“FIRE ON THE MOUNTAIN”: WILDFIRE MITIGATION FOR COMMUNITIES IN BOULDER COUNTY, COLORADO

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"We're still making the same mistakes we've been making since 1910, and the situation is getting worse, and worse, and worse. We're starting to burn more and more homes every year, we're starting to get more fire, and fire size is getting bigger and severity is getting worse."- Chad Julian, Boulder County's lead forester[1]

FIGURE 1: PICTURE OF FOURMILE FIRE FROM CU BOULDER SEPT. 6-16TH 2010

I. Executive Summary:

The intention of this memorandum is to highlight the problems associated with insufficient wildfire mitigation efforts in Boulder County, Colorado. As larger populations continue to construct new developments in wildfire prone areas, public

[1] Turner, Christi. "Boulder County Wildfire Mitigation Hinges on Citizen Engagement."

policy prioritizes suppressing wildfires rather than preventing them[2]. The public policy solution has invariably been eradication and suppression. In spite of that, forest ecologists understand wildfires to be a natural, beneficial and necessary means of promoting biodiversity. Wildfire suppression policies' methods of operations along the Colorado Rocky Mountain region have eroded the efficacy of wildfire mitigation efforts.

This year is projected to be one of the worst wildfire seasons on record. There have already been 850 wildfires in California which is 70% to last year. This is due to a variety reasons including record low snow pack, large fuel deposits and extreme drought. The budgets designed to control the conflagrations are already depleted and borrowing from underutilized mitigation coffers. Conflagrations are defined as wildfires that consume a large amount of property and land. In addition to consequences this has to Colorado, the effects of wildfires reverberate through the other eleven Western states. These effects are economic, political, social and increasingly ecological. Climate conditions, growing fuel depots and residential sprawl into wildfire prone areas are creating a perfect storm for catastrophic damage. According to the Congressional Budget Office, every $1 in wildfire mitigation funding saves $5 in future disaster losses.[3] The final report on the 2010 Fourmile Canyon fire showed that more than 80 percent[4] of homes burned when *surface fuels* around each house caught fire.[5]

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[2] "Wildfires." FEMA-Wildfires. <http://www.ready.gov/wildfires>
[3]"Bennet Holds Senate Hearing to Highlight Need for Wildfire Mitigation Resources." *Bennet.senate.gov*
[4] Graham, Russell T. *Fourmile Canyon Fire Findings*.
[5] Graham, Russell T. *Fourmile Canyon Fire Findings*.

"Boulder County officials, analyzing data from the 2010 Fourmile Canyon fire that burned 169 of 474 homes in its path, have found that 83 percent of the homes where inspectors had done fireproofing reviews survived, compared with 63 percent of homes that were not inspected" (Denver Post)[6].

Recent studies have bolstered the reports position to increase funding because these efforts can reduce the future cost related to calamitous wildfires. Fire has historically been considered a threat in urban and wildland-urban interface (WUI) environments[7], however, this recognition has not translated into public policy. The indiscriminate and destructive nature of wildfire jeopardizes natural resources, commercial and private structures, public safety, water systems, and air quality. Boulder County has nearly 10,000 residences that fall into the WUI. These threats warrant compulsory wildfire mitigation in the form of public policy interventions at the state and local level[8]. This constitutes a market failure because the costs for suppressing and rebuilding after these wildfires is transferred to the state as a whole and not to communities that are directly affected. Suppression alone is insufficient and mitigation measures must be implemented immediately in preparation for the next disaster. Therefore, policy interventions are required during the average fire season in order to accomplish two objectives: 1) reduce the severity and intensity of the conflagrations and 2) curtail the repercussions of a wildfire once ignited. There are 3 policy options that can be utilized individually or in tangent with another. These alternatives will

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[6] http://www.denverpost.com/ci_23705317/after-big-colorado-burns-homeowners-communities-try-fire
[7] Titus, Marc, and Jennifer Hinderman. "A Collaborative Approach to Community Wildfire Hazard Reduction."
[8] Wildfire Insurance and Forest Health Task Force Report September 2013

supplement current wildfire efforts which will benefit the communities in the WUI and add another resource to their action plans. All of the policy alternatives will be analyzed for the CBA: Policy Alternative 1. *Mandate and Implement the FireWise Program* ("Residential Mitigation Strategy #1"), Policy Alternative 2. *Treating Stands in the Adjacent Wild lands*, and Policy Alternative 3. *Construction of Retaining Walls* ("Residential Mitigation Strategy #2").

This policy memorandum recommends the second policy alternative. This policy will not require resident compliance and enforcement. By treating stands, communities in Boulder can be confident public lands will have reduced fuel deposits. This policy choice is not mutually exclusive from communities voluntarily mitigating residences.

Key Terms:

Wildlands—forests, shrub lands, grasslands, and other vegetation communities that have not been significantly modified by agriculture or human development*. A more specific meaning for fire managers, used by the National Wildfire Coordinating Group (which coordinates programs of participating wildfire management agencies nationwide), refers to an area in which development is essentially non-existent (except for roads, railroads, power lines, and similar transportation facilities); structures, if any, are widely scattered.

Wildfire—unplanned fire burning in natural (wildland) areas such as forests, shrub lands, grasslands, or prairies**.

Prescribed fire (or controlled burn)—the intentional application of fire by management under an approved plan to meet specific ("prescribed") objectives.

Mechanical treatments—the use of people or machines to thin or reduce the density of live and dead trees and plants.

* By "human development" is meant the construction of homes or other structures; we are not referring to forest management.

** The complete definition of wildfire from the National Wildfire Coordinating Group glossary is "an unplanned ignition caused by lightning, volcanoes, unauthorized, and accidental human-caused actions and escaped prescribed fires"[9].

Wildfire Mitigation- is the implementation of various measures designed to minimize the destructive effects a wildfire has on private and public property. Some measures are designed to modify the forest environment surrounding a structure that puts the structure at risk from destruction by a wildfire. Others focus on modifying the construction of a structure itself or changing its location to improve its ability to withstand a wildfire without being dependent upon fire suppression resources.

Wildfire Suppression- to put out a fire, heat, fuel or oxygen must be removed. In nature it is often impossible to remove oxygen, so heat and fuel are the components most vulnerable to the firefighters' actions. Putting dirt or water on fire removes the oxygen from the fuel, allowing a single person using a hand tool such as shovel, axe, rake, Pulaski, McLeod or flapper to extinguish small fires. Larger fires require more people and equipment such as engines, pumps, bulldozers, helicopters and air tankers dropping water or fire retardant.[10]

II. Problem Definition:

Residential and commercial development in the wildland urban interface (WUI) carries a substantial risk of wildfires, which can be detrimental to private property and public safety.

Wildfire is the most likely natural disaster for Boulder County on an annual basis. All natural disasters require preparation and mitigation, especially disasters that occur every fiscal year. Conflagrations (large wildfires) in Boulder County involving home loss account for only 8.6% of the total area burned along the Colorado Front Range but 49.6% of the homes lost[11]. Funding, research and public policies have historically utilized suppression methods for each wildfire season. The default policy option for wildfire managers and policy makers has been to extinguish the fires as quickly as

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[9] National Wildfire Coordinating Group (NWCG) 2010
[10] United States. National Park Service. "Wildland Fire: Fire Suppression"
[11] Graham, Russell T. *Fourmile Canyon Fire Findings*

humanly possible. While suppression is necessary in certain circumstances, dealing with natural disasters like wildfires require adaptive, and often preventive, practices. Focusing solely on suppression methods for decades has created an environment conducive to large fuel depots encouraging a crown fire. Mitigation should not be treated as a deterrent rather it should be recognized as a set of measures that will attempt to reduce the destruction of the wildfire once it starts. The inevitability of fires for mountain communities makes mitigation essential rather than optional. Wildfire suppression policies' method of operations in the Boulder County (as well as the rest of the Colorado Rocky Mountain Region) have eroded the efficacy of wildfire mitigation efforts. The wildfires occur on an annual basis and they are becoming more frequent in residential communities. Some of the wildfires will have to burn themselves out and the more fires we suppress prematurely the more likely conflagrations and crown fires will ignite in the near future. Eradication should not be the default policy option for policy makers and wildfire managers. Adding more layers to the equation are the affected populations in conjunction with congruent jurisdictions. The nondiscriminatory patterns of wildfire paths create jurisdictional confusion and difficulties making this policy inherently problematic. These problems facing the local, state and federal governments today require massive coordination between various layers of government, and spanning across commercial, non-profit and private industries.

The primary threats to public safety are derived from two separate reasons: increased human development into wildfire prone districts and contemporary wildfire suppression policy. The public policy solution has invariably been eradication and suppression. Today, forest ecologists understand wildfires to be natural, beneficial and

necessary. The political environment is hostile to mandatory mitigation legislation with attached penalties and additional disincentives. If there is not adequate mitigation before the wildfire season starts, the fires could be more costly (economically) and pose a greater threat to habitats, structures and human populations. The response to wildfires is positively correlated with the required funds to combat the fires.

a. Treating Wildfire as a Natural Disaster

By classifying wildfires as a natural disaster, we can help communities understand the role of precautionary actions during the wildfire season. Other natural disasters and conflagrations are similar in the sense that they are both natural disasters and pose an immediate threat to public safety. Therefore, policy interventions are required during the average fire season in order to accomplish two objectives: 1) reduce the amount of conflagrations and 2) curtail the repercussions of a wildfire once ignited. Public policies addressing wildfires are divided into two umbrella categories: mitigation and suppression. Mitigation involves any policy directive prior to the ignition of a wildfire which includes prescribed burns as controlled fuel reduction by authorities.

> "The big question is not how to stop these fires altogether, but how to prevent them from becoming behemoths that destroy hundreds of thousands of acres and cost tens of millions of dollars in one fell swoop. … The method proposed by the report to move away from aggressive fire suppression campaigns and let the natural fire cycle reestablish itself in areas with extreme overgrowth. If nature is allowed to remove overgrowth and other debris from the forest floors through naturally occurring fires, future wildfires won't be as intense or large as they are today. The United States government acknowledged this in 1995 and altered its policy to allow some natural fires to occur, as well as using prescribed burns."[12]

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[12] Stephens, Scott L. "FEDERAL FOREST-FIRE POLICY IN THE UNITED STATES."*FEDERAL FOREST-FIRE POLICY IN THE UNITED STATES*.

According to Colorado U.S. Senator Michael Bennet: "… Attention to shrinking budgets for mitigation efforts that studies have shown can reduce the future costs associated with catastrophic wildfires. According to the Congressional Budget Office, every $1 in wildfire mitigation funding saves $5 in future disaster losses.[13]"

Background on Boulder County:

Currently, Colorado does not have any state laws requiring property owners in wildfire-prone areas to actively participate in risk-mitigation efforts, leaving such requirements to the discretion of local authorities. The City of Boulder contracts with 12 fire protection districts in Boulder County that have initial attack responsibility on city public lands. The Wildland Fire Division management staff provides oversight on all prescribed and wildfires on or threatening the City of Boulder or its properties. Many incidents in Boulder County are multi-jurisdictional and are jointly managed by the city and affected fire jurisdiction. Boulder County has 9,000 residences that fall into the Wildland-Urban Interface. During the 1960's, Colorado had roughly 460 fires annually burning an average of 8,000 acres[14]. In the last decade, Colorado has averaged 2,500 fires a year consuming 100,000 sq. acers[15]. This data extrapolated is close to the average 15,000 wildfires that the western US faces every year, making the problem exponentially more difficult to contain[16]. This totals to 15 billion dollars' worth of damage to structures, federal parks and habitats as well as damage to infrastructure and

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[13] "Bennet Holds Senate Hearing to Highlight Need for Wildfire Mitigation Resources." *Bennet.senate.gov*
[14] Kodas, Michael.
[15] KODAS, MICHAEL. "Policies Put More Coloradans at Risk."
[16] Olinger, David. "After 11 Years, U.S. Fire Program Analysis System Still Isn't Ready."

air quality[17]. That does not include the more than $3 billion annually the US Forest Service spends fighting wildfires which now accounts for a staggering 45% of its operating budget compared to just 13% in 1995[18]. The federal level of government is dominant when determining how resources and operations will be distributed. This is accomplished through the National Interagency Fire Center (NIFC), which is the headquarters supervising all interagency coordination activities throughout the United States[19]. The NIFC is the authority centralized within a single organization acting as the base of operations for any wildfire on federal land. State representatives, foresters, and first responders are also are part of NIFC. However, local jurisdictions and municipalities are not, leaving holes in the processes.

III. Methods:

Boulder County was chosen for the target location due to its proximity to the WUI as well as the plethora of data, research and strategies designed specifically by the city and county of Boulder. Scholarly journals and peer reviewed articles were used to support the quantitative methods supplemented with fire scientists and ecologists. The social costs and benefits are also derived from peer-reviewed publications rather than just relying the data from state and federal agencies. The proposal data will rely on open-access and proprietary legal research databases such as *Lexis-Nexis*[20]. The

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[17] Olinger, David. "After 11 Years, U.S. Fire Program Analysis System Still Isn't Ready."
[18] Appendix A
[19] "Geographic Area Coordination Center (GACC) Website Template." http://www.nifc.gov/
[20] *Wildfire Mitigation Law in the Mountain Sates of the American West: A comparative assessment*

strategic recommendations are largely based upon the research from the Forest Service, National Parks Division and the union of scientists.

