Vulnerability in the Avalanche Capital:

The Human Dimensions of Avalanche and Landslide Hazard in Juneau, Alaska

by

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DISSERTATION ABSTRACT

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Title: Vulnerability in the Avalanche Capital: The Human Dimensions of Avalanche and Landslide Hazard in Juneau, Alaska

In the United States, climate disasters kill thousands of people and cost billions of dollars each year. In 2023, the United States experienced 28 environmental disasters that cost more than one billion dollars each—the most ever in a single year—highlighting the accelerating convergence of climate change and hazard zone development. The cryosphere faces some of the most amplified climatic changes, yet snow hazards continue to receive little attention from social scientists. This dissertation therefore examines snow hazards from avalanches and landslides in downtown Juneau, Alaska, one of the most exposed cities in the country.

Using mixed qualitative methods—including interviews, participant observation, document and media analysis, and geospatial analysis—this dissertation draws on Juneau as a case study to advance the existing research on vulnerability in hazard zones. To contribute to vulnerability and unnatural disasters literature, chapters two through four examine the actors, sites, and moments that produce vulnerability and offer three key findings. Chapter 2, "Hazard Zone Conflicts in the Avalanche Capital," argues that political, economic, and legal conflicts create windows of opportunity for powerful actors to influence the trajectory of hazard management. Chapter 3, "Housing Justice in a Hazard Zone," argues that not only inequitable city planning and development initiatives create unnatural disasters, but also the process of hazard mitigation itself. Hazard mitigation strategies, such as the 2018-2023 hazard zone mapping project, disproportionately distribute new risks throughout the community. Chapter 4, "Shifting

Climate Hazards and the Inertia of Disasters," argues that the momentum of powerful societal forces, such as longstanding avalanche research programs and public unfamiliarity with landslides, obstructs Juneau's ability to adapt to climate change and the increasing landslide hazard.

While the details in each chapter are contextual and place-based, the broader findings offered in this dissertation are relevant for hazard zones around the world. This dissertation recommends: 1) scientists proactively integrate research on local social dynamics into their hazard and risk studies; and 2) decision-makers prioritize greater equity in the hazard mitigation and climate adaptation process.

This dissertation includes previously published coauthored material.

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DEDICATION

This dissertation is dedicated to my parents, Kelly and Ralf, and my best friend and life partner, Nan.

Mom and Dad, I am forever grateful for the life you provided Chris and me. The world you showed me inspired my commitment to environmental studies. The doors you opened for me made it possible.

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CHAPTER I

INTRODUCTION

Every day, people around the world face the worsening impacts of climate change. Yet communities on the climate frontlines repeatedly demonstrate their resilience and adaptive capacity. In impressive displays of ingenuity, humans respond to environmental changes like sea level rise, permafrost thaw, and drought. They engineer seawalls, relocate villages, and increase water storage capacity. Peruvian farmers select new crops alongside changing temperatures and precipitation, and Maldivians construct water desalination facilities as freshwater becomes scarce. In the United States, cities take on large projects—Miami raises streets to stay above sea level, and Ventura backs away from the coastline through what is known as managed retreat. As the climate changes over time, people adapt.

This ability to adapt breaks down when the climate impacts are unpredictable and instantaneous rather than slow and calculated. Environmental hazards like hurricanes, floods, and tsunamis do not offer years to react—they are low frequency, high severity events that ignore the “slow burn” tendencies of sea level rise and global warming. Yes, the likelihood of extreme natural hazard events increases incrementally alongside climate change. However, the impacts of a large-magnitude disaster are far from incremental. In one moment, a climate disaster can change everything.

Even though natural hazards are unpredictable and unforgiving, humans still play a crucial role in whether—and to what degree—natural hazard events become a disaster. Decisions spread across days, decades, and centuries, turn hazards into impacts for people before, during, and after a disaster. These decisions are made by a select few with power and resources, but their consequences percolate disproportionately through

society. This dissertation examines the impacts of these decisions—historically, ongoing, and into the future.



Figure 1. Downtown Juneau is nestled between Mount Juneau and Mount Roberts. Image by author.

Looking past the left wing of a Boeing 737, I watched the lights of downtown Juneau fade behind the low-hanging clouds. This was not my first time flying home from Alaska, but this trip left me with a new feeling—anxiety. It had been raining heavily for the past week, and the local weather forecasts called for heavy precipitation and a flood warning. Heavy rain is expected in September, but the magnitude of this particular storm conjured up images of Southeast Alaska's recent landslides disasters. In 2022, just one year earlier, a landslide in downtown Juneau destroyed three houses in a similar September storm. A year later, only days before boarding this plane home, I interviewed two residents from these destroyed homes—they are both lucky to be alive today.

As the plane lifted from the Gastineau Channel, my mind wandered beyond Juneau. In 2020, a landslide in nearby Haines killed two people. Some of my interview participants knew the deceased, as Southeast Alaskans are a close-knit bunch. Further

back, a 2015 landslide in Sitka killed three. One hazard expert told me the sad story of flying to Sitka to help with the search and rescue effort. These landslides forced many Southeast Alaskans to reckon with their new reality—do Alaskans have to worry not only about tsunamis, avalanches, and earthquakes, but landslides, too? What can they do about these increasingly frequent landslide disasters?

I feared this September storm would produce a deadly landslide that night in Juneau. It seemed only a matter of time, and 2022's close call must mean that Juneau's number is about to be called. I felt a strange sense of guilt for leaving—for escaping the hazard zone that so many Juneau residents call home—even though I knew my home was in Oregon, and there was little help I could offer in the case of a landslide. For the rest of the night, I anxiously awaited a text message from someone in Juneau. When the morning finally arrived without any breaking news, my nerves settled. I drank my morning coffee and reflected on how personally invested I had become in understanding and mitigating Juneau's landslide and avalanche hazard. This was no longer just dissertation research. I felt connected to Juneau's hazard zones and the residents that live there. This was the most meaningful and important thing I had ever done.

As my dissertation committee can attest, I did not begin the Environmental Sciences, Studies, and Policy PhD program at the University of Oregon with the intention of researching avalanches and landslides in Alaska. At that time in 2018, I was not even thinking about hazards. I would explain that I was interested in "the impacts of changing snow for people in the Pacific Northwest." After all, hydrologists and climate scientists forecast dramatic and unavoidable changes to mountain snowpacks around the world (Hock et al., 2019; Masson-Delmotte et al., 2018; Mote et al., 2005; Nolin & Daly, 2006; Sproles et al., 2017). The US National Climate Assessments and the Intergovernmental Panel on Climate Change (IPCC) reports repeatedly highlight that snow cover, snowpack,

and season extent are all declining rapidly. Further, Sproles et al. (2013) predict that a two-degree increase in average air temperature will correlate with an average peak snowpack 12 days earlier and a 56% reduction in water storage. This will undoubtedly have significant impacts throughout Pacific Northwest watersheds. For example, the Pacific Northwest ski industry is positioned to lose hundreds of millions of dollars per year by 2050 (Wobus et al., 2017). In addition, hydropower generation is expected to decrease while demand increases (Hamlet et al., 2010). Salmon populations, an important cultural food and source of income for Indigenous Peoples in the Pacific Northwest, are struggling with warming stream temperatures (Dittmer, 2013). The list goes on. Declining snow—more specifically, the decadal reductions in winter snow due to climate change—is a serious problem with the potential to dramatically impact the lives of millions of people.

However, these impacts I have mentioned—water resources, the ski industry, and salmon, among others—are predominantly changing on a longer scale. There can be extremes—such as a drought or salmon die-off—but the impacts will generally accumulate alongside the marginal year-on-year changes. They are the persistent, chronic, "slow burn" impacts that sneak up over decades. Rob Nixon (2011) calls this a "slow violence." What's more, winter snowfall has always been unpredictable. That is simply the nature of snow. Some winters are way above average, like the 2022-2023 season where the Sierra Nevada Mountains received nearly 1000 inches of snow, just shy of Mt. Baker's global record of 1,140 inches in 1998-1999 (NASA, 2023). Other winters are below average, like the 2014-2015 that skiers still complain about and snow scientists frequently study to model climate change (Sproles, 2017). Thus, while the averages for snowpack, snow cover, and season length will continue to decrease, snow variations throughout history have people well-equipped to deal with dramatic swings

in snow totals. Reservoirs open or close their dams based on that year's expected snowmelt. Ski resorts use snowmakers to produce artificial snow based on the conditions. Farmers store additional water in preparation for a late-summer drought. In many ways, then, the Pacific Northwest has built-in adaptive capacity to changing snow.

Long-term, the projected massive reductions in snow will undoubtedly cause significant problems—but scientists and engineers are already developing ways to adapt to these changes, too. Hydropower operations in the Pacific Northwest study how to expand water storage capacity to account for decreased summer snowmelt (Office of Energy Efficiency and Renewable Energy, 2024). As winter snow becomes unreliable, ski resorts are shifting to four-season business models that generate additional revenue during the summer (Sellers, 2024). Eight states in the western US are even experimenting with cloud seeding programs, which is the release of silver-iodide crystals by planes to stimulate cloud growth and promote snowfall (Harvey, 2021). Whether these technoscientific solutions do in fact successfully buffer the impacts of changing snow is yet to be seen, but they represent climate adaptation actions that might keep pace with the long-term decline in winter snow.

As I worked through the first few years of my doctoral program, the 2021 spring flooding in the Fraser Valley of British Columbia forced mass evacuations, caused $675 million in damage, and became the most expensive weather-related disaster in B.C. history (Ghoussoub, 2023). In addition, I began to research snow-related flooding, learning about the increasing risk of rain-on-snow floods in the Pacific Northwest (McCabe et al., 2007; Musselman et al., 2018). I traveled to Medford, Oregon, where I explored the flood-prone banks of the Rogue River. In December 1964, the Rogue River experienced dramatic rain-on-snow flooding that destroyed the river's bridges and many small towns. This Christmas Day Flood, as it was called, affected Washington,

Oregon, California, Idaho, and Nevada. The flood killed 47 people and caused $540 million in damage, which is equivalent to $3.9 billion today (USGS, 2014). Newsreel footage, which can now be found on YouTube, covered the disaster like a war zone. Of course, climate change only amplifies the chance of similar floods. I realized that deadly and destructive hazards are the most urgent impact of changing snow in the Pacific Northwest. In addition, I noticed how the complexity of hazard zones—the various actors, mitigation strategies, and obstacles—could make adaptation a difficult endeavor.

Once I committed to studying the impacts of snow hazards, I stumbled upon something I did not know existed in the Pacific Northwest or even the entirety of North America. I found myself on the page of an "Urban Avalanche Advisory" (Figure 2). Being a backcountry skier, I was aware of the typical backcountry avalanche forecasts throughout most of the Pacific Northwest. In this case, however, replacing "backcountry" with "urban" conjured up images of villages tucked into the avalanche-prone Alps. To my surprise, this urban avalanche report serviced the entire downtown area of Juneau, Alaska. I then learned that the avalanche zones included critical transportation routes (e.g., the only road to the airport and hospital), hundreds of single-family homes, a homeless shelter and a women's shelter, local businesses, and a hotel, among other things. Questions emerged. How does the city manage this extraordinary hazard? How

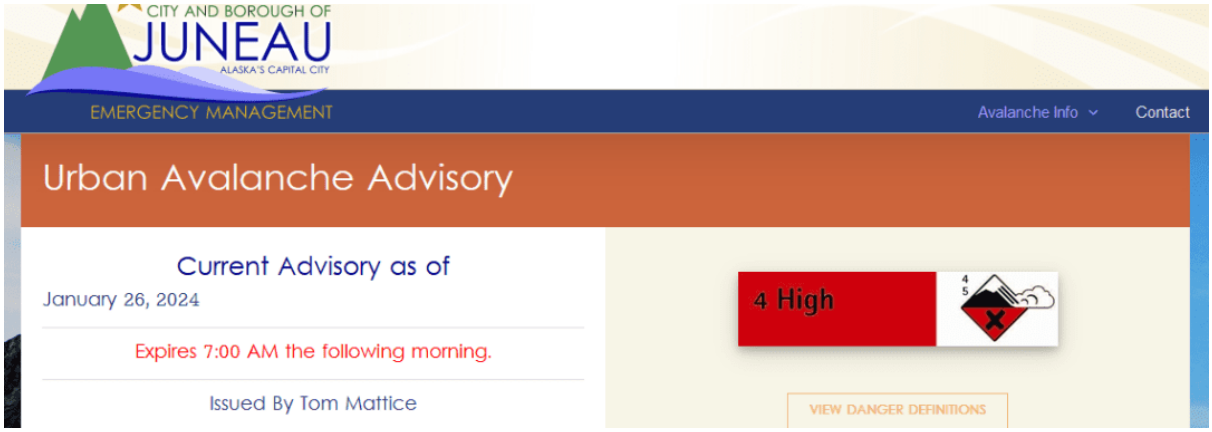


Figure 2. A screenshot from the CBJ website of Juneau's Urban Avalanche Advisory on January 26th, 2024.

do people feel about living in the hazard zones, and what are their conceptualizations of vulnerability? Is climate change altering the risk they experience? I was on the next flight to Juneau to learn more.

As I sat in a room with Teri Camery, a senior planner and hazard expert for the Community Development Department, all I could think about were avalanches. The city's avalanche history and ongoing avalanche exposure baffled me. When she said, "You know, you should really be studying the city's landslide hazard, because that's an even bigger deal right now than the avalanches," I did not initially give the statement much weight. I was there to study the relationship between avalanches, climate change, and the city's urban avalanche hazard. By the time I left Juneau a week later, however, I was beginning to understand why I kept hearing about landslides. Not only are they closely linked to winter snowfall and winter temperatures (see Chapter 4), but they are a crucial part of Juneau's disaster history, property owners' rejection of updated hazard maps (see Chapter 3), and Juneau's growing vulnerability to climate change. Now, landslides make up a fundamental part of my dissertation.

The City and Borough of Juneau: background information

Inaccessible by road, Juneau's isolation from the rest of Alaska gives it a unique personality. The city is a political and cultural blend of the Pacific Northwest and further north Alaska. This is immediately apparent upon stepping foot in Juneau—electric cars park at the docks of deep-sea fishing vessels, cruise ship tourists walk alongside subsistence hunters, and state legislature buildings contrast with the backdrop of the nearly vertical Coast Range Mountains. There is minimal flat land, as the mountains drop over 3000 vertical feet directly into the Gastineau Channel (Figure 3). The weather

is as rugged as the landscape, with downtown Juneau averaging over 90 inches of annual rainfall. Most of this precipitation occurs during the fall and winter seasons. The summers are drier, and the average high temperatures in June, July, and August barely break 60 degrees Fahrenheit. This climate is home to temperate rainforests, and the City and Borough of Juneau (CBJ) is surrounded by the largest national forest in the United States, the Tongass National Forest. There are also an impressive 580 square miles of glaciers in the City and Borough of Juneau, which means that 18% of the borough is covered by ice.



Figure 3. Looking south from Mount Roberts, a cruise ship arrives in Juneau. Photo by author.

Juneau is Alaska's capital city with a population of about 32,000 people. Residents are spread across three main population centers of the CBJ: downtown Juneau, the Mendenhall Valley, and Douglas Island (Figure 4). Downtown Juneau, which I

focus on in this dissertation, was developed as a mining town in 1880 and named Juneau in 1881. Despite downtown Juneau's precarious location between the Gastineau Channel and Coast Range Mountains, the city grew into an important economic and political hub for Alaska. In 1906, Alaska transferred the state government from Sitka to Juneau, officially recognizing Juneau as the new state capital. The small size of Juneau compared to Anchorage—Anchorage is nearly 10 times the size at almost 300,000 people, despite starting development almost 50 years later—is primarily due to the city's inaccessibility and the lack of developable land. In recent decades, this has led to concern about "Capital Creep," which is the slow movement of the state legislature



Figure 4. Reference map for the City and Borough of Juneau. Map created by author with data provided by the City and Borough of Juneau and ESRI.

buildings from Juneau to the more affordable and spacious Anchorage (discussed in Chapter 2). However, despite its small size and isolation, Juneau remains a popular tourist destination, a political hub for the state government, and a vibrant cultural center for Alaska.

Although European settlers did not arrive in Juneau until the late 19th century, the Auke and Taku tribes have inhabited the area for thousands of years. Today, the Central Council of the Tlingit and Haida Indian Tribes of Alaska is based in Juneau. It is important to recognize that the Tlingit and Haida have fought for "the rights of our people to claim lands we had used from time immemorial, lands we were given no claim to under the Western concept of land ownership" (Tlingit and Haida, 2024). While my dissertation does not study lands currently owned by the Central Council of the Tlingit and Haida Indian Tribes of Alaska, it is important to note their rights to land in Southeast Alaska and their valuable contributions to the Juneau community. For example, when it comes to emergency response, the Tlingit and Haida's Tribal Emergency Operations Center (TEOC) is undoubtedly the most advanced and organized operation in Southeast Alaska—they have invested significant time and resources into state-of-the-art technology and highly trained staff. In the event of a destructive avalanche or landslide in Juneau or wider Southeast Alaska, I am certain the TEOC would be indispensable first responders. It is also interesting to note that, according to an informal meeting with the TEOC, Indigenous communities did not traditionally inhabit the area that is now downtown Juneau. Instead, they primarily lived in the Mendenhall Valley. Although only 10 miles away, the Mendenhall Valley's microclimate is warmer and drier than downtown Juneau. The valley is also much less prone to avalanches and landslides. The area that is now downtown Juneau was only established by European settlers to live near the mine.



Figure 4. Downtown Juneau in 1887. Photo publicly available from DeGolyer Library, Southern Methodist University.

Juneau is a costly place to live. According to the 2010 *CBJ Housing Needs Assessment*, housing costs in Juneau are 35-64% higher than the US average (CBJ, 2010). In addition, this study identified that 38% of renters and 39% of homeowners could not find affordable housing (CBJ, 2010). The US Census categorizes 7% of the Juneau population as "in poverty" (United States Census Bureau, 2024). In 2012 (latest available data), Juneau's per capita homeless count per 1000 residents was 17.5 (CBJ, 2013). For reference, Anchorage and Fairbanks had values of 11.3 and 4, respectively (CBJ, 2013). During visits to shelters like The Glory Hall and Saint Vincent de Paul, I noticed that a disproportionately large number of the shelter occupants were Alaska Native populations. According to one dataset, Alaska Native or American Indian individuals made up 38% of Juneau's homeless population in 2020 (Lockett, 2021). Various sources—interview data, meeting transcripts, government documents, and media articles, among others—highlight Juneau's ongoing housing crisis. The Glory Hall,

also known as the Juneau Housing First Collaborative, and Saint Vincent de Paul are two organizations working to provide shelters and affordable housing throughout the borough. As studied in Chapter 4, the intersection between this housing crisis and Juneau's avalanche and landslide hazard zones creates significant impacts and justice issues for downtown residents.

According to the US Census, Juneau residents are 64% white, 9% American Indian and Alaska Native, 7% Asian, and 7% Hispanic or Latino. According to census tract data, the Alaska Native population is the fastest-growing group in Juneau (Alaska Department of Labor and Workforce Development, 2015). Downtown Juneau, which I focus on in this dissertation, is less diverse and more expensive than other parts of the CBJ. Demographic data reflects this, but I also saw this discrepancy clearly during fieldwork. According to a 2015 report, the Lemon Creek/Salmon Creek area, which sits halfway between downtown Juneau and the Mendenhall Valley, is the most diverse part of the CBJ at nearly 50% nonwhite (Alaska Department of Labor and Workforce Development, 2015). This area also has lower average incomes and property values (Alaska Department of Labor and Workforce Development, 2015). As the last two paragraphs only begin to demonstrate, there are urgent environmental, housing, and health justice issues in Juneau. Even though these broader social issues are mostly out of the scope of my dissertation—my work focuses on downtown Juneau because that's where the avalanche and landslide hazards intersect with residents—they are issues that demand more attention from scholars and decision-makers. For future research in Juneau, I aim to broaden the geographical boundaries of my project to more directly address the inequities that exist across the borough.

This context section briefly introduces Juneau's environmental and social landscapes. Additional background information about Juneau hazard zones, historical

approaches to hazard management, the 2022 Tetra Tech hazard maps, and climate change can be found in the appropriate chapters.

Theoretical Contributions

My dissertation makes several core arguments, which I summarize here and place within the context of existing literature in the following subsections. First, I argue that political, economic, and legal conflicts create windows of opportunity for powerful actors to influence the trajectory of hazard management. This not only advances existing scholarship by revealing the actors, sites, and moments that lead to vulnerability in a hazard zone, but it also offers a starting point for envisioning more holistic and justice-based strategies for hazard management. Second, I argue that it is not only inequitable city planning and development initiatives that create unnatural disasters, but also the process of hazard mitigation itself. While hazard mitigation—such as mapping efforts, development regulations, and engineering projects—are designed to minimize hazard vulnerability, they simultaneously and disproportionately distribute new risks throughout the community. I show that even the *idea* of adopting hazard maps—the potential economic concerns, the public debates, and the political tensions surrounding the mapmaking process—unleashes a whirlwind of differential impacts for people in hazard zones. Third, I argue that the momentum of powerful societal forces, such as scientific research programs and public awareness campaigns, act as blinders for decision-makers. Despite a changing climate with shifting hazards, this momentum—or the "inertia of disasters"—obstructs the possibility for meaningful and equitable climate adaptation.

The dissertation directly contributes to research on hazards-risks-disasters and hazard mitigation. Each chapter clearly outlines how the specific article fits into the landscape of hazard research. In the following three subsections, I demonstrate how my dissertation arguments also offer broader theoretical interventions to several important bodies of literature: vulnerability, unnatural disasters, and human dimensions of changing snow scholarship.

Vulnerability

Scholars have long developed the concept of social vulnerability—the relative susceptibility of certain population groups to environmental hazards based on their social, economic, and political positions (e.g., Adger, 2006; Blaikie et al., 1994). For decades, vulnerability indices used predetermined indicators like income, gender, race, and health (Cutter, 1996). However, scholars have identified a number of problems with these quantitative approaches (Barnett et al., 2008). Vulnerability scholarship has also recently demonstrated how top-down, science-based hazard risk reduction that fails to collaborate with communities can lead to greater inequalities and receive local pushback (Nightingale et al., 2020; Scoville-Simonds et al., 2020). In fact, research shows that vulnerability assessments—designed to help hazard mitigation and climate adaptation reduce vulnerability—often do not benefit marginalized groups (Atteridge & Remling, 2018). Scholars have therefore worked to move away from the "quantification of vulnerability," and the notion that quantifiable data can provide an objective or "apolitical" assessment of vulnerability has been increasingly contested in the last decade (Eriksen et al., 2015).

Instead, Moulton and Carey (2023) show that vulnerability is contextual and place-based rather than calculable and transferrable. Vulnerability, after all, "does not just fall from the sky" (Ribot, 2013). In addition, O'Brien and Wolf (2010) argue that "values" are fundamental to vulnerability, as hazard mitigation and climate adaptation should be designed to protect what communities themselves deem valuable. Finally, rather than identifying certain groups of marginalized people as perpetually in need of assistance from external sources, scholars now argue that vulnerabilities lie within systems—in particular, within unjust systems of oppression built upon structures such as colonialism, imperialism, and capitalism (Marino & Faas, 2020). Marino and Faas (2020) write that they "recognize vulnerability conceived not merely as historical inequity that produces negative outcomes, but as nested and contested sites of struggle for different visions of utopian futures" (1). My dissertation builds from the notion that vulnerability is not a "condition" that some people have, but rather it is *the conditions* that decades of decisions and conflicts have produced.

My dissertation advances vulnerability scholarship by demonstrating how a system—in this case, a local community of government officials, business owners, residents, scientists, and non-profit organizations, among others—produces and conceptualizes hazard vulnerability. Specifically, I show how vulnerability emerges as a product of hazard zone conflicts and the decisions of powerful actors through time (see Chapter 2). I also demonstrate how hazard vulnerability intersects with various other local issues including housing insecurity, political instability, scientific uncertainty, and climate change, among others. In fact, the way residents and decision-makers interweave various local issues into hazard mitigation decisions shapes and reshapes the concept of hazard vulnerability altogether. These findings not only advance existing scholarship by revealing the actors, sites, and moments that lead to vulnerability in a

hazard zone, but they also offer a starting point for envisioning more holistic and justice-based strategies for hazard management.

