that allows FEMA to ascertain how a flood mitigation intervention reduces future losses and in which locations. For some NbS, it would also require new empirical studies to document and quantify their specific contribution to flood mitigation.

At the community scale, the FEMA accreditation process for levees is viewed as a clear indicator that a levee changes the underlying risk in a location. Accredited levees alter the FEMA mapped floodplain and which properties are subject to the mandatory purchase requirement (FEMA 2021a). Accreditation is a rigorous process, which includes detailed modeling and analysis that determines which geographies and properties will experience a reduction in flood risk because of the new infrastructure. This rigor and data enabled NFIP to develop an adjustment that reflects the levee in the premium. This type of accreditation and verification process does not yet exist for NbS.

At a more localized or property-level, years of data and building science helped to establish NFIP premium credits for home elevation, flood vents and the elevation of building mechanical systems. Outside of the NFIP, the insurance industry has begun to accept various property-level mitigation and standardization including the Insurance Institute for Business & Home Safety FORTIFIED standard for roof construction and FM Approvals 2510 Standard for flood resistance, abatement and mitigation equipment. The avoided losses of these property-level solutions can easily be quantified, and the standard is simple and easy to document. But, property-level green infrastructure adaptations like bioswales, detention ponds or rain barrels are not incorporated into or credited within NFIP pricing.

Some flood risk-reduction strategies, including nature-based solutions, vary considerably from project-to-project and do not have single design standard or set of designs. Without these standards developing a discount is challenging. Nature-based solutions lack the type of accreditation and standardization that have made the levee adjustments and property-level premium discounts possible. Lack of clear design standards for NbS also presents numerous challenges to effectively deploying NbS at scale (Corwin et al., 2026). Though substantial analysis and engineering models are used when designing projects, each project is unique, making it difficult to easily determine how one individual project contributes to reduction in avoided losses at a given location.

These standards need to be modular enough to quickly assess avoided losses given the size of a project and to easily establish which properties and geographies would be eligible for a discount, as well as apply a discount that aligns with the risk reduction. This speaks to another consideration for establishing post model adjustments and discounts: they must be relatively easy to apply, with little additional information or research required from the insurer or the insured.

A post model adjustment and standard for nature-based solutions could leverage emerging analysis around marsh restorations to create a valuation system to understand how each independent factor contributes to flood risk reduction, such distilling the role of sand dunes vs. coral reefs vs. wetlands, could create clarity (Taylor-Burns et al., 2024).

Discounts are scaled to flood risk reduction impacts which can vary for different types of flood mitigation projects

The size of insurance premium discounts should be scaled based on the expected avoided losses of a project. Insurance costs prioritize and acknowledge strategies that demonstrate a meaningful reduction in the number and size of claims. The larger the anticipated reduction in avoided losses, the larger the reduction in insurance costs for a policyholder.

Many types of flood mitigation strategies reduce the risk to higher frequency, lower intensity storms and can reduce damages and claims. These strategies can help to reduce more frequent flood claims, which are an input in Risk Rating 2.0 and can lead to higher premiums. Nature-based solutions play an important role in addressing these higher-frequency, lower- intensity events. For example, green infrastructure, including green roofs and rain gardens, may not reduce the widespread damages caused by the overtopping of a river, but can play an important role in reducing run-off during heavy rainstorms. These types of investments are important to address costs by reducing repeated flood damages and the frequency of NFIP claims, suggesting they should be included in insurance pricing.

Experts caution that integrating nature-based solutions into insurance costs would result in a nominal premium reduction because many traditional NbS approaches are designed to address smaller, non-catastrophic events. For example, a recent study finds that the losses of one hectare of upstream wetlands increases individual claim amounts by only 0.01%–0.03% on average (Gourevitch et al., 2026). This indicates that a restoration project would need to be particularly large to translate into meaningful insurance savings.

There is mounting evidence, however, that some nature-based solutions can reduce coastal storm impacts. For example, recent research from the UC Santa Cruz Center for Coastal Climate Resilience (CCCR) and East Carolina University (ECU), in collaboration with Moody's RMS and the Nature Conservancy, indicates the important role mangroves play in significantly reducing storm surges and property damages during Hurricanes Irma in 2017 and Ian in 2022 (Narayan et al., 2025). A study led by the Community Resilience Center at The Water Institute in partnership with Moffatt and Nichol and Munich Re demonstrated that a restored marsh reduced average annual loss by 9-18% (DeJong et al., 2026). Another study found that protection of existing natural infrastructure can demonstrably reduce flood damages and that cumulative loss of wetlands could make existing built infrastructure more vulnerable, with losses increasing residential flood insurance claim payments by an estimated $10.1 billion nationwide since 1985 (Gourevitch et al., 2026).