Stakeholders:

The stakeholders include homeowners, hospitals and communities; real estate companies; construction companies and developers; local businesses; fire management – volunteer firefighters and local counties; Forest Service; local and state water facilities; environment and wildlife organizations; municipal and state legislators. If there is not adequate mitigation before the wildfire season starts, the fires could be more costly economically and pose a greater threat to habitats, structures and human populations. Mitigation policies are opposed by interest groups, homeowners associations, commercial operations, recreational groups, conservationists and some legislators. The political environment is hostile to mandatory mitigation legislation with attached penalties and additional disincentives. Transparency for risk assessments to potential consumers and the public has yet to be solidified in legislation as well. Developers and construction contractors are opposed to increasing the costs for construction. The real estate industry has no intention of voluntarily disclosing risk assessments on residences[21]. Homeowners in wildfire prone areas do not approve of increased fees, insurance hikes and special taxes in exchange for living in high risk areas. These are just some of the interests and stakeholders that will utilize their influence to modify potential policy recommendations.

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[21] Selvans, Zane. "Climate Science Archives - Clean Energy Action."

For the purpose of this memorandum the groups of stakeholders are divided into three sub categories: County of Boulder, Residents of Boulder, and Federal & State Agencies. The County of Boulder includes but is not limited to: County Commissioners, Sheriff Departments, and City of Boulder Fire Department. The Federal & State agencies include but are not limited to: Land Use, Parks and Open Space, Colorado State Forest Service, USDA Forest Service, National Park Service, American Red Cross. The Residents of Boulder include but is not limited to: Various local Fire Protection Districts and private citizens.

TABLE 1: STAKEHOLDERS

County of Boulder	Incorporates the city and county support services
Residents	Includes all communities, emphasis on the 9,000 individuals residing in the WUI
Federal and State Agencies	Federal Forest Service, Colorado Forest Service and Wildlife/Parks Agencies

Market Failure:

Market Failure- An economic term that encompasses a situation where, in any given market, the quantity of a product demanded by consumers does not equate to the quantity supplied by suppliers. This is a direct result of a lack of certain economically ideal factors, which prevents equilibrium.

The various stakeholders and interest groups also carry a considerable amount of political influence. The key groups advocating for suppression or opposing mitigation include: bureaucracies that thrive on suppression policies and stakeholders who oppose mitigation. Residents often oppose mandatory mitigation legislation due to the cost and

the difficulty finding a business to perform these duties. The residents also may see the mitigation efforts as either unwarranted or useless in the event of a large fire. Enforcing mitigation measures by the city can also be costly if the voluntary removal rate is low. Mitigation does not guarantee complete protection for every community. Funding and educational resources that have been dedicated to suppression efforts has come at a cost to mitigation efforts. This constitutes a market failure because an optimal allocation of resources and appropriations of funds are not attained.

Measures of Success: the following are quantitative and qualitative performance metrics for the proposed policy interventions.

- Measure the reduction in the number of fatalities among the public, firefighters, livestock and communities[22] due to wildfire per year. Record annually the total amount of damage to commercial and private structures prior to mitigation policy interventions and after. The total amount of damage to structures, private and commercial, can be expressed quantitatively.
- Reductions in post-fire rehabilitation costs can be determined on a cost per acre basis or an aggregate basis. Another metric can increase the amount of total acres burned each year to replicate naturally occurring and ecologically stabilizing wildfires. Measure the sustainability of the forest by analyzing the number of burned acres meeting revamped standards.
- Measure the total amount of wildfires that are considered out of control prior to mitigation policy interventions and after. Determine the probability of a fire

[22] Morey, Richard C. "A Performance Measure for the Medicaid Program."

potentially growing out of control prior to the policy intervention and after. Reductions in conflagrations and crown fires would be a performance metric associated with effective mitigation policies.

IV. Issue Analysis:

Wildfires also grow in strength as they run up a hill as it increase in elevation. A wildfire in a steep and rugged terrain is extremely difficult for crews and vehicles to negotiate. These sparsely employed fire stations throughout Boulder County are not

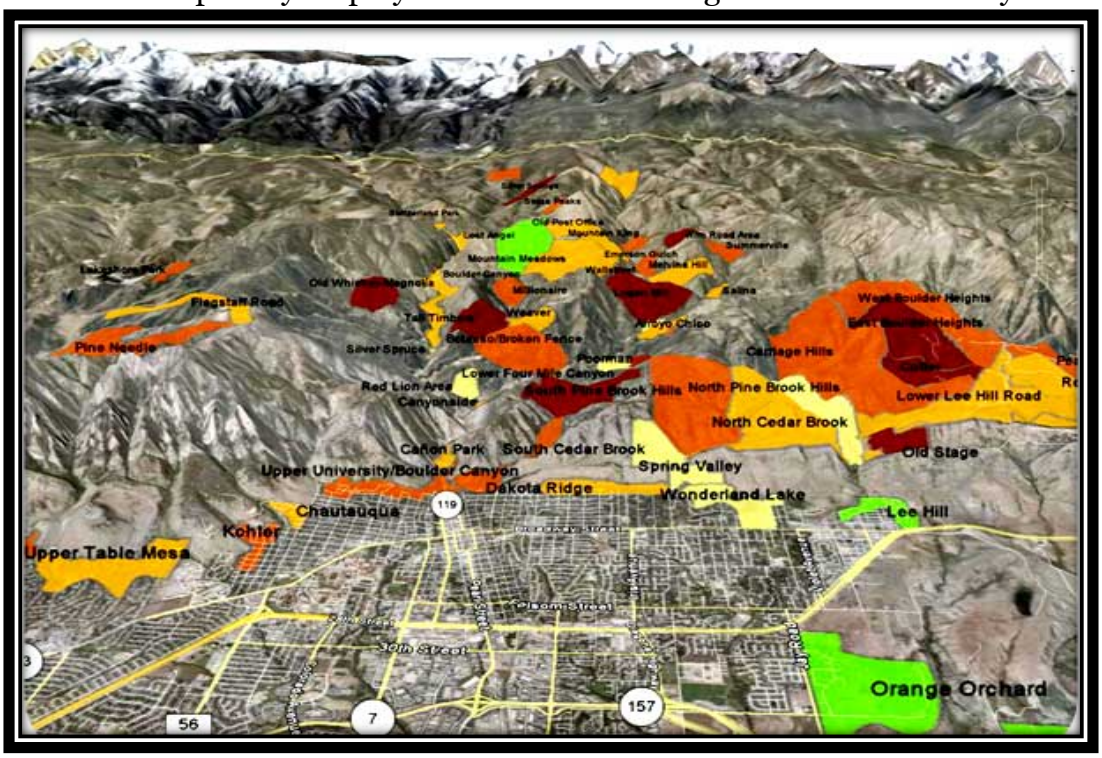

FIGURE 2: MAP OF BOULDER COUNTY, HIGHLIGHTED FIRE DISTRICTS

equipped with resources to handle wildfires and they usually will notify larger agencies immediately. Western officials continue to be concerned about the financial stability of wildfire suppression efforts[23] in their region. Under the current laws, congress must

[23] FY 2015 Budget justification. USFS.

appropriate funds ad-hoc to the wildfires as opposed to it being earmarked like other disasters (e.g. earthquakes or hurricanes)[24]. This year, Colorado Senator Mark Udall introduced legislation that would reclassify wildfires as a disaster thus allowing the funds to become centralized and not bound by annual congressional appropriations[25]. The beginning of the wildfire season is in sight and the budgets designed to control the conflagrations are already depleted and borrowing from already underutilized mitigation coffers[26]. This is a problem because the future costs of suppression efforts are forecasted to increase at the same pace it has been increasing for the last decade. In addition to the future budget constraints, there are a host of other financial concerns states are facing[27]. This pattern of stagnant funding in the face of growing costs has created havoc on the financial stability of the Forest Service[28], the western states budgets as well as the local municipalities that have deal with the consequences of these fires every year[29]. Year after year the budget for wildfire suppression has depleted well before the fire season ends.

a. History and Precedent:

The indiscriminate and destructive nature of wildfire jeopardized natural resources, commercial and private structures, public safety, water systems, and air quality. The threats constituted the necessity for institutional remedies in the form of

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[24] Kettl, Donald F. The Next Government of the United States
[25] USDA. News Release." *New Report Shows Budget Impact of Rising Firefighting Costs*.
[26] Kettl, Donald F. The Next Government of the United States
[27] Kettl, Donald F. The Next Government of the United States
[28] Wildfire Insurance and Forest Health Task Force Report September 2013
[29] Kettl, Donald F. The Next Government of the United States

public policy interventions at the state and local level[30]. The contemporary notion and structure of the US Forest Service was created in 1905. This occurred in the wake of devastating wildfires plaguing the country for over half a century. The origination of the Forest Service was an indirect result of the Progressive Era reforms because it served a purpose for conservation, public safety and recognition of potential political implications. Despite that fact, there was not one specific law that initiated the implementation of mandatory suppression policies for all fires. This changed in 1936 when a new informal policy required all fires (urban or otherwise) to be out by 10 am the next morning. This appropriately became known as "10 am" policy. At the Federal level, firefighting falls under two departments: the Department of Agriculture and the Department of Interior. There are five federal government entities responsible for wildfire mitigation and suppression in the western US: the US Forest Service, National Parks and Wildlife, Bureau of Indian Affairs, Bureau of Land Management and the U.S. Fish and Wildlife Service[31]. The Forest Service represents the lion's share of the operations, accounting for 70% of all federally funded resources dedicated solely to combating wildfires[32]. The Department of Interior has the other four federal agencies under its command for firefighting[33]. Firefighting at the state level is neither as uniform nor consistent as the federally designated agencies. Some states, like California (appropriately titled *Cal Fire)*, have their own dedicated firefighting agency. Most of the other 11 western states do not have the same resources or the operational capacity that is

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[30] Wildfire Insurance and Forest Health Task Force Report September 2013
[31] "Geographic Area Coordination Center (GACC) Website Template." http://www.nifc.gov/
[32] "The True Cost of Wildfire in the Western U.S." *Western Forestry Leadership Coalition*
[33] "The True Cost of Wildfire in the Western U.S." *Western Forestry Leadership Coalition*

provided to California. Instead, smaller states like Colorado rely on local jurisdictions commonly referred to as fire protection districts and Fire Wise communities[34]. Although California consumes the majority of the press coverage, the other 10 western states have also had to deal with the consequences of the fires, including the byproducts of conflagrations and crown fires from neighboring states[35].

Homeowners and developers claim the best policy prescription for the entire wildfire season is to suppress any fire regardless of the size, location or resources. Many in the policy community are proposing strategies that mimic those of a century ago around the inception of the US Forest Service. Similar policies like the ones being suggested today arose around the turn of the 20th century especially after the Great Fire of 1910[36]. After the Great Fire, the modus operandi became known as the "10 AM" policy which stated all fires must be extinguished (if possible) by the next morning at 10:00[37]. The size, intensity or likelihood of success could never be a relevant deterrent for suppression efforts for the next four decades. Regardless of the cause, local fire departments in the U.S. responded to an average of 356,800 such fires annually between 2004 and 2008.[38]

When a wildfire is first spotted and reported to authorities, initially, the local agencies partnering with urban firefighting forces attempt to extinguish the fire. If the fire increases in size or intensity, the first responders will request additional help from

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[34] Olinger, David. "After 11 Years, U.S. Fire Program Analysis System Still Isn't Ready."
[35] ibid
[36] "Fire & Aviation - About Us." *Fire & Aviation - About Us*. Forest Service
[37] "Fire & Aviation - About Us." *Fire & Aviation - About Us*. Forest Service
[38] "Becoming a Recognized Firewise Community"/ FireWise.org/ See the National Fire Protection Association (NFPA) and the NIFC for more information on wildfire causes and frequency

the broader geographic area that the fire is located in. Once the geographic area is no longer able to sustain operations against the fire, the National Interagency Coordination Center (NIFC) steps in to locate the necessary resources and personnel[39]. The federal wildfire management was initiated in response to various stakeholders outcry for cohesive federal strategy. In lieu of satellite and advanced thermal technology, the Forest Service could not have known the potential long term problems stemming from the universal management strategy. The size, intensity or likelihood of success would could never be a relevant deterrent for suppression efforts for the next four decades. If there was a fire it would be extinguished by any means necessary and available to the state. As larger populations continued to construct new developments in wildfire prone areas, public policy prioritized suppressing wildfires rather than preventing them[40].

"The old conservation biology approach of just put your arms around it, and protect it, and keep all disturbance out, is what's gotten us into this problem," Julian said. "We're essentially taking disturbance-driven systems and politically and socially saying it's just not acceptable to have those kinds of disturbances in those systems, because people don't want to see it."-Chad Julian, Boulder County's lead forester[41]

b. Consequences:

An astronomical amount of the brush, grass and forest fires are caused by humans, accounting for over 90%. This statistic is from the Federal coordination agency called the National Interagency Fire Center (NIFC) as well as the National Fire Incident Reporting System. This dispels the myth that most wildfires are caused by lightening or other natural processes[42]. Of the fires that are caused by humans,

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[39] "Geographic Area Coordination Center (GACC) Website Template." http://www.nifc.gov/
[40] ibid
[41] Turner, Christi. "Boulder County Wildfire Mitigation Hinges on Citizen Engagement."
[42] "Becoming a Recognized Firewise Community"/ FireWise.org

approximately 20% are ignited intentionally adding another social dimension to stopping conflagrations[43]. The following are four direct implications due to underutilized wildfire mitigation policies, while also noting that the conditions that cause the problem are also problems that must be addressed by policy makers[44]: 1) conflagrations are becoming more frequent, 2) conflagrations are a hazard to public safety, 3) wildfires are natural and ecologically beneficial, and 4) various interests oppose new policy recommendations.

