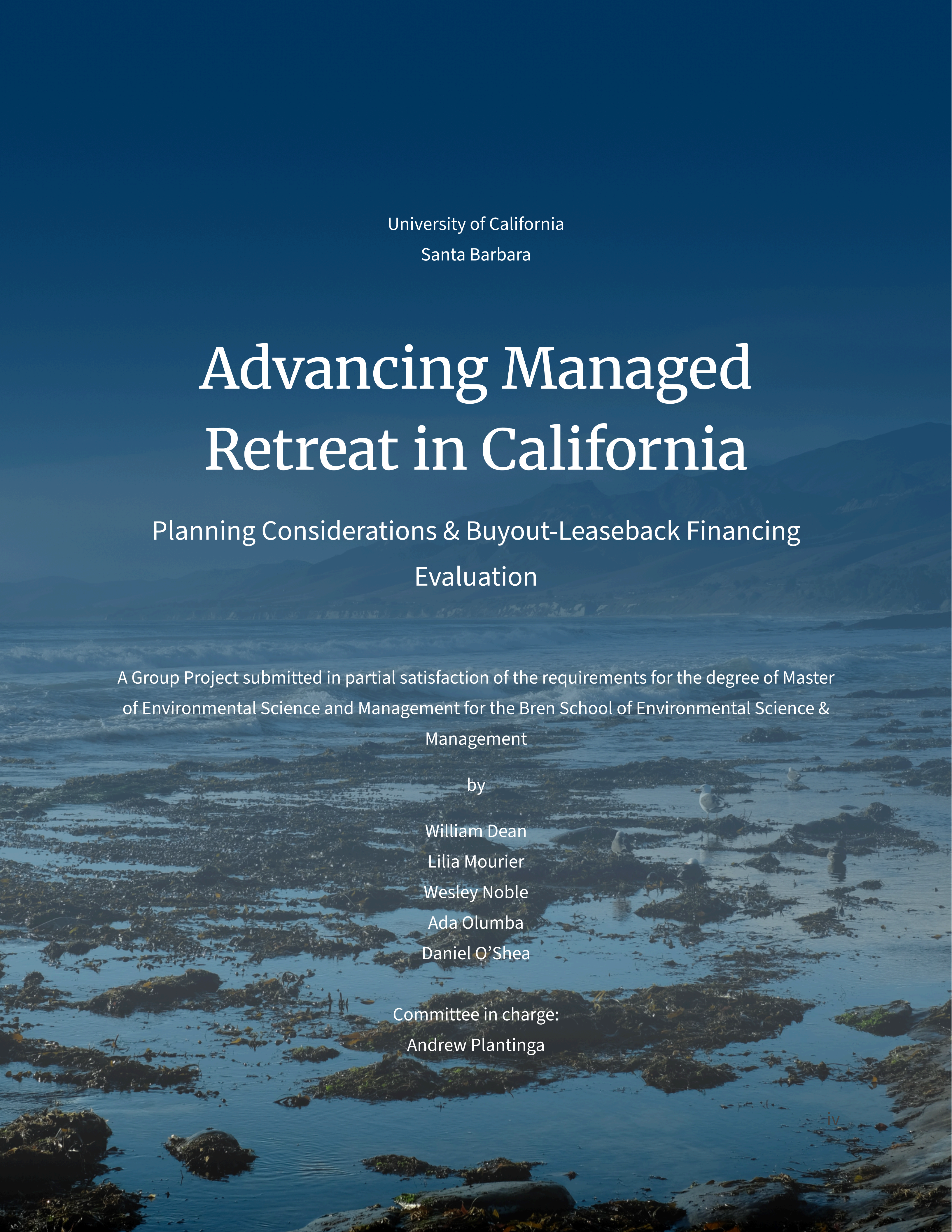


University of California
Santa Barbara

Advancing Managed Retreat in California

Planning Considerations & Buyout-Leaseback Financing Evaluation

A Group Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management for the Bren School of Environmental Science & Management

by

William Dean
Lilia Mourier
Wesley Noble
Ada Olumba
Daniel O’Shea

Committee in charge:
Andrew Plantinga

Advancing Managed Retreat in California

Planning Considerations & Buyout-Leaseback Financing Evaluation

As authors of this Group Project report, we archive this report on the Bren School's website such that the results of our research are available for all to read. Our signatures on the document signify our joint responsibility to fulfill the archiving standards set by the Bren School of Environmental Science & Management.

Signed by:
William Dean
74017F24C76E4C4... 3/30/2026

Signed by:
Lilia Mourier
958E54CE971E494... 3/30/2026

Signed by:
Wesley Noble
20F089994E764E8... 3/30/2026

Signed by:
Ada Olumba
8CABB30008A24EF... 3/30/2026

Signed by:
Daniel O'Shea
0138FB9367AB4D0... 3/30/2026

The Bren School of Environmental Science & Management produces professionals with unrivaled training in environmental science and management who will devote their unique skills to the diagnosis, assessment, mitigation, prevention, and remedy of the environmental problems of today and the future. A guiding principle of the Bren School is that the analysis of environmental problems requires quantitative training in more than one discipline and an awareness of the physical, biological, social, political, and economic consequences that arise from scientific or technological decisions.

The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a year-long activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

DocuSigned by:
Andrew Plantinga
016C7CC361A9403... Date: 3/30/2026

Author Contributions

All authors contributed equally to the development of this report. Author order does not indicate relative contribution effort. William Dean led BOLB model development, data management, and contributed to report writing. Lilia Mourier led project management and communications, led BOLB program design, contributed to thematic coding, data visualization and interpretation, and report writing, and led report formatting and editing. Wesley Noble contributed to model development, data management, report writing, and thematic coding. Ada Olumba led background research on the policy and planning context, contributed to thematic coding and report writing, and managed the project budget. Daniel O'Shea supported project management, led thematic coding and analysis, contributed to data visualization and interpretation and report writing, and led project outreach. For questions about specific sections of the report, readers are welcome to contact the team members most closely associated with the relevant components described above at the email addresses listed below.

William Dean, wdean@bren.ucsb.edu

Lilia Mourier, liliamourier@bren.ucsb.edu

Wesley Noble, wnoble@bren.ucsb.edu

Ada Olumna, adaolumba@bren.ucsb.edu

Daniel O'Shea, oshea@bren.ucsb.edu

Acknowledgements

This report was made possible through the guidance and support of many individuals and partners. We thank Charles Lester (UCSB Ocean and Coastal Policy Center) for leading proposal submission and for advising on all aspects of the project. We are grateful to Kelsey Ducklow and Carey Batha (California Coastal Commission) for their leadership in proposal submission, advising throughout the project, and for providing internship funding and oversight. We also thank Andrew Plantinga (UCSB Bren School of Environmental Science and Management) for serving as our faculty advisor and providing comprehensive guidance across the project. We are grateful to Jonah Danziger (UCSB Department of Economics) for advising on the model framework and providing code support, and to Summer Gray for external advising on thematic coding and synthesis. Finally, we acknowledge Kim Kimbell, John Campanella, and the James S. Bower Foundation for their generous project funding and support.

CALIFORNIA
COASTAL
COMMISSION

UC SANTA BARBARA
Ocean and Coastal
Policy Center
msi
Marine Science Institute

JAMES S. BOWER
FOUNDATION
Re-envisioning.

Table of Contents

Acronyms and Abbreviations

Acronym or Abbreviation	Full Term
BOLB	Buyout-Leaseback
CCC; Coastal Commission; Commission	California Coastal Commission
CoSMoS	United States Geological Survey Coastal Storm Modeling System
FEMA	Federal Emergency Management Agency
LCP	Local Coastal Plan
MR	Managed Retreat
NPV	Net Present Value
OPC	California Ocean Protection Council
SLR	Sea level rise
TDR	Transfer of Development Rights
USGS	United States Geological Survey

1. Managed Retreat in California

1.1 Introduction to Managed Retreat

Sea level rise, coastal erosion, storm surge, and groundwater intrusion increasingly threaten California's coastal communities, public resources, and infrastructure. Scientific assessments project that these hazards will accelerate shoreline retreat, increase coastal flooding, and intensify cliff instability and beach loss along much of the state's coastline (Griggs & Patsch, 2019; Lester et al., 2022). In areas where limited physical space and existing development constrain adaptation options, these projected changes pose growing risks to housing, transportation corridors, wastewater systems, recreational resources, and coastal ecosystems.

Historically, coastal communities in California have relied on shoreline protection strategies, including seawalls, revetments, groins, and beach nourishment, to manage erosion and flooding hazards. While these approaches can provide short-term protection for existing development, extensive research shows they are expensive to maintain and often produce unintended environmental impacts, including beach narrowing, disruption of sediment transport, and loss of coastal habitat. Together, these effects can contribute to coastal squeeze, in which rising seas push the shoreline landward while fixed infrastructure prevents beaches and other coastal habitats from naturally migrating inland (Griggs & Patsch, 2019). In addition, the long-term environmental and economic effectiveness of shoreline protection under rising sea levels remains increasingly uncertain.

In response, scientists, planners, and policymakers have increasingly considered managed retreat (MR) as part of the coastal adaptation strategy. Managed retreat refers to the planned relocation or removal of development and infrastructure from vulnerable shorelines to reduce exposure to coastal hazards while allowing natural shoreline processes to continue (Koslov, 2016; Siders, 2019; Mach et al., 2019). Managed retreat is often contrasted with unmanaged or reactive retreat, in which communities abandon coastal areas following repeated disasters or losses. By contrast, MR emphasizes proactive planning that seeks to balance risk reduction, environmental sustainability, and social considerations.

This chapter introduces the environmental and policy context that has led to increasing interest in managed retreat in California. It outlines the coastal hazards driving adaptation planning, situates MR within the state's coastal governance framework, and identifies key challenges associated with implementing retreat strategies.

1.2 Significance of Managed Retreat

Managed retreat is receiving growing attention in California as the economic, environmental, and governance challenges associated with coastal hazards intensify. Projections indicate that sea levels along the California coast may rise approximately 0.6 to 1.1 meters by 2100 under intermediate to high emissions scenarios, with significant impacts occurring well before the end of the century (California Ocean Protection Council, 2024; Sweet et al., 2022). Even under more moderate scenarios, rising seas are expected to increase flooding, erosion, and storm damage to coastal infrastructure within the planning horizons of existing development and public investments.

These hazards already impose substantial economic costs. Repeated storm damage, emergency repairs, and infrastructure maintenance are placing growing financial pressure on local governments and state agencies. It has been indicated that continued reliance on shoreline protection and beach nourishment may require substantial public and private investment over the coming decades, often to protect assets that are increasingly exposed to coastal risk (Griggs & Patsch, 2019; Lester et al., 2022). As a result, policymakers are increasingly evaluating strategies that reduce long-term exposure rather than continually defending vulnerable areas.

The significance of managed retreat also lies in the distribution of coastal risks and adaptation burdens. Flooding, erosion, and loss of coastal resources do not affect communities equally. Research on climate adaptation highlights that lower-income households and renters often face greater challenges recovering from hazard events and participating in adaptation decision-making (Siders, 2019; Ajibade et al., 2022). At the same time, public funds are frequently used to maintain protective infrastructure or repair storm damage in coastal areas, raising questions about how adaptation investments are allocated and who ultimately benefits from them.

Equity considerations are particularly relevant in California because the coastline is a public trust resource. Sea level rise threatens beaches, wetlands, and shoreline access that support recreation, ecological functions, and cultural uses. When protective infrastructure is used to defend private shoreline development, it can accelerate beach loss and reduce the availability of these public resources. As a result, adaptation decisions raise important questions about how coastal risks, costs, and benefits are distributed across communities.

In this context, managed retreat is increasingly being examined as one potential component of California’s long-term coastal adaptation strategy. Understanding the governance, financing, and implementation challenges associated with MR is, therefore, critical for evaluating the policy tools that could support more coordinated, economically feasible, and equitable retreat strategies.

1.3 Coastal Regulatory Setting for Managed Retreat

Managed retreat (MR) is fundamentally a governance process shaped by legal authority, planning frameworks, and institutional coordination across multiple levels of government (Siders, 2019; Hino et al., 2017). In practice, retreat outcomes emerge from the interaction of coastal land-use regulation, environmental policy, disaster programs, and climate adaptation planning rather than from a single dedicated retreat statute.

In California, the policy context for MR is anchored by the California Coastal Act, which establishes the state's mandate to protect coastal resources, maintain public access, and minimize risks to life and property. Since its adoption in 1976, the implementation of the Act by the California Coastal Commission (Commission) has generated an extensive planning and policy framework for managing coastal hazards. Early Commission guidance and Local Coastal Program (LCP) policies incorporated tools such as geotechnical analysis, development setbacks, risk-assumption requirements, and hazard-avoidance siting standards designed to reduce long-term exposure to erosion and coastal hazards (Lester, 2005; Lester & Matella, 2016). These policies distinguish between existing development, which may be eligible for shoreline protection under Coastal Act §30235, and new development, which must be sited and designed to avoid coastal hazards under §30253. This distinction has long shaped how hazard management decisions are made along the California coast.

LCPs serve as the primary mechanism through which Coastal Act policies are implemented at the local level. LCPs translate state coastal policies into local zoning, land-use designations, and development standards, thereby structuring how communities address shoreline change, erosion, and flooding hazards (California Coastal Commission, 2018; Griggs & Patsch, 2019). Recent LCP updates increasingly incorporate sea level-rise vulnerability assessments and adaptive planning frameworks, including consideration of retreat among a range of potential adaptation strategies (Reguero et al., 2023; California Coastal Commission, 2024). This shift is also being reinforced through state legislation: SB 272 requires local governments in the coastal zone to incorporate a sea level rise plan into new or updated LCPs by January 1, 2034 (California Legislature, 2023). Approaches vary across jurisdictions, reflecting differences in local geography, exposure, planning capacity, and community priorities. Such variation is expected in California's decentralized coastal planning system, where adaptation strategies are developed in response to place-specific environmental and social conditions.

Beyond coastal regulation, several additional policy frameworks influence retreat implementation. Local hazard mitigation plans, required for eligibility for certain federal disaster funds, focus primarily on reducing disaster losses through measures such as structure elevation, emergency preparedness, and post-disaster recovery planning(Federal Emergency Management Agency [FEMA], 2023; Siders, 2019). Federal programs administered by the Federal Emergency Management Agency (FEMA), including the Hazard Mitigation Grant Program and related voluntary buyout initiatives, represent the primary public funding source for property acquisition and relocation in high-risk areas (Hino et al., 2017; FEMA, 2023). These programs, however, are typically triggered after declared disasters and operate under criteria that prioritize near-term risk reduction, which can limit their use for proactive coastal adaptation.

These overlapping regulatory and funding structures create a policy environment in which MR is legally feasible but implemented through multiple planning and decision-making processes rather than through a single coordinated program. Coastal regulation shapes where and how development occurs, local planning determines adaptation strategies, and federal hazard-mitigation programs provide limited funding pathways for relocation when risks become severe. As a result, retreat in California most often emerges incrementally through permitting decisions, infrastructure relocation, or post-disaster property acquisition rather than through a unified statewide retreat program.

1.4 Existing Coastal Adaptation Approaches

Across California, most coastal jurisdictions address sea level rise through LCP updates, hazard mitigation plans, and stand-alone climate adaptation or resilience plans. These planning processes are guided by technical recommendations from the Coastal Commission and the Ocean Protection Council (OPC), which encourage jurisdictions to evaluate a range of adaptation strategies, including protection, accommodation, and retreat, across multiple sea level rise scenarios (California Coastal Commission, 2024; OPC, 2024). While many plans acknowledge all three approaches, they differ substantially in how strategies are prioritized and operationalized at the local level.

1.4.1 Protection

Protection strategies remain the most common near-term response to coastal hazards in local planning documents. These approaches include seawalls, revetments, bluff stabilization, and beach nourishment designed to reduce erosion and flooding risks and protect existing development and infrastructure (Griggs & Patsch, 2019; California Coastal Commission, 2024).

Although plans frequently acknowledge that shoreline armoring can contribute to beach narrowing and coastal squeeze under rising sea levels, protection measures are often framed as near-term risk-reduction strategies, particularly in highly urbanized areas where development and public infrastructure already occupy vulnerable shorelines (Griggs & Patsch, 2019; Lester et al., 2022).

1.4.2 Accommodation

Accommodation strategies aim to reduce hazard exposure while allowing development to remain in place. Common measures include structure elevation, floodproofing, utility relocation, drainage improvements, and adaptive building design standards incorporated into LCP policies and zoning regulations (California Coastal Commission, 2018; OPC, 2018). Some measures, such as development setbacks, assumption-of-risk requirements, and restrictions on future shoreline armoring, have also been used by the Coastal Commission since the 1990s to limit long-term exposure to coastal hazards. These policies function similarly to rolling easements by allowing development to proceed while acknowledging the potential for future shoreline migration (Lester, 2005; Lester & Matella, 2016). Sea level rise considerations have increasingly informed coastal planning decisions since the early 2000s, with the Coastal Commission formalizing statewide guidance in 2015 and updating it in subsequent years (California Coastal Commission, 2015, 2018). Within adaptation plans, accommodation is often presented as a transitional strategy that can extend the usable life of existing development while longer-term responses are evaluated.

1.4.3 Retreat

In contrast to protection and accommodation, retreat is typically framed as a long-term or conditional strategy within existing adaptation plans. Many LCP updates and coastal adaptation plans acknowledge that retreat may ultimately be necessary in areas experiencing chronic erosion, bluff instability, or repeated infrastructure impacts, but retreat is rarely accompanied by specific implementation mechanisms, timelines, or funding strategies (Lester et al., 2022; Bragg et al., 2021). Recent legislative efforts have sought to address this gap through mechanisms such as buyout-leaseback financing, in which a public entity acquires a vulnerable property and temporarily leases it back before eventual relocation. For example, California Senate Bill 1078 proposed a state-supported mechanism to help local governments acquire and temporarily lease vulnerable coastal properties, but the bill was ultimately vetoed by Governor Gavin Newsom (see Chapter 3.2).

Where retreat is discussed, it is commonly linked to damage thresholds, infrastructure failure, or the exhaustion of protective options rather than being planned proactively based on projected sea level rise trajectories (Moser et al., 2016). Few plans specify how properties would be acquired, how displaced residents or infrastructure would be supported, or how land would be managed following relocation.

At the same time, although retreat is often framed as an adaptation strategy needed decades in the future, evaluating retreat pathways earlier can help communities understand when implementation may become economically or socially viable. Early analysis may also reveal opportunities for gradual or voluntary approaches such as buyouts, land swaps, or leaseback arrangements that allow investment values to be recovered over time while reducing long-term risk exposure (Koslov, 2016; Lester et al., 2022). These considerations highlight the importance of identifying practical institutional tools that can support incremental retreat before crisis conditions emerge.

1.5. Project Objectives and Approach

This chapter has situated managed retreat within California's broader coastal hazard, planning, and governance context. Although retreat is increasingly acknowledged in adaptation planning, it is still rarely accompanied by clear implementation pathways, funding strategies, or analytical tools for determining when proactive action may be warranted. This project addresses that gap by evaluating how managed retreat planning in California can be informed by broader social and environmental considerations, as well as by a more explicit assessment of buyout-leaseback financing as one potential tool for supporting more proactive and coordinated retreat.

This report addresses three core questions:

1. What values, trade-offs, and implementation challenges shape managed retreat planning decisions across California?
2. When does continued occupation of a coastal property become economically unsustainable for the property owner?
3. How can this timing inform proactive acquisition strategies that balance public cost with fair compensation to property owners?

To answer these questions, the report combines qualitative analysis with economic modeling and applied case study evaluation. Chapter 2 identifies key values, trade-offs, and implementation considerations through thematic coding of a wide range of literature, policy documents, and planning materials. Chapter 3 outlines major buyout-leaseback program design considerations and institutional pathways relevant to California. Chapter 4 develops an economic model to estimate buyout price, lease duration, and retreat timing under different conditions. Chapter 5 applies this model and broader planning framework to a set of contrasting neighborhood case studies, then compares results across cases to identify higher-level insights about where buyout-leaseback financing may be most viable and informative as a managed retreat strategy.

2. Values, Trade-offs, and Challenges of Managed Retreat

As coastal risks intensify, managed retreat has emerged as a necessary, though challenging, element of climate adaptation. Despite growing recognition of its importance, managed retreat remains one of the most politically, socially, and culturally contentious responses to sea level rise. This chapter examines the fundamental values, trade-offs, and challenges of managed retreat, highlighting the broader considerations needed to evaluate retreat and buyout-leaseback holistically. Using thematic analysis, this research develops grounded recommendations for managed retreat implementation by identifying, analyzing, and reporting recurring patterns across qualitative data sources (Braun & Clarke, 2006).

2.1 Thematic Coding Methods

The analysis was conducted using data from published articles and dissertations, public comments from state and local government hearings, draft guidance documents, news articles, government reports, including LCPs, Vulnerability Assessments, Adaptation Pathways, State Agency Reports, and legal documents. The search criteria used to identify these sources are outlined in Appendix 1, and a matrix of source citations is provided in Appendix 2. The matrix identifies the origin of each code and its accompanying citation using the following abbreviations:

- N = News Articles
- GR = Government Reports
- PC = Public Comment
- L = Legal Documents
- PA = Published Articles
- D = Dissertations
- SG = State Guidance Reports

In each case, the number corresponds to the specific source. In addition to sources identified through the search process, a small number were included through targeted literature review and expert recommendations from professionals in California's coastal resilience field.

Values are defined as the co-benefits, opportunities, and positive outcomes associated with managed retreat that stakeholders identify as reasons to support or advance retreat policies. Challenges are defined as the barriers, uncertainties, and tensions that complicate the implementation of managed retreat. Trade-offs capture the competing considerations and consequential decisions inherent to managed retreat, where one element may come at the cost of another.

Using these definitions, the sources were coded and organized into categories using Braun and Clarke’s (2006) thematic coding method for qualitative analysis and Dr. Philip Adu’s *Thematic Analysis Guide* (2023) through an inductive approach, moving from specific observations to broader generalizations. Four main categories were identified to further analyze values, trade-offs, and challenges: environmental and ecological, planning and governance, economic, and social considerations. Codes from each source were grouped within these categories and then combined into themes based on shared patterns and similarities. In addition to thematic coding, frequency analysis was used to count how often particular codes and themes appeared across document types, regions, and analytical categories, helping identify broader patterns of emphasis, intensity, and distribution across the dataset. This helped identify broader patterns of emphasis, intensity, and distribution across the dataset. Together, the thematic and frequency analyses inform the values, challenges, and trade-offs associated with managed retreat planning and implementation in California. The following subsections describe results within each category, highlighting direct quotes from the data, commonly recurring themes, and key trends relevant to managed retreat decision-making in California.

2.2 Key Patterns from the Frequency Analysis

A frequency analysis was conducted to identify themes associated with document types, regions, and categories. The goal of this analysis was to provide an overview of where specific themes arise across the literature and across regions of California in order to help pinpoint where certain considerations should be addressed. Initial theme-building identified 84 distinct themes across 12 categories. These were grouped by similarity and condensed into 20 broader themes. The top 10 themes by quote count were then analyzed by document type, region, and category; these themes are listed in Table 2.2.1.

Analyzing the proportion of quotes classified under the values, trade-offs, and challenges framework revealed that values associated with managed retreat were found more commonly in state guidance documents, legal documents, and government reports, whereas challenges were more associated with news articles, dissertations, published academic articles, and public comments (Figure 2.2.1). The specific themes underlying these values, trade-offs, and challenges are discussed in more detail in the following sections.

Table 2.2.1. Top 10 combined themes by document type, based on raw quote counts. "T" denotes theme, and the accompanying number indicates each theme's rank (1–10) by frequency of appearance in the dataset.

Code	Theme	Total Quotes
T1	Inclusive community engagement, equity, and public stewardship of coastal resources are prerequisites for successful managed retreat implementation	69
T2	Funding gaps, revenue losses, property value disparities, and equity challenges complicate managed retreat	59
T3	Local and statewide coordination, novel resilience tools, and public land planning advance managed retreat	59
T4	Communication failures, social disruption, and displacement of communities are social risks managed retreat policy must address	53
T5	Denial, skepticism, distrust, and feasibility doubts undermine managed retreat acceptance	46
T6	Managed retreat offers significant environmental co-benefits when planned with long-term engagement	46
T7	Political barriers, legislative ambiguity, and short-term interests hinder long-term adaptation planning	45
T8	Early triggers, monitoring systems, and multiple adaptation strategies drive governance success	44
T9	Miscommunication, framing, real estate fears, and equity concerns complicate public perception	40
T10	Buyout programs and available state/federal funding make managed retreat cost-effective long-term	32

The most frequent theme across all categories is “Inclusive community engagement, equity, and public stewardship of coastal resources are prerequisites for successful managed retreat implementation”, found predominantly in government reports, published academic articles, and news articles (Table 2.2.1). Classified under social values, this theme reflects a statewide focus on bottom-up, community-guided sea level rise adaptation decisions. Beyond this emphasis on community-centered adaptation, the next most prevalent themes highlight the institutional and economic conditions shaping retreat implementation. These themes are “Local and statewide coordination and novel resilience tools advance managed retreat” and “Funding gaps and other economic factors complicating managed retreat.” Together, these themes suggest that while communities may value inclusive, locally grounded adaptation, implementation often depends on whether sufficient coordination mechanisms and funding tools are in place. In this context, novel approaches such as buyout-leaseback may help address the financial barriers that frequently stall managed retreat.

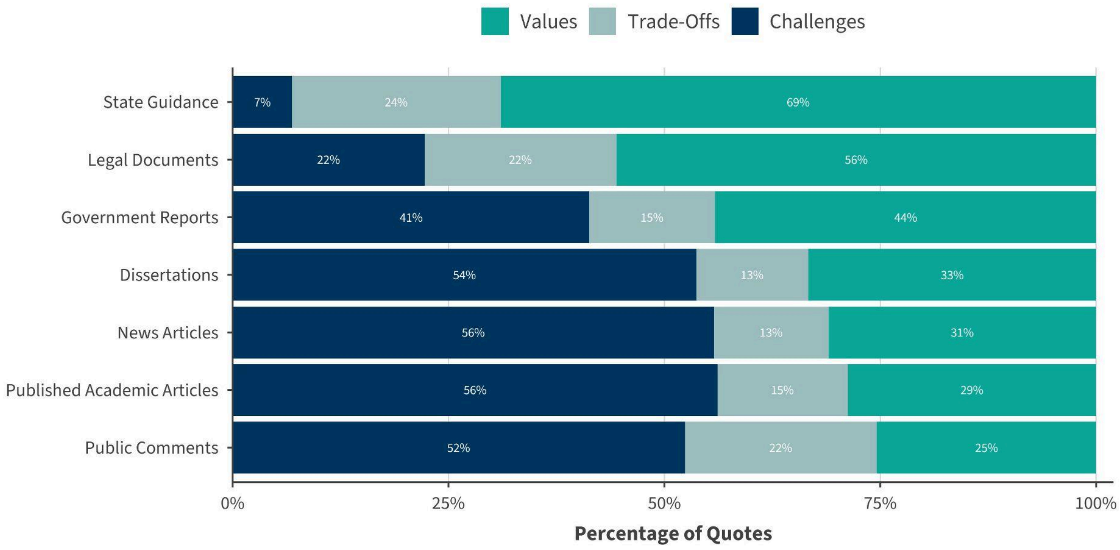


Figure 2.2.1. Distribution of values, trade-offs, and challenges by document type. Bars show the percentage of quotes within each document type that were coded as values, trade-offs, or challenges.

Different document types frame managed retreat in notably different ways, helping clarify how retreat is discussed across contexts in California. Legal documents are dominated by themes related to coordination, novel resilience tools, and public land planning, suggesting a strong emphasis on the feasibility and advancement of managed retreat. State guidance documents similarly prioritize early triggers, monitoring systems, and buyout programs. News articles, by contrast, are dominated by denial, skepticism, distrust, miscommunication, and real estate fears, themes that are largely absent from institutional sources and consistent with a more publicly anxious framing of retreat. Published academic articles focus more heavily on communication, community engagement, and equity than on technical feasibility. Together, these patterns indicate that different knowledge sources are framing managed retreat quite differently, with direct implications for how coherent or fragmented the broader public conversation becomes. These normalized results by document type are presented in Appendix A.1.

Because California's coastline encompasses diverse geomorphologies, demographics, and political contexts, it is important to identify where certain themes are more prevalent. In Central California, "Early Triggers, Monitoring Systems, and Multiple Adaptation Strategies Drive Governance Success" emerges as a leading theme, suggesting that trigger-based approaches such as buyout–leaseback tied to predefined physical thresholds may be well suited to communities already experiencing bluff collapse and property loss. In Northern California, "Communication Failures, Social Disruption, and Displacement of Communities" is more prominent, reflecting both the implementation challenges of managed retreat and the significant engagement needs already evident in communities such as King Salmon. In Southern California, "Funding Gaps, Revenue Losses, Property Value Disparities, and Equity Challenges Complicating Managed Retreat" and "Political Barriers, Legislative Ambiguity, and Short-Term Interests Hinder Long-Term Adaptation Planning" emerge as the leading themes, indicating that high coastal property values amplify economic concerns and keep funding equity and political barriers at the forefront of the regional conversation.

Overall, this analysis helps clarify the most important considerations surrounding the implementation and effectiveness of managed retreat in California, and highlights that greater focus must be placed on communication throughout the state, with certain regions requiring particular attention. These findings are revisited in Section 2.7 to guide planning considerations for decision-makers.

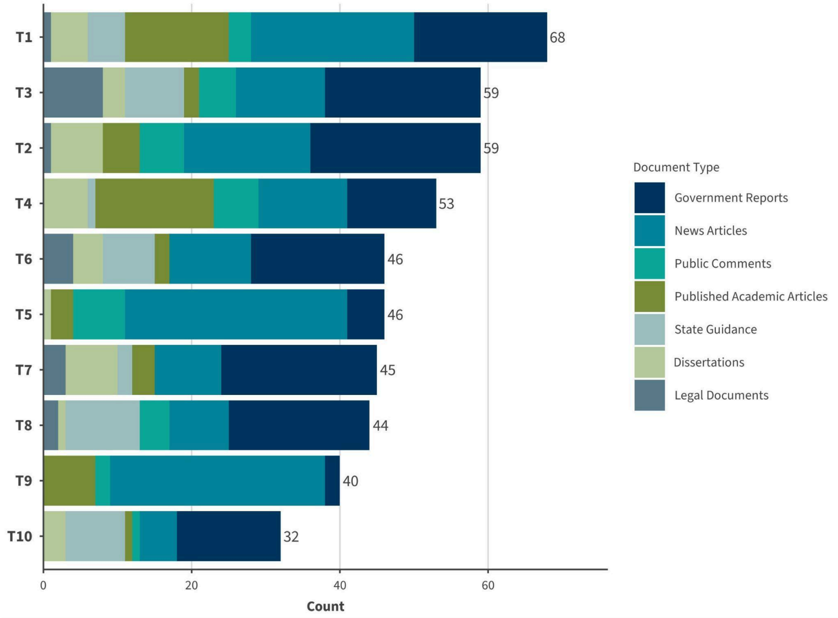


Figure 2.2.2. Combined Themes by Document Type. Raw quote counts are shown for each theme. The y-axis lists the themes shown in Table 2.2.1, and bars are stacked by document type to highlight where each theme is most prevalent.

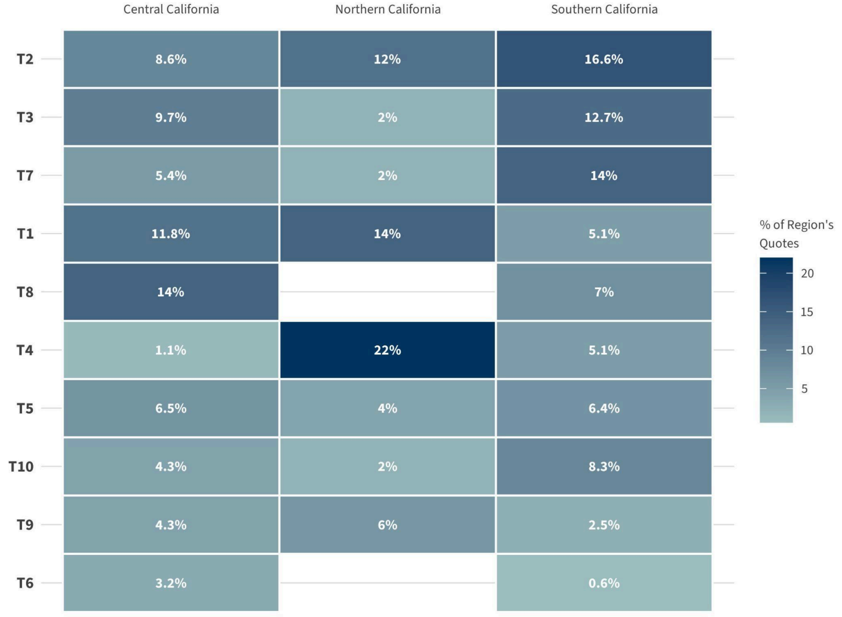


Figure 2.2.3. Regional Distribution of Combined Themes. Values are normalized to account for differences in quote volume across regions. The y-axis lists the themes shown in Table 2.2.1.

2.3 Environmental & Ecological Considerations of Managed Retreat

The environmental significance of managed retreat extends beyond immediate risk reduction to include the cumulative effects of development, shoreline armoring, and retreat itself on beaches, wetlands, habitats, and coastal landforms. Across sources, managed retreat is framed as a response to environmental degradation and, if carefully managed, as a unique opportunity to restore natural coastal systems, thereby establishing its central argument as a proactive solution for ecological and community resilience.

2.3.1 Environmental & ecological values

Three leading themes emerged within the environmental and ecological values category:

1. Managed retreat has a long list of environmental co-benefits.
2. Meaningful engagement from communities can help managed retreat become a conservation strategy that preserves access and habitats.
3. Long-term planning and the creation of monitored triggers can lead to the most successful managed retreat implementations.

The first and most prominent value of managed retreat is the long list of environmental co-benefits (GR25) that could arise from successful implementation. Managed retreat reduces long-term exposure to chronic coastal erosion, intensifying storm surge, and coastal squeeze by allowing shorelines to migrate naturally, preserving beach width, restoring natural buffers, and protecting homes, infrastructure, and public access along California's coast. Managed retreat reduces the hazard risk to critical infrastructure posed by rising groundwater tables, inland flooding, and threats to septic systems and underground utilities, which conventional protection and accommodation strategies cannot resolve.

Managed retreat as a conservation strategy can involve transitioning developed areas to open space or restoring habitat to maintain the cultural and ecological value of the coast. Guidance from the California Coastal Commission *Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits* includes multiple step by step processes to help determine which coastal resources may be affected by sea level rise over a given time period, determining whether sea level rise impacts degrade or enhance each resource, considering a wide range of characteristics (SG12). Sources further cite that managed retreat as a conservation strategy supports the minimal management of created and preserved coastal habitat (GR31), leverages already-protected areas to enable relatively straightforward and uncontroversial sea level rise planning (N8), and facilitates the transition of public coastal space from built to more natural environments (GR27).

Sources consistently discuss natural co-benefits of managed retreat and encourage conservation strategies that lead to more successful restoration outcomes, long-term planning, and the creation of monitored triggers that are key to successful implementation in the environmental context. Retreat is key to long-term, effective natural shoreline infrastructure, as it increases adaptive capacity and reduces future exposure (SG7), especially in areas not anticipated to face significant future development pressure. Predictive models, such as CoSMoS projections, should be used to monitor trigger events far in advance, promoting a proactive strategy and maximizing public benefits and ecological value. This can be achieved by developing predefined physical triggers, such as erosion within a certain distance of a structure, monthly high tides within a certain distance of the finished floor elevation, or a wetland decreasing to a certain width (SG8).

2.3.2 Environmental & ecological tradeoffs

Environmental trade-offs associated with managed retreat reveal tensions among alternative adaptation pathways. Two leading themes emerged within the environmental and ecological tradeoffs category:

1. Managed retreat alternatives lead to coastal squeeze
2. Relocation activities and demolition can have environmental impacts

Sources frequently described how approaches that delay or avoid retreat, such as armoring, can intensify coastal squeeze (D5), trapping beaches and habitats between rising seas and fixed development. In contrast, retreat was often framed as a way to alleviate these pressures by allowing shorelines and ecosystems to migrate inland (SG9, SG11).

Retreat itself was acknowledged to involve some environmental tradeoffs. Relocation and demolition activities can generate environmental impacts, including construction-related disturbance (PC3), debris management challenges (SG7), and short-term ecosystem disruption from contamination by building materials (SG7) if not carefully managed. These concerns highlight the importance of proper cleanup and planning to avoid replacing one form of environmental harm with another.

Despite these short-term impacts, retreat is widely associated with significant ecological benefits over the longer term (see section 2.1). Sources described how removing development and infrastructure can restore natural sediment dynamics (GR28, SG11), expand habitat area (GR28), and should be prioritized to support wetland and marsh migration (SG7, GR30).

Retreat was frequently framed as creating opportunities for ecological recovery that are otherwise threatened under protection strategies (D5).

2.3.3 Environmental & ecological challenges

The following three themes reflect how existing shoreline management practices and ecological conditions shape the environmental outcomes of retreat strategies:

1. Shoreline armoring contributes to coastal squeeze and ecosystem degradation
2. Ecological success of managed retreat depends on landscape connectivity
3. Ecological recovery following retreat may require active restoration

While these themes emerged from the thematic coding process, the initial document set contained limited discussion of the ecological dynamics that influence the long-term environmental outcomes of retreat. To better contextualize these challenges, we supplemented the thematic analysis with additional peer-reviewed literature examining coastal ecosystem responses to sea level rise, shoreline armoring, and restoration processes.

A persistent environmental challenge identified across sources is the historical preference for shoreline armoring, which has contributed to widespread maladaptation along California's coast and intensified coastal squeeze. Hard structures such as seawalls, revetments, and riprap were often implemented as short-term responses to erosion and storm damage but frequently disrupt natural sediment transport processes (D8, N29), accelerate beach narrowing, and degrade coastal ecosystems (D5). Over time, these interventions constrain the natural landward migration of habitats under rising sea levels (GR45) and increase reliance on increasingly costly protective measures that limit future adaptation options (G9). Research on coastal systems suggests that continued armoring combined with sea level rise may push beach and wetland ecosystems toward ecological tipping points, where relatively small increases in sea level can result in substantial habitat loss and declines in ecosystem functioning (Barnard et al., 2021).

Beyond the impacts of armoring, the ecological success of managed retreat strategies depends strongly on landscape connectivity and the ability of coastal ecosystems to recover following infrastructure removal (Myers et al., 2019). Coastal environments function as interconnected systems shaped by sediment transport, hydrology, and biological dispersal across large spatial scales. Disturbances such as sea level rise, storms, watershed changes, and human development interact across these systems, influencing ecosystem resilience and recovery potential (Myers et al., 2019). Where retreat occurs adjacent to functioning wetlands, dunes, or beaches, natural sediment supply and biological colonization can facilitate habitat migration and ecological recovery. However, in heavily developed coastal regions, retreat sites may be ecologically isolated from these functioning systems, limiting natural recolonization processes and requiring more proactive restoration interventions to rebuild ecological function (Myers et al., 2019).

2.4 Economic Considerations of Managed Retreat

Economic considerations of managed shoreline retreat shape how adaptation options are evaluated, delayed, or pursued, often serving as a primary lens through which decision-makers assess feasibility. In this context, economic factors extend beyond the direct costs of relocation or protection to include changes in municipal revenues, funding uncertainty, property market dynamics, and competing interpretations of what constitutes an “affordable” or “cost-effective” solution. Across sources, economic arguments were frequently invoked both to justify retreat and to postpone it.

2.4.1 Economic values

Three leading themes emerged within the economic values category:

1. Buyout-leaseback programs are encouraged by the California Coastal Commission and provide safety nets for property owners, allowing for long-term cost effectiveness.
2. Holistic analysis of buyout programs and other funding mechanisms would be beneficial for future planning.
3. Funding opportunities are available and can be supported by state and federal sources.

Sources suggest that over time horizons longer than 25 years, managed retreat may be more cost-effective than maintaining shoreline armoring, outweighing upfront public costs and reducing long-term public losses (GR9, GR41, SG8). In addition to serving as a barrier to storm surge and large waves, California beaches generate billions of dollars in direct revenue annually (D4). Managed retreat has been closely studied to yield the highest net benefits for wider beaches (GR41), while sea wall usage negatively impacts beach revenue (GR30, GR41). Tests were conducted in Pacifica to assess the value of a beach day in light of net benefit rank-ordering of adaptation strategies, and, consistently, managed retreat was ranked highest regardless of the value of a beach day per person (GR14).

Buyout-leaseback (BOLB) programs, the topic of discussion for this research, were cited as an economically justified adaptation (D6) and a resilience-building tool (D6; Curran-Groome et al., 2022). Buy-back strategies are frequently described as cost-effective over longer periods and at higher sea levels (GR26, N3), and have been shown to generate returns for communities within the timeframe of a typical 30-year mortgage (GR30). Beyond long-term cost-effectiveness, sources also emphasize the value of proactive action over reactive emergency response. The County of San Mateo Sea Level Rise Vulnerability Assessment & Adaptation Report (2022) captures this distinction clearly:

> *"Communities must decide whether to take a proactive approach that is controlled and optimized to maximize public and private benefits, or a reactive one characterized by sudden, emergency responses to extreme events like landslides and cliff collapse."*

The keywords optimize and maximize public and private benefits underscore that proactive approaches, planned to avoid emergency responses, are perceived to be more cost-effective than reactive approaches. From a risk-alleviation point of view, BOLB offers coastal homeowners guaranteed safety nets by protecting their equity through public investment and leaseback (PA5). Furthermore, managed retreat has been supported in specific situations, such as the inward movement of Highway 1 in Piedras Blancas and bike paths in Ventura, CA, supported through state sources like Caltrans (SG7, SG11, N30, GR11). However, the availability of funds for buyout leaseback is also cited as a challenge by communities opposed to relocation (See Section 2.6.3).

2.4.2 Economic tradeoffs

Three leading themes emerged within the economic tradeoffs category:

1. Time matters when considering the cost of different solutions.
2. Adaptation strategies should be evaluated on an economic basis.
3. A managed retreat approach that is appropriate in one area may not be suitable everywhere.

When considering when to implement managed retreat, timing emerged as the most pressing trade-off. The longer a community waits, the more expensive retreat becomes (N14). Retreat is also more costly when adopted only after protection strategies fail, underscoring the importance of investing in the right solution sooner rather than later (GR9). In communities where armoring is the predominant strategy, reactive spending often prioritizes high-value properties, leaving lower-value properties to fall into disrepair (PA14) and further reinforcing equity and justice concerns.

Other trade-offs include potential losses in recreational tourism revenue and declines in property tax revenue when communities relocate under a managed retreat pathway (GR30). These economic impacts can be important considerations when comparing adaptation strategies. In addition, managed retreat may not be cost-effective in some coastal regions (PC2), particularly where property values are high or where relocating a community to a comparable area would be especially expensive.

2.4.3 Economic challenges

Economic challenges include uncertain funding for managed retreat in many communities, high coastal property values that create tension, reductions in local tax revenue associated with community relocation, and broader financial considerations that complicate implementation.

Many news articles and public comments cited that funding is simply unclear (GR31, N20, N31), that there is a lack of funding structures (N6, PA11), and that federal funding is too complex to qualify for (L5). This issue is compounded by uncertain funding scenarios arising from shifting federal government priorities. Sustained political will through multiple election cycles to maintain financing for managed retreat strategies (N5) was cited as a particularly challenging dynamic for keeping BOLB working across longer time horizons. International examples suggest that central government funding has been critical to managed retreat programs (N16; Peart et al., 2023), but securing similar centralized funding in the United States may prove difficult given competing national priorities.

Another key challenge is the value of coastal properties. Despite proposed regulations to address risk disclosure in coastal real estate, property values of potentially vulnerable homes continue to rise (Anderson, 2022). In many communities, belief in climate change tends to drive home the value of and the likelihood of adopting a more proactive adaptation strategy (GR31).

> *"...homes projected to be affected by sea level rise in neighborhoods where the residents have a high tendency to believe in climate change tend to sell for less than comparable homes in neighborhoods where there is less belief in climate change (Baldauf et al., 2019)."*

Because proposed buyout–leaseback strategies are voluntary, building community consensus around climate change and adaptation is especially important. Implementation can also impose major financial burdens on cities that may lack the up-front resources needed to purchase vulnerable properties and support relocation (D7, N18, N25). In high-value coastal areas, the desire to protect existing investments can further constrain adaptation options and fuel opposition from real estate and development interests along the coast (D7, N27).

Another key concern in the literature is how managed retreat may affect local tax revenues and how communities respond to the prospect of relocation. Relocation of communities and houses could reduce a city's tax base if improperly planned (GR41, GR42), while, at the same time, emergency repairs for existing threatened coastal infrastructure cost 10's of millions of California tax dollars (N30, PA7). Litigation over managed retreat by coastal homeowners petitioning to protect their homes by armoring could bankrupt even the most well–resourced cities (N2). Along with lost tax revenue and potential litigation, the mention of managed retreat has sparked fears that insurance rates will soar or that companies will withdraw entirely from flood insurance programs (D6, N16). Finally, additional costs of managed retreat, namely demolition, property management, and the relocation of public infrastructure such as roads, could add greater complexity to the already complicated financing calculations, potentially delaying implementation by years and undermining the cost-effectiveness of BOLB (D6, GR28, PC2).

These economic challenges are also unevenly distributed across communities. California's coastal communities are characterized by highly uneven property values and economic capacity, which can shape who is able to challenge regulations, protect property values, or absorb relocation-related losses. Property owners in certain lower-income communities, such as Imperial Beach or King Salmon, have been found to have less ability to challenge regulations and protect property values (D7). Historical evidence also reveals unequal distribution of federal recovery funds for elderly and Latinx communities (Muñoz & Tate, 2016). For this reason, equity and justice must remain central considerations in evaluating the economic implications of managed retreat and buyout–leaseback. Lower-income communities should be consulted early and often to ensure that retreat planning does not reproduce existing disparities (Curran-Groome et al., 2022).

2.5 Planning and Governance Considerations of Managed Retreat

Planning and governance considerations shape how managed retreat is conceptualized and implemented over time. Across sources within this category, retreat is framed as a long-term governance strategy that requires early policy establishment, continuous monitoring and engagement, and multi-jurisdictional cooperation. Planning for retreat is linked to values of preparedness, public safety, hazard mitigation, and long-term sustainability, reflecting a growing recognition that traditional fixed-timeline planning approaches are not suited to dynamic coastal conditions. Planning and Governance considerations represent values, trade-offs, and challenges in how managed retreat will be implemented and monitored, as well as in how the systems of rules, processes, and people in charge will be responsible for this adaptation strategy.

2.5.1 Planning & governance values

Three leading themes emerged within the planning and governance values category:

1. Rolling easements, buyout programs, transfer of development rights, and new development rules allow for proactive preparedness.
2. Statewide plans followed up with localized governance is a potential political strategy.
3. Early establishment of triggers, monitoring, and equitable policies will impact program success.