Risk and vulnerability mapping is an increasingly important component of vulnerability scholarship (De Sherbinin et al., 2019). With a similar goal to quantitative vulnerability calculations, these maps aim to quickly describe how vulnerability is distributed throughout a community. However, the rollout of hazard, risk, or vulnerability maps is not an apolitical process that objectively defines a hazardscape. Instead, scholars have shown for decades that maps wield power and impact citizens (Harley, 2008; Wood & Fels, 1992). In fact, emerging research demonstrates that maps produce an array of unexpected impacts for residents of hazard zones (Elliott, 2019). Elliott (2019) writes, "The map does more than simply measure current flood risk. For its users in New York City, the flood insurance rate map was the apparent source of economic risk; it posed political risks surrounding flood insurance; and it posited ambiguous relationship to climate change risk." It is important to note, however, that mapping and zoning projects do not affect "passive" residents, but rather individuals wield economic and cultural power to influence the outcomes of mapping and mitigation projects (Carey, 2010; Lea & Pralle, 2022; Provant & Carey, 2023). This means that, even on a local scale, the exertion of economic and political power transforms the hazard mapping process and shapes the impacts experienced by residents. My dissertation expands this research on the impacts of maps, offering empirical evidence of how hazard map debates and decisions can further marginalize certain segments of the population (see Chapter 3). In particular, my dissertation argues that it is not just the existence of hazard maps that impact residents. Even the *idea* of hazard maps—the potential economic concerns, the public debates, and the political tensions surrounding the mapmaking process—unleashes a whirlwind of differential impacts for people in

hazard zones. Beyond providing crucial knowledge for hazard zone management, these findings contribute to both vulnerability and critical cartography scholarship by demonstrating the importance of justice considerations during hazard mapping efforts.

Unnatural Disasters

The consequences of natural hazard events are never evenly distributed across society. Due to inequitable city development and planning policies that reinforce structural violence, marginalized communities regularly face the worst impacts from environmental hazards like hurricanes, floods, tornados, and heat waves. Many decision-makers—including past US presidents—frame the consequences of these disasters as "acts of god" due to the human inability to control their occurrence. In reality, decades and centuries of decisions made by powerful and wealthy elites determine who is most vulnerable to disasters. Catastrophic disasters, then, are not unpredictable acts of god, but rather they are the culmination of persistent and systemic marginalization. They are not natural disasters; decades of scholarship have redefined them as "unnatural disasters" (e.g., Abramovitz, 2001; Bullard, 2008; Montano, 2021; Steinberg, 2006).

Unnatural disasters scholarship builds from social vulnerability work, demonstrating that social processes and social structures place certain segments of the population at greater risk of natural hazards. It also weaves hazards and disaster research together with principles from foundational political ecology. Political ecology, which first emerged as a term in the 1970s and was more widely recognized in the following decades (Blaikie & Brookfield, 1987; Peet et al., 2010; Wolf, 1972), links the power analyses of Marxist political economy with the study of environmental degradation. This literature progressed to examine how "webs of relations" produce

power imbalances, inequities, and environmental harms (Rocheleau, 2008). Of course, this knowledge is also valuable and transferable for hazard and disaster research, and scholars began studying the "political ecology of risk" for environmental disasters (Johnson, 2010; Peacock & Ragsdale, 2012). Political ecology of risk literature demonstrates, for example, how power relations, economic pressures, and profit influence risk management decisions (Huber, et al., 2017). My dissertation on avalanches and landslides in Juneau contributes to this body of scholarship, arguing that political, economic, and legal conflicts create windows of opportunity for powerful actors to influence the trajectory of hazard management (see Chapter 2). Through this work, I respond to calls for the diversification of political ecology and the engagement with feminist political ecology (e.g., Sultana, 2021), as my work necessarily hinges on contextual and place-based understandings of hazards and unnatural disasters.

Perhaps the most widely researched unnatural disaster case study is Hurricane Katrina. Research spotlights how patterns of land development and New Orleans' political and economic history disproportionately placed Black communities at risk (Laska & Morrow, 2006). Other work describes the catastrophe as a "planned failure" and an example of the "American Caste" system (Levitt & Whitaker, 2009). Finally, scholars show that post-Katrina New Orleans only served to marginalize Black populations further, as city policy choices disproportionately assist whiter, more affluent neighborhoods (Logan, 2008). In an example more closely related to this dissertation, Di Stefano (2014) documents how construction companies placed workers in dangerous railroad and mine construction zones without informing them of the severe avalanche hazard. When avalanches killed railroad workers, mine workers, or train passengers, the responsible companies offered "act of god" as the explanation and legal protection for their actions. These case studies, among countless others (other compelling examples

include: Davis, 1995; Klinenberg, 2002), demonstrate how natural hazard events become disasters through unjust processes such as gentrification, redlining, and highway development. My dissertation advances this unnatural disaster scholarship further. I argue that not only city planning and development create unnatural disasters, but also the process of hazard mitigation itself. While hazard mitigation—such as mapping efforts, development regulations, and engineering projects—is designed to minimize hazard vulnerability, it simultaneously and disproportionately distributes new risks throughout the community. I demonstrate that, despite the well-intentioned efforts of hazard managers, the lack of equity in the hazard mitigation process helps construct the next unnatural disaster (see Chapter 3).

Finally, research has also begun to examine power and justice in post-disaster landscapes. Scholars show that power imbalances only further entrench existing marginalization in the wake of disaster. In many cases, the "build back better" mantra does not produce better conditions for all (Montano, 2021). Naomi Klein (2007) highlights how disaster events "shock" communities into accepting policies that largely benefit private corporations and the wealthy elite. Through this "disaster capitalism," economic and political power shifts to foreign actors through industries like security, tourism, and transportation. In addition, Rivera (2022) introduces the concept of "disaster colonialism," where hurricane response in Puerto Rico further disenfranchises marginalized communities and deepens ongoing coloniality. Clearly, the "blank slate" following a natural hazard event is not a silver lining for everyone. My dissertation demonstrates that the "inertia of disasters" is yet another obstruction to meaningful and equitable hazard mitigation and climate adaptation moving forward (see Chapter 4). I argue that the momentum of powerful societal forces, such as scientific research programs and public awareness campaigns, act as blinders for decision-makers. This

unique contribution adds to the scholarship that questions the motives and ethics of disaster planning and response in hazard zones.

Human Dimensions of Changing Snow

The cryosphere—our world's snow- and ice-covered places—is rapidly changing. For this reason, scientists rush to study melting snow and ice at high elevations and latitudes. Hydrologists, snow scientists, and climate scientists forecast dramatic and unavoidable changes to mountain snowpacks around the world (Hock et al., 2019; Masson-Delmotte et al., 2018; Mote et al., 2005; Nolin & Daly, 2006; Sproles et al., 2017). In the Pacific Northwest, researchers highlight environmental impacts including: a positive feedback loop between snow and wildfire (Gleason et al., 2013); streamflow reductions in salmon spawning grounds (Dittmer, 2013); increased rain-on-snow flood risk (Musselman et al., 2018); and biodiversity loss (Niittynen et al., 2018), among many other changes. For avalanches specifically, scientists have spent decades highlighting how climate influences avalanche type, frequency, and severity in mountains around the world (Allen et al., 2011; Jakob & Lambert, 2009; Lazar & Williams, 2008; Martin et al., 2001). Emerging research by avalanche scientists now suggests that large-magnitude avalanches are decreasing in overall activity (Peitzsch et al., 2021). On the other hand, landslide science demonstrates that climate change is increasing landslide activity (e.g., Ozturk et al., 2022; Patton et al., 2019; Pei et al., 2023; Scheidl et al., 2020). In fact, Jakob and Lambert (2009) forecast as many as 30% more landslides along the Pacific Coast by the end of the 21st century. A large part of this increase in landslide activity is due to the transition of winter precipitation from snow to rain. Clearly, climate change is altering

avalanche and landslide activity, and understanding these changes is important for keeping people safe in avalanche and landslide hazard zones.

As the previous paragraph makes clear, a growing abundance of physical science research explains how snow, avalanches, and landslides respond to climate change. Beyond the physical sciences, environmental historians have also dedicated attention to human experiences with snow. For example, environmental historians study how avalanche disasters occur following industry negligence (Di Stefano, 2014), the growth of avalanche science and its attempt to open up the mountains for human activity (Atwater, 1968), the transition of snow from a force to be conquered to a material to be consumed (Mergen, 1997), and the role of snow in defining the relationships between Indigenous people and early European settlers (Wickman, 2018). This environmental history work has advanced important knowledge about how people build relationships with snow and the cryosphere.

However, to date, there remains little social science research that studies the impacts of changing snow on mountain communities. Further, the social science work on snow that does exist focuses primarily on quantitative assessments of long-term water resources and ski industry economics (e.g., Dierauer et al., 2019; Hamlet, 2011; Lazar et al., 2006; Malek et al., 2020; Scott & McBoyle, 2007; Wobus et al., 2017). Climate change is not just a far-off threat to water resources and ski economies—it affects people's ongoing experiences with snow and snow hazards in places like Juneau. There is a crucial need for more social science research that studies the experiences people have with increasingly frequent and severe snow-related disasters, especially as the line between hazard management and climate change adaptation is blurred (Jones & Preston, 2011; Mercer, 2010; Schipper, 2009). This dissertation therefore offers a timely example of how mountain communities are immediately impacted by changing snow. By

centering an analysis of obstacles to avalanche and landslide mitigation, justice issues in hazard mapping, and barriers for climate adaptation, I demonstrate the importance of and advance the calls for additional social science work on snow.

Overview of the Dissertation

As I developed this project, I established three key questions to guide my work. First, *how did Juneau get here?* How has the trajectory of hazard management in Juneau led to this point—where avalanches and landslides threaten thousands of people? Second, *how does the rollout of new hazard maps impact residents?* What are the economic, cultural, and political ways people feel the hazard maps affect their lives? Third, *what does climate change mean for Juneau's hazards?* How are avalanches and landslides changing due to climate change, and what do these changes mean for Juneau's hazard exposure and hazard mitigation strategies? I explore these three overarching questions in chapters two, three, and four of this dissertation. Before jumping into the first, below are the abstracts for the three articles.

Hazard Zone Conflicts in the Avalanche Capital: stress points for avalanche and landslide mitigation in Juneau, Alaska

Scientific research on mountain hazards has rapidly expanded knowledge of how and when snow avalanches and landslides can occur. Yet mass wasting events continue to produce deadly disasters and expose millions to extreme risk. Governments and scientists have responded by commissioning studies, creating hazard maps, and managing hazard zones to protect people, property, and infrastructure. Property owners, however, frequently contest and challenge avalanche and landslide hazard zones, indicating a continued need to analyze and understand the social dynamics and political struggles embedded in hazard mitigation. Expanding the limited social science research on mountain hazards, this paper examines hazard zone conflicts during a time when an increasing number of people around the world are at risk in the mountains. The goal of this empirical case study from Juneau, Alaska is to show how various societal forces (political, legal, and economic) shape risk and vulnerability at three crucial stages of hazard management: (1) hazard mapping, (2) zoning regulations, and (3) disaster prevention engineering projects. This research demonstrates how hazard mitigation involves a host of intertwined socio-political processes and actors—from experts producing studies and delineating risk zones to city officials and hazard zone property owners redefining those maps, zones, and projects. The paper therefore recommends that scientists and decision-makers proactively integrate research on local social dynamics into their risk studies to better understand how people might influence the trajectory of hazard management. This article is published in the *International Journal of Disaster Risk Reduction* with coauthor Dr. Mark Carey.

Housing Justice in a Hazard Zone: the impacts of hazard maps on property owner, renter, and housing-insecure groups in Juneau, Alaska

Avalanches and landslides threaten thousands of people living in downtown Juneau, Alaska. However, when Juneau's Community Development Department utilized a FEMA grant to update the downtown area hazard maps in 2018, the new maps were met with opposition from downtown residents. Like many hazard mapping projects around the country, people in hazard zones worried about how the maps would impact their lives. This paper examines how property owners, residents, and housing-insecure groups each experience unique impacts of the hazard mapping project—and how each group develops its own conceptualization of housing justice in a hazard zone. The paper also shows that, while property owners are undoubtedly impacted by the rollout of hazard maps, the needs of other groups—such as renters and housing-insecure populations—often go unaddressed. This research offers a novel contribution to hazard scholarship that: 1) focuses on justice and social dynamics prior to disaster; and 2) contrasts the experiences of three different resident groups during the process of hazard mapping. By highlighting the unique impacts for each group, this paper demonstrates the need for increased attention to justice in hazard mapping and hazard mitigation efforts.

Shifting Climate Hazards and the Inertia of Disasters: the avalanche capital has a landslide problem

The growing number of deadly landslide disasters worldwide demonstrates an urgent need for additional research on hazard mitigation and climate adaptation in mountain communities. In Juneau, Alaska—historically known as the "Avalanche Capital"—climate science forecasts decreasing avalanche hazard but increasing landslide hazard in future decades. This paper examines why the city is not reacting to these shifting climatic hazards. The study reveals that Juneau's legacy of avalanche research and longstanding public awareness of avalanches obstruct the city's ability to adapt to growing landslide hazards. This paper therefore argues that the inertia of disasters can impede adaptation to new climate hazards. To analyze how scientific research and public perception fuel the inertia of disasters, this study applies a mixed methods approach with interviews, document analysis, spatial analysis, and climate scholarship. The findings offered here are relevant for hazard zones around the world, as they exemplify how local environmental, scientific, and societal dynamics can mediate how communities experience climate hazards. This article has been submitted for publication in *Climatic Change*. I am the sole author for this article submission.

CHAPTER II

HAZARD ZONE CONFLICTS IN THE AVALANCHE CAPITAL:

STRESS POINTS FOR AVALANCHE AND LANDSLIDE MITIGATION IN JUNEAU, ALASKA

This dissertation chapter is co-authored with Dr. Mark Carey and published in the peer-reviewed journal *The International Journal for Disaster Risk Reduction* (Provant & Carey, 2023). As the first author, I conducted the data collection, data analysis, and initial drafting of this article. Dr. Carey provided valuable contributions during the drafting of the article—in particular, he wrote portions to help situate the article within existing scholarship, strengthen the clarity of the article's contributions and arguments, and integrate reviewer feedback.

1. Introduction.

On March 22nd 1962, a snow avalanche in downtown Juneau's Behrends Neighborhood destroyed dozens of homes and brought widespread awareness to Juneau's severe avalanche and landslide risk. While avalanches and landslides have always plagued Juneau's confined location between the ocean and steep mountain slopes, this 1962 disaster sparked heightened fear of slope instability. Experts have long agreed the city's risk is "far beyond an acceptable level" (Margreth & Mattice, 2012), and scientific risk assessments have existed for well over half a century. In addition, recent research suggests two additional factors exacerbate risk in Juneau: first, climate change may be further amplifying avalanche and landslide hazard (Jakob & Lambert, 2009; Peitzsch et al., 2021); and, second, landslide hazards in particular are more severe than they have been historically treated (TetraTech Inc., 2021). The science seems clear and

convincing: people in downtown Juneau's hazard zones continue to live with risk of slope failure.

However, when it comes to solutions that could protect people in Juneau's hazard zones, actions have been quite limited. This is because risk encompasses both exposure to the natural hazard and human vulnerability, which frequently hinges on politics and money. Juneau avalanche specialist Keith Hart predicted this early on, stating "it is rather obvious that any of these courses of [hazard mitigation] action will raise financial, legal, political, and moral questions (and not necessarily in that order)" (Hart, 1967, p. 18). Hart continued, "However, to do nothing may lead to consequences too terrible to contemplate" (18). Just as Hart predicted in 1967, people have worked to derail hazard mitigation by identifying economic and cultural risks associated with hazard zones. They have not only challenged the science but also obstructed, contested, and negotiated over government action to map, regulate, and protect hazard zones. For example, the City and Borough of Juneau (CBJ) used a FEMA grant to hire the consulting firm TetraTech to update downtown Juneau's hazard maps in 2019. These TetraTech maps are significantly more accurate and detailed than the previous version adopted in 1987, and these new maps utilize a variety of innovative technologies, such as LiDAR imaging. Yet in May 2023, Juneau's Planning Commission voted against adopting the TetraTech maps and the associated zoning regulations. A host of stakeholders and actors—from government officials to local property owners—have challenged these state-of-the-art hazard maps.

Rejection of the TetraTech maps exemplifies decades of conflict over how hazards have been managed and debated in Juneau. It also sparks a conversation about why the CBJ has failed to implement other avalanche and landslide mitigation measures, such as retaining walls, warning systems, and home buyouts. The risk reduction process—that

is, the path from science to policy to protection—is one of social negotiation, not just the science of geophysical processes like slope stability and precipitation. This study advances existing research because it shows just how important the negotiations over mapping and managing of hazard zones can be for the analysis and implementation of disaster risk reduction. More specifically, we argue that understanding the stages between map creation and disaster prevention projects—what we call the "social negotiation of risk management"—is essential for better understanding what risks residents and cities face as well as how natural hazards such as avalanches are mapped, managed, and mitigated over time.

Of course, experts have long acknowledged how various societal forces influence disaster risk as well as how political forces infiltrate mapping processes (Oliver-Smith, 1996; Wisner & Luce, 1993; Wood & Fels, 1992). Researchers have also studied hazard vulnerability in disaster zones, with research increasingly addressing the human dimensions of risk and vulnerability (Adger, 2006; Carey, 2010; Kasperson et al., 2022; Wisner et al., 2014). Foundational disaster studies identified that “natural” disasters are in reality a symptom of human-produced vulnerability (O'Keefe, 1976; Smith, 2006; Steinberg, 2006; Wisner & Luce, 1993), and scholarship has since demonstrated how top-down hazard risk reduction that fails to collaborate with communities can lead to greater inequalities and receive local pushback (Atteridge & Remling, 2018; Nightingale et al., 2020; Scoville-Simonds et al., 2020). Researchers have also shown that supposedly objective or “apolitical” assessments which identify specific groups of people as inherently vulnerable to hazards are usually flawed or incomplete—they generally fail to sufficiently account for the social production of vulnerability based on systemic inequalities (Eriksen, Nightingale, & Eakin, 2015; Marino & Faas, 2020). If “vulnerability

does not just fall from the sky," as Ribot (2013) explains, then hazard zones are important sites where negotiations over risk and vulnerability take place.

Yet there is only limited work on the social, political, economic, and cultural negotiations over hazard maps and hazard zone delineation. Recent research on flood risk in the United States has begun to examine these social dimensions and politics of hazard zones, including the mapping and regulating of hazard zones (e.g., Lea & Pralle, 2022). These studies expose how the adoption of both flood insurance rate maps and FEMA flood maps are controversial and contested, but they also underscore how more research is needed to understand these mapping and zoning processes. As Pralle (2019) explains, "Accurate flood maps are critical to communicating flood risk to vulnerable populations, to mitigating and adapting to floods, and to the functioning of the federal flood insurance program. Yet, we know little about how the mapping process works in practice" (239). Understanding these mapping processes is crucial, because as Elliott (2019) shows, flood insurance rate maps can actually be "scarier than another storm." In another study, Koslov (2019) found that New Yorkers after Hurricane Sandy feared their property might end up in a new flood map depicting flood-prone zones, which they worried would trigger home devaluation, higher insurance premiums, depopulation, and disinvestment in their neighborhoods. What's more, the process itself—including the time and money property owners must invest in counter-mapping or appealing hazard zones—has significant social inequalities that privilege the wealthiest actors (Wilson & Kousky, 2019). Lea and Pralle (2022) show through their GIS analysis that people challenge hazard maps in diverse ways: some floodplain property owners ignore FEMA flood maps, others appeal them in court, and still others have hired independent technical experts to redraw flood maps. The maps themselves—and the processes

surrounding map making and subsequent hazard zoning—constitute significant but still poorly understood impacts on people and communities.

There is thus a need to better understand the social negotiation of risk management at the local and regional level. This is particularly necessary for avalanche and landslide hazard zones (Eckert & Giacona, 2023; Van Westen et al., 2006), which pose significant risks to people, property, and infrastructure. For avalanches and landslides, there is no federal program for insurance. Avalanche and landslide risk is instead managed by local and state agencies. This Juneau case study therefore illuminates the crucial but often overlooked dynamics playing out below the federal level. Additionally, this paper expands beyond flood risk to provide new research on the human dimensions of avalanches and landslides. The USGS warns that avalanches are more lethal than earthquakes in the western United States, despite attracting much less research (USGS, 2020). In addition, the latest National Climate Assessment warns about increased winter landslide risk following changing snow conditions (Reidmiller et al., 2019). It is therefore crucial to understand specifically how mountain communities negotiate the avalanche hazard mitigation process.

This paper on snow avalanches and landslides in Juneau, Alaska identifies key points of conflict in the hazard mitigation process and examines why these conflicts keep occurring. It offers an empirical case study of how social obstacles shape the way avalanche and landslide hazards are mapped, regulated, and engineered. The paper accomplishes this—and offers a structure for the social negotiation of hazard mitigation—by focusing on three key aspects. The first section examines why conflict arises during the hazard mapping process. It shows how city officials worry about hazard maps hindering development of the capital city and how residents resist the delineation of their neighborhoods as vulnerable. The second section examines why

conflict arises in the regulatory process. Residents worry about the impacts of regulations on property values and insurance premiums. In addition, some residents also appeal the government's hazard zone designations for their individual properties. The third section examines why conflict arises surrounding engineering projects in and around hazard zones. City officials adopt an "all or nothing" approach that makes mitigation seem unreasonably expensive, and city officials worry about liability following the construction of any project. Our study shows overall that local social dynamics are an important factor in not just conceptualizing risk and vulnerability, but also in shaping hazard mitigation options. It is city officials and hazard zone property owners—not just experts producing new hazard studies or the geohazards themselves—that negotiate and mold the trajectory of hazard mapping and hazard mitigation across history.

2. Geographic Context.

Juneau is the capital city of Alaska and has a population of just over 32,000 permanent residents. The City and Borough of Juneau (CBJ) is the second largest city in the United States by area, and it has no connecting roads to the rest of mainland North America. Only accessible by air or water, Juneau is nestled in between the rugged Boundary Range mountains and Gastineau Channel. The State of Alaska government has considered connecting Juneau to the rest of the state with road projects costing hundreds of millions of dollars, but these projects were abandoned in part due to the unmanageable avalanche threat during the winter season (Ferry, 2016).