1. Wildfires are getting larger and less controllable resulting in the classification as a "conflagration". Eight out of the nine largest wildfires in US history have occurred after 2000. Wildfires are difficult to stop once they start and require vast amount of resources. The two most destructive wildfires in state history have occurred in the last two summers[45]. Suppression policies that require immediate eradication of a fire unintentionally allow more dry fuel to build up and increase the likelihood of a future crown fire. Wildfire mitigation policies are being underutilized by local, state and federal agencies. Fire suppression policies are expensive, imprecise and increase the amount of fuel for future wildfires. Wildfire suppression policies have confiscated mitigation funding in recent years diminishing the capacity for mitigation efforts[46]. In

[43] "Becoming a Recognized Firewise Community"/ FireWise.org
[44] Bardach
[45] Wildfire Insurance and Forest Health Task Force Report September 2013
[46] Healy, Jack. "Cost of Battling Wildfires Cuts into Prevention Efforts."

addition to increasing fiscal constraints, recent studies show that destruction from wildfires has doubled every decade since the 1960's[47].

2. Wildfires threaten structures, public safety and the sustainability of federal and state funds designed to diminish the consequences of the annual fire season. Nearly ten percent of all residences in Colorado are vulnerable to wildfires which leads the nation for the share of most homes vulnerable to wildfire[48]. Mountain terrains and steep slopes are difficult to navigate when fighting wildfires and many communities rely on volunteer fire fighters for prevention and suppression efforts. Current research determined that the most hazardous places to live in the WUI of the Mountain West are in the locations where the natural hazard threats are high and local communities have not reduced risk through mitigation[49].

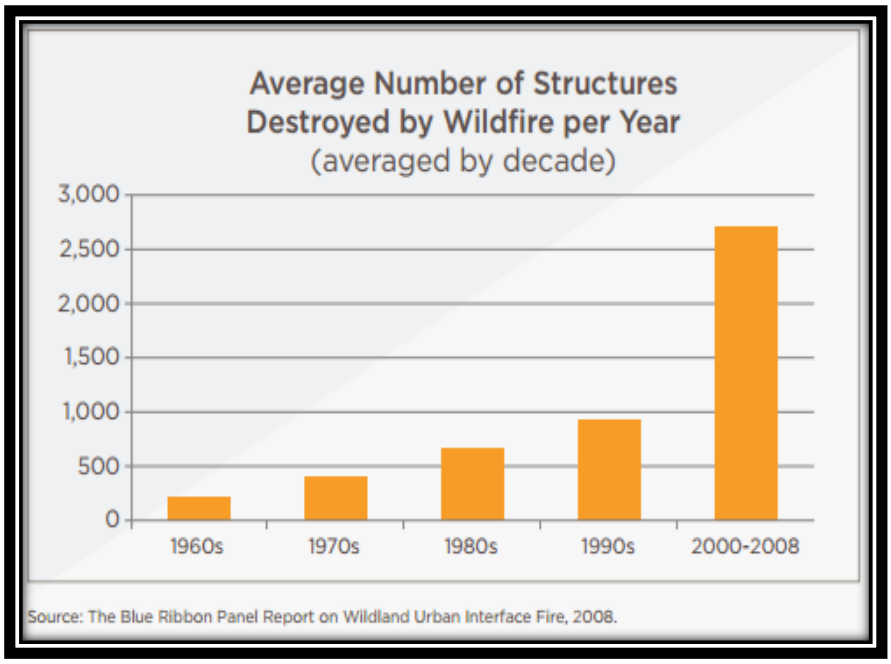

FIGURE 3: NUMBER OF STRUCTURES BURNED PER YEAR

3. Cattle, moose, deer, elk, raptors and other

[47] Lee, Kurtis. "As Colorado Wildfires Continue to Worsen, Only Moderate Laws Proposed."
[48] Svaldi, Aldo. "Colorado Leads Country for Share of Homes Most Vulnerable to Wildfires."
[49] Wildfire Insurance and Forest Health Task Force Report September 2013

non-mammal species benefit from the browse created by fire. Only 10% of wildfires are started by lightning or other natural causes while the rest are caused by humans, unintentional or otherwise[50]. Wildfire in the Rocky Mountain Region of Colorado is a beneficial and integral component of the ecological integrity as well as overall forest ecosystems. They are naturally occurring; destroying beetle infested fuel as well as other invasive species.

4. Mitigation policies are opposed by interest groups, homeowners associations, commercial operations, recreational groups, conservationists and some legislators as well. The political environment is hostile to mandatory mitigation legislation with attached penalties and additional disincentives. Transparency for risk assessments to potential consumers and the public has yet to be solidified in legislation as well. Developers and construction contractors are opposed to increasing the costs for construction. The real estate industry has no intention of voluntarily disclosing risk assessments on residences[51]. Homeowners in wildfire prone areas do not approve of increased fees, insurance hikes and special taxes in exchange for living in high risk areas. These are just some of the interests and stakeholders that will utilize their influence to modify potential policy recommendations.

c. Cost for Suppression Efforts

[50] United States. National Park Service. "Wildland Fire: Wildfire Causes | U.S. National Park Service."
[51] Selvans, Zane. "Climate Science Archives - Clean Energy Action."

Due to the sequestration that was passed in Congress in 2013, the US Forest Service budget was cut by 13% which is $28 million. At a time when funding strategies are lacking and federal support is unlikely to increase, the Forest Service has been morphed into the wildfire fighting service. The cost for fighting wildfires dwarfs the cost for mitigation efforts[52]. Last year, the U.S. Forest Service spent more than $1.3 billion on fire suppression alone. This is a stark contrast to the less than $3 million for mitigation and fire resistant adaptations in vulnerable communities. Another $24 million was given to states for efforts that were devoted to reducing fuel in fire prone areas[53]. This amount devoted to mitigation efforts is less than the sequestration total. They also project this trend to continue and Paul L. Cooke, Colorado director of the Division of Fire Prevention and Control said, "It's only going to get worse. We're building more in the woods. The amount of fuel in those woods is growing, which is not good."[54] Decreasing the amount of total spending on suppression policies will not be addressed in this mitigation policy proposal. Western officials continue to be concerned about the financial stability of wildfire suppression efforts[55] in their region. Under the current laws, congress must appropriate funds ad-hoc to the wildfires as opposed to it being earmarked like other disasters (e.g. earthquakes or hurricanes)[56]. “Overall, the economic impact of the Schultz Fire — which burned no structures — was between $133

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[52] Healy, Jack. "Cost of Battling Wildfires Cuts into Prevention Efforts."
[53]Wildfire Insurance and Forest Health Task Force Report September 2013
[54] Lee, Kurtis. "As Colorado Wildfires Continue to Worsen, Only Moderate Laws Proposed."
[55] FY 2015 Budget justification. USFS.
[56] Kettl, Donald F. The Next Government of the United States

million and $147 million. In comparison, preventative methods, such as thinning the forests in the area of the Schultz Fire, would have cost only $15 million."[57]

The cost of the Fourmile Canyon Fire exceeded $225 million which included $73.6 million in property damage to residences and businesses alike. The federal government absorbs the majority of this cost. Wildfire related costs have consumed more than half of the US Forest Service operating budget the last few fiscal years. Wildfire fighting costs only consumed 25% of the operating budget a decade ago. This points to a larger systemic issue that fires are becoming more frequent, more expensive and more intense than in previous decades. The 2012 Waldo Canyon fire was even more costly than the Fourmile fire and set a record for the costliest wildfire in the 176 year old history. This fire resulted in a $352.6 million in insured losses. The U.S. Forest Service and the Department of the Interior (DOI) are projected to spend over $470 million more than is available to fight wildfires this season[58]: "The USDA and Interior call the practice of moving funds into firefighting "fire borrowing." But they warned that would take money away from thinning and controlled burns that could reduce future wildfires. The agencies have used 'the borrowing' in seven of the last 12 years.[59]" The US Forest Service needs a standard operating procedure for all forest fires recognizing the limits on funding and ecological sustainability. The central budget problem has resulted from the allocation of funding which has not adequately kept pace with the explosion of costs and expenses to tax payers and the states[60]. Sen. Ron Wyden (D-Ore.) said:

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[57] Peterson, Jeff. "Wildfire Prevention Costs Far Less Than Fires (Op-Ed)."
[58] USDA. News Release." *New Report Shows Budget Impact of Rising Firefighting Costs*.
[59] The Hill. Cana, Tim. "Feds Expect to Break Wildfire Budget Due to Climate Change."
[60] Kettl, Donald F. The Next Government of the United States

"The wildfire report shows the need to reform the budget for firefighting. Sen. Mike Crapo(R-Idaho) has sponsored a bill to treat large wildfires as natural disasters and to fund them from the same account as relief efforts like those after hurricanes. "It is time to break the destructive cycle that underfunds fire prevention and shorts forest management and start treating the largest wildfires that rage across the West every year for what they are — natural disasters."[61]

In addition to that report, research after the Hayman Fire indicated that suppression costs accounted for only about 20 percent of a total estimated cost of over $207 million. Included in the total estimate are direct costs like suppression, rehabilitation, and broader impacts. It's safe to assume this total cost is likely substantially under-estimated because restoration work in the Hayman Fire burn scar is still ongoing to this day.[62]

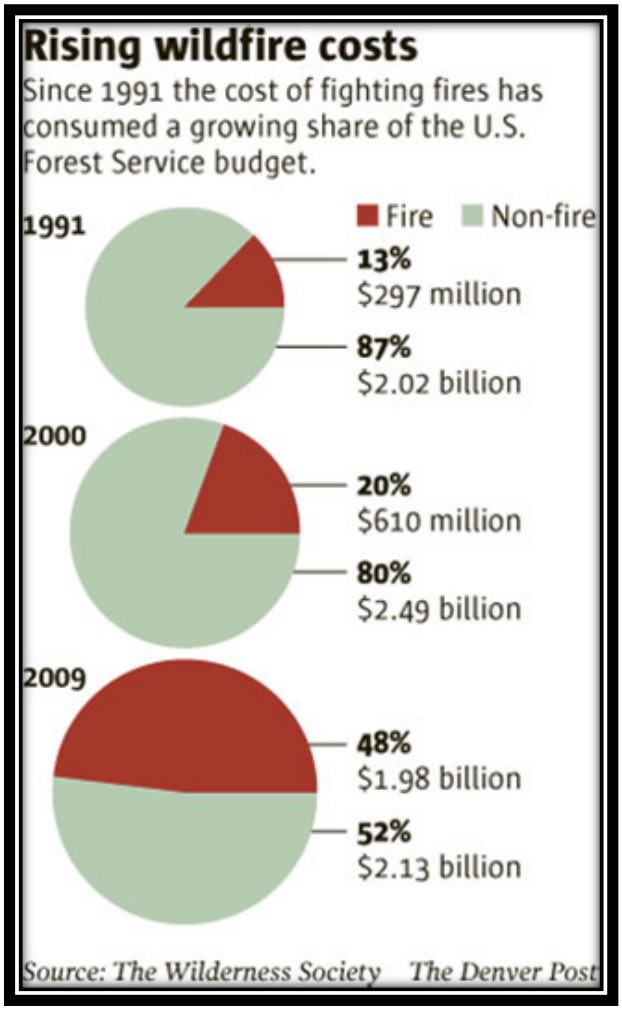

FIGURE 4: RISING WILDFIRE COSTS

Increasingly, especially in the last decade, the operating budget for these efforts continues to grow. This is a problem because the future costs of suppression efforts is forecasted to increase at the same pace it has been increasing for the last decade. In addition to the future budget constraints, there are a host of other financial

[61] The Hill. Cana, Tim. "Feds Expect to Break Wildfire Budget Due to Climate Change."
[62] Jacobi, Amy. "The Economics of Wildfire – 1/21/2015 | Coalition for the Upper South Platte."

concerns states are facing. This pattern of stagnant funding in the face of growing costs has created havoc on the financial stability of the Forest Service, the western states budgets as well as the local municipalities that have deal with the consequences of these fires every year. Year after year the budget for wildfire suppression has depleted well before the fire season ends.

V. **Proposed Solutions:**

The complexities of wildfire mitigation in mountainous terrain necessitates the consideration of wildlife habitats, ecological impacts, populations in vulnerable areas, limits of natural resources (such as water) and allocating federal and state coffers appropriately. Policy should aim to reduce the ground fuel near and surrounding the residences in order to increase the likelihood the house will survive a wildfire. The solutions, in the form of "soft" and "hard" laws[63], can be implemented as standalone interventions or in concurrence with other policies. By focusing efforts on mitigation, resources can be allocated to help reduce the effect of the wildfire once it ignites. The best predictor of damage to structures is correlated to the amount of adjacent vegetation and undergrowth. If there is not adequate mitigation before the wildfire season starts, the fires could be more costly economically and pose a greater threat to habitats, structures and human populations. Differing from forestry ecologists, many homeowners and developers continue to claim the best policy prescription for the entire wildfire season is to suppress any fire regardless of the size, location or resources.

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[63]Burton,, Lloyd. "WILDFIRE MITIGATION LAW IN THE MOUNTAIN STATES OF THE AMERICAN WEST: A COMPARATIVE ASSESSMENT."

Similar to other mitigation efforts, it is important to recognize that the alternatives are not meant to replace suppression efforts, educational outreach or legislative action. These alternatives will supplement current wildfire efforts which will benefit the communities in the WUI and add another resource to their action plans. There will be three policy alternatives analyzed for the CBA: Policy Alternative 1. *Mandate and Implement the FireWise Program* (fuel treatments near residential structures within an urban interface), Policy Alternative 2. *Treating Stands in the Adjacent Wild lands*, and Policy Alternative 3. *Construction of Retaining Walls* ("Mitigation Strategy #2").