This evidence underscores that not all NbS functions the same. Context, type, geography and interaction with other features can influence the degree to which a project can reduce flood losses and, if accounted for in pricing, could influence the size of the impact on premiums.

The Community Rating System (CRS) already provides some acknowledgment of nature, but greater recognition requires programmatic changes

CRS is one of the clearest ways the NFIP currently acknowledges nature-based solutions. Communities can receive points for activities such as open space preservation, natural shoreline protection, wetland habitat protection or restoration and coastal erosion area protection. However, eligible NbS activities remain limited. CRS does not award points for restoration projects outside the floodplain, even when they meaningfully reduce flood risk. **Currently, the program is not designed to award points for watershed-scale flood mitigation projects where benefits span multiple political boundaries.**

Several program challenges also limit CRS as a tool. Participation remains low, and many communities face significant costs to joining and advancing in the program due to the staffing, paperwork, and oversight burdens that can be especially difficult for smaller and under-resourced communities (GAO 2021). Participating CRS communities have also noted the need for greater transparency and guidance on eligible activities, documentation requirements and pathways to achieve better classifications (Wetlands Watch 2018). Adding new NbS or flood mitigation activities without addressing these challenges could further increase confusion and weaken the program's impact.

These equity challenges could be exacerbated by CRS' revenue-neutral structure: increased discounts in one participating community can raise rates for non-participating or under-resourced communities. That is, the CRS discounts are not actuarial but are cross subsidies from non-participating communities to higher ranking communities. Communities could be investing in flood mitigation (that is not captured already in the models or pricing) but see higher rates because they are not participating in CRS due to barriers of entry. This is further complicated by the current structure of CRS which does not directly tie eligible activities to measurable flood-risk reduction benefits. For participating communities, the accrual of points may not align with actual reduction in future flood losses. Expanding CRS credit for NbS could help create pathways for more communities to receive discounts, but without additional program adjustments it may also create new equity concerns if it leads costs to shift to nonparticipating communities (Brent et al., 2024).

3.3 Nature-Based Solutions have Unique Complexities

Nature-based solutions are not the only flood mitigation that is not well-reflected in the models and pricing used by the NFIP. There are, however, some unique elements related to NbS that can further complicate the ability to integrate these solutions into the NFIP: **1)** Not all nature is the same, with geography, scale and typology influencing how a project performs; **2)** The flood risk reduction benefits of nature are not always onsite which can complicate how projects are valued or reflected; and **3)** the flood risk reduction benefits of nature can fluctuate as systems mature and age.

Not all nature is the same

Nature is most effective at reducing flood risk at larger scales, such as through preservation of natural assets or large-scale restoration. Research on some NbS typologies, such as wetlands and mangroves is more established compared to others, including smaller green infrastructure projects. Interviewees also highlighted the growing number of studies and confidence around coastal ecosystems reducing flood losses along the Gulf Coast, but they acknowledged a need for more analysis in other coastal or waterfront regions, particularly along the Pacific Coast where topography and weather patterns could influence the performance of NbS.

Existing science around these different typologies and geographies may limit locations where nature is going to be most impactful and where integration of nature into the NFIP could more directly influence insurance pricing.

Flood risk reduction benefits of NbS are not always on-site

The flood risk reduction benefits of nature-based solution may not always be isolated to—or even the greatest at—the site of the project. For example, wetlands may be constructed in uninhabited locations, yet reduce flooding for communities that are many miles away. Wetlands function like "natural sponges." During heavy storms, wetlands and other NbS store flood waters and slow its movement across the landscape, which can have significant downstream effects. When storm runoff is stored temporarily on the landscape it reduces the flood peak in the river. NbS can be thought of as much smaller, distributed reservoirs on the landscape rather than a single reservoir that stores a large volume of water.

