Supporting Community Engagement in Wildfire Resilience Planning in Boulder

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in collaboration with

Erin Fried and Maya MacHamer from

THE BOULDER WATERSHED COLLECTIVE

Supporting Community Engagement in Wildfire Resilience Planning in Boulder

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by

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Abstract

Climate change has dramatically affected the lives of residents in the Front Range of Colorado. In 2020 and 2021, Boulder experienced unpredictable weather conditions leading to the most destructive wildfires in the county's history. We worked with the Boulder Watershed Collective to gauge perceptions of wildfire risk and effectiveness of emergency communication among area residents of Boulder, Superior, and Louisville. We identified opportunities for engagement including public service announcements and outreach events for residents.

Acknowledgements

We would like to acknowledge the contributions of Professor Ingrid Shockey and Professor Leslie Dodson of Worcester Polytechnic Institute as well as Ms. Maya MacHamer and Ms. Erin Fried of the Boulder Watershed Collective for helping shape this project.

We would also like to dedicate this project to our local liaison Linda Amos, without whom we would not have been able to perform our research.

Authorship

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Meet the Team

Emily Abbe

Hello, my name is Emily Abbe and I am from Warren, Massachusetts. I am currently pursuing a degree in aerospace engineering at WPI. It has been an amazing experience working with my team on this project and immersing myself in the natural Rocky Mountain landscapes.

Het Patel

Hi, I am Het and I am pursuing a degree in biomedical engineering at Worcester Polytechnic Institute. Growing up in rural India has taught me the importance of nature in a world competing to urbanize. My passion for nature and tackling the issues that have arisen with a changing climate has culminated in this report. I hope that my team can be the catalyst for facilitating community engagement in Boulder.

Ritesh Prasannakumar

Greetings, my name is Ritesh Prasannakumar and I am from Holliston, Massachusetts. I am currently pursuing a degree in civil engineering at WPI. I am humbled by the opportunity to make an impact in the local community.

Ethan Turett

Hey, I'm Ethan Turett, a robotics engineer (in-training) from Irvington, New York. I've always wanted to live in a mountainous region, so this opportunity to simultaneously live in the mountains and learn about the local perspectives on the ecology has been fascinating and eye-opening.

Executive Summary

The effects of climate change in the Rocky Mountain West have led to longer droughts, higher temperatures, and less precipitation, all of which make the region more susceptible to wildfires. Furthermore, wildfires in the region have been burning with increased frequency and intensity. In 2020 and 2021, the Front Range experienced wildfires of unprecedented destruction and size, including the Marshall and Cameron Peak Fires. In December, 2021, the Marshall Fire that struck the towns of Superior and Louisville, adjacent to Boulder, destroyed 1,084 homes and caused more than $513 M in damage across Boulder County (Phillips, 2022). The Marshall fires were preceded by the Cameron Peak fires, which were the largest fires in state history, burning 208,913 acres in 2020.

Figure 1 – Ruins of homes in the Davidson Mesa Neighborhood, Louisville, from the Marshall Fire

The Boulder Watershed Collective, the non-profit organization sponsoring our project, collaborates with communities on wildfire resilience strategies. The scope of our project included documenting perceptions of wildfire risk across high-risk neighborhoods in Boulder, investigating experiences of emergency communications during Boulder-area wildfires, and gauging interest in and opportunities to participate in wildfire resilience

networks in Boulder. To the last point, the Watershed Collective is planning to kickstart a City Wildfire Neighborhood Ambassador Program, a wildfire resilience networking opportunity for community members and leaders alike.

Background

We analyzed factors that contribute to wildfires including the climate conditions. A recent report by the United Nations Environment Programme (UNEP) warns that "wildfires are projected to rise by 50 per cent by the end of the century due to the climate crisis" (UN Environment, 2022). Researchers modeling climate change found that warming temperatures made forests more arid, increased the fire risk, and expanded the area burned in the western part of the United States between 1984 and 2015 by about 4.2 million hectares (Abatzoglou et al., 2016).

This is especially significant in Boulder, as the Front Range of Colorado is currently in the driest 22-year period that the West and Southwest U.S. have seen in at least 1,200 years (Cameron Peak: Fighting Fire Together, 2021). In February 2022, the percent of average precipitation compared to usual conditions was below 50% across Boulder (Yulsman, 2022). Increased aridity and lower precipitation is especially dangerous in the city of Boulder, which is located in an intersection between urban development and wildlands, known as a wildland-urban interface, that allows wildfire to easily transition between the two entities (Radeloff et al., 2005). The frequency of wildfires and the rate of wildfire-caused property damage has been increasing in Boulder County (Boulder County, 2022)

Figure 2 - WUI at the edge of the Foothills Neighborhood

Approaches

Our objectives guided our methods, which primarily consisted of interviews and site assessment. Interviews are an effective way to gain detailed insight into people's experiences with both pre-2020 and recent wildfires. In order to find specific information about wildfire communications in Boulder, we developed additional interview questions to add to those assessing perception of risk.

Findings

One major finding was that the perceived wildfire risk in Boulder has heightened for many residents since 2020. The Marshall Fire seems to have amplified the perceived risk most significantly. We learned through our interviews that despite the wildfire risks present in Boulder, many residents perceive the city as well-prepared given the ecological circumstances of the region, especially when compared to other, smaller municipalities. Other factors contributing to concerns about fire center on the fact that Boulder buildings are often built close together, allowing for quick wildfire spreading, and many residents cite this as a primary preparedness issue in Boulder. Many residents also held the perception that wildfires could be largely mitigated through controlled burns and the reduction of dry vegetation. Perceptions regarding the effectiveness of emergency communications during wildfires in and around Boulder were divided. In our small sample of interviews, we found that the experience and problems in the communication methods largely varied by proximity — residents closer to the Marshall fire were more likely to rate the communication methods as inadequate, while those

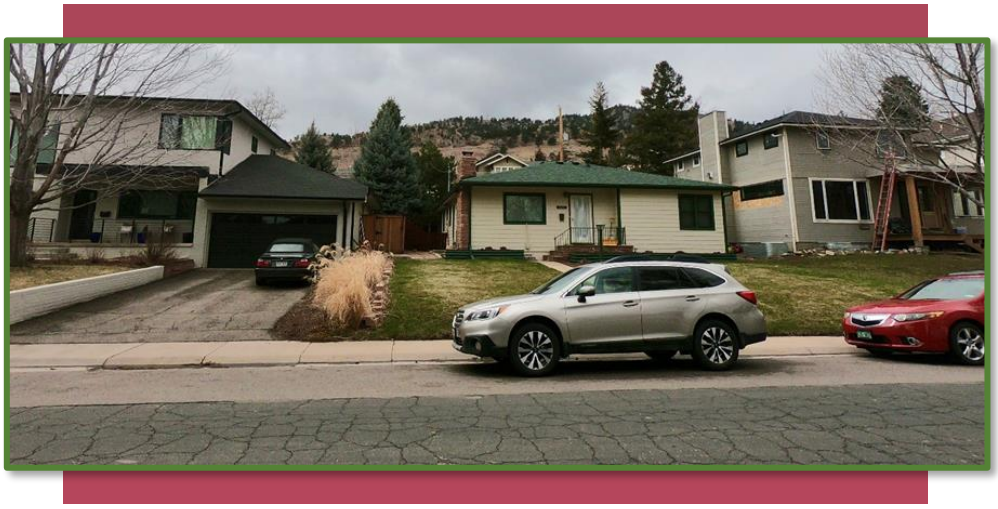

Figure 3 – Tightly packed, mostly-wooden homes connected by wood fences and dense vegetation.

further from the fire rated the communication methods more generously. We found that most respondents were interested in attending informational sessions in the form of webinars on fire resiliency. Additionally, shorter digital and analog information would also be welcome

Recommendations

Recommendation 1: Design and distribute an instructional pamphlet, physical and digital, for packing a to-go bag and signing up for county emergency alerts.

Figure 4 – Public transport advert we created to provide easy access to official city emergency alert systems

Recommendation 2: Designate a "Wildfire Awareness Month" to focus attention on the issue of wildfires, involving events and media related to the topic.

Recommendation 3: Utilize serious games, trivia, etc. in order to gamify the wildfire resilience education process

Recommendation 4: An event aimed at residents with animals, such as a pet social, could be used to workshop the creation of pet evacuation plans and rescue networks.

Recommendation 5: Petition the city to pay for advertisements in public transportation, such as buses , relating to emergency notification services residents can sign up for and packing to-go bags. Each Public Service Announcement (PSA) should contain a QR code linking to web pages with further information or forms to opt into wildfire alert systems.

Recommendation 6: Create and utilize non-fungible tokens (NFT) related to wildfires and resiliency in order to raise funds for community initiatives.

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Chapter 1: Introduction

The effects of climate change in the form of higher temperatures in the West have led to longer droughts and less precipitation, which make the region more susceptible to wildfires. Wildfires in the West have been burning with increased frequency and intensity. As of mid-2022, the Front Range of Colorado was in the driest 22-year period that the West and Southwest U.S. had seen in at least 1,200 years (Cameron Peak: Fighting Fire Together, 2021). In 2020 and 2021, the Front Range experienced wildfires of unprecedented destruction and size, including the Marshall and Cameron Peak Fires. In December, 2021, the Marshall Fire that struck the towns of Superior and Louisville, adjacent to Boulder, destroyed 1,084 homes and caused more than $513 million in damage across Boulder County (Phillips, 2022). Many residents were rendered homeless and will not be able to return and rebuild their homes for many years. The Marshall fires were preceded by the Cameron Peak fires in 2020, which were the

Figure 1: Remains of trees at a Davidson Mesa burn site (photo credit: Emily Abbe).

Figure 2: One of the largest burn sites at the Davidson Mesa burn site (photo credit: Emily Abbe).

largest fires in state history, burning 208,913 acres. In the wake of these and other area wildfires, local and regional agencies have come together to develop strategies to improve the community's resilience to the increased fire risk.