Soon after prospectors developed Juneau as Alaska's first mining town in 1880, avalanches and landslides began taking lives and destroying infrastructure in the new

downtown area. Hundreds of avalanches and landslides have affected people in Juneau, either through transportation disruptions, property damage, or loss of life (CBJ, 2017; Mears et al., 1992). Destructive events proved to be a regular occurrence in areas such as Behrends Avenue, White Subdivision, and Starr Hill, among others (Figure 1). Among the early scientists contracted to study the city's geohazards, avalanche expert Ed LaChapelle (1968) wrote: "I strongly urge that the Greater Juneau Borough, and the City of Juneau, explore all possible means to place a formal limitation in further development in the Behrends Avenue area" (LaChapelle, 1968). LaChapelle's report, which discussed the depopulation of some severe hazard zones, was largely ignored. There have been numerous studies addressing Juneau's avalanche and landslide risk, including multiple rounds of hazard mapping by the CBJ and contracted risk assessments by experts. The most notable of these include the currently adopted 1987 hazard maps, the 2011 study

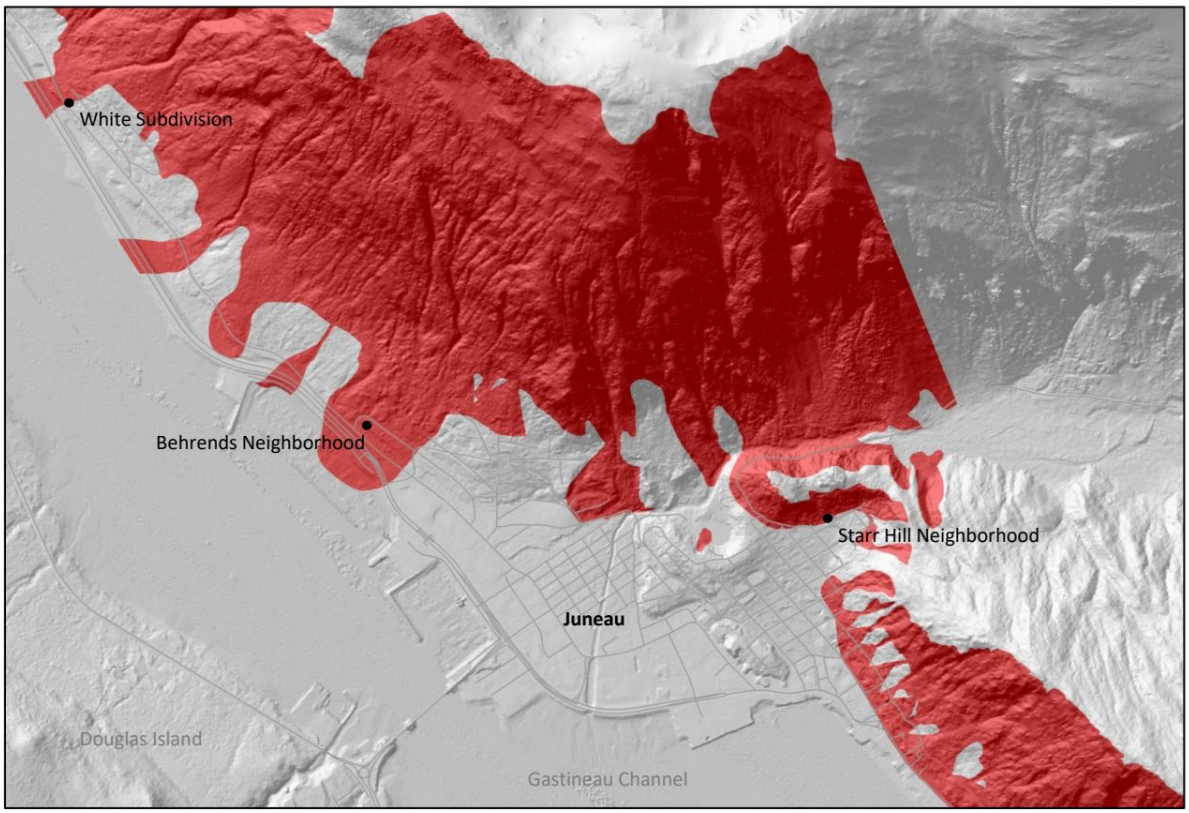


Figure 1. Downtown Juneau and high/severe avalanche and landslide hazard zones. Map created by authors.

from WSL Institute for Snow and Avalanche Research SLF, and the newly released (but not yet adopted) hazard maps created by TetraTech in 2022.

Avalanche research has led to two principal actions by the CBJ: zoning regulations and online information-sharing. In 1987, the CBJ created ordinance 49.70.300 for severe hazard zones, disallowing any future population density increases. Hazard insurance covering avalanches, landslides, and floods is now recommended or required in many of the hazard zones. The CBJ also now operates a daily "urban avalanche forecast" during the winter. In this forecast, the Emergency Program Manager discusses the day's risk level, snow conditions, weather forecast, and areas to avoid, among other pieces of information. Outside the urban hazard zones, the Department of Transportation and Alaska Electric Light & Power occasionally close roads and artificially trigger avalanches to keep dangerous conditions from growing—historically using a howitzer along Thane Road but now exclusively using helicopters with dynamite or a daisy bell. Larger-scale infrastructure projects to protect urban hazard zones, such as slope reinforcement or retaining walls, have been proposed but not implemented due to a variety of political, legal, and economic obstacles. Home buyouts have been discussed but not conducted due to upfront cost and the assumption that residents won't voluntarily leave. Thus, despite more than sixty years of scientific assessments identifying slope instability and the likelihood of slides, many downtown Juneau residents still live with severe avalanche and landslide risk.

Most recently, in 2018, the CBJ received a grant from the U.S. Department of Homeland Security to "update information on the landslide and avalanche risk in downtown Juneau" (CBJ, 2018). The CBJ contracted TetraTech, a consulting firm based in British Columbia, to produce a new downtown hazard map for the sum of $205,000. At this cost, however, TetraTech was only able to conduct a remote study based on aerial

images and existing scientific data rather than a fieldwork-intensive site-specific study. In other words, the remote study was conducted entirely via computer modeling, whereas a site-specific study would have included rigorous ground truthing within the hazard zones. The site-specific study could have cost more than $50,000 per property and millions of dollars in total to assess avalanche and landslide risk. The CBJ opted for the remote study, accepting a larger degree of error in the risk assessment. The remedy for this larger degree of error was to make the maps "extra safe"—enlarging the hazard zones to include particularly complex or dynamic areas that would otherwise require more in-depth, site-specific analysis. This economic decision turned into a political problem when property owners protested their placement within hazard zones. They questioned the city's passing down of costs to residents, the integrity of TetraTech's maps, and the implications of a new zoning ordinance. Money, science, politics, and public perceptions all intersected in the TetraTech hazard zones—as they always have in Juneau's avalanche paths—thereby demonstrating a clear need for more analysis of the social negotiation of hazard management in Juneau.

3. Methods.

This paper analyzes obstacles and points of conflict in the hazard mitigation process. Results stem from an analysis of documents and interviews related to: 1) avalanche and landslide hazard assessments; and 2) hazard management projects in Juneau. The collected documents include: 6 complete hazard assessments from 1967-2022; 6 sets of meeting minutes from the CBJ Planning Commission and the CBJ General Assembly from 2021-2023; three video transcripts from the CBJ Planning Commission and the CBJ General Assembly from 2021-2023; and 36 documents from the CBJ's Emergency Management Program including internal memos, citizen letters, public

announcements, and disaster records from 1968-2023. These documents were collected from the CBJ Emergency Management Program, the CBJ Community Development Department, the Alaska State Archive, and the Alaska Historical Collections. Interviews were primarily conducted in-person in Juneau, Alaska, with a few interviews taking place over phone- and video-calls. Participant observation and informal interviews with 26 individuals were summarized and transcribed as typed field notes. The interviews were composed of 3 government employees, 6 avalanche and landslide experts, 10 hazard zone residents, and 7 local business / organization employees. These interviews, typically ranging from 30 minutes to 1 hour, were unstructured conversations about CBJ hazard management, hazard science in Juneau, and resident experiences and perceptions. In accordance with human subject protections, all interview participants are kept anonymous.

Analysis of the documents, interviews, and field notes consisted of several steps to yield research results. Initial analysis focused on identifying cases of conflict during hazard mitigation. Using the qualitative analysis software MaxQDA, approximately 20 themes were identified, such as insurance, property value, zoning, politics, and scientific uncertainty. These themes were then grouped based on obstacle type, which resulted in categories of political, legal, or economic obstacles. Within these three categories, the data was also grouped based on the primary actors creating the obstacles, including government officials, hazard zone residents, and local organizations. After reviewing the analysis, it was clear that obstacles were occurring within three steps of the hazard mitigation process: 1) hazard mapping; 2) development regulations; or 3) engineering projects. This paper's main sections were developed to examine the social negotiation of hazard management within each of these components of hazard mitigation.

4. Hazard Mapping Conflicts.

Scientists and government officials often create hazard maps as a first step in the hazard mitigation process. Utilizing remote sensing and/or site-specific analysis, risk assessment studies depict hazard zones of ranging from low to severe. These maps are used for the communication of risk to the public, and they regularly lead to zoning regulations and disaster prevention engineering projects. However, scholarship has shown that hazard maps are often contested by local communities (e.g., Carey, 2010; Mezei et al., 2023; Wilson & Kousky, 2019). This pushback from communities can lead to decades of conflict and negotiation around the adoption of hazard maps and the implementation of hazard zone policies. Despite research on the politics of hazard mapping, there remains significant need for research that identifies and unpacks reasons why hazard maps become contentious, especially for mountain hazards that are less well-documented than floods (Eckert & Giacona, 2023; Hovelsrud, Karlsson, & Olsen, 2018). Focusing on the examples of statewide politics and cultural perceptions, this section examines how and why avalanche and landslide hazard maps are transformed into points of negotiation.

4.1. The statewide struggle over political authority

Political conflicts can influence hazard zones in surprising ways, such as the impact of internal state and local political agendas on the production of hazard maps. In Juneau, the hazard mapping process has been affected by contentious negotiations and power struggles over the location of the Alaska state capital. For decades there have

been recurring waves of pressure to move the state legislature from Juneau to Anchorage. This struggle, which has been named “capital creep,” exacerbates political insecurity among city officials who have long worried about power dynamics in Alaska. Officials and others in Juneau fear that, since government employees make up nearly one-third of Juneau’s permanent working population, a transfer of the state capital to Anchorage would cause job loss and Juneau's connection to state funding. One official even stated in 2022 that, “Juneau will definitely fall apart if the capital actually moves.” As illustrated by the news article titled “a hot topic in Juneau” (Alexander, 2009), capital creep has grabbed significant attention in legislative sessions and newspaper articles in recent decades, particularly since governor Sarah Palin’s administration began in 2006 (Downing, 2019). Now, a renewed and improved identification of serious avalanche and landslide risk could offer yet another reason to transfer Alaska’s state capital to Anchorage.

Yet even without the adoption of the latest 2022 TetraTech hazard maps, capital creep continues to occur through the gradual movement of the state legislature apparatus to Anchorage. According to a Juneau representative, from 2018 to 2019, “34 jobs have left Juneau while 17 have moved to the Capital City for a loss of 17 positions” (KINY, 2019). The state also cut subsidies for Juneau’s ferry system, making it more difficult and expensive to travel to Juneau. These actions have placed an increased pressure on the CBJ to ramp up development in order to portray Juneau as a modern and growing capital city. However, despite the state’s desire to continue expanding the Alaska Legislature, Juneau’s Community Development Department (CDD) explained that there already isn’t enough space in Juneau for all current state employees. State offices are spread across smaller, older buildings, and Juneau does not have a site large enough to house the legislature in one centralized, modern building. This worry about capital

creep is held by the same government officials that must consider development regulations in hazard zones. While some of these government officials loudly proclaim their dedication to updated hazard maps, others are focused on development in Alaska's hazardous capital city.

Discussion about the location of Alaska's capital has woven together political, economic, and hazard-related issues for decades. In a 1975 statement opposing capital creep, Juneau's mayor stated development restrictions in hazard zones "would be aiding and abetting cutting our throats" (Fredston, 2007, p. 329). The CBJ's Comprehensive Plan describes how concern about capital creep fluctuated through the 1980's, for example, based on future downtown development in connection to the cruise ship industry (CBJ, 2017). Now, it is once again hazard mapping that is creating uncertainty for Juneau development. In an ongoing effort to protect Juneau's position as capital, the CDD is working to develop downtown through a project called Blueprint Downtown, which is the "community's 20-year vision, goals, priorities, and action strategies to guide downtown development into the future" (CBJ, 2023a). However, the existence of avalanche and landslide hazard zoning limits the city's future downtown development options. If hazard management was to depopulate certain areas of Juneau, enact stricter zoning regulations, or frame parts of downtown as "vulnerable," it could provide additional logic for the movement of the state capital to Anchorage. Unsurprisingly, then, Blueprint Downtown does not mention hazard zone development restrictions. In fact, the 2019 Blueprint Downtown Final Report states the city aims to "change zoning to accommodate higher residential density in downtown neighborhoods" (CBJ, 2019, p. 24). It is widely known that Juneau's current city manager has a history of prioritizing development over risk reduction, and multiple interview participants confirmed the city manager is "pushing back against the maps." At the same time, government officials

dedicated to hazard mapping within the CDD believe the city "must consider public safety." This means there is disparity within Juneau-based government offices: the technical experts in the CDD and Emergency Program recognize a need for detailed hazard maps, while other individuals and offices prefer to promote development and bolster Juneau's position as the state capital. Thus, while local hazard mitigation and state politics may seem at first unrelated, hazard management decisions made by city officials can be significantly influenced by state politics. It also demonstrates how negotiations *within* local and state governments—rather than between governments and citizens—can create obstacles for hazard mapping.

4.2 Residents' refusal of vulnerability narratives

In addition to power struggles within local and state government, residents worry the hazard mapping will lead to the public framing of their neighborhoods as vulnerable. This has led residents to challenge the creation of new hazard maps. During a 1992 meeting about zoning regulations, multiple residents objected to the White Subdivision being referred to as the "White Death Subdivision" in the official assessment and map documents. This name emerged because avalanches are sometimes referred to as "white death"—and Juneau's White Subdivision has about a dozen properties in a moderate or severe avalanche hazard zone. One resident complained, however, that, "according to the maps there were few properties located in the severe avalanche hazard zone." The resident suggested that "CBJ initiate a detailed study of those properties to determine their exact hazard level, rather than 'branding' the whole subdivision with a reputation for being dangerous" (Juneau Planning and Zoning Commission, 1992). In multiple interviews, residents repeatedly mentioned that they dislike their homes being framed as dangerous. In a 1998 National Geographic

documentary titled “Avalanche: The White Death,” a Behrends Avenue resident complained about such negative branding, stating “people live in floodplains, people live in mudzones, people live in hurricane [zones]…there is no place on earth, I don’t think, that is completely hazard free” (Nye, 1998). More recently in 2022, an interview participant explained that “my sunny porch is more important to me than avalanche risk.” This comment, noted in one form or another by most people interviewed for this study, demonstrates how residents view hazard maps as harmful portrayals of their neighborhoods. They see hazard maps as cementing a singular narrative of impending disaster, which devalues their lives, their sunny porches, and their community.

Property owners’ rejections of a vulnerability label can obstruct the CBJ’s attempts to introduce new hazard maps. Our analysis of public comments on hazard mapping projects illustrates that personal experiences often supersede technical assessments. In other words, memories of avalanches and landslides can carry more weight than risk assessments. For example, one interview participant has lived underneath the Behrends slide path for over a decade without any incident. Despite living in an identified severe avalanche hazard zone, the resident “isn’t worried because there are houses above them and there are pictures of those houses not being hit in a large 1962 avalanche.” This perspective was repeated numerous times in the latest public comment meeting for the 2022 TetraTech maps. One property owner argued that their property is safe because “all the houses above everything I own are 100 year old houses” (*Planning Commission Regular Meeting*, 2023). Thus, in contrast to avalanche scientists and some government officials who label zones as risky, some local residents create contradictory framings—ones that emphasize security and long-term safety instead of vulnerability—based on their own interpretations of history.

5. Regulation Conflicts.

Zoning regulations and city ordinances are commonly designed to restrict development in hazard zones. These regulations are based on the hazard zoning levels, and the development restrictions typically parallel the level of risk for a specific location. For example, in Juneau, low risk zones do not have hazard-related restrictions while higher risk zones do not permit increased population density. The creation of these regulations, however, often leads to conflicts between hazard zone residents, scientists, and city officials (Pardoe et al., 2011; Prater & Lindell, 2000). In many cases, residents and business owners push back against zoning regulations due to real and perceived economic impacts associated with development restrictions.

5.1 Wielding science to challenge city ordinances

Property owners in Juneau have opposed both the adoption of new hazard zones and the restrictions associated with existing zones. The 1987 city ordinance 49.70.300 states that "no development, or any part of a development, which is within a severe avalanche area shall, by the addition of bedrooms, conversions of buildings, or otherwise, increase the density of that parcel" (CBJ, 2023b). However, the CBJ leaves room for exemptions within the policy, stating that "the commission may require mitigating measures certified as effective by a professional engineer for development in landslide and avalanche areas" (CBJ, 2023b). The CBJ's allowance for site-specific engineering studies set the stage for appeals and has resulted in numerous conflicts between the CBJ and residents over development regulations. Property owners with

sufficient economic resources can contract an engineer to appeal their property's location within a moderate or severe hazard zone. According to city officials, these studies can easily cost more than $50,000 per property. If the application is successful, the CBJ's Community Development Department removes the property's development restrictions and insurance requirements.

According to interviews with property owners and government employees, certain engineers have historically been supportive of hazard zone exemption applications with their evaluations. If the consultant's fee was paid, the property was either: a) cleared by the engineer for exemption from the hazard zone; or b) the owner was required to construct relatively minimal protective infrastructure. In 1991, for instance, a local developer in Juneau applied to build a 7-Plex within an identified hazard zone. After much deliberation, the CBJ decided "the net result of these reviews and the extra effort and features provided by you and your designers is that the risk to the proposed building is now deemed to be reduced to the same as the general risk faced by any building in Juneau" (Walsh, 1991). In another case from the late 1990s, two entrepreneurs began the process of developing the "Alaska Fur Gallery"—a large, multistory shop aimed at tourists arriving in Juneau by cruise ship. The CBJ discussed requiring liability insurance for three surrounding properties during the construction process due to fear of construction-triggered landslides, but developers of the Alaska Fur Gallery worked with lawyers, engineers, and hazard scientists to challenge city laws. The Alaska Fur Gallery ultimately did not move forward, but the project had already demonstrated that, with the right amount of resources and privately-hired experts, zoning ordinances could be challenged. Finally, in a third example, one property owner is currently advancing a housing development project on an empty lot within the downtown landslide hazard zone. The project hinges on a privately hired engineer's

report that successfully contested the hazard zone delineation. Even though multiple interview participants have called that report an "inadequate two-page memo," a previous CBJ Director of Engineering and Public Works—an individual who has repeatedly questioned hazard maps and promoted development in the hazard zones—allowed the housing development project to proceed. In these cases, property owners with financial means, privately hired engineers, and well-positioned government official intersected to challenge city hazard zoning regulations.

While property owners' appeals to zoning ordinances create obstacles for the city's hazard management, the CBJ also frames the appeal process as a "check and balance" system for hazard zone regulations. Simply put, the city tells residents that the ability to apply for hazard map exemptions justifies the acceptance of imperfect hazard maps and associated regulations. This has several implications. First, it passes the economic responsibility of site-specific analysis from the city to the residents. This creates inequality in who can appeal the regulations. For example, The Glory Hall, a Juneau-based affordable housing nonprofit, applied to redevelop their downtown emergency shelter into 7 single-occupancy low-income apartments. The Glory Hall, however, did not have the funding to hire a private engineer for a site-specific analysis. Without financial resources to contest the science and regulations, the Glory Hall's project stalled. Second, the CBJ's reliance on appeals hinges upon the availability of engineers. As this section shows, engineers in the 1990s were willing to do site-specific analysis for individual properties and assert their safety. That trend, however, has diminished over time; today downtown residents do not believe engineers would be willing to make such an assurance. In a public meeting, one resident explained that "I have had several very capable local engineers tell me that their professional liability insurance will not allow them to certify anything with regard to avalanches or

landslides" (*Planning Commission Regular Meeting*, 2023). Clearly, negotiations over hazard maps and zoning regulations are dynamic and ongoing, which leads to both resident and government official insecurity over the future of risk reduction.

5.2 The economic priorities of residents

Not surprisingly, zoning classifications that impose development regulations are contested for economic reasons. For example, a public meeting was held on April 30, 1992 to discuss regulations associated with hazard maps. It was primarily attended by Juneau residents that found their homes affected by the city ordinance 49.70.300. This ordinance prohibits increases in population density in Juneau's most severe hazard zones. Most residents in attendance were primarily concerned about the emerging relationship between avalanche and landslide risk, hazard insurance, and bank financing. One resident stated "the report will negatively affect property values and financing opportunities—thus penalizing homeowners—without offering any solutions to the problem" (Juneau Planning and Zoning Commission, 1992). Another resident "doubted that assessments and appraisals would make up for the financial impact of the study on some properties and the difficulty in obtaining financing on higher risk houses" (Juneau Planning and Zoning Commission, 1992). In their eyes, the combination of hazard zone properties being "red flagged" as dangerous and the requirements of expensive insurance would scare away mortgage lenders and homebuyers. Since this 1992 meeting, property owners have consistently pushed back against hazard maps due to the economic impacts associated with development regulations.

Property owners' concerns, however, could be more perceived than real: there is still insufficient evidence that property values will be significantly impacted if the newest hazard maps are officially adopted. Existing research shows that, in some cases,

vulnerable properties can continue to maintain some of the highest property values (Bin & Kruse, 2006). One CBJ official stated that they "don't believe that property values will go down due to the new hazard maps because property value is market-driven and downtown Juneau is a highly desirable place to live." Indeed, Juneau's *Assessment Report—Residential Overview* published by the CBJ shows that downtown properties have increased in value at a rate comparable to surrounding areas without hazard zones (CBJ, 2022). In addition, one downtown resident explained that many of the homes in downtown hazard zones belong to intergenerational "old time" families with little interest in selling the properties. Another hazard zone resident explained that "Glacier Avenue may be under the Behrends slide path and in the high hazard zone, but it is one of the most desirable places to live because it is an area of Juneau that gets far more sunshine each day." This is explained by a 1996 League of Women Voters survey that states "Because high hazard areas often have a good view or other desirable features, some towns have found that those homes even rise in price ahead of homes elsewhere" (Juneau League of Women Voters, 1996). Clearly, while fear of economic impacts creates considerable conflict in hazard zones, the specific impacts to property owners in Juneau are still largely unknown.

Other studies, however, suggest the economic impacts of hazard zone regulations are not simply imagined. Emerging research shows that landslide insurance can be impossible to obtain in some southeast Alaska hazard zones (Dixon et al., 2023). In addition, concerns about increasing geohazard risk due to climate change has led some insurers to withdraw from risky markets or increase their policy premiums (Starominski-Uehara & Keskitalo, 2016). It is reasonable to assume that property values and bank loans could be destabilized by this insurance change. Writing about flood insurance, Koslov (2019) reminds that "Fears abounded that classifying a place as flood-

prone could be a self-fulfilling prophecy, devaluing homes and neighborhoods, spurring depopulation and disinvestment, and producing vulnerability and decline regardless of whether predictions proved correct" (668). Thus, regardless of whether the economic impacts to residents are predominantly real or imagined, money drives regulations (and ensuing appeals) and makes city ordinances for avalanche and landslide hazard zones hotly contested.

The economic concerns of hazard zone residents are a powerful force that continue to influence how zoning policies are adopted. While the differences between the 1992 adopted official maps and the proposed 2022 TetraTech maps are small, the minor changes have attracted the attention of homeowners. For example, the 2022 TetraTech maps more effectively differentiate between avalanche and landslide hazards. This has placed the Star Hill community in a newly defined hazard zone based on severe landslide risk—a change that has sparked significant controversy among residents. Additionally, the CBJ proposed the strictest development codes in these new areas of severe landslide risk. In public meetings following the release of the 2022 TetraTech maps, residents echoed the 1992 meeting and voiced their economic concerns. Reflecting on these public opinions, one government employee stated that "everyone only talks about money and not safety. Homeowners don't ask questions about their safety during public meetings, only about home values and insurance rates." Another government employee mentioned that "residents claim that if government is going to put their house in a new hazard zone, then they should also pay to protect the houses. They are angry that there was funding for a study with no money allocated to them for protections." In response to this public criticism, city officials discussed weakening the proposed zoning regulations. These conflicts over hazard zone regulations, which are

common in Juneau and other mountain communities, reveal how policy-related negotiations play an important role in defining and regulating hazard zones over time.

6. Engineering Conflicts.

In mountain communities around the world, engineering projects are constructed to protect people against avalanches and landslides (Boensch et al., 2007; Kamal et al., 2023). These projects include retaining walls, diversion dams, snow sheds, and snow supporting structures, among others. These solutions are designed to either minimize the possibility of a slide or protect people and infrastructure in the case of a slide. Many of these projects have been considered in Juneau (Hart, 1967; SLF, 2011), but to-date there has been no attempt at a large-scale engineering project to protect residents in Juneau's most severe hazard zones. Proposed projects have failed largely due to unfeasible costs of complete protection and the threat of disaster liability, rather than scientific assessments of hazard risk.