This makes NbS distinct from many other flood mitigation approaches, where the benefits are typically isolated to the location where the project was completed. A property owner elevating their home, doesn't reduce the flood risk to neighboring properties. A levee or other larger infrastructure project in one community does necessarily not reduce risk to neighboring communities unless they are also behind the same levee. Though NbS projects may have spillover impacts, communities do not often coordinate flood mitigation projects, meaning a community may be unaware there is a project outside of their jurisdiction lowering their flood risk.

As we've noted, if an NbS project is large enough, a catastrophe model may be able to capture the investment through existing datasets. For these large projects, models should be able to reflect the benefits of the project both onsite *and* for downstream communities. A smaller restoration effort, however, may be too small for the models, but may still have downstream benefits.

This presents unique challenges to integrate NbS into insurance pricing, requiring a clear process to appropriately apply a premium discount for watershed level projects in the geography where the flood-risk reduction benefits of nature are the greatest.

The flood risk reduction benefits of nature can change over time

Unlike gray infrastructure, the full flood-risk reduction benefits of nature-based solutions are not stagnant and benefits may not be fully realized for many years. A natural system matures overtime, allowing it to absorb more runoff during flood events. A marsh may be less effective when first restored than the healthy system will be five, ten or fifteen years after restoration. Newly planted saplings do not absorb as much water as a fully grown tree. Other systems may decline as they age or conditions change. For example, saltwater intrusion can lead to a decline of a marsh, decreasing the performance of the system.

The changes in flood-risk reduction benefits as NbS matures or declines can be difficult to quantify and are not easily captured by catastrophe models. A model may be able to capture the presence of a large nature-based solution, but without clear data on these changes overtime, it likely cannot capture how the performance of the project changes, even if those changes are instrumental to the impact of the project in reducing flood damages. And, these changes could be difficult to translate into insurance premiums.

3.4 Incentivizing Investment in Nature-Based Solutions Requires Additional Levers

Prior to the implementation of Risk Rating 2.0. NFIP pricing was highly correlated to a property's location on the FIRMs and the implementation of certain mitigation approaches, such as home elevation. NFIP pricing prior to Risk Rating 2.0. significantly misrepresented flood risk. But, while Risk Rating 2.0. provides more accurate pricing for flood insurance policies, it does not provide the same information about how flood risk reduction benefits will lower insurance costs.

Given the many factors that contribute to NFIP premiums, several interviewees indicated difficulties understanding how different mitigation strategies may impact premiums and how to prioritize flood mitigation strategies that both reduce risk and households insurance costs. Instead, many noted that floodplain management approaches, absent clear communication on changes to insurance rates or requirements, are driven by the FEMA flood maps and the minimum floodplain management standards.

Incentivizing investment in NbS as a flood mitigation strategy could require changes to the FIRMs and flood standards. Our research underscores two important considerations addressing this gap and incentivizing NbS practices: **1)** Lack of alignment between NFIP pricing and the FEMA maps and standards; and **2)** Need for communication and transparency:

Lack of alignment between NFIP pricing and the FEMA maps and standards can be a barrier to driving investment in NbS

Modernizing NFIP pricing under Risk Rating 2.0. has evolved how risk is reflected in premiums, but the mandatory purchase requirement and minimum floodplain management standards remain informed by the FIRMs. Communities prioritize mitigation investments based on minimum standards, which they are required to adopt as part of their participation in the NFIP, and the data provided on the FIRMs.

Reliance on the FIRMS to inform minimum standards, without clear price signals, can result in continued investment in new development in flood-prone areas—such as those at risk from heavy rainfall or in areas where the floodplain has expanded—which reduces permeable surfaces and the natural assets that play a vital role in reducing the intensity of flood events, increasing the flood risk on-site and for surrounding areas.

Without clear flood risk information and maps, local governments and residents may be unaware of their risk and forgo flood-mitigation projects, all of which can leave communities physically and financially vulnerable. This can have significant and catastrophic consequences. Hurricane Helene in 2024, the third deadliest hurricane on-record, caused an unprecedented amount of rainfall in the Appalachian Mountains and led to flash floods in areas outside of the SFHA (Federal Reserve Bank of Richmond 2024). Floods in Texas Hill Country in July 2025 killed at least 120 people, including 27 girls at a summer camp, and resulted in riverine flooding that extended more than 500 feet beyond the SFHA in some locations (Kerem Inal et al., 2025). Better reflection of flood risk on the FIRMs can help to communities to target local mitigation investments, including NbS, to areas outside FEMA-mapped floodplains, helping to minimize loss of life and reduce future property damage.