It is estimated that a majority of the US population and employment growth by 2050 will occur in eight to ten mega-regions (Wheeler, 2009, p. 865). The Front Range is one of these mega-regions, spanning the I-25 corridor from Pueblo, Colorado to Cheyenne, Wyoming. This area encapsulates some of the fastest growing cities and suburbs in the United States. For example, the population of Denver between 1980 and 2020, grew from 492,686 to 715,522 residents (U. S. Census Bureau, n.d.). Population growth is not just limited to the cities. In suburban Boulder County, the population increased from 189,625 to 330,758 in these same four decades (U. S. Census Bureau, n.d.).

The Boulder Watershed Collective is a local organization dedicated to improving wildfire resilience, specifically the community's ability to adapt to the changing nature of wildfire in and around Boulder, Colorado. The Collective is a "stakeholder-driven organization" that works closely with communities in Boulder and Larimer counties by providing education, surveying local needs, and developing proposals for wildfire resilience (The Boulder Watershed, 2022). Like many organizations in the Front Range, the Boulder Watershed Collective has done extensive work in rural areas, but the suburban landscape, largely affected and threatened by the Marshall Fires, brings unique challenges when developing community resilience. In addition to irreparable damage to fragile ecological buffer zones, wildfires in a populated urban or suburban center can threaten and displace thousands of people in an instant. Long-term consequences could include population migration from regions prone to wildfires, in turn isolating remaining residents, changes to housing stock, damage to the economy, and a narrowing of the cultural spectrum of the area (The Boulder Watershed, 2022).

To help the Watershed Collective collaborate with regional communities on wildfire resilience strategies, our project supported community engagement in wildfire resilience planning in the city of Boulder. Our scope included documenting perceptions of wildfire risk across high-risk neighborhoods in Boulder, investigating experiences of emergency communications during Boulder-area wildfires, and gauging interest in and opportunities to participate in wildfire resilience networks in Boulder.

Timeline of Major Wildfires in Colorado

JUL 1989

Black Tiger Fire, considered the most destructive fire in terms of property loss and damage at that time, burned 2,100 acres and destroyed 44 homes in 6 hours

JUN 2002

Hayman Fire burned 137,760 acres, caused more than $238 million in damages and destroyed a total of 133 structures

SEP 2010

Fourmile Canyon Fire burned 6,181 acres and destroyed 168 structures with estimated claims up to $217 million

JUN 2012

High Park Fire burned 87,415 acres and destroyed 259 homes with damages of $151 million

JUN 2012

Waldo Canyon Fire burned 18,247 acres and 347 homes and resulted in estimated insurance losses of $454 million

JUN 2013

Black Forest Fire burned 14,280 acres and destroyed 511 homes with damages as high as $423 million

JUL 2020

Pine Gulch Fire burned over 30,000 acres overnight and had a total damage of 139,007 acres

AUG 2020

Cameron Peak Fire burned 208,913 acres and destroyed 469 homes

OCT 2020

East Troublesome Fire burned 193,812 acres along with 366 residences and 214 commercial structures

OCT 2020

Calwood Fire burned 10,113 acres and was a couple days after the East Troublesome Fire, destroyed 26 homes and caused $37 million in damages

DEC 2021

Marshall Fire burned 6,080 acres and destroyed 1,084 homes becoming the most destructive wildfire in state history; led to damages of $513 million

MAR 2022

NCAR Fire burned 190 acres in the Table Mesa neighborhood near the National Center for Atmospheric Research

Cameron Peak Fire:

The Cameron Peak Fire of 2020 was the largest wildfire the state of Colorado has faced in terms of the acreage burned. The fire burned for almost four months, burning a total of 208,913 acres. While the cause of the fire remained under investigation, it is believed to be a human-caused fire.

East Troublesome Fire:

The East Troublesome Fire was first reported on October 14, 2020. Within three days, the fire burned over 10,000 acres with the help of the high winds and low humidity. Between October 20 and October 23, the fire more than tripled in size, increasing from 18,550 acres to 187,964 acres within the span of this time. The cause for this fire remains under investigation.

Calwood Fire:

The Calwood Fire was first reported on October 17, 2020. Although this fire did not last long, it had a rapid spread of nearly a thousand acres per hour. The Calwood Fire burnt 10,113 acres and damaged 26 structures. It was fully contained on November 14, 2020.

Marshall Fire:

The Marshall Fire is widely considered as the most destructive fire in terms of property damage in state history. With a burn perimeter of 6,080 acres, the fire swiftly swept into the neighborhoods of Louisville and Superior and burned 1,084 homes and led to damages of over $513 million. The cause of the fire is under investigation.

NCAR Fire:

The NCAR Fire started on March 26, 2022 near the National Center of Atmospheric Research. The fire burned a total of 190 acres in the Table Mesa neighborhood. The fire was 100% contained on March 31, 2022. Preliminary reports suggested that the NCAR Fire was human-caused, but authorities continue to investigate as of May 2022.

Chapter 2: Wildfire resilience and dynamics in Boulder, Colorado

There is no one-size-fits-all approach to wildfire resilience planning. While there are many factors that affect wildfire resilience planning, factors such as topography, population data, climate change and weather of the study area all affect fire dynamics. This chapter also introduces the stakeholders and research focusing on understanding attitudes and practices that support fire resilience. We begin with a deeper look at the city and our partners.

2.1 The complex geography of Boulder, Colorado

Little is known about Indigenous communities in the Front Range before White settlers, but records indicate that it was primarily a rangeland for wild animals (Exploring

Figure 3: Panoramic camera shot of the City of Boulder (photo credit: Het Patel).

Colorado's Rangelands, n.d.). Located on the eastern edge of the Rocky Mountains, the area around Boulder was considered inhospitable by the early European settlers. In the 1800s, the area was a small mining town on the frontier, and the city of Boulder gradually became an important urban hub in Colorado in part with the founding of the University of Colorado in 1861 ("Boulder, CO History," n.d.). Today, Boulder has a flourishing local economy and a beautiful natural landscape that attracts a sharply increasing number of new residents and visitors. Most of the original mines are no longer in operation, having been replaced by industries specializing in science and technology research, and businesses which service the outdoor recreational industry ("Boulder, CO | Data," n.d., "Key Industries & Companies," n.d.).

To manage the pressures of rapid development, Boulder developed a growth-management plan that limits the amount of urban expansion in the city boundaries in order to preserve the rural landscape and natural mountain backdrop ("Boulder Valley Comprehensive," n.d.). However, development has stretched into the areas known as Wildland-Urban Interfaces (WUI), where buildable land intersects with protected land. While the proximity to natural landscapes is part of the appeal of Boulder, these zones are at increased risk from wildfires. While some grasslands are fire-adapted ecosystems that periodically burn, the suburban communities and WUIs are not reliably fire-adapted. Large swaths of fire-fuel, in the form of tall, dry grass, run all the way up to the side of residential

Figure 4: High fuel grasslands and wooden construction in North Boulder (photo credit: Yasmine Aoua).

properties (Figure 1). Many properties in the Foothills community of North Boulder are wooden homes that are closely bunched together, often with trees and brush between

them. Buildings in the WUI allow wildfires to transfer easily from the surrounding wild grasslands to nearby houses.

A recent report by the United Nations Environment Programme (UNEP) warns that "wildfires are projected to rise by 50 per cent by the end of the century due to the climate crisis" (UN Environment, 2022). Climate researchers found that warming temperatures made the forests more arid, increased the fire risk, and expanded the area burned in the Western part of the United States between 1984 and 2015 by approximately 4.2 million hectares (Abatzoglou et al., 2016). This is especially significant in Boulder, as the Front Range of Colorado is currently in the driest 22-year period that the west and southwest U.S. has seen in at least 1,200 years (Cameron Peak: Fighting Fire Together, 2021). In February 2022, the percent of average precipitation compared to usual conditions was below 50% across Boulder (Yulsman, 2022). The increased aridity and lower precipitation has increased wildfire risk across Boulder county. The frequency of wildfires and the rate of wildfire-caused property damage has been increasing in Boulder county (Boulder County, 2022).The consequences of these climate crises have serious implications for residents and planners in Boulder County.

2.2 Understanding WUI dynamics in strategic planning

Various best practices that can be implemented with regard to wildfires in the WUI communities involve quickly identifying and securing priority sites for conservation in the face of strong development pressure in WUI areas (Radeloff et al., 2005). Figure 2 below shows the progression of land, in terms of human development, from wildlands to urban centers (City of Redwood City, 2022). The wildland-urban interface falls close to suburban regions and is especially dangerous due to the amount of unmanaged vegetation and number of residents living there (U.S. Fire Administration, 2021). As the state of Colorado finds new ways to accommodate its growing population, development on WUI could be a potential solution. However, that strategy involves an understanding of the risks. Experts say land use planning and zoning should take into account the ecological principles and fire dynamics present in WUIs (Radeloff et al., 2005).