More resilience approaches, such as rolling easements (L7, PC2), the transfer of development rights (SG7, SG11), and rules for new developments (L7, SG11), will enable greater preparedness and encourage retreat strategies in communities. Rolling easements could alleviate financing concerns by delaying future losses for decades and can include different purchase strategies based on whether rural areas or urban cores are involved (Caldwell & Holt Segall, 2007). Transfer of Development Rights (TDR) can be used to restrict development in areas vulnerable to sea level rise and to allow the transfer of rights to parcels less vulnerable. TDR could be used in tandem with BOLB and encourage relocation away from vulnerable locations (SG11). Land use and zoning ordinances can be used to encourage retreat by limiting development in hazardous areas (GR30). New structures should be built only where shoreline armoring will never be required, thereby forcing landowners to account for sea level rise risk in future investments (L7, SG7). Private property owners should also be encouraged to remove existing armoring in order to facilitate the eventual relocation of assets (GR14, GR15, SG7). These planning decisions are important to implement now because traditional planning processes, which rely on fixed timelines and decision points, may not provide enough flexibility to prepare for the uncertainty of sea level rise (N6). Buyout leaseback in the context of proactive preparedness will be discussed in more detail throughout the rest of this report.

As previously noted, the early establishment of triggers, monitoring, and equitable policies will influence program success. Trigger pathways for retreat must be created that can respond to changing flood risks over time (SG11). These triggers can be tied to infrastructure that can no longer be feasibly maintained, a growing need for new shoreline protection, or predefined environmental thresholds such as erosion distance, wetland buffer loss, tidal reach, or beach width (SG7, SG11). Community visioning is critical at these thresholds (SG7) and should be nested within Adaptation Plans or Beach Management Plans, along with the early establishment of equitable managed retreat policies (GR42, GR42) (See Section 2.6.1). Setting triggers and monitoring are crucial to success, as retreat programs must be established decades before actual implementation. Ventura County illustrates how LCP trigger thresholds can be combined with project prioritization criteria to determine both when action should occur and which projects should take priority:

> *“Sea level rise policies in the LCP can be triggered by specific thresholds that prompt specific actions in the future. Factors to consider when prioritizing projects include: imminent risk, public health and safety, available funding sources, legal mandates, planning consistency, capacity and level of service, cost-benefit relationship, environmental impacts, and public support. Risks that present the most serious consequences and are projected to occur first should raise a project’s level of priority. (Maier et al., 2018)”*

Multiple sources cite the effectiveness of a hybrid solution in which short-term protective strategies (beach nourishment and armoring) are coupled with long-term retreat strategies to help buy time (GR14, GR27, GR30). This hybrid solution would allow for temporary barriers to be constructed before retreat strategies are fully implemented (GR30). This must be weighed against the cost of temporary sea walls, which could undermine the cost-effectiveness of managed retreat or simply serve as a semi-permanent solution, sidestepping the actual implementation of long-term strategies. Overall, managed retreat as a replacement for sea walls avoids maladaptive protection measures (D7) and must remain the primary goal if used in conjunction with protection strategies.

2.5.2 Planning & governance trade-offs

Three leading themes emerged within the planning and governance trade-offs category:

1. Regulatory measures today assess trade-offs between armoring and retreat.
2. Planning decisions now have lasting impacts.
3. Community decisions and evaluation dictate future resilience.

When comparing adaptation strategies, each option comes with trade-offs that must be carefully considered. Protection strategies reduce recreational use of beaches and can lead to more frequent and severe winter wave impacts. Delays in funding, support, or coordination can further reduce the long-term cost-effectiveness of retreat strategies, which already tend to involve higher up-front costs and greater implementation complexity (GR50). A delicate balance must be struck to plan managed retreat effectively while still conveying to communities the urgency of acting relatively quickly. If sufficient private or public funds and support are unavailable, planning initiatives to implement managed retreat will likely fall by the wayside, and unplanned retreat will become the de facto alternative (L13).

Planning and governance trade-offs center on community decisions and their lasting impacts on resilience. Communities must decide between proactive and reactive adaptation strategies to sea level rise, where proactive solutions are optimized to maximize public and private benefits, while reactive solutions are characterized by costly, sudden emergency responses (GR26, GR36). This decision becomes even more imperative as evaluating retreat strategies takes significant time and resources for community planners to make feasible.

2.5.3 Planning & governance challenges

Three leading themes emerged within the planning and governance challenges category:

1. Short-term interests getting in the way of planning.
2. Legislature on property rights stone-wall legal development.
3. Intricacies of existing infrastructure create complications.

Short-term decision-making often undermines proactive managed retreat planning, even when early action would better support long-term adaptation. Because the programs, policies, and implementation processes needed to support proactive retreat can take years to establish, immediate pressures often take precedence over longer-term adaptation needs. One example is the use of emergency permitting, which can favor armoring over more durable and potentially more effective long-term solutions (N7). In some cases, even inaction is framed as a form of adaptation. A news article highlights this tension clearly:

> *"Del Martians will deal with it [Sea Level Rise] when they see the actual impacts of global warming on a more weekly, yearly basis," he said. "And until that happens, it's still theoretical." (N12)*

Temporal sentiments like this hinder efforts to promote urgency in communities and create tension between property owners who are preserving their investments and state governments that are attempting to protect the public good.

Existing infrastructure also complicates managed retreat, delaying the implementation of plans. Certain communities with complex infrastructure functions have considered managed retreat strategies inapplicable to their circumstances (GR13). Multiple government reports identify road rerouting (GR6, GR9, GR30), transportation and traffic impacts (GR31), and the potential loss of roads and utilities (N17) as factors that can make managed retreat harder for communities to accept as a viable solution.

While statewide planning is helpful for establishing managed retreat and sea level rise adaptation policy, retreat planning still varies across communities and is often shaped through place-based approaches. The success of community-driven planning in past managed retreat efforts globally (Ajibade et al., 2022) suggests that this variation can be a strength, but it also underscores that managed retreat is not appropriate in every community (PC2, PC4) and, even where it is viable, requires place-based rather than one-size-fits-all implementation (N7). Because geographies and demographics vary along the California coast, intricacies such as setting relocation triggers and thresholds, monitoring, cleanup, and other considerations must be developed on a community-by-community basis, which could result in major staffing and funding issues.

Finally, limited communication among government agencies and misalignment in strategy endorsement create challenges for sustained governance commitment. There is a lack of resources and limited coordination between agencies in planning and securing commitment and support from government agencies to address the realities of local adaptation (GR30, GR31). Communicating the need for adaptation to elected officials and local departments remains an issue throughout the state, and successful strategies have been identified through regional dialogues and partnerships to help implement solutions (GR30). Challenges also arise when seeking federal assistance for adaptation planning, because federal resources have historically been directed more toward repairing already flooded properties than supporting proactive planning efforts (L5).

2.6 Social Considerations of Managed Retreat

As managed retreat becomes an increasingly necessary coastal adaptation strategy in California, it is important to consider how communities will experience, interpret, and respond to it. The social considerations presented here shape how relocation unfolds, how communities make collective decisions, and whether managed retreat is perceived as fair, legitimate, and feasible. In practice, these considerations include housing availability, governance capacity, representation, community dynamics, coastal identity and culture, and how costs and benefits are distributed across groups.

2.6.1 Social values

Three leading themes emerged within the social values category:

1. Risk understanding, communication, and trust.
2. Procedural justice, participation, and community agency.
3. Community engagement and dialogue need to begin early and be consistent.

When communities face the prospect of managed retreat—or any major change—sources indicate that clear program information delivered in culturally and linguistically appropriate ways should be prioritized (GR26). Straightforward messages describing different adaptation options (N5), including accurate risk information about sea level rise and clear property rights language (PA5), along with transparent explanations of the benefits and tradeoffs of managed retreat (L19), should be shared by trusted messengers (PA5). One published article on communicating managed retreat in California underscores the role of trusted local messengers and social reinforcement:

> *"When residents learn about plans from a trusted local source who supports the changes, they are more likely to be accepting. As more people support the plan, the effect snowballs, as residents who are initially against managed retreat may concede to the idea when it becomes evident that others in the community are planning to relocate (Bragg et al., 2021)."*

This suggestion can be accomplished through interpretive community science stations that educate communities on coastal change, paired with early and sustained investment in community needs (N6). In some areas, residents express that sea level rise is inevitable (PA19) and show openness to future relocation, with greater confidence in managed retreat once a shared baseline understanding is established (N12). As stated earlier, communities that accept managed retreat should be studied to better understand the support dynamics that enable successful retreat.

In addition to improving risk understanding, managed retreat planning must also support procedural justice by strengthening community participation and agency. In some circumstances, co-producing sea level rise adaptation with community stakeholders (PA5) and understanding the culture a community is trying to build (N3) can boost procedural justice through thoughtful, transparent, and thorough communication (N13, P11). During a workshop that assessed community perceptions of coastal flooding in King Salmon, California, in response to sea level rise inundation maps in 2023, residents who were presented with external sea level rise projections seemed open to the idea of relocation even after general maintenance issues had not been addressed by local governments for decades

(Richmond & Kunkel, 2024). Showcasing information on sea level rise, especially for those in dire need of adaptation, can help bring communities into the conversation related to their potential futures.

One reason King Salmon is so extensively studied and explored in sea level rise adaptation conversations is its lower property values compared to the rest of coastal California. While many coastal communities face high property values that can make market-value buyouts extremely expensive, other places, such as King Salmon, have more moderate home values but still face serious exposure and relocation needs. Ensuring sufficient compensation and relocation support for disadvantaged communities should not depend on local property values or surrounding market conditions (GR26). There must be sufficient compensation for disadvantaged communities that also allows for local or regional relocation, regardless of the value of the surrounding area (GR26). Incentive programs for voluntary relocation will be critical and can be funded through increased development fees, in lieu fees, or other funding mechanisms (SG11). Renters must also be considered as legitimate members of the community (GR26) and not simply removed from a property during managed retreat or voluntary buyout.

Finally, public benefit, safety, and stewardship of coastal resources remained key themes throughout. Managed retreat was cited as a way to protect public safety (PC2, SG7), preserve beach access and coastal recreation (GR49, PA13), and prioritize broader public benefits over protecting individual private property (GR6, GR9). In places where managed retreat has been approved, sources report less conflict between private property interests and public shoreline management (N16), suggesting that shared flexibility can support mutually beneficial agreements.

2.6.2 Social tradeoffs

The social trade-offs category emphasizes potential social losses and inequities associated with managed retreat. Three dominant themes emerged:

1. Loss of social institutions.
2. Uneven burdens of managed retreat.
3. Environmental justice implications in managed retreat communities.

Critics of BOLB argue that the approach may disproportionately benefit wealthy homeowners, who are more likely to have the financial cushion, time, and legal support to navigate program rules and protect their interests while continuing to live in high-risk locations (N2, N15). In contrast, disadvantaged households may have fewer nearby relocation options and may be pushed farther from their communities if they cannot afford housing in surrounding areas (N2). Related public comments and editorials also raise concern that buyout-leaseback shifts the consequences of risky private real estate decisions onto the public sector (N15, PC2).

While a clear benefit of managed retreat is the preservation of natural coastal habitats and beaches in California, a tradeoff involved with the relocation of facilities is the potential for reduced access to coastal recreation (GR29, N6), loss or relocation of coastal businesses and livelihoods (GR32), and other structures and properties needing to be moved out of vulnerable areas.

2.6.3 Social challenges

The top themes within the social challenges category focus on the threat relocation poses to social institutions. Three dominant themes emerged:

1. How and where communities are relocated.
2. Place attachment to community has high emotional values.
3. History of relocation programs fraught with inequality.

One of the defining social challenges of managed retreat is the impact that relocating entire communities can have on local culture, social networks, and place-based identity. Pushback often reflects fears about equity and who bears the burdens of relocation, especially in communities with fewer resources or a history of displacement. At the same time, retreat can face resistance from real estate and development interests seeking to protect the financial stability of existing investments. Across these perspectives, many of the most persistent social challenges are rooted in place attachment—the emotional, cultural, and social value people associate with where they live—which strongly shapes how communities evaluate whether retreat is acceptable or even possible.

Concerns have grown about the lack of effective moderation and community representation, leading to underserved populations being excluded from managed retreat discussions. City councils are responsible for serving their constituencies, yet local political influence often disproportionately reflects homeowners and higher-value property interests, who tend to have greater capacity to participate in governance processes (Richmond & Kunkel, 2024). This can lead to a persistent overrepresentation of private property owner interests in governance (D7), leaving other residents feeling less prepared, less heard, and less able to shape solutions for their own communities (PA19). An example from Richmond & Kunkel (2024), who interviewed community members in King Salmon, highlights this situation:

> *"During the question and comment period several residents expressed concern and/or bafflement about having to come up with suggestions related to a SLR strategy, when for many of them, this was the first time they were even learning about the extent of the issue"*

In a survey of King Salmon residents, a frequently flooded community in Northern California, 56.8% believed that flooding would be worse in the coming 5 years, yet were still puzzled by the extent of the issue and did not feel prepared to propose alternatives (Riggio & Richmond, 2025). Public willingness is cited as one of the greatest challenges to managed retreat, and success has been shown in communities being engaged at all stages, with effective moderators needed (PA5). Unfortunately, many cities lack the capacity to proactively support their most vulnerable residents (N15). Managed retreat is also rarely discussed as a viable solution in urbanized contexts where many disadvantaged communities are located (GR17). In situations like King Salmon, there may be a higher level of preparedness if proactive solutions were suggested by trusted community advocates. Currently, the Fields Landing and King Salmon (FLKS) Living with Water Project with Cal Poly Humboldt is searching to help this community, a good example of community-led engagement.

The commodification of California's coastline has created deeply polarizing stances on managed retreat, as property owners and real estate interests resist policies that could affect coastal property values (Anderson, 2022). The California coastline has become monetized to the point that interest groups are pitted against the realities of sea level rise (N14), to the point that removing shoreline property could create an economic burden so large that it may put cities underwater before sea level rise reaches developments (PC2). There is concern that homeowners will be forced to surrender their property within the shortest legally possible timeframe (PC3) and that the legal complexities of managed retreat on private property may impose hardships on homeowners (GR21).

2.7 Planning and Policy Considerations From Key Thematic Insights

The values, challenges, and tradeoffs identified across environmental, economic, governance, and social categories suggest that managed retreat succeeds or fails largely based on when and how it is conceptualized. Research shows that managed retreat can deliver substantial long-term public benefits through ecological restoration, reduced long-run public costs, risk reduction, public safety, and maintained access to coastal recreation. However, these benefits are realized only when retreat is planned proactively, implemented early, and communicated as a long-term public investment rather than a crisis response. Delayed action, continued reliance on armoring, and reactive spending narrow future options, increase costs, and exacerbate environmental degradation and the loss of culturally significant coastal landmarks. For decision-makers, this underscores the need for early planning, trigger-based implementation, and multi-jurisdictional cooperation, with key considerations summarized below.

2.7.1. Establish planning foundations early

Planners should define clear, pre-identified triggers and monitoring systems within LCPs or adaptation plans that link retreat decisions to measurable changes in hazards and public coastal resources. Triggers can be tied to physical thresholds such as erosion proximity to structures, tidal elevation relative to foundations, flood frequency, beach width or recreational function, and wetland extent or buffer width. Framing retreat as a planned response to observable conditions can reduce perceived subjectivity and help build predictability and legitimacy in decision-making.

2.7.2. Lead with community visioning and trusted messengers

Engage trusted community voices early in the planning process. Engagement should include delivery of risk information in culturally appropriate ways and be framed as public safety rather than a retreat or a sacrifice.

2.7.3. Conduct holistic economic analyses specific to communities

When resources permit, a comparison should be made between the long-term costs of protection strategies and managed retreat, including lost ecosystem services, recreational revenue, property tax implications, and potential litigation costs. Because of major questions around funding from managed retreat opposition, identification of funding sources should be conducted early in the process.

2.7.4 Build equity safeguards into program design from the start

Given the history of eminent domain and the relocation of disadvantaged communities in the United States, the following steps should be taken to ensure procedural justice in the implementation of managed retreat.

- **Engage Disadvantaged Communities First and Often:** These communities are least likely to be represented in government and most likely to bear disproportionate burdens from retreat and inaction.
- **Ensure Compensation Reflects True Relocation Costs:** Compensation frameworks should account for regional relocation costs and include support for renters as well as property owners.
- **Include Renters as Legitimate Stakeholders:** Programs should explicitly define renter protections and relocation support.

- **Distribute Costs and Benefits Transparently:** Communities should be able to see who benefits from proposed relocation and managed retreat programs. Who bears the costs, and how equity considerations have been factored into the design to earn buy-in from other communities throughout the state.
- **Prioritize Regional Relocation Options:** Relocation pathways should keep communities intact and within their existing region.
- **Monitor Equity Outcomes After Implementation:** Commitments should be tracked throughout implementation. Post-retreat monitoring should include social and economic indicators.

2.7.5. Coordinate across jurisdictions and agencies

Regional dialogues, cross-agency coordination, and state-level partnerships should be pursued to build resilience and sustained political will for the implementation of managed retreat in California. When applicable, learning from other counties/countries' successes and failures will only prepare the state for a more climate-resilient future.

2.7.6. Advance buyout-leaseback as a multi-benefit retreat financing tool

Of the funding mechanisms examined in this analysis, one stands out as particularly well-suited to address the cross-cutting challenges described above. If planned with community visioning at the outset, a buyout-leaseback program can be implemented to protect public access to coastal recreational activities and natural ecosystems once set triggers are met. It can provide fair buyouts to property owners, transferring ownership, and the associated exposure to future climate damages, from private households to the public sector. Buyout-leaseback can relocate at-risk communities in an organized, gradual manner to alleviate loss of social institutions and prioritize regional relocation to limit community disruption. Chapter 3 examines these benefits and the key program design choices in more detail, while Chapters 4 and 5 illustrate how BOLB outcomes vary across coastal hazard settings and geomorphologies.

3. Pathways to a Buyout-Leaseback Financing Strategy

3.1 Introduction to Buyout-Leaseback Financing

Effective managed retreat depends on proactive government programs that define clear criteria for when and where retreat is warranted and establish rules, incentives, and support mechanisms to guide development away from high-risk coastal areas. While retreat is often perceived as voluntary or reactive, such as post-disaster relocations, implementing it equitably and at scale requires intentional public planning and policy. A central mechanism within such programs is the public acquisition of private property, most commonly through voluntary, publicly funded buyouts. Buyouts are a well-established hazard mitigation tool used to permanently remove vulnerable or damaged structures, reduce exposure to flood and storm risks, prevent future economic losses, and support ecological restoration (Mach et al., 2019). Because participation is voluntary, governments typically incentivize relocation by offering the pre-disaster fair market value of a property. However, as sea level rises and coastal hazards intensify, the scale of retreat needed to address these risks will become increasingly costly and politically challenging. This growing need and challenge have prompted interest in more feasible approaches to retreat, including buyout-leaseback (BOLB) strategies that offer a phased and more financially viable alternative to immediate displacement.

The BOLB strategy extends the traditional buyout model by allowing continued occupancy through a leaseback arrangement for a defined period or until a risk-based trigger is reached. A key innovation of this approach is its separation of property ownership from occupancy, which offers several benefits:

- It incentivizes voluntary participation by allowing flexibility in the timing of relocation (Georgetown Climate Center, 2020).
- It smooths community transitions by staggering shifts in demographics, public service demand, and tax revenues (Keeler et al, 2022).
- It facilitates the planning, clearing, and stewardship of properties as they are phased out (Georgetown Climate Center, 2020; Keeler et al, 2022); and
- It enables more centralized and coordinated decision-making around public investment and risk management (Keeler et al, 2022).

Beyond these social and governance benefits, the leaseback component can improve the financial feasibility of retreat by generating rental income to help offset the initial public investment in property acquisition and maintenance (e.g. flood repairs) during a defined transition period (Revell et al, 2021). To function effectively, the approach requires clearly defined and mutually agreed-upon terms for rent, lease duration, maintenance responsibilities, eviction processes, and demolition triggers (Keeler et al, 2022). In practice, jurisdictions can tailor BOLB design to local priorities, and program terms may reflect a mix of objectives beyond cost recovery, including community values and coastal management goals. See Section 3.3 for more details.

Leases can be structured in different ways depending on their purpose. Two piloted structures are orphan parcel leasebacks and triple net leasebacks (Georgetown Climate Center, 2020). Under orphan parcel leasebacks, property is leased to individuals, often adjacent property owners, to use and maintain in exchange for in-kind services rather than rent. This arrangement is suitable for small parcels with no immediate public use, helping lessors prevent neglect or misuse while deferring restoration or repurposing. Under a triple net leaseback arrangement, the lessor (e.g., a local or state government) purchases the property and begins leasing immediately upon closing. The lessor is not responsible for ongoing operations, maintenance, or repairs beyond meeting basic safety and sanitary requirements. Instead, the lessee assumes responsibility for maintenance and associated costs, and rent is typically set lower to reflect these obligations. This arrangement minimizes the lessor's involvement and can feel less disruptive for residents because day-to-day property responsibilities remain similar to ownership. This arrangement may be implemented over decades with the goal of recovering a majority of the buyout investment through rental revenue, or it may be used for shorter-term leasebacks, such as for long-time residents who prefer to remain in place for a limited period or for households seeking a transition period while securing new housing. Another similar arrangement to a triple net leaseback is one where the lessor both owns and manages the property, through direct property management or by contracting a property management company. We refer to this arrangement as a managed leaseback. This approach may be more practical for long-term leasebacks where consistent oversight, maintenance, and enforcement of lease terms are required over an extended period (Revell et al., 2021). We adopt this managed leaseback structure for the leaseback assumptions explored in Section 3.3 of this chapter and for the model described in Chapter 4 and applied in the Chapter 5 case studies.

The BOLB model is fairly new and has only been economically modeled for one case study in Imperial Beach, California, and only piloted for a small number of properties in Mecklenburg County, North Carolina (Revell et al, 2021; Georgetown Climate Center, 2020). In the Imperial

Beach model, Revell et al. (2021) applied a comprehensive and novel cost-benefit framework that valued ecosystem service benefits using a replacement cost approach based on the cost of restoring an equivalent length of beach, rather than directly pricing ecosystem services, to evaluate a public buyout and rentback retreat scenario. The model results suggest that leasebacks could repay buyout investment costs, help maintain tourism-related revenues such as transient occupancy taxes, and deliver significant recreational and ecological benefits over time. The analysis does not explicitly evaluate how property tax revenues would change under public acquisition and leaseback. In the modeled scenario, property acquisition is publicly financed through local bonds, followed by long-term leasing to former owners, with retreat initiated once a trigger threshold is met. In Mecklenburg County, the leaseback model was implemented on a limited scale as part of a locally funded floodplain buyout program. Between 2008 and 2019, triple net or orphan leaseback arrangements were implemented across twelve properties. Leasebacks were short-term and primarily used to incentivize voluntary buyout, especially to elderly adults and people who needed time to find new homes, rather than being implemented for long-term recovery of buyout cost.

Despite its potential, the BOLB strategy faces several challenges. Incentivizing participation is difficult, particularly in high-value coastal markets where owners may resist selling (Keeler et al, 2022). Securing consistent and flexible funding also remains a major barrier, especially since some federal funding sources prohibit local governments from leasing back acquired properties (Georgetown Climate Center, 2020). The model also does not address renter-specific outcomes, including how tenants in bought-out rental properties would be protected from displacement at lease termination and how affordability and relocation support would be handled, given that renters typically do not receive the equity and risk-transfer benefits that owners capture through buyouts and leasebacks (Dundon & Camp, 2021). In addition, buyouts and retreat can tighten local rental supply over time, increasing affordability pressures and amplifying displacement risks for renters even when a leaseback period is offered. Leaseback design may also affect who benefits from continued occupancy, since jurisdictions may choose to prioritize higher-revenue short-term leasing in some contexts, potentially disrupting existing long-term tenants (Revell et al., 2021). Successful implementation depends on careful, upfront planning and detailed lease agreements. Unlike standard residential leases, these agreements must incorporate additional complexities, such as risk-based termination clauses, demolition triggers, and public accountability requirements, which demand legal, administrative, and financial oversight that many local jurisdictions may not be equipped to manage (Keeler et al, 2022). Economically, recovering a meaningful share of buyout costs through lease revenue may require long time horizons and sustained program administration (Revell et al., 2021). A public net cost is not inherently a reason to avoid BOLB, but it does affect program financing needs and expectations around cost recovery. Finally, and more broadly, government-funded buyouts at pre-hazard market values can distort the real estate market by signaling that high-risk properties will be financially rescued, encouraging continued investment and development in hazard-prone areas (Young, 2018). The remainder of this chapter draws on recent California policy efforts (Section 3.2) and key program design considerations for local jurisdictions (Section 3.3) to describe practical ways these challenges can be anticipated and addressed in implementation.

3.2 Recent Supporting Legislation for Buyout-Leaseback Financing

In California, legislative interest in a BOLB program has grown in response to the state's urgent need for scalable and long-term coastal adaptation strategies. Senate Bill 1078, introduced by Senator Bill Allen from District 24 in 2021, proposed creating a state-level revolving loan fund overseen by the State Coastal Conservancy and the California Ocean Protection Council to support local governments in purchasing properties and leasing them back temporarily (California State Legislature, 2022). SB 1078 is the most developed policy model in California for how local jurisdictions could actually run a BOLB program. Importantly, the bill laid out what local jurisdictions would need to plan for and demonstrate in a Vulnerable Coastal Property Plan to qualify for the loan.

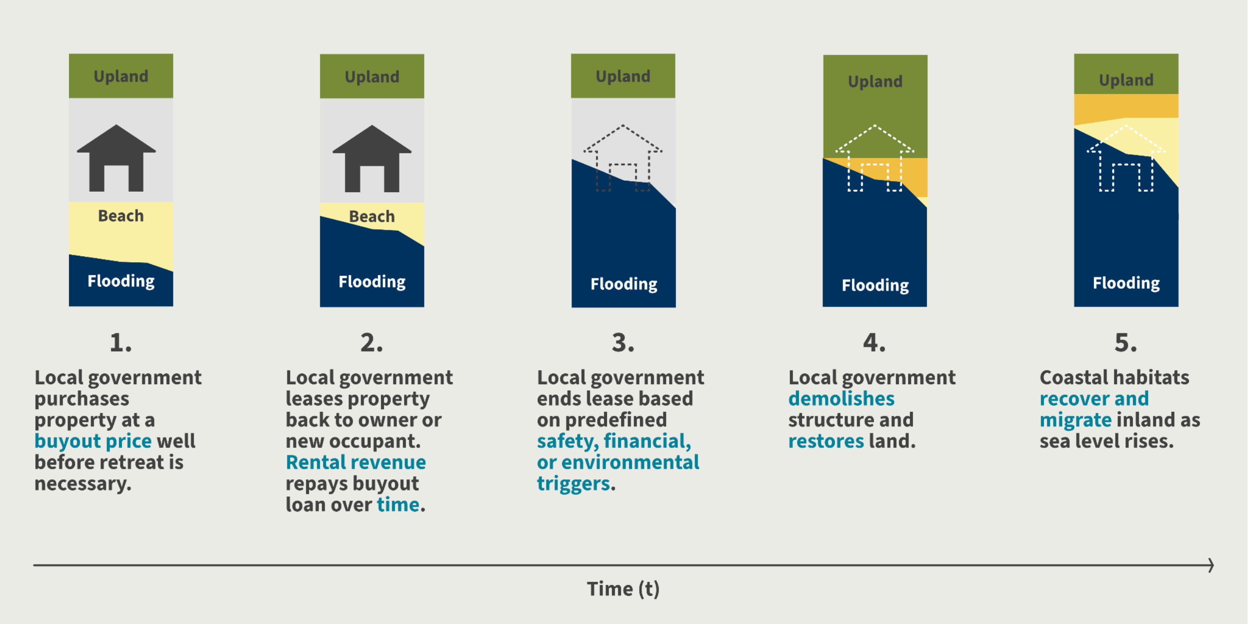
The program would operate by creating a Sea Level Rise Revolving Loan Fund in the State Treasury to be administered by the State Coastal Conservancy in consultation with the Ocean Protection Council and contingent on legislative appropriation. Once funded, the Conservancy would be authorized to issue low-interest loans to local jurisdictions. Repayments and related fees would be returned to the fund to support continued lending and administration. These overseeing agencies would adopt guidelines and eligibility criteria that require jurisdictions to demonstrate (1) a repayment pathway (e.g. the property can generate enough revenue to repay the loan, (2) cost-effectiveness, (3) alignment with implementation of an adopted sea level rise adaptation plan, and (4) public benefits such as improved natural infrastructure or coastal access, especially where multiple adjacent properties within a neighborhood are targeted as a coordinated strategy. The bill also required jurisdictions to define a methodology for determining when structures are no longer habitable, develop strategies to support community relocation, and apply equity criteria for selecting properties (Section 30978). To apply, jurisdictions would submit a Vulnerable Coastal Property Plan detailing for each chosen property (1) how the property meets the criteria described above, (2) the acquisition process and timeline, (3) a lease agreement plan that demonstrates rental income can repay the loan, (4) a management plan covering the repayment period, (5) a clear structure removal plan, and (6) an assessment of potential impacts to adjacent severely disadvantaged communities (Section 30979).

Although the bill passed both legislative chambers, it was ultimately vetoed by Governor Gavin Newson, who cited that the proposal did not fully address the long-term costs and administrative realities of a program likely to unfold over decades and fell short of a comprehensive implementation framework. In his veto message, the Governor noted that a tool like SB 1078 should be considered within a broader approach that (1) supports cooperation and feasibility among necessary stakeholders, (2) considers the impacts of placing local jurisdictions in the property rental market, and (3) reflects unified agreement across local, state, and federal partners that this is the right tool for coastal residential properties (Office of the Governor, 2022).

Together, the Vulnerable Coastal Property Plan requirements outlined in the bill and the Governor's veto comments provide a high-level roadmap for the design decisions local jurisdictions would need to make to implement a buyout–leaseback program in practice. In Section 3.3, we build on this roadmap by outlining the key policy design details local jurisdictions would need to specify with added detail intended to address the feasibility and implementation questions highlighted in the veto message.

3.3 Key Buyout-Leaseback Financing Program Design Details

Drawing on the loan applicant requirements of SB 1078, core BOLB design components outlined by Keeler et al. (2022), and existing adaptation planning in local coastal jurisdictions, this section describes the practical design choices a jurisdiction must consider to implement BOLB. We focus on how to price acquisitions, structure leases, define occupancy transition triggers, manage properties, and plan for demolition and restoration. Together, these design details provide a basis for comparing program options and considering tradeoffs among cost recovery, coastal resource protection, equity, and implementation feasibility. Where relevant, we connect each design choice to the BOLB economic model outputs presented in chapters 4 and 5.



1. Local government purchases property at a buyout price well before retreat is necessary.

2. Local government leases property back to owner or new occupant. Rental revenue repays buyout loan over time.

3. Local government ends lease based on predefined safety, financial, or environmental triggers.

4. Local government demolishes structure and restores land.

5. Coastal habitats recover and migrate inland as sea level rises.

Figure 3.3.1. Stages of managed shoreline retreat financed through buyout–leaseback. The conceptual diagram summarizes the major implementation stages of a BOLB program. Blue-highlighted text marks policy design details that require explicit definition (e.g., pricing, rental terms, triggers, and restoration planning).

3.3.1 Buyout price

Under a BOLB program, properties are purchased before severe damage occurs as part of a planned sea level rise adaptation pathway. This contrasts with traditional buyouts, which are often triggered after disasters and typically offer homeowners the pre-damage fair market value. Buying ahead of damages creates a key challenge of setting a purchase price that is defensible and convincing to homeowners while still reasonable for a long-term public program. We suggest this be addressed by tying the value of the property to the time the structure can reasonably remain occupied under sea level rise, defined as the discounted value of expected rents over the remaining economically viable period. This approach does not require assumptions about whether current market prices reflect climate risk, since pricing depends on annual rental value and projected future damages from SLR. See Chapter 4 for the detailed model implementation.

3.3.1 Financing

Financing a local BOLB program will require an upfront source of capital to fund program development and acquisitions, paired with long-term revenue and avoided-cost streams that repay or justify the initial investment over time (Keeler et al., 2021; Revell et al., 2021). Upfront, local jurisdictions could combine external transfers and financing tools, including state and federal resilience or relocation funding (e.g. a state revolving loan program like SB 1078), state bond-supported grant programs (e.g. coastal resilience allocations of Prop 4 Climate Bond), and local municipal financing (e.g. bonds as modeled by Revell et al., 2021). In the long-term, program revenue from leasing would become the primary cost-recovery mechanism, where net rent helps repay debt and replenishes revolving loan funds. Revell et al. (2021) note that short-term rentals may generate higher revenue and transient occupancy taxes compared to long-term rentals, though may introduce other policy and justice issues. Local jurisdictions can further justify financing by accounting for avoided public costs and losses, such as reduced flood damages, reduced need for alternative repeated risk-reduction investments, and avoided loss of public trust resources like beach recreation and ecosystem services (Keeler et al. 2021; Revell et al. 2021). Finally, coordinated, neighborhood-scale implementation, as opposed to parcel-by-parcel planning, can reduce per-property administrative and demolition costs through economies of scale, improving overall program efficiency (Keeler et al. 2021).

3.3.3 Rental terms

Lease terms can be designed to advance a portfolio of objectives, including maximizing cost recovery, preserving and restoring public coastal resources, minimizing displacement, and aligning lease sunset timelines with community-defined retreat thresholds. Clear, detailed, and community-informed rental terms—covering rent price, maintenance and management responsibilities, lease duration, and the conditions that end occupancy—are essential to making a BOLB program functional and successful for both households and local jurisdictions. In the simplest arrangement, rent price would be set at the fair market rental value. However, in practice, jurisdictions may choose to set rent below fair market value as part of the program design. For example, rent may be lowered in exchange for a reduced buyout price, in exchange for the lessee taking on defined maintenance responsibilities, or in exchange for in-kind services (e.g. property management). Maintenance expectations may also need to be explicitly defined to evolve over time. As lease termination trigger points are approached, jurisdictions may reduce major reinvestments and shift toward a maintenance standard that prioritizes safety and habitability over long-term improvements. Flood-prone properties may also incur recurring damage and repair needs over time that are distinct from routine home maintenance. In our modeling, we assume the lessor is responsible for repairing hazard-related damages during the leaseback period. These repair costs are deducted out of leaseback revenue when calculating public net cost. As a result, jurisdictions may have an added incentive to pair BOLB with short-term protective measures that reduce recurring losses and limit public repair burdens as lease termination triggers approach.

Lease duration should be adaptively structured such that occupancy continues until predefined trigger thresholds are met, similar to the adaptation “decision points” increasingly used in local adaptation plans (Keeler et al 2021, Lester et al., 2024). These triggers may be driven by SLR, such as a threshold loss of public trust resources shoreward of the property (e.g. beach width or recreational function) or a hazard/health threshold (e.g. a specified frequency or extent of flooding, erosion, or loss of safe access). Lease duration may also be shaped by program finance or coordination triggers such as setting a minimum occupancy period needed to recoup or repay the initial public investment or ending a remaining lease once adjacent properties have already met retreat triggers so demolition and restoration can proceed efficiently as a coordinated effort. Operationally, jurisdictions can estimate when retreat triggers are likely to be reached and work backwards to design a lease term that aligns with program goals, including cost recovery targets, affordability constraints, and coordinated restoration timelines. In some cases, the time remaining before triggers are reached may be too short to recover a substantial share of acquisition costs through rent alone, which does not preclude BOLB participation but implies that additional public subsidy or complementary funding would be needed if earlier retreat is prioritized.

3.3.4 Ownership and management

Ownership and management of properties in a BOLB program can vary, ranging from complete public ownership and management to public ownership with contracted private property management, and in some contexts, continued ownership with public program oversight (Keeler et al 2021). For the purposes of this report, we assume the local jurisdiction or other public entity acquires the property and remains the owner through the leaseback period. As the owner, the government is ultimately responsible for associated public costs, including hazard-related repair expenses where applicable. We do not specify whether day-to-day property management is conducted in-house or through a contracted property management firm, since either approach could be used depending on local capacity and program design.

3.3.2 Property tax treatment

Property tax implications under public acquisition and leaseback remain a gap in the BOLB literature, and more research is needed on how program design could minimize impacts on local property tax revenues. In California, publicly owned property is typically exempt from standard property taxation. If public property is leased for private use, counties may assess taxes on the lessee's possessory interest (California State Board of Equalization, n.d.). Jurisdictions may also use payments in lieu of taxes to help offset local service costs (California Health & Safety Code § 34401, 2025; Kenyon & Langley, 2010). Where legally feasible, jurisdictions could explore program structures that define purchase offers in after-tax terms for homeowners and define leaseback rents or related charges to partially offset foregone property tax receipts during the leaseback period.

3.3.5 Demolition and restoration costs

Keeler et al. (2022) recommend including expected demolition costs in the buyout agreement so that structure removal is explicitly accounted for in the transaction. Alternatively, SB 1078 framed structure removal as an implementation requirement by directing jurisdictions to plan for removal and identify funding mechanisms once properties can no longer be safely occupied. In our framework, demolition and site restoration are treated as separate implementation costs and are not netted out of the buyout price, since reducing the purchase offer to cover demolition could discourage voluntary participation; accordingly, demolition costs are not modeled in Chapters 4 and 5.

3.4 Property-Owner Incentives Under Buyout-Leaseback

A buyout-leaseback can be attractive to homeowners because it transfers downside risk while preserving flexibility. Under BOLB, the owner receives an up-front payment based on the property's remaining economically viable years of use and can remain in the home as a renter for a defined period. Those proceeds can effectively "pay for time" by supporting continued occupancy through rent, while also preserving the option to exit earlier if the household chooses. Because our buyout offers are tied to remaining economic lifespan, earlier participation preserves more value for homeowners, and the structure naturally incentivizes earlier action in higher-risk areas. The key benefit is that the owner converts an increasingly risky, illiquid asset into liquid capital and gains an exit option. For example, a homeowner may expect increasing flood damages over time but cannot predict whether major repairs will be needed in a year or a decade. BOLB reduces the household's exposure to that timing risk by providing liquid capital and an exit option so that if conditions worsen faster than expected, the household can move earlier and retain the remaining buyout proceeds rather than absorbing the full financial shock of sudden damage, declining resale value, or forced displacement. In this way, BOLB shifts significant climate risk from individual households to the program while supporting a more gradual transition. At the program level, this structure can still function even when occupants leave earlier than expected, because the public owner can continue leasing the property to other tenants until the relevant retreat trigger is reached.

4. Buyout-Leaseback Retreat Model

This financial model is designed as a decision-support tool rather than a comprehensive cost-benefit analysis. It evaluates retreat timing and buyout pricing from the perspective of a single economic actor (i.e. a property owner) asking when continued occupancy ceases to be financially rational given rising flood damages and declining remaining use value. The model produces buyout prices that reflect actual remaining viable life rather than current market value, creating a more defensible and fiscally sustainable basis for public acquisition than traditional approaches. The model does not weigh all social costs and benefits of retreat. For example, it does not capture tax base losses to municipalities, ecosystem service gains from shoreline restoration, displacement costs to renters, or the full range of behavioral factors that shape whether homeowners choose to participate. These broader considerations are real and policy-relevant, but they are not variables in the core economic model. Readers should interpret model results as one analytically grounded input into a larger governance decision rather than as a complete accounting of retreat's costs and benefits. The following section provides a brief overview of the model structure, and a complete technical description of methods and assumptions is included in Appendix B. The model's application is demonstrated through the Chapter 5 case studies.

4.1 Model Rationale and Scope

To support BOLB program design, we developed a financial model that defines the following key program components discussed in Section 3.3 for individual properties: purchase price, annual rents, lease duration, and public cost.

Three interconnected calculations drive the property-level analysis. First, the model identifies the year at which continued occupancy is no longer economically viable, hereafter referred to as T*, by comparing the present value of future rental income against the present value of expected future damages. We define the year when damages overtake income as the year when retreat becomes economically optimal for the owner, defining the remaining years from present to T* as the remaining economic lifespan of the property. Second, it calculates a buyout price based on that remaining viable use period rather than current market value, producing compensation that is fair to the homeowner while reflecting actual remaining economic life. Third, it projects government cash flows under a leaseback arrangement in which the former owner or a new lessee pays rent, the government collects rental income, the government covers flood repair costs, and the arrangement continues until T* is reached and the property is retired.

4.2 Coastal Hazard Data

Hazard projections come from the U.S. Geological Survey's Coastal Storm Modeling System (CoSMoS), a physics-based model that integrates wave dynamics, coastal morphology, and bathymetry to project inundation and erosion under future sea level conditions (Barnard et al., 2014, 2019; USGS, 2021). CoSMoS is the primary data product used by the Coastal Commission and OPC for site-level retreat planning and represents the best-available science for parcel-scale coastal hazard assessment in California.

Two versions of CoSMoS are used depending on site type. Flood-prone communities use CoSMoS v3.0, which provides flood depth projections in meters at discrete sea level rise increments ranging from 0 to 3 meters above present. Bluff and cliff communities use CoSMoS v3.1, which projects the future position of the cliff edge under two management scenarios: "Let It Go," representing natural erosion without protective intervention, and "Hold The Line," representing the maintenance of existing armoring. The distance from each property to the projected cliff edge is the key hazard metric for bluff sites.

For flood sites, the model uses projections at three storm return periods: average annual coastal conditions, 20-year storms (5% annual exceedance probability), and 100-year storms (1% annual exceedance probability, equivalent to FEMA's Base Flood Elevation). Having all three return periods allows the model to treat storm occurrence probabilistically rather than assuming worst-case conditions every year—a critical distinction that makes a large difference to long-term damage projections and retreat timing.

Full documentation of the spatial extraction workflow, coordinate system handling, and data quality checks is provided in Appendix B.1.

4.3 Sea level Rise Scenarios

The analysis uses three sea level rise scenarios from the OPC’s 2024 sea level Rise Guidance, the current standard for California state planning (California Ocean Protection Council, 2024):

- **Intermediate (3.12 ft by 2100):** The median projection under moderate emissions pathways. Represents a planning baseline consistent with moderate climate action.
- **Intermediate-High (4.89 ft by 2100):** The 75th percentile outcome under high emissions, reflecting enhanced ice sheet contributions. Appropriate for risk-averse planning where consequences of underestimating sea level rise are severe.

- **High (6.7 ft by 2100):** An extreme scenario incorporating ice sheet instability and tail-risk dynamics. Represents the upper bound of current scientific consensus for planning purposes.

The model brackets projections to let users ask: how do retreat timing and program costs change across the plausible range of futures? A property that requires near-term acquisition under the Intermediate scenario is a clear priority. A property that only crosses the retreat threshold under the High scenario warrants monitoring and contingency planning. Refer to Appendix B.9 for more details, including sensitivity analysis results.

All three scenarios project accelerating sea level rise over the planning horizon, with the most significant increases occurring after 2060. The planning horizon spans 2026 through 2100 (74 years), chosen to align with the OPC projection period and the expected structural lifespan of coastal residential buildings. Refer to Appendix B.2 for more detail.

4.4 Property Data and Valuation

Property data were drawn from Redfin MLS exports for each study area, providing current market values, property characteristics, and geocoded locations for residential parcels. Annual rental income for each property is estimated using a 5% rental yield applied to the current property price. This means a $1.2 million home is assumed to generate approximately $60,000 per year in rental income. The 5% figure is a conservative, literature-grounded benchmark for coastal California residential markets, where rental yields typically fall between 3% and 8% for residential properties (ManageCasa, 2025). Using a uniform yield simplifies analysis and avoids property-specific rent estimation for parcels that may not currently be rented. Because rents are inferred by applying a constant yield to current market price, this approach may understate annual rent if market prices already reflect an expected finite rental horizon under sea level rise rather than a perpetual stream. In that case, the appropriate annualization factor would be slightly higher than 5%, and the potential downward bias grows as the expected remaining rental horizon shortens. Sensitivity analysis explores the effect of 4% and 6% yields. Refer to Appendix B.3 for more details.

4.5 Determining the End of a Property's Lifespan (T*)

The end of the property's economic lifespan, T*, is the year at which continued occupancy no longer makes economic sense for the property owner. For flood-exposed properties, T* is estimated using net present value (NPV) analysis. For bluff and cliff properties, T* is determined using a physical safety threshold. This distinction matters for how results should be interpreted across sites.

4.5.1 Flood sites: NPV-based retreat timing

For flood-exposed properties, each year in the planning horizon is evaluated by asking: from this year forward, is the present value of expected future rental income greater than or less than the present value of expected future flood damages? T* is the first year when damages overtake income, the tipping point where staying becomes economically irrational for the owner.

Both streams are valued using a 5% market discount rate, which reflects private-sector opportunity costs and is aligned with typical real estate returns. Rental income is treated as a perpetuity since the property could, in principle, continue generating income indefinitely at its current level if hazards were not increasing. Expected flood damages are calculated through 2100 using the modeled hazard projections, with a perpetual tail added beyond 2100 to ensure the two streams are comparable. This framing means that T* is not driven by a single catastrophic event. A property retreats when the cumulative weight of expected future damages, including both frequent minor flooding and occasional severe storms, exceeds the cumulative value of future housing services. Refer to Appendix B.7 for more details.

4.5.2 Cliff sites: threshold-based retreat timing

For bluff and cliff properties, the economic NPV framework does not directly apply because bluff failure is discrete rather than gradual. A property does not “accumulate cliff damage" in the way that a flooded home sustains incremental structural losses. Instead, retreat is triggered by a safety threshold: T* is the year when the projected cliff edge reaches within 10 meters of the structure. The 10-meter setback represents a minimum safe distance before imminent structural failure risk triggers evacuation or condemnation. Properties already within 10 meters at baseline receive a T* of 1, meaning immediate acquisition is recommended regardless of economic calculations. Properties where the cliff never approaches within 10 meters during the modeled planning horizon are classified as beyond the 2100 planning horizon.

Because cliff retreat in CoSMoS projections is deterministic, having no stochastic element analogous to storm timing, cliff-based T* values are single-point estimates rather than distributions. They are also insensitive to economic parameters like rental yield and discount rate, which makes cliff retreat results more straightforward to interpret and potentially more amenable to regulatory mandates than flood-based timing. Refer to Appendix B.5 for more details.

4.6 Accounting for Storm Uncertainty: The Monte Carlo Approach

Coastal flood damage does not arrive on a predictable schedule. A property might experience a 100-year storm when sea levels are still relatively low, or it might go 30 years with nothing worse than minor nuisance flooding while baseline hazard creeps upward. Treating storm events as annual certainties, assuming the worst-case storm depth every year, would dramatically overestimate damages and produce retreats that are far too early. Ignoring extreme events entirely would underestimate risk and produce retreats that are too late. A simpler approach, common in economic damage assessments, is to select a single design storm (typically the 1% annual chance event) and apply it deterministically throughout the planning horizon; this avoids both extremes but substitutes an arbitrary threshold for the full distribution of storm outcomes, obscuring how sensitive retreat timing is to that choice. Monte Carlo simulation addresses this by drawing storm events probabilistically in each year of each simulation, sampling from the observed return-period distribution rather than fixing a single scenario.

The model resolves this by running 1,000 independent simulations for each property under each SLR scenario, drawing storm intensity probabilistically for every year in the planning horizon. In each simulated year, average conditions occur with 94% probability, a 20-year storm occurs with 5% probability, and a 100-year storm occurs with 1% probability. These probabilities correspond directly to the standard statistical return period definitions used in floodplain management (FEMA, 2022). Each simulation produces its own T* based on that particular storm sequence, generating a distribution of 1,000 retreat years per property.

The reported T* for each property is the mean of that distribution, the expected retreat year across all plausible storm sequences. The median, standard deviation, and 5th/95th percentile values are also calculated. These statistics matter for planning in different ways: the mean captures expected value including tail risk, the median represents the most likely single outcome, and the spread of the distribution indicates how much storm timing uncertainty affects retreat timing for that particular property.