Communication and transparency is needed to drive confidence and clarity

Integrating additional variables into flood insurance premiums would require transparency and communication to help residents and community officials understand the impact of different mitigation strategies on insurance costs. This transparency can help encourage greater investments in these loss reduction activities. **Several interviews emphasized the importance of coupling nature-based solutions and reforms with transparent information, which could enhance local governments and resident interest in different solutions and help communities to better prioritize different types of activities.** This also underscores existing research that highlights the need for more transparent and clear communication for policyholders and local governments about the impact flood mitigation may have on premiums particularly following the implementation of Risk Rating 2.0. (GAO 2023).

Our research also highlighted the importance of clear guidance on the types of flood events different strategies may be most effective in addressing. For example, communicating that some solutions may reduce flood impacts to high-tide events, but may be less effective in addressing hurricane-scale damages. Communicating the flood risk reduction differences of different strategies can help to instill community trust in NbS as a tool, as well as avoid community frustration when residual risk exists and damages occur.

IV. RECOMMENDATIONS TO BETTER INTEGRATE NATURE-BASED SOLUTIONS INTO THE NATIONAL FLOOD INSURANCE PROGRAM

Our findings and research indicate that to meaningfully incorporate NbS into NFIP pricing and drive greater investment in NbS as a flood mitigation strategy, a multi-pronged approach is needed. Existing catastrophe model frameworks and the institutional structure of the NFIP present unique challenges and opportunities. Because NbS is not uniform and considerable variation exists in how these strategies function as flood mitigation across project types, scales and geographies, it necessitates the need for a combination of strategies to facilitate integration of nature-based solutions into the NFIP.

We identified four recommendations, which if designed and deployed together, can comprehensively acknowledge the flood risk reduction benefits of nature-based solutions within the models and pricing of the NFIP and incentivize the deployment of NbS for flood mitigation:

1. **Develop a post-model adjustment for nature-based solutions**
2. **Better recognize existing natural assets and nature-based solutions within the catastrophe models**
3. **Enhance the Community Rating System (CRS)**
4. **Modernize floodplain management standards and FEMA Flood Maps**

Advancing these solutions will require analysis and collaboration to impactfully scale and deploy, however, we see one clear opportunity: **focus initial efforts where the research and the science is most developed.** Research and analysis on coastal ecosystems such as wetlands and mangroves has demonstrated their direct role in reducing flood-related losses and NFIP claims. Though our research looked broadly at nature-based solutions typologies, **a phased approach that prioritizes coastal regions where the evidence connecting nature-based solutions to hazard risk reduction is well-tested, can build a runway that allows for smoother integration of other types of NbS and across geographies.** Additionally, changes to the NFIP must be coupled with public information for policyholders and communities that communicates any impacts to flood insurance pricing and mandatory purchase requirements, as well as, how different flood mitigation strategies influence premiums and avoided losses.

Below we provide a short description of each recommendation and its purpose, identifying the benefits and limitations of each, and highlighting critical next steps and actions needed:

1. Develop a post-model adjustment for nature-based solutions

Building on precedents established through the NFIP's approach to levees, create a post-model adjustment, for nature-based solutions. This approach is particularly promising and particularly beneficial for new nature-based solutions projects, rather than existing natural systems or identifying the impacts of nature loss on flood risk. An adjustment would be undertaken by FEMA and not based on updates to the

proprietary catastrophe models. As such, it allows the flood mitigation benefits to be applied to the pricing after the completion of the project without the delays associated with standard timelines for model updates. Additionally, such adjustment can better accommodate different scales and forms of NbS.

A critical first step is to establish a cross-sector team —a combination of modelers, the NFIP, insurance experts, engineers, actuaries and communities—to begin design on a standard that balances engineering needs with the confidence needed by insurers to accurately price the flood risk reduction benefits. Starting with coastal systems where the science and the research is the strongest can create a playbook for developing future NbS standards and post-model adjustments in non-coastal settings and that is flexible enough for the significant variety of green infrastructure or gray-green infrastructure solutions.

