Nature-based Solutions in Insurance: Resilience Pathways for Humboldt Bay, California

A framework and guide to scoping, methodology exploration and implementation

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UC Davis Policy Clinic with Ocean Science Trust and the California Department of Insurance

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Findings and key insights from the interviews have influenced and contributed to the following document.

How to use this document

This document was created with the intent to convene all stakeholder groups and to imply a discussion on potential pilot projects in Northern California for building coastal climate resilience. It can be used as a basic tool to learn more about climate adaptive insurance and provides general information about how to approach implementation. Due to limited scope, the information provided is still held generally, but it articulates the major steps with regard to ecosystem selection, insurance mechanisms as well as stakeholder and social equity considerations.

In Chapter 1 we provide background information on the topics of nature-based solutions, insurance and Humboldt Bay ecosystems. We then focus on two potential resilience pathways for Humboldt Bay by pairing local ecosystems with a suitable insurance mechanism. Chapter 3 aims to summarize our findings and offers general implications for the implementation of pilot projects. Specifically, we consider two types of projects: (1) nature-based solutions insurance or parametric insurance, which involves insuring an ecosystem with payouts in response to ecosystem damages following extreme weather events (see Chapter 2.1 for further definition) and (2) nature-based solution risk reduction or risk reduction policy that inhibits long-term conservation work to enhance climate resilience of the ecosystem and nearby coastline (see Chapter 2.2 for further definition). Both types of projects may be referred to as climate adaptive insurance.

Chapter 1: Background

Almost 75% of California's population currently lives near the Pacific coast. Over the next decades, that population will become increasingly vulnerable to climate change - specifically sea level rise (SLR), increased flooding and atmospheric rivers will pose major threats. In order to adapt to a changing climate and increase coastal resilience, immediate attention must be taken towards maintaining healthy marine and coastal ecosystems. One timely approach is to enable and sustain conservation projects of Nature-based Solutions (NbS) through insurance.

In partnership with California Ocean Science Trust and the California Department of Insurance, we have created a holistic landscape review on existing projects of NbS enabled through insurance mechanisms, scientific findings on NbS as well as social equity considerations for future projects.

Subsequent to the general overview, this document aims to explore potential implementation and resilience pathways for NbS in Northern California. Using Humboldt Bay, a region highly vulnerable to SLR, the following document will provide guidance and information on how insurance mechanisms may work with regard to insuring NbS and protecting local ecosystems. Two potential pathways will be presented – one incorporating eelgrass (*Zostera marina*) and another with coastal salt marsh.

This document, however, provides a general overview for climate adaptive insurance installation in Humboldt Bay and requires further research to scope, fund and implement a pilot project. Expert interviews were conducted and independent research has taken place in an effort to best inform framework design. However, it should be acknowledged that this document uses case studies of statewide and international hydrology and ecosystem function as no literature was found that specifically study the ecosystems of Humboldt Bay as NbS. This document utilizes these existing case studies and applied them in good faith through critical analysis. Furthermore, stakeholder engagement and community outreach was outside the scope of our study. We want to emphasize this would be a critical step to complete in developing a pilot project. Lastly, the permitting process for restoration projects in California can be complex and requires compliance with local ordinances. We attempt to highlight some of these regulations at a high level.

1.1 A Growing Market: Climate Adaptive Insurance

Insurance against extreme weather events, natural catastrophes and various climate impacts is an established product in the global marketplace of climate insurance solutions. Yet, SLR remains a phenomenon that has not experienced an increase in deployment of insurance-related solutions. Nonetheless, Humboldt Bay amongst other coastal regions, is highly subject to SLR, which primarily increases the risk of flooding. In Humboldt Bay, coastal infrastructure, 30 electrical transmission towers, 9.6 miles of municipal water transmission lines, 52 cultural sites of the Wiyot tribe, and 7,376 residential properties are at risk. Therefore, investments in conservation projects and NbS are crucial to protecting Humboldt Bay from future threats. The following section describes how risk reduction policies in insurance can be a useful vehicle to explore SLR risk and enhance climate resilience.

1.2 Fundamental principles: An Investment for Insurers

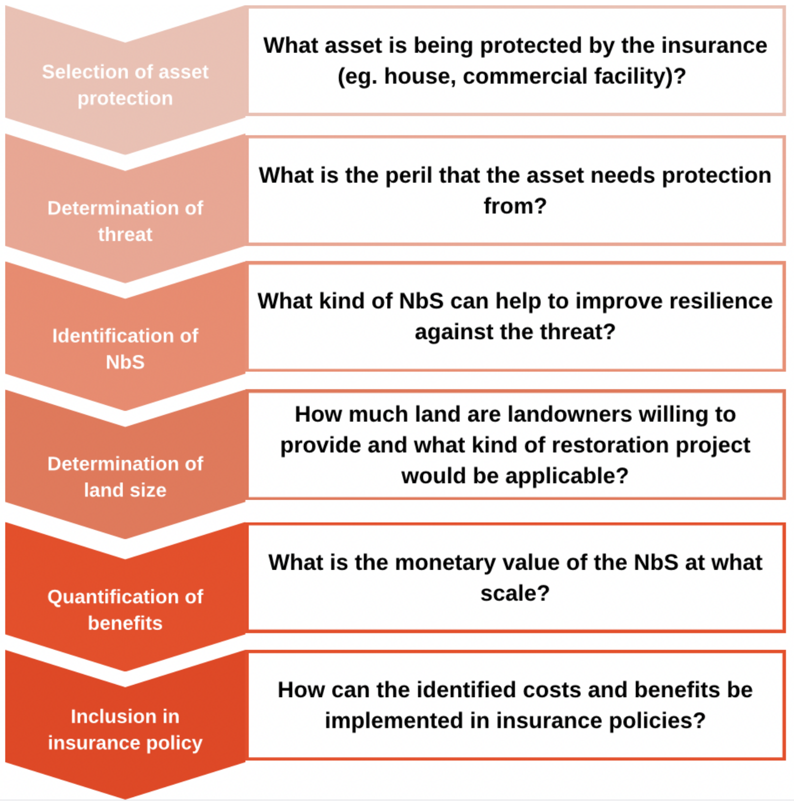

Figure 1. Schematic representation of major steps for insurance practitioners when considering NbS integration into new or existing programs.