A key interpretive note: when the *mean* T* for a property is, say, year 52, but the *median* is beyond the planning horizon, this means that the majority of storm realizations never trigger retreat by 2100, but a meaningful minority do, in the 60–75 year range, and those scenarios pull the mean down. This is not a contradiction; it reflects genuine uncertainty. Planners should read both statistics: the mean as the expected cost exposure, and the median as the most likely single outcome.

The Monte Carlo simulation applies only to flood sites. Cliff retreat is deterministic within CoSMoS projections, so single T* values are reported for cliff-exposed properties without simulation uncertainty. Refer to Appendix B.6 for more details.

4.7 Defining Buyout Pricing

Traditional government property buyouts—most commonly through FEMA's Hazard Mitigation Grant Program—pay pre-disaster fair market value (Hino et al., 2017; Freudenberg et al., 2016). Because coastal property values in many markets have not yet fully incorporated future flood risk, this approach can result in the government paying for risk-inflated prices (Bernstein et al., 2019). It also creates no financial distinction between a property facing imminent hazard and one with decades of viable use remaining—a structural inefficiency that NPV-based pricing is designed to correct.

The model calculates buyout prices using the same NPV framework that determines T*. The buyout price equals the present value of rental income the property could generate from the present through T*, not beyond, because T* marks the end of a property's economic lifespan. Formally, this is the discounted sum of annual rental income over the remaining viable occupancy period, discounted at the 5% market rate.

This pricing approach has several practical consequences worth understanding before reviewing the results:

- **Prices scale with remaining viable life.** A $2 million property facing T* in 20 years receives approximately $1.25 million in buyout compensation, the discounted value of 20 years of rental income. The same property facing T* in 50 years receives approximately $1.83 million. The $580,000 difference reflects a genuine economic difference in remaining use value, not arbitrary discounting.
- **More vulnerable properties receive lower buyout prices.** This is by design: properties with shorter T* are closer to the end of their economic life and are correctly valued less. This creates natural incentives for early participation, waiting to sell reduces compensation as each year of viable income is foregone.
- **Prices do not include structure value at T*.** At T*, by definition, the structure has reached the end of its economic life. Paying for structure value at that point would compensate owners for an asset that is no longer generating net economic value. Land value is implicitly captured in the rental income stream, since rental income reflects the full value of occupying the property, land and structure alike.

Refer to Appendix B.8 for more details.

4.8 Government Costs and the Leaseback Revenue Offset

The buyout-leaseback structure distinguishes this model from traditional one-time buyout programs. After acquisition, the government leases the property back to the original owner or a new lessee at market rent. The owner continues living in the home, paying rent, and remains responsible for normal maintenance, while the government covers repair costs for major flood damage until T* is reached and the property is vacated.

This rental income stream creates a meaningful revenue offset against acquisition costs, and both are discounted at a government discount rate lower than the 5% market rate used to set buyout prices. As proposed under SB 1078, the State Coastal Conservancy would administer a revolving loan fund issuing low-interest loans to local jurisdictions for managed retreat, implying a public cost of capital below typical private market rates. We therefore use 2% as the baseline government discount rate to reflect concessional public financing conditions, with sensitivity analysis at 3% and 4% to bracket higher borrowing-cost environments. This rate difference matters: because the same stream of rental income is worth more when discounted at 2% than at 5%, the government effectively collects more value from the leaseback than it paid for the income stream in the buyout price. This is the discount rate arbitrage that makes the leaseback structure financially advantageous relative to a conventional buyout.

Whether any individual property generates net revenue or net cost for the government depends on how much flood repair is required during the leaseback period. Properties with low flood damage exposure and high rental income tend toward revenue generation; properties that suffer repeated severe damage before T* is reached tends toward net cost. The results section reports net public cost, which is equal to the buyout price plus expected repair costs and minus expected leaseback revenue, for each property and site. The government discount rate (δ_g) reflects social discount rates appropriate for long-term public planning. Lower rates increase both leaseback revenue (favorable) and the present value of repair costs (unfavorable), with the net effect varying by property. Refer to Appendix B.8 for more details.

4.9 How to Read the Model Results

The results in Chapter 5 follow a consistent structure across the five case study sites. For each site, results are generated under the baseline Intermediate-High sea level rise scenario and shared model parameters listed in Table 5.0. A few interpretive points help when reading the figures and tables:

- **T* is an economic signal, not a prediction.** The model identifies when retreat becomes economically optimal for a property owner given stated assumptions. Properties may remain occupied beyond T* if owners choose to accept escalating damage costs, or may retreat earlier if hazards accelerate faster than projected.
- **Cliff and flood results use different metrics and should not be directly compared.** Cliff-based T* reflects a physical safety threshold and is deterministic; flood-based T* reflects an economic optimization and is probabilistic. Both answer the same policy question, when to acquire, but through different mechanisms.

Complete technical documentation of the model equations, parameter choices, data processing pipeline, and sensitivity analysis design is provided in Appendix B. Readers interested in replicating or extending the analysis should begin there.

5. Case Studies of Buyout-Leaseback

This section uses a neighborhood-scale case study approach to examine how a BOLB strategy could support managed shoreline retreat across coastal California by asking four related questions for each neighborhood analysis:

1. What is the public cost of a BOLB program at the parcel and neighborhood scale?
2. How do BOLB program timelines vary across properties and communities?
3. How do modeled buyout prices compare to current market prices?
4. How do outcomes vary across hazard types (flood and cliff erosion) and property values?

The selected case studies include Carpinteria, King Salmon, Isla Vista, Stinson Beach, and Pacifica, and were chosen to represent diverse coastal geomorphologies such as sandy beaches, low-lying floodplains, and bluff-backed shorelines, as well as a range of property market conditions, governance, and social-demographic contexts. Each case study has documented exposure to sea level rise, flooding, erosion, or bluff instability and has engaged, either explicitly or implicitly, with coastal adaptation planning through LCPs, hazard mitigation plans, vulnerability assessments, or adaptation plans.

For each case study below, we model expected economic lifespan, buyout price, leaseback advantage, and public net cost at the property level. Leaseback advantage is defined as leaseback revenue minus buyout price. We use modeled expected economic lifespan as the assumed lease duration for subsequent BOLB estimates. This simplified assumption does not incorporate planning and acquisition time before leaseback begins and likely represents an upper-bound lease duration, as retreat could occur earlier due to other site-specific retreat triggers prioritized by the community or local government (e.g., environmental thresholds or coastal resource conditions). Public net costs further assume that flood damages occur annually over each property's expected economic lifespan. As a result, net costs could be lower if the program were paired with short-term protective measures that reduce damages during the leaseback period. All model runs apply the same baseline sea level rise scenario and model parameters listed in Table 5.0.

Table 5.0. Baseline BOLB model inputs for case study applications.

Planning Horizon	SLR Scenario	Mgmt. Scenario (Cliffs Only)	Market Discount Rate	Gov. Discount Rate	Depth Damage Threshold
74 yrs; 2026 - 2100	Intermediate - High	Let It Go	5%	2%	0.15 Meters

5.1 Carpinteria, Santa Barbara County

The City of Carpinteria is a small coastal community located along the southern edge of Santa Barbara County, situated between the Santa Ynez Mountains and the Pacific Ocean. Carpinteria was selected as a case study because it exhibits a convergence of physical vulnerability, high-value coastal development, and an advanced coastal planning framework that explicitly acknowledges managed retreat (City of Carpinteria, 2025). The city has already experienced significant coastal damage during past storm events, such as the 1983 El Niño, and anticipates increasing exposure to coastal flooding, erosion, and tidal inundation over the coming decades. At the same time, Carpinteria's economy is closely tied to coastal tourism and recreation, raising the stakes of adaptation decisions that affect shoreline access, housing, and public infrastructure.

Within Carpinteria, this analysis focuses specifically on the Sandyland and Sand Point neighborhoods, two low-lying residential areas located directly along the shoreline. These neighborhoods contain coastal development situated immediately landward of the beach and adjacent to the Carpinteria Salt Marsh. Their proximity to the shoreline, combined with relatively low elevations and a history of storm damage and flooding, makes them among some of the most physically vulnerable areas in the city.

5.1.1 Environment and infrastructure

Carpinteria's coastline is characterized by a transition from sandy, low-lying beaches in the western portion of the city to higher coastal bluffs and open spaces to the east (City of Carpinteria, 2022). The beach neighborhoods (Sandyland and Sand Point) which contain a concentration of multi-family residential development along the shoreline, are particularly vulnerable to wave runup, storm surge, and tidal flooding. These structures account for a substantial share of the city's vulnerable coastal parcels and include a significant number of short-term vacation rentals that contribute to local tourism revenue and transient occupancy taxes (City of Carpinteria, 2025). The city also relies on engineered measures such as seasonal beach berm construction to reduce storm damage to shoreline residences such as the Beach Neighborhood (City of Carpinteria, 2025).

In addition to shoreline hazards, Capinteria is bordered by the Carpinteria Salt Marsh and associated wetland system, which provides important ecological functions but also contribute to tidal inundation risks in surrounding low-lying developed areas (City of Carpinteria, 2025). Many of the city's most vulnerable neighborhoods were historically constructed on former wetland or floodplain areas, increasing their exposure to rising groundwater and flooding under future sea level rise scenarios (City of Carpinteria, 2023). The spatial configuration of development, combined with limited inland space for relocation and the presence of sensitive habitats, constrains retreat approaches that rely on largescale relocation or redevelopment farther inland, as opposed to approaches that might simply retire development.

5.1.2 Social, cultural, and historical considerations

Carpinteria has a strong cultural identity rooted in its history as a coastal settlement and its long-standing relationship with the ocean. Predating modern development, Indigenous Chumash communities inhabited the area. Today, coastal residential neighborhoods are not perceived solely as assets at risk, but as long-standing communities with cultural significance and social networks closely tied to the coast (City of Carpinteria, 2022).

Carpinteria's coastal development reflects broader patterns of coastal settlement in California, where homes, transportation corridors, and public infrastructure were constructed in close proximity to the shoreline during periods when long-term sea level rise was not considered in land use planning. The Local Hazard Mitigation Plan highlights how legacy development decisions have increased exposure to coastal flooding, erosion, and storm damage, particularly in low-lying areas adjacent to the beach and former wetland systems (City of Carpinteria, 2023).

5.1.3 Coastal governance and policy framework

Carpinteria's entire land area lies within the California Coastal Zone, meaning that all development is subject to the policies of the California Coastal Act and the city's Local Coastal Program. The Coastal Land Use Plan and General Plan explicitly recognize sea level rise, coastal flooding, and shoreline erosion as long-term hazards that must be addressed though land use planning and adaptation strategies (City of Carpinteria, 2025).

While the city’s Coastal Resilience Element prioritizes protection of public access, recreation, and coastal resources, rather than relying on a single adaptation strategy, the City identifies a portfolio of responses, including protection, accommodation, managed retreat, and hybrid strategies, that can be implemented incrementally as hazards intensify over time (City of Carpinteria, 2025). Within this framework, Carpinteria explicitly acknowledges managed shoreline retreat as a possible long-term strategy in areas where continued protection or accommodation is no longer feasible (City of Carpinteria, 2025). The city mentions acquisition and buyout programs, relocation incentives, and limitations on new development in hazardous areas as tools to support retreat. Importantly, managed retreat is not presented as an immediate solution, but as part of a longer-term transition that may be preceded by protective or accommodative measures that provide time for planning and financing.

5.1.4 Application of buyout-leaseback model

We applied the buyout-leaseback framework to properties in the Sandpoint and Sandyland neighborhoods located seaward of Carpinteria Salt Marsh. Across these neighborhoods, 82% of properties are expected to reach the end of their economic lifespan within our modeled 75-year planning horizon through 2100. For these properties, the median expected economic lifespan, T*, is 22 years, ending in 2048 (Table 5.1.a). The largest share of properties (43%) are projected to reach the end of their economic lifespan within 10-25 years, followed by 29% within 25-50 years and 10% within the first 10 years. Expected economic lifespan shows localized clustering across adjacent properties, but no consistent spatial gradient across the neighborhood. In some cases, properties with short modeled lifespans of just 10-25 years occur next to properties whose lifespans exceed the planning horizon (Figure 5.1.b). This variability likely reflects fine-scale differences in site conditions and property values. Because expected rental returns scale with property price in our framework, very high-value properties can retain long modeled economic lifespans even under high exposure, implying that risk would need to be substantially greater for these parcels to reach end-of-lifespan within the planning horizon. As expected economic lifespan underlies the other BOLB outputs, similar patchy spatial variation is also seen in buyout price, leaseback revenue, and public net cost.

Based on these expected economic lifespans, the median buyout price across properties is $1.48 million and the total neighborhood buyout cost for all applicable properties is approximately $263 million (Table 5.1.a). This median buyout price is roughly 40% of the median market property value across both neighborhoods, indicating a substantial gap between current market prices and values adjusted for the SLR-related risks captured in our model. This gap may reflect market expectations and policy uncertainty around future protection and assistance, but it may also partially reflect limitations in our rent estimation approach, which infers rents from current prices using a uniform yield and could understate rents if prices already embed a finite rental horizon under SLR. Property buyout values across the two neighborhoods are high overall, but notably the distribution is strongly right-skewed due to a small number of properties valued above $10 million. As shown in Figure 5.1.a, this skew carries through to the modeled distributions of leaseback revenue and public net cost.

Using the public discount rate of 2%, versus 5% for private benefits, the leaseback program generates a median discounted public revenue of $432,124 per property. Assuming the government is responsible for flood repair costs during the leaseback period, the median public net cost is $529,178 per property, with an estimated total neighborhood net cost of approximately $75 million for all applicable properties (Table 5.1.a).

Table 5.1.a. Key BOLB model results in Carpinteria. Table reports summary statistics for modeled BOLB outcomes in Carpinteria at the property and neighborhood scale. All results are generated using the baseline model parameters.

BOLB Model Outputs	Median Per Parcel	Neighborhood Total
Market Value	$3,869,644	-
Expected Economic Lifespan	22 years	-
Buyout Price	$1,481,178	$263,124,986
Leaseback Advantage	$432,124	$88,167,864
Public Net Cost	$529,178	$74,903,233

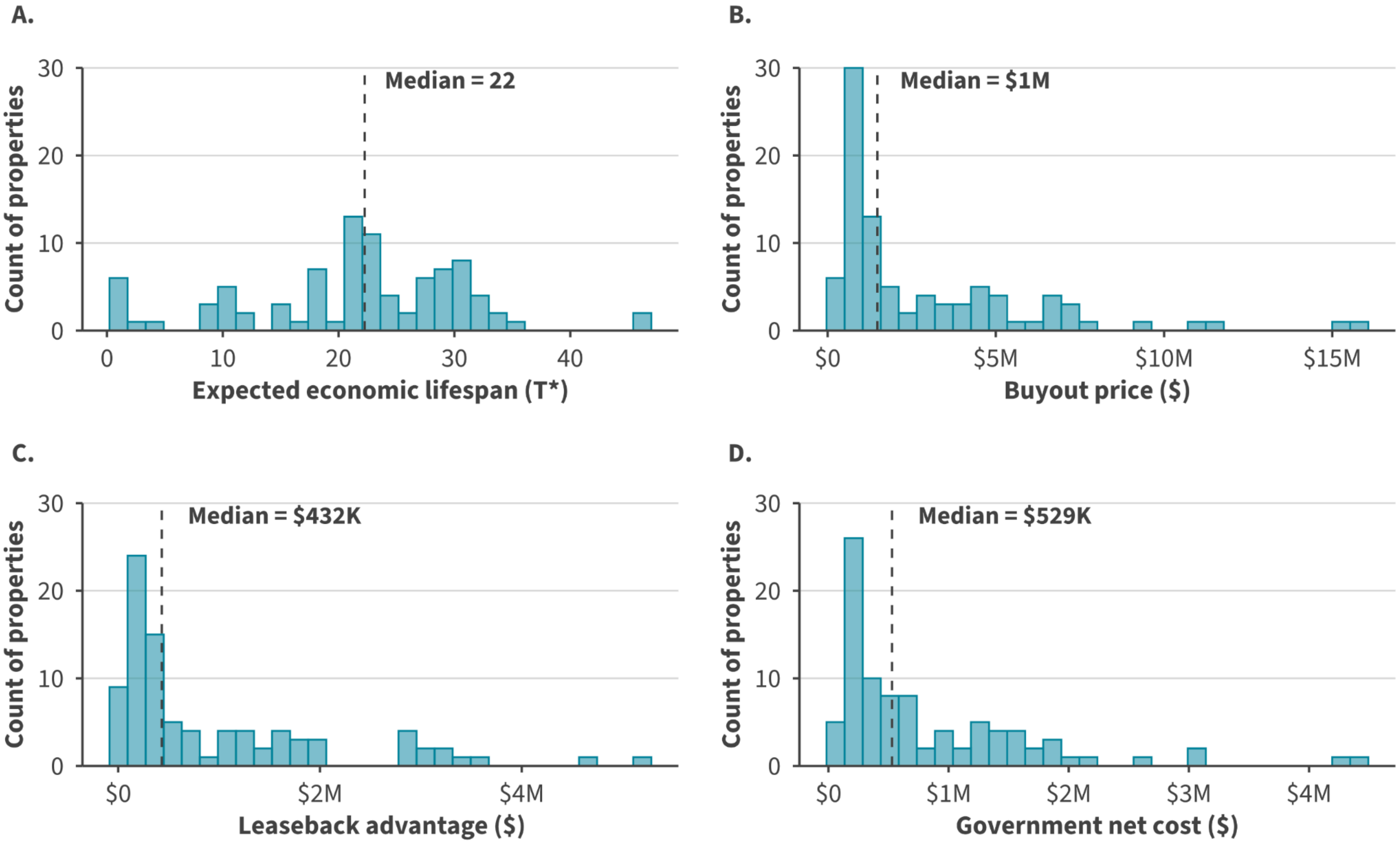


Figure 5.1.a. Distributions of key BOLB model results for Carpinteria. Subfigures show histograms of property-level modeled outcomes for expected economic lifespan (A), buyout price (B), leaseback advantage (C), and public net cost (D), with each distribution plotted using 30 bins.

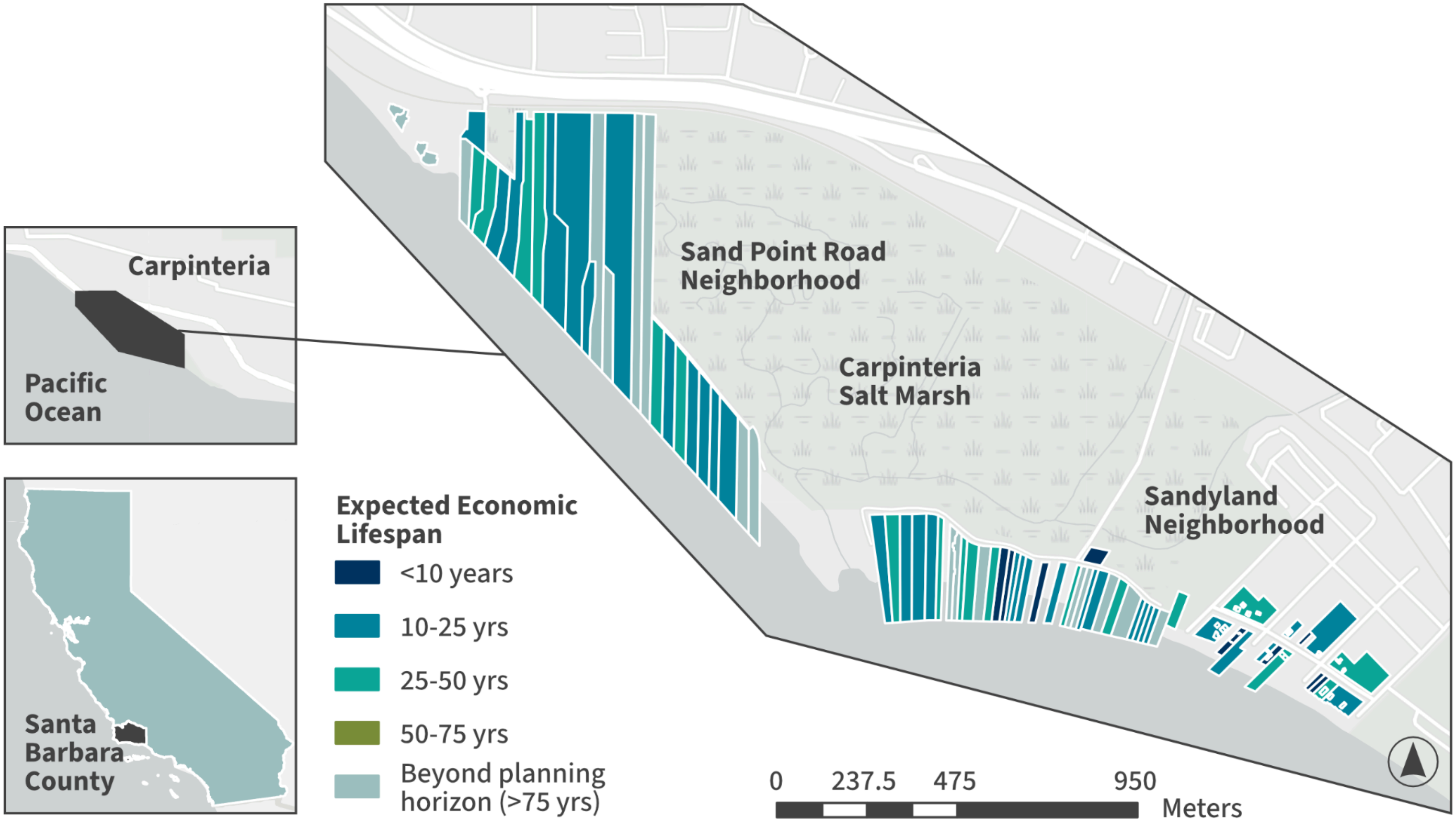


Figure 5.1.b. **Property-level map of expected economic lifespan in Carpinteria.** Properties are symbolized by their modeled expected economic lifespan under the baseline scenario, showing spatial variation in retreat timing across the case study area.

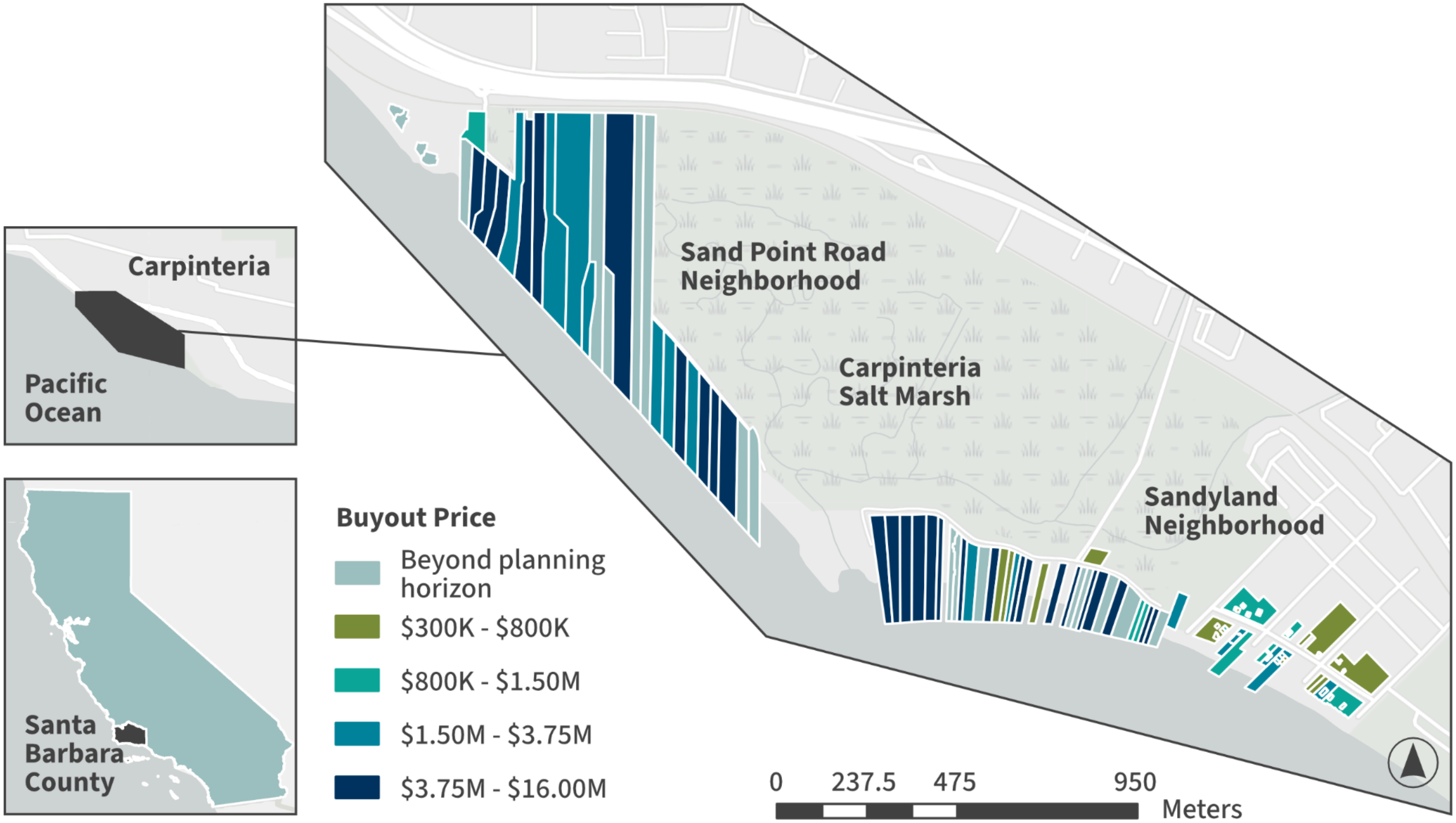


Figure 5.1.c. Property-level map of buyout price in Carpinteria. Properties are symbolized by their modeled buyout price under the baseline scenario, showing spatial variation in price across the case study area. Symbol classes are based on rounded quartile breaks.

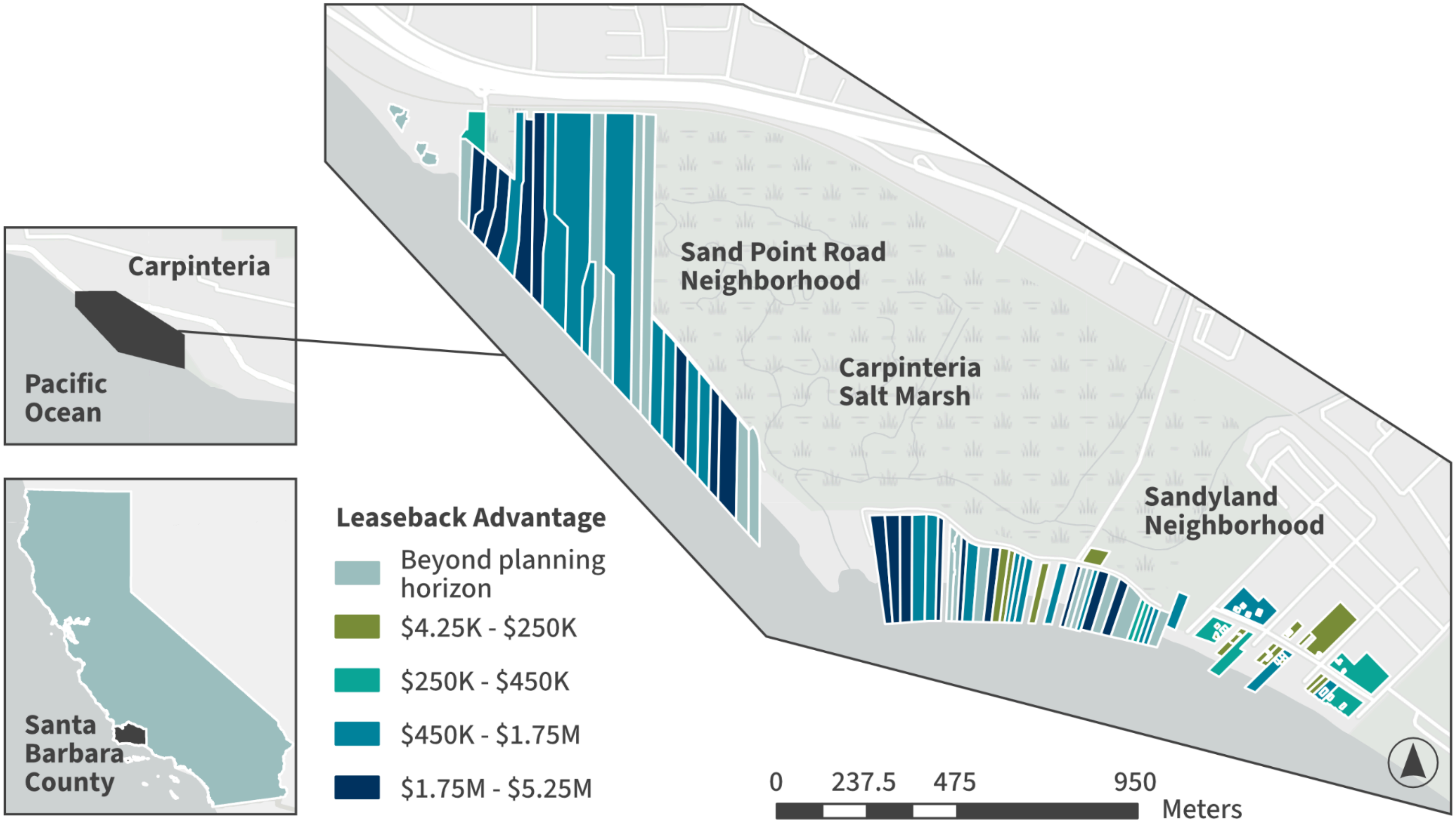


Figure 5.1.d. Property-level map of leaseback advantage in Carpinteria. Properties are symbolized by their modeled expected leaseback advantage under the baseline scenario, showing spatial variation across the case study area. Symbol classes are based on rounded quartile breaks.

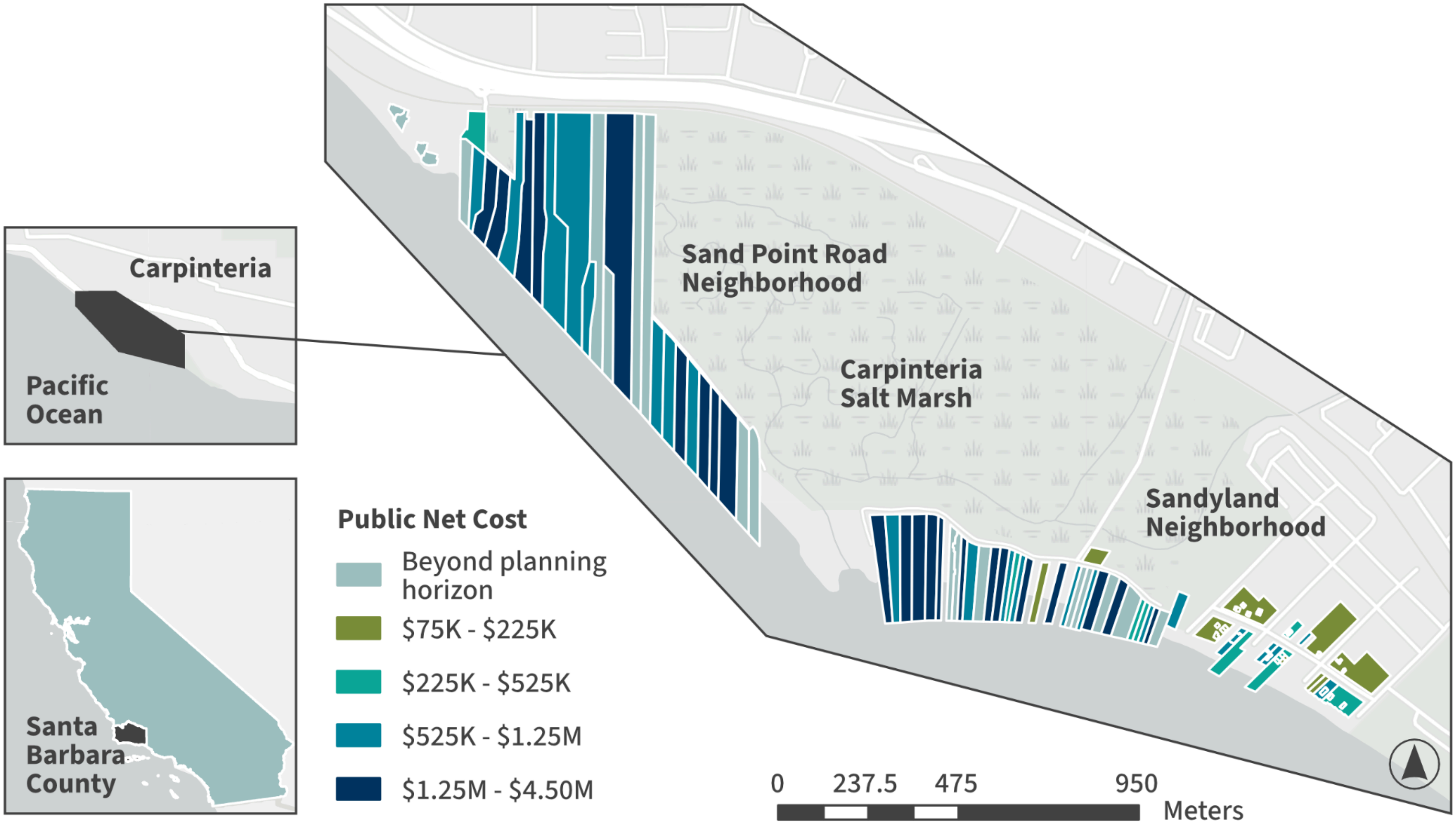


Figure 5.1.e. Property-level map of public net cost in Carpinteria. Properties are symbolized by their modeled public net cost under the baseline scenario, showing spatial variation in BOLB program cost across the case study area. Symbol classes are based on rounded quartile breaks.

5.2 Isla Vista, Santa Barbara County

Isla Vista is a densely developed, unincorporated coastal community located along the south coast of Santa Barbara County, west of the City of Santa Barbara and adjacent to the University of California, Santa Barbara campus. Residential development in Isla Vista is concentrated atop coastal bluffs that front the Pacific Ocean, placing a large share of the housing stock directly at risk (County of Santa Barbara, 2019). Isla Vista represents a coastal setting where erosion-driven land loss is already occurring, and where retreat is being implemented incrementally through regulatory mechanisms rather than comprehensive relocation (County of Santa Barbara, 2024).

5.2.1 Environment and infrastructure

Isla Vista's coastline is characterized by high coastal bluffs composed of unconsolidated terrace deposits and marine sediments that are subject to weathering, wave undercutting, slumping, and episodic landslides (County of Santa Barbara, 2024). Historical analyses indicate average bluff retreat rates of approximately six inches per year, with single-event failures capable of removing substantially larger portions of the bluff face without warning (County of Santa Barbara, 2019). Sea level rise is expected to exacerbate these processes by increasing wave energy and erosion at the base of the bluffs, further reducing bluff stability over time (County of Santa Barbara, 2024).

Residential development in Isla Vista is dominated by dense, multi-unit rental housing oriented toward student occupancy, with buildings located directly along Del Playa Drive within very close proximity to active erosion hazards (County of Santa Barbara, 2024). Many of these structures were originally constructed with greater separation from the bluff edge; however, continued bluff retreat has since reduced setbacks over time, placing buildings in increasingly vulnerable locations (County of Santa Barbara, 2019). In addition to housing, public access stairways, utilities, and local roadways serving bluff-top development are also vulnerable to erosion and slope instability as the bluff face retreats landward (County of Santa Barbara, 2019).

5.2.2 Social, cultural, and historical considerations

Isla Vista was initially characterized by low-intensity land uses, including agriculture, open coastal bluff terrain, and sparse development (County of Santa Barbara, 1993). In the mid-20th century, residential development accelerated alongside the expansion of the University of California, Santa Barbara, transforming the area into a dense coastal community designed primarily to accommodate student housing demand (County of Santa Barbara, 2019). This growth pattern prioritized rapid residential construction and proximity to campus over long-term hazard considerations, resulting in a built environment dominated by multi-unit rental structures with limited setbacks from the coastal bluffs (County of Santa Barbara, 2019; County of Santa Barbara, 2024).

Isla Vista's social and economic character is defined by its role as a renter-dominated, student-oriented housing market serving a large university population (County of Santa Barbara, 2019). High occupancy rates and persistent housing demand have produced a supply-constrained housing environment with limited capacity to absorb housing loss or displacement associated with ongoing bluff retreat within the community itself (County of Santa Barbara, 2019; County of Santa Barbara, 1993). This structure complicates adaptation to coastal hazards, as tenants typically have little control over structural investment decisions, while property owners face increasing regulatory constraints on redevelopment or reinforcement near the bluff edge (County of Santa Barbara, 2024). As erosion progresses, the social costs of bluff retreat are therefore borne disproportionately by residents who may have few comparable housing alternatives nearby. This raises significant concerns about displacement, housing access, and the feasibility of retreat strategies that do not account for Isla Vista's constrained housing market and transient population.

5.2.3 Coastal governance and policy framework

Isla Vista, as an unincorporated community, is subject to Santa Barbara County land use authority rather than municipal governance (County of Santa Barbara, 2019). Coastal planning and hazard management in Isla Vista are guided by the County's Coastal Land Use Plan, which includes policies addressing coastal erosion, bluff instability, and limitations on shoreline protection measures (County of Santa Barbara, 2019). The Land Use Plan emphasizes avoidance of new development in hazardous bluff areas and generally discourages the use of shoreline armoring except where necessary to protect existing principal structures, consistent with Coastal Act policies that prioritize natural shoreline processes and public access (County of Santa Barbara, 2019). The plan further limits bluff protection measures that would fix the shoreline, exacerbate erosion, or require ongoing armoring to maintain development, placing an emphasis on long-term risk reduction rather than permanent stabilization of bluff edges (County of Santa Barbara, 2019).

Santa Barbara County's Isla Vista Bluff Policy establishes a site-specific regulatory approach that effectively functions as an incremental retreat mechanism. The policy requires monitoring, geotechnical evaluation, structural cutbacks, or vacancy as buildings approach defined setback thresholds from the bluff edge (County of Santa Barbara, 2024). Structures located within 20 feet of the bluff are subject to mandatory monitoring and engineering review, while structures within 10 feet may be required to vacate unsafe portions of the building (County of Santa Barbara, 2024). Rather than relying on large-scale shoreline protection, this approach acknowledges that continued occupation of bluff-edge development is time-limited and that retreat is likely to occur progressively through partial building removal and loss of developable land over time.

5.2.4 Application of buyout-leaseback

We applied the buyout-leaseback framework to properties in the Del Playa Bluffs neighborhood. Across this neighborhood, 82% of properties are expected to reach the end of their economic lifespan within our modeled 75-year planning horizon through 2100. For these properties, the median expected economic lifespan, T*, is 34 years, ending in 2060 (Table 5.2.a). The largest share of properties (48%) are projected to reach the end of their economic lifespan within 25-50 years, followed by 20% within the first 10 years and 10% within 50-75 years. The distribution of expected economic lifespan is tightly and unimodally clustered, producing a relatively smooth pattern in the histogram (Figure 5.2.a-A). Spatially, lifespans show localized clustering across adjacent properties but no consistent neighborhood-scale gradient. In some cases, properties with short modeled lifespans of just 10-25 years occur next to properties whose lifespans exceed the planning horizon (Figure 5.2.b). Because expected economic lifespan underlies the other BOLB outputs, similar patchy spatial variation is also seen in buyout price, leaseback advantage, and public net cost. At cliff-erosion sites, T* is determined by when projected cliff retreat crosses a fixed setback threshold, so spatial patterns primarily reflect variation in initial setback distances between parcels and the cliff edge rather than differences in property value or retreat rates. The patchier pattern in Isla Vista is therefore consistent with more irregular parcel geometry and variable starting buffers relative to the cliff edge, and it may be amplified by our use of a uniform setback threshold rather than parcel-specific thresholds (e.g., varying by parcel size or site geometry).

Based on these expected economic lifespans, the median buyout price across properties is $1.21 million and the total neighborhood buyout cost for all applicable properties is approximately $45.5 million (Table 5.2.a). This median buyout price is roughly 70% of the median market property value across both neighborhoods, indicating a moderate gap between current market prices and values adjusted for the SLR-related risks captured in our model. This gap may reflect market expectations and policy uncertainty around future protection and assistance, but it may also partially reflect limitations in our rent estimation approach, which infers rents from current prices using a uniform yield and could understate rents if prices already embed a finite rental horizon under SLR. Property buyout values across the neighborhood are fairly moderate overall, but the distribution is broad and spans a wide range from roughly $75,000 to over $2 million. Notably, the distribution is bimodal, with higher concentrations of both low and high buyout values. As shown in Figure 5.2.a, this pattern carries through to the modeled distributions of leaseback revenue and public net cost.

Using the public discount rate of 2%, versus 5% for private benefits, the leaseback program generates a median discounted public revenue of $663,752 per property. For cliff-retreat cases, retreat is treated as a one-time acquisition and relocation decision prior to catastrophic failure, rather than being driven by cumulative damages over time. Because ongoing damages are not modeled during the leaseback period, the public net cost is simply the inverse of the leaseback advantage, and the net-positive outcome is driven primarily by the discount-rate differential. Accordingly, the median public net cost is -$663,752 per property, totaling -$24M across the neighborhood. These results indicate that BOLB can be net-profitable for the public sector in cliff settings, highlighting an important implication of the framework.

Table 5.2.a. Key BOLB model results in Isla Vista. Table reports summary statistics for modeled BOLB outcomes in Isla Vista at the property and neighborhood scale. All results are generated using the baseline model parameters.

BOLB Model Outputs	Median Per Parcel	Neighborhood Total
Market Value	$1,706,681	-
Expected Economic Lifespan	34 years	-
Buyout Price	$1,215,839	$45,435,756
Leaseback Advantage	$663,752	$24,355,025
Public Net Cost	-$663,752	-$24,355,025

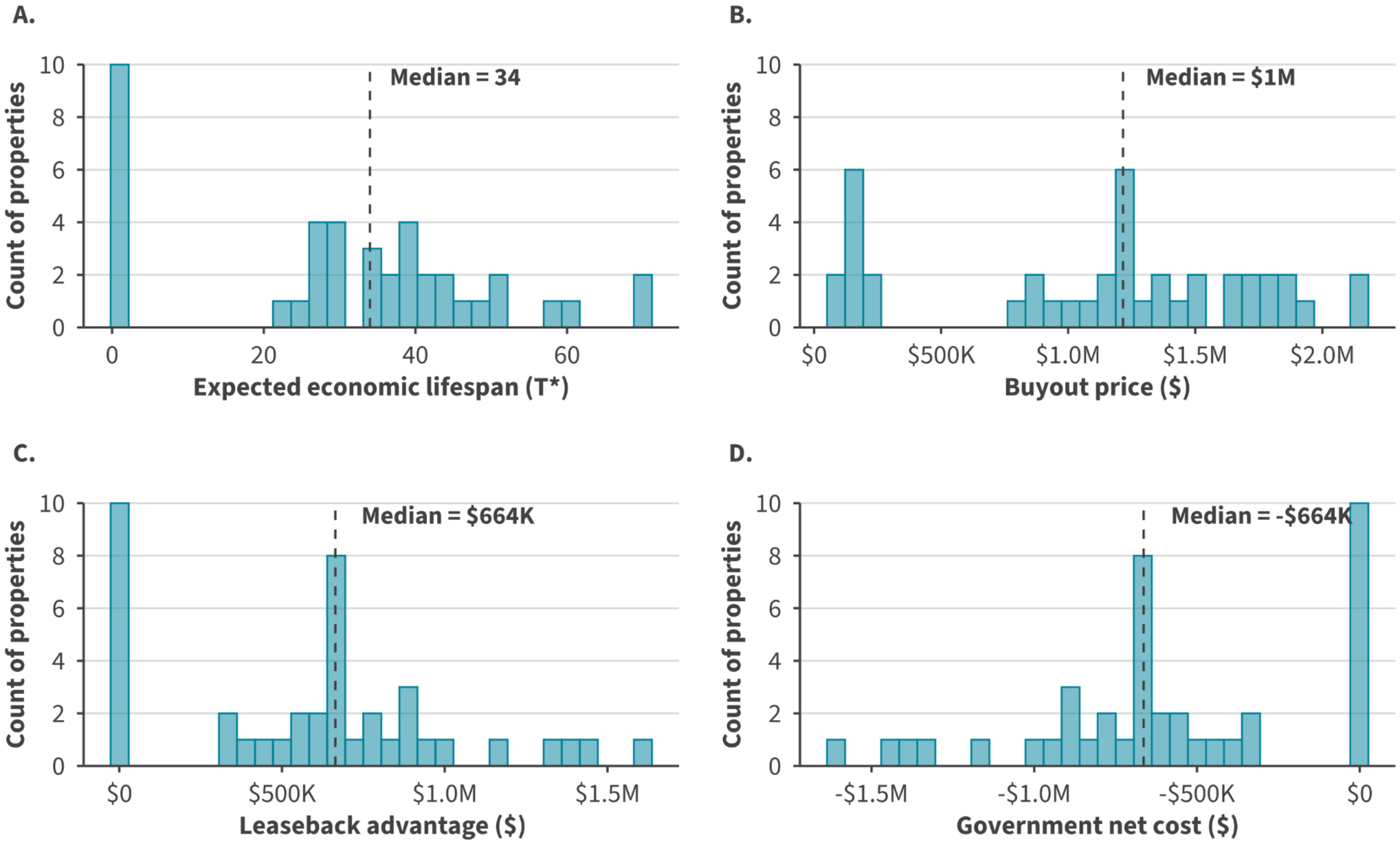


Figure 5.2.a. Distributions of key BOLB model results for Isla Vista. Subfigures show histograms of property-level modeled outcomes for expected economic lifespan (A), buyout price (B), leaseback advantage (C), and public net cost (D), with each distribution plotted using 30 bins.