6.1 The unfeasible cost of complete protection and the threat of disaster liability

Mitigation costs pose real obstacles in terms of the price of science, engineering, and infrastructure, but cost can also be a scare tactic deployed rhetorically and discursively to skirt responsibility. In Juneau, an "all-or-nothing" approach to mitigation projects turns cost into barriers. Scientists and government officials often dismiss the possibility of structural mitigation projects because they approach mitigation options as a binary: no protection or complete protection. After analyzing the hazard reports from five official hazard risk assessments ranging from 1967 to 2021, the typical structural mitigation recommended by experts for a single slide path ranged from $4 million to over $30 million. In 1992 planning and zoning commission meeting minutes, avalanche

specialist Art Mears stated that retaining walls to protect houses in Juneau would cost "at least $500,000 per acre…. [Thus] for the 50+ acres in question it would cost $25 million" (Juneau Planning and Zoning Commission, 1992). The 2011 Swiss Study stated that "we do not recommend that a financial compromise is sought and only a portion of the proposed structures be built" (25). It continued to state that "with such an incomplete solution there would still be the possibility that an avalanche might reach the subdivision" (SLF, 2011, p. 25). Most recently, in a 2021 Q&A session with hazard zone residents, TetraTech consultant Alan Jones stated that "in terms of protecting and cost – we're talking tens, if not hundreds, of millions of dollars to protect them" (TetraTech Inc., 2021). Projected costs alone have served to block action by CBJ government officials.

Yet the CBJ does not just adopt this "all-or-nothing" approach to make mitigation appear exorbitantly expensive—the city is also concerned about the liability that could accompany half-measures. The city's concern about liability is perhaps justified, as interviews with city officials revealed that past small projects on city-owned land have affected private property and led to at least four different lawsuits. These lawsuits are not in the public record, because, according to a research participant, they have all been quietly settled out of court. Any mitigation effort—whether protective structures, artificially triggered avalanches, or warning systems—could place the city in a position of responsibility following a disaster, especially if the mitigation projects were unsuccessful at protecting residents and structures in the hazard zones. In the 2011 SLF Study, the experts did not recommend the construction of a $6-million deflecting dam to protect Behrends Avenue residents because "the realisation of such a structure would cause lengthy discussions and possible lawsuits" (SLF, 2011, p. 28). Thus, by prioritizing

the fear of future lawsuits, expert scientists and the CBJ's legal counsel are obstructing the possibility of engineering projects to improve public safety.

Finally, the CBJ also evades responsibility for avalanche and landslide events by denying their existence or implicitly defining them as "acts of god," as identified by research on other hazard zones (Di Stefano, 2014; Steinberg, 2006). For example, one Starr Hill resident described how a recent landslide destroyed their neighbor's house. The resident maintained that damage was the city's fault because the landslide originated on uphill city-owned land. The neighbor claims the CBJ would not return phone calls about the landslide. The interviewed resident explained "if they don't acknowledge it then it's not their problem," and "the solution is to look the other way." Right now, there was simply a landslide in a publicly known landslide zone. If the city were to protect against these hazards with engineering projects, any subsequent disaster would instead mean the project failed. Contrary to how many people feel about hazard maps and regulations, residents want the city government to take responsibility for risk and begin engineering projects. Yet the city's potential exposure to costs and lawsuits halts the projects before they start. Thus, despite widespread agreement between property owners, CBJ employees, and scientists that mitigation is necessary to minimize risk, the potential conflicts created by lawsuits has handcuffed the city's ability to improve public safety.

7. Conclusions.

In Juneau, Alaska, a history of destructive snow avalanches and landslides has led to decades of attention to hazard management from scientists, government employees, and hazard zone residents. Political, legal, and economic forces have shaped a history of

social negotiations around hazard mitigation and management, particularly related to the hotly-contested processes of mapping, zoning, and engineering projects (Figure 2). Hazard management is therefore not strictly dictated by the technical work of experts nor the policy work of officials. Instead, analysis of this Juneau case study shows that various political and economic dimensions shaped decisions in the hazard zones, including: capital creep, resistance to vulnerability framings, seemingly overwhelming costs, and fear of liability. This demonstrates that public safety is only partially about the geohazards and the risk assessments, because slides and science are woven into the "social negotiation of hazard management."

In addition, property owners form a double-edged relationship with hazard expertise—dismissing expertise when they perceive negative impacts on their properties and wielding expertise when they pursue positive impacts for themselves. On the one hand, this study shows how property owners have pushed back against attempts to introduce and update the city's hazard maps for decades. They did this politically, legally, and publicly in fear of subsequent zoning regulations that might affect

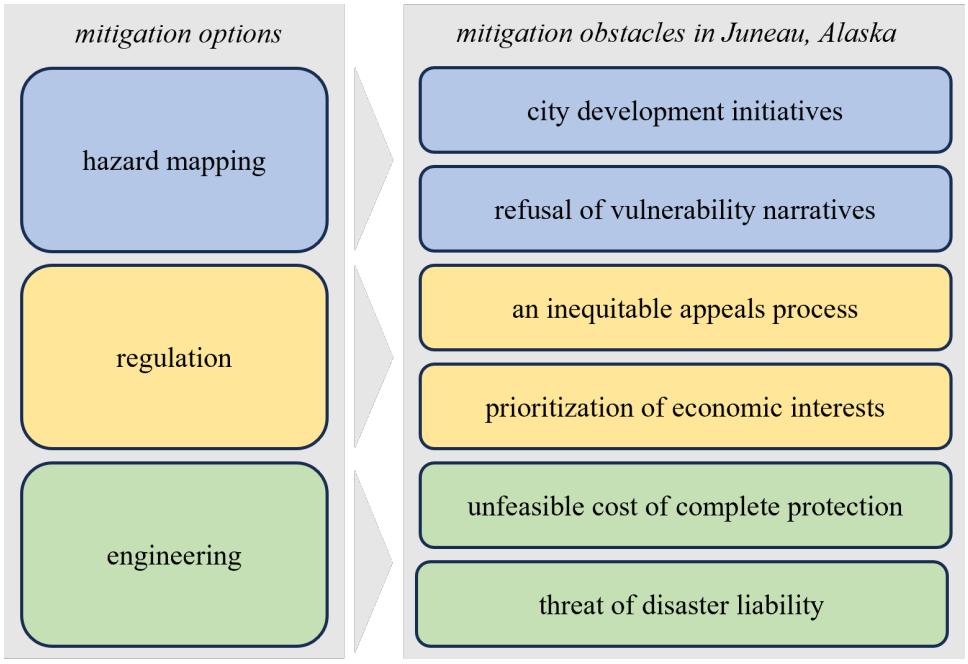


Figure 2. Conceptual model of the obstacles for hazard mitigation during the processes of hazard mapping, zoning regulation, and engineering projects.

their property values, insurance premiums, or mortgage loans. On the other hand, property owners have also individually challenged the existing hazard zone boundaries. Many who could afford an engineering consultant applied to either have their property removed from the hazard zones or to have their own development projects approved with minor infrastructural adjustments. Property owners have thus continuously shaped and reshaped the boundaries of hazard maps across history—blocking the rollout of new, updated maps that frame their properties as vulnerable and chipping away at the existing map borders through expensive appeals. As property owners strategically reject and wield hazard science, their conceptualizations and priorities directly influence the future of hazard management strategies.

The broader conclusion from this study is that social conflicts—in this case among government employees, hazard zone property owners, engineers, scientists, and others—have tremendous influence on the trajectory of hazard mapping and hazard mitigation. It is people who shape how technical hazard maps, zoning regulations, and engineering projects materialize in avalanche and landslide zones—rather than the geophysical processes or the occurrence of natural disasters. In other words, local social dynamics are the primary factor in conceptualizing, defining, mapping, and regulating risk and vulnerability. While the detailed findings from this case study are necessarily limited to Juneau, the broader policy and management implications are clear: it is crucial to understand local political, legal, and economic dynamics in hazard zones prior to committing large amounts of time and resources on scientific studies and risk assessments. Decision-makers in hazard zones around the world should anticipate obstacles and objections to disaster mitigation at all stages of risk identification, assessment, mapping, regulation, and engineering. Thus, rather than relying primarily on the technical aspects of geohazards, disaster risk reduction should involve social

scientific analysis of hazard zone politics and economics. In particular, scientists and decision-makers should proactively integrate research on local social dynamics into their risk studies to better understand how people might influence the trajectory of hazard management. This study has discovered the influence that social negotiations can have over various stages of disaster assessment, management, and prevention; yet there are many other human dimensions of disaster risk reduction that are beyond the scope of this project, such as other social divisions and inequalities, territorial disputes, and cultural understandings and perceptions. These are important areas for future research. Additional research will also be essential to expand into other hazard zones and beyond existing topics such as prediction and modeling, federal-scale hazard programs, and the impacts of disasters.

CHAPTER III

HOUSING JUSTICE IN A HAZARD ZONE:

THE IMPACTS OF HAZARD MAPS ON PROPERTY OWNER, RENTER, AND HOUSING-INSECURE GROUPS IN JUNEAU, ALASKA

1. Introduction.

In Juneau, Alaska, avalanches and landslides threaten thousands of downtown residents. The city has a long history of deadly and destructive slides, including a 1936 landslide that killed fifteen people and a 1962 avalanche that destroyed dozens of homes (Canny, 2024; Dickson, 2021). In 2018, Juneau's Community Development Department (CDD) set out to update the city's hazard maps using a grant from the Federal Emergency Management Agency (FEMA). After all, the existing maps had not been updated since 1987. However, updating the hazard maps was not the seamless integration of advanced science and technology envisioned by the CDD. Instead, the new maps rekindled heated debates about whether the city should be mapping hazards at all. Finally, on December 11th, 2023, after three years of public testimony and pinballing between various committees, Juneau's publicly-elected General Assembly voted to: 1) adopt the newest avalanche hazard maps; 2) reject the newest landslides maps; and 3) repeal all development regulations in landslide hazard zones. To some, this was a major step backward. The introduction of updated maps backfired and reduced the city's ability to protect residents from landslide hazards. To others, it was a victory—the city did not rebrand hundreds of downtown properties as dangerous and unleash a whirlwind of potential economic impacts for property owners.

The series of meetings that culminated in the December 11th vote were about far more than hazard maps—the meetings interrogated the government control of private property. Years of public testimony challenged Juneau's approach towards hazard governance, weighing the city's obligation to protect citizens from hazards against residents' demands for reduced government interference. After all, the city holds competing responsibilities—it must balance the need to keep residents safe and the need to protect property values for tax revenue. Unsurprisingly, many residents, including elected committee and assembly members, framed this latest hazard mapping project as a major destabilizing force for the city's economic vitality. In fact, one person described the vote to adopt new maps as a decision:

"to kill downtown or not to kill downtown."

Clearly, the government aim to improve collective public safety collided with the concerns and experiences of residents. However, as this paper shows, there is not a homogenous group of "downtown residents" that experience hazard mapping impacts in the same way. While property owners draw nearly all the attention from the city government and the local media outlets, renters and housing-insecure groups also constitute an important part of Juneau's downtown population. Thus, while property owners frame the attempt to introduce new hazard maps as an injustice, the experiences of renters and housing-insecure groups complicate this singular conceptualization of housing justice in a hazard zone. This study demonstrates how renters are forgotten in the hazard mapping process—they are overlooked when it comes to hazard education, and they are not offered a seat amongst the decision-makers. In addition, the specific needs of housing-insecure groups are often

overshadowed by the danger of hazard zones. For these people, the calculations of risk look quite different—it is not about economic investments or hazard education, but rather it requires weighing the benefits of shelter in a hazard zone. Thus, while the genuine concerns of property owners about value, insurance, and mortgages capture the spotlight and influence city decisions in Juneau, this paper shows that housing justice in a hazard zone must prioritize the experiences of renters and housing-insecure groups.

Of course, the notion that maps wield power and impact citizens is not new (Harley, 2008; D. Wood & Fels, 1992). In addition, research also shows that mapping and zoning projects do not affect "passive" residents, but rather individuals wield economic and cultural power to influence the outcomes of mapping and mitigation projects (Carey, 2010; Lea & Pralle, 2022; Provant & Carey, 2023). Finally, emerging research demonstrates that maps do in fact produce an array of unexpected impacts for residents of hazard zones (Elliott, 2019). Elliott (2019) writes, "The map does more than simply measure current flood risk. For its users in New York City, the map was the apparent source of economic risk; it posed political risks surrounding flood insurance; and it posited ambiguous relationship to climate change risk." To date, however, little research has addressed the convergent and divergent impacts that different groups experience during hazard mapping. By examining the unique impacts experienced by property owners, renters, and housing-insecure populations—as well as the contradictory concerns within and across the groups—this case study in Juneau advances hazard mitigation scholarship by highlighting the need for greater equity in the hazard mapping process.

This paper also contributes to unnatural disaster scholarship and climate justice scholarship in two key ways. First, this paper demonstrates that hazard risk does not only affect certain groups during or after a disaster. For decades, unnatural disasters

literature has emphasized that marginalized populations regularly experience the worst impacts of a disaster (Abramovitz, 2001; Bullard, 2008; Montano, 2021; Steinberg, 2006). However, this paper shows that hazard zones produce housing justice issues during the process of hazard mitigation—long before a disaster. There is an urgent need for additional research that how the impacts of hazard mitigation are distributed throughout hazard zone communities during the years and decades prior to disaster. Second, the minimal literature that does examine justice during the hazard mitigation process typically separates hazard zone residents into wealthy-poor or winners-losers binaries (e.g., Penning-Rowsell & Pardoe, 2012; Thaler et al., 2018). Instead, this paper demonstrates that housing justice in a hazard zone exists on a spectrum. Property owners, renters, and housing-insecure groups all experience unique impacts and create their own conceptualizations of justice. The following sections therefore advance the literature on unnatural disasters and environmental justice by arguing that: 1) hazard mitigation produces impacts for an array of resident types; and 2) the impacts to property owners often overshadow the needs of other resident groups.

This paper weaves together interview data and public comment data to examine the public response to the 2022 Tetra Tech avalanche and landslide hazard maps. Following the Methods and Context Sections, Sections 4, 5, and 6 address the impacts and justice implications of the 2022 Tetra Tech hazard maps for property owners, renters, and housing-insecure groups, respectively.

2. Methods.

To examine the impacts of the 2022 Tetra Tech hazard maps on Juneau residents, this study began with the research questions:

1) How do the 2022 Tetra Tech avalanche and landslide maps impact Juneau residents?
2) How do the impacts of hazard maps differ across groups of people, such as housing-insecure, renters, and homeowners?

To answer these research questions, I analyzed interview transcripts, public meeting transcripts, and public meeting materials. I collected this data through fieldwork in Juneau as well as the CBJ's website and YouTube channel. I conducted 12 in-depth, recorded interviews and 26 interviews with notetaking between March 2021 and September 2023. I identified interview participants through their participation at hazard mapping public meetings, and I identified additional interview participants through snowball sampling. In addition, I contacted and interviewed the government officials involved in the hazard mapping process. I transcribed the recorded interviews using OtterAI, and I typed the handwritten interview notes following each interview. In addition, I collected the video recordings for 8 public meetings that occurred between November 22, 2022 and December 11, 2023. I attended some of these meetings in person and virtually, and the CBJ published all the video recordings to its public YouTube channel. I transcribed these public meetings using MaxQDA's "import YouTube data" function. Finally, I collected all the submitted documents for each of the 8 public meetings from the CBJ's online "meeting directory." These documents included meeting minutes, presentation slideshows, and submitted materials (e.g., public letters, government memos, or other submitted evidence).

I analyzed the data using the qualitative analysis software MaxQDA. First, to identify the most frequently mentioned impacts of the 2022 Tetra Tech hazard maps, I conducted a word-based content analysis using the process described by Gizzi and Rädiker (2021). This analysis provided word frequencies across the interviews, recorded meetings, and meeting documents. After creating a stop list of uninteresting words, the most frequent words included: landslide, avalanche, insurance, property, house, plan, map, zone, risk, lot, hazard, slide, build, downtown, study, ordinance, project, adopt, engineer, impact, owner, development, community, work, flood, state, water, land, and public. To address this paper's research questions, I autocoded the data for words representing potential "impacts": insurance, property, house(-ing), lot, development, build, plan, impact, risk, community, work, land, state, and public. I then manually reviewed the coded segments for accuracy, keeping only the segments that referred to impacts experienced by residents in hazard zones.

During data analysis, I recognized that these "impacts" identified through word-based content analysis primarily referred to impacts experienced by property owners rather than other resident types. This is due to the heavy involvement of homeowners in the hazard mapping process and the relative exclusion of renters and housing-insecure groups. This is known as self-selection bias. In a second round of analysis, I queried and autocoded the data for resident type to highlight the impacts for homeowners, renters, and housing-insecure groups. The successful queries for homeowners included "homeowner," "property owner," "owner," "mortgage," and "loan." The successful queries for renters included "renter," "rental" and "lease." The successful queries for housing-insecure groups included "homeless," "affordable," "subsidy," and "subsidize." I then manually reviewed the coded segments, keeping only the segments that addressed "impacts" to either homeowners, renters, or housing-insecure groups. From here, I used

thematic analysis to separate impacts within each population group. For homeowners, the key impacts included: "insurance availability", "property value and mortgage concerns," and "government overreach." For renters, the key impacts included: "renter notification of hazards" and "lack of safe options." For housing-insecure groups, the key impacts included: "shelter versus hazard" and "development for affordable housing." I used these themes and the associated interview, transcript, and document data to develop the three main sections of this paper.

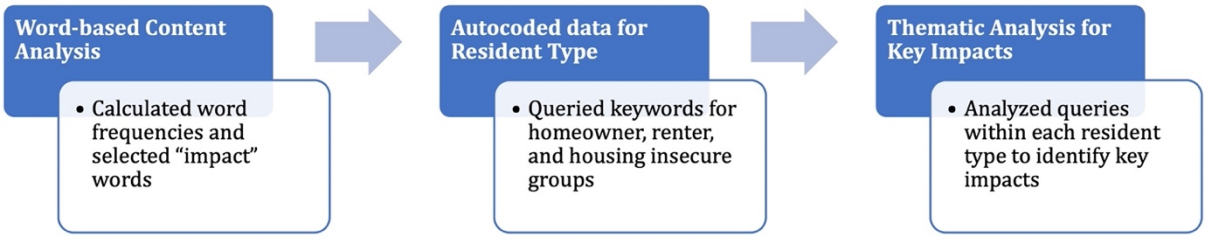


Figure 1. Methods flow chart.

This paper uses quotes, images, and maps throughout the sections to help communicate research findings. All quotes are from interviews, public meeting transcripts, and public meeting documents (e.g. resident letters or government memos). In accordance with human subject protections, all interview participants are kept anonymous. All images were taken by the author unless otherwise stated. All maps were created with GIS shapefiles provided by the CBJ's Community Development Department.

Acronyms, in order of appearance:

CDD	Community Development Department
FEMA	Federal Emergency Management Agency

CBJ	City and Borough of Juneau
TGH	The Glory Hall, an affordable housing nonprofit organization in Juneau

3. Context: The 2022 Tetra Tech Avalanche and Landslide Hazard Maps.

In 1987, the City and Borough of Juneau (CBJ) adopted its first avalanche and landslide hazard maps. These maps covered only the downtown area, spanning White Subdivision to Gastineau Avenue (Figure 2). These maps were hotly debated, with property owners opposing the maps due to concerns about the impacts to their property values. For example, even five years after the adoption of maps and a development ordinance, 1992 meeting minutes describe residents' ongoing concerns about the impacts of hazard maps (Juneau Planning and Zoning Commission, 1992). Worried about their neighborhood's reputation, one resident said that:

> *"although it is important to be informed of the danger from avalanches in Juneau, the report casts the White Subdivision in a bad light. The report will negatively affect property values and financing opportunities—thus penalizing homeowners—without offering any solutions to the problem" (7).*

Despite the property owners' concerns about the 1987 hazard maps, the maps and associated City Ordinance 49.70.300 remained in effect for decades. This ordinance restricted development in the severe avalanche and landslide hazard areas—specifically,

it restricted any projects that increased population density or the total number of dwelling units. In practice, this meant that homeowners could not add accessory dwelling units (also known as mother-in-law suites) and developers could not turn lots into apartment complexes or townhouses. As an exception, the city still allowed the construction of single-family homes on empty lots in hazard zones—however, according to city officials, no single-family homes were ever constructed in the severe hazard zones following the adoption of the 1987 maps. The city ordinance had one major loophole, however. If a property owner paid for a site-specific engineering report that presented the property as safe from hazards, the property owner would be allowed to move forward with the intended project despite increasing population density in the hazard zone. Developers with enough money used this loophole to move forward with their projects, especially in the 1990s before engineering firms became worried about the liability attached to such reports (Provant & Carey, 2023). Regardless, the 1987 hazard maps and City Ordinance 49.70.300 effectively minimized the development in

downtown hazard zones.

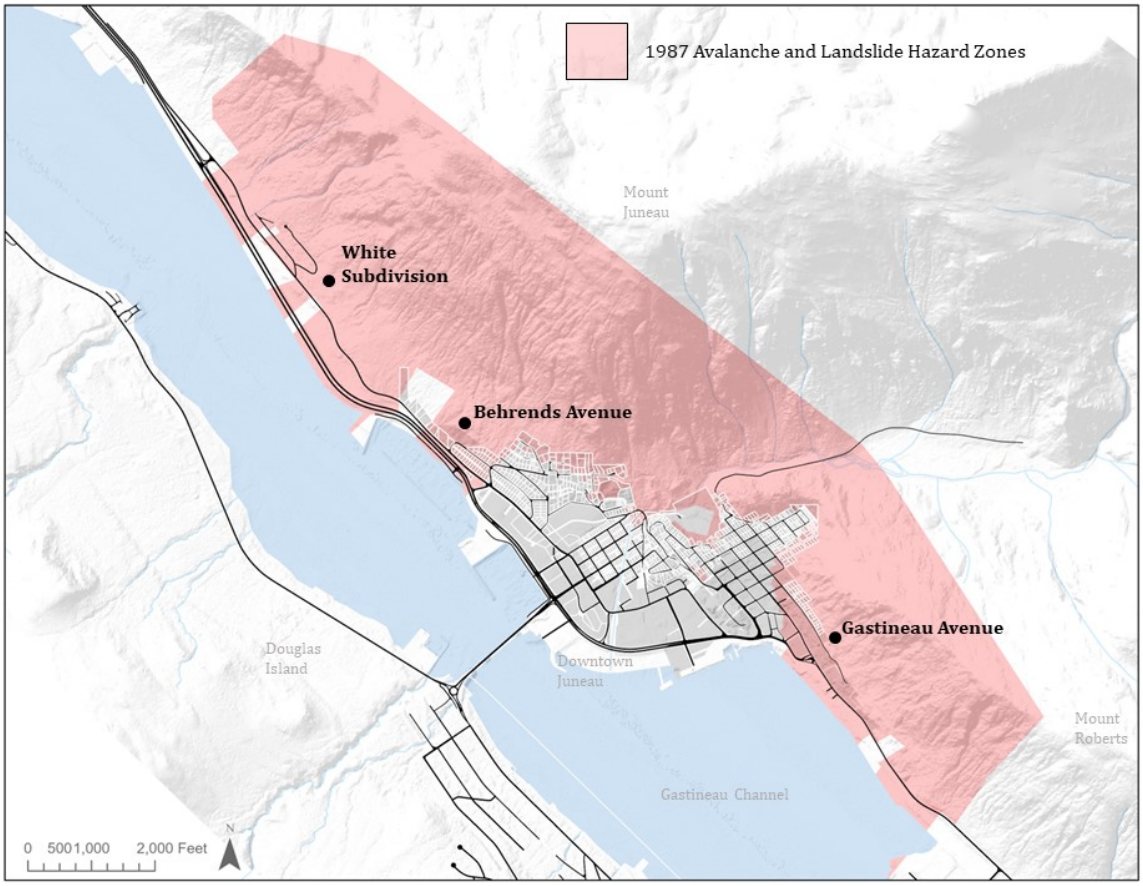


Figure 2. 1987 downtown Juneau avalanche and landslide hazard map. Map created by author with data provided by the City and Borough of Juneau.