Insurers have experienced a significant increase in payouts due to higher frequency of extreme weather events such as flooding, storms, or wildfires. This has caused a steep incline in insurance premiums and in some cases, clients were even rejected from obtaining insurance at all.

In order to prevent further premium increases and to allow landowners to insure their property, disruptive measures in the insurance environment need to take place. One approach is for insurers to not only aid clients in natural disaster recovery but also to help them increase their climate resiliency and to invest in climate adaptive insurance measures to address the root of the problem. Figure 1 describes the mechanism of risk reduction policies in housing or flood insurance from an insurer's standpoint.

1.3 Streamlining Policy Transitions: Cost Reduction for Land Owners

The protection gap describes the gap between total losses and insured losses due to weather-related damages and catastrophes. Insured communities hereby recover much more quickly than those who rely on government support. However, higher premiums as well as increased threats from natural disasters have widened the gap significantly. Currently, less than half of the homes in California with a relatively high risk of flooding also possessed flood insurance. In order to lower this protection gap, it is critical to (1) enhance climate resilience to reduce future loss for affected landowners and (2) keep insurance options accessible and affordable to everyone.

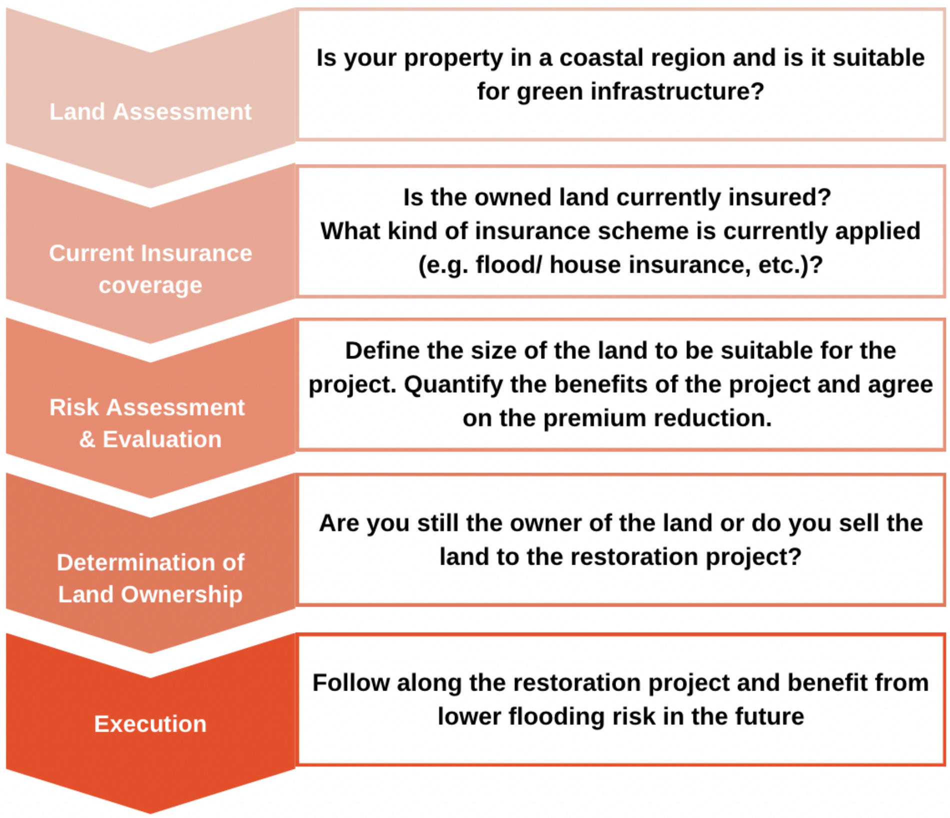

Figure 2. Schematic representation of major steps for insurance practitioners when considering NbS integration into new or existing programs.

Figure 2 indicates potential ways to lower the landowner's premium for their house or flood insurance by providing land in coastal regions for NbS projects.

In regards to Humboldt Bay, these steps are highly applicable. Because the shoreline of the Bay currently inhibits green and gray infrastructure and the land is owned by different entities, many landowners would be affected by such implementation processes. In order to make an NbS project successful, it is important from a landowner perspective that (a) the reduction of the premium covers the opportunity costs for landowners and (b) the NbS project will be implemented in a timely manner and would have beneficial effects on the landowners risk to SLR.

1.4 Case Study: Humboldt Bay

This study applies the principles and pathways of climate adaptive insurance to the Humboldt Bay region. Located along the Northern California coast, Humboldt Bay's unique ecology, land use and industry make it an exceptional case study of potential NbS insurance implementation. The Bay is experiencing the fastest rate of SLR on the West Coast, but capacity is limited by socioeconomic constraints. Local climate and land use have preserved much of the shoreline, although hydrology has been degraded by levees and dikes. Restoration potential, interest and current action is high, suggesting there is potential for rerouting these efforts into climate adaptive insurance programs.

1.4.1 Local Ecology and Environment

The environmental history of Humboldt Bay is turbulent and intersects with colonialist displacement, environmental degradation, overharvesting and fishery collapse. The Wiyot peoples have called this area home for thousands of years and as the rightful caretakers of this land they consider the Bay to be sacred and the birthplace of their people. In the nineteenth and twentieth centuries, colonialist massacres and persecution drove the Wiyot peoples from their homeland and began decades of environmental exploitation through (redwood) logging, salmon fishing and development.

Humboldt is a large, shallow bay pocketed by eelgrass and salt marsh habitats spanning about 20,400 acres. Periodic dredging is needed to keep access to the Bay's harbor open, carving a track through eelgrass beds and oyster aquaculture areas. The Bay is flanked by working agricultural and partially intact salt marsh on its Northern and Southern shores, with the community of Eureka and Highway 101 running alongside the majority of its Eastern shoreline. Samoa Peninsula, the narrow spit of land separating the Bay from the Pacific, houses impoverished communities as well as one of the Pacific's most intact coastal sand dune habitats. The Elk and Mad Rivers, along with a number of small creeks, drain into the Bay, connecting estuarine habitat with upstream salmon spawning grounds.