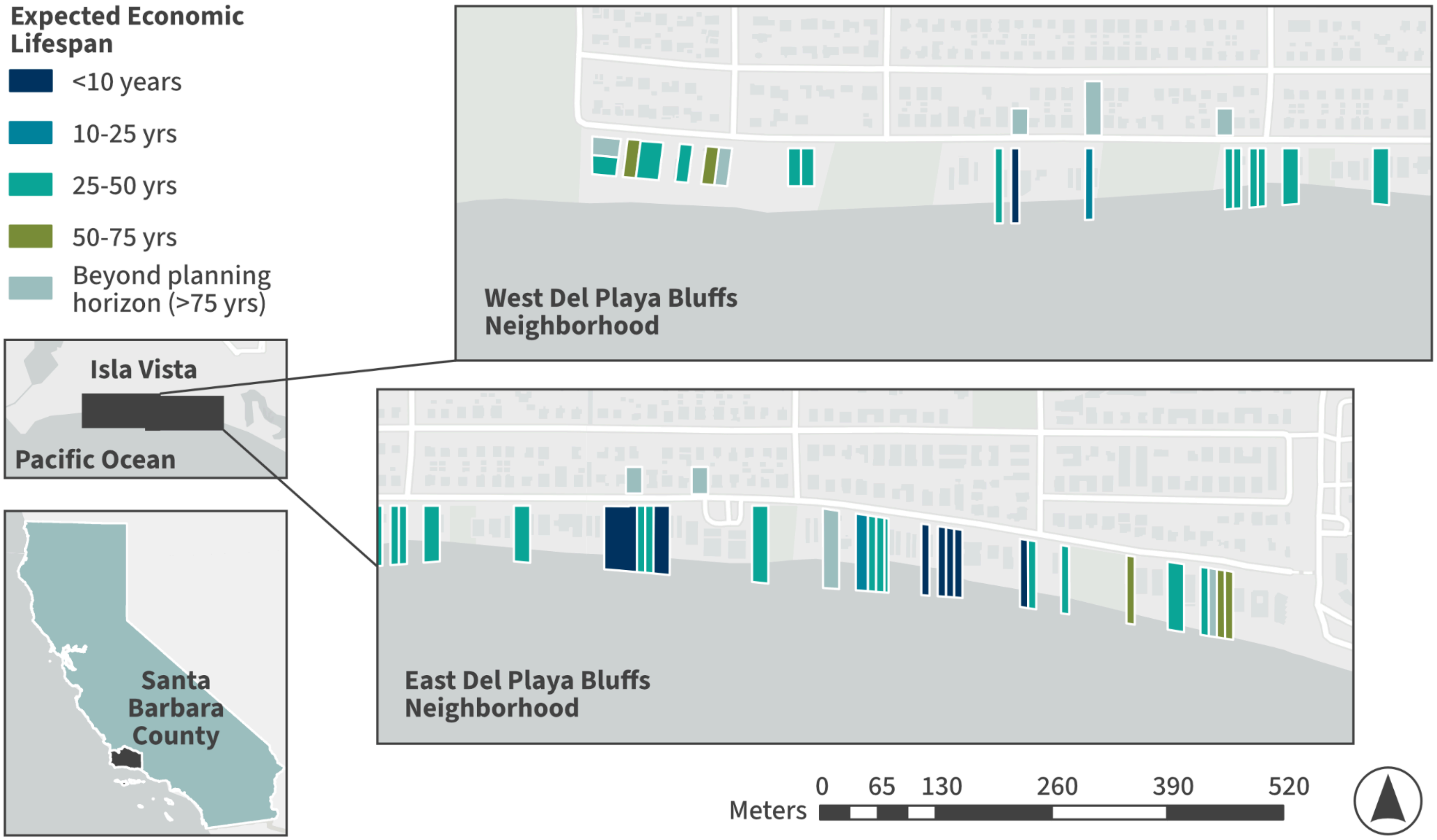


Figure 5.2.b. **Property-level map of expected economic lifespan in Isla Vista.** Properties are symbolized by their modeled expected economic lifespan under the baseline scenario, showing spatial variation in retreat timing across the case study area. Symbol classes are based on rounded quartile breaks.

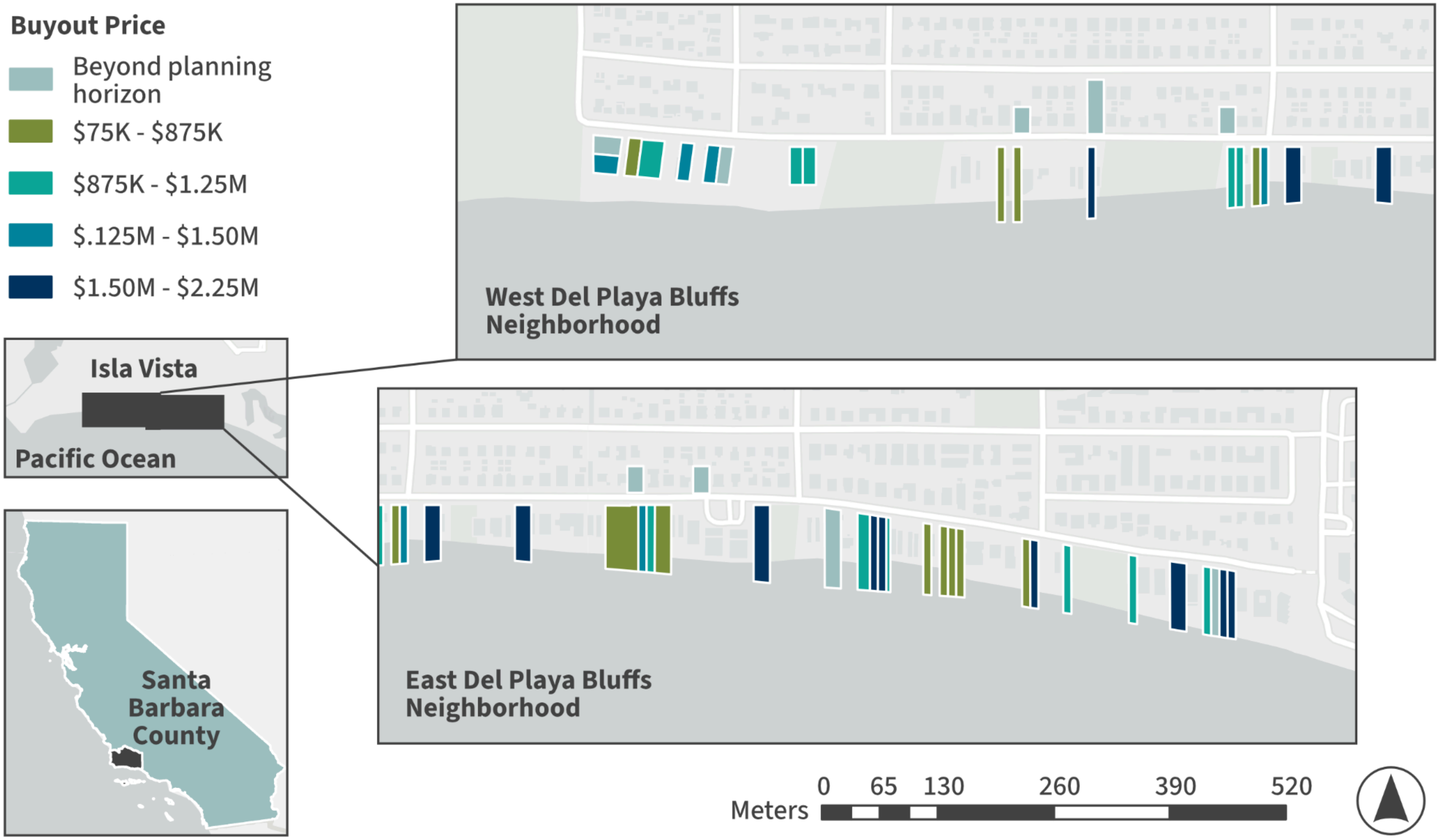


Figure 5.2.c. Property-level map of buyout price in Isla Vista. Properties are symbolized by their modeled buyout price under the baseline scenario, showing spatial variation in price across the case study area. Symbol classes are based on rounded quartile breaks.

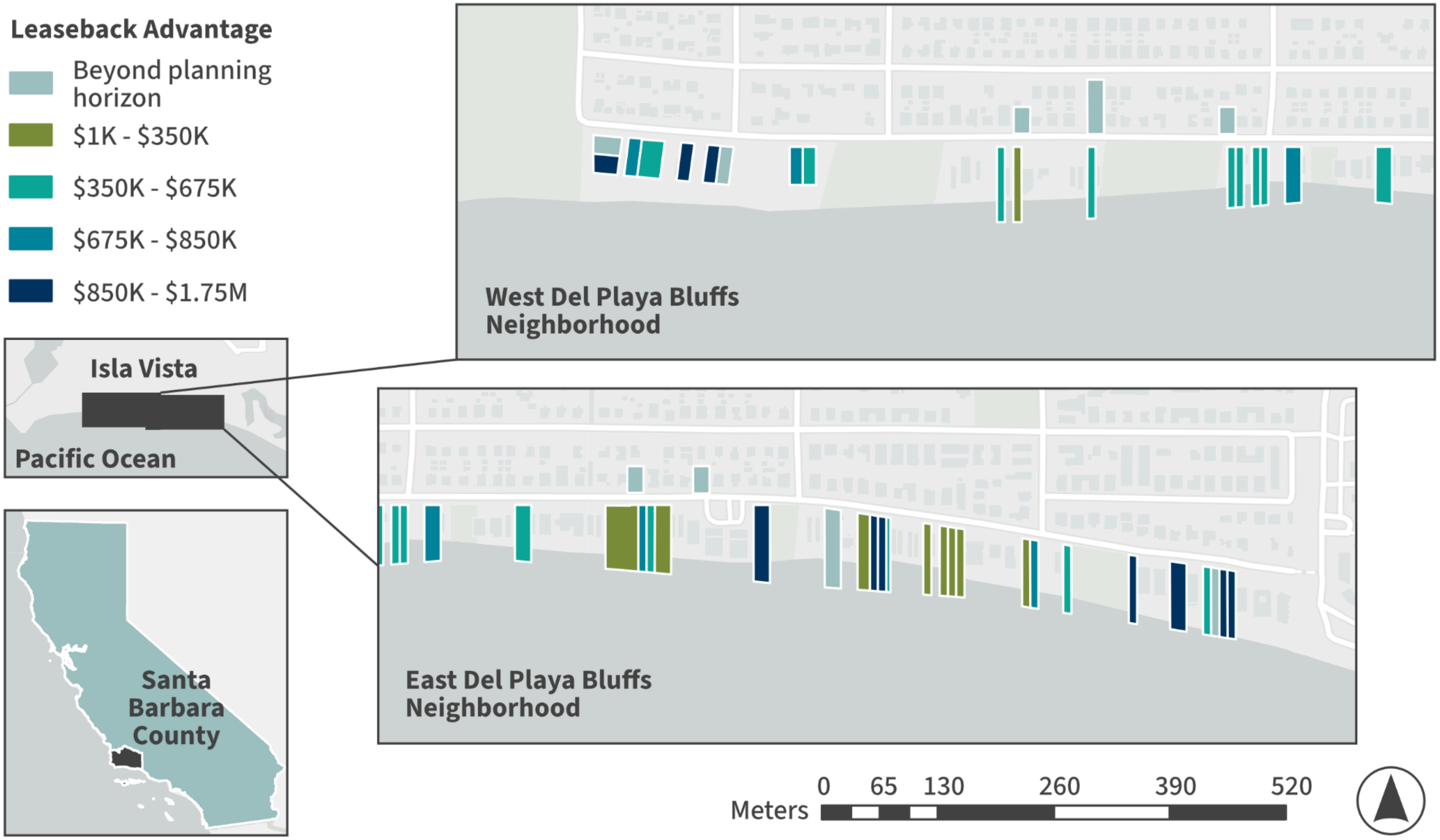


Figure 5.2.d. Property-level map of leaseback advantage in Isla Vista. Properties are symbolized by their modeled expected leaseback advantage under the baseline scenario, showing spatial variation across the case study area. Symbol classes are based on rounded quartile breaks.

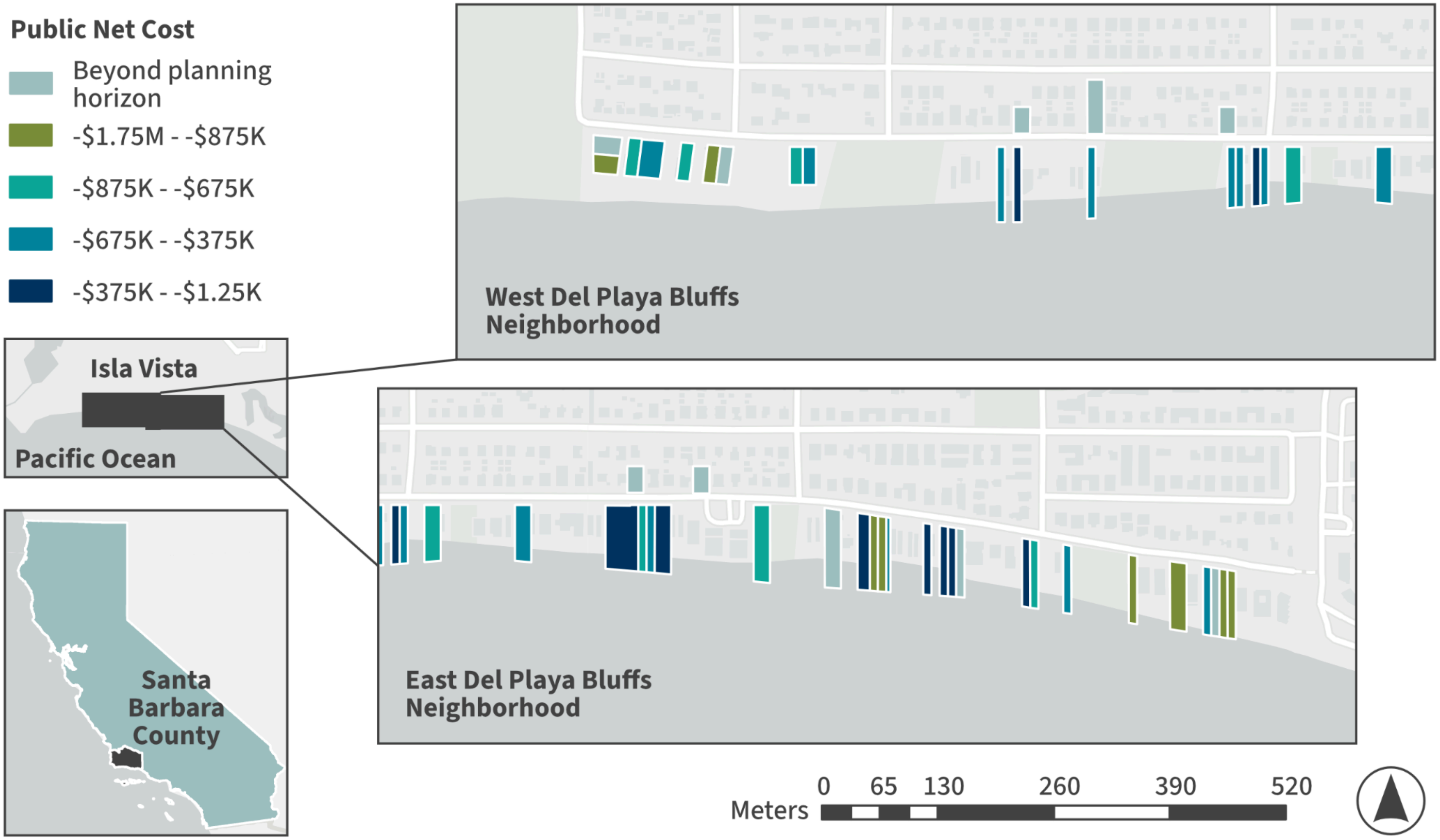


Figure 5.2.e. Property-level map of public net cost in Isla Vista. Properties are symbolized by their modeled public net cost under the baseline scenario, showing spatial variation in BOLB program cost across the case study area. Symbol classes are based on rounded quartile breaks.

5.3 Pacifica, San Mateo County

Pacifica is a coastal city in San Mateo County located along the northern California coast just south of San Francisco. With approximately six miles of beaches and bluffs, Pacifica contains some of the most erosion-prone urban coastline in the state and has experienced repeated damage to housing, infrastructure, and public access from coastal erosion, storm surge, and wave overtopping (City of Pacifica, 2023). The city was selected as a case study because it represents a dense, urbanized bluff-backed shoreline where retreat has already occurred in practice through property acquisition and demolition, even as formal policy continues to prioritize protection and accommodation (City of Pacifica, 2018b). Managed retreat has also been a prominent and often contentious public conversation in Pacifica, even as formal policy continues to prioritize protection and accommodation.

5.3.1 Environment and infrastructure

Pacifica's coastline is geomorphically diverse, ranging from wide sandy beaches such as Pacifica State Beach in the south to steep coastal bluffs composed of weak sedimentary materials in the north and central portions of the city (City of Pacifica, 2018b). Much of the developed coastline consists of tall bluffs ranging from approximately 60 to over 120 feet in height, with residential and multi-family buildings located on or near bluff edges (City of Pacifica, 2018b).

Bluff erosion in Pacifica is among the fastest documented on the U.S. West Coast, with long-term average retreat rates of approximately two feet per year along sections of Esplanade Avenue, though erosion is highly episodic and can remove much larger areas during major storm events (City of Pacifica, 2023). Since 2015, bluff erosion has resulted in the demolition of multiple multi-unit apartment buildings and single-family homes along Esplanade Avenue, despite the presence of extensive shoreline armoring at the bluff toe (City of Pacifica, 2018b).

Public infrastructure is also highly exposed. Roads, sewer lines, beach access stairways, and public trails run parallel to the bluff edge in several sub-areas, placing them at risk as erosion progresses landward (City of Pacifica, 2018b). The City has relied heavily on emergency permits to repair and expand shoreline armoring following storm damage, and since 2016 has spent more than $7 million on emergency coastal repairs, a significant burden relative to its annual general fund budget (City of Pacifica, 2023).

5.3.2 Social, cultural, and historical considerations

Much of Pacifica's coastal development predates the California Coastal Act and reflects historical settlement patterns that emphasized ocean access, scenic value, and proximity to regional transportation corridors rather than long-term hazard avoidance (City of Pacifica, 2023). Bluff-top neighborhoods include a mix of single-family homes and multi-family apartment buildings, some of which have historically provided relatively affordable housing compared to surrounding coastal communities in the Bay Area (City of Pacifica, 2023).

As bluff erosion has accelerated, the social consequences of coastal hazards and adaptation decisions have become increasingly visible. Since 2015, erosion along Esplanade Avenue has led to the demolition of multiple apartment buildings, displacing residents and permanently removing housing from the local market (City of Pacifica, 2018b). In other locations, the City has purchased severely threatened properties and converted them to open space or public access areas following demolition (City of Pacifica, 2018b). Despite these losses, community engagement conducted through sea level rise planning indicates that many residents and property owners continue to favor armoring strategies that allow continued occupancy for as long as possible, expressing concern that retreat-oriented policies could prematurely devalue homes, limit rebuilding options, or force displacement without clear compensation or relocation pathways (City of Pacifica, 2017; City of Pacifica, 2018a). Although there are varying opinions among the public, much of the community reflects a strong desire to remain in place and a preference for incremental or protective responses (City of Pacifica, 2023).

5.3.3 Coastal governance and policy framework

The City of Pacifica exercises municipal land use authority and implements coastal policy through its LCP, which includes sea level rise adaptation policies adopted in 2025 (City of Pacifica, 2025). The City's LCP adopts a phased adaptation framework that prioritizes protection and accommodation in the near term, while requiring monitoring of erosion and flooding to determine when additional measures may be necessary (City of Pacifica, 2025). Policies allow for the maintenance and expansion of shoreline armoring to protect existing development and critical infrastructure, but often limit permit durations and require mitigation for impacts to beaches and public access (City of Pacifica, 2025). Tools such as transfer of development rights are identified as mechanisms to reduce exposure over time, particularly where redevelopment is constrained by hazard conditions (City of Pacifica, 2025).

Notably, managed retreat is explicitly excluded from near-term adaptation policies and is framed as a potential mid- to long-term option that would only be reconsidered if monitoring and feasibility assessments warrant a shift away from protection-based approaches (City of

Pacifica, 2025). In practice, however, Pacifica has already experienced de facto retreat through property acquisition, demolition, and conversion of hazardous parcels to open space following repeated damage (City of Pacifica, 2018b). This disconnect between policy intent and on-the-ground outcomes underscores the challenge of relying on emergency response and project-by-project decisions rather than proactive retreat planning.

5.3.4 Application of buyout-leaseback

We applied the buyout-leaseback framework to properties in the Esplanade Ave and Palmetto Ave bluff neighborhoods in Pacifica. Across these neighborhoods, 77% of properties are expected to reach the end of their economic lifespan within our modeled 75-year planning horizon through 2100. For these properties, the median expected economic lifespan is 38 years, ending in 2064 (Table 5.3.a). The largest share of properties (31%) are projected to reach the end of their economic lifespan within 25-50 years, followed by 26% within 50-75 years, and 19% within the first 10 years. The distribution of expected economic lifespan is broad and relatively flat, with a smooth, unimodal shape (Figure 5.3.a-A). Spatially, economic lifespans show localized clustering across adjacent properties as well as a clear landward gradient across the neighborhood (Figure 5.3.b). Because expected economic lifespan at cliff-erosion sites is determined by when projected cliff retreat crosses a fixed 10m setback threshold, the spatial distribution of T* primarily reflects variation in existing bluff setback distances rather than variation in retreat rates. Properties with less initial buffer cross the threshold sooner. This pattern is reinforced by the relatively homogeneous retreat rates observed within the study area, a consequence of the small spatial extent of analysis, where cliff segments share similar lithology and wave exposure. Across broader spatial scales, retreat rate variation would contribute more substantially to the spatial structure of outputs. Because expected economic lifespan underlies the other BOLB outputs, similar spatial variation is also seen in buyout price, leaseback revenue, and public net cost.

Based on these expected economic lifespans, the median buyout price across properties is $962,731 and the total neighborhood buyout cost for all applicable properties is approximately $57 million (Table 5.2.a). This median buyout price is roughly 90% of the median market property value, indicating a relatively small gap between current market prices and model-adjusted values, suggesting that market pricing may partially incorporate SLR-related risk. This gap may reflect market expectations and policy uncertainty around future protection and assistance, but it may also partially reflect limitations in our rent estimation approach, which infers rents from current prices using a uniform yield and could understate rents if prices already embed a finite rental horizon under SLR. Property buyout values are moderate overall, but the distribution is strongly bimodal and spans roughly

$50,000 to $1.5 million, with peaks around $100,000 and $1 million. As shown in Figure 5.3.a, this pattern carries through to the modeled distributions of leaseback revenue and public net cost.

Using the public discount rate of 2%, versus 5% for private benefits, the leaseback program generates a median discounted public revenue of $550,065 per property. For cliff-retreat cases, retreat is treated as a one-time acquisition and relocation decision prior to catastrophic failure, rather than being driven by cumulative damages over time. Because ongoing damages are not modeled during the leaseback period, the public net cost is simply the inverse of leaseback advantage, and the net-positive outcome is driven primarily by the discount-rate differential. Accordingly, the median public net cost is -$550,065 per property, totaling -$36M across both neighborhoods. These results indicate that BOLB can be net-profitable for the public sector in cliff settings, highlighting an important implication of the framework.

Table 5.3.a. Key BOLB model results in Pacifica. Table reports summary statistics for modeled BOLB outcomes in Pacifica at the property and neighborhood scale. All results are generated using the baseline model parameters.

BOLB Model Outputs	Median Per Parcel	Neighborhood Total
Market Value	$1,105,789	-
Expected Economic Lifespan	38 years	-
Buyout Price	$962,731	$57,304,629
Leaseback Advantage	$550,065	$35,941,885
Public Net Cost	-$550,065	-$35,941,885

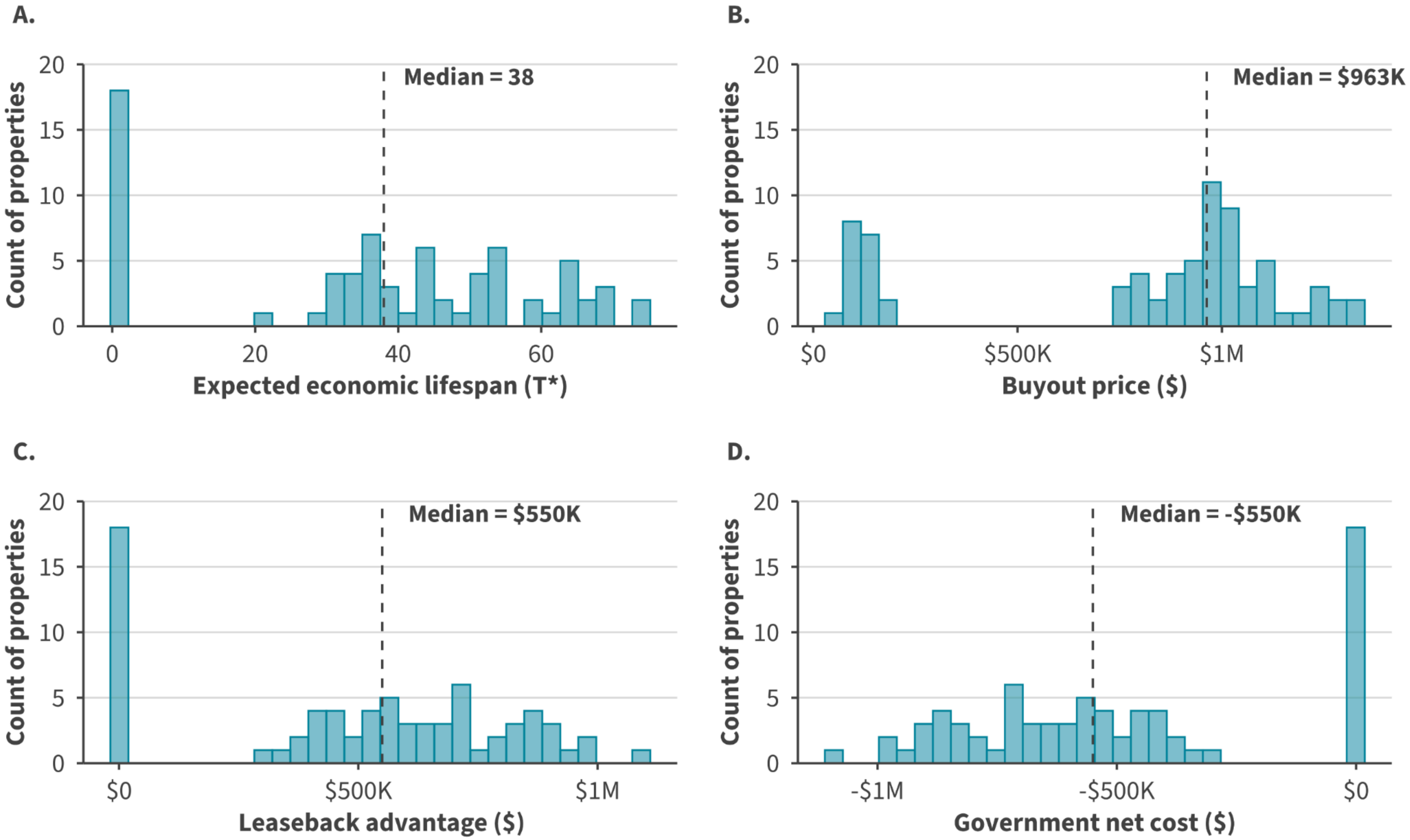


Figure 5.3.a. Distributions of key BOLB model results for Pacifica. Subfigures show histograms of property-level modeled outcomes for expected economic lifespan (A), buyout price (B), leaseback advantage (C), and public net cost (D), with each distribution plotted using 30 bins.

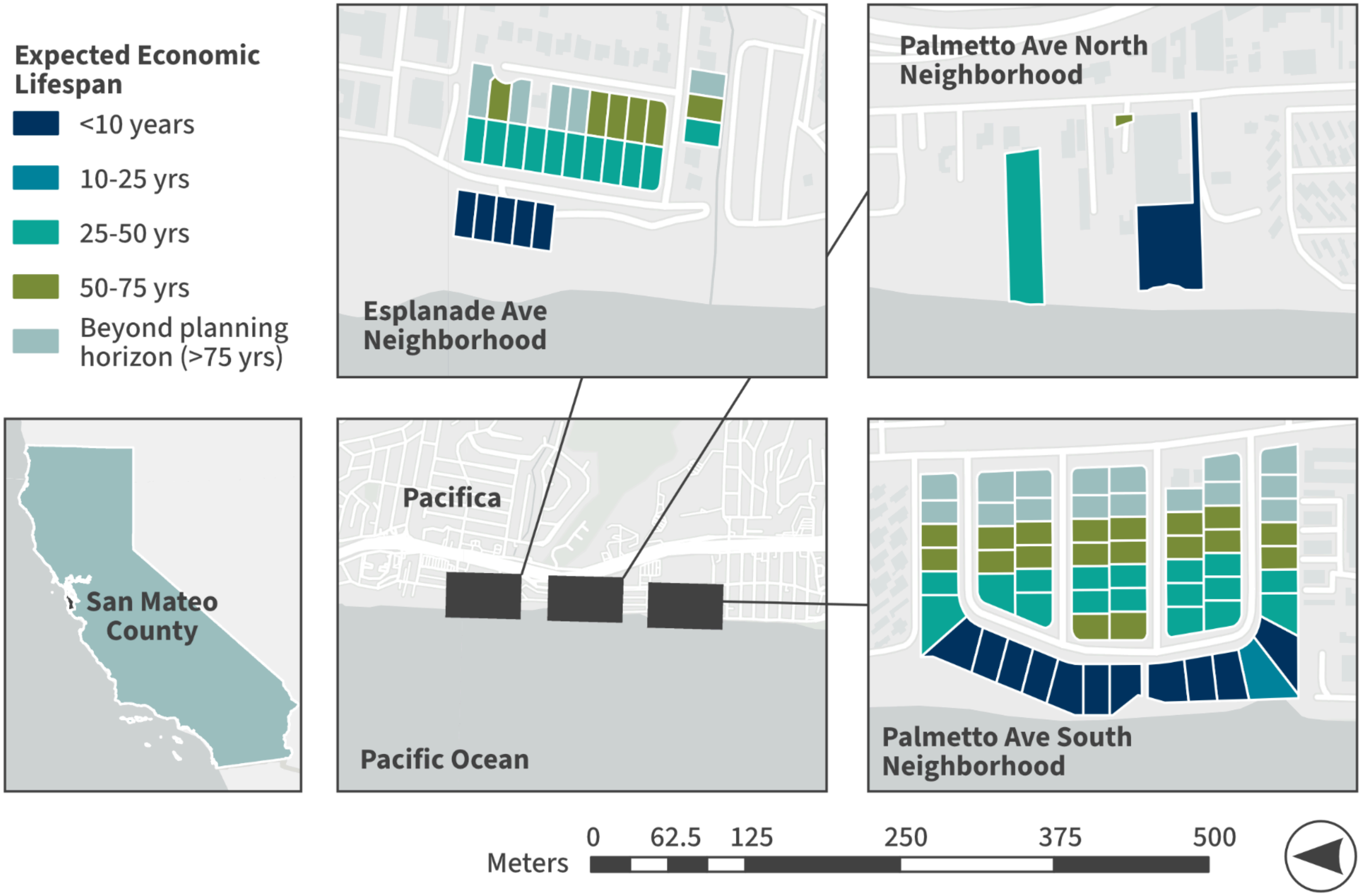


Figure 5.3.b. Property-level map of expected economic lifespan in Pacifica. Properties are symbolized by their modeled expected economic lifespan under the baseline scenario, showing spatial variation in retreat timing across the case study area.

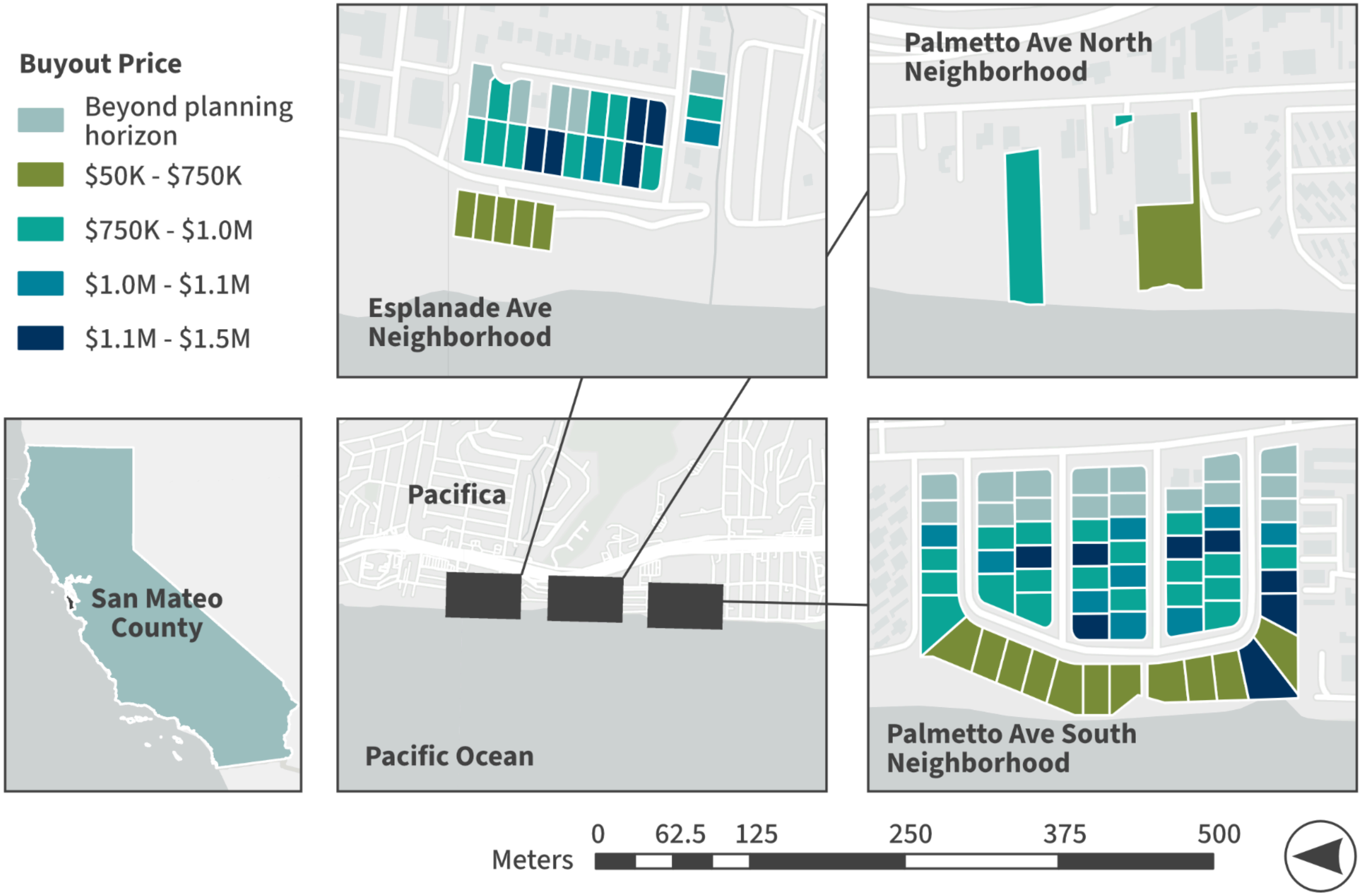


Figure 5.3.c. Property-level map of buyout price in Pacifica. Properties are symbolized by their modeled buyout price under the baseline scenario, showing spatial variation in price across the case study area. Symbol classes are based on rounded quartile breaks.

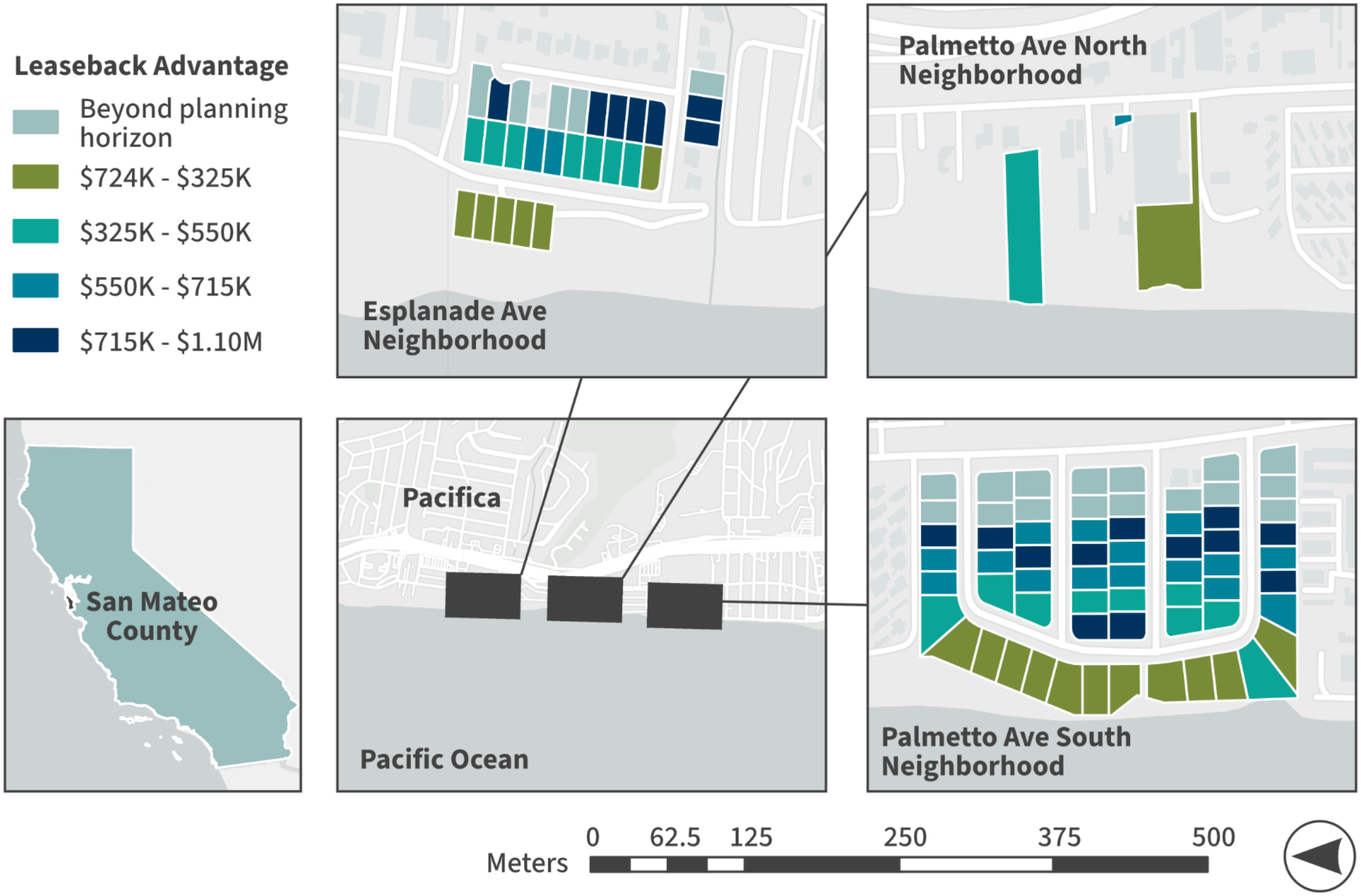


Figure 5.3.d. Property-level map of leaseback advantage in Pacifica. Properties are symbolized by their modeled expected leaseback advantage under the baseline scenario, showing spatial variation across the case study area. Symbol classes are based on rounded quartile breaks.

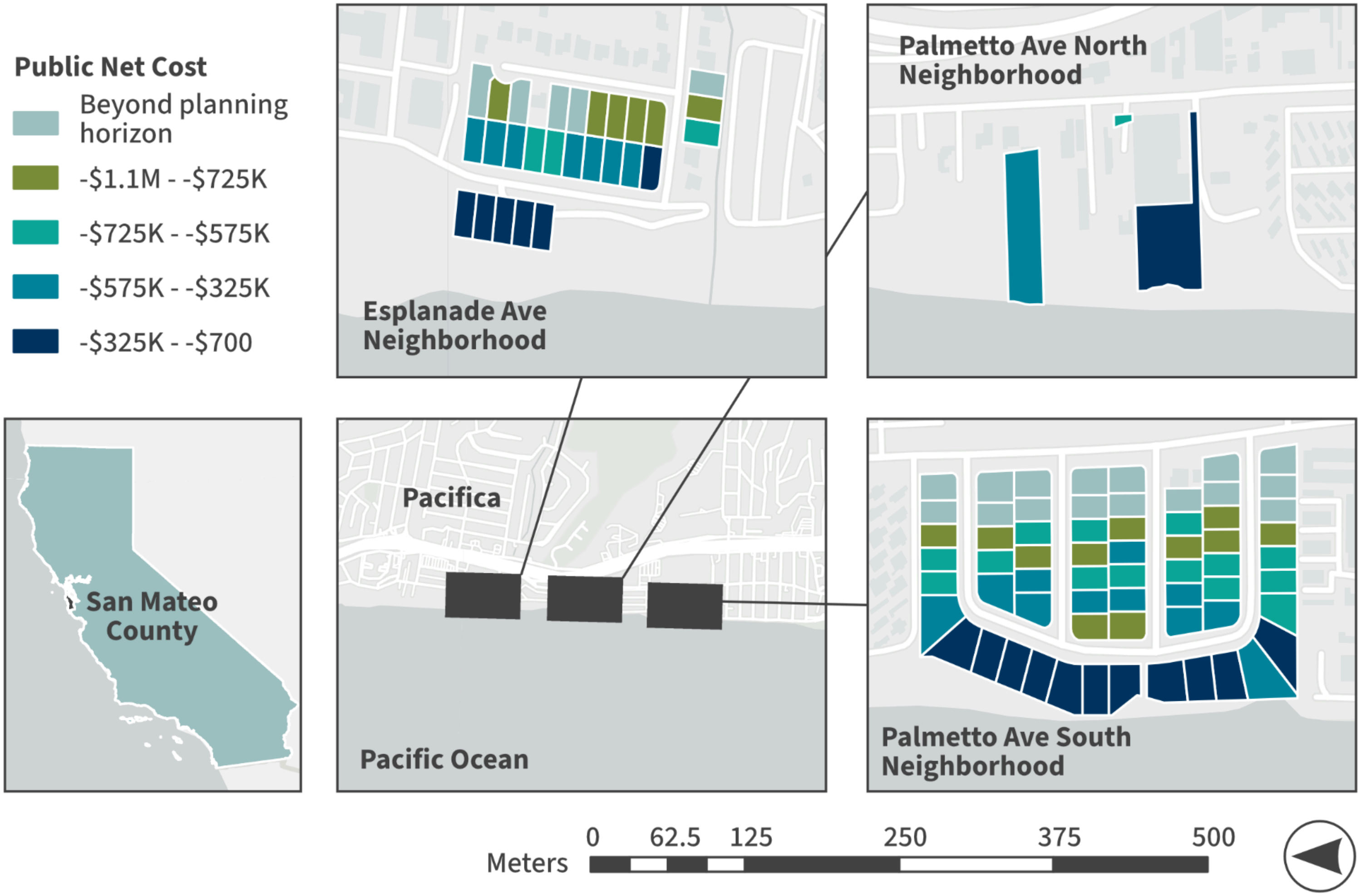


Figure 5.3.e. **Property-level map of public net cost in Pacifica.** Properties are symbolized by their modeled public net cost under the baseline scenario, showing spatial variation in BOLB program cost across the case study area. Symbol classes are based on rounded quartile breaks.

5.4 Stinson Beach, Marin County

Stinson Beach is a small, unincorporated coastal community located along the Pacific shoreline of western Marin County. The community's physical setting exposes it to multiple coastal hazards, including wave runup, beach and dune erosion, and coastal flooding associated with sea level rise (Marin County Community Development Agency [MCCDA], 2025b). Sea level rise assessments for West Marin identify Stinson Beach as among the most immediately vulnerable communities in the county, with impacts already occurring during storm events and king tides and projected to intensify over time (MCCDA, 2025b).

5.4.1 Environment and infrastructure

The community occupies a narrow strip of land between a sandy barrier beach and the Bolinas Lagoon, Easkoot Creek, and adjacent wetlands (MCCDA, 2025b; MCCDA, 2018). This coastal landscape functions as a dynamic beach-lagoon-wetland system, where sand movement, tidal exchange, creek inflows, and groundwater levels are closely linked (MCCDA, 2025b). As a result, Stinson Beach is shaped by natural processes that historically allowed the shoreline and lagoon to migrate and adjust over time. These processes now threaten fixed residential developments by increasing the community's exposure to flooding and erosion (MCCDA, 2025b).

Residential development in Stinson Beach consists primarily of single-family homes, including a significant number of second homes and short-term rentals, mixed with a smaller stock of full-time residences (MCCDA, 2018). Many structures rely on onsite wastewater treatment systems that are increasingly compromised by high groundwater levels, raising concerns about system failure, water quality, and long-term habitability (MCCDA, 2025b). Under current conditions, portions of the community already experience flooding during king tides and storm events, as elevated ocean water levels back up through the lagoon and creek system (MCCDA, 2025b). The Shoreline Highway serves as the primary access route into and out of the community and is itself also vulnerable to flooding, creating risks related to emergency access, evacuation, and long-term infrastructure reliability as sea levels rise (MCCDA, 2025b).

5.4.2 Social, cultural, and historical considerations

Stinson Beach developed as a coastal settlement oriented around beach access, recreation, and its location at the western edge of Marin County's public lands. Early development concentrated along the narrow strip of land between the ocean and the lagoon because it was one of the few relatively flat and buildable areas along an otherwise steep and rugged coastline (MCCDA, 2018).

Proximity to the beach remains central to residential value, social attachment, and the seasonal tourism economy in Stinson Beach (MCCDA, 2025b; MCCDA, 2016). Residents and visitors alike place high cultural value on maintaining access to the wide sandy beach and preserving the open, natural character of the shoreline (MCCDA, 2025b). At the same time, community engagement indicates that many residents express a desire to maintain use and occupancy of coastal homes for as long as possible, stemming from both strong attachment to place and the limited availability of alternative locations that offer comparable coastal access (MCCDA, 2025b; MCCDA, 2018). This combination of values creates a central tension for adaptation planning, as continued residential occupation of the narrow coastal strip may ultimately conflict with the long-term need to maintain shoreline function, beach access, and the natural coastal processes that underpin the qualities that define Stinson Beach (MCCDA, 2018).

5.4.3 Coastal governance and policy framework

Land use, coastal development, and hazard management in Stinson Beach are administered by Marin County through the County's Local Coastal Program and Coastal Zoning Code (MCCDA, 2018; MCCDA, 2025a). Coastal Development Permits are required for most development within the coastal zone, and certain actions, including shoreline protection measures or projects affecting public access or coastal resources, may be subject to review or appeal by the California Coastal Commission under standard Coastal Act oversight (MCCDA, 2025b). County policy emphasizes avoidance of new development in hazardous areas, limits shoreline armoring, and prioritizes protection of natural shoreline processes and public access (MCCDA, 2018).

In response to the scale and immediacy of sea level rise risks in Stinson, Marin County conducted the Stinson Beach Adaptation & Resilience Collaboration as a comprehensive, community-driven planning effort focused on long-term adaptation for one of the region's most vulnerable coastal communities (MCCDA, 2025b). Rather than prescribing a single outcome, the Adaptation & Resilience Collaboration establishes an adaptation pathway framework that evaluates protection, accommodation, avoidance, and retreat through phased responses tied to measurable thresholds such as flooding frequency, groundwater rise, and erosion extent (MCCDA, 2025b). Near- and medium-term strategies prioritize accommodation and nature-based or hybrid measures, including elevating structures and infrastructure, improving drainage and wastewater systems, dune restoration, and beach nourishment, while explicitly recognizing that these actions are unlikely to remain viable under higher sea level rise scenarios (MCCDA, 2025b). Managed retreat is identified as a potential long-term response for the most vulnerable low-lying areas, particularly adjacent to the lagoon and creek system, but is framed as a gradual, spatially targeted transition that may only occur after other measures reach their limits (MCCDA, 2025b).