There are some challenges to consider for post-model adjustments to be effective and impactful. One challenge is establishing a clear process by which communities could communicate to FEMA a project has been completed and should be evaluated for the adjustment. Another challenge is determining how to use the adjustment in a way that avoids double counting nature's benefits that may already be reflected in the models. For example, if a model is already accounting for a project, an additional post-model adjustment could result in those benefits being double-counted. This could be resolved by only developing a post-model adjustment for NbS of a specific size or scale to ensure that benefits are not double counted after the models are updated or identifying processes to phase out the adjustments when the models are updated.

Finally, a post-model adjustment must be paired with clear, transparent communication to communities about any impacts on their premiums.

Next Steps and Key Actions:

- **Identify science-driven NbS projects and pilots to inform development of a post-model adjustment:** Establish and leverage insights from existing restoration efforts and emerging pilots where evidence exists about the flood risk reduction benefits of the projects and where the work can be used to inform a data-driven, science-based post-model adjustment for NbS. Potential pilots and opportunities include: the marsh restoration risk assessment project led by the Community Resilience Center at the Water Institute that evaluated adding 60 acres of marsh to Graveline Bay on Dauphin Island, Alabama[5] (Dejong et al., 2026) or recently completed Louisiana Coastal Master Plan projects by the Coastal Protection and Restoration Authority (CPRA), like the Lake Borgne Marsh Creation Project or the LaBranche Shoreline Protection Project.
- **Build Cross-Sector Partnerships**: Establish partnerships with engineers, modelers, NFIP and actuaries to assess and develop a post-model adjustment for NbS. And, through collaboration with FEMA and communities create a process for communities to communicate and incorporate new datasets and project information associated with NbS flood mitigation strategies to the NFIP and into the Risk Rating 2.0 methodology.
- **Advance Critical NFIP Reforms:** Through Congressional reforms to the NFIP require that NbS be incorporated into NFIP pricing

5 This project is a partnership with the Water Institute, MunichRe, Moffatt & Nichol, and the GOAA

2. Better recognize existing natural assets and nature-based solutions within the catastrophe models
Take steps to understand the degree to which nature is already integrated in the models and establish new datasets or approaches that fill gaps to ensure existing natural assets and NbS are reflected in the NFIP. Catastrophe models play a critical role in helping to shape the understanding and pricing of risk by the NFIP and private insurers. Better understanding of how nature already appears in the models, can help to clearly enumerate and communicate the impact of existing natural features within the models and could create important incentives for communities to protect existing nature or at minimum avoid new development that encroaches on critical natural resources.

Catastrophe models on their own are unlikely to capture the full range of nature-based solutions due to the variable resolution of the models (limiting their ability to capture more localized projects), as well as the extended period between model updates (impacting the expediency of capturing NbS in pricing). But, given that many vendors use similar data inputs and some of those existing data sets may already reflect natural assets and nature-based solutions, **a critical first step is to better understand, with greater specificity, the degree to which nature-based solutions are already incorporated within the models.** This analysis could provide deeper clarity around the role of NbS in reducing NFIP-insured losses. It could also illuminate remaining gaps where improvements to existing data or new datasets are needed.

Partnerships with engineers, modelers and actuaries could ensure existing data is communicated and presented in the ways needed to feasibly integrate information into the models and adjust pricing; and such partnerships could help to facilitate the co-creation of new datasets to fill existing gaps.

Next Steps and Key Actions:

- **Create a cross-sector taskforce that includes NFIP staff, flood mitigation experts, academic partners, actuaries, local governments, and catastrophe modelers to:**
  - **Assess how nature appears in existing datasets:** Review existing datasets utilized by catastrophe models in the NFIP to identify what information on NbS is already incorporated and identify existing gaps in the available data. This includes ensuring that the key data sets being used in the models (such as land cover) are comprehensive, improving existing data on natural features and ecosystems, and identifying where new datasets may be needed
  - **Conduct analysis & research on how nature-loss impacts flooding and insurance.** Leverage existing models and data to begin analysis in targeted geographies, using existing large-scale plans and projects to explore their impact on coastal and inland communities' losses and premiums.
  - **Co-Develop new datasets through cross-sector collaborations:** Explore co-development of a dataset that can be updated over time that includes information necessary to incorporate various NbS types into the models and pricing. This co-development should initially focus on large-scale projects that are easier to track, while also exploring the feasibility of developing accurate and updatable datasets for smaller green infrastructure projects.
- **Advance NFIP Reforms***:* Through Congressional legislation require NFIP to incorporate NbS in their pricing and models, including within the catastrophe models used by the NFIP for Risk Rating 2.0.