Protected lands include the USFWS Humboldt Bay National Wildlife Reserve, which hosts over dozens of migrating bird species, including those of recreational interest including the Brant (Branta bernicla), a species threatened by climate change and valued by recreation and subsistence hunters. The Bay's history of logging has left heavy metals contaminating its soils and the historic removal of upstream riparian (streamside) habitat creates siltation events that negatively impact water quality and turbidity (clarity), especially during storm events. Agricultural practices around the Bay since the late 1800s have resulted in a miles wide system of levees and dikes, the upkeep of which now falls to private landowners and grazers.

1.4.2 Projections & Infrastructure Vulnerability

With landscape that was once abundant tidal channels traversing the salt marsh plain now altered to just three tidal channels and agricultural lands behind dikes, we are left with a Bay with little capacity for SLR. Over the last 40 years, the Bay has seen an increase in mean annual high tides and king tides occurring in greater frequency and intensity, overtopping shorelines and dikes, flooding agricultural fields and causing worrisome additional emergent groundwater flooding. In 2005, a State of Disaster was declared in Humboldt Bay as a result of king tides and record water elevation (9.6’), less than one foot higher than the annual high tide (8.8’). By 2030, water levels will reach this disaster state annually; by 2045, monthly; by 2060, daily. By 2065, with a projected meter (~3’) of SLR, the Bay is expected to expand inland, reaching about 31,100 acres.

Shoreline inventory mapping over the last 10 years has shown the Bay's shoreline to run about 102 miles long, 77 miles of which is structurally artificial (75%) and 26 miles of which is natural (25%). Dikes (41 miles) and railroad grades (12 miles) are the dominant shoreline structures. An estimated 65 miles of the Bay’s shoreline is vegetated (unmaintained), about 30 miles is fortified (with rock or concrete) and about 10 miles of wave-deteriorated exposed shoreline. In their current state, the Bay’s artificial shorelines will not provide necessary protection. 59 miles of shoreline is considered highly vulnerable, eroding and subject to overtopping with 2 feet (2045 projection) of SLR, with 11 miles consisting of diked shoreline. Increase SLR to 3 feet (2065) and more than half of total dikes (23 miles) will be overtopped. If the dikes breach as projected and the landscape is opened up to tidal inundation, due to subsidence most of the area historically consisting of salt marsh (pre-1870) would be converted into mudflats rather than back to salt marsh. The probable divergent landscape, land use and habitat distribution of the Bay provides additional rationale for an exploration of the co-benefits of preemptive NbS in the region.

Much of Humboldt Bay’s most vulnerable infrastructure lies on or very near a rapidly eroding shoreline, including two municipal wastewater treatment plants, PG&E’s Humboldt Bay Power Generating Station and the former Humboldt Bay (Nuclear) Power Plant (HBPP) housing an Independent Spent (nuclear) Fuel Storage Installation (ISFSI). The California Coastal Commission initially issued PG&E a permit for the ISFSI on Buhne Hill nearly 20 years ago with expectations that the storage site would be interim, but there has been no movement to relocate. During the 2005 State of Disaster, emergency rock slope repairs of the bluff near the ISFSI were required and emergency repairs had to be completed in this same area again in 2018. Tidal inundation of the King Salmon PG&E site could potentially occur with 3.3 feet of SLR and while the ISFSI at Buhne Hill is above the high projection for SLR by 2100 (14.3 feet), it will become an island under current projections. The nuclear waste could be mobilized in the event of tidal inundation and untreated or exposed contaminated sites could result in pollution of waterways and degradation of water quality. Saltwater intrusion has further potential to affect sewer lines and wastewater treatment facilities, threatening water quality, ecosystem health and safe energy and sanitation delivery, putting the surrounding communities at risk.

Figure 3. Eureka Bay, shoreline areas overtopped by 3 feet of SLR (red), 6 feet (yellow) and the 1870 tidal inundation footprint (blue). See the Humboldt Bay Shoreline Inventory, Mapping and Sea Level Rise Vulnerability Assessment Report.

Chapter 2: Insurance Based Climate Resilience Pathways

This chapter provides an overview of the three major insurance resilience pathways applicable to Humboldt Bay. This is not to exclude the possibility of other insurance mechanisms or structural approaches, but it is our hope that this may act as a scaffold to build future knowledge. Our methodology in creating these resilience pathways is centered around the application of known best practices and scientific knowledge in climate adaptive insurance as well as expert interviews from the private, public and academic sectors in and around Humboldt Bay. A generalized methodology is provided in chapter 3 of this report, but it should be emphasized the value of engaging with local experts brings to pathway design.