FIGURE 5: FIREWISE MITIGATION SUGGESTIONS

a. Policy Alternative 1- FireWise Program:

Preparations by the homeowners greatly increase the likelihood of their residence surviving the wildfire season. "Without fire to control re-growth, it is unclear how the

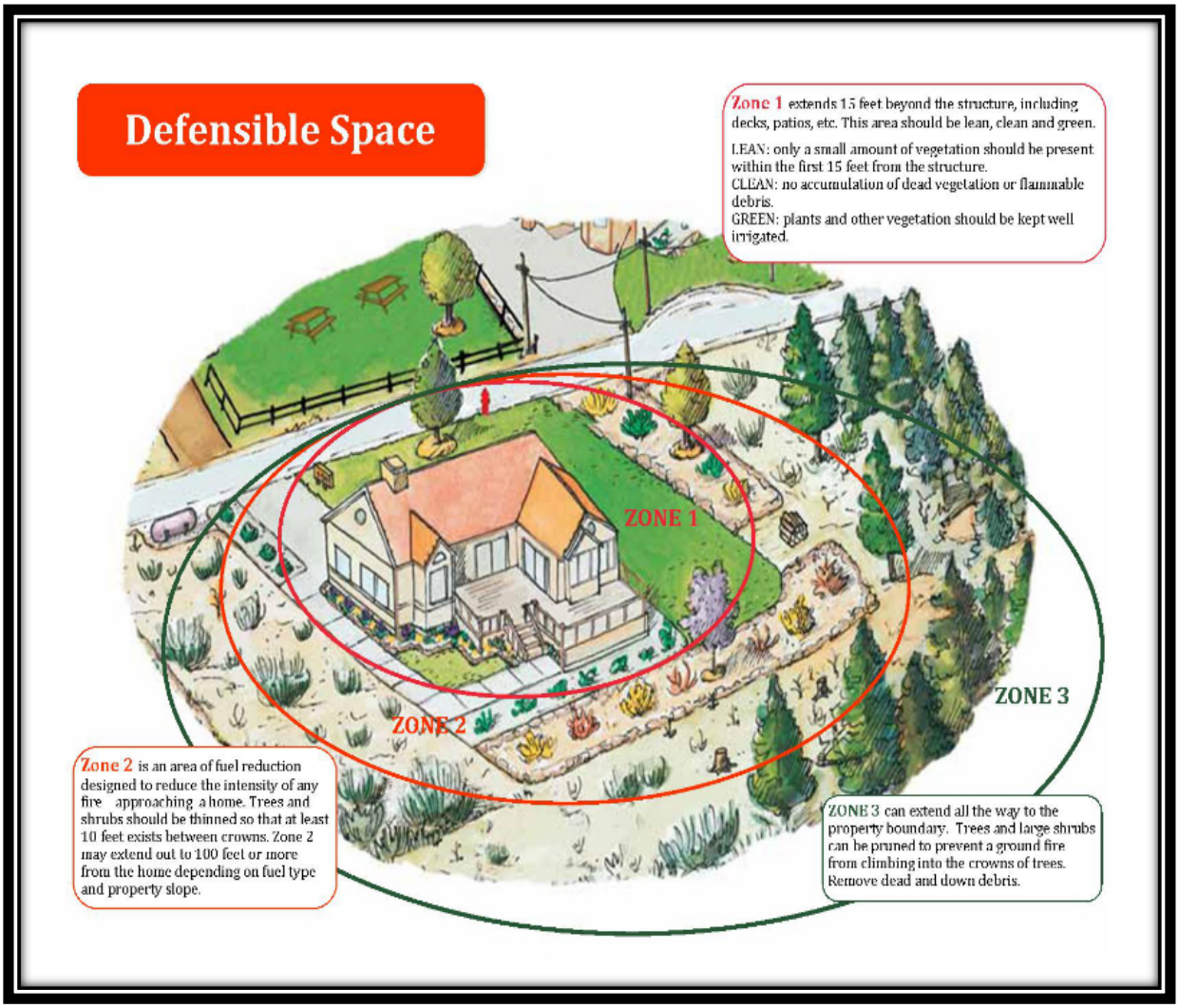

FIGURE 6: DEFENSIBLE SPACE FOR FIREWISE PROGRAM "MITIGATION - WEST REGION WILDFIRE COUNCIL." WEST REGION WILDFIRE COUNCIL

work can be maintained in the long run".[64] Wildfire partners is a voluntary program already in place and this policy solution would make this type of program compulsory. The current program in place right now includes an on-site expert assessment of the residence and the surrounding area. These site visits provide the home owners specific mitigation recommendations.[65] These recommendations vary from creating a

[64] Steelman, Toddi A. "Boulder – Wildfire Summary." NCSU
[65] *Boulder County Community Wildfire Protection Plan*. Boulder County

defensible space to clearing gutters that are occupied with debris and dry fuel. This program also offers $300 in rebates for each household that enrolls.[66] 350,000 people in Boulder multiplied by $2.00 per person for the FireWise Program = $700,000.

Community meetings and workshops are effective tools to disseminate important information and educational materials[67]. The FireWise programs are utilized to engage community groups and establish collaborative Wildland-Urban Interface (WUI) wildfire education campaign in concert with rigorous national standards to identify at-risk communities. Currently, there is little research indicating the FireWise programs reduce the costs for suppression policies[68]. The FireWise program was not designed to decrease suppression costs. According to the program, reducing structural ignitability by concentrating on the 'home ignition zone' is the easiest way for homeowners to mitigate wildfire hazards in their neighborhood. Preparations by the homeowners greatly increase the likelihood of their residence surviving the wildfire season.

"The program boasts a wide range of public and private sector collaboration, including representatives of the insurance industry. Insurers will be watching how the new program proceeds, in order to determine whether a Wildfire Partners certificate could make a property more insurable. Of the 445 residents who applied, 400 will be officially accepted into the program next week. Participants must be homeowners in unincorporated Boulder County, or nearby mountain towns of Nederland, Jamestown or Lyons; they must also agree to home inspections and prove a long-term commitment to the program."

Community recognition by the Fire Wise Communities is the ultimate qualitative measure of success. The more Colorado communities that earn this designation, the less

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[66] Turner, Chrisiti. "Wildfire Mitigation Program Helps Homeowners Create Safer Communities."
[67] Titus, Marc, and Jennifer Hinderman. "A Collaborative Approach to Community Wildfire Hazard Reduction."
[68] Becoming a Recognized Firewise Community/USA. Quincy, MA: Firewise Communities

likely structures in fire prone areas will ignite. Community recognition by the Fire Wise Communities is an indicator of progress and commitment to a national standard. The five steps of Firewise recognition[69]: 1. Enlisting a WUI specialist to complete an assessment and create a plan that identifies locally agreed-upon solutions that the community can implement, 2. Sponsoring a local Firewise task force, committee, commission or department which maintains the Firewise Community program and tracks its progress or status, 3. Observing a Firewise Communities Day each year that is dedicated to a local Firewise project, 4. Investing a minimum of $2.00 annually per capita in local Firewise Communities efforts. (Work by municipal employees or volunteers using municipal and other equipment can be included, as can state/federal grants dedicated to that purpose), 5. Submitting an annual report to Firewise Communities, documenting continuing compliance with the program.

b. Policy Alternative 2- Treating Stands and Ecological Restoration:

In total, the City of Boulder owns approximately 50,000+ acres of public lands and watershed. According to the estimates from the Ecological Restoration Institute (ERI) at NAU the costs for thinning 30% of any given area is around $500-$1,000 per acre. Treatment costs account for only a fraction of the costs to fight fires, in Arizona, for example, treatment of the forests costs the state 51% less than the damage created by the Chediski Fire and the 89% less than the costs for the damage from the Schultz fire.[70]

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[69] *Becoming a Recognized Firewise Community/USA*. Quincy, MA: Firewise Communities
[70] Peterson, Jeff. "Wildfire Prevention Costs Far Less Than Fires (Op-Ed)."

Each individual prescribed burn will cost approximately $60,000[71]. This policy alternative will reduce the amount and type of fuel in order to lessen the magnitude of a crown fire or conflagrations. These policies are already in existence but are sparsely implemented and not prioritized as high as it should be. Fuel mitigation on public lands will include: prescribed burns by local and state authorities, residential and neighborhood prescribed burns with approved permit[72], eradication of beetle and other diseased infested fuel, removal of overgrowth and brush from stands and infected trees, goat and sheep grazing, mandated priority zones for fuel removal, and the establishment of state-wide mandatory measures for mitigating conflagrations and forest restoration. This policy solution could be funded by the Hazardous Fuels Reduction (HFR) Grant Program: which is a community-based cost share program[73]. Through this program, a representative of a neighborhood, HOA or subdivision works with local wildfire mitigation experts to develop a fuels reduction plan that fits the needs of the local community. The community receives financial assistance to implement the plan. The biggest challenge Boulder county faces is how to utilize the wood from thinning projects.[74] "A Northern Arizona University paper finds that forest thinning and restoration efforts significantly reduce fire suppression costs even if a wildfire comes through a 'restored' area of the forest. A wildfire that does hit an area that has received restoration treatments are more easily contained, allowing fire crews to attack other

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[71] Burness, Alex. "Foothills Fire Aims to Reduce Future Threats." *Foothills Fire Aims to Reduce Future Threats*

[72] **House Bill 7:** Permits counties to restrict the ability of agricultural producers to conduct burning on their own property during red flag warnings.

[73] Hazardous Fuel Reduction Grants

[74] Steelman, Toddi A. "Boulder – Wildfire Summary."

fires”[75]. Because wildfires appear to be affected by either suppression or prescribed fire, but not both, this suggests that prescribed fire and suppression act as substitutes rather than complements. “After accounting for potential endogeneity and nonlinearities of prescribed fire and fire crew response time with wildfire behavior, I find evidence that quicker response times limit wildfire size and intensity, and that prescribed fire may provide beneficial effects against wildfire extent and intensity up to three years of its application, especially in combination with quick response time. Thus, for every $1spent

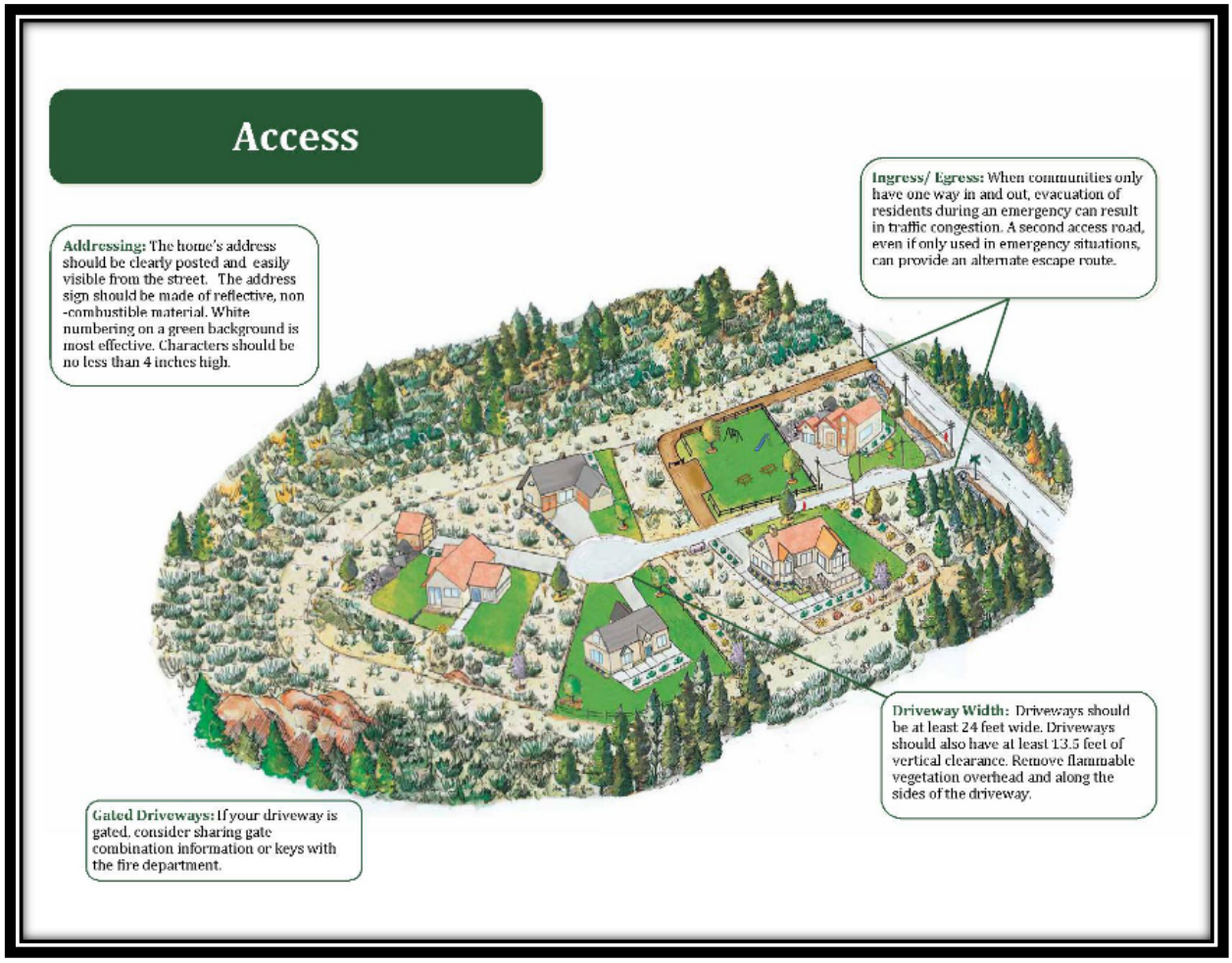

FIGURE 7: FIREWISE MITIGATION FOR ACCESS POINTS AND VARIOUS MEASURES

[75] Hoagland, Kolby. "Forest Fire Update and the Cost of Suppression."

on prescribed fire treatments, $1.53 in wildfire damage was avoided." For this policy option, the outcome after the proposed forest restoration treatments, would reduce the suppression costs to $287–$327 per acre for the same size fire. According to the True Cost of Wildfires, benefits for treating medium and high risk stands in the state of Washington exceeded the costs by $1,000-$2,000 per acre[76].

c. ***Policy Alternative 3 –Retaining Walls*:**

The construction of retaining walls between adjacent properties can help stymie the spread of a wildfire. Although the retaining wall is not a guarantee to stopping the fire it can slow it down and act as a fire break if the wall is designed and placed correctly. Retaining walls, and in some cases fences, act as physical barriers and visual barriers for firefighters and first responders in the area. These walls can be constructed from a variety of materials, but non-combustible materials are strongly recommended. Often times, fences and barriers that are already built are made from combustible materials like wood and vinyl. The retaining walls will act as a fire break and they can be built along ridgetops, between houses, and along roadways.

