

Comparative Wildland Urban Fire Policy: The Australian Prepare, Act, and Survive
Approach During the Waldo Canyon Fire in the United States

A Thesis

Presented to

The Faculty of the Environmental Program

The Colorado College

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Arts in Environmental Policy

By

Charles King Landsman

May 2014

Phillip Kannan
Distinguished Lecturer and
Legal Scholar in Residence

Dr. Eric Perramond
Associate Professor

Abstract

Wildfires worldwide are increasing in intensity and frequency while more residents move into the wildland urban interface. Fires such as the Waldo Canyon Fire near Colorado Springs, Colorado emphasized this sad reality in June of 2012. Because of worsening conditions, many regions around the United States are exploring innovative policies to ensure residents are protected and the loss of structures is reduced. One such policy is the *Prepare, Act, Survive* approach developed by the Australians. *Prepare, Act, Survive* emphasizes mutual responsibility between residents and fire or land management authorities and encourages residents located in fire prone areas to prepare their property well before a blaze. Residents are then formally allowed to stay and defend their properties if they wish to do so or encouraged to leave well before the fire threatens them if they desire. This paper explores both the American *Mandatory Evacuation* policy and the Australian *Prepare, Act, Survive* approach. Finally, it predicts how many homes could have potentially been saved if residents had been allowed to stay and defend their property during the Waldo Canyon Fire.

Table of Contents

Introduction	4
<i>Prepare, Act, Survive</i> in Australia	12
<i>Mandatory Evacuation</i> in the United States	26
Evidence in Support of and Against <i>Prepare, Act, Survive</i>	36
Would <i>Prepare, Act, Survive</i> Work in the United States?	59
Waldo Canyon Fire and <i>Prepare, Act, Survive</i>	7
Conclusion	100
Acknowledgements	101
Works Cited	102

Introduction

Cities are expanding further into the wild forests and grasslands that surround them (Stephens et al., 2009). With this expansion, more residents are exposed to wildfires, which destroy property and can take lives if residents are unprepared. The United States generally requires evacuation from neighborhoods and cities that are threatened by incoming fires (Stephens et al., 2009).

Unfortunately, there is not always time and infrastructure to allow everyone to evacuate safely. Furthermore, firefighters are generally preoccupied with stopping the advance of the fire and therefore generally do not have the resources to protect personal property that is affected by the fire. The lack of available firefighters leads to houses being destroyed that otherwise could be protected by able bodied residents trained and prepared to defend their property. In this thesis I analyze Australia's *Prepare, Act, Survive* approach and evaluate the possibility and effectiveness of adapting the Australian policy to regions of the U.S. most often disrupted by wildfires.

Fire regimes naturally vary from low-intensity high-frequency fires, which occur on average in 1-5 year intervals to low-frequency high-intensity fires, which occur about every 100 years or less often (Bradstock, 2010). The majority of fire regimes can be explained by three factors: climate, fuel, and ignition along with a lesser emphasis on terrain, land management, and other influences (Bradstock, 2010; Gibbons et al., 2012; Stephens et al., 2009). Unfortunately, climate change has the ability to affect many of these factors increasing fire regularity and intensity, while simultaneously increasing the threat to lives and property in the wildland

urban interface. These changes require policy changes as stated by Dr. Timothy Brown of the Desert Research Institute in Reno, Nevada, “New strategies and policy may need to be incorporated to address both suppression and fuel treatment needs in complex and changing ecosystems” he concluded his article with, “our results suggest that new fire management strategies and policies may be needed to address the added climatic risks” (Brown et al., 2004; 385). The climactic changes Brown is referring to are increasing CO2 levels and temperature with decreasing rainfall and humidity in dry climates (Brown et al., 2004).

Elevated CO2 levels may increase the amount of biomass thus causing an excess of fuel and therefore making it easier for fires to expand at an alarming rate (Bradstock, 2010). Climate change is also expected to alter weather patterns making dry regions drier, which will leave fire prone regions with less rainfall and lower humidity. Climate change is increasing the regularity of extreme weather conditions like droughts (Wardell-Johnson, 2009). These changes will likely increase the ability for biomass to burn making fires grow faster in size and intensity (Bradstock, 2010). Furthermore, the increase in frequency and severity of droughts leaves nations like Australia and the U.S. scrambling to adopt new land management policies to protect their citizens (Price & Bradstock, 2012).

Higher temperatures and lower humidity will also make fighting future fires even more difficult (Bradstock, 2010). These changes will be significant in regions like the southwest United States where we are entering a bi-decadal period of lower humidity (Brown et al., 2004). While environmental changes are increasing fire

intensity and frequency, past land and fire management policies also play a significant role in understanding and mitigating risk to the wildland urban interface.