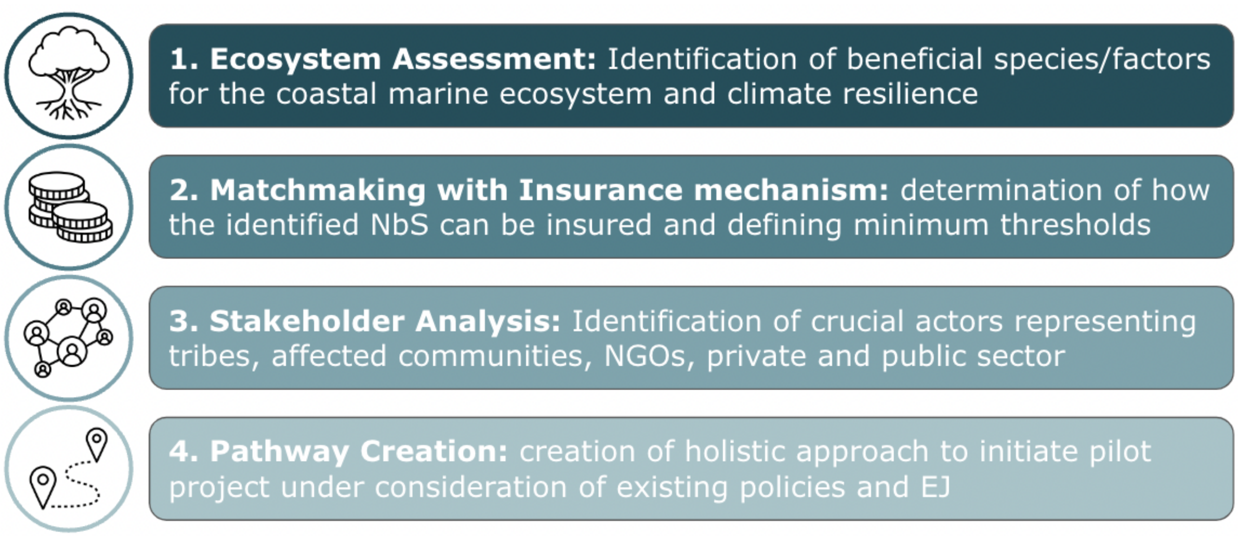

Figure 4. Schematic overview of important steps for a resilience pathway.

We have identified two ecosystems for climate adaptive insurance within Humboldt Bay: eelgrass beds and salt marshes. Using expert interviews and independent research, we paired these ecosystems with insurance mechanisms and best practices when considering the social and ecological landscape of Humboldt Bay. Here, we share a four step system of ecosystem assessment, insurance matchmaking, stakeholder analysis and resilience pathway creation.

2.1 Parametric Policy

2.1.1 Overview

Parametric insurance products offer an opportunity to protect existing ecosystems. Programs incorporating a parametric insurance product have become increasingly used at the international level to increase resilience to future climate stressors. For more information regarding these programs, please see our Landscape Review of Nature-Based Solutions as an Incentivization for Insurance Policy. In Humboldt Bay, an insurance product of this nature may prove to be beneficial. Below we demonstrate how eelgrass beds could benefit from a parametric insurance product by directly protecting this ecosystem from future climate stressors and indirectly protecting the local economic benefits associated with the habitat.

2.1.2 Use Case: Eelgrass Protection

Humboldt Bay is home to an expansive area of ecologically and economically important eelgrass habitat. This habitat houses a variety of fishes, particularly during early life stages, and is used annually by migratory shorebirds. The eelgrass not only supports these various species populations, but also provides additional ecological benefits such as ocean acidification reduction, water filtration and erosion prevention. These benefits are distributed across local economic activities including the oyster fishery and waterfowl hunting, among others. Eelgrasses, however, can be sensitive to marine heatwaves and poor water quality. According to an expert on eelgrass we interviewed, a 2-3ºC increase in water temperature over a multiple week period could be detrimental to eelgrass, leading to long term consequences including die offs that may not be apparent until well after the extreme heat event has passed. Given the potential negative effects future climate stressors could have on this habitat, Humboldt Bay may provide an appropriate case study for a parametric insurance product to protect eelgrass, ultimately protecting the associated ecosystem and economic benefits.

2.1.3 Parametric Insurance Resilience Pathway

Through independent research and expert interviews, we have identified a possible resilience pathway incorporating a parametric insurance product protecting eelgrass in Humboldt Bay. Given the economic benefits the eelgrass habitat provides for migratory shorebirds and fisheries, we believe there are multiple stakeholders in the Humboldt community who would benefit from such a product. In the case of the oyster fishery, a study by Cal Poly Humboldt (formerly Humboldt State University) and California Sea Grant researchers estimated the industry to have a total local economic impact of $19.3 million supporting 100 full-time jobs in 2016 and was predicted to grow. Through expert interviews, we learned eelgrasses benefit oyster beds due to their ability to locally reduce ocean acidification and improve water quality, however, there is an issue of competing for space. Fishers involved in the industry face state fines when their production interferes with eelgrass beds, resulting in conflicting viewpoints of the costs and benefits of the habitat. If properly coordinated, the benefits of eelgrasses through improved water quality and future protection of the oyster fishery could be developed into a parametric insurance product.

Eelgrass beds in Humboldt Bay also hold high significance to the protection of migratory shorebirds. In a series of studies from 2020, researchers from Cal Poly Humboldt found Humboldt Bay to be home to over 850,000 shorebirds representing 32 species annually, making eelgrass critical habitat for migratory shorebirds. This habitat, however, has been threatened by the desired expansion of oyster aquaculture, which would result in the removal of eelgrass. Nonprofits including the National Audubon Society and hunting organizations who value migratory shorebirds have fought proposals for the expansion of oyster aquaculture, demonstrating the existing conflict in Humboldt Bay. Given these findings, it's clear that any parametric insurance policy would have substantial stakeholder interest and should be developed in consideration of varying ideologies.