Fuel break System: a series of modified strips or blocks tied together to form continuous strategically located fuel breaks around subdivisions or land units. In the past Boulder County has proposed two types of fuel breaks (descriptions per Boulder County website):

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[76] "The True Cost of Wildfire in the Western U.S." *Western Forestry Leadership Coalition*

Ridgetop Fuel breaks – Ridgetops are excellent locations for fuel breaks as there are often changes in factors that may help change or at least slow fire behavior and spread. These include changes in fuel types, aspect, slope and more.

Roadside Fuel breaks – Roadside fuel breaks may be developed along roads found at bottoms, top or at midsole. While fuel breaks located at the bottom or at midsole are not ideal, all have the advantage of having road access which can provide an existing surface from which burnouts of fuels can quickly be done to strengthen the fuel break; or from which other defensive actions can be taken to help suppress the wildfire.

It is important to replace combustible fences and walls with noncombustible materials such as steel, concrete, masonry, or fireproof fiberglass. If the fence or wall is connected or adjacent to a building, it may provide a path for the spread of flames to that building. Conversely, noncombustible walls can function as a flame deflector and thus add to the fire defense of an adjacent building.[77] Home owners can also retrofit existing fences and retaining walls that are made with combustible materials by treating them with fire retardant coating[78]. Steel, masonry, and concrete fences and walls are the most effective for reducing vulnerability to wildfire damage in all fire zones. Masonry and concrete walls are visually obstructive but may act as flame barriers or deflection walls for adjacent buildings. Chain-link and barbed-wire fences allow the fire to pass through and do not act as protective barriers. However, metal may melt if exposed to long periods of extremely high temperatures.[79]

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[77] Graham, Russell T. *Fourmile Canyon Fire Findings*.
[78] *Becoming a Recognized Firewise Community/USA*. Quincy, MA: Firewise Communities
[79] Graham, Russell T. *Fourmile Canyon Fire Findings*.

> "Wildfire damage is typically the result of ignition or melting of the fence or wall construction materials. Ignition or melting may result from radiant heat, direct contact with flames, or contact with blowing embers and firebrands. Fences and walls have large surface areas that often contain cracks, openings, and rough areas, or are wire barriers. All of these characteristics increase the risk that fences and walls will trap fire elements. The potential for ignition is also related to the condition of the fence or wall: its age, the amount of debris accumulated adjacent to or on the fence, and the proximity to combustible vegetation or general landscaping."[80]

"I very rarely see a home that I drive by in Boulder County that has what I would say is good defensible space," said Chad Julian, the county's lead forester[81]. The first and third proposed solutions aim to make a residence and the surrounding area "Lean, Clean and Green." Lean indicates that a residence has very little flammable vegetation within 30 feet of their residence. Clean refers to the lack of dead vegetation and other materials near the house. Green is the color that accompanies the plants near the residence which should be healthy, irrigated and maintained during the fire season[82]. Two of the mitigation solutions proposed will fall under the community mitigation for wildfires, the other alternative is in the category of Wildland fuel reductions. All three of the alternatives have the same end goal, decrease the destruction of a conflagration or brush fire. (Design Issues and limitations: chain-link and barbed-wire fences allow the fire to pass through and do not act as protective barriers. Melting may occur if the metal is exposed to long periods of extremely high temperatures).

VI. Cost-Benefit Analysis

[80] FEMA- "Wildfire Hazard Mitigation Handbook for Public Facilities."
[81] Turner, Christi. "Boulder County Wildfire Mitigation Hinges on Citizen Engagement."
[82] "Mitigation - West Region Wildfire Council." *West Region Wildfire Council.*

An Ex-ante analysis has been chosen to be the most effective form of the CBA for the Memo. Costs that are negative externalities, such as increased ER visits due to smoke from wildfires and the loss of revenue to businesses that must shut down during a wildfire, were not included in the Status Quo. The CBA will be used to illustrate the costs and the benefits of each policy alternative and the status quo. The time horizon for the Status Quo will be 3 years and the social discount rate is set at .03 %[83]. A cost-benefit analysis (CBA) will be utilized in the memo as a tool for decision makers and their subsequent policy alternatives. The CBA is a quantitative approach to program evaluation and it is the primary tool available to the policy analyst in the modern organizational framework. The net present value will represent the best indicator of the most efficient option. Notwithstanding, the most efficient and market friendly policies may still not be beneficial to the community in a social or cultural context. These differences are important because policy makers must be made aware of the negative externalities associated with policies (which would not be limited to further marginalization of some stakeholders). Wildfire mitigation policies will be evaluated on a monetary scale and the viability of political approval will be explained as assumptions.

TABLE 2: COSTS AND BENEFITS

Costs	**Benefits**
Treatment to wildlands (Residential and volunteer)	Reduce Severity & Intensity of Wildfires

[83]"The True Cost of Wildfire in the Western U.S." *Western Forestry Leadership Coalition*

Federal Efforts	Reduce Suppression costs
County Efforts	Forest Ecology
Education	Protect Residences

"Ecosystem services are the benefits we derive from ecological processes and functions. Examples from the forests and grasslands affected by wildfire include timber and non-timber forest products, wildlife enjoyed for viewing or hunting, regulation of water quality and quantity, carbon sequestration and storage, soil creation and retention, nutrient cycling, and satisfaction of recreation, cultural, and spiritual needs and desires."[84]

Social and economic impacts of wildfires:

1) wildlife habitat destroyed or substantially altered, 2) water quality and watersheds impacted (on both public and private land), 3) public recreation facilities damaged or destroyed, 4) tourism impacts, 5) private property affected (including homes and other structures lost), 6) communities evacuated, 7) volume of timber destroyed on public and private lands, 10) public health impacts, 11) transportation impacts, 12) acres burned, and 13) suppression costs.

TABLE 3: SUMMARY OF MAJOR ENVIRONMENTAL, SOCIAL, AND ECONOMIC IMPACTS FOR THE CANYON FERRY FIRE

Suppression Costs	$9,544,627
Watershed Remediation	$745,300
Reseeding and Erosion Barriers	$455,394
Reforestation	$155,757
Resurveying and Range Improvements	$4,338,900
Invasive Species Remediation	$2,380,570
Value of Houses Burned	$300,000- $450,000
Decline in Recreational Visits (Helena NF)	80%
Restoration of Archaeological Sites	$48,520
Supervision of Mushroom Collectors	$6,790

[84] "The True Cost of Wildfire in the Western U.S." *Western Forestry Leadership Coalition*

TABLE 4: SUMMARY OF HAYMAN FIRE IMPACTS

Suppression	$39,000,000
Structures Destroyed	133 homes, 1 commercial building, 466 outbuildings
Evacuation	38,000 people
Smoke	1 Fatality, 1.8 million people impacted
Denver Water	$4,013,189
Recreation Interruption of hunting, fishing, and recreational visits	Pike National Forest closed one month Rehabilitation/Restoration
BAER	$24.8 million
EWP	$10 million
2003 Restoration	~$4 million

TABLE 5: COST BENEFIT ANALYSIS

Time Horizon= 3 years	Cost-Benefit Analysis for Wildfire Mitigation to Residences in Boulder County			
Social Discount Rate= .03	**Projections for Year 3**			
	A. Status Quo	**B. FireWise**	**C. Treating Stands**	**D. Retaining Walls**
BENEFITS				
City and County of Boulder	$ 3,749,287.00	$ 4,284,900.00	$ 31,065,525.00	$ 12,854,700.00
Residences	$ 2,142,450.00	$ 3,213,675.00	$ 8,569,800.00	$ 11,462,107.00
Federal and State Agencies	$ 10,712,250.00	$ 26,780,625.00	$ 29,993,000.00	$ 5,356,125.00
NET PRESENT BENEFITS	**$ 16,603,987.00**	**$ 34,279,200.00**	**$ 69,628,325.00**	**$ 29,672,932.00**
COSTS				
City and County of Boulder	$ 1,874,643.00	$ 2,892,307.00	$ 2,678,062.00	$ 1,071,225.00
Residents	$ -	$ 1,606,837.00	$ 21,424,500.00	$ 1,446,153.00
Federal and State Agencies	$ 27,851,850.00	$ 32,136,750.00	$ 27,851,850.00	$ 27,004,185.00
NET PRESENT COSTS	**$ 29,726,493.00**	**$ 4,499,144.00**	**$ 51,954,412.00**	**$ 29,521,563.00**
NET PRESENT VALUE	**$ (13,122,506.00)**	**$ 29,780,056.00**	**$ 17,673,913.00**	**$ 151,369.00**

TABLE 6: STATUS QUO- COSTS

County of Boulder	$500,000 for mitigation reimbursements to homeowners[85] + $1,250,000 on city funded mitigation measures and tax incentives[86]. TOTAL= $1,750,000
Residents	Do not pay directly for mitigation measures, the amount that is used from taxpayers is minimal[87]. TOTAL= 0.
Federal and State Agencies	Based on historical data, Boulder County experienced at least 29 significant (>50 acres) fires since 1916. This is an average of one fire every 3.31 years and a 30.2 percent chance of a fire in any given year. Assuming there is one large wildfire every 3 years, accounting for a $75,000,000 total cost, would average out to $25,000,000[88]. Wildfire Partners is funded by Boulder County and a $980,000 Wildfire Risk Reduction Grant from the Colorado Department of Natural Resources[89] and includes more than 20 partner organizations[90]. TOTAL= $26,000,000

TABLE 7: STATUS QUO- BENEFITS

County of Boulder	Doubling the cost of the city and county efforts[91]. TOTAL= $3,500,000
Residents	Doubling the cost of the wildfire partners program = $2,000,000[92]. TOTAL= $2,000,000
Federal and State Agencies	This is the amount of money saved on suppression efforts as well as lack of

[85] Steelman, Toddi, and Devona Bell. "Boulder County, Colorado Case Study, January 4-10, 2004."
[86] "Community Chipping Reimbursement Program." *Community Chipping Reimbursement Program*
[87] Steelman, Toddi, and Devona Bell. "Boulder County, Colorado Case Study, January 4-10, 2004."
[88] Table 1 and Table 2
[89] Turner, Chrisiti. "Wildfire Mitigation Program Helps Homeowners Create Safer Communities."
[90] Steelman, Toddi, and Devona Bell. "Boulder County, Colorado Case Study, January 4-10, 2004."
[91] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."
[92] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."

	damage to residences. TOTAL= $10,000,000.

Alternatives:

Policy Alternative 1- FireWise Program:

TABLE 8: FIREWISE COSTS

County of Boulder	Implementation of this program will cost $2,700,000. TOTAL= $2,700,000.
Residents	300,000 people in Boulder multiplied by $2.00 per person for the FireWise Program = $600,000.[93] Plus volunteer hours which will cost $950,000[94]. TOTAL= $1,550,000[95]
Federal and State Agencies	In addition to the existing $26,000,000, $4,000,000 will be needed to cover the rest of the FireWise Program. TOTAL= $30,000,000.

TABLE 9: FIREWISE BENEFITS

County of Boulder	The county is set to save $4,000,000[96]. TOTAL= $4,000,000
Residents	Doubling the cost of the FireWise program = 3,000,000[97]. TOTAL= $2,000,000. TOTAL= $3,000,000
Federal and State Agencies	The amount of money saved on suppression efforts as well as lack of damage to residences is $25,000,000. TOTAL= $25,000,000

[93] "Becoming a Recognized Firewise Community"/ FireWise.org
[94] "Becoming a Recognized Firewise Community"/ FireWise.org
[95] Snider, Laura. "High-risk Homeowners Less Likely to Mitigate Wildfires."
[96] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."
[97] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."

Policy Alternative 2- Treating Stands and Ecological Restoration[98]:

TABLE 10: TREATING STANDS- COSTS

County of Boulder	Assistance from the Boulder Mitigation group will cost $750,000 in addition to the status quo. TOTAL= $2,500,000
Residents	Adding a 0.15 percent sales tax, to be collected for eight years, to fund county mitigation expenses[99]. The funds are used for prevention and protection services. 20,000 acres (to be treated) x $1,000 per acre (for treatment) = $20,000,000[100]. TOTAL= $20,000,000
Federal and State Agencies	Funding from state and federal agencies does not need to be adjusted. TOTAL= $26,000,000[101]

TABLE 11: BAER COSTS FOR HAYMAN FIRE

BAER Projects Cost Land Treatments	
Aerial Hydro-mulching 6,955 acres	$19,139,865
Aerial Dry-mulching 4,500 acres	$3,195,000
Mechanical Scarification 15,000 acres	$637,500
Heritage Sites 2 sites	$1,340
Other Land Treatments 6 sites	$12,438
Noxious Weed Treatments 495 acres	$103,950
"Colorado Cares" Volunteer Work 125 projects	$8,700
Flood Warning Signs	$2,600
Flood Warning System	$67,350
Seed	$407,000

[98] Rummer, Bob. "Assessing the Cost of Fuel Reduction Treatments: A Critical Review."
[99] "New Boulder County Sales & Use Tax Rate for 2015." *New Boulder County Sales & Use Tax Rate for 2015.*
[100] Snider, Laura. "High-risk Homeowners Less Likely to Mitigate Wildfires."
[101] Peterson, Jeff. "Wildfire Prevention Costs Far Less Than Fires (Op-Ed)."