Prescribed burns have been used for thousands of years to clear land and mitigate risk because it is the only cost-effective large-scale management technique compared to other methods such as clearing of vegetation or mechanical thinning of trees (Wardell-Johnson, 2009; Price & Bradstock, 2012; Gibbons et al., 2012; Cohen, 2008). When used correctly, prescribed burns can effectively decrease size and intensity of unplanned fires which helps limit the wildland urban interface's exposure to harm. Fuel treatment, however, has undesirable side effects to human health, the environment, and it is expensive (Gibbons et al., 2012; Wardell-Johnson, 2009). Prescribed burns can reduce fuel by up to 50% but only for about 2-3 years (Guyette et al., 2002). In a study by Bradstock, he concluded that, "intermediate to high levels of prescribed fire (10-20% per year) reduced the mean size of unplanned fires to 20-30% of that achieved under low or nil levels of prescribed fire" (Bradstock et al., 2006; 12). Furthermore, the same study found that fire intervals were increased from prescribed burns; this means that prescribed burns are effective in causing smaller fires less often (Bradstock et al., 2006).

To protect property, however, homes must have a 40-meter buffer zone to protect from radiant heat (Gibbons et al., 2012; Cohen, 2008). Homes with either non-native, well irrigated buffer zones, or those with only 5% groundcover within 40 meters reduced their risk of loss by 43% and for every 10% reduction in ground cover, a structure is about 5% more likely to survive a passing fire (Gibbons et al., 2012). Structures are also more likely to survive if they are in areas fragmented by

agriculture or rural development (Guyette et al., 2002). In the United States, 89% of federal fuel-reduction treatments were more than 2.5km from private property rendering them ineffective in protecting property from wildfires (Gibbons et al., 2012).

While prescribed burns can be effective at mitigating risk, they do not completely eliminate it. Prescribed burns cannot occur often enough to eliminate young fuels that can feed fires in extreme conditions (Wardell-Johnson, 2009). Furthermore, prescribed burns can be detrimental to forest health. Either over or under-burning forests can deplete populations of native species (Cohen, 2008). If over 50% of a species is exposed to an unfavorable regime the species becomes at risk of going extinct (Bradstock & Kenny, 2003). If native species go extinct, invasive species can move into their niche and alter the fire regime, requiring officials to reform their land management policies to adapt to the new vegetation. If an entire population of a species is located in a small geographic region, a single burn could completely wipe out the population since there is no hope for dispersal and recolonization (Bradstock & Kenny 2003). Furthermore, there are many fire mitigation techniques that will be more effective, “prescribed burning will not be the most important element in preventing the tragedy of the Victorian fires from being repeated many times in many parts of Australia” (Wardell-Johnson, 2009; 48).

There are, however, multiple aspects of risk, which must be discussed. It is generally accepted that $\text{Risk} = \text{Magnitude of Harm} \times \text{Percent Chance of Harm}$ (Kannan, 2012). This definition of risk encompasses two important aspects; risk is based on both the chance of harm and how great the harm will be. Driving a car, for

example, going one mile per hour over the speed limit does not increase a person's risk very significantly. The magnitude for harm is still very similar since a car will not behave drastically in a crash based on one mph difference in speed. The percent chance in harm does increase but still not significantly since it is only a one mph difference. Speeding by 20 mph, however does increase both significantly. A car will sustain more damage with that speed increase (magnitude of harm) and going too fast for the road significantly increases the likelihood of a crash (percent chance of harm). While this example keeps the two variables moving in the same direction, that is not always the case.

Fire mitigation can be an example of this. Fuel mitigation theoretically reduces the percent chance of harm. If fires are immediately put out it is harder for them to hurt people. This approach, however, increases the magnitude of harm that will occur if a fire is started and cannot be controlled immediately. This increase in fire intensity represents an increase in the magnitude of harm. Now that we have a better understanding of harm we can move on to discuss better ways to mitigate risk and prevent fires from unnecessarily harming people and destroying structures.

Rather than rely solely on controlled burns to fight fire, nations must utilize every tool at their disposal, including their citizens, to combat fires. The first step in utilizing residents of the wildland urban interface to fight back against fires is altering societal ideas and attitudes towards risk management (Wardell-Jonson, 2009). With prescribed burns becoming riskier and more expensive, especially in conditions when fires can thrive, it is unlikely that they will become more effective in protecting lives and property from fire.

Other management techniques must be considered to give residents a fighting chance. I will look at two distinctly separate policies from Australia and the United States. To do this, I will use a case study from each country. To ensure adequate data, I chose two of the most destructive fires in each nation. In Australia, I will look at the 2009 “Black Saturday” Fires in Victoria; these fires were the worst in Australian history based on structures and lives lost. In the United States I will look at the Waldo Canyon Fire from 2012. The “Black Saturday” Fires cost the country of Australia approximately A\$1.2 (Gill et al., 2013). The Waldo Canyon Fire was the most destructive in Colorado history until the Black Forest Fire of 2013. I chose a fire in Colorado rather than California or Montana (two states with the highest regularity of fires) because of the Waldo Canyon Fires close proximity to Colorado College and my home. Additionally, being only a few months old, limited information is available about the homes that were destroyed from the Black Forest Fire.