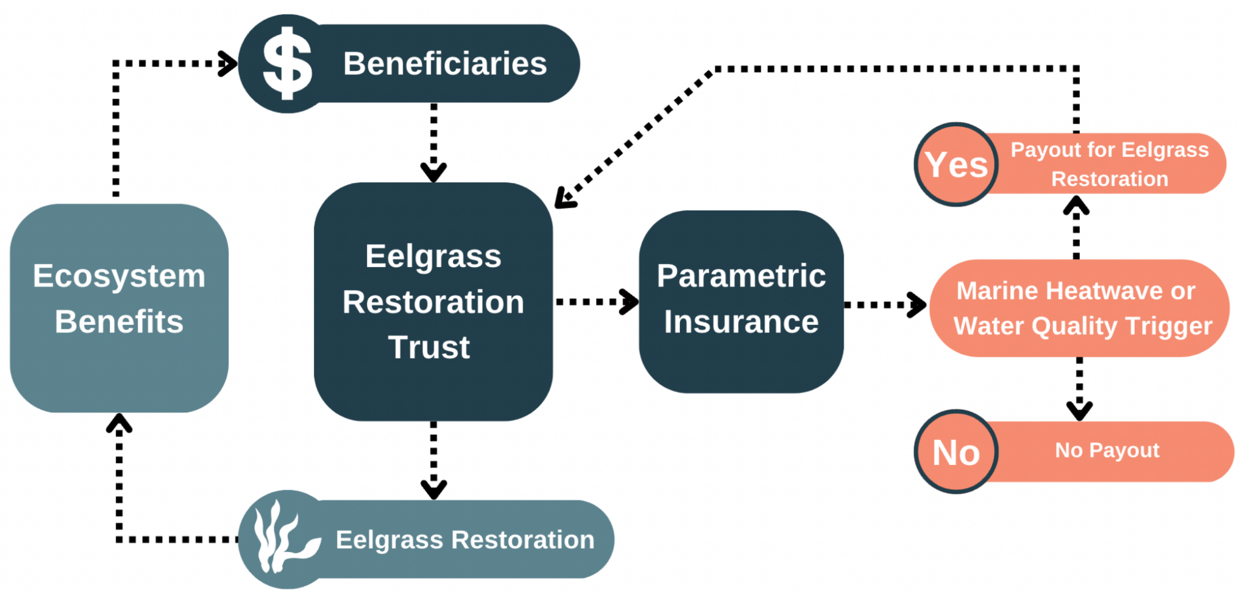

Figure 5. Adapted from The Nature Conservancy's Institutional arrangement and operation of the Coastal Zone Management Trust and insurance in the Mexican Caribbean, this figure demonstrates a general overview of the structure of a potential parametric insurance framework for eelgrass in Humboldt Bay, California.

In either case of the beneficiaries of such a product, the design would remain consistent. As outlined in Figure 5, potential beneficiaries (possibly including government funds, Audubon Societies and other nonprofits, members of the oyster fishery industry, etc.) would pay into a trust fund. This trust fund is then used to pay policy premiums on a parametric insurance policy, which would receive a payout under particular parameters. In Figure 6 we represent the pros and cons of two possible metrics to trigger a payout: marine heatwaves (temperature) and water quality (turbidity). Depending on the design of the insurance product, one of these selected metrics would be triggered if a specified temperature or turbidity threshold is passed in a defined region, resulting in an insurance payout to fund eelgrass restoration efforts through turion planting (planting of buds). According to expert interviews, this form of restoration is more effective on the West Coast in comparison to seeding. Turion planting is more intensive and costly, but full regrowth of the eelgrass beds may be observed in a matter of years (see resources provided by NOAA on seagrass conservation).

Marine Heatwaves		Water Quality	
Pros	**Cons**	**Pros**	**Cons**
• Temperature is easy to record accurately • Fewer variables impact temperature • Understandable to stakeholders	• Data needs: seagrass locally adapts to temperature, so site-specific data is needed [1] • Increased uncertainty: less modeling and information available	• Covers a wide range of potential impacts to water quality • Well known issue with models and information available [2]	• Turbidity thresholds can be difficult to define • Many variables impact water quality making projections less predictable [3]

Figure 6. Examination of the pros and cons of selecting temperature or turbidity as the stressor metric in a parametric insurance product for eelgrass. Information is provided from a culmination of expert interviews and independent research. See footers associated with marine heatwave cons[1], water quality pros[2] and water quality cons[3] for additional information.

[1] Eelgrass has a wide latitudinal range encompassing vast temperatures. More recent research, however, demonstrates local adaptation to temperature. Exact thresholds are difficult to determine, but deviations from the norm (prolonged marine heatwaves) are likely to cause a disturbance.

[2] Dissimilar to temperature, many variables impact water quality, so our ability to develop projections to suggest water quality will diminish in the future requires site specific data.

[3] See work by Dr. Richard Zimmerman of Old Dominion University for additional information on eelgrass distribution models in relation to water quality.

2.2 Risk Reduction Policy

2.2.1 Overview

Within the climate adaptive insurance context, NbS can reduce climate induced risk and can be applied to conventional financial mechanisms for adoption. Two pathways for NbS insurance with salt marsh habitat are (1) a conservation easement style program that incentivizes land owners to sell property or (2) development rights to a NbS bank and a modified flood insurance program that factors salt marsh land cover and health into risk assessment and premium costs.

2.2.2 Use Case: Salt marsh Restoration

Salt marsh habitat restoration can play an important role in creating SLR resilience with added benefits for habitat, water quality and storm surge protection. Salt marshes act like anchors reducing erosion and are natural sponges, absorbing large inflows of water during storm events and stopping silt from being stirred up by large waves; some wetlands are able to continue functioning as a stormbreak under Category I hurricane conditions. Salt marsh plants filter water, removing excess nutrients and can draw down toxins, improving water quality.

In Humboldt Bay, these adaptation mechanisms are most applicable to landowners in the Northern areas of Arcata Bay because of its proximity to the Mad River inlet and sloughs as well as salt marsh habitat protected by governmental agencies. Parcels in this area of the Bay are large and are primarily used for grazing, and adjacency to the Mad River and associated sloughs opens opportunities for both resilience pathways to be used in conjunction. Proximity to existing protected salt marshes allows for increased habitat connectivity and thus greater SLR mitigation benefits. Potential NbS expansion into the confluence and sloughs of the Mad River may also use funding from oyster and aquaculture industry insurance subscribers as a rate offset incentive in their own parametric insurance subscriptions (more details in chapter two) incentivized by water quality improvements and reduced severity of extreme turbidity events.

2.2.3 Varying Methodologies: Increasing Flexibility and Universal Application

Development Rights Policies

Transfers development rights or ownership to beneficiary trust to be converted to marshland

- Decreases permitting costs and effort
- Allows for stepwise restoration and prioritization of critical areas
- An attractive option for land owners transitioning away from farming

Land Improvement Policies

Private ownership is retained with commitment to gradual greening of infrastructure and NbS installation

- Suited for land owners with existing grey infrastructure obligations (levee owners)
- Can be integrated into existing flood insurance policies
- May expand marsh network inland into riparian and freshwater habitats

Figure 7. Descriptive overview of potential risk reduction policies in indemnity insurance.