As to be expected with maps that are over 30 years old, experts acknowledge that the 1987 hazard maps have scientific flaws. First, the map lines follow property boundaries. The hazard zones therefore either entirely encapsulate a property or entirely avoid a property. Avalanche and landslide runout zones are not dictated by property lines, of course, yet Juneau's hazard zones morphed into unrealistic jigsaw-like shapes. There is thus a clear need to update the maps with zones that more accurately reflect the runout of avalanches and landslides—not the start and end of property boundaries. Second, the 1987 maps are based on science from the 1970s. This makes them quite outdated—the scientific understanding of avalanches and landslides has

progressed enormously in the half-century since the original studies. For example, LiDAR imaging is now a crucial component of hazard mapping, as it allows scientists to collect data like snowpack depth, rock bed type, and deformation (Hopkinson et al., 2004; Jaboyedoff et al., 2012). Finally, the 1987 maps combined avalanche and landslide hazard. These two hazards have distinct properties, and combining them into a single maps produces an unclear assessments of hazard exposure throughout the city. For these reasons—in addition to wanting a better understanding of downtown hazards for the rollout of a new long-term development plan in Juneau called "BluePrint Downtown" (CBJ, 2023a)—Juneau's CDD believed it was important to invest in a new set of hazard maps for the downtown area. One city official explained:

> *"So when you're looking at planning efforts for downtown, it's all about: where do we want to locate high-density housing? Where do we want to change the zoning to address the city's housing issues? To potentially place new tourist facilities? How do we want to plan out our downtown? And in order to do that, we needed a better understanding of where the critical hazard areas were. And we knew the 1987 maps are outdated and very problematic. We know that avalanches and landslides behave very differently, and, of course, the 1987 maps combine the two. So that was the big driver."*

In 2018, Juneau's CDD applied to FEMA's Cooperative Technical Partner Grant Program to "obtain grant funding for the mapping and analysis of potential landslide and avalanche areas within the CBJ" (CBJ, 2017b). The CDD won the FEMA grant and received $200,000 to "update these maps with current scientific analysis, and to evaluate landslide and avalanche areas separately" (CDD, 2021). The CDD reviewed bids

for the project from numerous hazard consultants, eventually hiring Tetra Tech, Inc. as the contractor. To create the 2022 Tetra Tech avalanche and landslide hazard maps, Tetra Tech analyzed climate data, reviewed historical studies, reviewed historical avalanche and landslide events, reviewed imaging such as satellite and LiDAR data, and conducted avalanche modeling, among other methods (Tetra Tech Inc., 2022). Once Tetra Tech completed and published its study in 2022, the CDD began the process of forwarding the new study to Juneau's General Assembly for adoption.

On December 11th, 2023, Juneau's General Assembly voted unanimously on the 2022 Tetra Tech hazard maps. Specifically, the assembly voted to: 1) adopt the newest avalanche hazard maps; 2) reject the newest landslide maps; and 3) repeal all development regulations in landslide hazard zones. The avalanche maps were adopted because they largely mirrored the existing 1987 avalanche hazard zones. The landslide maps, on the other hand, were the primary reason for the reclassification of over 200 downtown properties to severe hazard—from 173 to 374 properties. (CDD, 2021). This dramatic change resulted in significant public protest, and it led to over a year of deliberation bouncing between the Planning Commission, the Committee of the Whole, the Lands Housing and Economic Development Committee, and the General Assembly. In the end, the 2022 Tetra Tech hazard maps successfully improved the CBJ's knowledge of precisely where avalanche and landslide hazard exists. However, the project also reintroduced widespread concern about the impacts of hazard maps on residents, eventually leading to the rejection of the landslide maps and the repeal of all development restrictions in the landslide hazard zones. Clearly, the impacts of hazard maps can be more worrisome than the hazards themselves.

4. Property Owners: Economic Concerns in New Hazard Zones.

When the CDD and Tetra Tech introduced the new 2022 avalanche and landslide maps, they were immediately met with fierce opposition from downtown property owners. After all, the 2022 Tetra Tech hazard maps included 201 new properties in the severe hazard zones compared to the 1987 maps (CDD, 2021). These property owners worried that the new maps would produce unfair economic impacts for people in the newly designated severe hazard zones. Through public meetings and written letters, an overwhelming majority of property owners plead with the CDD not to adopt these latest maps. The concerns that most frequently emerged surrounded property values, insurance requirements, and mortgage availability. On July 21st, 2021, the CDD and Tetra Tech hosted a "Landslide and Avalanche Public Meeting – Question and Answer Session" to discuss the preliminary version of the new hazard maps. In this meeting, experts from the CDD and Tetra Tech responded to resident questions. Foreshadowing the discussions that would span the next three years, property owners questioned the impacts of these maps:

> *"So if we change from moderate to high does that mean I will no longer be able to insure my house?"*

> *"How is it anticipated to affect property values/taxes in the newly mapped landslide areas above the cemetery and downtown?"*

> *"In Tetra Tech's experience with mapping hazard areas in other communities, what were the impacts to property owners, for example, loss of value, home insurance,*

and lending? Also, what were the local government's responses to the property owner impacts? What is CBJ's plan moving forward for impacted property owners?"

Clearly, property owners were immediately concerned about the economic threat posed by the draft hazard maps. Property owners felt it was unfair for the city to infringe on their property rights. Unsurprisingly, then, the finalized 2022 Tetra Tech hazard maps were met with amplified public protest.

Existing scholarship suggests that these Juneau property owners have valid economic concerns. First, in some cases, property values have declined in defined hazard zones. For example, Ma et al. (2024) show that, in California wildfire hazard zones, homes with hazard disclosures sell for less than nearby homes without hazard disclosures. Property devaluation can also be exacerbated by climate change, as studies elsewhere show that property values can decline due to climate risks (Daniel et al., 2009; Gibson et al., 2017; Keenan et al., 2018; Westerling & Bryant, 2008). Second, the ability to access hazard insurance is variable. When it comes to localized hazards like avalanches and landslides, it can be impossible to obtain insurance (Izenberg et al., 2022). For example, Dixon et al. (2023) show that landslide insurance is not available for homeowners in Southeast Alaska. Finally, if banks were to require this (often unobtainable) avalanche or landslide insurance for mortgage approval, residents would be unable to secure home loans. In Juneau, this leaves residents worried about their mortgages and the ability of future homebuyers to secure loans. In this situation, property sales in the hazard zones might become primarily cash deals. Based on the research from other hazard zones in the United States, it is likely that some of these impacts could occur in Juneau following the adoption of new hazard maps.

In interviews, public meetings, and written letters, property owners expressed concern about the relationship between property value, insurance requirements, and mortgage availability. As they perceived the potential financial threats to be worth fighting against, property owners demonstrated a commitment to opposing the 2022 Tetra Tech hazard maps. One property owner who lives in a newly designated landslide hazard zone describes his decision to participate in the public meetings:

> *"There's so many things going on that affect a local or wider government, you're not going to engage on all of them. But you are likely to engage on the ones that really impact you. As I've thought about it, there's a pretty clear economic impact for me were these maps to get passed. If you take your biggest investment, which is your home, and it's also tied to a sense of belonging, a sense of a lot of things—security too. So you know, for me it was easy to just let this process go. But then I was like, wait a second, realistically, if this happened, it's probably going to impact my property values by several hundred thousand dollars. And so where is my time best spent? It's like, well, actually, this is something I should engage with, it's gonna have a big impact."*

This resident's participation in the hazard mapping meetings reflects a wider consensus amongst homeowners that the hazard maps posed a significant financial risk. Thus, while the maps were designed to effectively delineate avalanche and landslide hazards, residents instead saw the map boundaries as a threat to their economic stability. This has been seen elsewhere; for example, residents in New York City found flood insurance rate maps "scarier than another storm" (Elliott, 2019). In Juneau, the selective coverage of the maps—which only included the downtown area—became a point of contention.

Property owners felt as though they were being unfairly targeted. Since hazard risk exists throughout the entire City and Borough of Juneau, many perceived the rollout of the 2022 Tetra Tech hazard maps as an injustice to those in the new hazard zones. Following the release of the Tetra Tech maps, one homeowner requested a disclosure to remove the spotlight from certain neighborhoods:

> *"You could easily use it [a hazard zone disclosure] to clarify that not just the mapped areas are at risk, but other areas that have not been mapped and should not be assumed to be safe. So you're not just targeting a few neighborhoods when risk exists."*

In addition, some property owners feel that the CBJ's attempt to adopt the 2022 Tetra Tech hazard maps is a clear example of government overreach. In 2023, one hazard zone property owner questioned the CDD's motives for "pushing through" the Tetra Tech hazard maps:

> *"The Community Development Department didn't seem to have any interest in trying to find out what other kinds of things are going on in other places. They just had the grant, they got the contract, and now they're going to push through. There are a number of people, and to some extent I agree with them, that think this thing is being pushed hard by the outgoing city manager, the fellow was about to retire. Why, we don't know."*

Like this property owner, many people in the hazard zones felt like the 2022 Tetra Tech maps were being unfairly overlaid onto their lives. If the maps were to be adopted,

residents noted several potential impacts. The first way they saw the maps as unfairly impacting their properties was through the risk of decreasing property values. After all, existing research from hazard zones elsewhere demonstrates that hazard maps can reduce property values (e.g., Daniel et al., 2009; Gibson et al., 2017). Two hazard zone property owners confidently reiterated the impact of the maps on property values:

> *"I think that it would affect our property values very deeply. There's no way you can get around that. So you know, when it comes time to sell or buyers are looking here, their hands are going to be tied."*

> *"It will hurt property values. But let's say that it causes the values to go down. People are still gonna want to live there. And is that really fair?"*

Beyond property values, property owners also worry about the relationship between hazard insurance and mortgages. Avalanche and landslide insurance is not available to Juneau residents (Lempert et al., 2023), yet mortgage lenders can require any insurance they deem necessary regardless of availability. Thus, if the bank requires insurance, but the insurance does not exist, then mortgages will be impossible to acquire. Many residents fear the rollout of the 2022 Tetra Tech maps will trigger this type of response. One homeowner in a new landslide hazard zone reflected on the publication of the Tetra Tech maps:

> *"I don't know where appraisers are going to be if, let's say, I put this place up for sale and somebody goes and says 'I'm interested, I can't make a cash offer, I need to get a bank loan,' [then] goes downtown, goes to the bank, says I'm interested in*

buying unit 15, sends something off to the appraiser, appraiser comes in and looks at and says, 'everything's in hunky dory order except that they know that there is a set of maps out there that says that this is in severe landslide area.'"

Another homeowner expanded on the insurance concerns following the release of the Tetra Tech maps:

"It's already happening when they go to the lender. I have a letter from a lender that talks about this. You go to the lender, and he says, 'If you want me to lend you money to buy this place, you need to buy insurance.' But as I'm sure you're aware, landslide insurance is not available."

Beyond impacts to themselves, downtown property owners also question how the adoption of these maps would create inequalities within hazard zone homeowners. After all, hazard zones are often occupied by lower-income or marginalized groups (Chakraborty et al., 2014). Demonstrating an awareness of hazard zone justice issues, one property owner worried about how the maps would affect demographics in his neighborhood during a September 2023 interview:

"Right now you look at the avalanche zones that are on the Behrends avalanche path—you just look at the property values. The impact isn't that the houses are not occupied. The impact is that the housing values are lower. And so people who are looking for a lower price house live there. And so you haven't made people safer, you've just made it that lower income strata lives in the hazard zone."

This property owner offers a scenario where the adoption of hazard maps could result in an influx of lower-income residents. This is a plausible concern—even if this particular resident is brandishing environmental justice concerns to protect their property value. However, it is also possible that the potential inability to get a mortgage loan due to insurance requirements could produce the opposite impact. If the 2022 Tetra Tech hazard maps were adopted, it is possible that only the wealthy would be able to pay cash for properties in the hazard zones. In fact, some research shows that hazard zones can be home to some of the wealthiest residents if the hazard zone is a highly desirable place to live (Bin & Kruse, 2006). In 2023, a city official in Juneau acknowledged that some residents could get priced out of downtown if they can't acquire a mortgage:

> *"If you can't get home insurance, that means you can't buy a place downtown if you have a mortgage. So is it only the independently wealthy who can lay down $800,000 in cash that can live downtown? And those are very real very, very serious impacts."*

Regardless of whether the maps would result in lower- or higher-income property owners residing in the downtown hazard zones, these different scenarios demonstrate the variety of impacts that residents fear. However, in the end, some people believe that the downtown property owners' rejection of the 2022 Tetra Tech Hazard maps was a futile attempt to preserve their property values. Some government officials and property owners question if a formal adoption of the maps really makes a difference. During a 2023 interview, one property owner highlighted the fact that insurance

companies can make their own decisions regardless of whether the CBJ formally accepts the new Tetra Tech hazard maps:

> *"But the bottom line is, once the professionals produce the maps, do we have to adopt them for an insurance company to honor them? Not really."*

In addition, a city official suggests that downtown Juneau's desirability outweighs any property value impacts from the 2022 Tetra Tech hazard maps.

> *"We've had these 1987 hazard maps in place for decades, right, downtown has still been a hugely desirable place to live with high property values."*

The same city official continued, questioning the causal relationship between the Tetra Tech maps and suggesting that there may be broader reasons for declining property values.

> *"Property owners are saying, wow, since [CDD] came out with this study, I can't sell my house. That's heartbreaking. But is it the maps? is it a growing awareness of climate change? Is it nationwide disasters? What has led to that change in the insurance companies' response to this?"*

As this section shows, downtown property owners feel that the CDD's attempt to adopt the 2022 Tetra Tech hazard maps unfairly targets residents in the new hazard zones and represents an example of government overreach. In particular, the property owners worry about the impacts of maps, such as decreasing property values and insurance

requirements from mortgage lenders. If the 2022 Tetra Tech hazard maps were to be passed, residents fear that they would lose their life investments and struggle to sell their homes. They also worry that the maps would either a) force lower-income homeowners into the hazard zones or b) only allow wealthier homeowners to buy properties with all cash. Regardless of the outcome, downtown property owners frame this as an injustice—staking their claims in the landscape of hazard zone housing justice.

5. Renters: The Forgotten Tenants of Hazard Zones.

As part of the vote to adopt or reject the Tetra Tech hazard maps in December 2023, the CDD proposed that "Owners shall provide written notice to potential buyers or renters that the property is located in a severe landslide area prior to sale or rental of the property." The same notice was proposed for severe avalanche areas (CBJ, 2023c). In discussions about this written notice, a representative for Juneau's Engineering and Public Works Departments explained:

> *"CDD would mail a postcard (similar to the abutter notification) to property owners who live within 500 feet of mapped landslide or avalanche zones at a cost of about $1500. The postcard would notify the owner that their property is in or proximate to a mapped hazard zone and direct them to the website for more information. A press release would be scheduled at the same time to provide notice to renters who would not receive direct mail."*

Unlike most discussions about the 2022 Tetra Tech hazard maps, this attention to a hazard zone disclosure highlights the importance of renters. An important part of Juneau's downtown population is short- and long-term renters, yet there was little attention to how the hazard maps might affect renters during the public meetings. This proposed notification system was the single acknowledgment that renters have a right to know if they are living in an identified hazard zone, but the required disclosure was dropped during the final rounds of editing the new ordinance in December 2023. This is not the first time the CBJ's "duty to warn" has been discussed and dismissed—in 1996 Juneau's League of Women Voters conducted a Severe Hazard Survey and found that responders "overwhelmingly agreed that the city has a 'duty to warn' (so that Juneau will not continue to have 'open secrets' of which many, but not all people know)" (Juneau League of Women Voters, 1996). In this survey, 80% of respondents said that the city had a duty to warn (Juneau League of Women Voters, 1996). As it turns out, the "duty to warn" tenants of hazard risk is regularly absent from landlord requirements (Dundon & Camp, 2021). The disclosure itself would have been inadequate to protect tenants from avalanche and landslide hazards in Juneau, but even this small precaution for renters was removed from the final adopted ordinance. This neglect of renters by decision-makers and homeowners demands an attention to housing justice in hazard zones—not only in Juneau but in hazard zones around the world.

Justice research shows that renters regularly experience greater risk from environmental hazards than homeowners (Burby et al., 2003; Greif, 2018; Ma & Smith, 2020). Renters are less well prepared to survive disasters due to their lack of access to resources and their lack of control over property development decisions (Lee & Van Zandt, 2019; Rohe et al., 2013). Emerging scholarship therefore recommends solutions such as the mandatory disclosure of hazard risk to tenants (Heiman, 2021). However, as

climate change amplifies the impacts of environmental hazards, lower-income renters continue to be forgotten in hazard mitigation and climate adaptation solutions (Dundon & Camp, 2021). In Juneau, local decisions about hazard maps are driven by property owners but directly affect the safety of current and future renters. Thus, while property owners push back against the anticipated economic impacts of hazard maps, they simultaneously pass on physical risk to renters.

In Juneau, renters comprise a substantial portion of the permanent and seasonal population. 64.7% of housing units were occupied by their owner in 2021 (Data USA, 2024), which means that over 1/3 of the permanent population (35.3%) is long-term renters. This proportion of long-term renters is very similar to the national average. However, 62.9% of Juneau homes are valued between $300,000 USD and $700,000 USD, which is double the national average of homes in the same range (Data USA, 2024). This means that home ownership is more often unattainable for renters in Juneau, and lower-income renters will struggle to find affordable housing options. This is reflected in the 2010 *CBJ Housing Needs Assessment*, which states that 38% of Juneau renters do not have affordable housing (CBJ, 2010). Interviews with residents and public meeting transcripts also demonstrate that renters regularly struggle with housing options. Between Juneau's lack of developable land, Juneau's popularity as a tourist destination, and the state legislature's need for lodging, there are few options for renters. One renter who has worked various jobs in Juneau over the last few years explained:

> *"I think I'm lucky because I know a lot of people…but it is for a lot of people hard to find affordable housing. There's the seasonal crew that comes in beginning of the summer—and that's just like 'good luck' if you don't get in early. And then there's*

tons of Airbnb, which is an issue everywhere. Legislature season also takes up a lot of the rental scene. So it is hard. It's really hard."

This renter highlights some of the important influences on Juneau's rental market. Not only is housing expensive throughout the year, but there are seasonal rushes that make affordable housing options even more scarce.

As renters struggle to find housing options in Juneau, they often consider properties located in one of the downtown hazard zones. In fact, renters may not even know their rental unit is in a hazard zone. Dundon and Camp (2021) demonstrate that a lack of knowledge about local hazards is often a reason that renters experience heightened vulnerability to natural disasters. In Juneau, one property owner—who nevertheless opposed the adoption of the 2022 Tetra Tech hazard maps—expressed concern in a 2023 interview about new renters' knowledge of avalanches and landslides:

"To me, the biggest concern would be renters, you know, new to town who don't necessarily have a lot of options and don't know what to look for, and basically just coming to town to find a place to be where they can afford it. I don't know where the duty to inform would be on that because you don't want to scare people. But at the same time, the tragedy is not if somebody buys a house, knows it's in a hazard zone, and gets flattened in the middle of the night when there's a landslide. It's if somebody basically buys an investment property, rents it out, and some renter gets flattened in the middle of the night."

Even when renters are familiar with Juneau's avalanche and landslide hazards, they often don't have options beyond the hazard zones. According to a study by the Joint Center for Housing Studies of Harvard University (2022), 40% of renters in the United States reside in disaster-prone areas. In downtown Juneau, the lack of safe developable land means some renters must live in dangerous hazard zones. For many, hazard risk is something they simply must accept if they want to live in downtown Juneau. One renter who lived in a hazard zone during 2023 interviews explained her situation:

> *"My place I'm at right now is by a pretty sizable steep hill. Again. Part of that is just 'Well you've gotta do what you've gotta do.' It was the only housing that was available to me."*

For others, firsthand experience with avalanches and landslides is enough to avoid the hazard zones. In these cases, however, alternate housing options are limited and can even be a motivator for moving away. While discussing rental availability, one renter reflected on his neighbor's recent experience:

> *"I know one guy that lived in the apartments just up from me. He, after that [landslide] didn't even go back to his apartment. He ended up moving to Anchorage. And [the landslide] was a big factor—it was probably the biggest factor that actually got him to move. Because he wasn't going to live there, but everywhere he looked, he's like 'That's a dangerous spot' and 'That's a dangerous spot.' And I think it was just too overwhelming for him."*

Once living in a hazard zone, renters often reside in buildings that are under-maintained and particularly vulnerable to hazards. In addition, research shows that climate change is increasing the maintenance cost of homes and weather-related damage could leave a growing number of rental units uninhabitable (Joint Center for Housing Studies of Harvard University, 2022). In an article for *GRIST*, Mahoney (2022) writes that "Not only are rental units (and renters) more threatened by climate change — they're also less likely to see the improvements the housing sector needs to adapt to and slow global warming." This problem is particularly prevalent in Juneau, where older homes are built into steep mountainsides. Over 90 inches of rain per year in downtown Juneau damages structures and erodes the dirt and rocks below building foundations. As seen in Figure 2, many buildings in downtown Juneau cannot withstand the force of even a small avalanche or landslide. When coupled with the fact that landlords often delay necessary maintenance on rental units, it is clear that renters in Juneau face heightened avalanche and landslide hazards.



Figure 3. Landslide debris and three destroyed houses from a September 2022 landslide on Gastineau Avenue. Photo by author.

Finally, some property owners believe that the 2022 Tetra Tech hazard maps would affect their ability to offer affordable rental properties in Juneau. As the hazard maps raised concerns about insurance requirements, mortgage availability, and property values, homeowners are worried they might lose their long-term investments. In some cases, landlords even suggested that they would pass these potential impacts on to renters. At a 2023 public meeting about the Tetra Tech maps, a landlord hypothesized about this possibility:

> *"Now, instead of looking ahead to the day my investment bears fruit when I sell it, I am inclined to shift gears into the much more common mindset of 'invest as little as possible in the property while reaping the maximum profit. Make the money now, and it doesn't matter if the deferred maintenance and poor upkeep result in a lower sale price.' In my case, though I have resisted it at all costs, I am inclined to convert*

my four 2-bedroom apartments to short-term vacation rentals to maximize profit. I have loved being a part of the community by providing nice, affordable, stable rentals for a very long list of fantastic Juneau community members. If these maps move forward as proposed, with none of the additional work and research needed to make this decision responsibly, that's the decision I will be forced to make to protect my most important investment."

In this case, a landlord threatened to pass the economic impacts of hazard maps on to Juneau's renters. In an attempt to convince the CBJ not to adopt new hazard maps, this landlord openly acknowledged their disregard for long-term renters. Thus, the potential vulnerability of renters was weaponized by a property owner to protect property rights. Even when renters *are* mentioned during hazard mapping debates, they are often treated as temporary and disposable.

Despite all this evidence that renters are left out of hazard mapping and hazard mitigation processes, some residents believe that it is the individual's responsibility whether they reside in Juneau's hazard zones. In fact, as research shows, many Alaskans embrace of a culture rugged individualism that places responsibility on the citizen and trivializes fear of natural hazards (Bazzi et al., 2020; Hogan & Pursell, 2008). Regardless of whether the resident is a homeowner or renter, local or transplant, wealthy or poor—they should be diligent in deciding where they choose to live. While discussing an upcoming meeting about the hazard maps in September 2023, a past renter explained her struggle to find a safe and affordable place to live in Juneau decades earlier:

"I think that there is a responsibility on the part of people to pay attention to where they are. When I first came to Juneau and I couldn't afford to buy a house I wanted,

I didn't rent over in the Highlands [avalanche hazard zone] because that was a known avalanche chute. And I stayed out of that. I think people are responsible for making themselves aware of where they are, and sometimes that means there are some hazards. I mean, it's like people who come to Juneau, and then it snows and they're surprised. Excuse me?! You know, you have to pay attention to things, and different people have different levels of risk comfort with different things."

This previous renter now owns a home in an identified landslide hazard zone—her individual "risk comfort" kept her out of avalanche zones but in a landslide zone.

As shown in this section, avalanche and landslide hazard zones intersect with Juneau's housing crisis to create unique impacts for renters. While the removal of landslide zone development restrictions was widely supported by property owners, this decision places short- and long-term renters at heightened risk of avalanches and landslides. Even when renters are knowledgeable about the city's hazard risk, they are often still forced into hazard zones due to the short supply of affordable housing. In addition, the available rental stock often needs maintenance or improvement to keep occupants safe from inclement weather and hazards like avalanches and landslides. Thus, by rejecting the 2022 Tetra Tech landslide maps and repealing the existing landslide zone development restrictions, the CBJ committed to ongoing and future housing justice issues for renters. This decision also demonstrates how the physical risks experienced by renters are viewed as less important than the economic risks experienced by homeowners. Historically, the unique housing justice concerns of renters are ignored in favor of the concerns of the louder, more engaged property owners. All decisions in hazard zones—such as whether to adopt new maps, repeal

development restrictions, or require disclosure prior to the sale or rent of properties—affect the lives of renters and influence hazard zone housing justice.