3. Enhance the Community Rating System (CRS)

Currently, CRS is one of the only demonstrated ways NbS is integrated into the NFIP, providing a clear framework that could be built upon to further recognize more nature-based solutions. But, the eligible activity menu currently misses a wide range of NbS — upland wetland restoration, coral reef protection, green infrastructure projects. To address this existing gap, **a key first step is to perform an assessment and identify which NbS activities are currently missing and then use that assessment to expand the eligible NbS activities within the Program.**

CRS already provides a mechanism for recognizing community-level flood mitigation investments that are not captured in NFIP ratings by providing community-wide discounts for communities participating in the Program. Integrating more NbS into CRS could be a pathway to reward communities through insurance discounts for community-wide investments such as green infrastructure which may be difficult to integrate into catastrophe models or flood mitigation investments that are too bespoke for a post-model adjustment.

Structural changes are needed, however, to meaningfully optimize CRS to both incentivize NbS and reflect the benefits of NbS within insurance costs. Though the existing program is an important lever, ongoing issues with CRS (e.g., low program participation and administratively burdensome, revenue-neutral structure) must be addressed. Without systemic reforms, adding more NbS eligible activities into an already complex system could make the program more opaque and further exacerbate inequities.

Additionally, at this time, CRS is not the best solution to ensure the downstream flood risk reduction benefits of NbS are incorporated into the NFIP given the Program only awards points for activities within a community's own jurisdiction. An opportunity analysis and assessment is needed to understand how to recognize these watershed-level or multi-jurisdictional projects and avoid adverse impacts. It would require careful design to ensure that the impacts are appropriately distributed and to avoid double-counting benefits if projects (such as increased open space) are eventually integrated into the catastrophe models.

Next Steps and Key Actions:

- **Advance reforms to CRS:** Through FEMA action and Congressional reforms, maintain and reform CRS to better account for NbS by making improvements to the program that increases the number of eligible NbS activities, increases clarity about how CRS points accrue and drives greater participation in the program. This should also include addressing program limitations related to the revenue-neutral nature of the program and challenges around eligible activities not aligning with actual risk-reduction impacts.
- **Establish transparent procedures for new NbS and flood risk reduction strategies to be incorporated into CRS:** FEMA should use its authority to create a process for communities to easily communicate project information associated with flood mitigation strategies to the NFIP; and establish procedures for the flood risk reduction benefits of those strategies to be incorporated into CRS and the Risk Rating 2.0 methodology.
- **Explore opportunities to apply CRS credits for cross-jurisdictional and watershed scale projects.** Conduct analysis and case studies from across sectors to understand opportunities to better design CRS to account for watershed-level or cross-jurisdictional projects, including identifying methods to equitably account for flood risk reduction benefits and avoid double-counting benefits already captured in catastrophe models.

4. Modernize floodplain management standards and FEMA Flood Maps and incentivize use of NbS across mitigation programs

NFIP costs are only one important driver for households and communities as they choose flood mitigation strategies. FEMA's flood maps and the NFIP minimum floodplain management standards continue to be an important driver for which flood mitigation selection. These two levers also have the potential to incentivize greater adoption of NbS at scale because they can result in community-wide adjustments to floodplain management standards rather than focusing exclusively on property-level mitigation where NbS opportunities are generally more limited.

A critical pathway to incentivize more investment in NbS is to modernize the FEMA maps and minimum standards. Modernization should consider not only long-needed changes to address existing deficiencies of these tools, but also explore changes that further encourage the preservation of nature and the use of NbS, such as: further restricting development in the floodplain to help protect natural assets or require the integration of NbS within building and land use regulations as part of minimum floodplain management standards.

Additionally, communities leverage FEMA and other federal grant programs to invest in flood mitigation. Historically a considerable amount of flood mitigation activity occurs in response to flood disasters through post-disaster funding, though this funding is unreliable and limited (Kousky & Wiley, 2023). Updating post-disaster grant programs and requirements to incorporate and promote NbS can be an important driver in broader adoption of these solutions.