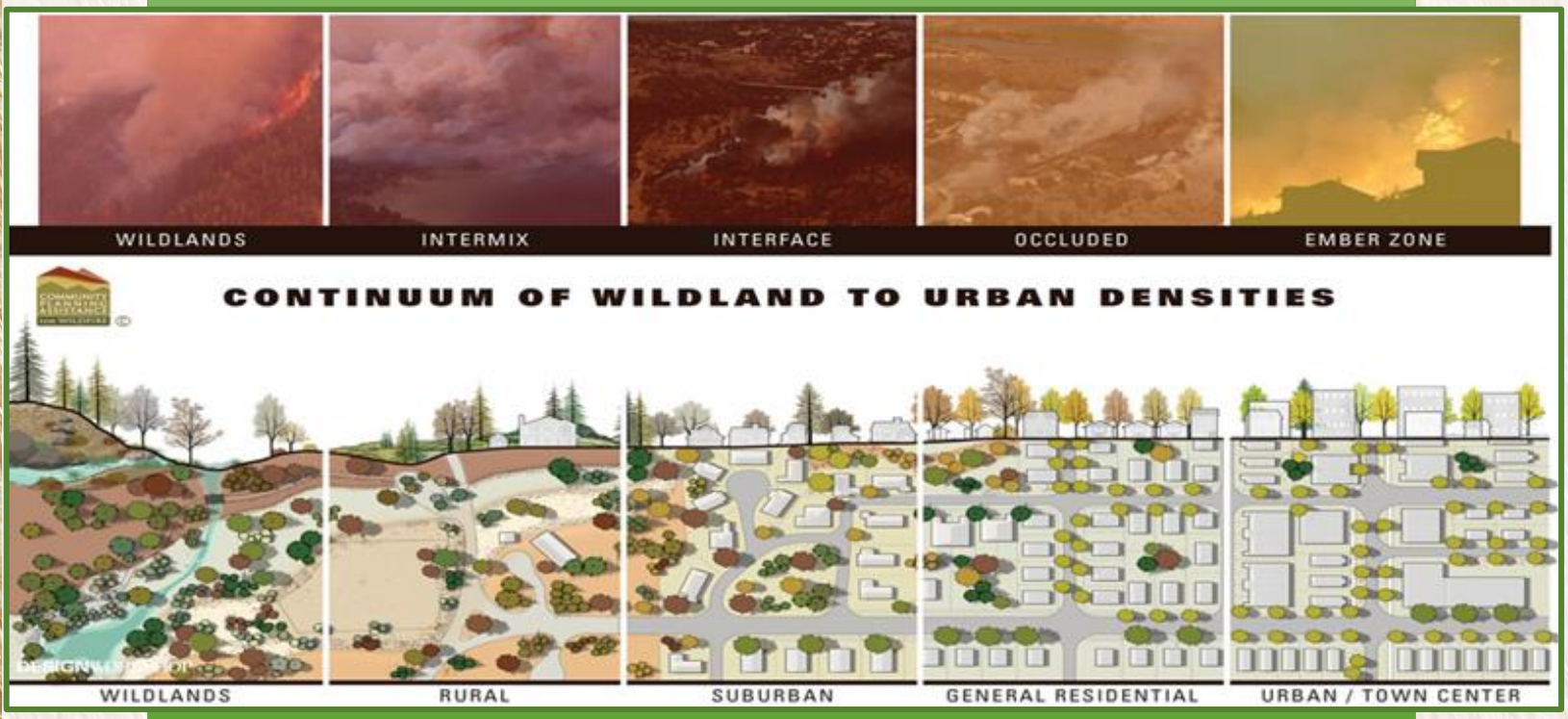


Figure 5: Continuum of WUIs from Wildlands to Urban Town Centers ("California Wildland Urban Interface", n.d.).

Although the WUI provides an explanation on why wildfires may spread in an environment such as Boulder County, the cause of the recent fires themselves is still under investigation (as of April 2022). Underground coal mine fires were considered as a possible cause of the Marshall Fires. At least two Colorado wildfires in the past 20 years have been attributed to mine fires that spread to the surface (Brown & Slevin, 2022). Brown and Slevin (2022) note that "underground coal seams are known to burn unpredictably and can break through to the surface without warning soon after a fire starts" (p.1). Another possible location for the start of the Marshall Fire was the Twelve Tribes community, a religious sect located between Boulder and Superior, that had a shed that caught fire and burned down the day of the fire (Bradbury, 2022). It is likely the WUI played a pertinent role in the propagation of the fire from the wildlands to the cities of Boulder, Superior, and Louisville.

2.3 Existing approaches to resilience in Boulder

Boulder has a long history of wildfires. The 1989 Black Tiger fire that destroyed 44 homes was, at the time, "the most destructive wildfire in terms of property loss and damage in Colorado history" ("The Black Tiger Fire," n.d.). The city of Boulder took precautions to limit further damage, issuing a mandate that all non-fire-retardant-treated wood roofs needed to be removed by January 1st, 2014, and to replace it with roofing approved by the International Building Code as adopted by the city ("Roofing Inspection and Insulation," 2021).

Boulder has building codes in place to prevent the spread of wildfires, but lawmakers and fire experts warn that they might not be adequate. Since Colorado is one of the "home-rule" states, local governments can establish their own "sets of codes and standards specific to their community" (Bueche & Foley, 2012, p.1). The fact that there is "no statewide building code" has only exacerbated the situation when it comes to wildfire resilience (Bueche & Foley, 2012, p.1). Boulder County saw stricter regulations as to how one and two family dwellings should be constructed in 2015 with the addition of Section R327 to the Boulder County Building Code Amendments (2015) ("Boulder County Building," n.d.). Some changes included requiring homes to have noncombustible gutters and downspouts, spark arrestors where heat sources are present, no fences made of non-

ignition-resistant material, and eaves protected by metal drip edges ("Ignition-Resistant Construction," 2018). However, these restrictions are only present on new "buildings, additions and repairs," without any requirements for pre-existing homes ("Ignition-Resistant Construction," 2018). Since wildfires are endemic to most areas of the state, state-wide policies with stricter building regulations must be proposed for all areas including homes that are built on grasslands for increased resilience to wildfires (Colorado Wildfires, 2012).

Resilience, though, goes beyond structural changes and code regulations. Affected communities benefit from coordination, outreach, and communication. Understanding the infrastructure of fire management and resilience strategies is just part of the problem.

2.4 Partners and stakeholders in community action

As seen during the Cameron Peak, East Troublesome, and the Marshall Fires, wildfires, droughts, and intensifying climate change coupled with the lack of preparedness in urban and suburban areas can be devastating. These factors make developing partnerships that can support communication and action between stakeholders and local agencies an ever more crucial form of resilience. Primary stakeholders include directly affected residents in Boulder County, whose properties were destroyed by the fast-moving Marshall Fire of December 2021 that destroyed more than 1,000 homes and caused at least $513 million in damage across Boulder County (Phillips, 2022). These residents have been gravely affected. Most lost not just property, but also memories and

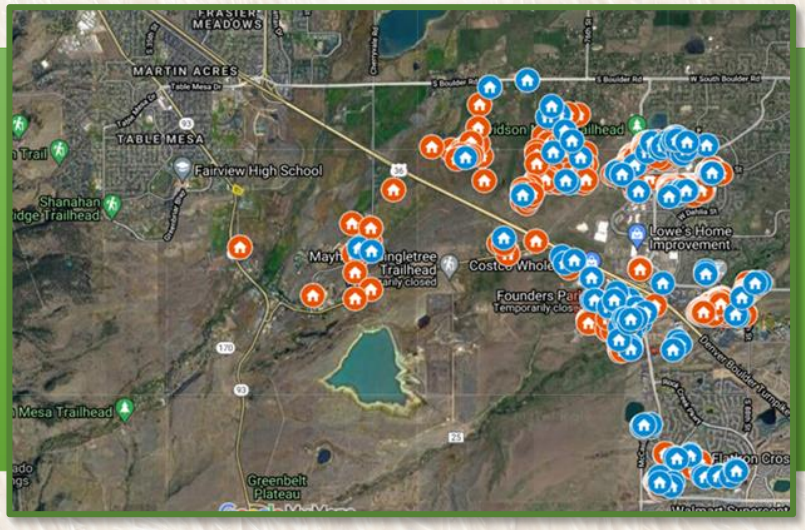


Figure 6: This image (adapted from the Colorado Sun) shows the neighborhoods affected by the Marshall Fires. Red symbols signify homes that were destroyed completely. Blue symbols depict houses that were partially damaged (Fish & Paul, 2022).

livelihoods, and they face an uncertain future. The fire fully destroyed neighborhoods, devastating community networks (Figure 3).

Many residents survived the Marshall Fire but they suffered the indirect impacts associated with the wildfire. Most of the county experienced a serious reduction in air quality (City of Louisville, 2022) This impacted local communities the most, but the particulates spread across the country as a hazard that can accumulate in the lungs making it dangerous to be outside. These particulates can cause negative health effects immediately or into the future (Wiedinmyer et al., 2022). Volatile organic compounds emitted from the wildfire can also collect in the HVAC systems of homes and can be toxic to humans (Wiedinmyer et al., 2022). Residents with no property damage consequently still have concerns about their vulnerability as a community, as secondary impacts could affect them. Questions have also been raised about wind-borne particulates, even months after the fires.

State-level governmental agencies also have a critical role to play. The Colorado Department of Natural Resources, the Boulder County Government, the municipal local governments, and their respective decision-makers, were tasked with addressing the fall-out from these fires. Building partnerships for action can catalyze sustained shifts in resources and attitudes. While governmental agencies are motivated by the electorate, local NGOs operate with academic, scientific, and community engagement services.

Finally, Boulder County has extensive biodiversity, with 3,154 different species identified by residents of Boulder County in an open survey conducted by the county government (Boulder County Wildlife, n.d.). Approximately 6,000 acres of land was burned by the Marshall wildfire (Hamm, 2021), with much of the wildlife facing a potential loss of habitat in a time of increased pressure from climate change and urban development (Fonesca, 2021). At the same time, wildfires can also allow for greater biodiversity — the patch-mosaic model is the idea that low-intensity wildfires can disrupt the ecosystem in certain sections to create new microhabitats with life that otherwise might not thrive there (Arnold, 2021).