Subtotal Land Treatments	$23,575,743
Roads and Trails	$136,708
BAER Evaluation	$135,800
Monitoring	$39,019
Implementation Logistics 45 days	$900,000
	Total $24,787,270

TABLE 12: TREATING STANDS- BENEFITS

County of Boulder	Doubling the cost of the funds provided by the tax payers will save the city $29,000,000[102]. TOTAL= $29,000,000
Residents	The sales tax will account for a savings of $8,000,000[103]. TOTAL= $8,000,000.
Federal and State Agencies	This is the amount of money saved on suppression efforts as well as lack of damage to residences. TOTAL= $28,000,000.

Policy Alternative 3- Retaining Walls

TABLE 13: RETAINING WALLS- COSTS

County of Boulder	The cost to the city for the walls, including subsidies, is $1,000,000. TOTAL= $1,000,000
Residents	Adding a 0.15 percent sales tax, to be collected for eight years, to fund county mitigation expenses. The funds are used for prevention and protection services[104]. 5,000 residences (to be treated) x $1,000 per wall = $5,000,000. TOTAL= $5,000,000
Federal and State Agencies	Funding from state and federal agencies does not need to be adjusted. TOTAL= $26,000,000

[102] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."
[103] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."
[104] Snider, Laura. "High-risk Homeowners Less Likely to Mitigate Wildfires."

TABLE 14: RETAINING WALLS- BENEFITS

County of Boulder	The county will save an average of $12,000,000 per year due to the walls. TOTAL= $12,000,000
Residents	Will save $10,700,000 from these walls, including insurance expenses[105]. TOTAL= $10,700,000.
Federal and State Agencies	Are set to save an average of $5,000,000[106] TOTAL= $5,000,000

TABLE 15: NET PRESENT VALUES

NPV	Status Quo	Alt. #1	Alt. #2	Alt. #3
Year 1	**(12,250,000.00)**	**27,650,000.00**	**16,500,000.00**	**(650,000.00)**
Year 2	**(12,678,750.00)**	**28,773,000.00**	**17,077,500.00**	**146,250.00**
Year 3	**(13,122,506.00)**	**29,780,056.00**	**17,673,913.00**	**151,369.00**

VII. Strategic Recommendations:

"The exclusion of fire creates forest that looks healthy, but it's actually a forest slowly dying."- Jay Stalnacker, chief fire management officer for Boulder County[107]

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[105] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."
[106] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."
[107] Burness, Alex. "Foothills Fire Aims to Reduce Future Threats."

The policy solution that is recommended for the stakeholders of the County of Boulder is: Policy Alternative 2. *Treating Stands in the Adjacent Wild lands*. This policy option had some advantages over the other two. The FireWise program will strengthen the defenses of the communities in the WUI but the voluntary wildfire partners program in place is already in existence. The third policy option would be the second best policy choice because it is relatively easy to implement and it does not conflict with the existing wildfire partners program. The main reason the second policy alternative was chosen was due to the fact that stands in adjacent wildlands can be treated efficiently and without enforcement (the other two would require enforcement and collaboration with local authorities to ensure mitigation is completed).

The best predictor of damage to structures is correlated to the amount of adjacent vegetation and undergrowth. Solutions should still be modeled off of FEMA's mitigation process. This process includes the public, which allows for a risk assessment, and finally a mitigation strategy. The mitigation strategy is further divided into a four step process: organize resources, assess risks, develop a mitigation plan and implement plan and monitor progress. The current shift from suppression to mitigation has not been in response to new legislation, instead it is it something that the implementing agency has recently decided to unilaterally undertake. If there is not adequate mitigation before the wildfire season starts, the fires could be more costly economically and pose a greater threat to habitats, structures and human populations.

The ubiquitous nature of mobile devices with internet connections has enabled real time crowd sourcing which can be extremely helpful for research. Computer models and crowd sourced applications for mobile phones have advanced to such a degree that it

can now track fuel levels, ignition risk and landscape updates in real time. Crowd sourcing information is currently being used to track the regrowth of a specific location that was affected by a wildfire. Anyone can take a picture and simultaneously share it on a social media site with a hashtag thus making it available for the public to research. This form of free data is not only beneficial to researchers but also to the public as well by allowing them to be a part of the process and restoration.

Unmanned aerial vehicles and computer programs like RAMS ("Risk Assessment and Mitigation Strategies" is a computer model that systematically illustrates landscape risk assessment and prioritize landscapes for mitigation strategies) represent the benefits technology has in reference to mitigation decision making. Federal agencies are currently using RAMS to prioritize fire prevention measures[108]. The standard criteria and requirements for the data in this model are: Fuel hazard, ignition risk, historical fire ignition, fire return interval values and protection capability.[109] Satellite imagery and aerial monitoring of fuel levels coupled with computer-modeled potential fire paths can illustrate the best practices to fight a fire given different wind, weather and terrain conditions. This is another tool that can be used to prioritize mitigation efforts and plan resources[110].

Another recommendation, irrespective of the policy options, is for the County of Boulder to conduct a *SWOT Analysis* (Strengths, Weaknesses, Opportunities and Threats) for evaluating how risk might change from proposed fuel treatments. Previous

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[108] Titus, Marc, and Jennifer Hinderman. "A Collaborative Approach to Community Wildfire Hazard Reduction."
[109] ibid
[110] ibid

studies have measured different fuel management techniques including animal grazing, mechanical treatment and prescribed burning. Measure the total amount of fuel prior to mitigation policy interventions and after. Compare fuel treatment and mitigation strategies versus fire severity and destructiveness. This type of analysis will give the policy makers and the forest ecologists a basis for comparing policy remedies. Even if none of these policy recommendations are undertaken by law makers, individual homeowners are encouraged to prepare and modify their residences for wildfire. State and local governments in the Western US need to consider stronger measures in prevention, education, penalties, and restricted fire zones. A conglomeration of research initiatives, federal grants, crowd sourced applications, computer models, satellite imagery, and aerial monitoring of fuel levels should be considered as policy proposals for Boulder County. Another set of possible legislative actions could include: tax credits and incentives for mitigation, fees on homes built in the mountains[111], revamped penalties, state building codes for use of fire-resistant materials[112], mandatory mitigation operations, defensible space requirements for homes in high risk areas, legislation eliminating suppression efforts from "borrowing funds", grants from the federal government, develop wildfire information resource centers[113], and mandatory risk assessments that are made available to the public.

Finally, residents, communities and the County need to continue to pursue funding through federal grants. These grants are an excellent funding source because they do not require

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[111] Finley, Bruce. "Task Force: Colorado Homeowners Should Pay to Live in Burn Zones."
[112] Lee, Kurtis. "As Colorado Wildfires Continue to Worsen, Only Moderate Laws Proposed."
[113] **Senate Bill 8:** Establishes a wildfire information resource center.

capital from the constituents or the local government. FEMA and other federal agencies offer various types of grants for mitigation measures. Federal Emergency Management Agency (FEMA) defines "hazard mitigation" as the:

> "Sustained action taken to reduce or eliminate long-term risk to people and their property from hazards. Hazard mitigation planning is the process State, Tribal, and local governments use to identify risks and vulnerabilities associated with natural disasters, and to develop long-term strategies for protecting people and property from future hazard events."

One of the grants that can be used for wildfire mitigation is the Hazardous Fuels Reduction (HFR) Grant Program is a community-based cost share program. Through this program, a representative of a neighborhood, HOA or subdivision works with local wildfire mitigation experts to develop a fuels reduction plan that fits the needs of the local community. The community receives financial assistance to implement the plan. [114]

VIII. Weaknesses and Limitations:

Weather conditions, severity of the fire and inadequate suppression policies can undermine the mitigation efforts. Mitigations will not stop large fires from occurring even after fuel reductions. The annual budget, national and local, for fire suppression has been completely depleted since 2011 prior to the end of the wildfire season and there is no guarantee mitigation efforts will drastically reduce suppression and rehabilitation costs. The chaotic and sporadic nature of wildfires induces disorganization creating another layer of difficulty when

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[114] "Grants - West Region Wildfire Council West Region Wildfire Council."

determining allocation of limited resources. Federalism and wildfire policy fragmentation create problems for implementation. Kettl's vending machine metaphor describes the proficiency for the role of government as intermediary for predictable and linear services. However, the vending machine model fails at more complicated and problems thus diminishing the possibility the policy prescriptions will succeed. Wicked problems such as natural disasters and terrorist attacks confound the vending machine model (Kettl uses Hurricane Katrina and 9/11 in previous writings)[115]. Wicked problems confound the vending machine model instead requiring abstract policies with an emphasis on utilizing the networks of organizations and contacts as opposed to relying heavily on a single centralized authority. These problems should not be solved by linear models. Kettl suggests using methods employed by the experts in their given field. Wildfire mitigation, similar to other natural hazard preventive measures, requires employing the scientists with experience in the field. The primary problems associated with wildfires in the Western US are not their management (or lack thereof) rather it is the fragmented and conflicting objectives for each agency combating wildfire within their given jurisdiction. Finally, as the Coalition for the Upper South Platte note "Respiratory illnesses from poor air quality and smoke inhalation during a fire, emotional damage from surviving a traumatic event, and grief from any number of losses during a fire can all impact the quality of life for individuals and communities long after the fire is extinguished"[116].

Consideration of carbon, tax revenues, mill levies and insurance costs, for example, were beyond the scope of this memorandum. I also did not consider the

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[115] Kettl, Donald. The Worst Is Yet to Come
[116] Jacobi, Amy. "The Economics of Wildfire – 1/21/2015 |

magnitude of other natural and anthropogenic influences on the landscape, such as beetle infestations, hurricanes or other natural disasters, or other variations in park visitation, which could provide added context for the wildfire impacts discussed in this report. Negative impacts from wildfire restoration, such as smoke impacts from prescribed burns, are also not explicitly considered.

IX. Conclusions:

As larger populations continue to construct new developments in wildfire prone areas, public policy prioritizes suppressing wildfires rather than preventing them. Policy maker's considerations must be predicated on models interpreting wildfire as a natural disaster. If we consider wildfire a natural disaster, then preparation and precautionary measures will be recognized as essential. Wildfire mitigation will continue to be a necessary process due to the fact that communities are continuing to expand into the WUI and the overall climate is becoming more prone to warmer weather and droughts. The following are five direct implications due to underutilized wildfire mitigation policies, while also noting that the conditions that cause the problem are also problems that must be addressed by policy makers[117]: 1) conflagrations are becoming more frequent, 2) conflagrations are a hazard to public safety, 3) the costs associated with wildfires continue to rise, 4) wildfires are natural and ecologically beneficial, and 5) various interests oppose new policy recommendations for mitigation. Wildfire mitigation reduces costs and damage due to the reduction in their intensity.

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[117] Bardach

Mitigation will not be the causation to protecting homes, rather it will be a strong correlate. Policies must be introduced in order to reduce the number (prevention) and severity (mitigation) of future wildfires in Boulder County[118]. Public policy should aim to reduce the ground fuel near and surrounding the residences in order to increase the likelihood the house will survive a natural disaster. The policy alternatives, in the form of "soft" and "hard" laws[119], can be implemented as standalone interventions or in concurrence with other initiatives. By focusing efforts on mitigation, resources can be allocated to help reduce the effect of the wildfire once it ignites.

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[118] "Community Wildfire Protection Plan (CWPP)." *Community Wildfire Protection Plan (CWPP).*
[119]Burton,, Lloyd. "WILDFIRE MITIGATION LAW IN THE MOUNTAIN STATES OF THE AMERICAN WEST: A COMPARATIVE ASSESSMENT."

Appendix:

Cost Benefit Analysis for Appendix

Time Horizon= 3 years
Social Discount Rate= .03

Problem Definition: Compulsory wildfire mitigation is necessary because wildfire is the most likely natural disaster for Boulder County. Within Boulder County, large fires involving home loss account for only 8.6 percent of the total area burned along the Colorado Front Range but 49.6 percent of the homes lost[120].

Thesis: mitigation reduces costs and damage due to wildfires. Mitigation will not be the causation to protecting homes, rather it will be a correlate. Policies must be introduced in order to reduce the number (prevention) and severity (mitigation) of future wildfires in Boulder County[121].

An Ex-ante analysis has been chosen to be the most effective form of the CBA for the Memo. Costs that are negative externalities, such as increased ER visits due to smoke from wildfires and the loss of revenue to businesses that must shut down during a wildfire, were not included in the Status Quo. The net present value will represent the best indicator of the most efficient option. Notwithstanding, the most efficient and market friendly policies may still not be beneficial to the community in a social or cultural context.

Social Discount Rate: A standard discount rate of 3 percent is assumed; thus, for every year it takes to replace a specific amount of service, an amount of habitat capable of producing an additional 3 percent of the remaining lost service must also be constructed. For a more detailed account of discounting, see NOAA (1999).[122]

1. Ray, G.L. 2008. Habitat equivalency analysis: A potential tool for estimating environmental benefits. Ecosystem Management and Restoration Research Program. http://el.erdc.usace.army.mil/elpubs/pdf/ei02.pdf

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[120] Graham, Russell T. *Fourmile Canyon Fire Findings*. Fort Collins, CO: U.S. Dept. of Agriculture
[121] "Community Wildfire Protection Plan (CWPP)." *Community Wildfire Protection Plan (CWPP)*.