5.4.4 Application of buyout-leaseback

We applied the buyout-leaseback framework to properties in the Seadrift neighborhood of Stinson. Across this neighborhood, only 50% of properties are expected to reach the end of their economic lifespan within our modeled 75-year planning horizon through 2100. For these properties, the median expected economic lifespan is 32 years, ending in 2058 (Table 5.4.a). The largest share of properties (17%) are projected to reach the end of their economic lifespan within 25-50 years, followed by 13% within 10-25 years, and 12% within 50-75 years. Notably, only 7% of properties have an expected economic lifespan of less than 10 years. This relatively even spread across timing categories is reflected in a wide, tri-modal distribution of expected economic lifespan. (Figure 5.4.a-A). Spatially, lifespans show localized clustering and a subtle landward gradient (Figure 5.4.b), with inland properties nearer Bolinas Lagoon exhibiting shorter remaining lifespans than the most seaward beachfront properties. Beachfront properties that fall within the planning horizon generally still have 50-75 years remaining and are often adjacent to beyond-horizon properties, indicating that a spatial gradient persists along the shoreline and that retreat pressures may become more relevant later in the planning horizon or beyond it. One possible explanation for the high share of beyond-horizon lifespans along the northern, seaward beachfront is that this area sits slightly higher on the sandspit and includes extremely high-value properties where expected rental returns offset even substantial modeled damages. Because rental returns scale with price in our framework, risk would need to be substantially greater for these parcels to reach end-of-lifespan within the planning horizon. As expected economic lifespan drives the other BOLB outputs, the same localized clustering and landward gradient are reflected in buyout price, leaseback revenue, and public net cost.

Based on these expected economic lifespans, the median buyout price across properties is $2,178,967 and the total neighborhood buyout cost for all applicable properties is approximately $450 million (Table 5.4.a). This median buyout price is roughly 60% of the median market property value, indicating a significant gap between current market prices and model-adjusted values and suggesting that market pricing may partially incorporate SLR-related risk. This gap may reflect market expectations and policy uncertainty around future protection and assistance, but it may also partially reflect limitations in our rent estimation approach, which infers rents from current prices using a uniform yield and could understate rents if prices already embed a finite rental horizon under SLR. Property buyout values across the neighborhood are high overall, but notably the distribution is strongly right-skewed due to a small number of properties valued above $10 million. As shown in Figure 5.4.a, this pattern carries through to the modeled distributions of leaseback revenue and public net cost.

Using the public discount rate of 2%, versus 5% for private benefits, the leaseback program generates a median discounted public revenue of $968,946 per property. Assuming the government is responsible for flood repair costs during the leaseback period, the median public net cost is $660,154 per property, with an estimated total neighborhood net cost of approximately $132 million for all applicable properties (Table 5.4.a).

Table 5.4.a. Key BOLB model results in Stinson. Table reports summary statistics for modeled BOLB outcomes in Stinson at the property and neighborhood scale. All results are generated using the baseline model parameters.

BOLB Model Outputs	Median Per Parcel	Neighborhood Total
Market Value	$3,498,603	-
Expected Economic Lifespan	32 years	-
Buyout Price	$2,178,967	$478,780,678
Leaseback Advantage	$968,946	$268,104,579
Public Net Cost	$660,154	$132,549,784

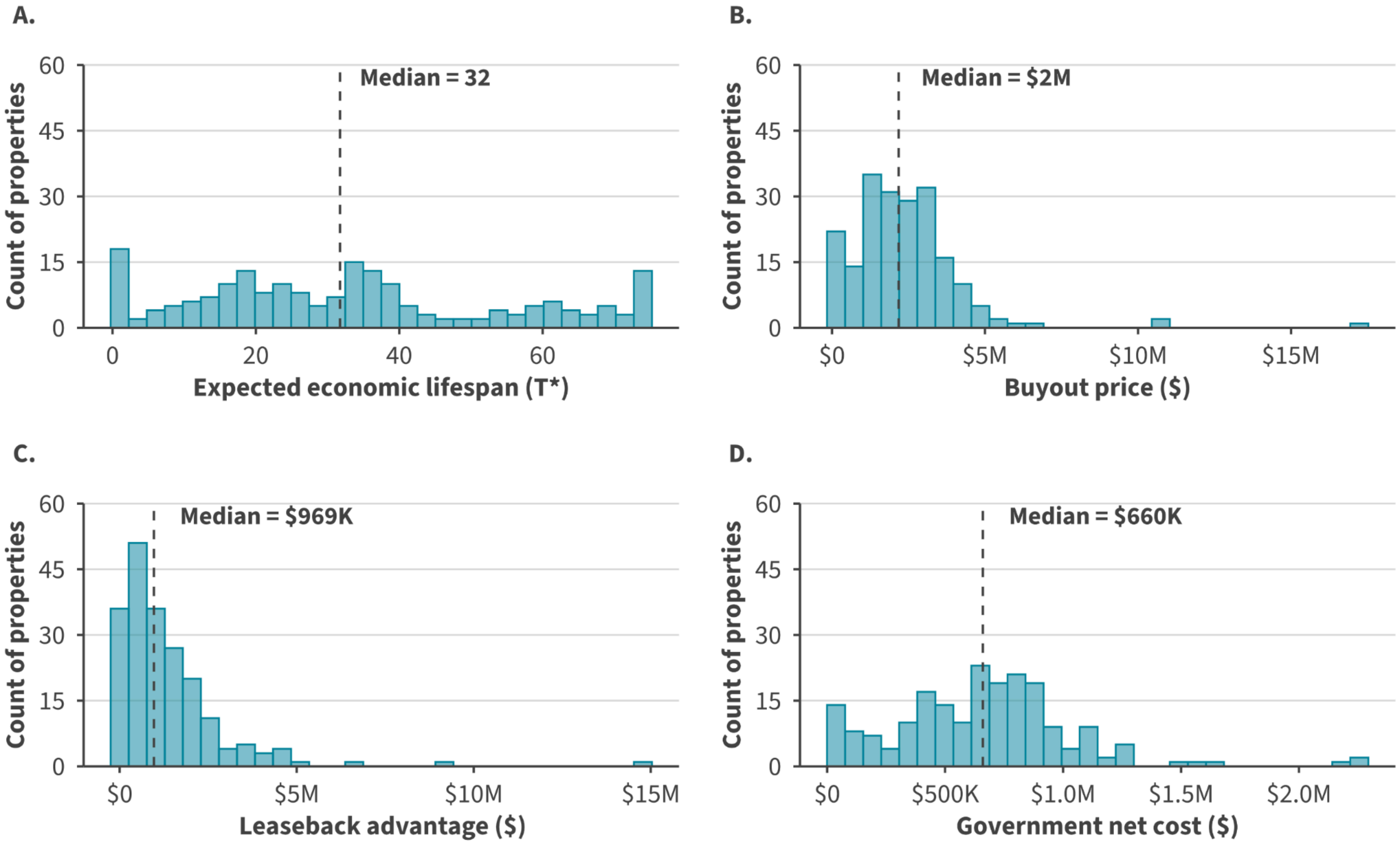


Figure 5.4.a. Distributions of key BOLB model results for Stinson. Subfigures show histograms of property-level modeled outcomes for expected economic lifespan (A), buyout price (B), leaseback advantage (C), and public net cost (D), with each distribution plotted using 30 bins.

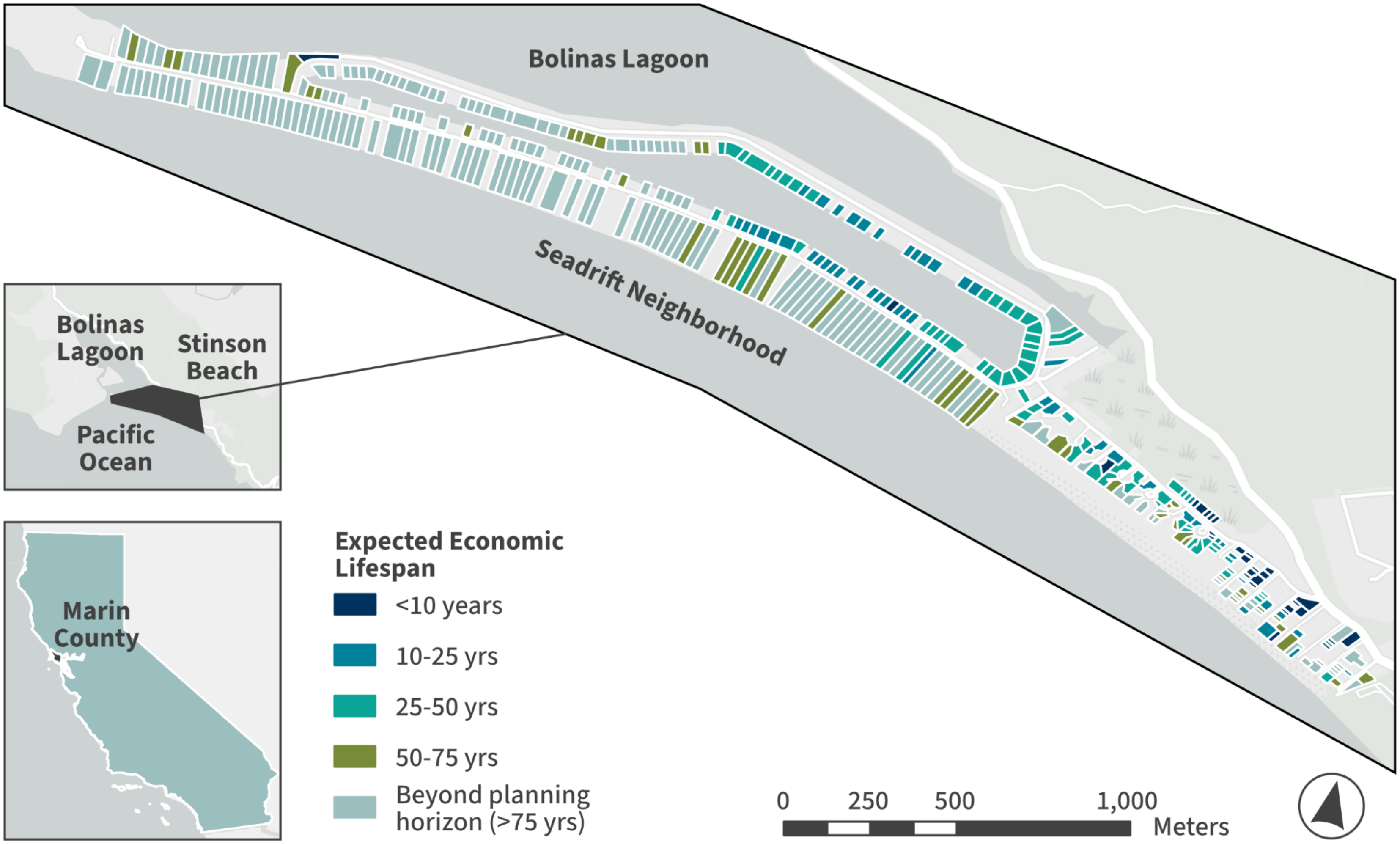


Figure 5.4.b. Property-level map of expected economic lifespan in Stinson. Properties are symbolized by their modeled expected economic lifespan under the baseline scenario, showing spatial variation in retreat timing across the case study area.

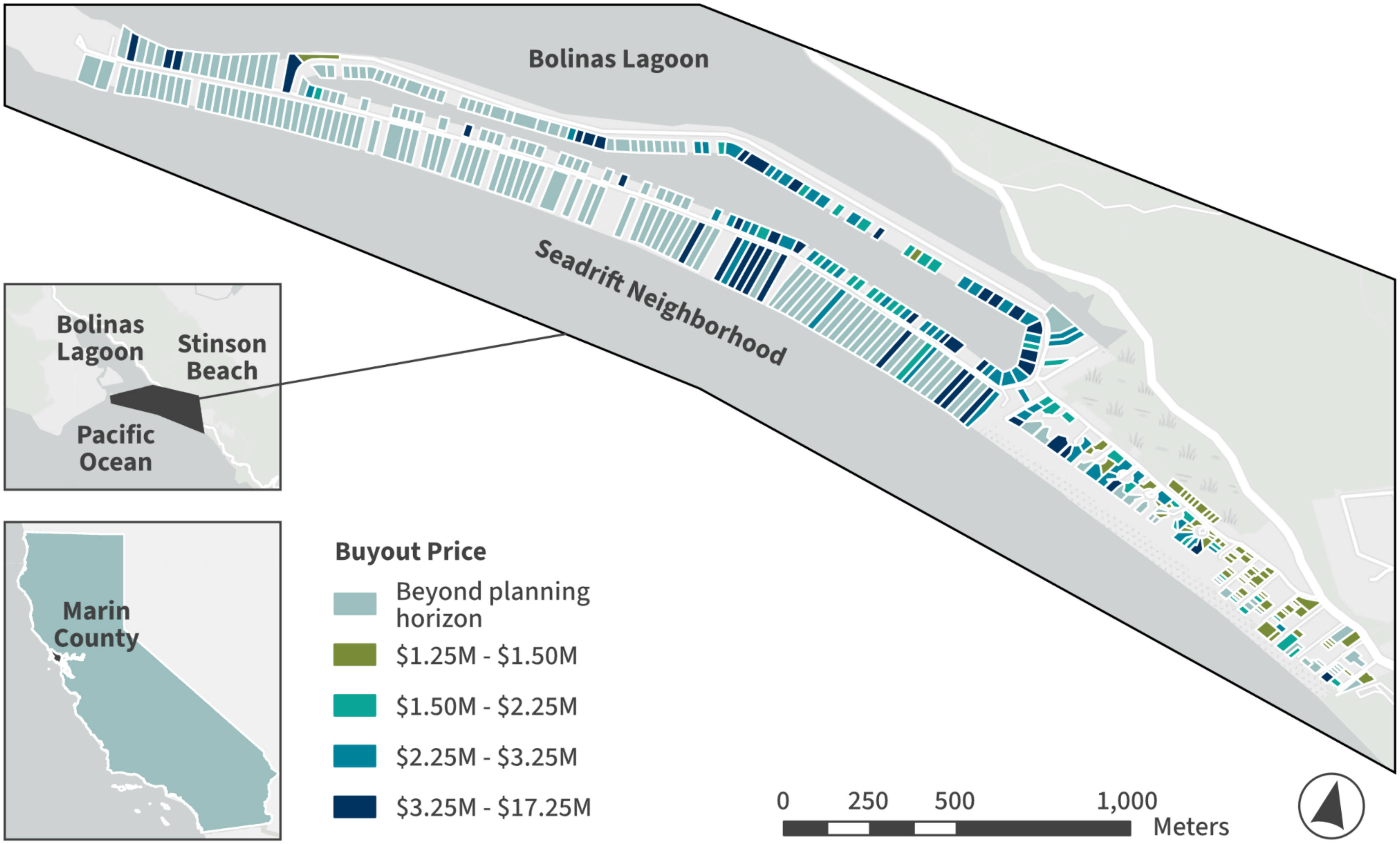


Figure 5.4.c. **Property-level map of buyout price in Stinson.** Properties are symbolized by their modeled buyout price under the baseline scenario, showing spatial variation in price across the case study area. Symbol classes are based on rounded quartile breaks.

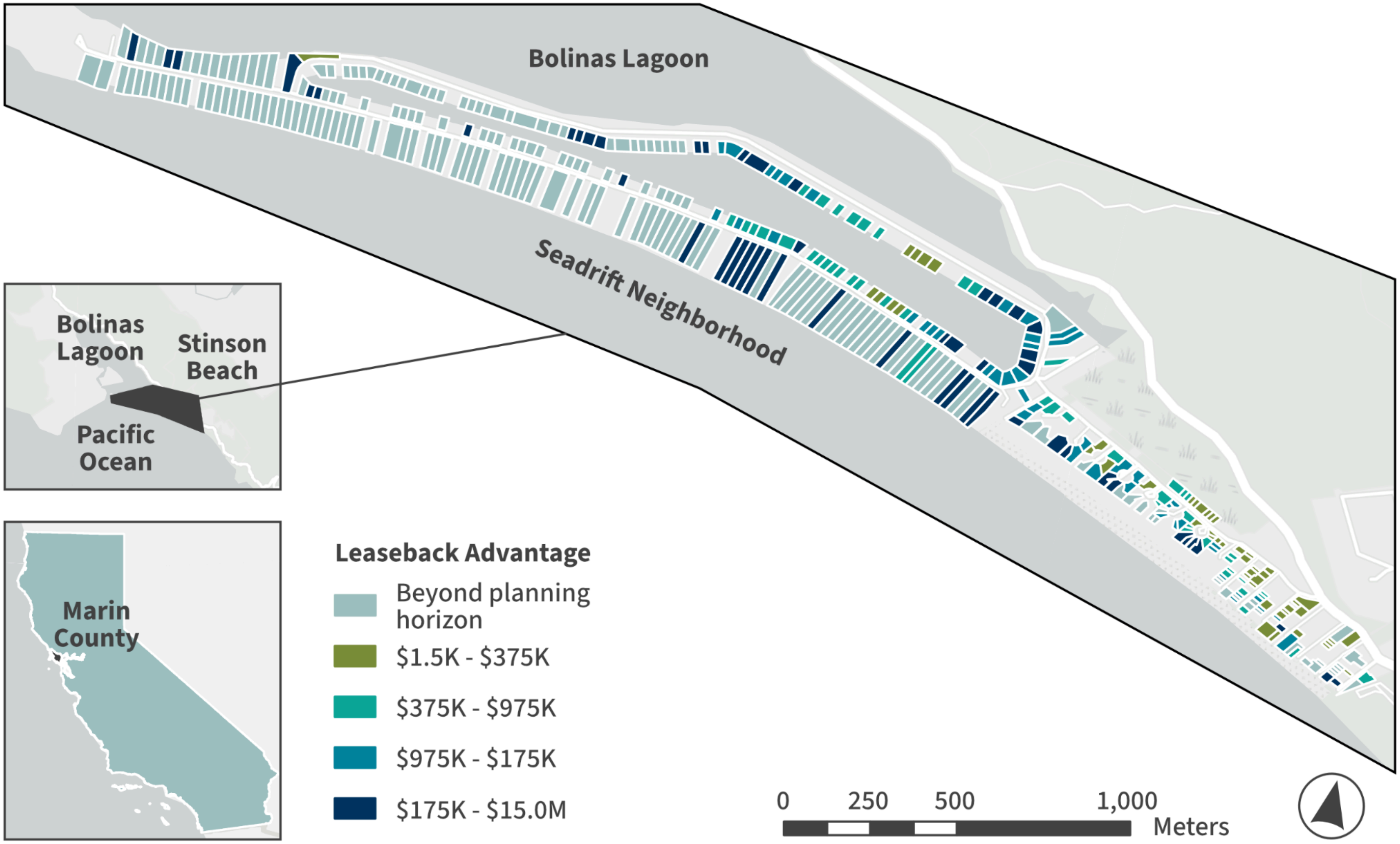


Figure 5.4.d. **Property-level map of leaseback advantage in Stinson.** Properties are symbolized by their modeled expected leaseback advantage under the baseline scenario, showing spatial variation across the case study area. Symbol classes are based on rounded quartile breaks.

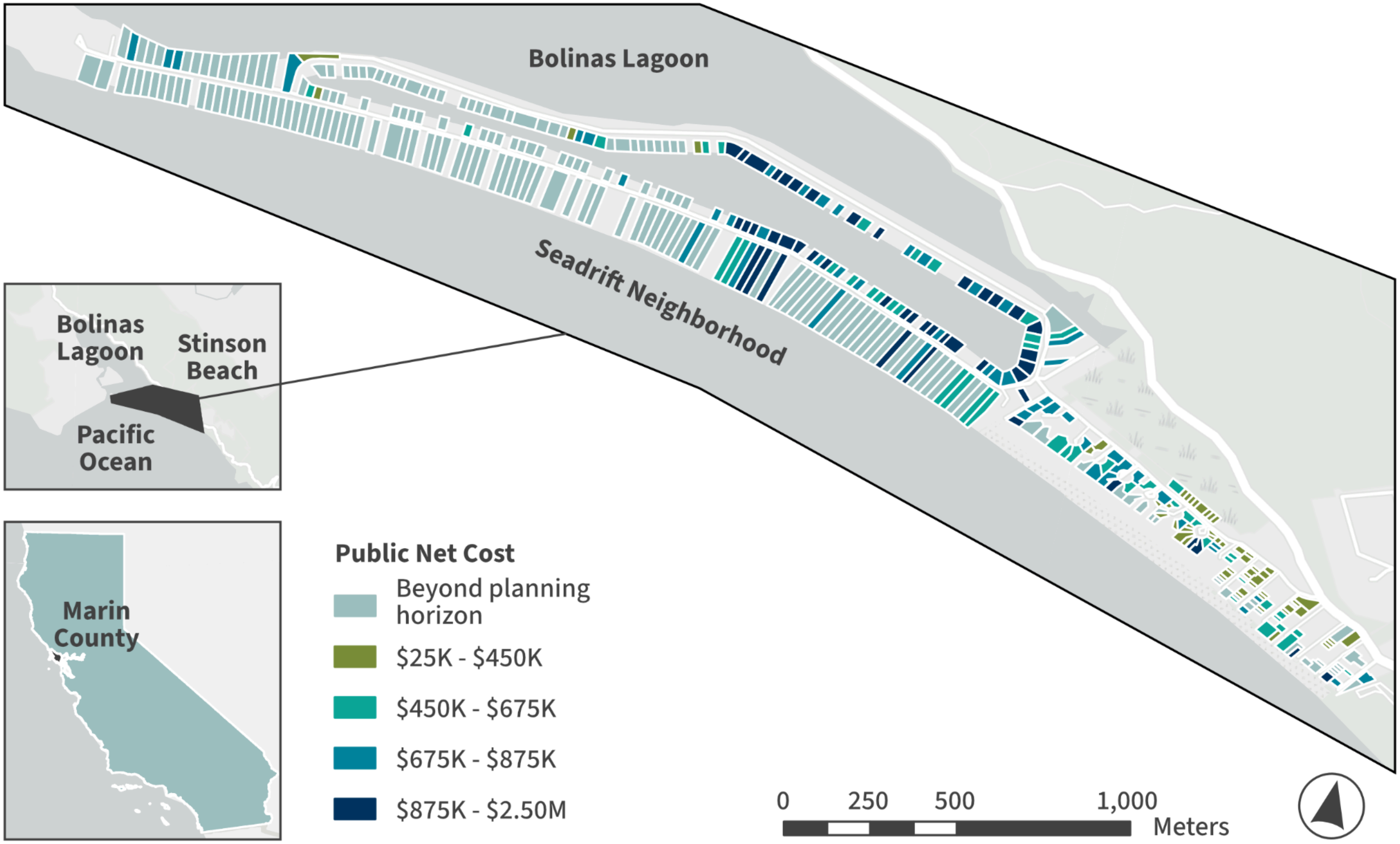


Figure 5.4.e. Property-level map of public net cost in Stinson. Properties are symbolized by their modeled public net cost under the baseline scenario, showing spatial variation in BOLB program cost across the case study area. Symbol classes are based on rounded quartile breaks.

5.5 King Salmon, Humboldt County

King Salmon is an unincorporated coastal community located along the eastern shoreline of Humboldt Bay in Humboldt County. The community is situated on low-lying lands composed largely of historic fill and former tidelands, with much of the residential area lying only a few feet above current mean sea level (Humboldt County, 2019a). Sea level rise assessments conducted for Humboldt Bay consistently identify King Salmon as among the first communities to experience chronic flooding, loss of access, and functional isolation as tides and groundwater rise (Humboldt County, 2019a). At the same time, the community's socioeconomic character, relatively low property values, and high share of renters raise distinct equity considerations from managed shoreline retreat strategies that rely on voluntary relocation or market-based adaptation.

5.5.1 Environment and infrastructure

King Salmon is bordered by Humboldt Bay to the west and low coastal bluffs to the east, with residential development concentrated on flat terrain intersected by canals, drainage infrastructure, and low points that already allow tidal waters to enter the community during king tides (Humboldt County, 2019a). The area is protected primarily by a narrow barrier dune and shoreline revetments, which provide limited defense against rising water levels and are not designed to accommodate long-term sea-vele rise (Humboldt County, 2019a).

The community is predominantly residential, with development concentrated on approximately 36 acres and consisting primarily of single-family homes, mobile homes, trailer, and RV park residences (Humboldt County, 2019b). The majority of developed properties are located at elevations between 8 and 10 feet above NAVD88, placing them within the range of current and projected tidal inundation under sea level rise scenarios (Humboldt County, 2019a). Sea level rise modeling conducted indicates that under future scenarios, King Salmon Avenue, the sole vehicular access route to the community, would also experience increasing frequency of tidal flooding, potentially cutting off access during high tide and storm events (Humboldt County, 2019a).

5.5.2 Social, cultural, and historical considerations

Settlement in King Salmon began in the mid-20th century following the formation of a sand spit near Buhne Hill and subsequent shoreline modification, when canals were excavated and waterfront lots were developed for recreational and residential use (Humboldt County, 2019b). Over time, the community evolved alongside adjacent industrial and energy facilities, maintaining a close physical and cultural relationship with the bay. These residential neighborhoods were constructed directly adjacent to the shoreline during periods when tidal flooding and long-term sea level rise were not incorporated into land use planning (Humboldt County, 2019a).

Today, King Salmon differs from many California coastal communities in its socio-economic profile. The area functions as a relatively affordable coastal community with a high proportion of working-class residents and renters, many of whom have limited financial capacity to absorb repeated flood damage or relocate independently (Humboldt County, 2019a). Community workshops, interviews, and household survey results indicate that residents are generally aware of increasing flood risk, but demonstrate varying perceptions of both the severity of future impacts and appropriate adaptation responses (Humboldt County Planning and Building Department, 2018; FLKS Living with Water Team, 2025). Data from a community survey conducted in 2025 shows a range of adaptation preferences, with a majority of respondents supporting resistance-based strategies (72%) while also rejecting a “no change” approach (55.4%) (FLKS Living with Water, 2025). At the same time, responses indicate that relocation is often viewed as conditional rather than immediate, with approximately 30% of residents reporting they would consider moving only after experiencing direct impacts such as water entering their home (FLKS Living with Water, 2025). These insights highlight community perspectives are not uniform, but instead reflect a spectrum of risk tolerance, economic constraints, and evolving responses to observed flooding.

5.5.3 Coastal governance and policy framework

As an unincorporated community, King Salmon is subject to Humboldt County land use authority rather than municipal governance (Humboldt County, 2019a). Coastal planning is guided by the Humboldt Bay Area Plan, and permitting authority for coastal development and adaptation is shared between Humboldt County and the California Coastal Commission (Humboldt County, 2019a). Humboldt County has evaluated a range of adaptation strategies for King Salmon, including shoreline protection, accommodation through elevation and floodproofing, and long-term relocation of development from the most hazardous areas (Humboldt County, 2019b).

County-led studies and community workshops acknowledge that while engineered protection measures such as dikes, revetments, or raised roadways may delay impacts in the near term, they are unlikely to provide a permanent or economically sustainable solution for King Salmon under higher sea level rise scenarios (Humboldt County, 2019b). The Coastal Commission has identified managed retreat as the preferred long-term response to sea level rise in highly vulnerable areas such as King Salmon, including the potential use of property acquisition and development restrictions to reduce exposure over time (Humboldt County Planning and Building Department, 2018).

5.5.4 Application of buyout-leaseback

The buyout-leaseback framework was applied to properties in the canal-lined neighborhood of King Salmon located on the shore of Buhne Point directly across from the mouth of Humboldt Bay. Across this neighborhood, nearly all properties (97%) are expected to reach the end of their economic lifespan within our modeled 75-year planning horizon through 2100. For these properties, the median expected economic lifespan is 22 years, ending in 2048 (Table 5.5.a). Two equal, largest shares of properties (42%) are projected to reach the end of their economic lifespan within 10-25 years and 25-50 years, followed by 13% within less than 10 years. Notably, less than 3% of properties have an expected economic lifespan of more than 50 years. This split between the 10-25 and 25-50 year timing bins is reflected in a wide distribution of expected economic lifespan, with a shallow unimodal shape spanning from just a few years to over 60 years and a notable concentration around 30 years (Figure 5.5.a-A). Spatially, lifespans show localized clustering and a subtle gradient across the neighborhood, with properties along the outer canal edges and those located farther south and west tending to reach the end of their economic lifespan earlier than more interior and northern properties (Figure 5.5.b). Several properties at the southern end of the neighborhood lacked sufficient data to be modeled; if these properties are systematically more exposed, the share of short-lifespan properties may be understated here. Because expected economic lifespan drives the other BOLB outputs, the same localized clustering and landward gradient are reflected in buyout price, leaseback revenue, and public net cost.

Based on these expected economic lifespans, the median buyout price across properties is $210,498 and the total neighborhood buyout cost for all applicable properties is approximately $13 million (Table 5.5.a). This median buyout price is roughly 65% of the median market property value, indicating a significant gap between current market prices and model-adjusted values and suggesting that market pricing may partially incorporate SLR-related risk. This gap may reflect market expectations and policy uncertainty around future protection and assistance, but it may also partially reflect limitations in our rent estimation approach, which infers rents from current prices using a uniform yield and could understate rents if prices already embed a finite rental horizon under SLR.

Using the public discount rate of 2%, versus 5% for private benefits, the leaseback program generates a median discounted public revenue of $67,005 per property. Assuming the government is responsible for flood repair costs during the leaseback period, the median public net cost is $109,471 per property, with an estimated total neighborhood net cost of approximately $6,479,081 million for all applicable properties (Table 5.5.a). Overall, modeled buyout costs in King Salmon are relatively low, reflecting comparatively low property values and short remaining economic lifespans under high flood risk. This suggests that a BOLB program may be more financially achievable in lower-value, high-risk neighborhoods where expected retreat timelines are measured in decades rather than generations. Notably, King Salmon and Carpinteria have the same median modeled economic lifespan (T*), yet their buyout and public net costs differ sharply because baseline property values differ substantially. This contrast highlights why equity considerations and community context matter alongside fiscal feasibility, since similar retreat timelines can correspond to very different financial burdens and relocation challenges.

Table 5.5.a. Key BOLB model results in King Salmon. Table reports summary statistics for modeled BOLB outcomes in King Salmon at the property and neighborhood scale. All results are generated using the baseline model parameters.

BOLB Model Outputs	Median Per Parcel	Neighborhood Total
Market Value	$314,417	-
Expected Economic Lifespan	22 years	-
Buyout Price	$210,498	$12,983,112
Leaseback Advantage	$67,005	$5,433,453
Public Net Cost	$109,471	$6,479,081

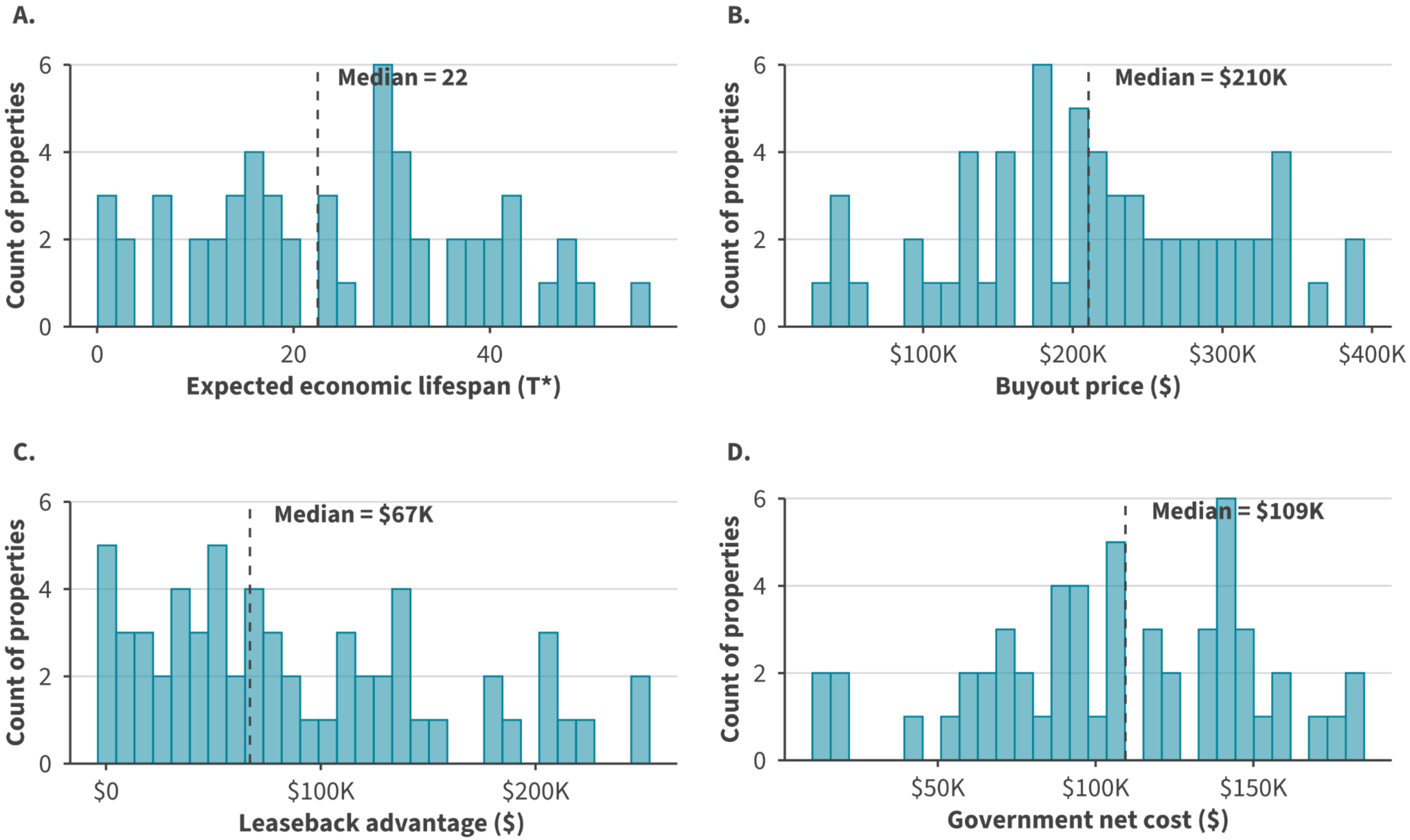


Figure 5.5.a. **Distributions of key BOLB model results for King Salmon.** Subfigures show histograms of property-level modeled outcomes for expected economic lifespan (A), buyout price (B), leaseback advantage (C), and public net cost (D), with each distribution plotted using 30 bins.

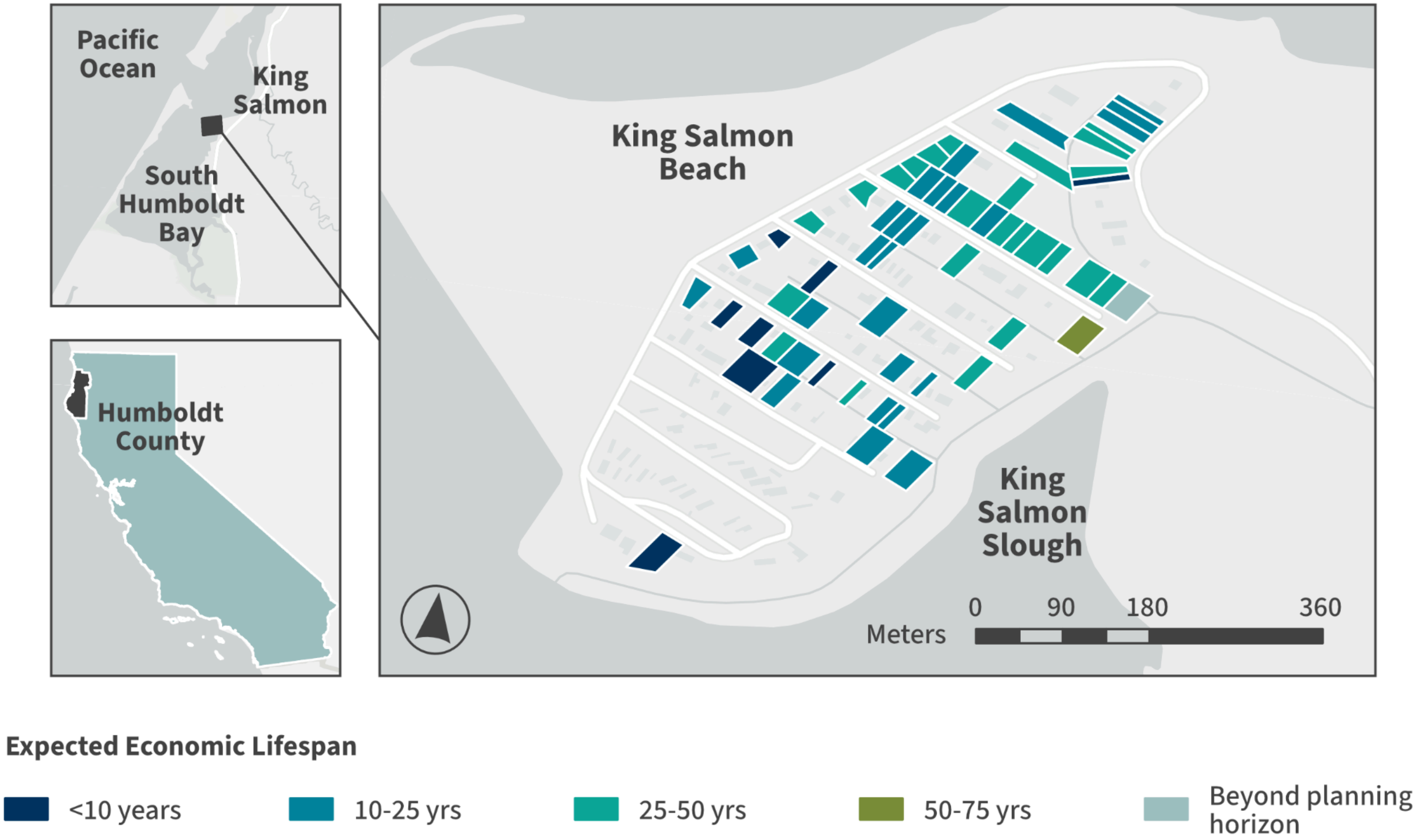


Figure 5.5.b. Property-level map of expected economic lifespan in King Salmon. Properties are symbolized by their modeled expected economic lifespan under the baseline scenario, showing spatial variation in retreat timing across the case study area.

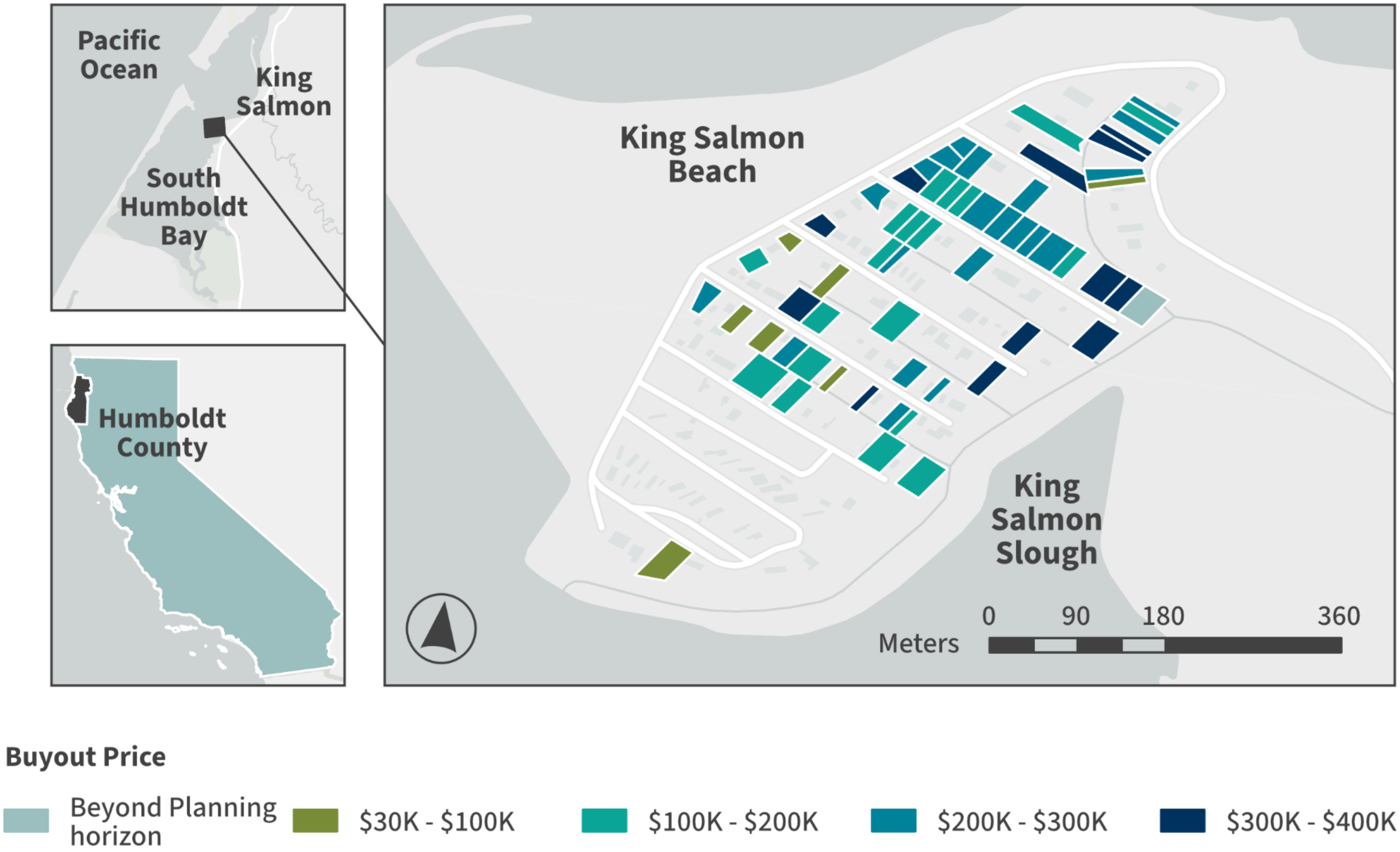


Figure 5.5.c. Property-level map of buyout price in King Salmon. Properties are symbolized by their modeled expected buyout price under the baseline scenario, showing spatial variation in price across the case study area. Symbol classes are based on rounded quartile breaks.

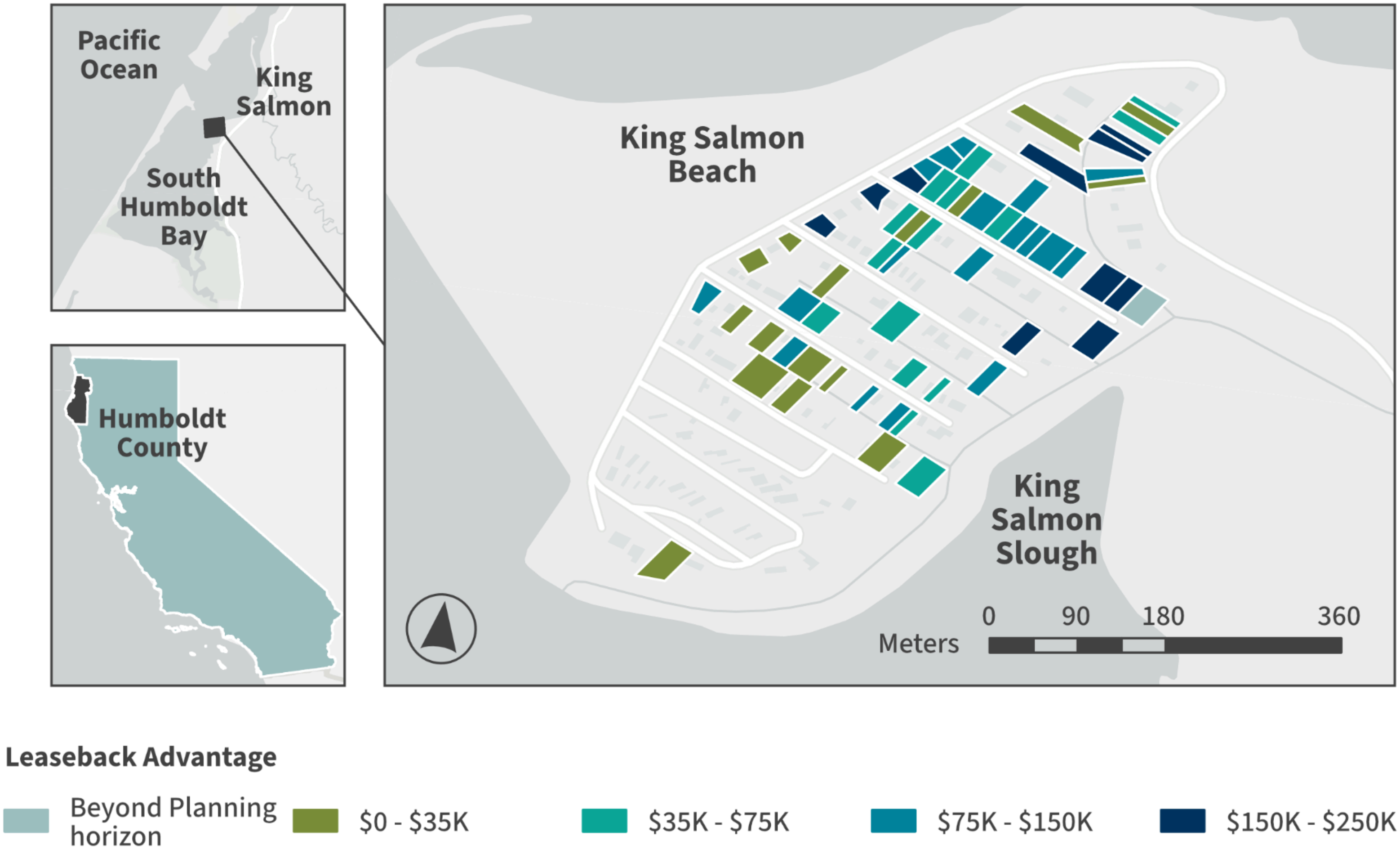


Figure 5.5.d. **Property-level map of leaseback advantage in King Salmon.** Properties are symbolized by their modeled expected leaseback advantage under the baseline scenario, showing spatial variation in revenue across the case study area. Symbol classes are based on rounded quartile breaks.