6. Housing-insecure Groups: Weighing Incompatible Risks.



Figure 4. The Glory Hall's downtown location on Franklin Street (blue building on the right). Photo by author.

While a major housing justice issue is knowingly or unknowingly forcing renters into hazard zones, this case study in Juneau also demonstrates how the perceptions of risk are considerably different for housing-insecure groups. Housing justice looks different based on one's situation, as a warm shelter or subsidized apartment in a hazard zone feels much safer than sleeping on the street. The intersection of a hazard zone and a housing crisis was highlighted in 2021 by local affordable housing non-profit The Glory Hall (TGH). TGH works to provide affordable housing and end housing

insecurity in Juneau. Established in 1982, the organization began as a soup kitchen to "alleviate the suffering and prevent the deaths of exposure by people suffering from homelessness, hunger, and alcohol dependence on the streets of Juneau" (Juneau Housing First Collaborative, 2024). TGH now owns multiple properties across the CBJ, including one location in a downtown hazard zone. According to TGH, Juneau's severe housing crisis must be prioritized over hazard zone regulations.

Various studies from the CBJ outline the city's housing insecurity. According to the 2010 *CBJ Housing Needs Assessment*, housing costs in Juneau are 35-64% higher than the US average (CBJ, 2010). In addition, this study identified that 38% of renters and 39% of homeowners could not find affordable housing (CBJ, 2010). These high housing costs have placed 7% of the Juneau population "in poverty" (United States Census Bureau, 2024). In 2012, there were over 500 homeless Juneau citizens. This results in a per capita homeless count of 17.5 per 1000 residents. For comparison with other Alaskan cities, Anchorage and Fairbanks had counts of 11.3 and 4 per 1000 residents, respectively (CBJ, 2017a). Without the ability to rapidly expand the availability of affordable housing in downtown Juneau, the city faces a worsening housing crisis moving forward.

A recent project from TGH represents one attempt to increase housing options in the downtown area. In November 2021, TGH applied to redevelop their downtown property into seven affordable housing apartment units. A week later, TGH's application was denied by Juneau's CDD. At that time, TGH's downtown location at 241 S Franklin Street was located in a severe avalanche hazard zone (Figure 3). City code 49.70.300 for landslide and avalanche areas stated, "Notwithstanding any other provision, no development or any part of a development, which is within a severe avalanche area shall, by the addition of bedrooms, conversions of buildings, or otherwise, increase the

density of that parcel" (CBJ, 2023b). According to the CDD, TGH's plans for renovation would alter the use of the property and increase the density of the parcel. While the property sat empty at the time of the application, 241 S Franklin Street had historically operated as a homeless shelter under a conditional use permit. By developing the property into subsidized apartments, the CDD viewed the project as increasing permanent population density in a hazard zone. The CDD's rejection of The TGH's project made local news, and KTOO reported that "Hazard maps and city code stall affordable housing project in Juneau" (Stremple, 2021). This situation represented a collision of risks—the CDD aimed to protect residents from natural hazards while TGH aimed to protect residents from a worsening housing crisis. Clearly, managing risk for housing-insecure groups requires different considerations than managing risk for homeowners and renters.

Research shows that housing-insecure populations are some of the most vulnerable to natural disasters and are often "invisible" to disaster risk reduction efforts (Walters & Gaillard, 2014). After all, people experience disaster risk based on preexisting social inequalities (Wisner et al., 2014). In addition, according to Goodling (2020), when cities do directly address the unhoused community, they often "respond to hazard exposure with displacement, creating a cycle of criminalization, dangerous living conditions, and serial forced removals" (1). On the other hand, research demonstrates that housing support can greatly improve mental and physical health (Fossey et al., 2020; Wood et al., 2016). In downtown Juneau, where space is limited and much of the city occupies avalanche and landslide hazard zones, city decision-makers and affordable housing organizations face this complex problem. When cases arise such as TGH's 2021 plan for subsidized apartments downtown, decision-makers must weigh two incompatible risks—the risks associated with housing insecurity and the risks

associated with living in a hazard zone. For some, the answer is obvious. One woman who works to address the housing crisis in Juneau voiced her frustration:

> *"Homeless people are literally dying in the streets. How is that [hazard zone development restriction] mitigating risk?"*

A local avalanche expert also weighed in. In a letter to the CDD, he wrote:

> *"Homelessness is much higher-risk than that [hazard risk]. I don't have the rate on hand, but every year, we hear of deaths among our unhoused population, usually multiple deaths. Getting people into housing has been well proven to be the best way to help them stabilize their lives, and reduce their risk of death or injury...Giving people the life stability of housing far outweighs the risk of being in a location that was only identified as a landslide risk in preliminary studies." (Glude, 2022)*

For others, however, there is concern that building affordable housing in a hazard zone perpetuates housing justice issues. After all, research shows that marginalized groups have been forced into severe hazard zones throughout history and around the world (e.g., Steinberg, 2006). In a 2023 reflection on the TGH's affordable housing project, a city official explained:

> *"They [The Glory Hall] won their appeal over the hazard designation—won their appeal to build in this area and they're putting low-income people in an area with a long history of hazard events. And the public safety discussion was largely absent*

from that appeal. That appeal was won based on a technicality in code and an interpretation of density. There was shockingly little discussion about the actual public safety risk of that property during that appeal."

As mentioned in this last statement, TGH did eventually win its appeal to the CDD in October 2022—nearly a year after they originally applied for a building permit. However, they didn't win the appeal based on its location in or out of a hazard zone. Instead, they won the appeal based on the technical definition of "population density" and "dwelling units" in the city code. Until the landslide hazard zone development restrictions were removed in December 2023, the city code prohibited any increase in population density via additional dwelling units within the severe hazard zones. This is the primary reason why the CDD rejected TGH's request to remodel its downtown shelter into single-occupancy apartments. TGH interpreted the code differently—the transition from a shelter to subsidized apartments would reduce the nightly population density. Other Juneau residents agreed. During a broader conversation about the 2022 Tetra Tech hazard maps and the CDD's role in regulating the hazard zones, one man stated:

"And then when I saw The Glory Hall debate…in a city with a housing crisis, and a homeless crisis, and not enough affordable housing…you're taking a building that's currently sheltering maybe 50 people and making it into affordable housing for 10 or 20. It's clearly a step in the right direction."

This resident, like many others, believed the project was an important step for Juneau. Even if TGH was increasing population density, the affordable housing project

represented a solution to far more important issues than hazard risk. For this reason, some people also suggested the CDD's rejection of TGH's 2021 application for subsidized apartments was about more than hazard maps, population density, and city code. Once TGH's conflict with the CDD concluded, one supporter of TGH's project said:

> "*I think what delayed the project [for The Glory Hall] was an overzealous nonsensical interpretation of the ordinances, which were not related to the maps at all."*

The same person continued to question the CDD's motives more broadly:

> *"I think CDD right now, it's just a department of saying 'no.' And it's not just [The Glory Hall] project. It's every project at this point. It's not 'how can we help your project move forward?' It's like, 'What possible reasons can we find to say no here?'"*

This resident, like others, see the rejection of the TGH's affordable housing project as part of a broader pattern of CDD rejections in the downtown area. There is a widespread belief that the CDD is misusing its power to over-regulate development projects. Either way—whether the hazard zone ordinance was the motivating reason or simply the tool for another rejection—downtown Juneau's hazard maps impacted TGH's ability to provide additional housing options for housing-insecure groups.

The statements in this section demonstrate conflicting perspectives towards the agency of affordable housing organizations and housing-insecure groups. The CDD and some residents believe that it is the city's responsibility to manage which residents live in the hazard zones. To some, this means protecting housing-insecure groups by keeping

them out of the hazard zones. However, as this section shows, many others believe that the affordable housing organizations should be supported in their efforts to address Juneau's housing crisis. Juneau's General Assembly agreed and voted to allow TGH to develop in the hazard zone. Overall, when it comes to housing-insecure groups in Juneau, there is a majority consensus that more housing—even housing in a hazard zone with high avalanche and landslide risk—is significantly better than less housing.

This section complicates housing justice by bringing together contradictory ideas—housing-insecure groups are most vulnerable to hazards and often forced into hazard zones (e.g., Walters & Gaillard, 2014; Wisner et al., 2014), but housing-insecure groups also greatly benefit from additional housing options (Fossey et al., 2020; L. Wood et al., 2016). As highlighted by this case study in Juneau, hazard risk may be deprioritized by affordable housing organizations, decision-makers, and the public. Instead, the city's need for additional subsidized housing motivated TGH's application to redevelop their downtown property, the work to appeal the CDD's rejection, and the eventual decision to approve TGH's project.

This example demonstrates the variability across hazard zone resident types—when it comes to renters and homeowners, there is a primary concern about whether residents should live in hazard zones. Some people believe that individuals have the right to decide whether they want to accept hazard risk without government interference. Others believe that it's the city's responsibility to enforce hazard zones and keep current and future homeowners and renters safe. Yet when it comes to housing-insecure populations, housing justice looks different—in this case, there is majority support for the development of additional housing in downtown Juneau's hazard zones. When it comes to the needs of housing-insecure groups, hazard risk does not always come first.

7. Conclusion.

In a hazard zone, housing justice is not a rigid concept that can be applied to improve housing insecurity and hazard exposure across the board. Instead, the needs of different population groups require tailored solutions—solutions that are repeatedly complicated by the overarching public safety concerns about natural hazards. Housing-insecure populations, renters, and property owners all have unique priorities that don't always align. In Juneau, the decision whether to adopt the 2022 Tetra Tech avalanche and landslide hazard maps clearly demonstrated how these different groups experience their own set of impacts. Property owners fear that the adoption of new hazard maps will unfairly affect their property values, insurance requirements, and mortgage options. Meanwhile, renters are often left out of the decision-making process, aren't provided with adequate knowledge of local hazards, and may be knowingly or unknowingly forced to live in a hazard zone. Finally, affordable housing organizations must weigh the incompatible risks of housing insecurity and hazard exposure—in Juneau, there is a majority consensus that additional housing options in a hazard zone help keep people safe. As these sections have demonstrated, housing justice cannot be addressed by attending to any one of these groups. In fact, this case study in Juneau shows how heightened attention to the concerns of property owners can overshadow the needs of renters and housing-insecure populations.

This paper also demonstrates that hazard maps impact population groups in divergent and dynamic ways. While downtown property owners felt that the 2022 Tetra Tech hazard maps threatened their personal economic independence, they also recognized that the maps could produce inequities for lower-income property owners.

In addition, property owners acknowledged that their outright rejection of the hazard maps could be in vain—without adoption the maps still exist, and residents may have little control over how insurance agencies and mortgage lenders use them. For renters, there are concerns that the 2022 Tetra Tech hazard maps could force more renters into the hazard zones. However, there are also concerns that the maps might encourage property owners to shift away from affordable or safe rental units. This could decrease the city's rental stock or worsen the rental options because it does not financially benefit landlords to maintain their properties for renters if they will ultimately lose money when they decide to sell. Finally, the 2022 Tetra Tech hazard maps offer improved resolution of where avalanches and landslides may occur, which helps decision-makers create policies that protect housing-insecure groups from hazard exposure. At the same time, the maps became a barrier for an affordable housing project and obstructed a nonprofit organization's attempt to reduce social vulnerability in Juneau. Clearly, hazard maps overlay complex social dynamics and produce a wide array of impacts for hazard zone residents.

While important scholarship addresses the relationship between housing justice and environmental hazards like air pollution and waste sites (e.g., Maantay et al., 2010; Rauh et al., 2008), there is an urgent need for research that studies housing justice in natural hazard zones. Within the little research on natural hazards and housing justice that does exist (e.g., Hendricks & Van Zandt, 2021; Zhang, 2010), there are urgent calls for further study. In addition, as climate change alters the frequency and intensity of natural hazards like landslides and avalanches, there is a growing need to better understand how people are affected by natural hazards and hazard mitigation. This paper offers a novel contribution to hazard research by studying the experiences of three different resident groups during the process of hazard mapping. By highlighting

the unique impacts experienced by property owners, renters, and housing-insecure populations—as well as the contradictory concerns within and across the groups—this paper demonstrates the need for increased attention to justice in hazard mapping and hazard mitigation. In addition, the analysis of residents by resident type—rather than by traditional environmental justice factors such as race, gender, and socio-economic status—offers a new way to think about justice in hazard zones. Moving forward, hazard management must consider the needs and concerns of various residents beyond property owners.

This site-specific study focuses on the 2018-2023 Tetra Tech avalanche and landslide hazard mapping process in downtown Juneau, Alaska. The specific details from this work are not necessarily transferable to other cases. However, the broader findings in this paper are widely relevant for hazard zones around the world. For example, it is important to recognize that dynamic and contradictory impacts and concerns are likely to occur during any hazard mapping process. Further, housing justice in a hazard zone means attending to all these impacts rather than prioritizing the loudest or most involved actors. Finally, future hazard mapping projects—in Juneau and elsewhere—will likely either fail or produce further injustices if a wide range of community groups are not considered from the start. In other words, hazard mapping decisions must consider housing justice for housing-insecure populations, renters, and property owners alike. Future research should continue to examine housing justice in hazard zones—in hazard zones around the world and for hazards beyond avalanches and landslides. Scholarship should also continue to develop the meaning of housing justice in a hazard zone—who constitutes the actors, the existence of power imbalances, and the impacts of hazard maps and risk assessments on residents.

CHAPTER IV

SHIFTING CLIMATE HAZARDS AND THE INERTIA OF DISASTERS:

THE AVALANCHE CAPITAL HAS A LANDSLIDE PROBLEM

This article is currently under review at the peer-reviewed journal *Climatic Change*. I am the sole author of this article.

1. Introduction.

On November 20th, 2023, a landslide in Southeast Alaska struck the small town of Wrangell and killed five people. This disaster adds to a string of recent landslide events in Southeast Alaska, with deadly landslides occurring in Haines in 2020 and in Sitka in 2015 (Czarnecki, 2024). As climate change results in warmer winter temperatures and increases in rainfall low-elevation mountain ranges, landslides will threaten an increasing number of people around the world each year (Pörtner et al., 2022; Pörtner et al., 2019). An *Alaska Beacon* news article linked the 2023 Wrangell landslide to climate change, explaining that scientists expect "increases in temperature to bring about increases in precipitation and increases in extreme [landslide] events" (Rosen, 2023). The article also highlighted a challenge for mountain communities: "how to prevent similar tragedies in the future as mountainous regions become more unstable" (Rosen, 2023). The growing number of deadly landslide disasters—in Southeast Alaska and mountain ranges around the world—expose the urgent need for additional attention to hazard mitigation and climate adaptation in mountain communities.

Research on climate-induced landslides has increased in recent years, but it primarily focuses on prediction and trigger mechanisms rather than the political, social, economic, and cultural dimensions of disaster risk reduction. Research has begun to address the ability of communities to adapt to landslide hazard (e.g., Acosta et al., 2016; Kim et al., 2018; Oktorie, 2017), yet more work is necessary to understand the obstacles for climate adaptation in local contexts. Social science research demonstrates that cultural, political, and economic conflicts have influenced the trajectory of hazard mitigation for centuries (e.g., Carey, 2010; Di Stefano, 2014; Provant & Carey, 2023). Some communities or regions adapt quickly to new hazards, while others struggle with funding shortages, political barriers, technoscientific limitations, and divergent cultural understandings. After all, local disaster risk reduction encapsulates everything from traditional stories and festivals to early warning systems and zoning ordinances (e.g., Ajay, 2019; Lempert et al., 2023; Mauch & Pfister, 2009; Moulton et al., 2021; Taylor & Peace, 2015; Wisner et al., 2015). While researchers have studied the role of memory in disaster risk reduction (e.g., Monteil et al., 2020; Pisa, 2024), little work has addressed how long-term relationships with hazards can obstruct adaptation to new climate risks.

Emerging scholarship has adopted the term "inertia" to highlight the governmental and institutional inability to quickly enact policy or operational changes. Climate policy researchers have begun to address "institutional inertia," demonstrating how mechanisms such as costs, uncertainty, path dependence, power, and legitimacy can obstruct policy interventions (Munck af Rosenschöld et al., 2014). In addition, disaster research has more recently examined how institutional inertia interferes with disaster response and recovery (e.g., Meng et al., 2022; Plein, 2019). However, these existing studies focus primarily on institutional structures and policy actions, and there remains a gap in research on how local community relationships with disaster also

produce inertia. As communities build cultural and technological relationships with climate hazards over time, they develop what I call the *inertia of disasters*. In this paper, I examine how the local history of hazards—including previous disasters, scientific research projects, public perception, and media attention, among others—perpetuates longstanding disaster risk reduction strategies despite shifting climatic conditions. As climate change alters the type of hazards that threaten people around the world, the inertia of disasters impedes new hazard management strategies. This concept of the inertia of disasters—and its demonstration through this paper's case study in Juneau—offers climate and adaptation scholarship new knowledge about how local communities may struggle to adapt to shifting climate hazards.

In Juneau, avalanches and landslides have killed people and damaged infrastructure since the downtown area was developed for mining in 1881. However, a few large avalanches earned Juneau the title of "North America's Avalanche Capital." In particular, a 1962 avalanche in the Behrends Avenue neighborhood damaged dozens of houses and sparked widespread concern about Juneau's avalanche risk. In response, the City and Borough of Juneau (CBJ) has spent over half a century hiring expert avalanche consultants, increasing public awareness of avalanches, and regulating avalanche hazard zones. In an illuminating example, in 2020 the CBJ contracted the consulting firm Tetra Tech to create new avalanche and landslide hazard maps for the downtown area. These maps were publicly released in 2022. However, on December 11th, 2023, Juneau's General Assembly voted unanimously to adopt a new ordinance that: 1) repealed the currently used 1987 landslide maps; and 2) did *not* adopt the new Tetra Tech landslide maps. Through this ordinance, the CBJ removed all regulation of landslide hazard but endorsed the latest avalanche maps and regulations. This is the inertia of disasters:

despite the scientific evidence and the recent landslides in Southeast Alaska, the city of Juneau continues to prioritize avalanche hazard management.

This paper therefore demonstrates how Juneau's avalanche history inhibits adaptation to the growing landslide hazard in two principal ways: 1) the legacy of past and ongoing avalanche research; and 2) public awareness and perception of avalanches. First, scientific research has neglected the growing landslide problem due to the abundance of avalanche experts in the region, the ability of past avalanche disasters to drive research agendas, and the fact that avalanches are more spatially predictable than landsides. Second, public perception has been shaped over decades by avalanche awareness campaigns, the ability to "see" avalanches, Juneau's ski town culture, and the role of disaster memories. Through these two dimensions of the inertia of disasters, this paper highlights how the social history of disasters can affect a community's ability to adapt to new hazards. There is a crucial need for this type of empirical research that simultaneously considers climatic changes and local social dynamics. This study demonstrates how mountain hazards are changing in Juneau and how the inertia of disasters produces long-term obstacles for public safety.

2. Methods.

This paper is a mixed-methods case study that blends: 1) analysis of scientific literature on avalanches and landslides; 2) interview data with Juneau residents, scientists, and policymakers; 3) document analysis of hazard assessments, meeting transcripts, and government documents; and 4) spatial analysis to compare avalanche and landslide hazard zones. These methods support the objective of this study, which is to connect emerging climate research with site-specific human dimensions to better

understand the impacts of shifting climate hazards. First, I reviewed climate change research on avalanches and landslides that emerged following the IPCC's 2019 *Special Report on Oceans and Cryosphere in a Changing Climate*. To do this, I ran a Google Scholar search for the terms "avalanches climate change" and "landslides climate change" from the years 2019-2023. After reviewing the search results, I selected the peer-reviewed articles on avalanches and landslides that directly studied their responses to climate change. I categorized these articles based on their findings as: 1) increasing avalanche hazard; 2) decreasing avalanche hazard; 3) increasing landslide hazard; 4) decreasing landslide hazard; and 5) no clear trend. Some articles received multiple categorizations, as avalanche and landslide hazard can respond to climate change in elevation-dependent and region-dependent ways. I used the analysis of these articles to produce the site-specific assessment of changing hazards in Juneau as found in Section 2.

Second, to collect and analyze interview data, I conducted interviews with 18 residents, 5 government officials, and 9 business owners/NGO directors. Interview participants were identified through their involvement in hazard mapping and hazard mitigation public meetings in Juneau, and additional participants were identified through snowball sampling. The interviews were primarily conducted in-person in Juneau, Alaska, with a few interviews taking place over phone- and video-calls. The interviews, which were semi-structured and typically ranged from 30 minutes to 1 hour, addressed CBJ hazard management, hazard science in Juneau, and resident experiences and perceptions. The interviews were recorded and then transcribed using OtterAI. Using the qualitative analysis software MaxQDA, I identified themes including scientific uncertainty, disaster memories, and ski town culture, among others. Following this thematic analysis, I grouped these themes into the categories of "scientific research" and "public perception." These categories were used to develop Sections 4 and 5 of this

paper. In accordance with human subject protections, all interview participants are kept anonymous.

Third, document analysis consisted of identifying, collecting, and analyzing documents, including: 6 complete hazard assessments from 1967-2022; 6 sets of meeting minutes from the CBJ Planning Commission and the CBJ General Assembly from 2021-2023; 4 video transcripts from the CBJ Planning Commission and the CBJ General Assembly from 2021-2023; and 36 documents from the CBJ's Emergency Management Program including internal memos, citizen letters, public announcements, and disaster records from 1968-2023. I collected these documents from the CBJ Emergency Management Program, the CBJ Community Development Department, the Alaska State Archive, and the Alaska Historical Collections. I autocoded the files in MaxQDA based on the thematic analysis from the interview data.

Fourth, I created the maps shown in this paper using GIS data provided by the CBJ. The provided GIS shapefiles include: 2022 Tetra Tech study avalanche hazard zones, 2022 Tetra Tech study landslide hazard zones, building footprints, water, streams, trails, streets, and a hillshade. The maps created in this paper illuminate key differences between avalanches and landslides, offering additional evidence for why scientific research prioritizes avalanches in section 4.

3. Avalanches, Landslides, and Climate Change.

Juneau, Alaska is located at sea level, sits at the base of 3500-foot-tall mountains, and averages over 90 inches of precipitation annually. This combination of steep slopes and heavy precipitation leaves the city prone to significant avalanche and landslide hazard. Juneau has experienced a few large avalanches over the last century, such as the

1962 avalanche that damaged dozens of homes in the Behrends Neighborhood and the 2008 avalanche that cut off Juneau's hydroelectric power (LaChapelle, 1968; Miller, 2021). The CBJ has documented hundreds of avalanches in and around town over the last century, and the city's history of destructive slides has earned Juneau the title of "North America's Avalanche Capital."

Climate change, however, is substantially altering Juneau's hazardscape. Now, a warmer and wetter climate is decreasing avalanche hazard while increasing landslide hazard in Southeast Alaska. According to the IPCC, avalanche hazard at low elevations is projected to decrease in future decades due to a transition of winter precipitation from snow to rain (Pörtner et al., 2019). On the other hand, warmer winter temperatures and increases in rainfall suggest an increase in landslide hazard in these same low elevation mountain ranges (Pörtner et al., 2019). This means that low elevation mountain areas around the world—from Greenland to New Zealand to Alaska—will experience heightened landslide hazard into future decades.

3.1 Climate Change and Avalanches

Snow avalanches are possible whenever there is snow on the ground, but they are most frequent following winter snowstorms and spring warming cycles. Avalanches occur on steep slopes ranging from 25 to 50 degrees, and they can be triggered by wind, precipitation, temperature changes, earthquakes, and disturbances (e.g., skiing or snowmobiling). In response to destructive and deadly avalanches in mountain ranges around the world, experts work to protect life and infrastructure by "preventing the release of avalanches, influencing its direction of movement, or avoiding endangered areas either in the long term or in the short term" (Bründl & Margreth, 2021, p. 259). They do this with a variety of strategies including snow supporting structures, snow

sheds, artificial release, zoning regulations, and avalanche forecasting, among others. Nevertheless, avalanches continue to impact important industries such as transportation, energy, mining, and recreation.