[122] Ray, G.L. 2008. Habitat equivalency analysis: A potential tool for estimating environmental benefits

2. National Oceanic and Atmospheric Administration (NOAA). 1999. Discounting and the treatment of uncertainty in natural resource damage assessment. Damage Assessment and Restoration Program. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3698326/#CR48

Boulder county voter's willingness to pay for mitigation:

1. Wildfire-Migration Dynamics: Lessons from Colorado's Fourmile Canyon Fire http://www.tandfonline.com/doi/abs/10.1080/08941920.2013.842275#.VDvWgvldXkU

2. "Boulder County, Colo. – With the addition of County Ballot Issue 1A – the Flood Recovery Tax – which was approved by voters in November, the county portion of sales and use taxes collected in Boulder County will increase to 0.985% for 2015.A breakdown of sales taxes in Boulder County is available online at:www.bouldercounty.org/gov/budget/pages/salesusetax.aspx

3. Cost shared wildfire risk mitigation in Log Hill Mesa, Colorado: survey evidence on participation and willingness to pay http://www.publish.csiro.au/?paper=WF13130

Studies for the Costs

1. Wildfire-Migration Dynamics: Lessons from Colorado's Fourmile Canyon Fire http://www.tandfonline.com/doi/abs/10.1080/08941920.2013.842275#.VDvWgvldXkU

2. A comparison of landscape fuel treatment strategies to mitigate wildland fire risk in the urban interface and preserve old forest structure http://www.sciencedirect.com/science/article/pii/S0378112710000514

3. "The True Cost of Wildfire in the Western U.S." *Western Forestry Leadership Coalition* (n.d.): n. pag. *Western Forestry Leadership Coalition*. Western Forestry Leadership Coalition, 9 Apr. 2009. Web. 9 Oct. 2014. http://www.blm.gov/or/districts/roseburg/plans/collab_forestry/files/TrueCostOfWilfire.pdf

4. Cost shared wildfire risk mitigation in Log Hill Mesa, Colorado: survey evidence on participation and willingness to pay http://www.publish.csiro.au/?paper=WF13130

5. Steelman, Toddi, and Devona Bell. "Boulder County, Colorado Case Study, January 4-10, 2004." *Boulder County, Colorado Case Study, January 4-10, 2004, Toddi Steelman and Devona Bell* (n.d.): n. pag. *Boulder County, Colorado*

Case Study, January 4-10, 2004. North Carolina State University, 10 July 2004. Web. 2 Feb. 2015. http://www.ncsu.edu/project/wildfire/Colorado/boulder/BoulderCaseStudy_final.pdf

6. Research after the Hayman Fire indicated that suppression costs accounted for only about 20 percent of a total estimated cost of over $207 million. Included in the total estimate are direct costs like suppression, rehabilitation, and broader impacts. It's safe to say this total cost is likely under-estimated because restoration work in the Hayman Fire burn scar is still ongoing. http://cusp.ws/the-economics-of-wildfire-1212015/

Studies for the Benefits

1. Trying Not to Get Burned: Understanding Homeowners' Wildfire Risk–Mitigation Behaviors http://0-link.springer.com.bianca.penlib.du.edu/article/10.1007/s00267-012-9949-8/fulltext.html

2. Calkin, David E., Jack D. Cohen, Mark A. Finney, and Matthew P. Thompson. "How Risk Management Can Prevent Future Wildfire Disasters in the Wildland-urban Interface." Proceedings of the National Academy of Sciences of the United States of America. National Academy of Sciences, 14 Jan. 2014. Web. 05 Jan. 2015. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3896199/

3. High-risk homeowners less likely to mitigate wildfires http://artsandsciences.colorado.edu/magazine/2014/09/high-risk-homeowners-less-likely-to-mitigate-wildfires/

4. Modeling wildfire potential in residential parcels: A case study of the north-central Colorado Front Range http://www.sciencedirect.com/science/article/pii/S0169204611001563

5. Risk Externalities, Wildfire Hazard, and Private Investment to Mitigate Wildfire Risk in the Wildland-Urban Interface http://ageconsearch.umn.edu/bitstream/149572/2/Taylor,%20Christman,%20and%20Rollins__May2013.pdf

6. How risk management can prevent future wildfire disasters in the wildland-urban interface http://www.pnas.org/content/111/2/746.short

7. Wildfire hazard in the home ignition zone: An object-oriented analysis integrating LiDAR and VHR satellite imagery http://www.sciencedirect.com/science/article/pii/S0143622814000617

Status quo:

Lawmakers re-authorized a 2008 bill that provides tax credits for 50 percent of a homeowners mitigation costs up to $2,500. But that only helps so much if neighbors don't mitigate as well. So they passed another law aimed at helping entire communities do mitigation. It provides nearly $10 million in matching grants for not only local governments, but homeowners associations.

http://denver.cbslocal.com/2013/06/22/new-state-legislation-helps-homeowners-with-wildfire-mitigation-costs/

Alternative 1

Advantage

1. Compulsory compliance with FireWise Programs for all residences in the WUI
2. Inspections and a model for the county to rely on, federally backed
3. Uniform mitigation, reduces the likelihood that next door neighbors will not mitigate

Disadvantage

1. It is similar to the voluntary programs now
2. It requires enforcement and assessments to guarantee federal funding
3. Residences will not be favorable to this policy compared to the others

Alternative 2:

Advantage:

1. It will reduce the amount of fuel in surrounding areas, thus reducing the likelihood of a conflagration
2. It does not require constant compliance from residences for mitigation purposes
3. It can be performed in targeted areas that are considered necessary

Disadvantage:

1. It's considered dangerous, and there have been incidents in the past where the fires have developed into uncontrollable contagions
2. It's still expensive per fire, but the costs of a larger wildfire sans prescribed burns are much higher than mitigation costs.
3. Treating stands will not stop a large fire

Alternative 3:

Advantage:

1. It can be erected easily and quickly.
2. It acts as a fire break/line in addition to retarding the fire on the ground

Disadvantage

1. Only works for certain residences
2. Requires adequate timing for construction as well as time to evacuate
3. Will not stop crown fires and fast moving conflagrations

COSTS

County of Boulder	$500,000 for mitigation reimbursements to homeowners[123] + $1,250,000 on city funded mitigation measures and tax incentives[124]. TOTAL= $1,750,000
Residents	Do not pay directly for mitigation measures, the amount that is used from taxpayers is minimal[125]. TOTAL= 0.
Federal and State Agencies	Based on historical data, Boulder County experienced at least 29 significant (>50 acres) fires since 1916. This is an average of one fire every 3.31 years and a 30.2 percent chance of a fire in any given year. Assuming there is one large wildfire every 3 years, accounting for a $75,000,000 total cost, would average out to $25,000,000[126]. Wildfire Partners is funded by Boulder County and a $980,000 Wildfire Risk Reduction Grant from the Colorado Department of Natural Resources[127] and includes more than 20

[123] Steelman, Toddi, and Devona Bell. "Boulder County, Colorado Case Study, January 4-10, 2004."
[124] "Community Chipping Reimbursement Program." *Community Chipping Reimbursement Program*
[125] Steelman, Toddi, and Devona Bell. "Boulder County, Colorado Case Study, January 4-10, 2004."
[126] Table 1 and Table 2
[127] Turner, Chrisiti. "Wildfire Mitigation Program Helps Homeowners Create Safer Communities."

	partner organizations[128]. TOTAL= $26,000,000[129]

1. "The True Cost of Wildfire in the Western U.S." *Western Forestry Leadership Coalition* (n.d.): n. pag. *Western Forestry Leadership Coalition*. Western Forestry Leadership Coalition, 9 Apr. 2009. Web. 9 Oct. 2014. http://www.blm.gov/or/districts/roseburg/plans/collab_forestry/files/TrueCostOfWilfire.pdf
2. "Boulder mitigation group treats around 500 acres a year at a cost around $1,000 an acre." Steelman, Toddi, and Devona Bell. "Boulder County, Colorado Case Study, January 4-10, 2004." *Boulder County, Colorado Case Study, January 4-10, 2004, Toddi Steelman and Devona Bell* (n.d.): n. pag. *Boulder County, Colorado Case Study, January 4-10, 2004*. North Carolina State University, 10 July 2004. Web. 2 Feb. 2015. http://www.ncsu.edu/project/wildfire/Colorado/boulder/BoulderCaseStudy_final.pdf

BENEFITS

County of Boulder	Doubling the cost of the city and county efforts[130]. TOTAL= $3,500,000
Residents	Doubling the cost (subsidized by the federal government) of the wildfire partners program = $2,000,000[131]. TOTAL= $2,000,000
Federal and State Agencies	This is the amount of money saved on suppression efforts as well as lack of damage to residences. TOTAL= $10,000,000.

Alternatives:

Policy Alternative 1- FireWise Program:
COSTS

[128] Steelman, Toddi, and Devona Bell. "Boulder County, Colorado Case Study, January 4-10, 2004."
[129] "The True Cost of Wildfire in the Western U.S." *Western Forestry Leadership Coalition*
[130] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."
[131] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."

County of Boulder	Implementation of this program will cost $700,000 + the existing costs to Boulder $1,750,000. TOTAL= $2,700,000.
Residents	350,000 people in Boulder multiplied by $2.00 per person for the FireWise Program = $700,000.[132] Plus volunteer hours which will cost $950,000[133]. TOTAL= $1,650,000[134]
Federal and State Agencies	In addition to the existing $26,000,000, $4,000,000 will be needed to cover the rest of the FireWise Program. TOTAL= $30,000,000.

BENEFITS

County of Boulder	The county is set to save $4,000,000[135]. TOTAL= $4,000,000
Residents	Doubling the cost of the FireWise program = 3,000,000[136]. TOTAL= $2,000,000. TOTAL= $3,000,000
Federal and State Agencies	The amount of money saved on suppression efforts as well as lack of damage to residences is $25,000,000. TOTAL= $25,000,000

Policy Alternative 2- Treating Stands and Ecological Restoration:
COSTS[137]

County of Boulder	Assistance from the Boulder Mitigation group will cost $750,000 in addition to the status quo. TOTAL= $2,500,000
Residents	Adding a 0.15 percent sales tax, to be collected for eight years, to fund county mitigation expenses[138]. The funds are

[132] "Becoming a Recognized Firewise Community"/ FireWise.org
[133] "Becoming a Recognized Firewise Community"/ FireWise.org
[134] Snider, Laura. "High-risk Homeowners Less Likely to Mitigate Wildfires."
[135] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."
[136] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."
[137] Rummer, Bob. "Assessing the Cost of Fuel Reduction Treatments: A Critical Review."
[138]"New Boulder County Sales & Use Tax Rate for 2015." *New Boulder County Sales & Use Tax Rate for 2015*.

	used for prevention and protection services. 20,000 acres (to be treated) x $1,000 per acre (for treatment) = $20,000,000[139]. TOTAL= $20,000,000
Federal and State Agencies	Funding from state and federal agencies does not need to be adjusted. TOTAL= $26,000,000[140]

"Because wildfires appear to be affected by either suppression or prescribed fire, but not both, this suggests that prescribed fire and suppression act as substitutes rather than complements. After accounting for potential endogeneity and nonlinearities of prescribed fire and fire crew response time with wildfire behavior, I find evidence that quicker response times limit wildfire size and intensity, and that prescribed fire may provide beneficial effects against wildfire extent and intensity up to three years of its application, especially in combination with quick response time. Thus, for every $1 spent on prescribed fire treatments, $1.53 in wildfire damage was avoided."

1. Residents Willingness to Pay- Wildfire-Migration Dynamics: Lessons from Colorado's Fourmile Canyon Fire http://www.tandfonline.com/doi/abs/10.1080/08941920.2013.842275#.VDvWgvldXkU

2. Rummer, Bob. "Assessing the Cost of Fuel Reduction Treatments: A Critical Review." Assessing the Cost of Fuel Reduction Treatments: A Critical Review. U.S. Forest Service, 8 Aug. 2008. Web. Feb.-Mar. 2015. http://0-www.sciencedirect.com.bianca.penlib.du.edu/science/article/pii/S1389934108000051

3. Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores." Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores. Environmental and Ecological Statistics, 1 Mar. 2008. Web. 09 Apr. 2015. http://0-link.springer.com.bianca.penlib.du.edu/article/10.1007%2Fs10651-007-0083-3

4. "The research team analyzed a survey of 217 residents of the community of Log Hill Mesa near Ridgway, Colo. The vast majority of landowners, 84 percent, said they would participate in a cost-share program for removing vegetation on their properties. Similar programs are offered throughout fire-prone regions of the West.

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[139] Snider, Laura. "High-risk Homeowners Less Likely to Mitigate Wildfires."
[140] Peterson, Jeff. "Wildfire Prevention Costs Far Less Than Fires (Op-Ed)."