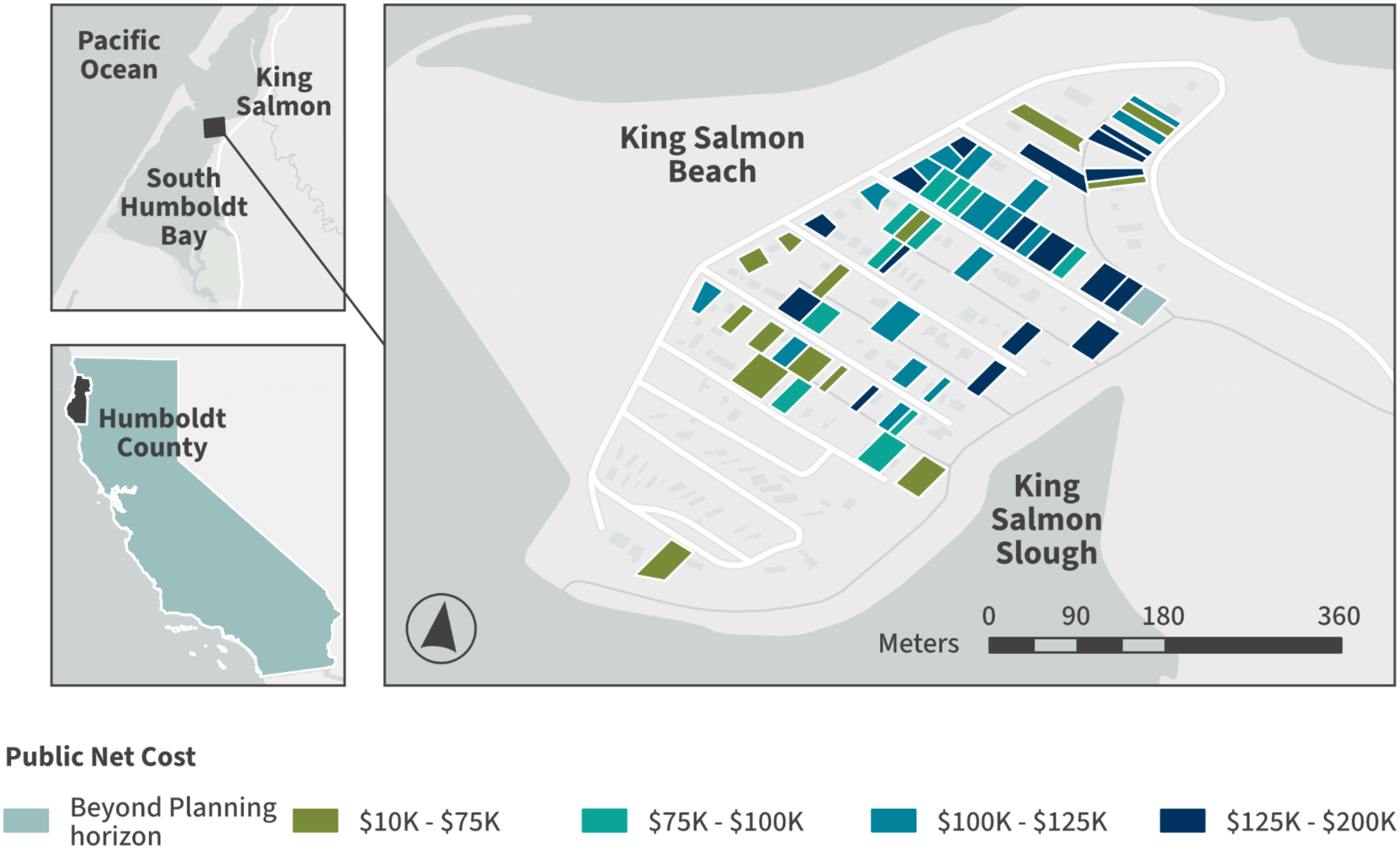


Figure 5.5.e. Property-level map of public net cost in King Salmon. Properties are symbolized by their modeled expected leaseback advantage under the baseline scenario, showing spatial variation across the case study area. Symbol classes are based on rounded quartile breaks.

5.6 Insights Across Case Studies

Across five neighborhood-scale case studies, the BOLB framework produces consistent patterns in program timelines, buyout prices, leaseback revenues, and public net costs that clarify how such a strategy could support managed retreat across coastal California. While site conditions (e.g. elevation or annual rents) shape property-level variation, cross-case comparisons highlight three recurring themes: (1) a BOLB program can substantially reduce public retreat costs relative to traditional buyouts and can generate net public benefits in cliff settings, (2) modeled buyout prices are often meaningfully below current market values, which may create homeowner perception challenges, and (3) spatial “patchiness” in remaining economic lifespans may complicate implementation even when program economics are favorable.

5.6.1 BOLB reduces public retreat costs and may produce net public benefit

Across flood-prone case studies (i.e. Carpinteria, Stinson, and King Salmon), the BOLB framework substantially reduces public costs compared to traditional market-value buyouts with no leaseback component. At the neighborhood scale, modeled public net costs to buyout property are roughly 65-86% lower than the property market value, implying a large reduction in the public expenditure needed to remove structures and restore land over time. For example, Carpinteria’s per-parcel median public net cost is $529.2 thousand, while the per-parcel median market value is $3.2 million (Figure 5.6.a). These public net cost estimates also assume that flood damages occur annually over each property’s expected economic lifespan. In practice, pairing BOLB with short-term protective measures during the leaseback period (e.g., revetments or sand nourishment) could reduce annual damages and further lower public net costs. This is especially important in floodplain settings, where cumulative damage costs can require longer lease durations to bring public net costs down over time.

In cliff-retreat cases, the framework produces an even stronger result than in flood-prone areas. Because retreat is modeled as a one-time decision prior to catastrophic failure and ongoing damages are not accrued during the leaseback period, public net costs are simply the inverse of leaseback revenues, meaning the public sector retains discounted lease revenue as a net benefit. In Pacifica, for example, the median public net cost is -$550,065 per parcel (net revenue) compared to a median market value of roughly $1.1 million, indicating that BOLB can be revenue-generating in cliff settings under the current model structure. This net-positive revenue stream may also provide greater flexibility in timing and program design. Jurisdictions could choose to end leases once cumulative leaseback revenues recover the initial buyout cost (i.e., at break-even), enabling earlier structure removal and retreat than in flood-prone areas where longer leases may be needed to offset ongoing damage costs. Alternatively, leaseback revenues could be used to cover other programmatic or site costs such as demolition, relocation assistance, or habitat restoration (Figure 5.6.a).

Taken together, the case studies suggest a “natural” cost prioritization where public net costs tend to be lowest in higher-risk areas where remaining economic lifespans are shortest, which concentrates program dollars in places where retreat urgency is highest. King Salmon illustrates this dynamic clearly, as the neighborhood’s high exposure and relatively low property values produce short lifespans and comparatively low total program costs, with the largest share of properties reaching end-of-lifespan within 10 years across case studies. These naturally prioritized, higher-risk neighborhoods may be strong candidates for early BOLB pilots because lower costs and shorter remaining lifespans can shorten program timelines and allow outcomes to be evaluated sooner.

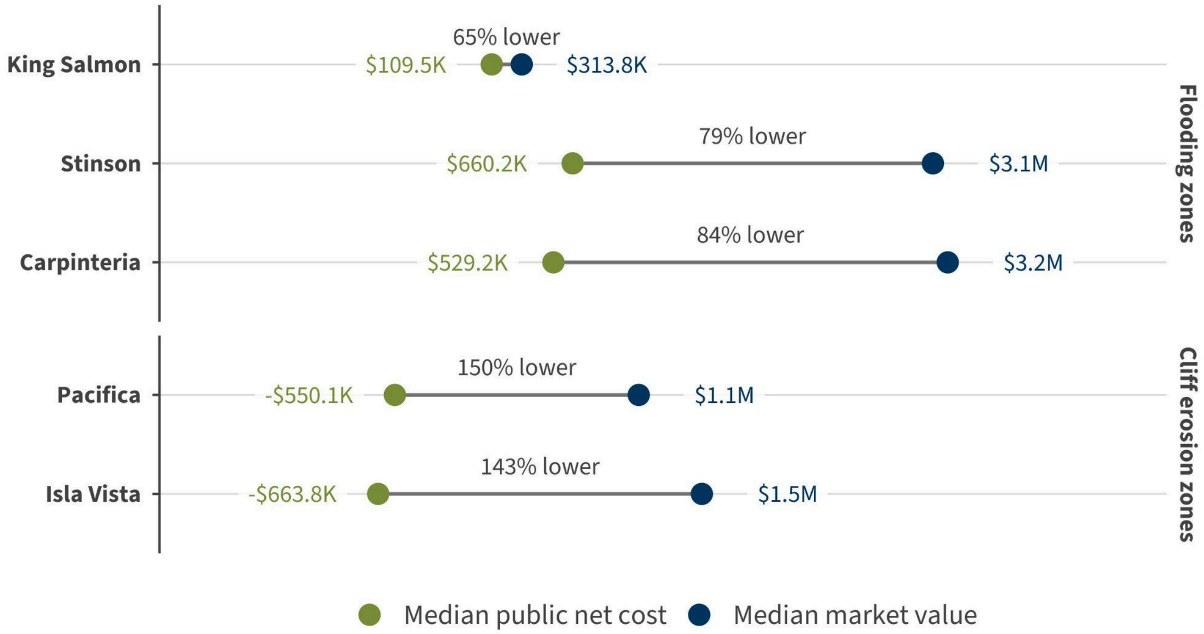


Figure 5.6.a. Comparison of median parcel public net cost and market value. Dumbbell plot compares median per-parcel public net cost under the BOLB framework to median market property value across case study neighborhoods. Lines connect the two metrics for each neighborhood to show the magnitude and direction of the gap.

5.6.2 BOLB buyouts fall below market values and may challenge public acceptance

Across case studies, modeled BOLB buyout prices are consistently lower than current market values, though the magnitude varies substantially (Figure 5.6.b). Median buyout prices are 13–54% lower than median market values. For example, Carpinteria's median buyout price is $1.5 million per parcel, compared to a median market value of $3.2 million (Figure 5.6.b). This pattern reflects the SLR risk-adjusted structure of our framework, where buyout prices are tied to remaining expected economic lifespan rather than recent comparable sales and therefore decline as expected remaining years shorten. As a result, the framework can create a sizable gap between what owners may perceive their property to be "worth" and what the program would pay under risk-adjusted assumptions. This gap should be interpreted with some caution, since it may reflect both expectations about future intervention and limitations in our rent estimation, which uses a uniform yield applied to current prices and may not fully capture rents implied by markets pricing a finite use horizon.

Addressing this public perception challenge will require clear communication that BOLB is not designed to replicate current market prices, but rather to transfer downside climate risk to the program while converting an at-risk asset into liquid capital tied to remaining economic lifespan and retaining the option to stay or exit with remaining value. Clear education around timing will also be essential. As modeled buyout value declines when remaining economic lifespan shortens, earlier voluntary participation can preserve more value for homeowners and shift more risk off of households before damages accumulate.

5.6.3 Spatial gradients in remaining economic lifespan support phasing while patchiness complicates implementation

Across case studies, spatial patterns in expected economic lifespan vary from clear gradients to highly patchy, property-by-property outcomes, and these patterns have direct implications for implementation. Patchiness can reflect fine-scale differences in elevation, property value, and flood and cliff modeling, which can shift modeled retreat timing between adjacent parcels. Where the economic lifespans of properties form clear spatial gradients, areas within a neighborhood can be grouped into phases for acquisition, lease termination, and structure removal, which can reduce "checkerboarding" and support coordinated restoration at a meaningful scale. This pattern is most apparent in cliff settings such as Pacifica, where modeled economic lifespans follow a clear gradient linked to distance from the cliff edge and retreat thresholds, creating more intuitive sequencing for phased retreat. In contrast, flood-prone neighborhoods such as Carpinteria show localized clustering without a consistent gradient, where short-lifespan properties can sit immediately adjacent to beyond-horizon properties, complicating decisions about when and where to end leases and restore sites.

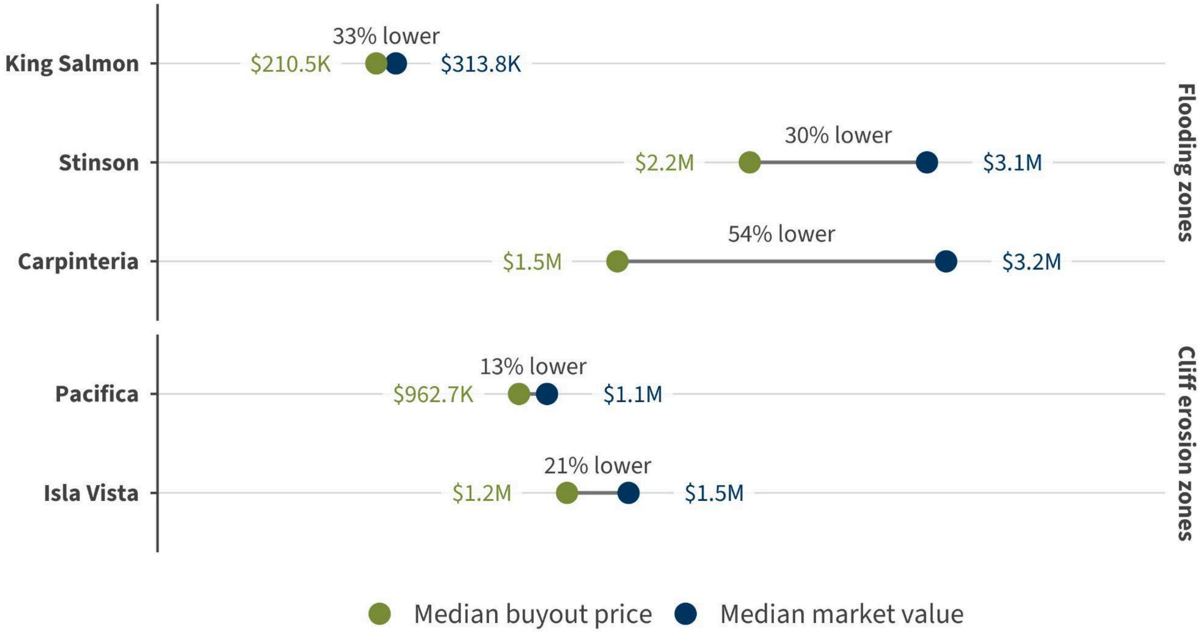


Figure 5.6.b. Comparison of median parcel buyout price and market value. Dumbbell plot compares median per-parcel buyout price under the BOLB framework to median market property value across case study neighborhoods. Lines connect the two metrics for each neighborhood to show the magnitude and direction of the gap.

Patchiness creates a practical tradeoff between a BOLB program's financial and coordination efficiency. From a cost-minimization perspective, the program would ideally maintain leases until public net costs are minimized. However, from a coordination and planning perspective, jurisdictions may prefer to end leases and remove structures at scale to support coordinated restoration and to avoid checkerboarding, which can prolong fragmented shoreline conditions and potentially intensify SLR-related impacts for adjacent properties that have not yet retreated. In practice, implementing BOLB at the neighborhood scale will likely require explicit phasing strategies and decision rules that balance these objectives, particularly in areas where parcel-level outcomes are highly heterogeneous.

5.6.4 Neighborhood-scale buyout costs are large, but comparable to other coastal adaptation expenses

In flood-prone case studies where neighborhood-scale buyouts generate a positive public net cost, total costs can be substantial but remain comparable in magnitude to other coastal adaptation investments already proposed or underway in California. Under our modeled baseline assumptions, total neighborhood buyout costs range from roughly $6.5 million in King Salmon to $132.5 million in Stinson. To contextualize our modeled neighborhood-scale BOLB public net costs, Marin County's Stinson Beach ARC cost estimates illustrate the scale of alternative protection and accommodation actions as sea level rise increases. Bulkhead replacement alone is estimated in the hundreds of millions (e.g., ~$294.9 million at ~0.8 ft SLR and ~$343.6 million at ~3.0 ft). Recurring living shorelines maintenance (multiple events of ~$16–37 million) and phased road/bridge elevation (multiple phases of ~$10–17 million) also accumulate across SLR triggers (Environmental Science Associates, 2025). Additional project-level cost benchmarks show similar orders of magnitude. For example, U.S. Army Corps of Engineers (USACE) estimates an initial sand placement cost of about $16.3 million for the San Clemente Shoreline project, while the Oceanside RE:BEACH pilot report estimates $55 million in upfront capital costs plus an additional $1.5 million per year in long-term maintenance (U.S. Army Corps of Engineers, 2023a, 2023b; Resilient Cities Catalyst, 2025). While our BOLB estimates apply only to a subset of properties expected to reach the end of their economic lifespan within the planning horizon (97% for King Salmon, 82% for Carpinteria, and 50% for Stinson), these comparisons still highlight that neighborhood-scale retreat costs can be on the same order as major protection investments and the cumulative costs of maintaining hybrid measures over time.

6. Key Findings, Limitations, and Next Steps

6.1 Key Findings

The thematic analysis presented in Chapter 2 highlights the complex social, economic, and governance dynamics surrounding managed retreat. Across policy documents, academic literature, government reports, and public discourse, retreat is widely recognized for its potential environmental benefits. Allowing shorelines to migrate inland can preserve beaches, restore coastal habitats, and reduce long-term hazard exposure for communities and infrastructure.

However, these environmental benefits are frequently outweighed by economic and political concerns. Coastal properties often represent significant private wealth as well as an important source of municipal tax revenue. The prospect of retreat can generate strong opposition from property owners and local governments concerned about declining property values and fiscal stability. Uncertainty surrounding funding mechanisms for property acquisition further complicates implementation, particularly for smaller communities with limited financial resources. Social factors also play a critical role. Coastal communities often have strong cultural and emotional ties to place, making relocation decisions deeply personal and politically sensitive. Trust in institutions, access to clear information about coastal risks, and meaningful community engagement all influence whether retreat policies are viewed as legitimate or feasible.

Managed retreat also involves a complex set of externalities that can be applied towards both costs and benefits. On the benefits side, restored shorelines generate significant public value. Functioning beaches and dune systems provide flood attenuation, carbon sequestration, biodiverse habitats, and better public coastal access. On the cost side, property abandonment and property relocations could reduce the municipal tax base and shift fiscal burdens onto remaining residents, complicating local service provision in transitioning communities. A full accounting of retreat's public value must weigh these gains and losses together, yet most existing frameworks, including fair-market buyout programs, evaluate retreat property-by-property rather than as a community-scale investment in long-term shoreline resilience.

These dynamics also raise a fundamental strategic question: given that some coastal properties face economic lifespans of 20-30 years or less even under moderate sea level rise scenarios, is proactive public acquisition always the right tool? An alternative strategy would have the public sector focus initially on risk disclosure, financial education, and voluntary buyout offers, while allowing market forces to progressively reprice exposed properties. In this framing, the most promising path forward may be one that combines patient observation of actual shoreline change with near-term interventions targeted at willing participants, holding proactive buyout capacity in reserve for communities where coordinated retreat at scale is both necessary and feasible. Identifying and prioritizing those communities should be guided not only by financial feasibility but by community-defined motivations and public objectives that call for proactive action, such as preserving coastal resources and access that may be lost under purely protective or reactive strategies, enabling gradual transitions that reduce disruption, and coordinating retreat and restoration at a scale that protects shared shoreline values.

What makes proactive acquisition feasible in practice is the financing structure underlying it. One of the most consistent barriers to retreat implementation across all contexts reviewed in Chapter 2 is not political will or community opposition alone, but the absence of a credible, fiscally sustainable mechanism for property acquisition. The buyout-leaseback framework we examine addresses this directly and, in doing so, opens space for the kind of voluntary, community-driven retreat programs that are most likely to succeed in practice. Our case study applications illustrate how these mechanics play out across hazard types and housing markets, clarifying how program economics and timelines shift across settings.

In flood-prone settings, modeled public net costs are substantially lower than traditional market-value buyouts because lease revenue offsets a portion of acquisition costs, though outcomes depend on lease duration and the extent of recurring damage costs over time. In cliff settings, the framework produces an even stronger result under current assumptions because damages are not modeled to accumulate during the leaseback period, allowing discounted lease revenue to generate net public benefit. Together, these patterns suggest that BOLB can expand the feasible space for voluntary, community-driven retreat by lowering near-term public cost barriers and, in some settings, creating revenue streams that could support earlier structure removal, relocation assistance, and restoration.

At the same time, the case studies highlight practical implementation challenges that would need to be addressed for BOLB to gain traction. Modeled buyout offers frequently fall below current market values, which underscores the importance of clear communication about what the program is designed to provide, namely risk transfer, continued occupancy options, and a more predictable transition rather than market replication. Spatial patterns in remaining economic lifespan also vary widely across sites, from coherent gradients to highly heterogeneous parcel-level outcomes, creating tradeoffs between maximizing cost recovery through longer leases and coordinating demolition and restoration at meaningful scales.

These findings suggest that BOLB feasibility depends as much on program design and legitimacy as on economics, including how jurisdictions set purchase offers, communicate homeowner value, define triggers and phasing rules, and align funding with community-defined objectives for coastal resources and orderly relocation.

6.2 Project Limitations

This analysis of buyout-leaseback in California was created in partnership with the UCSB Ocean & Coastal Policy Center and the California Coastal Commission as part of the Bren School of Environmental Science and Managed Group Project. This group project satisfies the graduation requirements equivalent to a traditional master's thesis. This project is designed to mimic the working demands of a full-time employee for one calendar year. In this project, these duties were split among a group of five authors over 9 months. Concurrently, group members were expected to maintain a full-time class load in addition to the expectations of this project. While there was a finite amount of time available to work on this project, there could be more work to be done to further study and help implement buyout-leasback in California. These recommendations, along with limitations to certain research methods, are outlined below.

6.2.1 Thematic analysis

The thematic and frequency analyses of values, trade-offs, and challenges surrounding managed retreat have some limitations that are important to acknowledge and could be addressed in future research.

First, due to time limitations, we were unable to do a more holistic analysis amongst all document types. In all document types, analysis was concluded once the researcher believed saturation had been reached. In the case of published academic articles, we supplemented our research with expert-curated research. If given more time, it would be helpful to increase our sample size of document types and have more codes to fully recognize trends in document type, region, and category.

Second, this analysis of existing discussions about managed retreat captures only sentiments that have been written down for public consumption. Interviewing different stakeholders, especially in our case study neighborhoods, and coding those interviews to compare with our document analysis would have provided an even more grounded approach for our analysis. Timing constraints limited our efforts to interview more community members, but this should be considered for future projects.

6.2.2 Buyout-leaseback financial model

The buyout-leaseback framework and case study modeling presented in this report provide useful insights into the feasibility of managed shoreline retreat, but several limitations should be considered when interpreting the results. Many of these limitations stem from simplifying assumptions required to model long-term coastal hazards and housing market dynamics across multiple case study locations.

The economic modeling framework assumes relatively stable property values and consistent leaseback revenues over the planning horizon. In reality, coastal housing markets may respond to increasing awareness of sea level rise risk, insurance availability, disclosure requirements, and future coastal policies. As climate risks become more widely recognized, property values in vulnerable coastal areas may decline relative to current levels, potentially reducing acquisition costs. At the same time, strong demand for coastal housing could maintain higher property values than those assumed in the model. Leaseback revenues may also vary across properties depending on local rental markets, housing conditions, and homeowner participation.

The hazard modeling approach relies on established sea level rise projections and simplified damage functions to estimate when coastal structures reach the end of their economic lifespan. As with any long-term projection, future coastal conditions may differ from modeled outcomes due to evolving climate dynamics and regional variability along California's coastline. Global sea level rise trajectories, local subsidence or uplift, storm patterns, and sediment dynamics can all influence how flooding and erosion risks develop over time. Rather than representing a fixed prediction, the modeling framework should therefore be understood as a decision-support tool that can be updated as improved coastal projections and hazard models become available. Continued refinement of coastal flooding and erosion models will help ensure that retreat planning frameworks remain aligned with the most current scientific understanding of coastal risk.

The analysis also does not explicitly capture the full range of behavioral and ownership considerations that influence retreat implementation. Participation in buyout programs is voluntary, and homeowner decisions may depend on factors such as personal attachment to place, financial expectations, or perceptions of future coastal risk. In addition, the current framework primarily evaluates the value of coastal structures rather than the full parcel value of land and improvements. In practice, flooding exposure and ownership risks may vary across parcels, and the valuation of land relative to structures may influence how property owners perceive buyout offers. Future modeling approaches could incorporate parcel-level land valuation, differential flood exposure across properties, and alternative ownership risk scenarios to better represent the full economic and behavioral dimensions of retreat decisions.

6.3 Recommendations and Next Steps

The case study results suggest buyout-leaseback could be a practical financing pathway for managed shoreline retreat, but moving from modeling to implementation will require targeted testing, clearer guidance for local jurisdictions, and policy support that centers equity and community legitimacy.

6.3.1 Build community legitimacy and participation

- **Conduct practitioner and community surveys**. Use short, targeted surveys to identify participation barriers, knowledge gaps, locally acceptable triggers, and needed relocation supports before program design begins.
- **Invest early in public education and trust-building.** Launch an education effort that clearly explains buyout pricing, leaseback terms, timing implications, and renter protections before any formal program rollout.
- **Advance BOLB through community-led engagement.** Co-design program objectives, triggers, and phasing strategies with residents and local partners so financing tools reflect place-based priorities such as coastal access, ecosystem protection, and gradual transitions.

6.3.2 Test feasibility through pilots

- **Fund and evaluate a pilot program to build an evidence base for a revolving loan bill.** A pilot spanning at least one flood-prone and one cliff-retreat site would test pricing, lease templates, engagement approaches, and real-world revenue performance, providing practical lessons to inform reintroduction of a state revolving loan program.
- **Identify near-term pilot funding sources.** Use existing grant pathways (coastal resilience, hazard mitigation, state programs) to cover start-up costs for outreach, legal templates, valuations, and administration.

6.3.3 Strengthen the policy, administrative, and modeling foundation

- **Clarify legal and administrative pathways for long-term public ownership with leaseback.** Develop standardized guidance on lease structures, management responsibilities, triggers, and property disposition so local agencies do not reinvent program mechanics case by case.
- **Design for equity alongside financial viability.** Pair BOLB with relocation assistance, renter protections, and replacement housing pathways so lower-cost, higher-risk neighborhoods are supported without exacerbating displacement or inequity.
- **Integrate parcel-scale hazard and "economic lifespan" screening into LCP updates.** Use neighborhood-scale hazard modeling to identify priority areas, define measurable retreat triggers, and support phased acquisition and coordinated restoration that avoids checkerboarding.
- **Improve representation of parcel value and exposure in the model.** Incorporate parcel-level land valuation, differential exposure within parcels, and alternative ownership/repair responsibility scenarios to better reflect how costs accrue and how homeowners perceive offers.

References

Adu P. (2023, July 29). *Conducting thematic analysis* [YouTube playlist]. YouTube. https://www.youtube.com/watch?v=LMaz9GsTL_Q&list=PLSOjmgd2Fg_kVYRQYNraRoX9ZoEntQk7z

Albouy, D., Ehrlich, G., & Shin, M. (2018). Metropolitan land values. *Review of Economics and Statistics, 100*(3), 454–466. https://doi.org/10.1162/rest_a_00710

Ajibade, I., Sullivan, M., & Lower, Chris, Yarina, Lizzie, Reilly, Allie. (2022). *Are managed retreat programs successful and just? A global mapping of success typologies, justice dimensions, and trade-offs. Global Environmental Change, 76, 102576.* https://doi.org/10.1016/j.gloenvcha.2022.102576

Baldauf, M., Garlappi, L., & Yannelis, C. (2019). *Does Climate Change Affect Real Estate Prices? Only If You Believe In It*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3240200

Barnard, P. L., Erikson, L. H., Foxgrover, A. C., Hart, J. A. F., Limber, P., O'Neill, A. C., van Ormondt, M., Vitousek, S., Wood, N., Hayward, C. S., & Jones, J. M. (2019). Dynamic flood modeling essential to assess the coastal impacts of climate change. *Scientific Reports*, 9(1), 4309. https://doi.org/10.1038/s41598-019-40742-z

Barnard, P. L., Erikson, L. H., Foxgrover, A. C., Limber, P., O'Neill, A. C., & van Ormondt, M. (2015). *Coastal Storm Modeling System (CoSMoS) for Southern California, v3.0, Phase 2* [Data release]. U.S. Geological Survey. https://www.sciencebase.gov/catalog/item/57f1d4f3e4b0bc0bebfee139

Barnard, P. L., van Ormondt, M., Erikson, L. H., Eshleman, J., Hapke, C., Ruggiero, P., Adams, P. N., & Foxgrover, A. C. (2014). Development of the Coastal Storm Modeling System (CoSMoS) for predicting the impact of storms on high-energy, active-margin coasts. *Natural Hazards, 74*(2), 1095–1125. https://doi.org/10.1007/s11069-014-1236-y

Bernstein, A., Gustafson, M. T., & Lewis, R. (2019). Disaster on the horizon: The price effect of sea level rise. *Journal of Financial Economics*, 134(2), 253–272. https://doi.org/10.1016/j.jfineco.2019.03.013

Bragg, W. K., Gonzalez, S. T., Rabearisoa, A., & Stoltz, A. D. (2021). *Communicating managed retreat in California. Water, 13(6), 781*. https://doi.org/10.3390/w13060781

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

California Coastal Commission. (2015). *Sea level rise policy guidance: Interpretive guidelines for addressing sea level rise in Local Coastal Programs and coastal development permits*. California Coastal Commission.

California Coastal Commission. (2018). *Sea level rise policy guidance: Interpretive guidelines for addressing sea level rise in Local Coastal Programs and coastal development permits (Updated)*. California Coastal Commission.

California Coastal Commission. (2024). *Sea level rise policy guidance: Interpretive guidelines for addressing sea level rise in Local Coastal Programs and coastal development permits (Updated)*. California Coastal Commission. https://documents.coastal.ca.gov/assets/slr/guidance/2024/2024AdoptedSLRPolicyGuidanceUpdate.pdf

California Health & Safety Code § 34401 (2025). https://law.justia.com/codes/california/code-hsc/division-24/part-2/chapter-1-5/section-34401/

California Ocean Protection Council. (2018). *State of California sea level rise guidance: 2018 update*. California Natural Resources Agency.

California Ocean Protection Council. (2024). *State of California sea level rise guidance: 2024 update*. California Natural Resources Agency. https://opc.ca.gov/wp-content/uploads/2024/05/California-sea level-Rise-Guidance-2024-508.pdf

California State Board of Equalization. (n.d.-a). *Property tax rule 20: Taxable possessory interests* [PDF]. https://boe.ca.gov/proptaxes/pdf/rules/rule20.pdf

California State Legislature. (2022). Senate Bill 1078: Coastal adaptation planning and financing [Bill text]. LegiScan. https://legiscan.com/CA/text/SB1078/id/2606284

California State Legislature. (2023). *SB-272: Sea level rise: planning and adaptation* (2023–2024 Reg. Sess., Chapter 384). https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202320240SB272

City of Carpinteria. (2022). *City of Carpinteria dune and shoreline management plan*. Prepared by Wood Environment & Infrastructure Solutions, Inc., with Moffatt & Nichol and Coastal Restoration Consultants.

https://carpinteriaca.gov/wp-content/uploads/2021/11/City-of-Carpinteria_Dune-and-Shoreline-Management-Plan_FINAL_2.9.22-Formatted-Changes.pdf

City of Carpinteria. (2023). *Local hazard mitigation plan: Annex to the Santa Barbara County multi-jurisdictional hazard mitigation plan*. City of Carpinteria. https://content.civicplus.com/api/assets/d1925858-67ba-4a7d-b1f2-569c9338e2b5

City of Carpinteria. (2025). *Coastal land use plan and general plan (Draft)*. Prepared by WSP USA Environment & Infrastructure Inc. https://carpinteriaca.gov/wp-content/uploads/2025/06/REVDraft_CLUP-GP_Carpinteria_June2025.pdf

City of Pacifica. (2017). *Local coastal plan update stakeholder engagement plan.* Prepared by Kearns & West. https://www.cityofpacifica.org/home/showpublisheddocument/876/637830111043400000

City of Pacifica. (2018). *Local coastal plan update: Sea level rise adaptation planning frequently asked questions.* City of Pacifica. https://www.cityofpacifica.org/home/showpublisheddocument/898/637830131667300000

City of Pacifica. (2018). *Sea level rise vulnerability assessment (Draft).* Prepared by Environmental Science Associates. https://www.cityofpacifica.org/home/showpublisheddocument/856/637830110980900000

City of Pacifica. (2023). *Pacifica's sea level rise adaptation & coastal infrastructure resiliency efforts.* City of Pacifica.

City of Pacifica. (2025). *Local Coastal Land Use Plan*. City of Pacifica. https://www.cityofpacifica.org/home/showpublisheddocument/22079/639039770406630000

County of Santa Barbara. (1993). *Goleta community plan (with amendments through October 1995)*. County of Santa Barbara, Resource Management Department. https://content.civicplus.com/api/assets/dad0b829-866a-4010-80c1-07ab63eb7ee7

County of Santa Barbara. (2016). *Santa Barbara County coastal land use plan.* County of Santa Barbara, Planning & Development Department. https://cosantabarbara.app.box.com/s/cx95k0r4hnfo58hg291fi5gzf5rrdurd

County of Santa Barbara, Planning & Development Department. (2024). *Isla Vista bluff policy (Revised August 2024)*. County of Santa Barbara. https://content.civicplus.com/api/assets/31504ee9-0731-4344-ae84-e77943cf5142

Curran-Groome, W., Hino, M., BenDor, T. K., & Salvesen, D. (2022). Complexities and costs of floodplain buyout implementation. *Land Use Policy*, *118*, 106128. https://doi.org/10.1016/j.landusepol.2022.106128

Davis, S. A., & Skaggs, L. L. (1992). *Catalog of residential depth-damage functions used by the Army Corps of Engineers in flood damage estimation* (IWR Report 92-R-3). U.S. Army Corps of Engineers, Institute for Water Resources.

Dundon, L. & Camp, J. (2021). Climate justice and home-buyout programs: renters as a forgotten population in managed retreat actions. *Environmental Studies and Sciences, 11*, 420-433. https://doi.org/10.1007/ s13412-021-00691-4

Environmental Science Associates. (2025, May). *Stinson Beach Adaptation & Resilience Collaboration: Sea level rise adaptation study report*. Marin County Community Development Agency. https://assets.marincounty.gov/marincounty-prod/public/2025-06/StinsonARC_StudyReport_ADA%20508%20Format.pdf

Federal Emergency Management Agency. (2023). *Hazard Mitigation Assistance Policies and Guidance*. FEMA. https://www.fema.gov/sites/default/files/documents/fema_hma-program-policy-guide_032023.pdf

FLKS Living with Water. (2025). *Neighborhood perspectives: Household survey results—Fields Landing & King Salmon (Summer 2025).* https://drive.google.com/file/d/1F2o6F9jTXKkxEfZZbDp8SWyj6vjsGt8C/view

Freudenberg, R., Calvin, E., Tolkoff, L., & Brawley, D. (2016). *Buy-in for buyouts: The case for managed retreat from flood zones*. Lincoln Institute of Land Policy.

Georgetown Climate Center. (2020). Managing the retreat from rising seas: Lessons and tools from 17 case studies. *Georgetown University Law Center.* https://www.georgetownclimate.org/files/MRT/GCC_20_FULL-3web.pdf

Griggs, G., & Patsch, K. (2019). California's coastal development: sea level rise and extreme events – where do we go from here? Shore and Beach 87:2: 15-28. https://doi.org/10.34237/1008722

Griggs, G. and Patsch, K. (2019). *The Protection/Hardening of California's Coast- Times are Changing. Journal of Coastal Research: 35(5):1051-106.* https://doi.org/10.2112/JCOASTRES-D-19A-00007.1

Hino, M., Field, C. B., & Mach, K. J. (2017). *Managed retreat as a response to natural hazard risk. Nature Climate Change, 7(5), 364–370.* https://doi.org/10.1038/nclimate3252

Humboldt County. (2019). *Humboldt Bay Area Plan: Communities at risk—Sea level rise vulnerability assessment (Rev. November 20, 2019)*. Prepared By Aldaron Laird, Trinity Associates. https://humboldtgov.org/DocumentCenter/View/62872/Humboldt-Bay-Area-Plan-sealevel-Rise-Vulnerability-Assessment-Report-PDF?bidId=

Humboldt County. (2019). *Humboldt Bay Area Plan: Communities at risk—Strategic Sea Level Rise Adaptation Planning Report.* Prepared By Aldaron Laird, Trinity Associates. https://humboldtgov.org/DocumentCenter/View/81417/Humboldt-Bay-Area-Plan-Communities-at-Risk-Strategic-SLR-Adaptation-Report-11-30-2019-final-reduced?bidId=

Humboldt County Planning and Building Department. (2018). *King Salmon/Fields Landing Sea Level Rise Workshop Notes.* https://humboldtgov.org/DocumentCenter/View/65367/King-Salmon-and-Fields-Landing--8-7-2018-Workshop-Notes-PDF?bidId=

Keeler, A., Mullin, M., McNamar, D., & Smith, M. (2022). Buyouts with rentbacks: a policy proposal for managing coastal retreat. *Environmental Studies and Sciences, 12*, 646-651.https://doi.org/10.1007/s13412-022-00762-0

Kenyon, D. A., & Langley, A. H. (2010). *Payments in lieu of taxes: Balancing municipal and nonprofit interests* [PDF]. Lincoln Institute of Land Policy. https://www.lincolninst.edu/app/uploads/legacy-files/pubfiles/payments-in-lieu-of-taxes-full_0.pdf

Koslov, L. (2016). The case for retreat. *Public Culture, 28*(2), 359–387. https://doi.org/10.1215/08992363-3427487

Lester, C. F. (2005). An overview of California's coastal hazards policy. In G. B. Griggs, K. Patsch, & L. Savoy (Eds.), *Living with the changing California coast* (pp. 138–162). University of California Press. https://www.degruyterbrill.com/document/doi/10.1525/9780520938670-009/html

Lester, C., & Matella, M. (2016). *Managing the coastal squeeze: Resilience planning for shoreline residential development. Stanford Environmental Law Journal, 36* (23).

Lester, C., Griggs, G., Patsch, K., & Anderson, R. (2022). *Shoreline retreat in California: Taking a step back. Journal of Coastal Research, 38(6), 1207–1230.* https://doi.org/10.2112/JCOASTRES-D-22A-00010.1

Lester, C., Manley, C., Dinh, Y., Rozal, S., Cooper, A., Winters, L., Munster, K., Bok, T., Wrubel, N., (2024). Planning for Sea Level Rise on California's Coast: Status, Trends, and Recommendations. Ocean and Coastal Policy Center, Marine Science Institute, University of California, Santa Barbara, California. https://drive.google.com/file/d/1IJjDN8OHJqxzRUDRTxUgcd2iZpUYAklk/view

Mach, K. J., Kraan, C. M., Hino, M., Siders, A. R., Johnston, E. M., & Field, C. B. (2019). *Managed retreat through voluntary buyouts of flood-prone properties. Science Advances, 5(10), eaax8995*. https://doi.org/10.1126/sciadv.aax8995

ManageCasa. (2025). *Rental property ROI: Top California cities for maximum returns in 2025*. https://managecasa.com/articles/rental-property-roi-top-california-cities-for-maximum-returns-in-2025

Marin County Community Development Agency. (2018). *Marin County Local Coastal Program.* Marin County. https://assets.marincounty.gov/marincounty-prod/public/2024-08/lcp_lup_240828.pdf

Marin County Community Development Agency. (2025). *Local Coastal Program: Implementation plan—Title 20 Coastal Zoning Code* . Marin County. https://library.municode.com/ca/marin_county/codes/municipal_code?nodeId=TIT20COZOCO_CH20.01PUAPCOZORE

Marin County Community Development Agency. (2025). *Stinson Beach Adaptation & Resilience Collaboration: Sea level Rise Adaptation Study.* Prepared by Environmental Science Associates. https://assets.marincounty.gov/marincounty-prod/public/2025-06/StinsonARC_StudyReport_ADA%20508%20Format.pdf

Moser, S. C., Finzi Hart, J., Newton Mann, A., Sadrpour, N., & Grifman, P. M. (2016). *Growing effort, growing challenge: Findings from the 2016 California coastal adaptation needs assessment.* California's Fourth Climate Change Assessment. California Energy

Commission. https://www.energy.ca.gov/sites/default/files/2019-12/Oceans_CCCA4-EXT-2018-009_ada.pdf

Office of the Governor. (2022, September 29). Veto message for Senate Bill 1078 [Letter]. Retrieved from https://leginfo.legislature.ca.gov/faces/billStatusClient.xhtml?bill_id=202120220SB1078

Reguero, B. G., Lester, C., Young, A. P., Rozal, S., & Pickett, C. (2023). *Coastal adaptation science needs in California: A roadmap for researchers to advance climate adaptation.* UC Coastal Resilience and Climate Adaptation Initiative. https://escholarship.org/uc/item/9n41w87d

Resilient Cities Catalyst. (2025, October 28). *The case for coastal resilience investment: Quantifying Oceanside Beach as an economic asset*. https://static1.squarespace.com/static/5dba154a6b94a433b56a2b1d/t/69710216fadcbc11c0ad687d/1769013782079/Oceanside%2BREBEACH%2BEIA%2BFinal.pdf

Revell, D., King, P., Giliam, J., Calil, J., Jenkins, S., Helmer, C., Nakagawa, J., Snyder, A., Ellis, J., & Jamieson, M. (2021). A Holistic Framework for Evaluating Adaptation Approaches to Coastal Hazards and Sea Level Rise: A Case Study from Imperial Beach, California. Water, 13(9), 1324. https://doi.org/10.3390/w13091324

Riggio, C., & Richmond, L. (2025). *Report: Fields Landing & King Salmon Household Survey Results (Summer 2025)*. https://drive.google.com/file/d/1-dF8n2DFu5bvPh4Rnx0FwkB6jBbdXZ_D/view

Sweet, W. V., Kopp, R. E., Weaver, C. P., Obeysekera, J., Horton, R. M., Thieler, E. R., & Zervas, C. (2022). *Global and regional sea level rise scenarios for the United. National Oceanic and Atmospheric Administration.* https://tidesandcurrents.noaa.gov/publications/techrpt83_Global_and_Regional_SLR_Scenario s_for_the_US_final.pdf

U.S. Army Corps of Engineers, Los Angeles District. (2023, April 19). *Construction - San Clemente Shoreline, CA* [Fact sheet]. https://www.spl.usace.army.mil/Media/Fact-Sheets/Article/3368056/construction-san-clemente-shoreline-ca/

U.S. Geological Survey. (2021). *Coastal Storm Modeling System (CoSMoS)*. Pacific Coastal and Marine Science Center.