The IPCC's *Special Report on Ocean and Cryosphere in a Changing Climate (SROCC)* states there is "no clear direction of trend for overall avalanche activity" (Pörtner et al., 2019, p. 161). However, the report does identify two smaller trends: 1) decreasing frequency of avalanches at lower elevations; and 2) increasing frequency of wet snow avalanches. Since the IPCC's *SROCC* was published in 2019, emerging research has confirmed these trends. Most predominantly, research identifies wet snow avalanches as growing in both frequency and severity due to warming winter temperatures, winter precipitation shifting from snow to rain, and rapid spring melting. Wet snow avalanches are occurring earlier and across a longer portion of the avalanche season (Hao et al., 2023; Komac & Zorn, 2023). They are also migrating to higher elevations (Giacona et al., 2021). Finally, Peitzsch et al. (2021) predict that large-magnitude wet snow avalanches could increase in the spring. Beyond wet avalanches, the latest research is beginning to demonstrate a decrease in large-magnitude dry avalanches (Ortner et al., 2023). In fact, Peitzsch et al. (2021) observed a decline of 14% in large magnitude avalanche activity from 1950-2017. In addition, climate research shows that the avalanche season is shortening in overall duration due to the earlier onset of spring warming (Castebrunet et al., 2014; Lazar & Williams, 2008; Pörtner et al., 2019). Thus, while the frequency of wet avalanches may be increasing, the likelihood of the most dangerous dry slab avalanches is decreasing in response to climate change.

3.2 Climate Change and Landslides

A landslide—a term often used synonymously to "mass wasting"—can be triggered by a variety of intersecting causes including rainfall, snowmelt, erosion, human activity, and earthquakes, among others. However, as Patton et al. (2023) demonstrated in a case study in Sitka, Alaska, heavy rainfall within a 3-hour period is an accurate way to predict landslide activity. Thus, while landslides are possible any time of the year, they are most likely to occur during winter storms and atmospheric rivers. Like avalanches, experts employ scientific and engineering strategies to manage landslide hazard, including early warning systems, retaining walls, and zoning regulations. In mountains around the world, landslides regularly threaten lives, property, and infrastructure.

In contrast to the unclear overall trend for avalanche activity, the IPCC's *SROCC* demonstrates that landslide hazard is increasing around the world (Pörtner et al., 2019). The IPCC states that "permafrost thaw increased the frequency and volumes of landslides from frozen sediments in many mountain regions in recent decades (Lacelle et al., 2015; Ravanel, 2010; Wei et al., 2006)." Additionally, the scientific studies reviewed for this paper all link climate change to increased landslide activity (e.g., Ozturk et al., 2022; Patton et al., 2019; Pei et al., 2023; Scheidl et al., 2020). Lader et al. (2022) also explain that "as temperatures continue to warm and summer precipitation amounts increase, the risk of landslide activity will likely rise" (20). Jakob and Lambert (2009) forecast as many as 30% more landslides along the Pacific Coast by the end of the 21st century. This is in part due to the rising rain-snow line and the more frequent thawing of permafrost and frozen ground—landslide hazard will migrate both upslope and downslope (Jin et al., 2000; Pei et al., 2023). Specifically, the rising rain-snow line means landslides can be triggered at higher elevations that historically had more snow

and frozen ground throughout the winter. Warmer temperatures also means that lower elevation ground will thaw more frequently during the winters, increasing the winter landslide hazard at these lower elevations. Low elevation landslides can occur in towns, putting people and structures at greater risk. Finally, landslides don't require an accumulation of snow—they just need one heavy rainstorm. Climate and landslide research has linked projected increases in fall precipitation to both growing landslide hazard (Jakob & Lambert, 2009) and earlier spring thaws (Patton et al., 2019). This means that fall and spring months will have heightened landslide hazard, extending the hazard into the shoulder seasons.

3.3 Implications for Juneau

The existing research on climate change and mountain hazards is important for a site-specific understanding of avalanche and landslide risk in Juneau. Juneau's coastal, maritime climate is typically accompanied by warmer, wetter snowpacks. According to the most detailed study of Juneau's avalanche hazard, Juneau's local climate favors "a greater frequency of wet snow avalanche conditions as opposed to extreme dry snow avalanche conditions which can explain why extreme dry snow avalanches occur rather seldom" (SLF, 2011, p. 8). As winter temperatures rise, wet snow avalanches will migrate upslope to higher elevations (Giacona et al., 2021). In Juneau, there is no room for this upslope migration of avalanches to occur—avalanches already start near or at the summit of the surrounding mountains (Fig. 1). Instead, a greater percentage of precipitation at the top of Juneau's mountains will fall as rain rather than snow. This will result in a shallower snowpacks and shorter seasons, both of which have been linked to decreasing avalanche activity (Hao et al., 2023; Komac & Zorn, 2023; Ortner et al., 2023). A Juneau resident identified this trend, explaining that "there hasn't been any

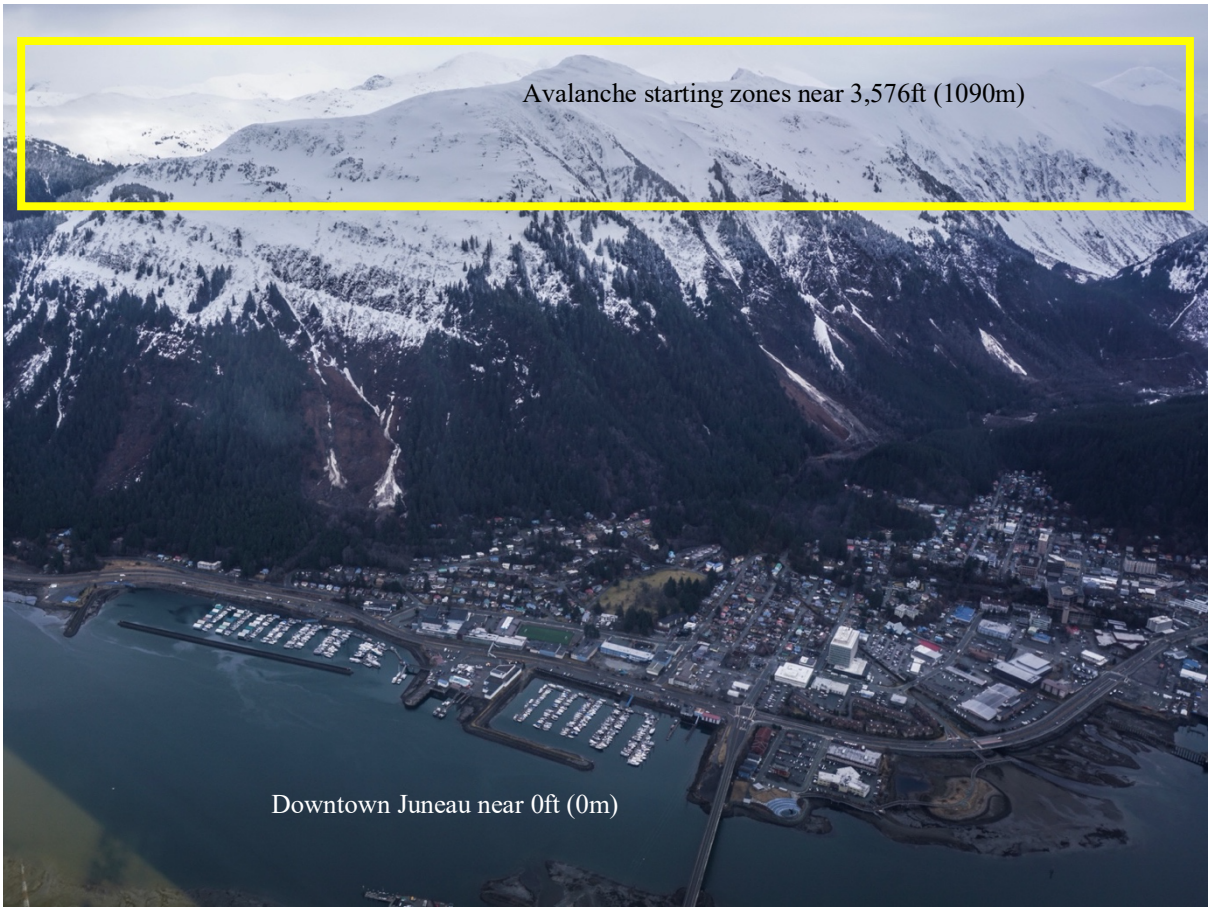


Figure 1. Downtown Juneau with avalanche starting zones highlighted for Mount Juneau. Image by author.

[deadly avalanches] in the past 60 years, and with global warming the winters will gradually get warmer, there will tend to be less overall avalanche weather." A local avalanche expert agreed, explaining that "it's easy to say over time you will slowly move away from the avalanche hazard, and some years where we have a really low snow year we will see less avalanches." Both the scientific research and local observations highlight decreasing avalanche hazard in Juneau.

On the other hand, Juneau will experience increasing landslide hazard due to more winter melt-freeze cycles and greater rainfall totals. The Alaska Coastal Rainforest Center (2023) explains that "as Juneau continues on its current trend of receiving higher amounts of precipitation, increased frequency of ARs [atmospheric rivers], rain-on-snow, and other extreme weather events, all of which are triggers for landslides, it will likely experience a commensurate increase in landslide magnitude and frequency."

Although Juneau has not seen a deadly event since a 1936 landslide that killed 15 people (Swanston, 1972), the recent landslide activity in Southeast Alaska demonstrates the potential consequences of Juneau's growing landslide hazard. In 2015, an atmospheric river produced a landslide that killed three people and led to the development of a landslide early warning system in Sitka (Woolsey, 2022). In 2021, a landslide in Haines killed two people and displaced nearly two dozen households (Stremple, 2021b). In Juneau, a 2022 landslide destroyed three houses and a 2023 landslide caused an emergency response and city warning (Cadotte, 2023; Stremple & Krumrey, 2022). Most recently, a landslide in Wrangell in November 2023 killed five people (Rosen, 2023). There is a growing trend of deadly and destructive landslides in Southeast Alaska, and Juneau's terrain, climate, and development put it at heightened risk for a landslide disaster.

The experiences of people in Juneau also affirms the relationship between landslides and climate change. A resident that was impacted by a landslide in downtown Juneau stated that "[in] the last five years, it's just been a steady increase in the amount of rain we get, especially in the fall." Another resident stated that "landslides don't happen when the ground is frozen…It used to be guaranteed [to be frozen] when I was kid from the middle of November until at least the end of March, if not the end of April." They continued to explain, "historically there was only one freeze-thaw cycle...because it didn't rain much [in winter] and we had cold winters. Last winter we had two or three freeze thaw cycles." A government official agreed that "we recognize that the patterns are shifting, and things are becoming more dynamic. That means an increased frequency of [landslide] activities." Finally, a local insurance agent described landslides by stating that "now it's scary, because now it's not the rare unknown—or as they say in insurance…low frequency, high intensity—it's now becoming normalized and high

intensity." Clearly, many individuals in Juneau recognize that climate change is increasing the frequency and severity of landslides. This demonstrates that the inertia of avalanche disasters in Juneau is not driven by a collective refusal of climate change or landslide hazard, but rather it is driven by a history of scientific research programs and the longstanding awareness of avalanches.

4. Scientific Research and the Inertia of Disasters

As demonstrated in Section 3, climate change affects the frequency and severity of avalanches and landslides in unique ways. Both hazards are linked to climate—specifically, the transition from snowfall to rainfall during winter months. Despite evidence that landslides are a growing risk in Juneau, avalanches continue to capture most of the public and media attention. Scientific research has played an important role in driving this attention to avalanches, constructing Juneau as "North America's Avalanche Capital." However, the city's longstanding relationship with avalanche science is masking the city's growing landslide hazard. Specifically, scientific research contributes to the prioritization of avalanches through: 1) the availability and history of avalanche expertise; 2) the spatial predictability of avalanches; and 3) the measurable damage potential of avalanches. Together, these components of scientific research contribute to an enduring focus on avalanches that overshadows the critical need for mitigation and adaptation to landslides.

4.1 The history of avalanche expertise

Juneau has been a hotbed for avalanche research for over 70 years. Many of the world's prominent avalanche experts have studied avalanches in Juneau, including Ed

LaChapelle, Jill Fredston, and Bill Glude. Avalanche risk assessments began as early as the 1950s, and various rounds of hazard maps have been proposed for downtown Juneau due to areas of extreme hazard. Rigorous scientific study and public debate followed the destructive 1962 Behrends avalanche, and the CBJ adopted its official hazard maps in 1987. In 2012, the world's leading avalanche research center—WSL Institute for Snow and Avalanche Research SLF—conducted an extensive review of Juneau's avalanche hazard (see: SLF, 2011). In 2018, the CBJ contracted Tetra Tech to update the 1987 maps using the latest scientific methods (see: Tetra Tech Inc., 2022). The CBJ currently operates the Urban Avalanche Advisory Board during the winter, and the Department of Transportation and Alaska Electric Light & Power both have ongoing avalanche mitigation programs. Through these many different research and mitigation projects, avalanche research in Juneau has played a longstanding role in city planning and development.

In contrast, there is less history of landslide research in Juneau or southeast Alaska. Juneau's FEMA-approved All-Hazards Mitigation Plan, published in 2012, states that "areas within the borough remain to be studied for landslide hazards" (CBJ, 2012, p. 49). In addition, the same mitigation plan compiled the history of hazard research in Juneau, identifying five avalanche studies but only two landslide studies. One avalanche expert addressed this discrepancy, stating that landslide science is "a newer science with a little less behind it, which makes it difficult to accept at face value." This perspective—which is echoed by many residents, decision-makers, and hazard experts—leads to the continued deprioritization of landslide science. For example, despite using state-of-the-art technology, the CBJ's official statement about the 2020 Tetra Tech hazard study is that "the landslide hazard assessment maps do not provide an indication of risk as would be necessary to determine whether landslide hazards

actually pose a threat to specific properties" (CBJ, 2023a). Thus, the hesitation to accept landslide science as a legitimate assessment of potential hazards hinders the advancement of landslide mitigation in Juneau. In other words, the history and abundance of avalanche science in Juneau makes landslide research appear disputable and uncertain.

Finally, each year the spectacular nature of avalanche events reaffirms the scientific attention to avalanches. When avalanches occur in or near downtown Juneau—such as a January 2024 avalanche in Behrends that produced a dramatic powder cloud—media coverage and public awareness drive additional avalanche research. This can happen explicitly, as the 1962 Behrends Avalanche singularly spurred multiple new avalanche studies. This also happens indirectly, as media coverage and public awareness frame Juneau as a city with extreme avalanche risk. Regular statements like "national experts consider Juneau to have one of the most hazardous avalanche areas in the country" identify avalanches as a key target for future research (CBJ, 2012, p. 23).

The influence of avalanche research has repeatedly affected Juneau's ability to address increasing landslide risk. In a recent example, the CBJ created new landslide and avalanche hazard maps using a FEMA grant in 2018. In December 2023, Juneau's General Assembly adopted the new avalanche maps and associated development regulations for hazard zones. However, after years of debate and public testimony, the assembly voted to reject the latest landslide hazard maps and repeal the previously adopted landslide hazard maps (Sabbatini, 2023). Even though the avalanche and landslide maps were created by the same consulting firm with the most advanced science available, residents and decision-makers assume the avalanche maps to be accurate and question the legitimacy of the landslide maps. This outright rejection of

landslide mapping demonstrates the inertia of disasters—Juneau's history with avalanche research continuously reinforces the city as North America's "Avalanche Capital."

4.2 Spatial predictability

There are clear spatial differences in how scientists understand avalanches and landslides. In particular, avalanches are more predictable spatially. For example, one of the world's first avalanche experts, Ed LaChapelle, wrote that "avalanches run in the same paths year after year, the danger zones often being well known in normal circumstances" (LaChapelle, 2001). This is primarily due to the buildup of snow in certain places every winter. In 2021, the CBJ issued evacuation recommendations for the Behrends neighborhood during "extreme" risk of historic-sized avalanches (Miller & Pemberton, 2021). These evacuations were manageable by the city because the boundaries of the slide zone were clearly defined and small in total area. However, while previous landslide paths can sometimes cause new landslides (Samia et al., 2017; USGS, 2018), landslides regularly occur on slopes with no signs of previous landslide activity. Scientists are working to improve the spatial predictions for landslides (Lombardo et al., 2020; Sachdeva et al., 2020; Wang et al., 2020), but landslides are to-date very difficult to forecast spatially.

In Juneau, avalanche and landslide maps confirm the inability to predict where landslides are going to occur. As seen in Figure 2, avalanche maps in Juneau are comprised of primarily high and severe hazard zones (red). In contrast, the landslide maps are composed of a range of low (green), moderate (yellow), and high/severe (red) hazard zones. This means that: a) there is high confidence in knowing where avalanches are going to occur; and b) there is lower confidence in knowing where landslides are

going to occur. Local hazard experts address this in interviews, with one stating “when you look at an avalanche map, it's easy to say, okay, we can not build here because we can't mitigate it.” However this recommendation is more difficult for landslides. In addition, residents and decision-makers often assume the lack of spatial knowledge

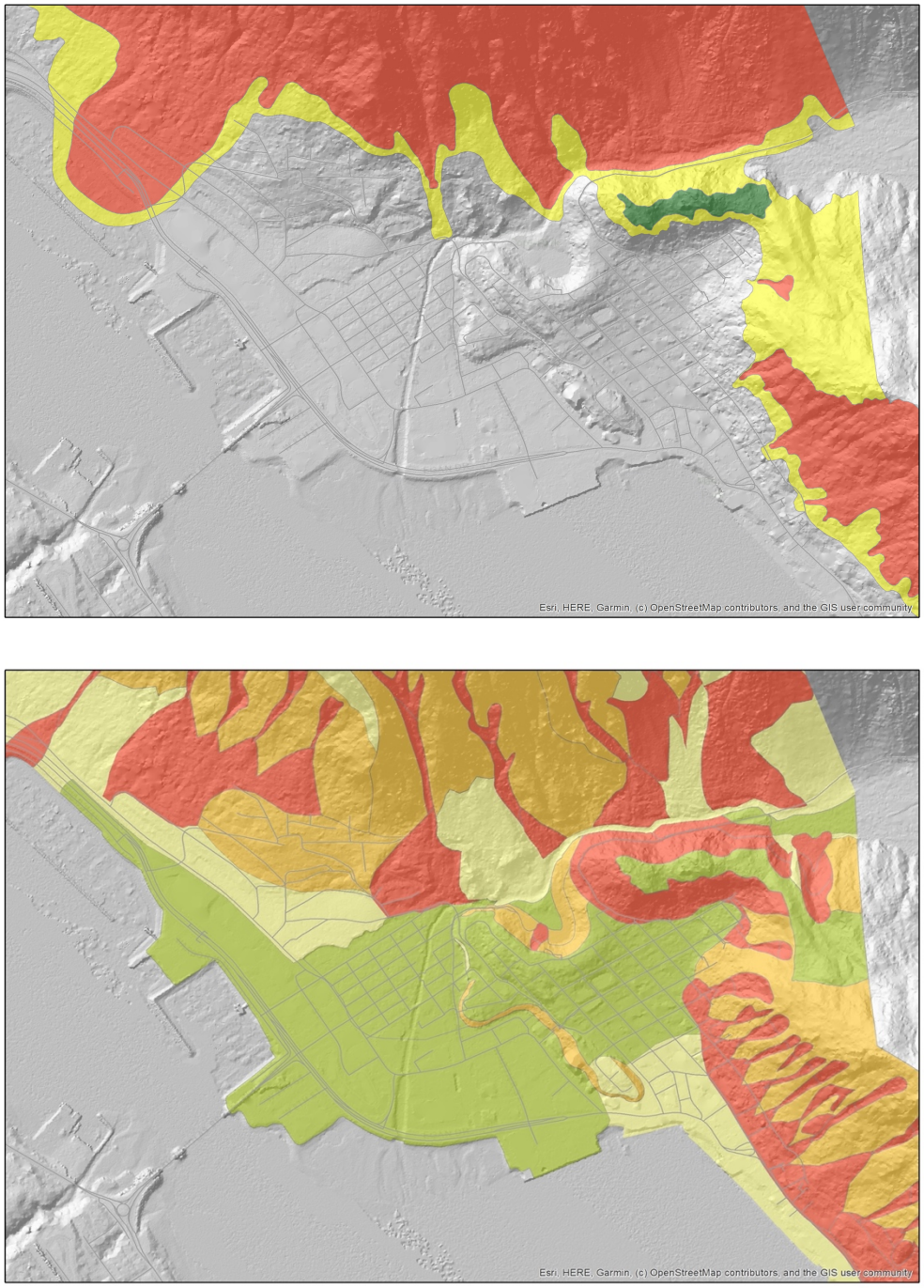


Fig. 2. Avalanche (top) and landslide (bottom) hazard maps created by author using data from the 2022 Tetra Tech Hazard Assessment. Red zones are high/severe hazard, yellow zones are moderate hazard, and green zones are low hazard.

about landslides means that scientists have little knowledge about landslides. One resident explained that, "[when] the scientists tell us the avalanches are somewhat predictable and the landslides aren't, you feel that you're in more danger…Because if they say it's snow mass hanging right up above you, you know, that tells you that you're in imminent danger. But by the same token, they don't know landslides." When compared to the spatial predictability of avalanches, landslide science appears uncertain.

However, while the scientific knowledge of landslides appears questionable to residents, experts explain that landslides are predictable temporally rather than spatially. Patton et al. (2022) show that rainfall in a 3-hour window is an excellent predictor for landslide activity. For example, two inches of rainfall in a 3-hour window has *always* triggered a landslide in the Sitka (Southeast Alaska) area (Patton et al., 2022). Landslides can therefore be accurately predicted based on rain forecasts, while avalanches depend on many dynamic variables including wind, solar radiation, and temperature. This gives scientists a strong knowledge of when landslides are going to occur, and it led to the development of a landslide warning system in Sitka, Alaska. The warning system describes high risk as: "Multiple landslides are very likely to occur in the Sitka area. There have been three storms in the last 20 years with similarly intense rainfall, and all three of them initiated multiple landslides" (Sitka Landslide, 2023). Nevertheless, despite scientists' detailed knowledge of the temporal dimensions of landslides, the comparison of landslide knowledge to avalanche knowledge in Juneau makes landslides appear "unknown." Residents, decision-makers, and scientists in Juneau have spent decades developing a spatial understanding of hazards through avalanches—now, some people see the lack of spatial certainty in landslide forecasting as a reason to disregard landslide science altogether. Thus, the inertia of avalanche

science has shaped the community's understanding of hazard risk and poses an obstacle to landslide hazard mitigation.

4.3 Measurability of damage potential

Landslides have much higher damage potential than avalanches due to the impact pressures of rocks and trees versus snow. According to the recent Tetra Tech hazard assessment completed for Juneau, "severe" avalanche hazard is calculated to be 30+ kPa (600+ lbs/ft^2), which is powerful enough to destroy wood frame structures and break trees (Tetra Tech Inc., 2022). The well-known 1962 avalanche in the Behrends neighborhood primarily damaged windows and roofs, and following Tetra Tech's impact pressure description would fit the category of "push in doors, damage walls, roofs" (Tetra Tech Inc., 2022, p. 7). The impact pressures for this avalanche would therefore have been approximately 3-6 kPa (62-125 lbs/ft^2), which is significantly lower than the 30+ kPa (600+ lbs/ft^2) necessary for severe structural damage. Thus, to destroy buildings in Juneau, an avalanche would need to be historic in size and larger than any avalanche Juneau has experienced. On the other hand, while Tetra Tech did not characterize landslide hazard zones based on impact pressures, even small landslides can easily reach destructive impact pressures. This makes sense, as one cubic meter of avalanche debris can weigh up to 500kg while one cubic meter of landslide debris can weigh over 2000kg (EAS, 2023; Iverson, 1997). The destructive nature of small landslides was displayed in September 2022, when a small landslide on Gastineau Avenue in downtown Juneau completely destroyed one home and partially destroyed two others. In addition, the ability of landslides to take lives has been repeatedly demonstrated in Southeast Alaska over the last decade. The growing frequency of small-

magnitude landslides—and, of course, the growing potential for a large-magnitude landslide—dramatically increases risk for people living in hazard zones.