2.5 Catalysts for change: The Boulder Watershed Collective

The non-governmental organization Boulder Watershed Collective has launched and completed a series of projects regarding ecosystem health, including replanting burned woodlands, restoring miles of stream, and removing mine tailings posing a threat to the health of the watershed ("About Boulder Watershed," n.d.). Initially created in 2015 as the Fourmile Watershed Coalition to provide assistance after the 2013 Colorado flood event, the organization has since expanded their outreach. Their work primarily takes place within the Boulder Creek watershed, a 286,000-acre area that spans the continental divide to the plains of the Front Range north of Denver ("About Boulder Watershed," n.d.). The Collective is committed to considering land health at the watershed scale, since any contaminants released into the upper sections of the watershed will eventually reach rivers and streams and carry those contaminants downstream to affect the rest of the land in the watershed. Such contaminants include charred debris from wildfires. Wildfires can also make the top layers of burned soil more hydrophobic, increasing runoff and risk of flooding downstream, which can further spread wildfire contaminants ("What is Boulder," 2021). The Boulder Watershed Collective has thus been trying to improve wildfire resilience to combat the destruction and poisoning of the watershed. They take a stakeholder-driven approach in which they work closely with communities in the area to understand, recognize, and address their needs with regards to wildfire mitigation and forest restoration ("About Boulder Watershed," n.d.).

The Collective has collaborated with the University of Colorado to build an understanding of how ecosystem planning plus the values, perspectives, and strategies of the residents can be organized for better resilience ("Gold Hill Collaboration", n.d.). To gain a holistic sense of how to approach wildfire forest management, the Boulder Watershed Collective initiated a 100-acre forest restoration project, which includes thinning the overly dense forests and removing fuel, on wildfire-afflicted land adjacent to the town by bridging communication between the government and private landowners ("What is Boulder", 2021). The Collective has planted more than 24,000 plants and trees and restored the health of over 13,000 feet of stream ("About Boulder Watershed", n.d.).

Community visioning

An example of the Watershed Collective's approach to collaboration with local residents can be seen in the Community Visioning Event workshop at Gold Hill in 2021. This event was held as part of a long campaign of community engagement with residents, which included surveying and interviewing the residents as well as creating educational media and hosting wildfire education programs. Members of Boulder Watershed Collective prompted residents to imagine what their community might look like in five years without any changes and asked the attendees to discuss how they think their community could look in five years under ideal conditions. Inviting reflection and envisioning different futures can support planning particularly in a time of climate change.

Figure 7: This image shows the site of one of the Boulder Watershed Collective's forest restoration projects (photo credit: Julien Blundell, Brian Chamberlain, Korey McQuaide | University of Colorado MENV Program).

The Collective also evaluated the risk perception — how endangered one believes themselves to be with regard to wildfires — among residents in Durango, Colorado, where the Vosburg Pike fire came within ten miles of the city. Residents who experienced this nearby fire developed two distinct attitudes: First, the wildfire served as a post-exposure wake-up call, in which individuals had greater awareness of risks and stronger motivations to engage in mitigation after the event. Alternatively, the wildfire resulted in a post-exposure letdown in which individuals believed they were the victims of a low probability hazard event unlikely to happen again. This belief coincided with individuals reporting feelings of safety, perceptions of being at low risk for future disasters, and lower motivations to engage in mitigation actions (Larsen et al., 2021). The study indicates the value of measuring perceptions and attitudes as part of community engagement so that complacency in terms of wildfire can be addressed.

2.6 Learning from wildfire policies in Oregon

Oregon is championing wildfire prevention. In 2019, the governor identified three goals for wildfire management which were in compliance with the best practices as suggested by the National Cohesive Wildland Fire Management Strategy. Those goals were "creating fire-adapted communities, restoring and maintaining resilient landscapes, and responding safely and effectively to wildfires" ("State of Oregon," n.d.). The notion of fire-adapted communities is best defined as communities coexisting with wildland fire ("Fire Adapted," n.d.). Fire-adapted communities increase diversity and promote the growth of healthy ecosystems ("Wildfire Impacts," n.d.). The state of Oregon has also appointed an adaptation and recovery committee to examine the impact of wildfires on public health ("State of Oregon," n.d.). This adaptation and recovery committee assesses the psychological effects of wildfires as well as their economic burden on the state ("State of Oregon, n.d.). Oregon is the only state that has a committee dedicated to improving community engagement so as to improve community recovery efforts and wildfire prevention. The state government has also proposed Senate Bill 287 and Senate Bill 248, which would facilitate the mapping of wildfire risk in the state. Oregon also plans to update its building codes to enforce new policies in fire-prone areas which includes mandating defensible spaces in conjunction with home hardening to prevent large-scale wildfires (Profita, 2021). Oregon's focus on community welfare and input to shape policies has interesting parallels for Boulder's efforts to support community engagement in wildfire resilience planning.

2.7 Summary from our literature review

A review of the events of the Marshall Fire and scholarly literature reveals three important points. First, by analyzing attitudes, researchers can gain a better understanding of perceptions of fire and related issues. Second, case studies in community engagement can apply to Boulder. And finally, an effective approach to wildfire resilience relies on education, community visioning and participation, and resources across many dimensions of community life.

Chapter 3: Listening to stakeholders: our approach

This project that supported community engagement in wildfire resilience planning in the city of Boulder, Colorado is composed of three primary objectives:

- Document perceptions of wildfire risk across high-risk neighborhoods in Boulder
- Investigate experience of emergency communications during Boulder-area wildfires
- Gauge interest and opportunities in participating in wildfire resilience networks in Boulder

To satisfy the overarching goal, we developed a specific methodology for each objective.

3.1 Document perceptions of wildfire risk across high-risk Boulder neighborhoods

Site assessments helped us identify and understand wildfire risks in high-risk neighborhoods in Boulder. Visual assessment of building materials and development patterns were designed to provide an understanding of risk factors. We photographed sites so that factors could be identified and documented. We also wanted to understand the scale of destruction facing our stakeholders. Site photographs enabled us to visually understand the experiences of our interviewees.

We sought to understand perceptions of wildfire risks within different neighborhoods using a mixed-methods approach, including one-on-one interviews and group interviews with residents of high-risk neighborhoods. Interviews are an effective way to gain detailed insight into people's specific experiences with both pre-2020 and recent wildfires. From these experiences and pointed questions, we gleaned their risk perceptions as they relate to past wildfires around the Boulder-area, such as the Calwood Fire, Marshall Fire, and NCAR Fire. We interviewed residents of Boulder with open-ended

questions about these risk perceptions and with regards to their experiences living through Boulder and outside-of-Boulder wildfires. We further assessed their risk perception through survey questions that asked them to rate a subject from 1-10 on topics such as how well they felt the city was prepared for wildfire events.

In order to understand the wildfire risks the residents of Boulder experienced, we developed a set of interview questions (See Appendix A for details). The interview questions were modified depending on the needs of the interviewee (such as short form and long form interview questions), so that we could hear more detailed perspectives on the wildfire experiences of experts on the matter while keeping the interviews for most of our interviewees relatively brief (10-20 minutes long). We conducted in-person, semi-structured interviews that sought to identify participant associations with the ecology of the area, participants' fears of wildfires, and their outlook on how well they think the city has been addressing these fears. In both the short and long versions of the interviews, one team member led the conversation while another took typed or handwritten notes, often in a quiet room in order to avoid interference with the voice recordings. The interviews were recorded with consent via TASCAM audio recorders (See Appendix B for details). The recorded interviews were used to extract quotes from past interviews for use in our final project recommendations.

Figure 8: One of our early interviews (photo credit: Emily Abbe).

The Boulder Watershed Collective, contacted community leaders within the Orange Orchard, Hartford-Yale, and University Hill neighborhoods of the city of Boulder. Our team chose these three communities from a map of neighborhoods they were interested in sampling because they each are at different proximities from the Marshall Fire. We expected this sample to be an opportunity to observe how wildfire perceptions relate to

distance to the most destructive fires. As our project progressed, we adapted this plan in order to group neighborhoods by proximity to the Marshall Fire: the northern neighborhoods include Newlands, Foothills, Orange Orchard, and North Broadway-Holiday, the middle neighborhoods include University Hill and Downtown, and the southern neighborhoods include Table Mesa and Hartford-Yale. Additionally, we interviewed residents from unknown locations and from outside Boulder. We categorized interviewees that are unknown or outside Boulder County together, and categorized interviewees that are from Superior and Louisville since they were the two areas hit the hardest by the Marshall Fire.

In addition to one-on-one interviews, we conducted group interviews. Although the team was not actively seeking to engage groups for interviews, when the opportunity presented itself, we conducted an interview using the same one-on-one interview questions but pointed towards the group as a whole. Our format was designed to foster a more natural conversation about wildfires and the communication during the events

3.2 Investigate experience of emergency communications during Boulder-area wildfires

We investigated both how officials throughout Boulder County communicate wildfire warnings to its citizens and how that experience was received by the residents. In order to find information about the experience of emergency communications in Boulder, we developed additional interview questions to add to those assessing perceptions of risk. We asked residents specifically about communications received from Boulder County during the Marshall Fire and other wildfires. As a conversational prompt, we developed a Likert scale rating. We asked respondents to rate the effectiveness of the city's fire warning communication systems on a scale of 1-10, with 1 being the worst and 10 being the best, which provided an intuitive way to compare the perceptions of interviewees from varying demographics.

We utilized archival research to determine the processes associated with emergency communications, which are often sent out by county and local governments during natural disasters like wildfires. It was useful to acquire archived emergency

communications (texts, emails, alerts, etc.) for different fires (NCAR, Marshall, Calwood) and compare them to each other. This made it apparent which platforms for communication were used for each fire specifically, and it indicated how the warning messaging systems have evolved from fire to fire. We also evaluated other scenarios in which Boulder County relays essential information to its residents, such as through sirens that exist throughout Boulder that alert people of encroaching tornadoes, but not wildfires.