> The study found that the decision to participate in cost-share programs, which bring in experts to thin vegetation on private property, is not just about the money. Study results show that not knowing what needs to be done on one's property was almost as strong a reason to participate in the program as not having the time or money to do the mitigation. At the same time, concerns about mitigation—such as how it might change the look of a property or whether it will actually be effective at reducing fire risk—tended not to influence whether homeowners said they would participate.
>
> "The good news is these cost-share programs are very effective at encouraging "some people in the community to reduce their wildfire risk," Meldrum said. "But they won't fix everything. They should be used as part of a suite of tools."
>
> "High-risk homeowners less likely to mitigate wildfires"
>
> http://artsandsciences.colorado.edu/magazine/2014/09/high-risk-homeowners-less-likely-to-mitigate-wildfires/

Quantifiable Cost= approximately $2.1 million per year (A). Each individual prescribed burn will cost approximately $60,000[141] (B). This policy alternative will reduce the amount and type of fuel in order to lessen the magnitude of a crown fire or conflagrations. These policies are already in existence but are sparsely implemented and not prioritized as high as it should be. The biggest challenge Boulder county faces are how to utilize the wood and slash from thinning projects.[142]

700-800 per acre x 5,000 total acres needed per a season = 4,000,000

http://www.ncsu.edu/project/wildfire/Colorado/boulder/b_improve.html

In total, the City of Boulder owns approximately 50,000+ acres of public lands and watershed.

https://bouldercolorado.gov/fire-rescue/wildland-home

BENEFITS

County of Boulder	Doubling the cost of the funds provided by the tax payers will save the city $29,000,000[143]. TOTAL= $29,000,000

[141] http://www.reporterherald.com/news/colorado-wildfires/ci_26811341/foothills-fire-aims-reduce-future-threats
[142] http://www.ncsu.edu/project/wildfire/Colorado/boulder/b_summary.html
[143] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."

Residents	The sales tax will account for a savings of $8,000,000[144]. TOTAL= $8,000,000.
Federal and State Agencies	This is the amount of money saved on suppression efforts as well as lack of damage to residences. TOTAL= $28,000,000.

In the Southwest, treating land helped to control wildfires 87 percent of the time in 2011, and in 75 percent of cases last year, according to Forest Service data.

After the proposed forest restoration treatments, the suppression costs should be reduced to $287–$327 per acre for the same size fire.

1. A comparison of landscape fuel treatment strategies to mitigate wildland fire risk in the urban interface and preserve old forest structure http://www.sciencedirect.com/science/article/pii/S0378112710000514

2. Yoder, Jonathan. "Economics and Prescribed Fire Law in the United States. “Economics and Prescribed Fire Law in the United States. Review of Agricultural Economics, 1 June 2003. Web. 09 Apr. 2015. http://0-www.jstor.org.bianca.penlib.du.edu/stable/1349873?pq-origsite=summon&seq=1#page_scan_tab_contents

3. Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores." *Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores*. Environmental and Ecological Statistics, 1 Mar. 2008. Web. 09 Apr. 2015. http://0-link.springer.com.bianca.penlib.du.edu/article/10.1007%2Fs10651-007-0083-3

4. Not only is the pursuit noble, but it's cost-effective, too — putting on this prescribed burn will cost about $60,000, Stalnacker said.
   "It sounds like a lot of money, and it is a lot of money. But, in theory, if you compare what suppression costs to what true forest restoration costs, it's incredible savings to the taxpayer," he said.
   The 2010 Dome Fire in Boulder Canyon, for example, cost roughly $1.5 million to suppress, even though its surface area was 6 acres smaller than this week's Heil burn patch.

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[144] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."

"Foothills fire aims to reduce future threats"
http://www.reporterherald.com/news/colorado-wildfires/ci_26811341/foothills-fire-aims-reduce-future-threats

5. Benefits for treating medium and high risk stands in the state of Washington exceeded the costs by $1,000-$2,000 per acre.
"The True Cost of Wildfire in the Western U.S." *Western Forestry Leadership Coalition* (n.d.): n. pag. *Western Forestry Leadership Coalition*. Western Forestry Leadership Coalition, 9 Apr. 2009. Web. 9 Oct. 2014.
http://www.blm.gov/or/districts/roseburg/plans/collab_forestry/files/TrueCostOfWilfire.pdf

6. The initial investment in infrastructure in the working group was $130 million in federal money. That now provides more than $20 million annually in new regional income and more than 300 jobs for local families. Just like investing in roads and bridges, this has proven to be a prudent investment with an effective return many times over.
http://www.azcentral.com/story/opinion/op-ed/2015/01/05/arizona-wildfire-forest-thinning/21301273/

Table 3. BAER costs for Hayman Fire

BAER Projects Cost Land Treatments	
Aerial Hydro-mulching 6,955 acres	$19,139,865
Aerial Dry-mulching 4,500 acres	$3,195,000
Mechanical Scarification 15,000 acres	$637,500
Heritage Sites 2 sites	$1,340
Other Land Treatments 6 sites	$12,438
Noxious Weed Treatments 495 acres	$103,950
"Colorado Cares" Volunteer Work 125 projects	$8,700
Flood Warning Signs	$2,600
Flood Warning System	$67,350
Seed	$407,000

Subtotal Land Treatments	$23,575,743
Roads and Trails	$136,708
BAER Evaluation	$135,800
Monitoring	$39,019
Implementation Logistics 45 days	$900,000
	Total $24,787,270

Policy Alternative 3- Retaining Walls

COSTS

County of Boulder	The cost to the city for the walls, including subsidies, is $1,000,000. TOTAL= $1,000,000
Residents	Adding a 0.15 percent sales tax, to be collected for eight years, to fund county mitigation expenses. The funds are used for prevention and protection services[145]. 5,000 residences (to be treated) x $1,000 per wall = $5,000,000. TOTAL= $5,000,000
Federal and State Agencies	Funding from state and federal agencies does not need to be adjusted. TOTAL= $26,000,000

1. Residents Willingness to Pay- Wildfire-Migration Dynamics: Lessons from Colorado's Fourmile Canyon Fire http://www.tandfonline.com/doi/abs/10.1080/08941920.2013.842275#.VDvWgvldXkU
2. Boulder County Community Wildfire Protection Plan http://www.bouldercounty.org/doc/forest/cwppbooklowres.pdf

BENEFITS

[145] Snider, Laura. "High-risk Homeowners Less Likely to Mitigate Wildfires."

County of Boulder	The county will save an average of $12,000,000 per year due to the walls. TOTAL= $12,000,000
Residents	Will save $10,700,000 from these walls, including insurance expenses[146]. TOTAL= $10,700,000.
Federal and State Agencies	Are set to save an average of $5,000,000[147] TOTAL= $5,000,000

1. Boulder County Community Wildfire Protection Plan http://www.bouldercounty.org/doc/forest/cwppbooklowres.pdf

2. Mercer, D., Pye, J., Prestemon, J., Butry, D., & Holmes, T. (2000). Economic effects of catastrophic wildfires: Assessing the effectiveness of fuel reduction programs for reducing the economic impacts of catastrophic forest fire events. Joint Fire Science Program, Topic 8 of the Research Grant, Ecological and Economic Consequences of the 1998 Florida Wildfires. Retrieved from www.floridaforestservice.com/publications/ joint_fire_sciences/jfs_pdf/economic_effects.pdf

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6. http://www.performanceinstitute.org/pdfs/wildfire-9747.pdf

Willingness to Pay for Sales Tax by Boulder County Residents:

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[146] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."
[147] Butry, David T. "Fighting Fire with Fire: Estimating the Efficacy of Wildfire Mitigation Programs Using Propensity Scores."

"The research team analyzed a survey of 217 residents of the community of Log Hill Mesa near Ridgway, Colo. The vast majority of landowners, 84 percent, said they would participate in a cost-share program for removing vegetation on their properties. Similar programs are offered throughout fire-prone regions of the West.

The study found that the decision to participate in cost-share programs, which bring in experts to thin vegetation on private property, is not just about the money. Study results show that not knowing what needs to be done on one's property was almost as strong a reason to participate in the program as not having the time or money to do the mitigation. At the same time, concerns about mitigation—such as how it might change the look of a property or whether it will actually be effective at reducing fire risk—tended not to influence whether homeowners said they would participate.

"The good news is these cost-share programs are very effective at encouraging some people in the community to reduce their wildfire risk," Meldrum said. "But they won't fix everything. They should be used as part of a suite of tools."

http://artsandsciences.colorado.edu/magazine/2014/09/high-risk-homeowners-less-likely-to-mitigate-wildfires/

	Time Horizon= 3 years	**Cost-Benefit Analysis for Wildfire Mitigation to Residences in Boulder County**			
	Social Discount Rate= .03	**Projections for Year 1**			
		A. Status Quo	**B. FireWise**	**C. Treating Stands**	**D. Retaining Walls**
	BENEFITS				
1	City and County of Boulder	$ 3,500,000.00	$ 4,000,000.00	$ 29,000,000.00	$ 12,000,000.00
2	Residences	$ 2,000,000.00	$ 3,000,000.00	$ 8,000,000.00	$ 10,700,000.00
3	Federal and State Agencies	$ 10,000,000.00	$ 25,000,000.00	$ 28,000,000.00	$ 5,000,000.00
	NET PRESENT BENEFITS	**$ 15,500,000.00**	**$ 32,000,000.00**	**$ 65,000,000.00**	**$ 27,700,000.00**
	COSTS				
1	City and County of Boulder	$ 1,750,000.00	$ 2,700,000.00	$ 2,500,000.00	$ 1,000,000.00
2	Residents	$ -	$ 1,500,000.00	$ 20,000,000.00	$ 1,350,000.00
3	Federal and State Agencies	$ 26,000,000.00	$ 30,000,000.00	$ 26,000,000.00	$ 26,000,000.00
	NET PRESENT COSTS	**$ 27,750,000.00**	**$ 4,200,000.00**	**$ 48,500,000.00**	**$ 28,350,000.00**
	NET PRESENT VALUE	**$ (12,250,000.00)**	**$ 27,800,000.00**	**$ 16,500,000.00**	**$ (650,000.00)**
	Time Horizon= 3 years	**Cost-Benefit Analysis for Wildfire Mitigation to Residences in Boulder County**			

	Social Discount Rate= .03	**Projections for Year 2**			4/8/2015
		A. Status Quo	**B. FireWise**	**C. Treating Stands**	**D. Retaining Walls**
	BENEFITS				
	City and County of Boulder	$ 3,622,500.00	$ 4,140,000.00	$ 30,015,000.00	$ 12,420,000.00
	Residences	2070000	$ 3,105,000.00	$ 8,280,000.00	$ 11,074,500.00
	Federal and State Agencies	$ 10,350,000.00	$ 25,875,000.00	$ 28,980,000.00	$ 5,175,000.00
	NET PRESENT BENEFITS	**$ 16,042,500.00**	**$ 33,120,000.00**	**$ 67,275,000.00**	**$ 28,669,500.00**
	COSTS				
	City and County of Boulder	$ 1,811,250.00	$ 2,794,500.00	$ 2,587,500.00	$ 1,035,000.00
	Residents	$ -	$ 1,552,500.00	$ 20,700,000.00	$ 1,397,250.00
	Federal and State Agencies	$ 26,910,000.00	$ 31,050,000.00	$ 26,910,000.00	$ 26,091,000.00
	NET PRESENT COSTS	**$ 28,721,250.00**	**$ 4,347,000.00**	**$ 50,197,500.00**	**$ 28,523,250.00**
	NET PRESENT VALUE	**$ (12,678,750.00)**	**$ 28,773,000.00**	**$ 17,077,500.00**	**$ 146,250.00**
	Time Horizon= 3 years	**Cost-Benefit Analysis for Wildfire Mitigation to Residences in Boulder County**			

	Social Discount Rate= .03	Projections for Year 3			
		A. Status Quo	**B. FireWise**	**C. Treating Stands**	**D. Retaining Walls**
	BENEFITS				
	City and County of Boulder	$ 3,749,287.00	$ 4,284,900.00	$ 31,065,525.00	$ 12,854,700.00
	Residences	$ 2,142,450.00	$ 3,213,675.00	$ 8,569,800.00	$ 11,462,107.00
	Federal and State Agencies	$ 10,712,250.00	$ 26,780,625.00	$ 29,993,000.00	$ 5,356,125.00
	NET PRESENT BENEFITS	**$ 16,603,987.00**	**$ 34,279,200.00**	**$ 69,628,325.00**	**$ 29,672,932.00**
	COSTS				
	City and County of Boulder	$ 1,874,643.00	$ 2,892,307.00	$ 2,678,062.00	$ 1,071,225.00
	Residents	$ -	$ 1,606,837.00	$ 21,424,500.00	$ 1,446,153.00
	Federal and State Agencies	$ 27,851,850.00	$ 32,136,750.00	$ 27,851,850.00	$ 27,004,185.00
	NET PRESENT COSTS	**$ 29,726,493.00**	**$ 4,499,144.00**	**$ 51,954,412.00**	**$ 29,521,563.00**
	NET PRESENT VALUE	**$ (13,122,506.00)**	**$ 29,780,056.00**	**$ 17,673,913.00**	**$ 151,369.00**

Net Present Values:

NPV	Status Quo	Alt. #1	Alt. #2	Alt. #3
Year 1	**(12,250,000.00)**	**27,650,000.00**	**16,500,000.00**	**(650,000.00)**

Year 2	**(12,678,750.00)**	**28,773,000.00**	**17,077,500.00**	**146,250.00**
Year 3	**(13,122,506.00)**	**29,780,056.00**	**17,673,913.00**	**151,369.00**

Social Discount Rate: A standard discount rate of 3 percent is assumed; thus, for every year it takes to replace a specific amount of service, an amount of habitat capable of producing an additional 3 percent of the remaining lost service must also be constructed[148]. An Ex-ante analysis has been chosen to be the most effective form of the CBA for the Memo. Costs that are negative externalities, such as increased ER visits due to smoke from wildfires and the loss of revenue to businesses that must shut down during a wildfire, were not included in the Status Quo. The net present value will represent the best indicator of the most efficient option.

2015 Chipping Program
Summit County has received a $100,000 grant from the Colorado Wildfire Risk Reduction Grant Program to continue the chipping program in 2015. Summit County will match the grant with in-kind contributions as well as direct funding from a voter-approved mill levy that dedicates funds to wildfire mitigation projects. During the winter and spring, property owners can collaborate with neighbors and make plans for next year's defensible space projects. Check back here in the spring to find the 2015 neighborhood chipping schedule.

http://www.co.summit.co.us/index.aspx?NID=885

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