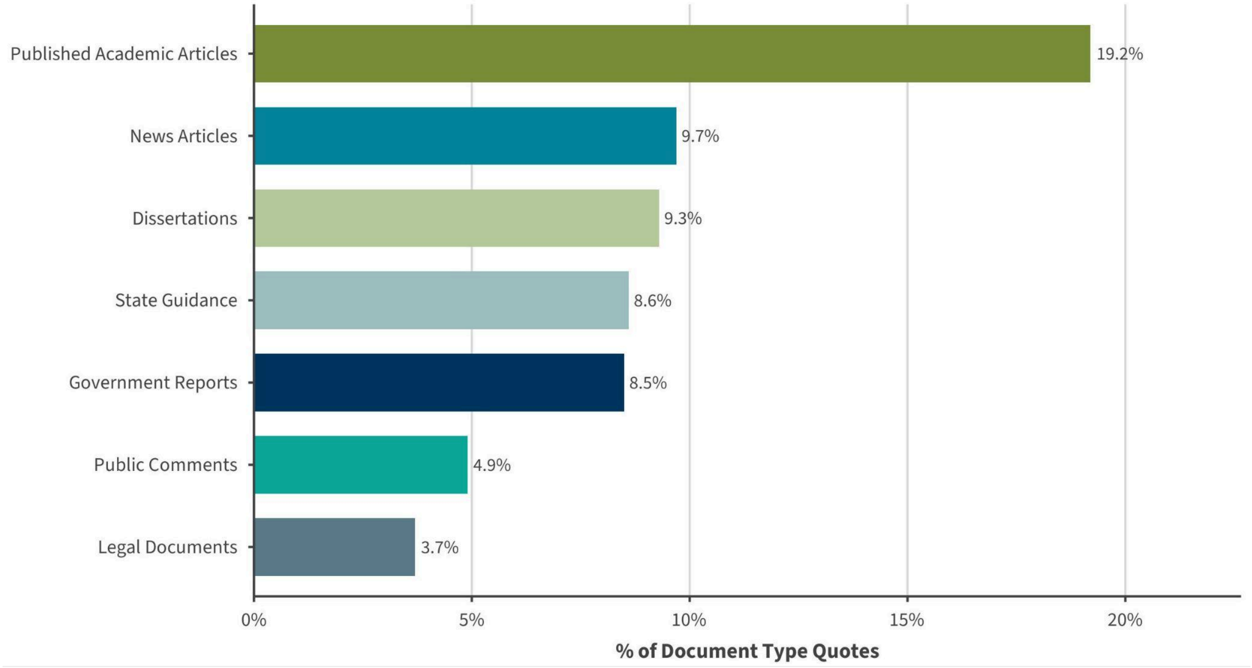
https://www.usgs.gov/centers/pcmsc/science/coastal-storm-modeling-system-cosmos

Young, A. W. (2018). How to retreat: The necessary transition from buyouts to leasing. *Coastal Management, 46*(5), 527–535. https://doi.org/10.1080/08920753.2018.1498716

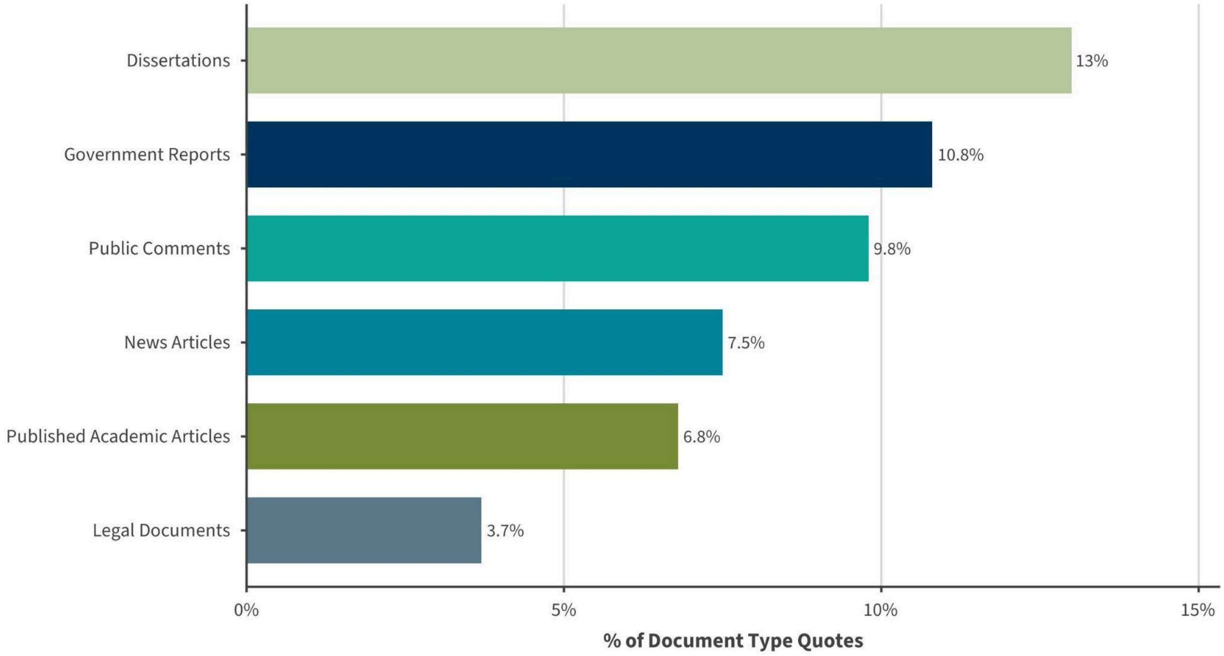
Appendices

Appendix A. Thematic Coding Materials

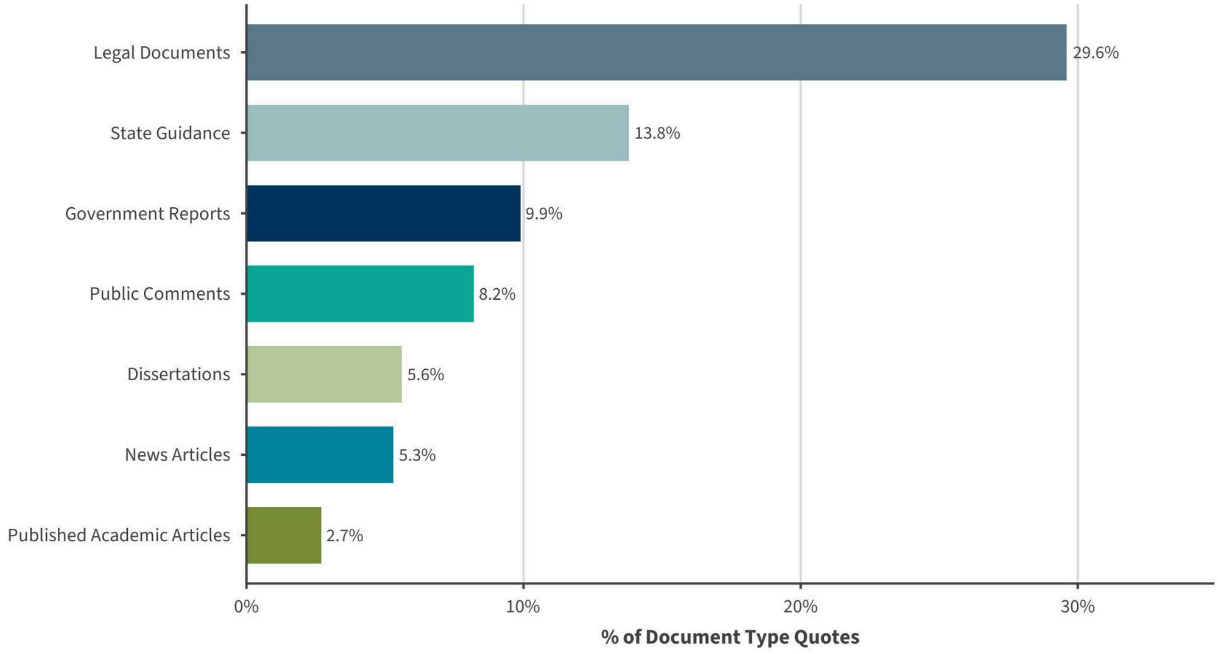
Appendix A.1. Supplementary figures of normalized quotes by document type



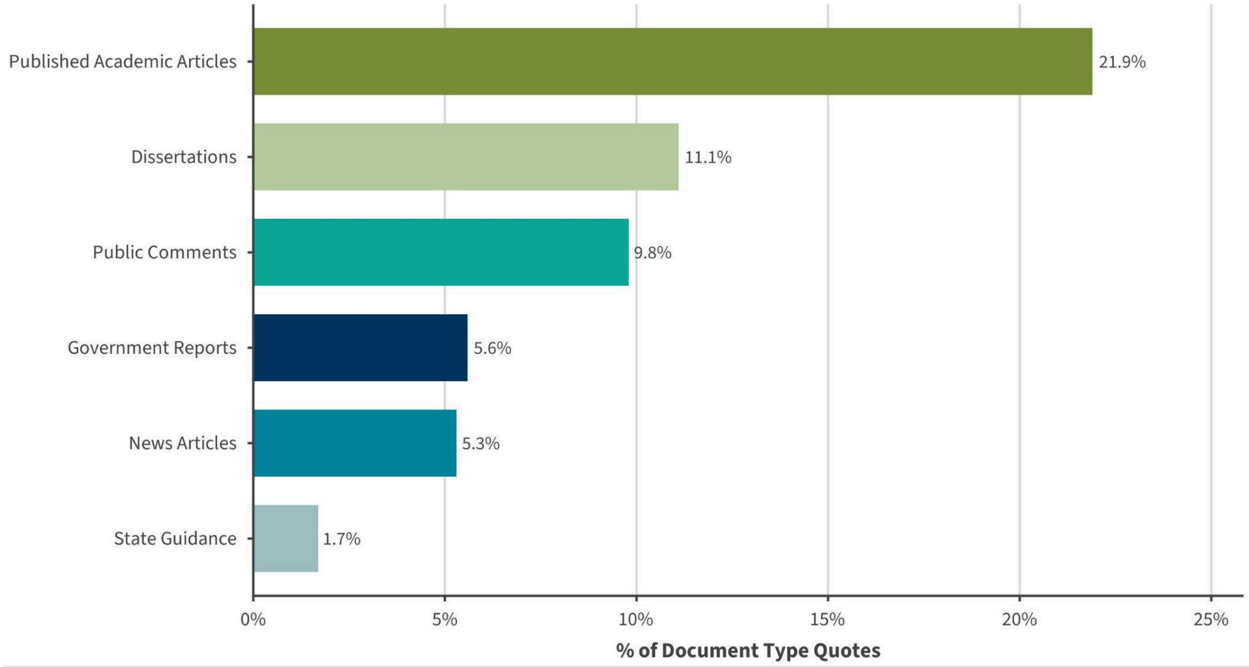
Appendix Figure A.1.1. Percent of quotes by document type for T1 - *Inclusive Community Engagement, Equity, and Public Stewardship of Coastal Resources are Prerequisites for Successful Managed Retreat Implementation*



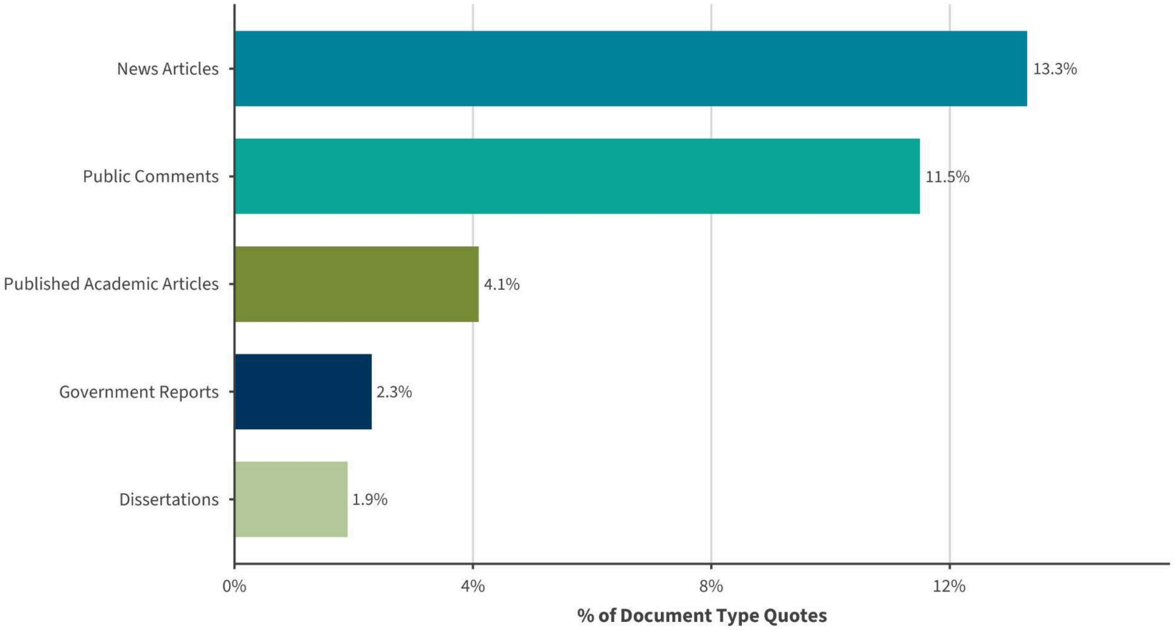
Appendix Figure A.1.2. Percent of quotes by document type for T2 - *Funding Gaps, Revenue Losses, Property Value Disparities, and Equity Challenges Complicate Managed Retreat.*



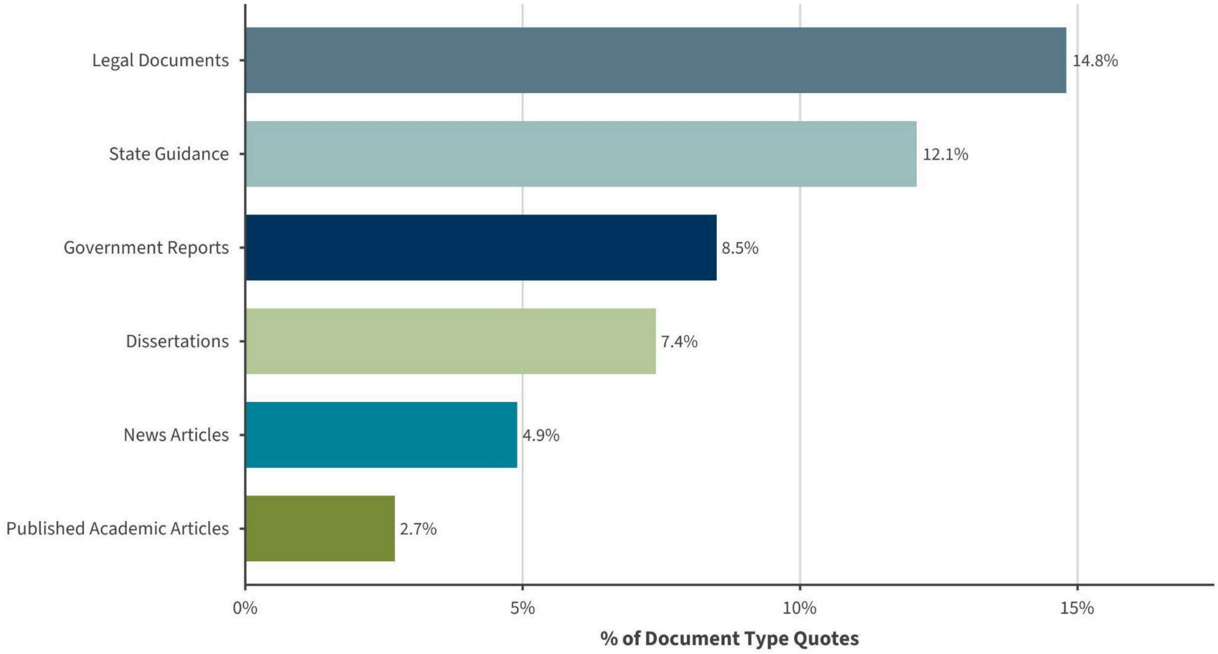
Appendix Figure A.1.3. Percent of quotes by document type for T3 - *Local and Statewide Coordination, Novel Resilience Tools, and Public Land Planning Advance Managed Retreat.*



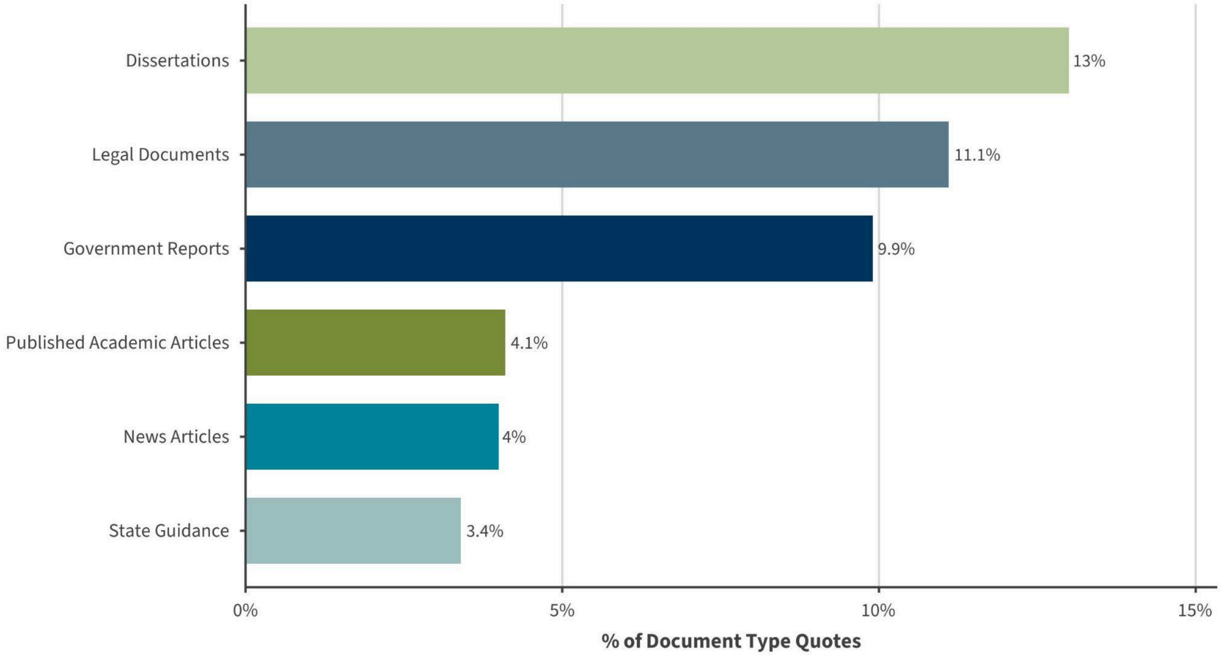
Appendix Figure A.1.4. Percent of quotes by document type for T4 - *Communication Failures, Social Disruption, and Displacement of Communities are Social Risks Managed Retreat Policy Must Address.*



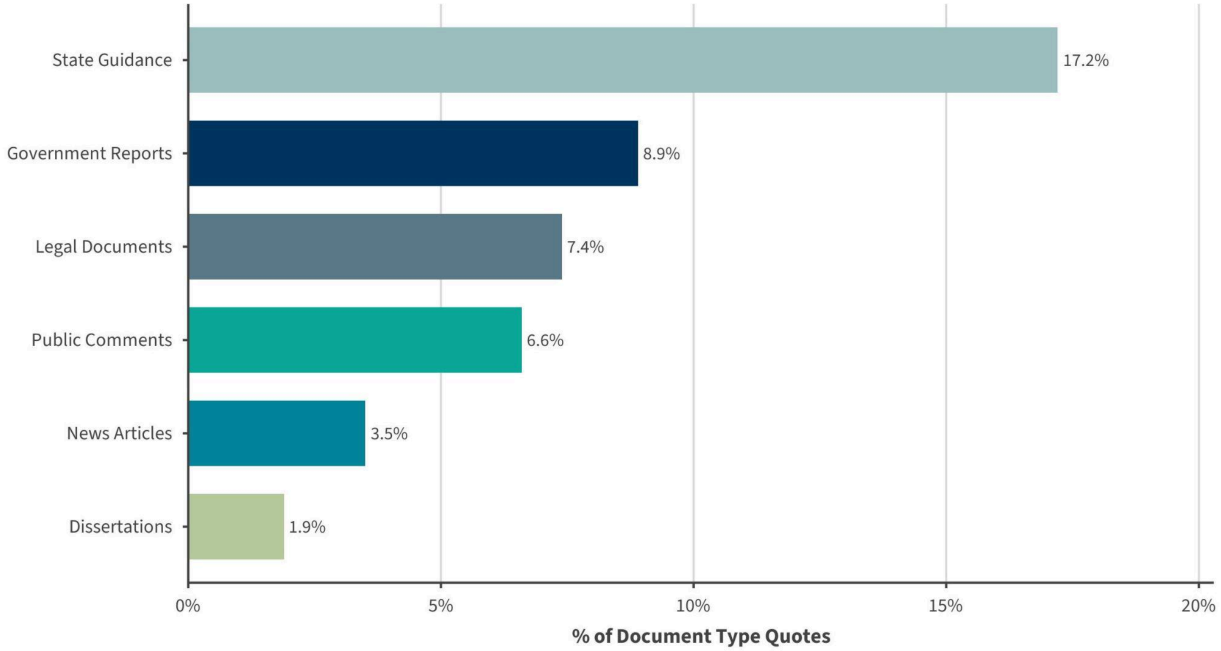
Appendix Figure A.1.5. Percent of quotes by document type for T5 - *Denial, Skepticism, Distrust, and Feasibility Doubts Undermine Managed Retreat Acceptance.*



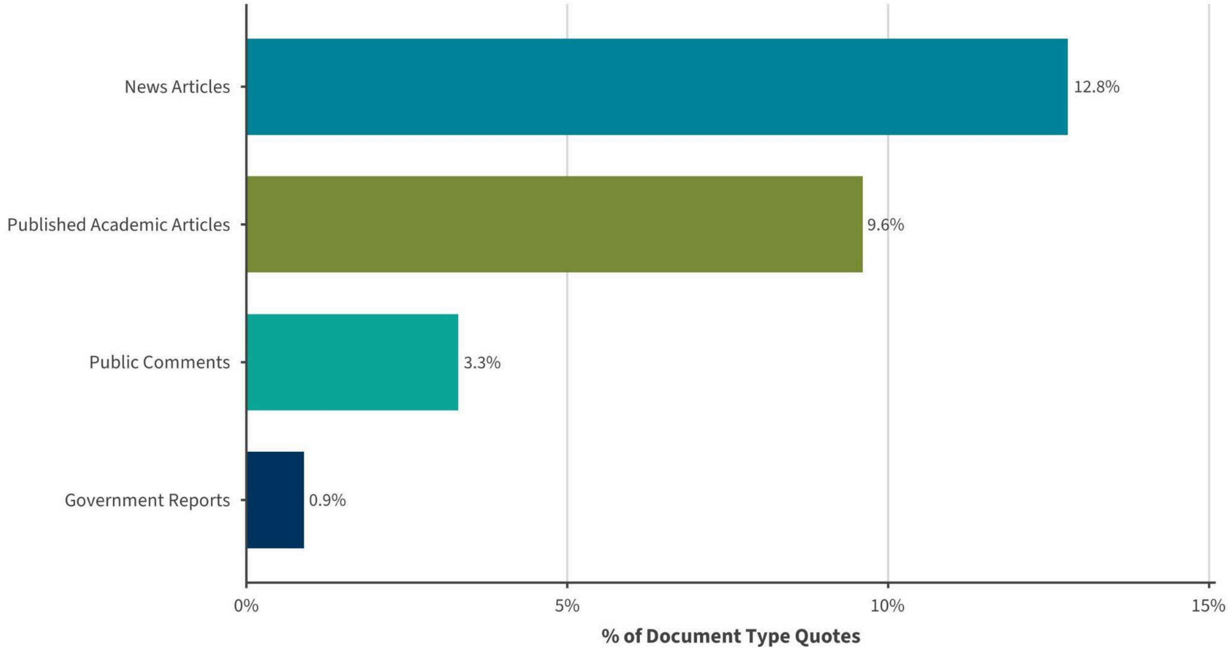
Appendix Figure A.1.6. Percent of quotes by document type for T6 - *Managed Retreat Offers Significant Environmental Co-Benefits when Planned with Long-Term Engagement.*



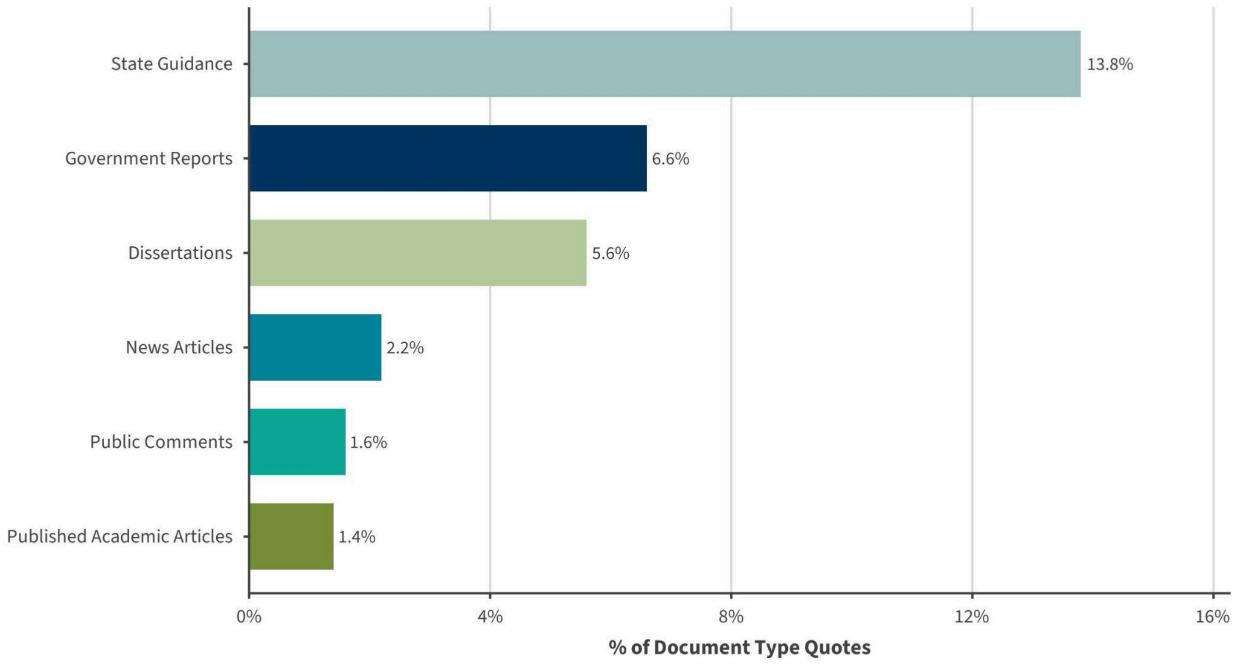
Appendix Figure A.1.7. Percent of quotes by document type for T7 - *Political Barriers, Legislative Ambiguity, and Short-Term Interests Hinder Long-Term Adaptation Planning.*



Appendix Figure A.1.8. Percent of quotes by document type for T8 - *Early Triggers, Monitoring Systems, and Multiple Adaptation Strategies Drive Governance Success.*



Appendix Figure A.1.9. Percent of quotes by document type for T9 - *Miscommunication, Framing, Real Estate Fears, and Equity Concerns Complicate Public Perception.*



Appendix Figure A.1.10. Percent of quotes by document type for T10 - *Buyout Programs and Available State/Federal Funding Make Managed Retreat Cost-Effective Long-Term.*

Appendix A.2. Further description of methods

The table below documents the search strategy used by each research team member to identify and collect sources for the thematic analysis. Searches were conducted across multiple databases and document repositories, targeting literature related to managed retreat and coastal adaptation in California. Each entry includes the data type collected, the database or platform searched, the search terms applied, any filters used to refine results, and the total number of results returned. We want to thank UCSB Librarian, Kristen LaBonte, for providing us with invaluable guidance during this process of our project.

Appendix Table A.2. Search criteria by data type.

Researcher	Data Type	Database	Search Terms	Search Filters	Results
Lilia Mourier	Legal Documents	Nexus Uni	(“Managed retreat” OR “resilient relocation” OR "Shoreline retreat" OR "coastal retreat" OR "strategic relocation") AND ("california" OR "del norte" OR "humboldt" OR "mendocino" OR "sonoma" OR "marin" OR "san francisco" OR "napa" OR "solano" OR "contra costa" OR "alameda" OR "santa clara" OR "san mateo" OR "santa cruz" OR "monterey" OR "san luis obispo" OR "santa barbara" OR "ventura" OR "los angeles" OR "orange" OR "san diego")	All available dates > Legal > Administrative Codes & Regulations > California	17
Wesley Noble	Public Comments	Google Advanced Search	(“Managed retreat” OR “resilient relocation” OR "shoreline retreat" OR "coastal retreat" OR "coastal relocation") AND (“public comment*” OR “public hearing*”) AND ("california")"	Region: US; Site/Domain: .gov; File Type: PDF	154
Dan O'Shea	Government Reports & State Guidance	UCSB OCPC California Coastal	Searched all government reports and state guidance documents throughout the state as documented by the California Coastal Adaptation Planning Inventory	—	—

Researcher	Data Type	Database	Search Terms	Search Filters	Results
		Adaptation Planning Inventory			
Ada Olumba	Published Articles	Web of Science	“Managed retreat” OR “resilient relocation” OR "shoreline retreat" OR "coastal retreat" OR "coastal relocation") AND ("California")	—	490,589 (35 most relevant to study)
Ada Olumba	Dissertations	ProQuest	(“Managed retreat” OR “resilient relocation” OR "shoreline retreat" OR "coastal retreat" OR "coastal relocation")	AND ("California")	1076
Dan O'Shea	News Articles	NexisUni	(“Managed retreat” OR “resilient relocation” OR "shoreline retreat" OR "coastal relocation" OR "strategic relocation") AND ("california" OR "del norte" OR "humboldt" OR "mendocino" OR "sonoma" OR "marin" OR "san francisco" OR "napa" OR "solano" OR "contra costa" OR "alameda" OR "santa clara" OR "san mateo" OR "santa cruz" OR "monterey" OR "san luis obispo" OR "santa barbara" OR "ventura" OR "los angeles" OR "orange" OR "san diego") AND ("Sea Level Rise")	North America, United States, California	69

Appendix A.3. Citations and denotation guide

Appendix A.2. provides full citations for all sources referenced in the thematic analysis. Sources are grouped by document type and assigned a sequential code. Each code consists of a document-type prefix (e.g., GR, N, SG) followed by a number indicating its position within that category. These codes appear throughout the report to attribute findings and quotations to their original sources.

Source Type Key

GR Government Reports
N News Articles
PC Public Comments
L Legal Documents
PA Published Academic Articles
D Dissertations & Unpublished Works
SG State Guidance Reports

Government Reports

GR1 Armstrong, L., & Westhoff, A. (2018). Marin Ocean Coast Sea Level Rise Adaptation Report.

GR2 Ascent Environmental, Inc. (2017). Climate Change Vulnerability Assessment County of San Diego.

GR3 Ascent Environmental, Inc., Energy Policy Initiatives Center, HF&H Consultants, & Aecom. (2018). County of San Diego Climate Action Plan.

GR4 Belleghem, B. V., Westhoff, A., Armstrong, L., & Baron, N. L. (2016). Marin Ocean Coast Sea Level Rise Vulnerability Assessment.

GR5 Carmel Area State Park's General Plan: Chapter 5 Environmental Analysis. (n.d.). Carpinteria Adaptation Strategy. (2019).

GR6 City of Santa Cruz—General Plan and Local Coastal Program. (2003).

GR7 Clark, R., & Stoner-Duncan, S. (2019). AB 691 sea level Rise Assessment Moss Landing Harbor Sea Level Rise Vulnerability and Adaptation Strategy Report.

GR8 Clark, R., Stoner-Duncan, S., Adelaars, J., & Tobin, S. (2017). City of Capitola Coastal Climate Change Vulnerability Report.

GR9 Clark, R., Stoner-Duncan, S., Adelaars, J., Tobin, S., & Hammerstrom, K. (2017). Santa Cruz County Coastal Climate Change Vulnerability Report.

GR10 Climate Resilience Comprehensive Action Plan—County of Sonoma. (2024).

GR11 County of Santa Barbara Coastal Resiliency Project. (2017).

GR12 County of Santa Cruz Local Hazard Mitigation Plan. (2021).

GR13 Dedina, D. (2025). South Beach Transportation Climate Resilience Plan.

GR14 Dyett & Bhatia Urban and Regional Planners. (2025). City of Pacifica Local Coastal Land Use Plan.

GR15 Environmental Science Associates. (2018). Final Draft Pacifica sea level Rise Vulnerability Assessment.

GR16 Environmental Science Associates. (n.d.-b). Sea level Rise Analysis and Vulnerability Assessment for Point Arena Cove. Technical Report. https://doi.org/10/2023

GR17 Environmental Science Associates. (2018a). City of Del Mar sea level Rise Adaptation Plan.

GR18 Environmental Science Associates. (2018b). Coastal Hazards, Vulnerability, and Risk Assessment—Del Mar, CA.

GR19 Environmental Science Associates. (2018c). Sea level Rise Adaptation Plan—Pacifica, CA.

GR20 Environmental Science Associates. (2020). Coastal Adaptation Vision for Naval Base Ventura County Point Mugu.

GR21 Environmental Science Associates. (2021). City of Santa Barbara sea level Rise Adaptation Plan.

GR22 Environmental Science Associates. (2023). Coastal Hazard Vulnerability Assessment, City of Malibu.

GR23 GHD Environmental. (2016). City of Trinidad Draft Climate Change Vulnerability Report and Adaptation Response.

GR24 Humboldt County LCP. (2022).

GR25 Hutto, S. (2016). Climate-Smart Adaptation for North-central California Coastal Habitats.

GR26 Integral Consulting, Inc. (2022). County of San Mateo Sea Level Rise Vulnerability Assessment & Adaptation Report.

GR27 Jorgensen, M., McGuinness, D., Dymoke, G., & Garibay, J. (2025). Seacliff State Beach and New Brighton State Beach—Sea Level Rise Vulnerability Assessment and Shoreline Adaptation Alternatives.

GR28 King, P. (2012). Ocean Beach Master Plan

GR29 Laird, A. (2018). Humboldt Bay Sea Level Rise Adaptation Planning Project Phase II Report.

GR30 Maier, T., Engstrom, A., Convey, A., Kim, A., Revell, D. L., Jamieson, M., King, P., & Giliam, J. (2018). Ventura Resilient Coastal Adaptation Project—Sea Level Rise Vulnerability Assessment.

GR31 Maier, T., Engstrom, A., Convey, A., Kim, A., Revell, D. L., Phil King, Jamieson, M., & Giliam, J. (2019). Ventura Resilient Coastal Adaptation Project—Sea Level Rise Adaptation Strategies Report.

GR32 Malais, G. (2022). County of Monterey Multi-Jurisdictional Hazard Mitigation Plan.

GR33 Mendocino County Coastal Element. (2021).

GR34 Michael Baker International. (2017). City of Morro Bay Community Vulnerability and Resilience Assessment.

GR35 Noble Consultants. (2016). Final Report Los Angeles County Public Beach Facilities sea level Rise Vulnerability Assessment.

GR36 Papendick, H., Sharma, J., Raider, C., Andrade, A., Hashizume, E., Plascencia, M., Prowitt, S., & Carter, T. (2018). County of San Mateo Sea Level Rise Vulnerability Assessment.

GR37 Peek, K. M., Young, R. S., Beavers, R. L., Hoffman, C. H., Diethorn, B. T., & Norton, S. (2015). Adapting To Climate Change in Coastal Parks Estimating the Exposure of Park Assets to 1 m of sea level Rise.

GR38 Pendleton, E. A., Thieler, E. R., & Williams, S. J. (2005). Coastal Vulnerability Assessment of Point Reyes National Seashore to sea level Rise.

GR39 PND Engineers. (2019). AB 691 sea level Rise Assessment—Crescent City Harbor District.

GR40 PND Engineers, Inc. (2019). AB 691 Sea Level Rise Assessment for Crescent City State Lands.

GR41 Revell Coastal, LLC. (2016). City of Imperial Beach Sea Level Rise Assessment.

GR42 Revell Coastal, LLC. (2019a). Final City of Carpinteria Sea Level Rise Vulnerability Assessment and Adaptation Project.

GR43 Revell Coastal, LLC. (2019b). Final West Cliff Drive Adaptation and Management Plan—Santa Cruz.

GR44 Revell Coastal, LLC & EMC Planning Group, Inc. (2019). Final City of Marina 2019 Existing Conditions and Sea Level Rise Adaptation Report.

GR45 Rincon Consultants, Inc. (2024). Sonoma County Climate Change Vulnerability Assessment.

GR46 Sinkyone Wilderness State Park Final General Plan & Environmental Impact Report. (2006).

GR47 Sloan, K., & Hostler, J. (2011). Yurok Tribe and Climate Change: An Initial Prioritization Plan.

GR48 Sonoma Coast State Park General Plan & Environmental Analysis. (n.d.).

GR49 Varat, A. (202 C.E.). Sea Level Rise Vulnerability and Consequences Assessments.

GR50 West Cliff Drive Adaptation and Management Plan: Public Works Plan. (2021).

GR51 White, L. (2020). City of Santa Barbara sea level Rise Adaptation Plan for the Local Coastal Program Update.

News Articles

N1 Barmann, J. (2022, February 17). The Fight Over “Managed Retreat” From Sea Level Rise In CA Coastal Towns Makes It to “This American Life.” SFist - San Francisco News, Restaurants, Events, & Sports. https://sfist.com/2022/02/17/the-fight-over-managed-retreat-from-sea level-rise-in-ca-coastal-towns-makes-it-to-this-american-life/

N2 Bittle, J. (2023, May 10). As California attempts a “managed retreat,” coastal homeowners sue to stay. Grist. https://grist.org/housing/california-managed-retreat-half-moon-bay-coastal-commission/

N3 Bittle, J. (2024, October 2). Climate change is destroying American homes. Who should have to move? Grist. https://grist.org/migration/climate-change-home-buyouts-displacement-managed-retreat/

N4 Bromhead, H. (2022, April 4). “Managed Retreat” Is a Terrible Way to Talk About Responding to Climate Change. https://slate.com/technology/2022/04/managed-retreat-climate-change-language.html

N5 Carter, S. G. (2025, June 18). Roadmap guides Stinson amid changing shores. Point Reyes Light. https://www.ptreyeslight.com/news/roadmap-guides-stinson-amid-changing-shores/

N6 Chun, M. (2023, February 14). ‘Managed retreat is on the table’: City discusses West Cliff’s future, will explore expanding one-way. Lookout Santa Cruz. https://lookout.co/managed-retreat-save-west-cliff-adaptation-management-plan-one-way-street/story

N7 Frausto, E. (2021, May 13). Experts at councilman’s webinar take on local sea level rise. https://advance.lexis.com/document/?pdmfid=1519360&crid=324e0138-6aaa-4f57-a6

a5-c94eaaeca66a&pddocfullpath=%2Fshared%2Fdocument%2Fnews%2Furn%3AcontentItem%3A64MF-H181-JBFS-C173-00000-00&pdcontentcomponentid=11811&pdteaserkey=sr9&pditab=allpods&ecomp=hc-yk&earg=sr9&prid=a10ed0c1-267b-405a-b633-5e6a6d5f326b

N8 Greenburger, C. (2024, February 27). A Tale of Two Sea Level Rise Solutions. Sierra Club. https://www.sierraclub.org/sierra/tale-two-sea level-rise-solutions

N9 Hari, A. (2025, January 22). Pacifica community wondering how city will approach coastal erosion issue—CBS San Francisco. https://www.cbsnews.com/sanfrancisco/news/pacifica-community-wondering-how-city-will-approach-coastal-erosion-issue/

N10 Harold, L. (2021, June 10). DEL MAR WITHDRAWS PLAN FOR SEA LEVEL RISE; City pulls it from Coastal Commission hearing set for today. https://advance.lexis.com/document/?pdmfid=1519360&crid=1b255766-205e-4a95-a08b-607efdd29d03&pddocfullpath=%2Fshared%2Fdocument%2Fnews%2Furn%3AcontentItem%3A62WK-P3R1-DXXV-332N-00000-00&pdcontentcomponentid=11811&pdteaserkey=sr15&pditab=allpods&ecomp=hc-yk&earg=sr15&prid=2e1a5c4a-004f-4af9-86d3-8f4737853103

N11 Hossfeld, D. (2020, January 7). Retreat is not defeat | California Sea Grant. https://caseagrant.ucsd.edu/news/retreat-not-defeat

N12 John, A. St. (2019, August 1). Coastal Cities Wrestling With “Managed Retreat” Ramifications Of Rising Sea Levels. KPBS Public Media. https://www.kpbs.org/news/midday-edition/2019/08/01/coastal-cities-managed-retreat-rising-sea levels

N13 Kearney, N. (2024, November 14). Managed Retreat | Santa Cruz Vibes Magazine. https://www.scvibesmagazine.com/stories/managed-retreat

N14 Kempe, Y. (2023, May 8). As sea levels rise, it’s time for West Coast communities to overcome ‘taboo of managed retreat’: Report | Smart Cities Dive. https://www.smartcitiesdive.com/news/sea level-rise-adapt-west-coast-managed-retreat/649294/

N15 Kirk, C. (2021, June 10). SB-83 is a Buyout for the Coastal Elite. Knock LA. https://knock-la.com/sb-83-sea level-rise-revolving-loan-program-ben-allen/

N16 Kvinta, P. (2021, December 13). The Terrifying War Over California’s Coast. Outside Online. https://www.outsideonline.com/outdoor-adventure/water-activities/beacons-beach-encinitas-managed-retreat-fight/

N17 McGrew, S. (2025, January 13). Pacifica divided on how to respond to rising sea levels. KCRA. https://www.kcra.com/article/pacifica-divided-rising-sea levels/63354001

N18 Mulkern, A. C. (2018, December 7). Calif. Prepares policy for coastal “retreat.” E&E News by POLITICO. https://www.eenews.net/articles/calif-prepares-policy-for-coastal-retreat/

N19 Mulkern, A. C. (2020, April 3). “It’s managed retreat.” Calif. Pushes homes back from ocean. E&E News by POLITICO. https://www.eenews.net/articles/its-managed-retreat-calif-pushes-homes-back-from-ocean/

N20 Mulkern, A. C. (2021a, September 24). For rent: Calif. houses endangered by rising seas. E&E News by POLITICO. https://www.eenews.net/articles/for-rent-calif-houses-endangered-by-rising-seas/

N21 Mulkern, A. C. (2021b, November 5). Managed retreat: Unpopular, expensive and not going away. E&E News by POLITICO. https://www.eenews.net/articles/managed-retreat-unpopular-expensive-and-not-going-away/

N22 Mulkern, A. C. (2021c, November 12). No one likes “managed retreat.” So it’s getting rebranded. E&E News by POLITICO. https://www.eenews.net/articles/no-one-likes-managed-retreat-so-its-getting-rebranded/

N23 Phil Diehl. (2021, October 18). Carlsbad OKs Local Coastal Program update; New rules adopted for development, sea level rise adaptations. https://advance.lexis.com/document/?pdmfid=1519360&crid=c0e8a0eb-73ed-4893-9d5c-c6d496f9dca3&pddocfullpath=%2Fshared%2Fdocument%2Fnews%2Furn%3AcontentItem%3A63W7-PDJ1-JBFS-C3K0-00000-00&pdcontentcomponentid=11811&pdteaserkey=sr19&pditab=allpods&ecomp=hc-yk&earg=sr19&prid=2e1a5c4a-004f-4af9-86d3-8f4737853103

N24 Pinto, L. M. (n.d.). After 30 years, Ventura’s Surfers Point Managed Retreat crosses the finish line. Surfertoday. Retrieved November 6, 2025, from https://www.surfertoday.com/environment/surfers-point-managed-retreat-project

N25 Rott, N. (2018, December 4). “Retreat” Is Not An Option As A California Beach Town Plans For Rising Seas. NPR. https://www.npr.org/2018/12/04/672285546/retreat-is-not-an-option-as-a-california-beach-town-plans-for-rising-seas

N26 Smolens, M. (2021, May 28). Sea level rise up north will happen in San Diego too. https://advance.lexis.com/document/?pdmfid=1519360&crid=152e1e1b-5ff4-4ce8-b9ac-61b5463699d7&pddocfullpath=%2Fshared%2Fdocument%2Fnews%2Furn%3AcontentItem%3A62TJ-XXV1-JBFS-C39S-00000-00&pdcontentcomponentid=11811&pdteaserkey=sr2&pditab=allpods&ecomp=hc-yk&earg=sr2&prid=a10ed0c1-267b-405a-b633-5e6a6d5f326b

N27 Solutions to Managed Retreat. (2023). Smart Coast California. https://www.smartcoastca.org/solutions-to-managed-retreat.html

N28 Surfrider Foundation. (2014, December 1). Beach Preservation Through Managed Retreat at San Francisco's Ocean Beach. https://www.surfrider.org/news/surfrider-activists-work-to-restore-sloat-and-preserve-san-franciscos-ocean

N29 Surfrider Humboldt. (2017, February 28). A Perfect Time To Pursue the Best Solution: Managed Retreat at San Onofre. https://www.surfrider.org/news/a-perfect-time-to-pursue-the-best-solution-managed-retreat-at-san-onofre

N30 Xia, R. (2020, November 27). Along the crumbling Sonoma Coast, an ambitious project paves the way for "managed retreat." Los Angeles Times. https://www.latimes.com/california/story/2020-11-27/gleason-beach-managed-retreat

N31 Xia, R. (2021, August 26). Urgency over rising sea level prompts wave of bills in California Legislature; Often overlooked threat to state's coastline receives greater political prominence. https://advance.lexis.com/document/?pdmfid=1519360&crid=ef12aacf-9b8d-4068-af6c-10a6f982787c&pddocfullpath=%2Fshared%2Fdocument%2Fnews%2Furn%3AcontentItem%3A63G1-Y1R1-JBFS-C1YC-00000-00&pdcontentcomponentid=11811&pdteaserkey=sr3&pditab=allpods&ecomp=hc-yk&earg=sr3&prid=a10ed0c1-267b-405a-b633-5e6a6d5f326b

Public Comments

PC1 Bullock, M., Griggs, G., Dueweke, P., Goncharoff, T., Flores, K., Reineman, D., Adler, T., Stoecker, M., Ecological, S., Schiff, D., Ramos, R., Snideman, L., Robertson, J., Debrunner, D., Wright, R., Matarazzo, S., Sandzimier, R., Cleveland, B., White, G., … Joseph, I. (2015). California Coastal Commission Response to Comments—On the October 2013 Draft Sea Level Rise Policy Guidance.

PC2 California Coastal Commission. (2017). Draft Residential Adaptation Policy Guidance Written/Emailed Public Comments. https://documents.coastal.ca.gov/assets/climate/slr/vulnerability/residential/Written_Draft_Guidance_Public_Comments.pdf

PC3 California Coastal Commission. (2018). CCC Revised Draft Residential Adaptation Policy Guidance List of Public Comments Second Public Comment Period. https://documents.coastal.ca.gov/assets/climate/slr/vulnerability/residential/2SecondCommentPeriodLetters.pdf

PC4 California Coastal Commission. (2018). Environmental Justice Draft Policy Public Review—Public Comments Received From August 9th, 2018 to November 6th, 2018. Santa Cruz. https://documents.coastal.ca.gov/reports/2018/11/W7f/W7f-11-2018-corresp.pdf

PC5 California Coastal Commission. (2019). LCP-6-DMR-18-0082-1 (Sea Level Rise) October 16, 2019 Correspondence. San Diego. https://documents.coastal.ca.gov/reports/2019/10/W10a/W10a-10-2019-correspondence.pdf

PC6 California Coastal Commission. (2020). Coastal Commission Public Review Draft 2020 – 2025 Strategic Plan. https://documents.coastal.ca.gov/reports/2020/3/W7d/W7d-3-2020-exhibits.pdf

PC7 California Coastal Commission. (2021). LCP-6-DMR-20-0005-1 (Sea Level Rise) June 10, 2021 Correspondence. San Diego. https://documents.coastal.ca.gov/reports/2021/6/Th9d/Th9d-6-2021-corresp.pdf

PC8 California Coastal Commission. (2023a). LCP-2-PAC-20-0036-1 (City of Pacifica LUP Update) March 8, 2023 Correspondence. San Francisco. https://documents.coastal.ca.gov/reports/2023/3/W14a/W14a-3-2023-corresp.pdf

PC9 California Coastal Commission. (2023b). Public Trust Guiding Principles & Action Plan (May 2023 Hearing). https://documents.coastal.ca.gov/reports/2023/5/W6e/w6e-5-2023-corresp.pdf

PC10 City of Carpinteria. (2025). All Public Comment, June—August 2025. https://carpinteriaca.gov/wp-content/uploads/2025/09/All-public-comment-June-Aug-2025.pdf

PC11 County of Sonoma. (2022). Public Comments and Responses Privided to The Planning Commission at the June 29, 2022 meeting. https://permitsonoma.org/Microsites/Permit%20Sonoma/Documents/Divisions/Planning/Long%20Range%20Plans/Local%20Coastal%20Plan/August%202022/Public%20C omments/Public%20Comments%20and%20Responses%20Provided%20to%20the%20Planning%20Commission%20at%20the%20June%2029%2C%202022.pdf

PC12 Goldzband, L., & Perrin-Martinez, J. (2024). Response to Public Comments for Proposed Bay Plan Amendment No. 1-24, a Proposed Bay Plan Amendment to Adopt a Regional Shoreline Adaptation Plan and Establish Guidelines for the Preparation of Sea Level Rise Plans Pursuant to Senate Bill 272 (Laird, 2023).

PC13 San Francisco Bay Conservation and Development Commission—Final Draft Minutes. (2024, October 17). https://www.bcdc.ca.gov/wp-content/uploads/sites/354/2024/01/Final-Draft-Minutes-From-10.17.2024-.pdf

Legal Documents

L1 2009 Bill Text CA A.B. 2598 Tidelands and Submerged Lands: Sea Level Action Plan., AB 2598, California State Legislature California 2009-10 Regular Session (2010).

L2 2011 Bill Text CA A.B. 752 Tidelands and Submerged Lands: Sea Level Action Plan., No. AB 752, California 2011-2012 Regular Session (2011).

L3 2011 Bill Text CA S.B. 1283. San Francisco Bay Area Sea Level Rise Planning Act., 1283, California State Legislature 2011 (2012).

L4 2021 Bill Text CA A.C.R. 77. Sea Level Rise Awareness Month., ACR 77, California 2021-22 Regular Session.

L5 Avila, A. (2025). Rising Tides and Shifting Sands: Inadequacies in American Climate Responses and an Urgent Call for a Federal Climate Adaptation Policy. Texas A&M Journal of Property Law, 11(239).

L6 Beach Erosion: South Central California Coast: Point Conception to Point Mugu., AB 826, California State Legislature California 2021-2022 Regular Session (2021).

L7 Caldwell, M., & Holt Segall, C. (2007). No Day at the Beach: Sea Level Rise, Ecosystem Loss, and Public Access Along the California Coast. Ecology Law Quarterly & Currents, 34(533).

L8 Casado Pérez, V. (2025). Water Reallocation in The West: Government and Markets. Utah Law Review, 235.

L9 Goldberg, H. S. R., & Powers, T. J. (n.d.). Midler v. City of San Diego.

L10 Grow Sun, L. (2011). Smart Growth in Dumb Places: Sustainability, Disaster, and the Future of the American City. Bringham Young University Law Review, 2157.

L11 Hernandez, J. (2022). In the Name of the Environment Part III: CEQA, Housing, and the Rule of Law. Chapman Law Review, 26(57).

L12 Herzog, M., & Hecht, S. (2013). Combatting Sea Level Rise in Southern California: How Local Governments can Seize Adaptation Opportunities While Minimizing Legal Risk. Hastings West-Northwest Journal of Environmental Law and Policy, 19(463).

L13 Lester, C., & Matella, M. (2016). Managing the Coastal Squeeze: Resilience Planning for Shoreline Residential Development. Stanford Environmental Law Journal, 36(23).

L14 Los Angeles County, California Code of Ordinances Sec. 22.44.2180, Los Angeles County, Sec. 22.44.2180 (2024).

L15 Morro Bay, California Code of Ordinances Sec. 17.14.100, 17 Ordinance No. 669 (2025).

L16 Redwood City, California Zoning Code Sec. 57.1, Redwood City City Council, Ordinance No. 1130-890 (2024).

L17 Redwood City, California Zoning Code Sec. 57.10, Ordinance No. 1130-890 (2024).

L18 Sea Level Rise Revolving Loan Pilot Program., SB-1078, 2020–2021 (2022).

L19 Sullivan, E., & Tarlock, D. (2022). The Paradox of Change in the American West: Global Climate Destruction and the Reallocation of Urban Space and Priorities. Journal of Environmental Law & Litigations, 37(23).