3.3 Gauge interest and opportunities in participating in wildfire resilience networks in Boulder

The Boulder Watershed Collective would like to host a City Wildfire Neighborhood Ambassador Program, to educate individuals about key strategies to use in neighborhood preparations for wildfires. The individuals who attend an informational session could ideally help spread the acquired knowledge to other people in their neighborhood. We gauged interest in such wildfire resilience events through the use of pointed interview questions. A brief description of the program was provided, after which the interviewee was provided with a yes/no prompt to indicate interest in participating in the informational session. While this step is preliminary to the strong commitment to community engagement through the ambassador program, it provided an avenue for many who would otherwise not to become involved in wildfire resilience. Our interview conversations were followed by an opportunity to work with others to improve wildfire resilience, possibly prompting some of our interviewees to become more active in local wildfire preparedness endeavors.

Chapter 4: What we learned from our fieldwork in Boulder

4.1 Findings

We discovered a range of perceptions and experiences related to local wildfire resilience planning and overall interest in preparedness for wildfires. From our conversations with residents from the three zones in the scope of this study (North Boulder, Central Boulder and South Boulder) we often received comments about "communication experiences," "trust in agencies," and the meaning of a healthy "ecology." Our key findings highlight these and other perceptions related to fear and uncertainty in the aftermath of the fires.

Objective 1: Document the perceptions of wildfire risk across neighborhoods

Perceptions of risk have been amplified by recent fires in the community. Despite the wildfire risks in Boulder, many residents perceive the city as better prepared than other smaller towns, especially in the mountains. One resident stated that "Boulder by far has surpassed what they're capable of up there in the mountain towns, predominantly due to the terrain and elevation factors. It's horrible, up there in the mountain towns" (interview 18, April 7, 2022). Another resident, who used to live in California, explained that "I'm going to jump in the lake" (interview 17, April 5, 2022) was her wildfire evacuation strategy, a strategy flawed due to the intense heat and massive amounts of toxic smoke one is exposed to near wildfires.

Not surprisingly, the recent Marshall Fire drastically increased concerns related to wildfire risks in 2022 compared to 2020. On a scale from 1-10, with one signifying no change and ten signifying complete change, most respondents identified the Marshall Fire

as having a significant effect on their perception of risk. One respondent explained that "wildfires are now cityfires" (interview 23, April 14, 2022). The respondent harbored the belief that wildfires, by nature, are supposed to be in the wild, but the Marshall Fire changed her perceptions about risks in her community. Even longtime residents indicated how drastically their perceptions changed regarding wildfire. One said that "wildfire was something that really wasn't an issue in my childhood. And just within the past three or four years, I've come to realize that there's now like a fire season in Colorado" (interview 23, April 14, 2022). A resident of Superior who lost his rented apartment to the Marshall Fire stated that prior to the fire, his concern for his house burning down and his own safety being put at risk due to wildfires was at a 0 out of 10. "It didn't even cross my mind," (interview 6, March 24, 2022).

Figure 9: Marshall Fire, from a distance (photo credit: Hart Van Denburg/CPR News).

Furthermore, many interviewees expressed a sense of resignation that wildfires are a force of nature that cannot be effectively stopped by humans, even as residents acknowledge that fires are often caused by humans. Residents who held this view cited the "hurricane speed" winds present during the Marshall Fire as evidence. One individual elaborated that "the winds were so strong that it was just like blowing on a coal fire"

(interview 5, March 17, 2022). Even firebreaks fail, he says, when the wind blows above 40 mph, let alone the near-100 mph wind during the Marshall Fire. “It was essentially a firestorm,” he said. When it comes to the natural spread of wildfire, “the biggest physical problem is when the wind blows and the fire starts up. There's physically no stopping it.” When it comes to the human spread of wildfire in Boulder, the respondent blamed densely developed neighborhoods. This resident proposed a “little pocket park” every three or four houses to act as a mini firebreak between houses to slow the spread of fires.

The wind in Boulder comes sweeping down the slopes of the mountains, usually blowing from west to east. This can cause houses built along the west-east axis to catch fire rapidly. One resident noted how rapidly the houses ignited one after another from seemingly the heat of the fire next door rather than the flames or embers themselves, since they were built so close together. Many interviewees shared a common theme of Boulder buildings and residents simply being built too close together, making it too easy for the fire to make its way through the city. Despite these suggestions, the sheer ferocity of the fire made him doubt that there was an effective way to avoid fire: “I don’t know; if I was an insurance company, I would leave the area.”

Conversely, many residents held the view that wildfires could be largely mitigated through controlled burns and the reduction of dry vegetation. One elderly resident expressed frustration that his young neighbors failed to perform fuel reduction around their properties while he frequently clears and thins vegetation on his own property, particularly highly flammable juniper. He suggested that there should be a government program in which unemployed people be hired to clear excessive fuel loads across the country. “Unless you hire people, train them, insure them, pay them, wildfires are just going to keep happening” (interview 9, April 5, 2022).

Multiple residents reported concerns about wooden fences and dry brush that act as conduits that carry fire house to house. One resident said “wooden fences acted like matchsticks [during the Marshall Fire]” (interview 22, April 14, 2022). She said that the city government should encourage homeowner’s associations (HOAs) to have metal fences instead of traditional wooden fences to prevent the rapid spread of fire. Many also believe that thinning and brush clearing should be done frequently and disposed of outside of city limits to prevent fires from breaking out nearby. Additionally, a number of interviewees

expressed dissatisfaction with how vulnerable the transition was from the wildlands to the city. For instance, many respondents mentioned firebreaks and not encroaching on the open space as important steps to strengthening the resilience of the city.

The notion of controlled burns being an important part of fuel mitigation was counteracted by an expert interview (See Appendix B and C for details) with Dr. Adam Mahood, a postdoctoral geography researcher in fire ecology and plant community ecology. Dr. Mahood stated, with regard to controlled burns, that he does not "see how they really protect anybody from wildfires" (interview 8, March 31, 2022). He explained that for some ecosystems, such as the fire-adapted Ponderosa pine forests, controlled burns keep fuel loads separated and aid the drought-stricken trees by reducing their competition. For others, controlled burns clear room in the ecosystem for fast-burning and more easily ignitable grasses to proliferate. He clarified that although controlled burns are not applicable in all scenarios, they could be of some use under the right circumstances. Instead, he encourages the "decarbonization of the economy and lowering the amounts of greenhouse gasses" as viable strategies for increasing wildfire resilience in the face of the changing fire regime.

In addition to concerns about fuel loads, many interviewees emphasized the importance of material possessions, pets, and pet safety. Even when respondents themselves did not own pets, they expressed concern for neighbors' pets. One respondent suggested that "services to help get pets out of harm's way" would help the community feel safer (interview 18, April 7, 2022). When asked about her evacuation plans, one woman emphatically said "I don't have a car, so I'm f*****. Carry my dog and run" (interview 14, April 5, 2022). One of the casualties from the Marshall Fire was the result of an elderly woman returning to her house to save her dog (Warwick, 2022). The other was a result of a man trying to save his "life's work" which was composed of "thousands of pages of documents of family memorabilia" (Kornfield, 2022). Some respondents explained that they felt the need to return to their house to save their cars and prized possessions if they were to face wildfire. Residents' attachment to pets and other material objects could be channeled for engaging the community in wildfire resilience planning.

Objective 2. The experience of emergency communications

Our findings revealed general frustration with communication methods in place for wildfires. Respondents viewed the current system of wildfire notification using landline calls as antiquated, as most people do not have landlines anymore. Of the 21 interviews we conducted, four respondents noted concerns with landline calls being the primary form of wildfire notification. Additionally, strong winds knocked down the power lines around the Town of Superior , knocking out landlines. While a similar system for notifications over cell phones could be effective, one respondent noted was concerned about some elderly people being at higher risk if they do not have internet access or smartphones. “They wouldn’t have any way of knowing until the firefighters were knocking on the doors.” One respondent expressed frustration that the outdoor emergency alert system present across Boulder county was silent during the fire. Another resident expressed a similar sentiment, suggesting speakers should be posted around streets for wildfire notification during emergency communication, not knowing sirens were already placed around Boulder. Historically, sirens have been mainly used for flood warnings and tornado sirens, however, since the Marshall Fire, the city is planning on utilizing this infrastructure to relay important messages during other kinds of emergencies such as wildfires.

Most respondents initially heard about both the Marshall and NCAR Fires from social media, especially Twitter. However, that in itself has its problems. One respondent complained that “we have an Office of Emergency Management and I was annoyed that I had to get my news from Twitter” (interview 12, April 5, 2022). The remainder of the respondents heard of the danger from an online news source, radio, or from friends and family. None of our respondents were informed of either of the fires from the official landline method. The reverse 9-1-1 call was another emergency

Figure 10: Tornado siren in Boulder with wildfire alert capabilities (photo credit: “Emergency Warning Sirens,” n.d.).

method used during the Marshall Fires. Our findings also indicated the presence of exclusive emergency notifications among certain organizations, such as the Boulder Public Library system. One library employee reported that "because I work in the library, I signed up for emergency through EventBridge, or something like that. I signed up for notifications for my home and for the George Reynolds Branch Library" (interview 22, April 14, 2022). The University of Colorado Boulder sent out emergency notifications exclusively to students and staff in its system. A student described the communication at CU Boulder by saying "I think everyone gets an email and then if you sign up, you can get texts as well. I don't think that's public, so if you're not a member of the university, I don't think you can get those," (interview 20, April 12, 2022). Another student singled out the setting of CU Boulder as helping to facilitate wildfire communications, stating that "normal residents don't have the social community college students do. Whether it's in class, who you live with, or who you see at school" (interview 21, April 12, 2022). The presence of exclusive emergency notifications among certain organizations suggests a disparity in communication between different groups of residents in Boulder.