Next Steps and Key Actions:

- **Advance several critical NFIP reforms:** Congressional reforms to the NFIP should be advanced including:
    - Modernize the FEMA flood maps to better reflect current and future flood risk in order to incentivize impactful flood mitigation, including NbS.
    - Prioritize "Build Back Better" approaches, including reforms to the Stafford Act to require the incorporation of nature-based solutions in post-disaster rebuilding.
    - Require NFIP to publish transparent, policyholder-focused documents that demonstrate how different flood mitigation strategies, including NbS, impact premiums in order to help households and communities prioritize and understand the risk reduction benefits of different flood mitigation activities.
- **FEMA should use its authority to** update floodplain management standards to incentivize states and localities to make smarter decisions about land use and building code provisions in order to reduce flood risk, minimize development in the floodplain, and enhance the use of nature-based solutions and nature preservation.

V. AREAS FOR FURTHER ANALYSIS AND RESEARCH

Our research explored opportunities to integrate nature-based solutions into the models and pricing used by the NFIP as a way to better acknowledge the role of NbS in reducing flood losses and to incentivize investment in these strategies.

The research illuminated several key insights and four primary recommendations, but there are some areas that require additional analysis and research, including: deepening the science on the role of NbS in reducing flood losses across different geographies, addressing potential double-counting of benefits, and analyzing how to address the dynamic nature of a living-and-breathing flood mitigation strategy.

Continue to deepen the research on the flood risk reduction benefits of different types of nature-based solutions across geographies:
Continued research and analysis measuring the flood risk reduction benefits of different natural assets and nature-based solutions - particularly in riverine systems where benefits may accrue in other parts of the watershed and in urban settings where green infrastructure is dispersed but can reduce run-off – to help buoy the more holistic integration of nature into flood pricing.

Develop systems to avoid double counting
Throughout our research, concerns were raised about inadvertently double or triple counting the benefits of various flood mitigation strategies, particularly given the existing uncertainties about how NbS may already be reflected in the catastrophe models. By integrating nature into certain pricing elements of the NFIP, such as through a post-model adjustment or CRS, we are able to more quickly capture and reflect the benefits of those projects, but these approaches could inadvertently lead to double counting when models are updated. For example, a discount could be applied for the project itself and then the change in the underlying risk could be captured when the model is updated. This could result in insurance rates that are not actuarially sound—a problem heightened by the history of NFIP pricing which resulted in artificially low insurance rates. As such, blending the approaches suggested in this report will require careful design.

Identify methods to account for change in performance of nature overtime
A new NbS project may perform differently than a mature project. A wetland in one location may cover the same amount of acreage as another, but the health of the system could impact its flood risk reduction performance. Our recommendations focus on integrating nature-based solutions into the NFIP, but more research and analysis is needed to determine the best way to capture within insurance ratings how the performance of nature can change over time.

VI. CONCLUSION

Nature-based solutions can reduce flood risk and improve community resilience, but to incentivize more investment, the full range of effective flood mitigation approaches needs to be recognized and accounted for in the NFIP. While some elements of natural assets may already be implicitly captured in existing models, significant gaps remain in how NbS are represented, measured and rewarded within the NFIP. Bridging these gaps is necessary to align financial incentives with the growing body of evidence demonstrating the protective value of nature.

Achieving this integration will require an approach that reflects the complexity of both flood risk and nature itself. Focusing initial efforts on coastal ecosystems, where the science is the strongest, we have identified four recommendations to incorporate NbS into the NFIP as a flood risk reduction tool:

1. Develop a post-model adjustment for nature,
2. Integrate existing natural assets into catastrophe models,
3. Enhance the Community Rating System and
4. Modernize floodplain management standards and FEMA Flood maps.

Advancing any of these paths will require some combination of Congressional NFIP legislation and regulatory reforms and FEMA action; improved data and pilots; cross-sector collaboration; and further analysis and research to better quantify flood reduction benefits of NbS. Combined, this would establish credible standards, improve transparency and ensure that the benefits of nature-based solutions can be consistently measured and incorporated. Importantly, these efforts must be designed to avoid unintended consequences such as double-counting benefits or creating barriers for smaller or under-resourced communities. Embedding nature into the broader ecosystem of policy, planning and funding decisions can help reduce losses, improve affordability and build more resilient communities.

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Jesse D Gourevitch and Nicholas Pinter 2023 Environ. Res. Lett. 18 034037

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