However, the city of Juneau faced pushback when attempting to implement new landslide hazard maps and regulations due to the lack of designated damage potential for landslide hazard zones. In particular, residents argued that the lack of quantifiable risk meant that the landslide zones should not be used for development regulation. For example, in a written letter to the CBJ, one resident wrote that "assertion of hazard is not a substitute for quantification of risk, and the proposed ordinance provides no mechanism for quantification of risk" (CBJ, 2023b). This sentiment was repeated by various residents and decision-makers at public meetings. While Tetra Tech created hazard zones based on variables such as slope angle, aerial imagery, surficial geology, and written records of property damage or loss of life, people found these designations insufficient when compared with the quantifiable impact pressure of avalanches. Even though avalanches and landslides are different hazards with unique environmental properties, the strategy for classifying avalanche hazard impact pressures nevertheless played an important role in the rejection of landslide hazard zones. In other words, the scientific knowledge about avalanche damage potential obstructed the adoption of improved landslide hazard maps.

5. Public Perception and the Inertia of Disasters

In addition to Juneau's history of avalanche research, Juneau residents also have a longstanding relationship with avalanches. This section demonstrates that local perceptions of avalanches regulate how landslides are understood and addressed. This public attention to avalanches developed from decades of avalanche awareness

campaigns and ski town culture, the visibility of avalanches, and the role of disaster memories. One government official introduced many of these dimensions, stating:

> "You know, people understand avalanches. They understand snow. Most people understand the basic layering and the different factors that lead up to producing an avalanche. We've had an avalanche warning forecaster for a very long time. So people are accustomed to avalanche risk. They're accustomed to hearing about it in the news. They're accustomed to varying levels of warning about avalanches, both downtown and just in the EagleCrest Ski Area. So the science is familiar to them, and it's been in the news every year to one degree or another for decades. The major landslide events, as you have noted, are way far in the past."

However, the perception that avalanches are Juneau's primary hazard impedes the city's ability to mitigate landslide hazard. First, the public awareness of avalanches overshadows the presence of landslide hazard. Second, the visibility of avalanches makes landslide hazard feel "made up." Finally, the power of disaster memories makes it difficult to accept the presence of other hazards and shift towards new forms of hazard mitigation. Through these different relationships with avalanches, the inertia of disasters is inhibiting Juneau's ability to adapt to growing landslide hazard.

5.1 Public awareness

First, alongside the high volume of avalanche research in Juneau is a longstanding public awareness of avalanches. The CBJ has held avalanche awareness meetings and offered public education for many decades. The CBJ also repeatedly holds public comment and informational meetings about avalanche hazard mapping and

zoning, particularly during the adoption of hazard maps in 1987 and the introduction of the Tetra Tech study in 2020. On a broader scale, the governor of Alaska proclaimed November 2017 as "Avalanche Education Awareness Month," writing that "we can reduce preventable avalanche injuries and deaths in Alaska through the use of education programs and continued practice of avalanche risk avoidance measures and rescue procedures" (Walker, 2017). Beyond government initiatives, Juneau's avalanche hazard has been regularly documented in the media. Local news stations often publish articles about avalanche risk (e.g., Miller, 2021; Stremple, 2021a), and the 2008 avalanche that destroyed the city's main hydroelectric power facility was covered by national media like NPR and The New York Times (NPR, 2008; Yardley, 2008). Juneau's avalanche risk has even been turned into films, such as a 2022 documentary called "ReVision Alaska: Alaska's Avalanche Capital" (Sparks et al., 2022). All this attention to avalanches, whether from the government or the media, works to slowly engrain avalanche hazard as a part of life in Juneau.

Juneau is also a ski town. Many residents participate in skiing at Eaglecrest, the local ski area. Eaglecrest, like many ski areas, contributes to avalanche education for skiers through its website and on-mountain signage. For example, the Eaglecrest website offers avalanche "educational resources" and recommends that residents "become educated on how to reduce the risk of injury or death from avalanches through your own actions and awareness" (Eaglecrest Ski Area, 2024). The ski area also conducts avalanche control both within the resort and in the nearby backcountry to keep skiers safe. Eaglecrest regularly closes off some of its expert terrain to conduct avalanche blasting—the dropping of dynamite into avalanche start zones in order to safely trigger avalanches with no people around. Throughout the winter, Juneau skiers watch and hear this blasting take place. Beyond the ski area, many Juneau residents are

backcountry skiers. Backcountry skiers often enroll in avalanche safety courses and have a heightened awareness of avalanches. This makes them attentive to avalanches beyond the ski area—in areas such as downtown Juneau. One experienced skier that lives in one of the downtown avalanche hazard zones joked that he "has one [avalanche safety] beacon for skiing and one beacon for sleeping." Juneau's community identity as a ski town contributes to a concern for avalanches, and residents' acquired knowledge about avalanches transfers to their experiences in the city.

However, avalanche awareness does not translate to landslide awareness. While skiers think about avalanches regularly during their visits to Eaglecrest and the Juneau backcountry, most people don't think about landslide hazard during recreational activities. In addition, there have been no landslide awareness campaigns in Juneau, and media coverage of landslides in Juneau is only a fraction of the coverage about avalanches. A government official explained that "Landslides may not be in the news in terms of major events in Juneau, but rock fall is happening all the time. There's random property damage happening all around us all the time through the project area." Nevertheless, interviews with hazard zone residents demonstrate that the lack of long-term public awareness makes landslide risk feel "new" or even "made up."

5.2 Visibility of hazards

Avalanche hazard is visible. Residents watch snowpacks grow as the winter season progresses, and they understand that large cornices along the ridge can collapse to trigger avalanches. Residents also witness small avalanches throughout the winter on Mount Juneau, Gastineau Peak, and Mount Roberts. These small avalanches, while not a threat to people and structures, produce dramatic powderclouds and leave avalanche debris in the runout zones. Avalanche debris can remain visible in runout zones for

weeks or months (Fig. 3). In addition, residents are regularly warned about avalanche control—usually bombing from helicopters—by both the Department of Transportation and Alaska Electric Light & Power. In some cases, crowds even gather to watch the artificially-triggered avalanches come down the mountain (KTOO, 2021). As mentioned in Section 5.1, residents also watch avalanche mitigation take place while skiing at Eaglecrest Ski Area. Clearly, avalanches are a visible part of Juneau's winter environment, and this visibility acts as its own form of avalanche awareness. By watching the winter cycles of snowstorms and avalanches, residents and decision-makers repeatedly confirm the presence of this hazard.

Landslide hazard, however, is not visible prior to the landslide event. Landslides do not occur following the visible buildup of snowpack and there is no ongoing landslide control by agencies like the Department of Transportation and Alaska Electric Light & Power. When landslides do occur, they don't produce the dramatic powdercloud seen



Fig. 3. Avalanche debris on Mount Juneau. Image by author.

with avalanches. Further, landslides debris can even be difficult to spot *after* a landslide event takes place. Unlike the juxtaposition of white snow against bare earth often seen in Juneau (Fig. 3), landslide debris made up of dirt, rocks, and vegetation can blend with its surrounding. When compared to avalanches, landslides are "out of sight, out of mind." Just as decades of public avalanche awareness by the CBJ and other agencies have conditioned Juneau residents to perceive avalanches as dangerous, the visual nature of avalanches themselves also demand heightened attention. Thus, the visibility of avalanches—and the invisibility of landslides—strengthens the inertia of avalanche disasters in Juneau.

5.3 Disaster memories

Finally, memory plays a powerful role in how hazards are prioritized in Juneau. One resident urged caution about landslides at a public meeting in Juneau, stating "I'm one of the last people standing who saw the mud against the cold storage [building] in 1936. It killed people." A recent news article also addressed this landslide, explaining that "Juneau's deadliest landslide tore through town like a 'mighty grinder.' Now it's a fading memory" (Canny, 2024). However, while most people don't remember this landslide event that killed 15 people, many do remember and recirculate stories about the 1962 avalanche in the Behrends Neighborhood. Additional recent avalanche events, such as the 2008 avalanche that damaged Juneau's hydropower facility and the 2021 avalanche evacuations, continue to center avalanches as Juneau's primary hazard. On the other hand, Juneau's lack of memorable landslides has masked the potential hazard. Landslides have not been continuously reinscribed as dangerous in people's memories, leading to less action on avalanches by scientists, hazard mitigation experts, and policymakers. One city official addressed this, stating: "I guess one thing I do find

puzzling, though, is that there's smaller landslides all the time. And it's just an interesting psychology for people not to see these smaller events happening all the time, and being so adamant that there won't ever be a bigger one." The memories of past avalanche disasters work to trivialize the city's growing vulnerability to landslides.

Research on disaster memories shows that communities integrate disaster events into their community history (Moulton, 2015). In Juneau, the power of avalanche memories is reflected in the priorities of hazard zone residents. One resident that currently lives in a landslide hazard zone stated that they "would never buy a house under the Behrends avalanche path." A different landslide hazard zone resident said, "I probably wouldn't live in White [Neighborhood] either"—another avalanche hazard zone. Public comments, resident interviews, and participant observation confirm this widespread mentality. For residents, the danger of avalanches has long overshadowed the potential for deadly landslides. Even as some residents acknowledge the growing landslide hazard, the community's collective memory of avalanche disasters has constructed a deep-rooted concern for avalanches.

Clearly, disaster memories play an important role in the public perception of hazards. While landslide hazard increases in Juneau, memories of avalanches continue to reinscribe avalanches as Juneau's primary hazard. In addition—since Juneau's General Assembly is a publicly-elected assembly that is largely influenced by resident testimony—these public perceptions directly affect local decision-making. In Juneau's latest rejection of landslide hazard mapping, the General Assembly voted unanimously to *not adopt* landslide maps due to heavy pushback from residents in landslide hazard zones. This pushback stemmed from the public's limited understanding of landslide hazard and the potential economic consequences of new landslide hazard zones. The assembly did, however, adopt the latest avalanche hazard maps and associated

development regulations. This shows how disaster memories—and the community history constructed around disaster events—can influence the trajectory of hazard mitigation. Disaster memories contribute to the inertia of disasters and inhibit potential climate adaptation solutions.

6. Conclusion: Shifting Mountain Hazards and the Inertia of Disasters

Downtown Juneau faces dangerous avalanche and landslide hazards, and these hazards are shifting due to climate change. Specifically, long-term avalanche hazard is decreasing while long-term landslide hazard is increasing. Recent deadly and destructive landslides in Southeast Alaska illustrate these changes, such as the 2015 landslide in Sitka, the 2020 landslide in Haines, and the 2023 landslide in Wrangell. In Juneau, however, the longstanding attention to avalanches overshadows the growing landslide hazard. In other words, the *inertia of disasters* obstructs Juneau's ability to adapt to landslides. This paper has analyzed two key explanations for the inertia of disasters in Juneau—the legacy of avalanche science and the power of public perception. Decision-makers repeatedly prioritize avalanche hazards due to the local history of avalanche science, the spatial predictability of avalanches, and the measurability of avalanche damage potential. Public perception has also played an important role in masking the growing landslide hazard through public avalanche awareness campaigns, the visible nature of avalanches, and the persistence of disaster memories. Through these examples, this paper demonstrates that Juneau's relationship with avalanches is obstructing the city's ability to adapt to climate change.

In both scientific research and public perception, the differences between avalanches and landslides are key obstacles for landslide mitigation. Identifying these

obstacles—which are moments when the inertia of avalanches obstructs landslide mitigation—offers new avenues for hazard management professionals to improve public safety and respond to climate change. For example, residents and decision-makers in Juneau have developed a spatial relationship with avalanches. They know the most dangerous avalanche paths, and the city has evacuated certain neighborhoods during periods of extreme risk. However, this paper demonstrates that scientists can predict landslides temporally with great accuracy. Rather than allowing these spatial and temporal forms of knowledge to conflict and result in the rejection of landslide science, the CBJ can work to reframe hazard mitigation on a temporal rather than spatial scale. This could mean implementing an automated landslide warning system for the entire downtown area rather than going door-to-door to recommend evacuation on a specific street. In another example, the disparity between avalanche and landslide awareness causes residents to question the validity of landslide science. Rather than immediately introducing new landslide hazard maps, the CBJ can work to implement landslide education and awareness campaigns. Addressing these key differences between avalanches and landslides can help the city overcome the inertia of avalanches.

This paper also illuminates points for further investigation. First, more research is necessary to understand precisely how avalanches and landslides are spatially and temporally distributed in Juneau—especially in response to a changing climate. Avalanche and landslide experts could collaborate to bridge the spatial and temporal gaps found in each field's knowledge of the hazards. Additionally, social science and decision-making research could study how to better communicate the realities of increasing landslide risk to hazard zone residents. There are emerging examples of this work in Southeast Alaska (e.g., Lempert et al., 2023), but the ongoing rejection of landslide hazards in Juneau demonstrates a critical need for more work on the human

dimensions of hazard risk. Finally, while this study on Juneau is necessarily limited to avalanches and landslides, the inertia of disasters is a concept that can be operationalized in contexts around the world. The paper's site-specific examples of scientific research and public perception may not translate to other regions, yet research in different geographies could demonstrate new ways the inertia of disasters influences local hazard management decisions.

This paper's interdisciplinary work to unpack the physical and social dimensions of changing hazards offers an important contribution to hazard and disaster research. It responds to calls for the blending of physical and human geography (Lave et al., 2014), and it moves beyond blanket assessments of climate vulnerability to build on scholarship that centers the role of history, culture, and science, among other things (Huntington et al., 2019; Moulton & Carey, 2023). Finally, the paper contributes to a growing body of hazard research that applies integrated approaches in the mountains and cryosphere (e.g., Carey et al., 2021). While climate hazards are undoubtedly changing in site-specific ways all around the world, the lessons learned here are widely relevant: there are environmental, scientific, and societal dynamics that directly mediate how shifting climate hazards are perceived and experienced. Future work should continue to assess avalanche and landslide hazard in Juneau, as well as the inertia of disasters in hazard zones around the world.

CHAPTER V

CONCLUSION

When I first visited Juneau in March 2022, it took only moments for me to be warmly welcomed. Within an hour of landing, I was sitting in the passenger seat of city planner Teri Camery's car. Teri was using one of her precious few vacation days and had a flight to catch a few hours later, but she nevertheless gave me a long tour of the City and Borough of Juneau. She even showed me the best smoked fish shop tucked into a warehouse in Lemon Creek—I lived on the smoked black cod and smoked salmon during all my research trips. The next day, Tom Mattice, Juneau's Emergency Program Manager, picked me up in his truck. It was Saturday morning, and he could have been home with his wife, but instead he chose to show me Juneau's avalanche and landslide paths. This generosity continued through that first trip and all the following. Juneau residents welcomed me—a stranger from Oregon—into their homes for coffee and chats lasting far longer than I requested. Mariya Lovishchuk, the director of affordable housing nonprofit The Glory Hall, invited me to join important meetings despite only just learning my name. Mike Janes, local avalanche guru and Alaska Electric Light & Power avalanche forecaster, made space for me in the helicopter as he monitored snow stability above Juneau's power lines. The Juneau community, despite being Alaska's second largest city at over thirty thousand people, has the warmth of a small town. It was this welcoming environment that allowed me to develop research questions, connect with research participants, and, ultimately, write this dissertation. It was the generosity of everyone in Juneau that helped me write the previous chapters.

My dissertation makes several core arguments, which I've situated within the existing literature in the introduction and demonstrated through the individual chapters. First, I argue that political, economic, and legal conflicts create windows of opportunity for powerful actors to influence the trajectory of hazard management. *Hazard Zone Conflicts in the Avalanche Capital* (Chapter 2) shows how various societal conflicts (political, legal, and economic) shape risk and vulnerability at three crucial stages of hazard management: (1) hazard mapping, (2) zoning regulations, and (3) disaster prevention engineering projects. The article demonstrates how hazard mitigation involves a host of intertwined socio-political processes and actors—from experts producing studies and delineating hazard zones to city officials and property owners redefining those maps, zones, and projects. This not only advances existing scholarship by revealing the actors, sites, and moments that lead to vulnerability in a hazard zone, but it also offers a starting point for envisioning more holistic and justice-based strategies for hazard management.

Second, I argue that it is not only inequitable city planning and development initiatives that create unnatural disasters, but also the process of hazard mitigation itself. While hazard mitigation—such as mapping efforts, development regulations, and engineering projects—are designed to minimize hazard vulnerability, they simultaneously and disproportionately distribute new risks throughout the community. *Housing Justice in a Hazard Zone* (Chapter 3) examines how property owners, renters, and housing-insecure groups each experience unique impacts of the 2022 Tetra Tech avalanche and landslide hazard mapping project—and how each group develops their own conceptualization of housing justice in a hazard zone. I show that even the *idea* of adopting hazard maps—the potential economic concerns, the public debates, and the political tensions surrounding the mapmaking process—unleashes a whirlwind of

differential impacts for people in hazard zones. Most importantly, I demonstrate how the demands of property owners often overshadow the needs of renters and housing-insecure groups.

Third, I argue that the momentum of powerful societal forces, such as longstanding avalanche research programs and public awareness campaigns, act as blinders for decision-makers. *Shifting Climate Hazards and the Inertia of Disasters* (Chapter 4) reveals how Juneau's legacy of avalanche research and public awareness of avalanches is inhibiting the city's ability to adapt to growing landslide hazards. In other words, this "inertia of disasters" obstructs the possibility for meaningful and equitable climate adaptation. The findings offered here are relevant for hazard zones around the world, as they exemplify how local environmental, scientific, and societal dynamics can mediate how communities experience climate hazards.

As a broader theoretical contribution of this dissertation, I demonstrate the need to more consistently integrate social justice principles into hazard management and hazard research. While research on unnatural disasters and political ecology has long shown the importance of money and power in the distribution of hazard risk (e.g., Huber, et al., 2017; Peacock & Ragsdale, 2012; Steinberg, 2006; Montano, 2021), few researchers actively study ongoing hazard management through a social justice lens. There are important exceptions, such as the emerging research on housing justice in hazard zones identified in Chapter 3 (e.g., Hendricks & Van Zandt, 2021; Zhang, 2010). However, the bulk of hazard research remains siloed from conversations about justice, instead continuing to focus on more technocratic solutions such as mitigation tools, communication strategies, and city management plans. These are undoubtedly crucial components of hazard risk reduction—and I call for these throughout my chapters and in the following "Policy Implications" section—but they are only part of understanding

hazard risk in a community. As this dissertation has shown, these tools, strategies, plans, and other hazard management "products" must also operate within a social justice lens to create equitable hazard management and climate adaptation moving forward.

Through this dissertation, I also offer a new way to conceptualize "justice" in a hazard zone. Specifically, the analysis of residents by resident type—rather than by traditional environmental justice factors such as race, gender, and socio-economic status—helps expose justice issues in a hazard zone (see Chapter 3). This is also important for the long-term adaptation to Juneau's increasing landslide hazard, as the embedded values of certain resident groups might overshadow the needs and concerns of others (see Chapter 4). In practice, this means redesigning the process of hazard management to better incorporate underrepresented residents, such as renters and housing-insecure groups. In Juneau, this could look like directly soliciting feedback from groups that are less likely to attend public meetings. It could also look like providing knowledge to newer or younger residents who might not have firsthand experience with Juneau hazards. Overall, this requires relearning what successful hazard mitigation looks like, whether in the past (Chapter 2), the present (Chapter 3), or the future (Chapter 4).

Policy Implications

Each of my dissertation chapters includes policy recommendations. This has been an important component of my work from the start, as hazard zone policies are highly divisive and regularly contested. Even when proven effective for managing hazard risk, they often provoke legitimate concerns from residents, decision-makers, and experts. Juneau is a clear example of this—restrictive development policies in the

hazard zones were so unsettling to property owners that Juneau's General Assembly ended up removing the longstanding landslide zone development restrictions. However, in hazard zones around the world, it is often the sole responsibility of policies—whether development restrictions, land use regulations, home buyout programs, and FEMA insurance requirements, among others—to keep people safe from hazards like avalanches, landslides, hurricanes, and floods.

However, the necessity for hazard mitigation policies does not mean that existing or proposed regulations are *good* policies. In fact, research shows that hazard mitigation and climate adaptation policies often benefit wealthier, white property owners (Marino, 2018). Through each of my three dissertation articles, I make policy recommendations for how to improve both the effectiveness and the justice of hazard mitigation practices. In Chapter 2, I recommend that scientists and decision-makers proactively integrate research on local social dynamics into their projects to better understand how people influence the trajectory of hazard management. Specifically, decision-makers should anticipate obstacles and objections to disaster mitigation at all stages of risk identification, assessment, mapping, regulation, and engineering. Thus, rather than relying primarily on the technical aspects of geohazards, disaster risk reduction should involve social scientific analysis of hazard zone politics and economics. As policy, this means contracting interdisciplinary project teams that have diverse knowledge spanning subjects such as geophysical hazards, urban planning, and environmental justice, among others. This not only improves a project's chance of success, but it also incorporates a wider range of community member perspectives into the policymaking process.

In Chapter 3, I recommend the incorporation of social justice work into the hazard mapping and hazard mitigation process. By highlighting the unique impacts

experienced by property owners, renters, and housing-insecure populations—as well as the contradictory concerns within and across the groups—I demonstrate how hazard zone policy decisions can unintentionally disregard the needs of some resident groups and even perpetuate injustices. To avoid this, the chapter calls for a dedicated attention to the needs and concerns of all hazard zone residents during the policymaking process. In some cases, this may even mean prioritizing the risks of a housing crisis over a hazard zone.

Finally, in Chapter 4, I propose that hazard mitigation efforts must pay attention to how hazards are shifting in response to climate change. In Juneau, long-term avalanche hazard is decreasing while long-term landslide hazard is increasing. This demands a shift in policy from the City and Borough of Juneau. In addition to writing policy that can effectively shift alongside climate hazards, the paper recommends that policymakers focus on "inertia of disaster" moments that obstruct public safety decisions. This requires policy writing that is in tune with local social dynamics, such as the unfamiliarity of residents with landslides. This recommendation not only encourages climate adaptation, but it also more closely connects the policymaking process with the local environment and society.

Future Research Directions

While completing this dissertation, I identified two priorities for future research in Juneau. First, as I mentioned in the dissertation's introduction, additional research must attend to the borough-wide justice issues that exist beyond the downtown area. In some cases, lower-income or marginalized groups likely live in unmapped hazard zones. For example, anecdotal evidence suggests that Juneau's prison is in an unidentified

landslide hazard zone. In addition, the Lemon Creek/Salmon Creek area, which is the most racially diverse part of Juneau and has the largest Alaska Native population, has not been adequately examined for potential hazards. Even if hazard mapping is an unpopular option for mitigation, researchers should work with these communities to establish community priorities and possible mitigation strategies. It is not only the wealthier downtown residents that deserve research on avalanches, landslides, and other hazards. Another direction for justice-based research in Juneau is to broaden from avalanche and landslide research to focus on overall climate vulnerability and resilience. While it's important not to frame marginalized communities as passive victims vulnerable to climate change (Carey, 2010)—and it's important to understand that climate change or hazard risk may not be the most pressing issue for some communities (Huntington et al., 2019)—there remains an urgent need to better understand Juneau's justice issues in the context of a changing climate.

Second, future research needs to examine actionable hazard mitigation tools that have the potential to obtain widespread public support. The vote on the adoption of the 2022 Tetra Tech avalanche and landslide hazard maps removed all development restrictions in landslide hazard zones, effectively dismantling one key piece of hazard mitigation that the City and Borough of Juneau used to keep people safe. I am deeply concerned about the potential for a deadly landslide in Juneau, and it is imperative that the city develop hazard mitigation strategies that are also supported by its residents. The answer is clearly not new maps—but there may be other solutions. For example, continuing research should examine the feasibility and public support for a landslide warning system similar to the one being tested in Sitka (e.g., Woolsey, 2022). In addition, while local government officials believe a home buyout program is impossible, research should investigate how the funding and implementation of such as program

might occur. After all, a League of Women Voters survey from 1996 suggests that many residents may in fact be willing to relocate (Juneau League of Women Voters, 1996). Finally, future work should study how to protect individual houses in the hazard zones. A research project could partner with the CBJ to identify funding sources to help individual residents reinforce their houses from avalanches and landslides. The study should also work with residents to determine the type of structural mitigation they are open to building—whether that be retaining walls, the reinforcement of upslope walls and windows, improving their property's drainage, or a different solution. As downtown Juneau isn't going anywhere—the ultimate goal is to keep people safe.

VI

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