Objective 3. Gauge interest and opportunities

Our third objective, and likely an important one for our sponsors at the Boulder Watershed Collective, was to gauge interest and opportunities in participating in wildfire resilience networks in Boulder. Towards the end of each interview, we asked participants whether they would be interested in attending informational sessions in the form of webinars on fire resiliency. A majority of respondents said that they would attend. There was also some interest in having those sessions in a different format such as in the form of a course offering for university students and a brief video/interactive platform for residents. An overwhelming number of respondents expressed that they were more likely to attend sessions if they were short and digital. Many observed that people tend to take paper pamphlets and brochures and "throw [them] away" (interview 15, April 5, 2022) so it was recommended to focus on a digital level. Texts and emails could also be an effective way of engaging people with "bulleted lists of facts that are short and sweet" (interview 14, April 5, 2022) to get the point across.

One interviewee commented positively on communities in Arizona that were "pro forest thinning" that engaged the community by publishing "positive newspaper articles about past and ongoing research." Exposing neighborhoods to the work that is being done with regard to wildfires in their community could encourage the residents to take on a more active role in resilience planning. When prompted to join the Boulder Watershed Collective's City Wildfire Neighborhood Ambassador Program, eight of the eleven people willingly accepted a business card for further inquiries. Most people expressed willingness to participate in activities and engage in community planning for wildfire resilience.

4.2 Discussion

Our interactions with residents of Boulder County revealed various themes. Many believed that the city of Boulder was doing well in terms of wildfire preparation and wildfire risk mitigation. That said, many of those same respondents believe that while Boulder is well-prepared for wildfires, the city is not necessarily safe from wildfires. Many reported feel that the problem of wildfire will not affect them. Respondents attributed the city's preparedness to the general affluence of Boulder, despite the seemingly unstoppable winds sweeping down from the mountains.

Respondents said that responsibility for resilience planning went hand in hand with a sense of lack of control. Many interviewees view the extraordinary winds as a force of nature that cannot be avoided or adapted to. These respondents adopted a defeatist or semi-defeatist attitude about wildfires. It is paradoxical that the perception of the high risk of wildfire is reconciled by the seemingly contradictory belief that Boulder is attuned to the need to prepare for and fight wildfires. The winds are seen as such a large part of the problem that, for many, it dwarfs the addressable wildfire risks still prevalent in Boulder, such as the dry foliage, close-together structures, and prevalence of wood as a building material.

The concern that the wind was "unmitigable" could itself be mitigated, through discussion of possible solutions. It is important to not make wildfire resilience seem like a hopeless endeavor, because that could potentially lead to lack of community interest and effort in wildfire resilience.

Some interesting insights came forth regarding wildfire communication methods. It was interesting to note the perception of communication vary based on proximity to the wildfires, with residents close to the wildfire having negative perceptions of communication, while those further from the fire more likely to rate the communication as being adequate. We also note that some organizations have exclusive emergency notifications, such as CU Boulder and the Boulder Public Library system. The existence of these exclusive notification systems means that certain affiliated residents are likely to be more prepared than others. The inconsistencies with the current public emergency alert systems in Boulder can put unaffiliated residents in greater danger because they may not be as well-informed as others.

To inspire the community to engage in wildfire resilience planning, one respondent suggested that there be more positive news articles and positive messages. With an increase in wildfires and confusion and uncertainty about future fires, positive reinforcement might address the concern that nothing can be done to mitigate fires or enhance resilience.

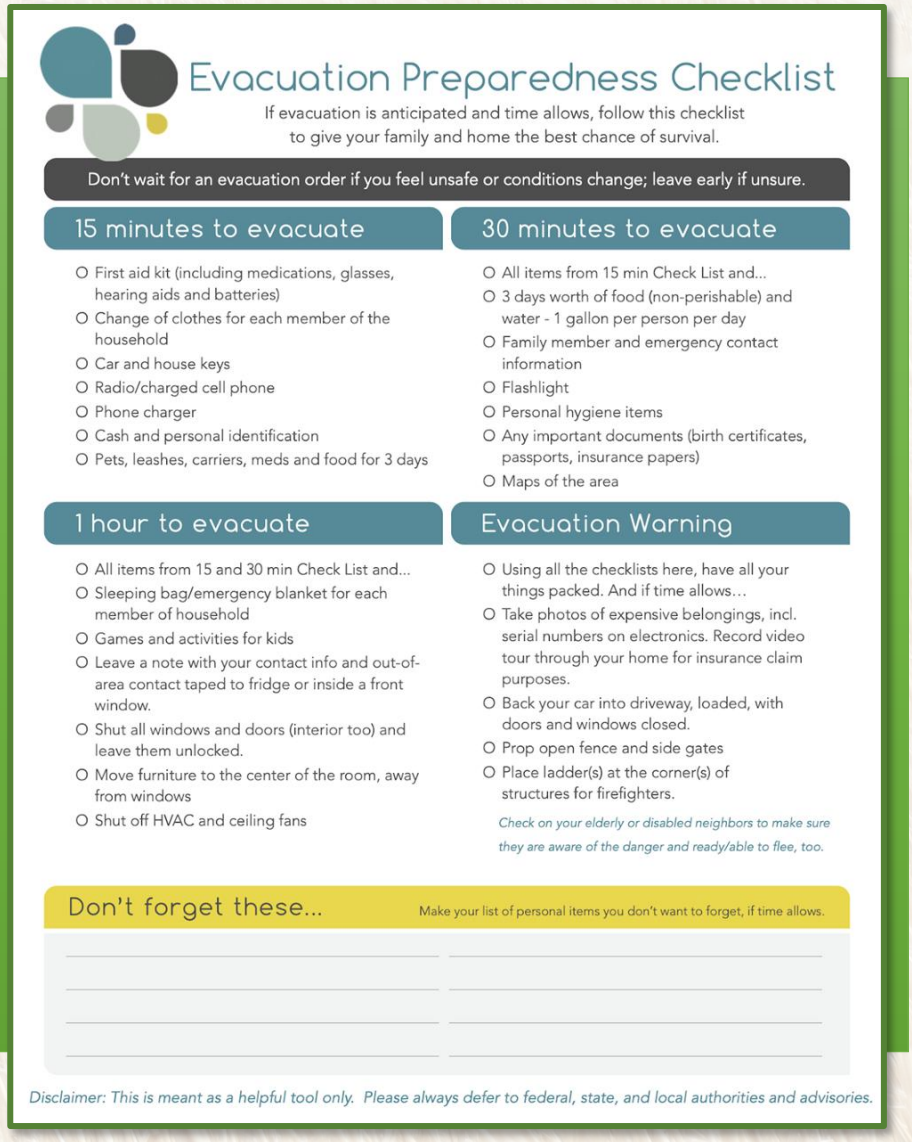
Chapter 5: Recommendations for motivating community engagement

Our findings revealed a number of concerns and interests that could be leveraged to catalyze or inspire community planning activities for the Boulder Watershed Collective. Some of these recommendations encourage personal responsibility, and others are meant to bring stakeholders together. All of these recommendations should also hopefully help to advance the Boulder Watershed Collective programs and increase their reach in Boulder. Our ideas ranged from simple outreach campaigns to quirky events designed to capture particular interest groups in the community.

Recommendation 1: Personal safety

Many respondents expressed the need for improved communication and evacuation preparation. A to-go bag is a major part of wildfire preparedness, as it can help residents safely and efficiently evacuate their homes. Furthermore, it is important that Boulder residents are able to be notified as soon as possible via the Reverse 9-1-1 system in which the city calls, texts, emails, faxes, and/or pages residents to inform them of emergency situations in their area ("9-1-1 Colorado Foundation," n.d.). Although the City of Boulder suggests that each resident be well prepared for wildfire, there seems to be a disconnect between the city government and residents. For examples, some residents are unaware of how to access fire safety resources. The Boulder Watershed Collective could tackle the awareness issue associated with to-go bags and emergency communication through various formats and platforms.

Information on how to create a to-go bag and how to opt into Boulder's emergency notification system already exists in various forms. The Boulder Watershed Collective could further support the distribution of this information, particularly in high-risk neighborhoods through their program of neighborhood "sparkplugs" who are local and neighborhood leaders. All residents, though, could be emailed a digital version of the pamphlet. A phone text link to an online version could also be sent out for those who do not have emails.



Evacuation Preparedness Checklist

If evacuation is anticipated and time allows, follow this checklist to give your family and home the best chance of survival.

Don't wait for an evacuation order if you feel unsafe or conditions change; leave early if unsure.

15 minutes to evacuate

- O First aid kit (including medications, glasses, hearing aids and batteries)
- O Change of clothes for each member of the household
- O Car and house keys
- O Radio/charged cell phone
- O Phone charger
- O Cash and personal identification
- O Pets, leashes, carriers, meds and food for 3 days

30 minutes to evacuate

- O All items from 15 min Check List and...
- O 3 days worth of food (non-perishable) and water - 1 gallon per person per day
- O Family member and emergency contact information
- O Flashlight
- O Personal hygiene items
- O Any important documents (birth certificates, passports, insurance papers)
- O Maps of the area

1 hour to evacuate

- O All items from 15 and 30 min Check List and...
- O Sleeping bag/emergency blanket for each member of household
- O Games and activities for kids
- O Leave a note with your contact info and out-of-area contact taped to fridge or inside a front window.
- O Shut all windows and doors (interior too) and leave them unlocked.
- O Move furniture to the center of the room, away from windows
- O Shut off HVAC and ceiling fans

Evacuation Warning

- O Using all the checklists here, have all your things packed. And if time allows…
- O Take photos of expensive belongings, incl. serial numbers on electronics. Record video tour through your home for insurance claim purposes.
- O Back your car into driveway, loaded, with doors and windows closed.
- O Prop open fence and side gates
- O Place ladder(s) at the corner(s) of structures for firefighters.

Check on your elderly or disabled neighbors to make sure they are aware of the danger and ready/able to flee, too.

Don't forget these...

Make your list of personal items you don't want to forget, if time allows.

Disclaimer: This is meant as a helpful tool only. Please always defer to federal, state, and local authorities and advisories.

Figure 11: Fire evacuation preparation checklist with varying instructions depending on time ("Fire Evacuation Checklist," 2020).