Varying methodologies in insurance application not only allows for flexibility within resilient systems, but allows insurers and stakeholders to utilize the most appropriate mechanisms for ecosystem protection and maximizes return on investment (ROI) for all parties. We have identified two methods of developing NbS risk reduction policies on private property through development rights and land improvement policies. Each of these policies is well suited for deployment on large tracts of agricultural land, but differ in asset ownership and involvement of each party.

2.2.4 Development Rights Policies Resilience Pathway

Because coastal marshes assist in protecting assets directly inland, the purchase of land or development rights of coastal parcels can lower flood damage risk and benefit both insurers and property owners. From a climate adaptation standpoint, the ultimate goal is to create a network of NbS across private property, therefore multiplying flood protection benefits. In this program, land or development rights are put into the climate insurance stakeholder trust which would result in lower premiums for the land owner depending on the size and quality of the salt marsh in question. This adaptation mechanism is specifically targeted at landowners with large, undeveloped parcels such as grazers or farmers and works under the assumption that either a) this land will depreciate due to SLR or saltwater intrusion in the next 50 years or b) these landowners are interested in transitioning away from farming/grazing. These assumptions provide reasoning as to why a landowner would engage with the insurance provider in such a way; under this resilience pathway, the land owner is either receiving the highest value for their land before it is degraded by climate impacts or the farmer is liquidating property that will be unused in the next five to fifteen years. Responsibility for the installation of any SLR adaptation infrastructure is reduced as is overall risk from flooding and therefore the policy holder's premiums. Agricultural and conservation easements are commonplace programs, and an increased familiarity with these types of sales may reduce trust barriers between landowners and insurance stakeholders. In this pathway, opportunities for entry are expected to peak in the next ten to thirty years, as this mechanism is particularly well suited for adoption during the transition of property ownership through inheritance.

2.2.5 Land Improvement Policies Resilience Pathway

Much like the conservation easement style program, this resilience pathway is most applicable to large landowners with undeveloped or agricultural coastal property. In this instance, incentives in the form of flood insurance rate reduction and assistance programs are given for landowners who install or restore NbS systems on their land (see case study 3, the NFIP Community Rating System from our landscape review for an applicable reference). Property and development rights remain intact for the landowner, but additional effort and coordination to ensure adequate and proper NbS salt marshes may be a barrier to implementation. Because of the increased investment of time, energy and coordination, this resilience pathway is less likely to provide substantial gains in the short term. However, because landowners are responsible for the upkeep of levees and dikes on their property, intervention through gradual transitioning towards green-grey infrastructure has the potential to disperse NbS systems inland and into freshwater systems, expanding the pool of potential subscribers (parcel owners with substantial freshwater riparian frontage may also be included with smaller rate reduction incentives). It should be noted that this resilience pathway is not suitable as a stand alone program but is most effective as an integration into existing flood and property insurance, and would benefit from the involvement of insurance regulatory policy making.

2.3 Stakeholder Engagement

In order to be successful, proper planning is essential for climate adaptive insurance projects. Stakeholder groups and interests should be carefully mapped out with special consideration given to those groups traditionally left out of the planning conversations. Potential community, government and non-profit stakeholders for a NbS project in Humboldt Bay are included in Figure 8 below. This table is specific to Humboldt Bay, but provides an example of the types of stakeholders typical to coastal resilience projects across Northern California. Of note is the wide variety of stakeholders and their varying levels of interest and involvement in a project like this. Mapping stakeholder interests is particularly important if considering parametric policies that may involve community buy-in motivated by intrinsic value over property protection.

Figure 8. Potential community, non-profit and community stakeholders for a NbS project in Humboldt Bay. For a full briefing of stakeholders, see the Humboldt Bay Sea Level Rise Regional Planning Feasibility Study Stakeholder Catalogue.

Chapter 3: Implementation Pathway Guidance

The methods of climate adaptive insurance vary widely, but general methods in their application can be systematized and fall into three steps: landscape scoping, pathway analysis, and local engagement. Note the cyclical feedbacks between each step (see Figure 10); this methodology is not intended to represent a direct pathway to project creation but a series of iterative guidance that need to be revisited and centered on understanding the needs of the community members and how that may synergize with the motivations of the insurance sector.