Published Articles

PA1 Amrouni, O., Heggy, E., & Hzami, A. (2024). Shoreline retreat and beach nourishment are projected to increase in Southern California. Communications Earth & Environment, 5(1), 274. https://doi.org/10.1038/s43247-024-01388-6

PA2 Anderson, R. B. (2022). The taboo of retreat: The politics of sea level rise, managed retreat, and coastal property values in California. Economic Anthropology, 9(2), 284–296. https://doi.org/10.1002/sea2.12247

PA3 Anderson, R. B., Carter, O. T., Pearce, K. G., & Capdevila, L. A. (2022). User Perceptions of the Pleasure Point Seawall in Santa Cruz County, California, USA. Journal of Coastal Research, 38(4), 828–843. https://doi.org/10.2112/JCOASTRES-D-21-00139.1

PA4 Barnard, P. L., Allan, J., Hansen, J. E., Kaminsky, G. M., Ruggiero, P., & Doria, A. (2011). The impact of the 2009-10 El Nino Modoki on US West Coast beaches. Geophysical Research Letters, 38, L13604. https://doi.org/10.1029/2011GL047707

PA5 Bragg, W. K., Gonzalez, S. T., Rabearisoa, A., & Stoltz, A. D. (2021). Communicating Managed Retreat in California. Water, 13(6), 781. https://doi.org/10.3390/w13060781

PA6 Elko, N., Briggs, T. R., Benedet, L., Robertson, Q., Thomson, G., Webb, B. M., & Garvey, K. (2021). A century of US beach nourishment. Ocean & Coastal Management, 199, 105406. https://doi.org/10.1016/j.ocecoaman.2020.105406

PA7 Griggs, G. B. (2015). Lost Neighborhoods of the California Coast. Journal of Coastal Research, 31(1), 129–147. https://doi.org/10.2112/13A-00007.1

PA8 Griggs, G. B., & Patsch, K. (2004). Cliff erosion and bluff retreat along the California coast—Coast of California caught between increasing numbers of people and ongoing process of shoreline retreat. Sea Technology, 45(9), 36–40.

PA9 Griggs, G., & Patsch, K. (2019). The Protection/Hardening of California's Coast: Times Are Changing. Journal of Coastal Research, 35(5), 1051–1061. https://doi.org/10.2112/JCOASTRES-D-19A-00007.1

PA10 Karasu, S., Work, P. A., Uzlu, E., Kankal, M., & Yuksek, O. (2016). Beach nourishment alternative assessment to constrain cross-shore and longshore sediment transport. Applied Ocean Research, 59, 459–471. https://doi.org/10.1016/j.apor.2016.07.001

PA11 Kodis, M., Bortman, M., & Newkirk, S. (2021). Strategic retreat for resilient and equitable climate adaptation: The roles for conservation organizations. Journal of Environmental Studies and Sciences, 11(3), 493–502. https://doi.org/10.1007/s13412-021-00692-3

PA12 Kono-Martinez, T., de Alegria-Arzaburu, A. R., Marino-Tapia, I., & Coco, G. (2023). Alongshore variability in berm and sandbar migration patterns on a highly dynamic beach. Geomorphology, 443, 108935. https://doi.org/10.1016/j.geomorph.2023.108935

PA13 Lester, C., Griggs, G., Patsch, K., & Anderson, R. (2022). Shoreline Retreat in California: Taking a Step Back. Journal of Coastal Research, 38(6), 1207–1230. https://doi.org/10.2112/JCOASTRES-D-22A-00010.1

PA14 Maxim, A., & Grubert, E. (2021). Effects of climate migration on town-to-city transitions in the United States: Proactive investments in civil infrastructure for resilience and sustainability. Environmental Research: Infrastructure and Sustainability, 1(3), 031001. https://doi.org/10.1088/2634-4505/ac33ef

PA15 Peterson, C. D., Erlandson, J. M., Stock, E., Hostetler, S. W., & Price, D. M. (2017). Coastal Eolian Sand-Ramp Development Related to Paleo-sea level Changes during the Latest Pleistocene and Holocene (21-0 ka) in San Miguel Island, California, USA. Journal of Coastal Research, 33(5), 1022–1037. https://doi.org/10.2112/JCOASTRES-D-16-00148.1

PA16 Peynador, C., & Mendez-Sanchez, F. (2010). Managing coastal erosion: A management proposal for a littoral cell in Todos Santos Bay, Ensenada, Baja California, Mexico. Ocean & Coastal Management, 53(7), 350–357. https://doi.org/10.1016/j.ocecoaman.2010.04.016

PA17 Quan, S., Kvitek, R. G., Smith, D. P., & Griggs, G. B. (2013). Using Vessel-Based LIDAR to Quantify Coastal Erosion during El Nino and Inter-El Nino Periods in Monterey Bay, California. Journal of Coastal Research, 29(3), 555–565. https://doi.org/10.2112/JCOASTRES-D-12-00005.1

PA18 Revell, D., King, P., Giliam, J., Calil, J., Jenkins, S., Helmer, C., Nakagawa, J., Snyder, A., Ellis, J., & Jamieson, M. (2021). A Holistic Framework for Evaluating Adaptation Approaches to Coastal Hazards and Sea Level Rise: A Case Study from Imperial Beach, California. Water, 13(9), 1324. https://doi.org/10.3390/w13091324

PA19 Richmond, L., & Kunkel, K. (2024). Living in the “Blue Zone” of a sea level rise inundation map: Community perceptions of coastal flooding in King Salmon, California. Climate Risk Management, 44, 100596. https://doi.org/10.1016/j.crm.2024.100596

PA20 Ruggiero, P., & Lists, J. H. (2009). Improving Accuracy and Statistical Reliability of Shoreline Position and Change Rate Estimates. Journal of Coastal Research, 25(5), 1069–1081. https://doi.org/10.2112/08-1051.1

PA21 Smith, S. A., & Barnard, P. L. (2021). The impacts of the 2015/2016 El Nino on California’s sandy beaches. Geomorphology, 377, 107583. https://doi.org/10.1016/j.geomorph.2020.107583

PA22 Thomas, M. A., & Loague, K. (2014). Devil’s Slide: An Evolving Feature of California’s Coastal Landscape. Environmental & Engineering Geoscience, 20(1), 45–65. https://doi.org/10.2113/gseegeosci.20.1.45

PA23 Young, A. P., Flick, R. E., O’Reilly, W. C., Chadwick, D. B., Crampton, W. C., & Helly, J. J. (2014). Estimating cliff retreat in southern California considering sea level rise using a sand balance approach. Marine Geology, 348, 15–26. https://doi.org/10.1016/j.margeo.2013.11.007

Dissertations

D1 Barnes, A. T. (2025). From Subsurface to Shoreline: Impacts of Sea Level Rise on Coastal Groundwater, Reef Dissipation, and Beach Morphology [Ph.D., University of California, San Diego]. https://www.proquest.com/pqdtglobal/docview/3229010265/abstract/AA77D2E9C0D14DE1PQ/17

D2 Caywood, C. (2025). Preserving the Past: Evaluating Erosion Risks to Archaeological Sites on Santa Rosa Island, California [M.A., University of Nevada, Reno]. https://www.proquest.com/pqdtglobal/docview/3226090046/abstract/AA77D2E9C0D14DE1PQ/4

D3 Constable, A. (1998). Stakeholder perceptions of risk from sea level rise in Ventura County, California [Ph.D., University of Southern California]. https://www.proquest.com/docview/304457887/abstract/69ABAE53C9EC4931PQ/126

D4 Griggs, G., & Patsch, K. (2019). The Protection/Hardening of California's Coast: Times Are Changing. Journal of Coastal Research, 35(5), 1051–1061. https://doi.org/10.2112/JCOASTRES-D-19A-00007.1

D5 Kahl, D. T. (2025). Beach Dynamics and Implications for Flood Risk in Southern California [Ph.D., University of California, Irvine]. https://www.proquest.com/pqdtglobal/docview/3201284188/abstract/AA77D2E9C0D14DE1PQ/10

D6 Marble, J. H. (2025). The Development of a Framework for a Home Buyout Program in Lake Hughes Area of Unincorporated Los Angeles County [M.S., California State University, Long Beach]. https://www.proquest.com/pqdtglobal/docview/3280290741/abstract/AA77D2E9C0D14DE1PQ/11

D7 Reynolds, D. E. (2025). An Exploration of Local Adaptation to Sea Level Rise in Southern California: The Case in Imperial Beach and Del Mar [M.A., San Diego State University]. https://www.proquest.com/pqdtglobal/docview/3205298589/abstract/AA77D2E9C0D14DE1PQ/1

D8 Wake, C., Kaye, D., Lewis, C. J., Levesque, V., & Peterson, J. (2020). Undercurrents: Exploring the human dynamics of adaptation to sea level rise. Elementa, 8(1). https://doi.org/10.1525/elementa.2020.060

State Guidance Reports

SG1 California Sea Level Rise Guidance: 2024 Science and Policy Update. 2024. California Sea Level Rise Science Task Force, California Ocean Protection Council, California Ocean Science Trust.

SG2 Critical Infrastructure at Risk: Sea Level Rise Planning Guidance forCalifornia's Coastal Zone. (2021, November 17). California Coastal Commission. https://documents.coastal.ca.gov/assets/slr/guidance/SLR%20Guidance_Critical%20Infrastructure_11.3.2021_FINAL_FullPDF.pdf

SG3 Heady, W., Cohen, B., Gleason, M., Morris, J., Newkirk, S., Klausmeyer, K., Walecka, H., Gagneron, E., & Small, M. (2018). Conserving California's Coastal Habitats: A Legacy and a Future withSea Level Rise. The Nature Conservancy. https://www.scienceforconservation.org/assets/downloads/TNC_SCC_CoastalAssessment_2018.pdf

SG4 Lester, C., Manley, C., Dinh, Y., Rozal, S., Cooper, A., Winters, L., Munster, K., Bok, T., & Wrubel, N. (2023). Planning for Sea Level Rise on California's Coast: Status, Trends, and

Recommendations. Ocean and Coastal Policy Center, Marine Science Institute, University of California, Santa Barbara.

SG5 Moser, S., Finzi Hart, J., Newton Mann, A., Sadrpour, N., & Grifman, P. (2018, August). Growing Effort, Growing Challenge: Findings from the 2016 California Coastal Adaptation Needs Assessment. California Natural Resources Agency. https://www.energy.ca.gov/sites/default/files/2019-12/Oceans_CCCA4-EXT-2018-009_ada.pdf

SG6 Newkirk, S., Veloz, S., Hayden, M., Battalio, B., Cheng, T., Judge, J., Heady, W., Leo, K., & Small, M. (2018). Toward Natural Shoreline Infrastructure to Manage Coastal Change in California. California Natural Resources Agency.

SG7 Regional Shoreline Adaptation Plan: One Bay Vision, Strategic Regional Priorities, and Subregional Shoreline Adaptation Plan Guidelines. (2024, December). San Francisco Bay Conservation and Development Commission. https://www.bcdc.ca.gov/wp-content/uploads/sites/354/2024/11/Appendix-B-Regional-Shoreline-Adaptation-Plan-spread.pdf

SG8 Residential Adaptation Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs. (2017, July 1). California Coastal Commission. 2017

SG9 Safeguarding California plan: 2018 update: California's climate adaptation strategy. (2018, January 1). California Natural Resources Agency.

SG10 Sea Level Rise Adaptation Strategy. (2021). California State Parks.

SG11 Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits. (2024, November 13). California Coastal Commission. https://documents.coastal.ca.gov/assets/slr/guidance/2024/2024AdoptedSLRPolicyGuidanceUpdate.pdf

Appendix B. Buyout-Leaseback Retreat Model Materials

This appendix documents the full technical methods underlying the Managed Shores economic model. It is intended for readers who wish to understand model mechanics, evaluate methodological choices, or replicate the analysis. Sections B.1.1 through B.1.8 correspond to the methods summarized in Chapter 4 and provide the mathematical detail, parameter justification, and implementation specifics omitted from the main text.

B.1 CoSMoS hazard data acquisition and processing

This analysis employs coastal flood and erosion projections from the U.S. Geological Survey's Coastal Storm Modeling System (CoSMoS), which provides spatially explicit hazard estimates at discrete sea level rise increments and storm return periods (Barnard et al., 2014; USGS, 2021). CoSMoS integrates wave dynamics, coastal morphology, and bathymetry to project inundation depth, duration, and extent under various climate scenarios.

B.1.a Data sources

Hazard data were obtained from two CoSMoS model versions covering different regions and hazard types. For flood-prone coastal communities, CoSMoS v3.0 Phase 2 provides raster datasets of flood depth (meters), flood duration (hours), and wave height (meters) at discrete sea level rise levels of 0, 0.25, 0.50, 0.75, 1.0, 1.5, 2.0, and 5.0 meters above mean higher high water (MHHW). These metrics are available for three storm return periods: w001 (annual/average coastal conditions), w020 (20-year storm, 5% annual exceedance probability), and w100 (100-year storm, 1% annual exceedance probability). All flood hazard rasters are derived from 2-meter resolution digital elevation models.

For bluff and cliff communities, CoSMoS v3.1 provides vector-based cliff retreat projections showing the predicted position of the cliff edge by year under two management scenarios. "Let It Go" represents natural cliff retreat without protective intervention; "Hold The Line" assumes armoring maintains the cliff face in its current position. Cliff retreat distances are calculated as the minimum distance from each property centroid to the projected cliff edge position for a given year and sea level rise trajectory.

B.1.b Spatial processing workflow

All geospatial processing was conducted in R. Study area boundaries were defined with a 1,000-meter inland buffer to capture properties beyond the immediate shoreline, and all spatial data were projected to California Albers Equal Area (EPSG:3310) to ensure accurate distance calculations. Property locations were geocoded from street addresses and converted to point geometries representing parcel centroids.

CoSMoS flood hazard data are distributed as multi-tile raster datasets requiring mosaicking before property-level extraction. For each combination of hazard metric, sea level rise level, and storm scenario, all raster tiles intersecting the study area were identified and mosaicked using maximum-value aggregation. This conservative approach ensures that in areas of tile overlap, the highest predicted flood depth is retained. Mosaicked rasters were then reprojected to EPSG:3310, masked to the study area boundary, and sampled at property centroid locations using bilinear interpolation.

A critical technical consideration is coordinate reference system alignment. CoSMoS rasters are delivered in NAD83 UTM zones that vary by region, while property data are typically geocoded in WGS84 (EPSG:4326). To ensure accurate spatial extraction, property points were transformed to match each raster's native coordinate system before sampling, with results subsequently merged in EPSG:3310.

CoSMoS 2-meter DEM products have inherent vertical uncertainty of approximately ±15 centimeters (Barnard et al., 2015). To filter model noise and focus on actionable flooding likely to cause structural damage, a minimum flood depth threshold of 0.15 meters was applied. Depths below this threshold were classified as not flooded and set to zero; depths at or above 0.15 meters were retained as flood exposure.

Cliff retreat data, provided as GeoPackage vector files, required a different processing approach. Each management scenario was processed separately. For each sea level rise level, cliff lines were filtered to the current scenario, property points were transformed to the cliff line's coordinate system, and minimum distances were calculated from each property to the nearest point on the cliff edge using sf::st_distance(). These distances, stored as *cliff_dist_m*, represent a property's exposure to bluff retreat hazards.

B.1.c Quality assurance

Several validation steps ensured data integrity. Coordinate reference systems were verified and printed for all datasets before extraction, with transformed property points visually inspected when overlaid on rasters. The number of non-zero flood values extracted per sea level rise scenario was logged to identify properties returning zero values across all scenarios, which may indicate coordinate transformation errors. Spatial outliers, properties with flood depths exceeding three standard deviations from the site mean, were flagged for manual review. For cliff sites, properties closest to the cliff edge were confirmed to have distances consistent with expected spatial patterns.

B.2 Temporal interpolation: SLR scenarios to annual timelines

CoSMoS hazard projections are provided at discrete sea level rise increments (0, 0.25, 0.50, 0.75, 1.0, 1.5, 2.0, and 5.0 meters above MHHW), representing static snapshots of coastal conditions at specific future sea levels. To evaluate managed retreat timing, these discrete projections must be converted into continuous annual hazard timelines spanning 2026–2100.

B.2.a OPC 2024 sea level rise projections

OPC projections are provided at decadal intervals relative to a 2020 baseline, with values reported in feet and converted to meters (1 foot = 0.3048 meters). The current analysis starts at OPC Year 6 (representing 2026). To generate smooth annual sea level rise trajectories for years 1 through 74, quadratic regression models were fitted to each scenario's decadal values. The quadratic functional form captures the well-established acceleration in sea level rise over time.

For each scenario, the model takes the form $SLR(t) = \beta_0 + \beta_1 t + \beta_2 t^2$, where t represents years from the OPC baseline. Parameters were estimated using ordinary least squares. To ensure physical realism, predicted values were post-processed using a cumulative maximum function, guaranteeing monotonically increasing sea level rise without year-to-year decreases.

B.2.b Hazard metric interpolation: cliff retreat sites

For cliff-exposed properties, cliff distance values at discrete SLR levels are interpolated to produce annual cliff distance timelines. For each property and management scenario, a piecewise linear interpolation function is constructed mapping SLR levels to cliff distances using R's approxfun with rule = 2 (flat extrapolation at boundaries). The interpolated annual *cliff_dist_m* values are used directly in the economic model to determine when properties cross the 10-meter safety threshold.

B.2.c Hazard metric interpolation: flood sites

For flood-exposed properties, interpolation creates the annual SLR(t) timeline that enables Monte Carlo storm simulation. Flood depth values at discrete SLR levels remain indexed by sea level rather than by year. Each year in the planning horizon is paired with its corresponding SLR(t) value; the Monte Carlo simulation (Section B.1.5) then uses that annual SLR value to look up storm-specific depths via interpolation from the original CoSMoS extractions. No management scenarios are applicable to flood sites, thus interpolation proceeds using three SLR scenario distinctions (Intermediate, Intermediate-High, High).

B.3 Property data and valuation

Property-level economic data were obtained from Redfin MLS exports for residential properties within each study area. Data collection focused on properties within 1,000 meters of the coast. The analysis includes single-family homes, condominiums, townhouses, and small multi-family properties (2–4 units). Larger multi-family buildings (5+ units), commercial properties, and vacant land were excluded. Properties with missing price data, obvious data entry errors (sale prices below $50,000 or above $50 million), or incomplete address information were removed.

B.3.a Data currency and price updates

Properties with sale dates older than two years were flagged for price updating. Updated price estimates were obtained through automated web scraping of current Redfin listings and Zillow Zestimate valuations where available. For properties without current online valuations, prices were inflation-adjusted using the Federal Housing Finance Agency's House Price Index for California coastal metropolitan areas.

B.3.b Rental yield estimation

Annual rental income for each property is estimated as property price multiplied by an annual rental yield. The baseline rental yield of 5% is grounded in real estate finance literature and coastal California market analysis. Rental yields for residential properties typically range from 3% to 8%, with coastal markets falling toward the lower end due to high property values relative to rental rates (ManageCasa, 2025). A 5% yield approximates the midpoint of observed ranges and aligns with industry benchmarks for single-family rental properties in high-value markets.

The rental yield approach implicitly assumes that current property prices do not yet reflect anticipated future flood damages or retreat timing, a reasonable assumption if markets expect government intervention through protective infrastructure or post-disaster buyouts at pre-hazard market values, as has historically occurred in many coastal communities. This assumption likely overestimates property values and rental income for highly vulnerable properties, making retreat timing estimates more conservative. Sensitivity analysis explores 4% and 6% yields.

B.3.c Land and structure value decomposition

Property values were decomposed into land and structure components using ZIP code-level land share estimates from the Lincoln Institute of Land Policy's 2022 dataset (Albouy et al., 2018). Land value equals total property price multiplied by the ZIP-level land share; structure value is the residual. Flood damage calculations apply only to structure value, reflecting the economic reality that land retains worth even after structures are damaged or destroyed. Buyout pricing uses total rental income, which implicitly captures both land and structure value.

B.3.d Spatial and demographic attributes

Property locations were enriched with elevation data from AWS Terrain Tiles at 30-meter resolution. Distance to coast was calculated as the minimum Euclidean distance from each property centroid to the California coastline vector layer. Census tract-level demographic data from the American Community Survey 2022 five-year estimates were spatially joined to properties to support environmental justice analysis, including median household income, poverty rate, renter-occupancy fraction, and racial and ethnic composition.

B.4 Flood damage assessment

Flood damages to residential structures were estimated using depth-damage functions that relate inundation depth to the percentage of structure value lost. These functions are a standard tool in flood risk assessment, applied widely by the U.S. Army Corps of Engineers, FEMA's Hazus model, and academic studies of coastal flood impacts (Davis & Skaggs, 1992).

B.4.a Depth-damage function specification

The model employs a logistic (S-shaped) depth-damage curve, reflecting the empirical observation that damage increases slowly at low depths, accelerates rapidly in the middle range as critical building systems are affected, and asymptotes at high depths when structures approach total loss. The functional form is:

$$Depth\ Damage\ Fraction \ = \ \frac{a}{1 + e^{-b\,(d-c)}}$$

Equation B.1. Where a = maximum damage fraction, b = steepness parameter, c = inflection point depth (m), and depth is flood depth in meters.

Parameters were adopted from the U.S. Army Corps of Engineers' 1992 Catalog of Residential Depth-Damage Functions (Davis & Skaggs, 1992): a = 0.4 (40% maximum damage), b = 1.0, c = 2.0 meters. These parameters reflect one-story residential structures without basements, the predominant building type in California coastal communities. The 40% maximum damage reflects that even catastrophic flooding rarely results in complete structure loss (foundations, framing, and land improvements often retain salvage value).

The choice of c = 2.0 meters as the inflection point aligns with typical residential floor heights and critical system elevations. Depths below 1 meter primarily affect flooring, lower cabinets, and appliances. Depths of 1–2 meters reach electrical outlets, HVAC systems, and lower wall framing. Depths exceeding 2 meters inundate upper-floor systems and require near-total interior reconstruction.

B.4.b Damage threshold

A minimum flood depth threshold of 0.15 meters was applied to filter model noise and focus on damage-causing events. This threshold reflects CoSMoS DEM vertical uncertainty (±15 cm) and the practical reality that minor wetting from shallow flooding typically results in cleanup costs rather than structural repair. Properties experiencing depths just above the threshold face minimal damage (1–3% of structure value); properties with depths of 0.5 meters or greater experience damages exceeding 10% of structure value.

B.4.c Damage calculation

$$Damage(t) = Depth\ Damage\ Fraction\ (d_t)\ *\ Structure\ Value$$

$$Retreat\ when\ T\ *$$

Equation B.2. Where depth_t is the flood depth in year t drawn from Monte Carlo storm simulation, and structure_value is derived from the land-structure decomposition.

Damages affect only structure value, not land value. In the deterministic baseline (no Monte Carlo), annual damages are calculated using average annual flood depths (w001 scenario). In Monte Carlo analysis, each year's damage is determined by the probabilistically drawn storm depth for that simulation iteration.

B.5 Cliff retreat thresholds

Properties located on coastal bluffs face a fundamentally different hazard mechanism than flood-exposed properties. Rather than accumulating incremental damage, bluff properties experience discrete failure events when cliff retreat reaches critical proximity to structures. Retreat timing is therefore governed by distance-based thresholds derived from California Coastal Commission guidance, case law, and geotechnical engineering standards.

B.5.a Threshold definition and regulatory basis

A single safety threshold governs retreat timing for cliff-exposed properties: 10 meters (≈33 feet) from the cliff edge. This represents the minimum safe setback based on geotechnical stability analysis and emergency evacuation requirements. Properties at or within 10 meters face imminent structural failure risk from episodic cliff collapse events and are typically subject to immediate evacuation orders or condemnation. The threshold applies to the horizontal distance from the structure's nearest point to the actively eroding cliff edge, measured perpendicular to the cliff face.

B.5.b Retreat timing determination

Properties with baseline (present-day) distances at or below 10 meters are assigned $T^* = 1$, indicating immediate acquisition regardless of economic considerations. Properties with baseline distances exceeding 10 meters are assigned T^* equal to the first year when projected cliff retreat reduces the distance to 10 meters or less. Properties where projected cliff distances never reach 10 meters within the 74-year planning horizon are classified as beyond horizon.

Properties are classified into two exposure categories based on their baseline distance to the cliff edge. Immediate hazard properties with baseline distances at or below 10 meters are assigned $T^* = 1$, indicating acquisition should proceed in the first year of the planning horizon regardless of economic considerations. Safe properties with baseline distances exceeding 10 meters are assigned T^* equal to the first year when projected cliff retreat reduces the cliff-to-structure distance to 10 meters or less. Properties where projected cliff distances never reach 10 meters within the 74-year planning horizon are classified as beyond horizon ($T^* > 74$).

B.5.c Distinction from flood-based retreat timing

Cliff retreat timing differs from flood-based timing in three important respects. First, it produces discrete threshold crossings rather than continuous damage accumulation, making T^* a function of physical proximity rather than economic NPV. Second, cliff retreat is deterministic within CoSMoS projections — no stochastic simulation is required, and T^* is a single value rather than a distribution. Third, cliff-based T^* is insensitive to economic parameters such as rental yield and discount rate, making it more amenable to regulatory mandates than flood-based timing.

B.6 Monte carlo storm simulation

Each year within the planning horizon, flood depth is drawn probabilistically from three CoSMoS storm scenarios based on their return period frequencies. Average annual conditions (w001) occur with 94% probability. The 20-year storm (w020, 5% annual exceedance probability) occurs with 5% probability in any given year. The 100-year storm (w100, 1% annual exceedance probability) occurs with 1% probability. These probabilities align with standard statistical definitions of storm return periods.

B.6.a Storm timeline generation

For each Monte Carlo iteration, a complete 74-year storm timeline is generated by drawing storm types independently for each year. A uniform random number between 0 and 1 is drawn for each year: values less than 0.01 trigger 100-year storm depths, values between 0.01 and 0.06 trigger 20-year storm depths, and values 0.06 or greater trigger average annual depths. The selected depth is passed to the depth-damage function (Equation B.2), producing an annual damage value multiplied by structure value and discounted to present value.

For computational efficiency, all 74 random draws per simulation iteration are generated in a single vectorized call. Storm-specific depth lookup functions are constructed once per property per scenario via approxfun interpolation and reused across all 1,000 iterations, avoiding repeated data filtering. These optimizations reduce runtime by approximately an order of magnitude relative to naive loop-based implementations.

B.6.b T* distribution and interpretation

After completing all 1,000 iterations, the model generates a distribution of T* values capturing uncertainty in storm timing. The reported T* is the mean of this distribution — the expected retreat year across all possible storm sequences. Critically, this represents the mean across 1,000 individual retreat years, not the retreat year calculated from mean damages across simulations. This distinction matters because of the nonlinearity of the threshold condition: a property might show a mean T* of 73 years and a median T* beyond the planning horizon, meaning the majority of storm realizations never trigger retreat by 2100, but a meaningful minority experience extreme late-period damage spikes that pull the mean down. The mean T* captures tail risk from low-probability high-consequence events; the median T* represents the most likely single outcome. When median T* exceeds the planning horizon but mean T* does not, retreat is driven by that tail subset rather than by the typical storm sequence. Summary statistics (mean, median, standard deviation, 5th/95th percentiles) characterize the full distribution for planning purposes. This distinction is critical: when viewing NPV plots, if the mean damage trajectory does not cross the rental income line but $T^* < 74$ years is reported, retreat is driven by tail risk rather than expected damages.

The mean T* represents expected value including tail risk from low-probability high-consequence events. The median T* represents the most likely single outcome. When median T* exceeds the planning horizon but mean T* does not, this indicates that retreat is driven by a subset of realizations with extreme late-period damage spikes rather than by the typical storm sequence. This distinction is critical: when viewing NPV plots, if the mean damage trajectory does not cross the rental income line but T* < 74 years is reported, retreat is driven by tail risk rather than expected damages.

B.7 NPV calculation and optimal retreat year

The optimal retreat year T* is determined by comparing the present value of continued occupancy benefits against the present value of expected future damages, evaluated for each year t in the planning horizon.

B.7.a NPV components

$$NPV_{rent} = \sum_{t=0}^{\infty} \frac{Rent}{(1+\delta)^{t}} = Rent \ * \ \frac{1+\delta}{\delta}$$

Equation B.3. Where rent = property price × rental yield, and δ = 0.05 (market discount rate). This perpetuity formula assumes rental income continues indefinitely at a constant real value.

$$NPV_{damages}(t) = \sum_{k=t}^{k=T} \left(\frac{D_k \ * \ Structure\ Value}{(1+\delta)^{(k-t)}}\right) + \frac{D_T * \ Structure\ Value}{\delta} * \frac{1}{(1+\delta)^{(T-t)}}$$

Equation B.4. Where T̂ = 74 (planning horizon year), damage_s = annual flood damage in years, and D_T̂ = year-2100 damage level used as the perpetual tail. The first term captures modeled damages through 2100; the second term represents damages continuing at the year-2100 level in perpetuity.

The perpetuity tail in Equation B.4 ensures symmetry with the infinite rental income stream in Equation B.3 and prevents artificial finite-horizon truncation effects. Both streams are valued from year t forward, enabling direct comparison. In the Monte Carlo framework, damages vary across simulation iterations, producing a distribution of NPV(damages) values rather than a single estimate; the perpetual tail is calculated separately for each simulation using that simulation's year-2100 damage level.

B.7.b Retreat tear determination

$$NPV_{staying}(t) = NPV_{annual\ rental\ income}(t) - NPV_{annual\ expected\ damages}(t)$$

Equation B.5. Homeowner net present value (NPV) of staying in the property from year t onward.

$$NPV_{staying}(t) \leq 0$$

Equation B.6. Definition of economically efficiency lifespan $T\ *$.

At T*, the present value of expected future damages equals or exceeds the present value of perpetual rental income. Remaining beyond T* generates negative net value, making retreat the economically optimal strategy from the market-value perspective.

B.8 Buyout pricing and government economics

B.8.a Buyout pricing formula

$$Buyout\ Price = \sum_{t=0}^{T*} \frac{Rent}{(1+\delta)^{t}} = Rent * \frac{(1+\delta)^{T*}-1}{\delta(1+\delta)^{T*}}$$

Equation B.7. Where the closed-form geometric series expression is used for computational efficiency. This equals the finite sum of discounted annual rental income from year 0 through T*, at market discount rate $\delta = 5\%$.

The buyout price compensates owners for the rental income they forfeit by selling. It does not include structure value at T*, because by definition T* is the year when the structure has reached the end of its economic life — paying for structure value at that point would compensate owners for an asset that no longer generates net economic value. The distinction between the finite-sum buyout price (Equation B.7) and the perpetuity-based T* calculation (Equations B.3–B.6) is intentional: perpetuities determine optimal retreat timing by comparing infinite streams, while the finite sum determines fair compensation for the remaining viable occupancy period only.

B.8.b Incentive structure

The buyout pricing formula creates natural incentives for voluntary participation. Owners of highly vulnerable properties (short T*) recognize that delaying retreat reduces compensation, as each passing year eliminates one year of rental income from the finite NPV sum. An owner facing T* = 10 years who delays for 5 years receives a buyout reflecting only 5 remaining years of rental income rather than 10. Conversely, owners of less vulnerable properties can defer participation knowing their buyout value remains protected by an extended viable use period. This structure maintains fair compensation while removing incentives to delay adaptation — a meaningful improvement over traditional buyout programs that pay pre-disaster fair market value regardless of when the owner participates.

B.8.c Government-side calculations

Government costs and revenues are discounted at the government discount rate δ_g (baseline: 2%; sensitivity: 3%, 4%), reflecting social discount rates appropriate for long-term public planning. As proposed under SB 1078, the State Coastal Conservancy would administer a revolving loan fund issuing low-interest loans to local jurisdictions for managed retreat, implying a public cost of capital below typical private market rates. The 2% baseline reflects concessional public financing conditions; sensitivity analysis at 3% and 4% brackets higher borrowing-cost environments. The dual-rate structure recognizes that government and private-sector actors face different opportunity costs and planning horizons: governments can finance projects through municipal bonds or state-backed loans at lower rates and consider intergenerational welfare, justifying discount rates below the 5% market rate used for homeowner-side calculations.

$$NPV_{Repairs} = \sum_{t=0}^{t=T*} \frac{D_k * Structure\ Value}{(1+\delta\_g)^t}$$

Equation B.8. Present value of structure repair costs from flood damages incurred during the leaseback period (years 0 to T*), discounted at the government rate δ_g.

$$Lease\ Back\ Revenue = \sum_{t=0}^{t=T*} \frac{Rent}{(1+\delta\_g)^t}$$

Equation B.9. Present value of rental income collected by government during the leaseback period (years 0 to T*), discounted at the government rate δ_g.

$$Government\ Net\ Cost\ = Buyout\ Price\ +\ NPV_{Repairs}\ -\ Lease\ Back\ Revenue$$

Equation B.10. The total cost to the government of acquiring and operating a property through buyout-leaseback.

B.8.d Discount rate arbitrage

The same rental income stream appears twice in the analysis at different discount rates. The buyout price reflects that stream discounted at δ = 5% (what government pays the homeowner); leaseback revenue reflects the same stream discounted at δ_g = 2–4% (what government collects). Because lower discount rates produce higher present values, this creates a discount rate arbitrage: the government pays for the rental stream at a relatively low valuation and collects it at a relatively high valuation. For a property with T* = 30 years and annual rent of $100,000, the rental component of the buyout at δ = 5% is approximately $1.537 million, while leaseback revenue at δ_g = 2% is approximately $2.226 million. This $689,000 advantage is partially or fully offset by repair costs, with the net outcome depending on property-specific damage trajectories.

This structure distinguishes buyout-leaseback from FEMA voluntary buyouts, where the government pays full acquisition costs with no revenue offset and immediately demolishes properties. The leaseback mechanism generates 40–60% revenue recovery in favorable cases, making proactive managed retreat more fiscally sustainable than traditional approaches, particularly when combined with avoided future disaster assistance costs.

B.9 Sensitivity analysis

B.9.a Sensitivity analysis design

The baseline analysis uses fixed parameters selected based on literature benchmarks and regulatory guidance. Sensitivity analysis tests the robustness of results to plausible alternative values for the key economic parameters. The analysis follows a simplified factorial design varying the government discount rate only, holding all other parameters fixed.

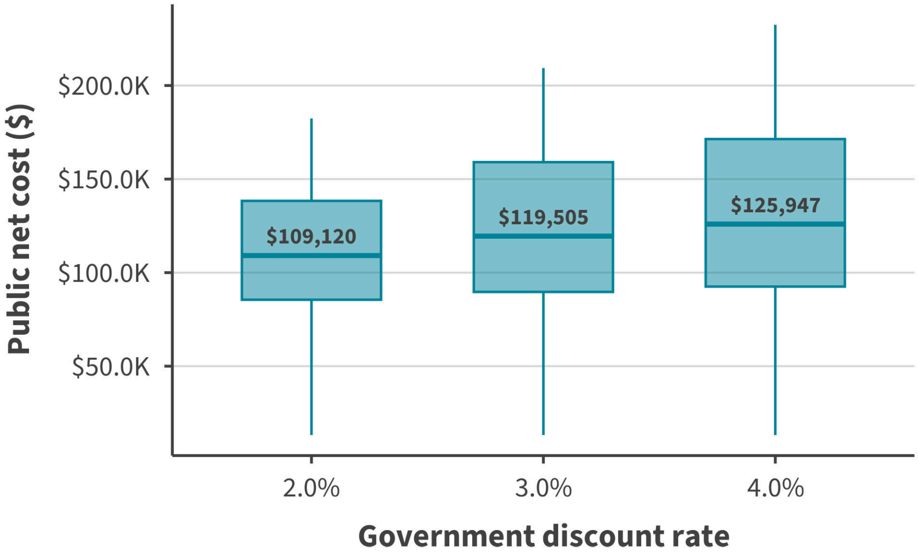
Table B.1.1. **Sensitivity analysis parameter ranges.**

Parameter	Baseline	Range Tested	Rationale
Market discount rate (δ)	5%	Fixed	Determines T* and buyout price; reflects private-sector opportunity cost
Rental yield	5%	Fixed	Literature range for coastal CA residential markets; tested in exploratory analysis
Government discount rate (δ_g)	2%	2%, 3%, 4%	Reflects concessional public financing conditions per SB 1078; brackets range of plausible government borrowing costs; primary sensitivity dimension
Flood depth threshold	0.15 m	Fixed	Tied to CoSMoS DEM vertical uncertainty; conservatively set
Sea level rise scenario	Intermediate-High	Intermediate, Intermediate-High, High	Range of OPC-recommended scenarios to use for SLR planning
Cliff management scenario	Let It Go	Let It Go, Hold The Line	Reflects actual policy choice; both scenarios calculated for cliff sites

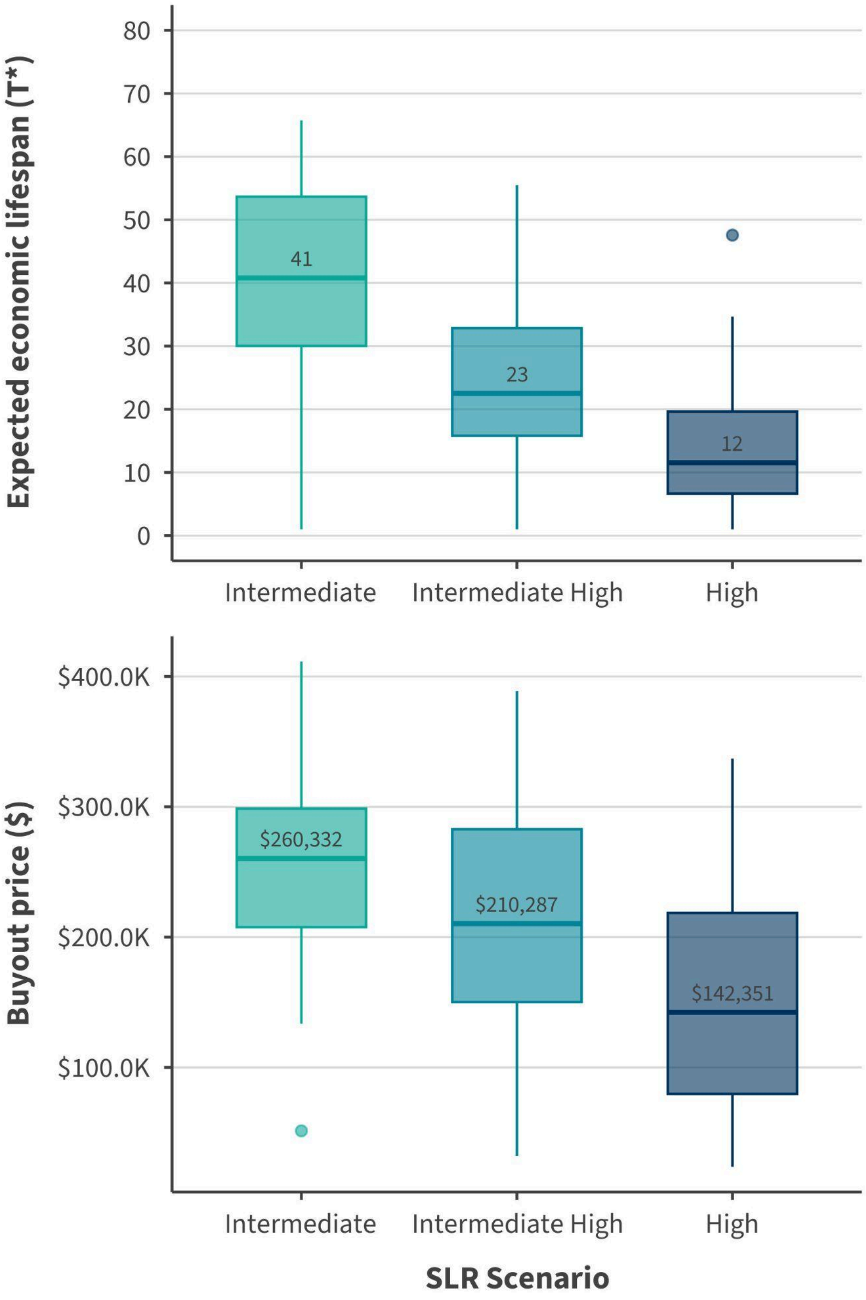
T* and buyout prices are calculated using the fixed market discount rate and are identical across sensitivity runs. Only government-side economics, leaseback revenue, repair cost present value, and net government cost, vary across the three δ_g values. This design isolates the effect of public financing assumptions from the underlying hazard-economic analysis while keeping computational demands tractable.

All three SLR scenarios (Intermediate, Intermediate-High, High) are run in full for both baseline and sensitivity analyses, yielding three SLR × three δ_g = nine government economics outputs per property. Monte Carlo simulation runs at 1,000 iterations per property per SLR scenario.

B.9.b Sensitivity analysis results



Appendix Figure B.9.b. Sensitivity of public net cost to the government discount rate. Boxplots show the distribution of modeled property-level public net costs under alternative government discount rates (e.g., 2%, 3%, and 4%). Boxes represent the interquartile range with median lines; whiskers indicate the spread of values, illustrating how discounting assumptions affect estimated public costs.



Appendix Figure B.9.b. Sensitivity of modeled economic lifespan and buyout price to sea level rise scenarios. Stacked boxplots show the distribution of property-level expected economic lifespan (top) and buyout price (bottom) under three sea level rise scenarios. Boxes represent the interquartile range with median lines; whiskers indicate the spread of values, highlighting how higher SLR scenarios tend to shorten lifespans and decrease buyout prices.

B.10 Limitations and assumptions

The model integrates hazard data, property economics, and probabilistic storm simulation to produce property-level retreat timing and buyout cost estimates. Each component involves simplifying assumptions whose limitations are documented here in consolidated form.

B.10.a Hazard data limitations

CoSMoS 2-meter DEM resolution may not capture micro-topographic features such as elevated foundations, localized high points, or drainage structures that affect actual flood exposure at individual properties. Properties smaller than approximately four square meters may not be fully represented in 2-meter rasters, and flood depths extracted at parcel centroids may not reflect variation across larger parcels. Wave runup calculations assume natural beach profiles and may be less accurate in locations with existing armoring. The model does not account for compound flooding from simultaneous coastal inundation, riverine flooding, and elevated groundwater tables — a meaningful gap for low-lying areas near stream outlets where coincident events can significantly increase flood depths beyond CoSMoS coastal-only projections. Chronic inundation from rising groundwater tables, which can degrade foundations and infrastructure without surface flooding, is similarly excluded.
Ground-truthing CoSMoS projections against observed high-water marks from historical flood events would improve confidence in depth estimates, though such validation data are sparse for California coastal communities. CoSMoS v3.0 was released in 2017–2018 and does not incorporate morphological changes or shoreline modifications that have occurred since that time. Projections assume static coastal infrastructure and do not account for future protective measures that property owners or jurisdictions may implement.

The Monte Carlo storm simulation assumes stationary storm return periods over the planning horizon, with 100-year storms maintaining 1% annual exceedance probability regardless of climate change. This aligns with current FEMA floodplain management standards but may underestimate future storm frequency and intensity if warming ocean temperatures increase tropical cyclone activity or atmospheric river events affecting California's coast. Incorporating non-stationary storm distributions based on climate model projections would provide more realistic damage trajectories under high-emission scenarios, though regional-scale storm projections carry substantial additional uncertainty.

B.10.b Economic assumptions

The model applies a uniform 5% rental yield across all properties within a study area, regardless of property type, size, or location-specific amenities. Actual rental yields vary substantially: larger homes and luxury properties typically exhibit lower yields due to compressed rent-to-price ratios, while smaller properties in more affordable submarkets may generate higher returns. Retreat timing estimates may therefore be less accurate for properties at the extremes of the value distribution, though sensitivity analysis across 4–6% yields provides bounds on this uncertainty.

Property values are held constant in real terms throughout the planning horizon, ignoring potential price depreciation as coastal hazards become more apparent or appreciation from continued coastal development pressure. Properties approaching their optimal retreat year may experience declining market values, while properties with distant retreat horizons may maintain or increase in value if coastal demand remains strong. The static value assumption likely overestimates buyout costs for highly vulnerable properties whose market values may already reflect discounted future risk. Hedonic pricing models tracking coastal property transactions over time could reveal how hazard awareness affects market values and improve cost projections for long-range planning.

The rental yield approach implicitly assumes that current property prices do not yet fully reflect anticipated future flood damages or retreat timing. This is reasonable given historical patterns of government intervention through protective infrastructure and post-disaster buyouts at pre-hazard fair market values, but means that rental income estimates may be somewhat inflated for highly exposed properties, producing retreat timing estimates that are slightly conservative.

B.10.c Damage function limitations

The depth-damage function represents average residential structures and does not account for property-specific features such as elevated foundations, flood-resistant construction, adaptive modifications (flood vents, waterproof materials), or degraded structures with heightened vulnerability. Damage estimates assume structures are maintained in typical condition and do not anticipate strategic neglect or deferred maintenance as retreat approaches. The function also does not capture indirect costs such as displacement during repairs, loss of possessions, or health impacts from mold and contaminated floodwater, meaning total economic losses to households may exceed modeled structural damages.

The 1992 USACE parameters have not been recalibrated for California-specific building stock. California building codes, foundation practices, and architectural styles may differ from the national average underlying the original catalog, potentially introducing systematic bias in damage estimates. Ideally the function would be recalibrated using observed flood insurance claims from California coastal communities, but FEMA National Flood Insurance Program claims data are not publicly available at the property level and privacy restrictions limit access to detailed loss records that would enable local calibration. Incorporating assessor parcel data or conducting field surveys for sample properties would enable property-type-specific damage functions, though resource constraints typically limit this level of detail in regional assessments.

B.10.d Spatial and data limitations

Property-level analysis requires detailed parcel data that are not uniformly available or standardized across jurisdictions. Current model inputs include property address, sale price, property type, and basic structural characteristics from Redfin MLS data, but lack information on foundation type (slab versus elevated versus basement), structural condition, and existing flood adaptation measures such as flood vents, sump pumps, or waterproofing. Properties with elevated first floors may experience substantially lower flood damages than the uniform depth-damage function predicts, while properties with deferred maintenance or degraded foundations may be more vulnerable than average.

The model treats each property as an independent unit without accounting for spatial dependencies or neighborhood effects. In reality, widespread property abandonment or coordinated retreat may generate spillover effects on nearby property values, community cohesion, and local tax bases. Similarly, phased retreat that creates natural buffer zones may reduce flood exposure for remaining properties by allowing beach and dune systems to migrate landward , a positive externality not captured in individual property NPV calculations. Spatial econometric approaches or agent-based models could represent these interdependencies, though such methods introduce substantial additional complexity and data requirements.

B.10.e Future research directions

Several extensions would enhance the model’s policy relevance and realism. Incorporating ecosystem service valuation would enable benefit-cost analysis that accounts for public gains from restored coastal habitat — properties acquired through buyouts can be converted to wetlands, beaches, or dune systems providing flood attenuation, carbon sequestration, biodiversity habitat, and recreation value. Existing literature on coastal ecosystem valuation provides benefit transfer estimates ranging from thousands to tens of thousands of dollars per acre annually. Integrating these public benefits into the retreat decision framework would strengthen the economic case for proactive acquisition, particularly for properties whose private costs alone do not justify buyout but whose ecosystem restoration value tips the balance.

Examining equity dimensions of managed retreat would address distributional concerns central to climate adaptation policy. Lower-income households may face greater displacement burdens if buyout compensation is insufficient to secure comparable housing in safer areas, particularly in high-cost coastal regions where inland alternatives are scarce. Elderly residents and communities of color may experience disproportionate hardship from relocation due to attachment to place, language barriers, or historical trauma from displacement. Future work could develop multi-objective optimization frameworks balancing cost-effectiveness with equity goals, or assess alternative compensation mechanisms such as replacement housing guarantees or community land trusts that preserve affordability after retreat.

Finally, incorporating dynamic property value adjustments as coastal hazards materialize would improve realism in retreat timing projections. If property markets begin pricing in sea level rise risk as retreat years approach, actual buyout costs may decline relative to static value assumptions, enabling jurisdictions to acquire properties more affordably. Conversely, if denial or information asymmetries prevent risk from being reflected in prices, buyouts may remain expensive even for highly vulnerable properties. Hedonic pricing models tracking coastal property transactions over time could reveal how hazard awareness affects market values, informing more accurate cost projections for long-range retreat planning.