Along with making pamphlets available, we recommend the widespread use of QR codes to easily access existing resources regarding to-go bags and emergency alert services. For emergency alert services, a QR code could link directly to a signup page to opt-in to services such as reverse-911 calls. QR codes can easily be distributed through print and digital mediums and can be implemented right away.

Recommendation 2: Designate a wildfire awareness month

A month of awareness sponsored by the Boulder Watershed Collective and other organizations in and around the city can focus attention on the issue of wildfires, especially by setting up events and spreading media related to the topic of wildfire. One potential avenue could be to run wildfire-related television programming on a variety of media channels. This programming could be similar to a "Shark Week" type of event that would help to raise awareness through interesting and engaging programming.

The Boulder Watershed Collective can support wildfire risk education in the primary, secondary, and higher education curricula. The Ambassador program might be a source of information on wildfire resilience through brief interactive sessions that encourage thought and discussion.

Along with a month-long awareness campaign, the Boulder Watershed Collective might consider hosting wildfire-related community events can also be held, such as a fuel reduction day. The fuel reduction day would involve residents volunteering to remove dry vegetation from their homes or in an area at a high-risk of wildfire. Residents will get the chance to socialize while helping to make a positive impact by clearing dry brush. Utilizing volunteers will help the organizations working to remove dry vegetation, as they do not currently have enough personnel to carry out this task.

Figure 12: Firecracker we found in North Boulder Park in the Newlands Neighborhood of Boulder (photo credit: Ethan Turett)

The Wildfire Resilience Month can be used to raise awareness regarding wildfire among all sorts of residents and potentially prompt them to take action in preparing their neighborhood for wildfires. The interest created through the awareness month could then be used to generate interest in the Boulder Watershed Collective's City Wildfire Neighborhood Ambassador Program, a webinar which would go over the key strategies for preparing neighborhoods for wildfires. The wildfire awareness month should ideally happen during one of the

summer months, as these months are the peak of the wildfire season in Colorado. Awareness would be the most effective during the times with the highest risk. A large amount of funding may be needed in order to carry out the activities planned during this month. Additional resources required might be found with local government support, as the venues could be hosted in municipal facilities across Boulder.

Recommendation 3: Serious Games for Resilience Awareness and Planning

Another effective way to engage people about wildfire resilience would be to gamify, or incorporate game-like elements into, resilience awareness events and education. Incorporating points and competition into awareness campaigns could include a trivia platform such as Kahoot!, which is an application commonly used in middle and high schools to challenge students in topics like language and history. We suggest a Wildfire Trivia Night. Trivia is an activity enjoyed by many, commonly featured in locations like YMCAs, bars, and libraries. The mental challenge of trivia can be appealing to some stakeholder groups. Additionally, multiple-choice style questions can help people learn about resilience strategies. Open-ended style questions can be very engaging for attendees who already have some knowledge of wildfires and wildfire resilience. Hosting games such as these can provide an opportunity for attendees to learn critical issues related to wildfire resilience.

Figure 13 : Serious game made by the UN to simulate disaster preparation. The image above is of a wildfire resilience planning scenario (Stop disasters! (n.d.).

In addition to trivia and quick-answer games, serious games could also be incorporated during awareness events. Serious games are games "aimed towards problem-solving rather than entertainment" (Pilote & Chiniara, 2019). Serious games help learners "gain a good understanding of a specific topic and sustain the acquisition of complex competencies" (Klemke et al., 2015). Some applications that could effectively engage the community in wildfire resilience planning are By Implication's Wildfire, the HEART Force Wildfire Game or the United Nations Office for Disaster Risk Reduction's (UNDRR) Stop Disasters! Game.

The Wildfire game from By Implication is a game that teaches players how to defeat environmental degradation through volunteerism, social interaction and nonviolent activism ("By Implication," n.d.). The HEART Force Wildfire Game is a serious game designed for middle school and high school students. In this interactive game, students work in three zone response teams to "solve community challenges that arise during the course of a wildfire event by using available individual and community resources" ("HEART Force," n.d.). UNDRR's Stop Disasters! Game helps players learn the risks posed by natural hazards and how to manage necessary resources in multiple realistic disaster scenarios like wildfires ("Stop Disasters!," n.d.).

The combination of community building games and serious games can be offered in a game night format. The Boulder Watershed Collective could host game nights with interactive games running on a computer alongside others who participate in trivia games. If the game night is an event that is open to everyone in the community, the Boulder Watershed Collective could collect residents' email addresses for future communications and help them become more active in their community.

Recommendation 4: Pet Safety

An event aimed at residents with animals, such as a pet social, could be used to workshop the creation of pet evacuation plans and rescue networks. We found that people are willing to go to great lengths to keep their pets safe, even if it means putting themselves at risk. During this event, residents could discuss how to evacuate animals in an emergency. If there is an evacuation order and a pet owner is out of town, plans might be made for a neighbor to rescue a pet. A rescue network could be facilitated by social media platforms, such as Facebook.

Figure 14: Poster to place outside home, so in the case of an emergency, people will know there are pets inside that need to be evacuated (Lotz, 2016).

Recommendation 5: Advertisements and Outreach

Many residents supported the idea of an advertisement campaign with critical information about wildfire preparation and resilience. This might include public service announcements on local news shows or print campaigns on buses.

Increasing public concerns about social and environmental causes has led many companies to affiliate their products with well-known causes as a key marketing strategy (Chang & Chen, 2017). This phenomenon, known as strategic cause-related marketing (CRM), is a campaign whereby a company donates a portion of their profits to a non-profit organization every time a consumer purchases a product. This form of promotion is a "win-win for businesses, non-profits, and the public" (Chang & Chen, 2017 The Boulder Watershed Collective could pursue this kind of campaign in partnership with local businesses. Other campaigns might include print and online campaigns and user-generated content campaigns. The Boulder Watershed Collective might partner with local newspapers and run print and online ad campaigns to create a "synergy effect" (Rosenkrans & Myers, 2013).

A user-generated content campaign is a promotion strategy where consumers advertise a product or a cause on social media. This type of campaign requires minimal funding and is consumer driven. User-generated content campaigns can generate high engagement and increased conversions. User-generated content campaigns can influence people to donate for wildfire resilience. This type of campaign ideally requires a loyal consumer base, where the consumers drive other consumers to donate.

Various campaigns can be strategically run as more resources become available. In the case of minimal funding, user-generated content campaigns might be a good place to start. While consumers lead the user-generated content campaign, the Boulder Watershed Collective might partner with local businesses to start cause-related marketing, such as a limited-edition drink at a local coffee shop. The Boulder Watershed Collective might also design merchandise where most of the proceeds go to wildfire resilience and education.

For running print ads on buses, the Boulder Watershed Collective can contact the Regional Transportation District (RTD) for interior advertising. Interior cards are 28 in. by 11 in. and should contain a QR code for more information ("Bus & Train Advertising," n.d.).

These QR codes can link to the Boulder Watershed Collective's website, informational blogs, the City Wildfire Neighborhood Ambassador Program's webpage, and signup pages for emergency alert services in Boulder. In addition to interior advertising, larger advertisements can be run on the exterior of the buses (See Appendix D for details). Exterior advertisements range from 72 in. by 21 in. to 30 ft. by 5 ft. ("Bus & Train Advertising," n.d.).

Recommendation 6: NFT Project

With the emergence of cryptocurrency, non-fungible tokens (NFTs) might be an unusual option for the Boulder Watershed Collective. NFTs are digital assets that have recently gained popularity in the arena of digital artwork. NFTs are unique on the blockchain and cannot be replicated or reproduced. Blockchain is a shared, immutable ledger for recording transactions, tracking assets and building trust (What Is Blockchain Technology?, n.d.). Since digital artwork is almost always "infinite in supply," introducing a non-fungible token is designed to increase the value of the asset (Conti, 2021). Since the transaction of the tokens cannot be altered on the blockchain, people pride themselves as holders of limited-edition art. The Boulder Watershed Collective might consider building an NFT project where they create NFTs with the help of graphic designers. One possibility would be to create NFTs that encourage community members to take initiative and ask them to draw what resilience means to them. Tokens that relate to wildfires and resiliency are possible avenues that can be explored. Once designs are finalized, the Boulder Watershed Collective would need to select a platform to offer the NFTs. If the Boulder Watershed Collective can launch and promote their own NFT collection with designs from community members, it might generate engagement and donations (See Appendix E for details).

5.2 Conclusion

As climate change continues to dry the lands of Colorado, the frequency and severity of wildfires is likely to increase. While there is no way to entirely prevent fires from occurring, it may be possible to decrease the impact that fires have on the community. Boulder area residents have many thoughtful suggestions on how to increase wildfire resiliency and many are willing to engage in wildfire resilience planning with the Boulder Watershed Collective. As the world pivots towards more sustainable development, climate change will stay central in those efforts. On a global level, the United Nations Sustainable Goal #13 urges countries to take action to combat climate change and its impact. This project aligns with that goal, which is consistent with the work of the Boulder Watershed Collective to engage communities in wildfire resilience planning.

Figure 15: United Nations Sustainable Goal #13 header ("Goal 13," n.d.).

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Appendix A: Interview questions for Boulder residents

Section 1: Demographics

1. What is your name?
2. What is your current occupation, if applicable?
3. Are you a current resident of Boulder County?
    a. *If yes*: How long have you been living in the area?
        i. If not for their entire lives:
            1. What brought you to Boulder?
        ii. Are you a homeowner, renter, or do you have a different living situation?
    b. If no:
        i. What city/town and state do you currently reside in?
        ii. What is your reason for visiting Boulder and how long will you be here?