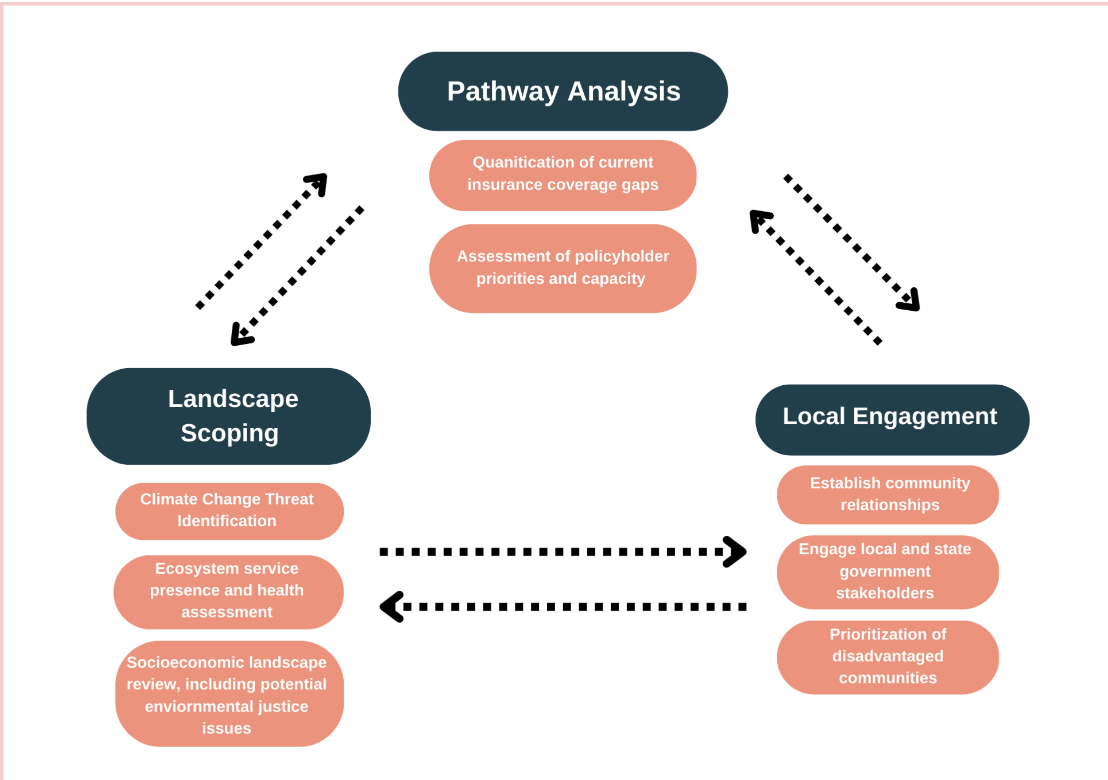

Figure 10. Overview of general guidance in creating NbS insurance. Steps shown in figure 4 will inform the landscape scoping phase here.

3.1 Scoping and Environmental Considerations

The theory of risk reduction policies in insurance is very appealing and applications have taken place to insure from other natural hazards such as wildfires. With the specific case of insuring coastal regions in Humboldt Bay, the following table presents major benefits to the region as well as potential challenges and risks for future implementation. Strong scientific understanding of the landscape in question must be the bedrock of climate adaptive insurance not only to ensure realized risk protection from NbS installation but to optimize and diversify ecosystem benefits.

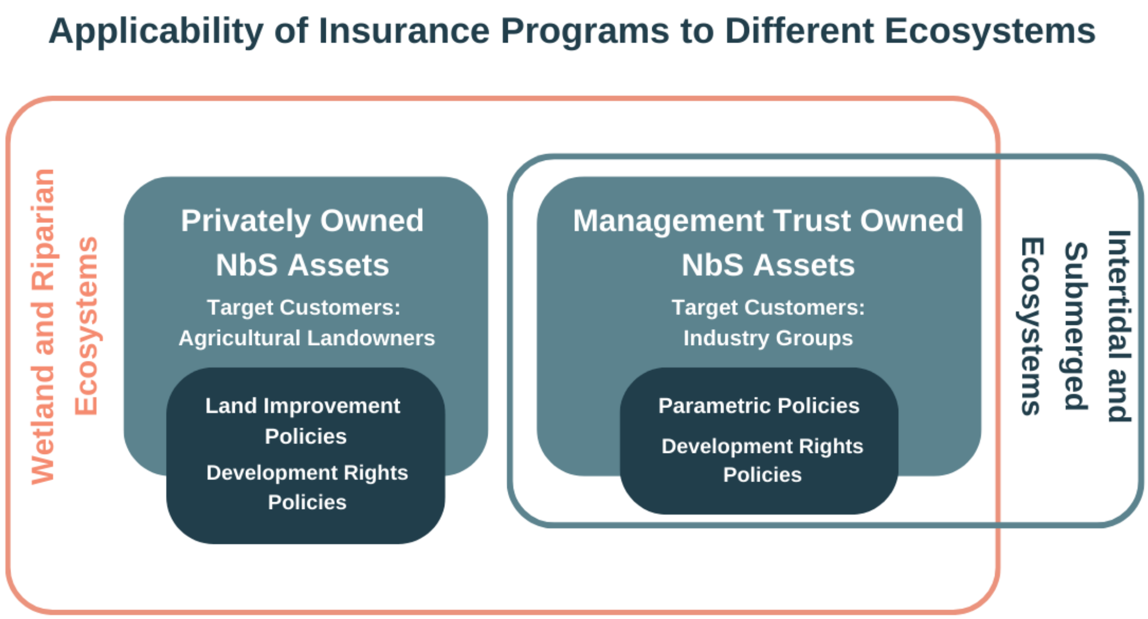

Figure 11. Potential considerations for NbS risk reduction in Humboldt Bay including the related ecosystem and insurance mechanism.

Humboldt Bay is a unique case study in that it contains the largest area of eelgrass habitat in California, so application of a similar insurance product may not be as applicable to the rest of the state. This is not to say that riparian and salt marsh restoration is the only applicable ecosystem to the rest of the state, but that unique opportunities for rare ecosystem preservation should be explored thoroughly, be that sand dunes, intertidal invertebrate beds, kelp forests, or others.

3.2 Stakeholder Considerations

Humboldt Bay is home to a premiere research university, Cal Poly Humboldt, creating an opportunity for climate adaptive insurance practitioners to collaborate with this community and co-create application minded science with local experts. Much of Northern California’s coastal areas are within a reasonable proximity to similar research institutions and collaboration with academic partners should be valued not as an extractive process but a means of connecting with a facet of the community that can foster long term relationships among other stakeholder groups.

Environmental justice issues that could result from NbS implementation must be evaluated through landscape scoping and community engagement, including potential tradeoffs and issues of scaling solutions and limiting economic losses. Social equity concerns inherent to mainstream insurance and financial markets pose additional concerns, including structural prioritization of economic returns and other quantifiable ROI over human-ecosystem co-benefits[4]. The displacement of vulnerable communities via inland retreat due to property value increases associated with NbS benefits is a distinct possibility and would create a market benefiting higher income populations. Climate finance markets must do their part to enable more focus on societal benefits of NbS and long-term ROI and the most effective means of prioritizing this is engaging with a diverse set of community stakeholders early on in scoping and maintaining those relationships throughout project design and implementation.