Section 2: Wildfire Risk Perceptions & Communications

Wildfire Risk (Before a Wildfire)

4. When you think about wildfires, what are you worried about?
5. Where were you when the Marshall Fire happened?
6. Where were you when the NCAR Fire happened?
7. On a scale from 1-10, how prepared do you believe the City of Boulder residents are for the next wildfire? Please explain your rating.
8. On a scale of 1-10, how well do you believe the City of Boulder's programs help prepare city residents for the next wildfire? Please explain your rating.
9. Were you provided with any meaningful wildfire education or outreach prior to the major wildfires in 2020?
10. In your neighborhood or community, are there residents who are especially at risk of a future wildfire in your area? What do these individuals have in common?
    a. Are there any recommendations you have that might reduce their vulnerability to the next wildfire?
11. In general, do you have any recommendations for how to reduce wildfire risks before the next wildfire in Boulder?

Wildfire Risk (During Wildfires)

12. On a scale from 1-10, how effective would you rate the general wildfire updates, communication, and evacuation procedures during the Marshall Fire? During the Calwood Fire? During the NCAR fire?
    a. *If they had to evacuate from Calwood, Marshall, or NCAR Fires:*
        i. How did you discover you needed to evacuate your residence? From this communication method, do you think you were given enough time to evacuate?
13. In the future, how concerned are you about having to evacuate your house due to a wildfire? What is your biggest concern about having to evacuate?
14. In general, do you have any recommendations for how to improve communication during wildfires around Boulder?

Wildfire Risk (Comparing Across Large Fires)

15. On a scale of 1-10, rate how much:
    a. The Calwood Fire changed your perception of wildfire risk in your neighborhood or community?
    b. The Marshall Fire changed your perception of wildfire risk in your neighborhood or community?
    c. The NCAR Fire changed your perception of wildfire risk in your neighborhood or community?
    d. Please explain why [SPECIFIC FIRE] changed your perception more than [OTHER FIRE] / Please explain why there was no change?

Wildfire Risk (Comparing Across Time)

16. On a scale from 1-10 before 2020, how concerned were you about each of the following being damaged or affected by wildfires:
    a. Your house or other structures you own
    b. Your land
    c. Your health or your family's health
    d. Your safety or your family's safety
    e. Your pets or livestock
    f. Local drinking water
    g. Public lands near your home
    h. Your neighborhood's structures
    i. Your neighborhood's safety or health
17. On a scale from 1-10 since 2020, how concerned are you about each of the following being damaged or affected by wildfires:
    a. Your house or other structures you own
    b. Your land
    c. Your health or your family's health
    d. Your safety or your family's safety
    e. Your pets or livestock
    f. Local drinking water

g. Public lands near your home
h. Your neighborhood's structures
i. Your neighborhood's safety or health

18. *If there are any shifts, have them explain why rankings increased or decreased…*
19. When comparing before and after the 2020 wildfire season, have you taken actions or intended to act for each of the following?
    a. Evacuation preparedness (like documenting items for insurance, creating a go bag, signing up for Office of Emergency Management alerts)?
        i. If so, which actions have you taken?
        ii. If not, why not?
    b. Home mitigation and defensible actions (like climbing trees, considering changing any home materials to fire-resistant materials)?
        i. If so, which actions have you taken in general?
        ii. If not, why not?

Section 3: Wildfire Resilience

20. We often hear the term 'wildfire resilience' after wildfires occur. How would you define wildfire resilience?
    a. Based on your definition of wildfire resilience, in an ideal scenario, how can wildfire resilience be improved in the city of Boulder? What does it realistically take to get there?
21. Have you been in the proximity of a wildfire elsewhere than the Boulder area?
    a. If yes:
        i. Where was the wildfire, and do you remember what it was called?
        ii. How was communication of the wildfire's progress different from your experience with Boulder area wildfire communication?
        iii. How was communication of the evacuation instructions different from your experience with Boulder area wildfire communication?
        iv. Were you able to notice differences in fire resilience (for instance, building materials, foliage density, spacing between buildings, etc.) between Boulder and the other area?
22. How aware are you of the City of Boulder's wildfire resilience policies?
    a. Would you like to receive more information about these policies?

Next Steps

23. Could you suggest a couple people we could contact who may be interested in being interviewed for this project?
24. Is there anything else you would like to share with us?
25. Based on what we heard today, you might be interested in being part of the 'City Wildfire Neighborhood Ambassador Program' that the Boulder Watershed Collective is creating. This would likely start up in the fall/next year and would be an opportunity to learn about key strategies to get your neighborhood more prepared for wildfires. An informational session will be offered first if you have an interest.
    a. Yes/No

Appendix B: Consent form for media recording

We are a team of undergraduate students from Worcester Polytechnic Institute (WPI) in the United States. We are participating in a project to collect information in order to support community engagement in wildfire resilience planning. If you are willing to participate in this project, please read and note your preferences on this form. The final results will be made public, and can be found at the following link:

Do we have your permission to audio record an interview?
Yes ☐ | No ☐

Do we have your permission to video record an interview?
Yes ☐ | No ☐

Will you allow us to use your words and image for use on public website platforms?
Yes ☐ | No ☐

I understand that these interviews will be published at WPI for educational purposes and made available to the public. Images and film clips may also be shared to social media platforms including Instagram and other outlets designed to amplify the experiences of wildfires.

Sign: Print: Date:

Appendix C: Interview questions for regional experts

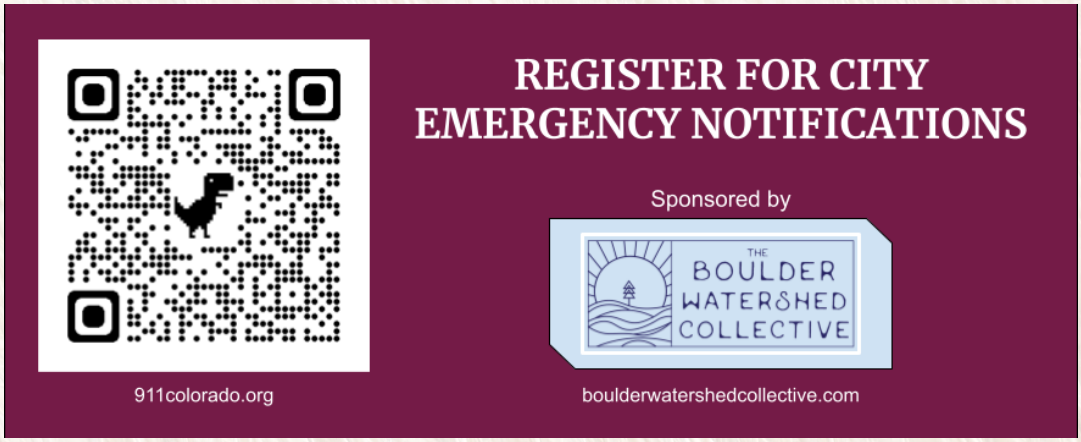
1. What is your name?
2. What is your current occupation?
3. Are you a current resident of Boulder County?
    a. *If yes*: How long have you been living in the area?
        i. *If not for their entire lives:*
            0. What brought you to Boulder?
        ii. Are you a homeowner, renter, or do you have a different living situation?

- How do you define wildfire resilience?
- What can people do to increase their resilience to the changing nature of wildfires? For example, fires are now getting bigger and hotter and have unpredictable behaviors. How can we combat this?
    - Could you please explain why the fires are getting bigger and hotter?
        - How does climate change factor into this?
    - What is the relationship between temperature and aridity?
- How has the "wildfire season" evolved over time?
- What is the impact of the increased fire frequency on the local ecosystems in Boulder?
- We've heard that biodiversity decreases as fire frequency increases, but wouldn't the wildfires make room for more growth in the area?
- How do wildfires impact wildlife, especially the animals in the burnt areas? Do we know how they react to wildfires and do they move back once the fire is contained?
- Why are human-caused fires different than lightning-caused fires?
    - What is your preliminary analysis of the NCAR fire? Does it show the characteristics of a human-made fire?
- Could you suggest a couple people we could contact who may be interested in being interviewed for this project?

- Is there anything else you would like to share with us regarding wildfires or fire ecology?

Appendix D: PSA Adverts and Stickers

Adverts:



Stickers:


CONCERNED
BY WILDFIRES?
THE
BOULDER
WATERSHED
COLLECTIVE
GET INVOLVED


CONCERNED
BY WILDFIRES?
THE
BOULDER
WATERSHED
COLLECTIVE
GET INVOLVED


THE
BOULDER
WATERSHED
COLLECTIVE
SUPPORTING WILDFIRE RESILIENCE IN BOULDER AND SURROUNDING AREAS
JOIN US
boulderwatershedcollective.com

Appendix E: NFT Project Extension

Potential options, in terms of minimal initial cost, might be either OpenSea or Rarible. These platforms have a “lazy minting” system, which means that the creator can bypass the fees for writing the NFT on the blockchain until the NFT is sold (Clark, 2021). Another consideration would be to decide which blockchain would mint the collection. Ethereum is among one of the most popular blockchains with more than 90% of all digital assets residing on the Ethereum blockchain. However, the saturation and the vast energy consumption has given room for more sustainable blockchains like Cardano and Polygon to grow. Polygon’s blockchain compatibility with OpenSea allows for lower transaction fees compared to the Ethereum blockchain when selling NFTs.

To minimize initial costs, the Boulder Watershed Collective could upload the NFTs on OpenSea and select Polygon for blockchain. Once that is done, the Boulder Watershed Collective will need to create a cryptocurrency wallet. With the creation of the cryptocurrency wallet, we need to ensure that this wallet is compatible with the Polygon blockchain. Creating a Coinbase cryptocurrency wallet would likely facilitate the pairing with the OpenSea marketplace. Once the wallet is connected to OpenSea, the Boulder Watershed Collective would need to name the file and provide a description for the NFT. Once that is complete, the NFT will be ready for sale. This could be a very lucrative fundraising option that would engage the youth in the community. Although the NFT market is only now gaining popularity, it has tremendous potential for growth in the future.