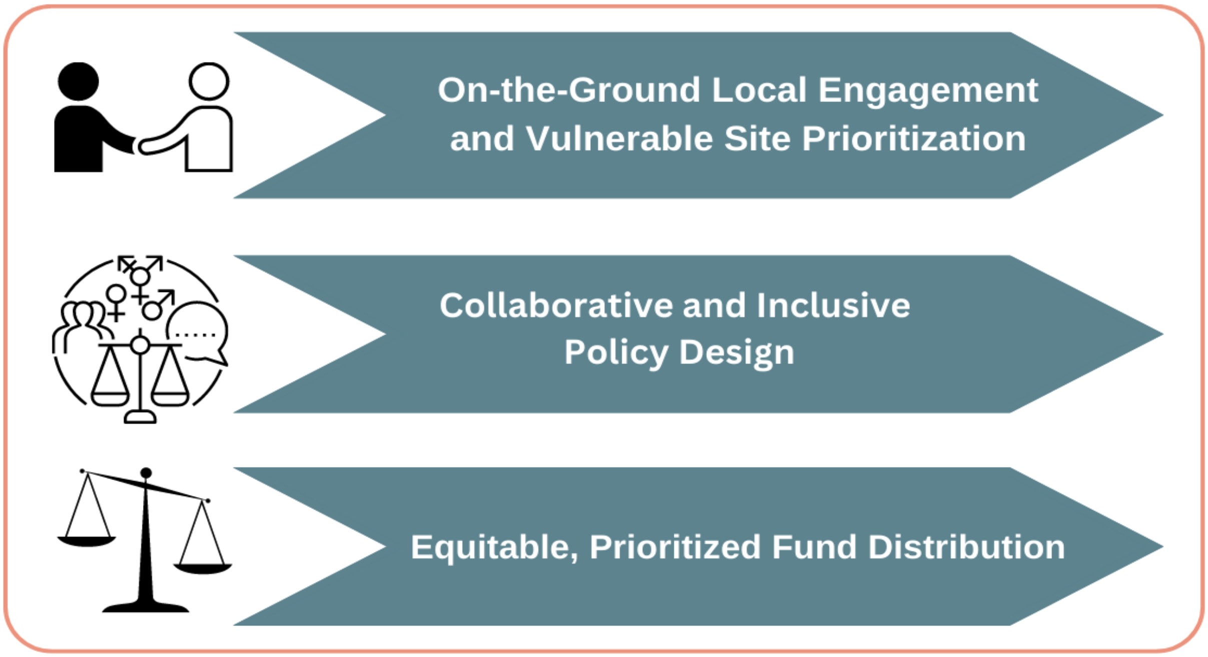

Figure 12. Criteria and thresholds for social equity assessment in NbS projects.

Collaborative governance is critical for successful NbS project realization and execution and is a powerful framework for reducing barriers to implementation while ensuring the greatest social and economic returns for all parties. Collaborative governance includes setting clearly defined roles as to who is responsible for the NbS asset, who is the lead stakeholder and who are the social groups that must be prioritized throughout the process, especially in cross-jurisdictional cases. There needs to be careful evaluation of the communities and populations that stand to benefit from NbS implementation, how long benefits will take and who will pay the cost. At-risk communities should be prioritized in site selection through an inclusive and transparent process. Moreover, payouts should be clearly defined and targeted

[4] We recommend reading Inclusive Insurance for Climate-Related Disasters, published by Ceres officers, exploring how local, state and federal regulators and policy makers can make the insurance market and disaster response in the U.S. more inclusive.

to populations projected to suffer the highest burden in the event of a climate hazard event[5].

Summary

Climate adaptive insurance is unique in that it integrates social-ecological systems into a market motivated industry in a way that can benefit all parties involved – in fact, climate adaptive insurance is a rare case of a win-win situation between stakeholders, insurers and environmental health. The complexity of coupled human-natural systems is not to be underestimated, but the simple act of prioritizing engagement and creating equal, two way community partnerships with local stakeholders and experts can significantly improve economic and social outcomes. Climate adaptive insurance must be understood as a long term and cyclical process that benefits from monitoring and adaptive management of ecosystems. The localization of these programs is critical to their success, both in optimizing ROI for insurers and avoiding pitfalls of environmental equity issues. With each iteration of climate adaptive insurance, increased scientific and industry know-ledge lowers costs for future projects. It is our hope that this document will provide not only a framework of under- standing these social- ecological approaches to building climate resilience, but will be used as a tool to spur further exploration and conversation around climate adaptive insurance.

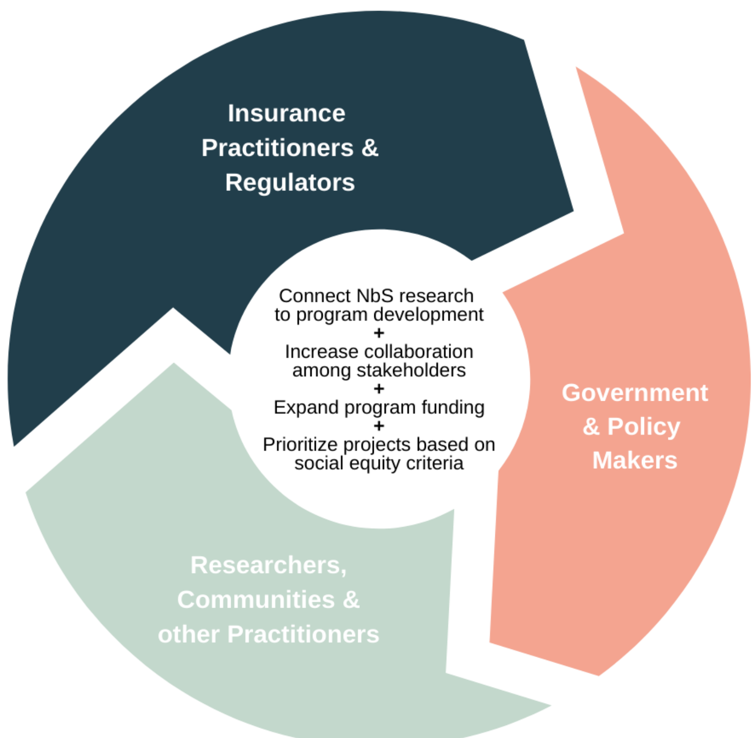

Figure 13. Overview of recommendations applicable for all stakeholders.

[5] See this recent study critiquing current methods of determining "disadvantaged communities" and recommendations for more holistically addressing environmental justice