The United States and Australia are similar in the high percentage of residents who live in the wildland urban interface. Because houses in this area are so spread out and far from fire departments not all houses can be protected by fire agencies. If residents attempt to flee as the fire approaches, the burn can overtake them while they are in the open, killing them from radiant heat (Stephens et al., 2009). This is why the Australian government has developed the *Prepare, Act, Survive* policy which educates citizens on how to prepare their property to be fire safe and then requires residents to either leave before the fire is near or stay and defend their property (Mutch et al., 2011). During a forest fire, embers destroy the

majority of houses either before the fire front has reached the property or after it has passed. Most residents are killed by radiant heat after evacuating too late (Mutch et al., 2011).

To prepare for a fire, residents are taught to: always have a 30-60 meter break of fire resistant landscaping around any structure, send children and elderly to safety long before the fire arrives, fill every available basin with water (bathtub, sinks, buckets, gutters, etc...), and then seal the home and move everything flammable away from windows and doors (Mutch et al., 2011; Stephens et al., 2009; AFAC, 2012; rfs.nsw.gov, 2009). Those who decide to leave early sometimes must vacate their homes during catastrophic weather conditions even if no fires have been reported while those who stay to defend are told to retreat into their homes to wait for the fire front to pass while monitoring the fire's progress and putting out any internal ignitions (Mutch et al., 2011). After the front has passed, trained residents will emerge in fire retardant clothing to monitor any ignition from embers (Mutch et al., 2011; rfs.nsw.gov, 2009)

In the United States citizens often move into the wildland urban interface to escape city life (Stephens et al., 2009). Policies are further complicated by property rights, which are not present in all nations. While governments may be unable to require certain safety precautions, they can educate and encourage citizens to clear vegetation from within 40 meters of any structures, install ember trapping ventilation systems, and use ignition resistant building materials when constructing their homes (Mutch et al., 2011; Colorado State Forest Service, 2012). When there is a fire in the United States, firefighters generally require mandatory evacuations,

which overcrowd roads and leave property unprotected. If a major evacuation occurs, roads carrying capacities will be exceeded making it so residents cannot escape the fire and emergency crews cannot safely enter through clogged streets (Mutch et al., 2011).

Overall, wildland urban fire problems are intensifying and land managers are looking for alternative policies to help cope with the severity and regularity of fires. Policies like *Prepare, Act, Survive* may be the answer to the wildland urban interface fire problem in the future within the United States.

Prepare, Act, Survive in Australia

Historically, Australia has always had a culture focused on self-reliance when it comes to bushfire protection. In fact, the current *Prepare, Act, Survive* policy stemmed from decades of rural citizens protecting themselves from bushfires without the aid of government emergency personnel:

“So the rural (volunteer) fire services have been in existence since 1900, so over 100 years old, a very engrained cultural identity – residents have been part of the rural fire service since the 1900s. So we’re going back to a time when Australia was much more rural so they simply had to rely on themselves...as we’ve moved into the 21st century we’ve got a much different scenario.” (Eriksen, 2013)

Other researchers expressed similar sentiments:

“For much of 200 years, there was very much a tradition of people in the bush had to look after themselves. The government wasn’t coming to help, so the notion of volunteer fire brigades arose. That came out of an attitude (I’m sure it’s true in your country) – us country folk take care of our own – we’ll have a volunteer fire brigade, look after our own properties. In this state, it didn’t really solidify until the 1940s when they started to get some formality in them... the old farmers used to tell their kids, if there’s a fire coming... you go inside, as soon as it goes past you go outside... The idea was that after a fire, there might be small fires on the house, which you can then put out with water if you’re there. But if you’re not there, you lose your dwelling.” (Morgan & Leonard, 2013)

With no lifeline, residents historically had to protect themselves. Even though in practice people have always stayed and defended their property in Australia, it was not formalized until the Ash Wednesday Fires in 1983, “stay and defend became crystallized as policy after the 1983 Ash Wednesday Fires so more or less became formalized around the 90’s” (Bradstock & Penman, 2013). Therefore, over time this self-reliant attitude was formalized in the national fire policy.

In 2009, the Australian government Rural Fire Service launched an advertising campaign emphasizing a new and different approach with the catch phrase *Prepare, Act, Survive* (rfs.nsw.gov, 2009). This campaign was created to diminish the gap between understanding risk and acting to decrease it (Conway & Llewellyn, 2012). Furthermore, this policy promotes shared responsibility between residents and emergency personnel (Conway & Llewellyn, 2012). *Prepare, Act, Survive* acknowledges a sad reality, “there will be instances when agencies are unable to provide sufficient fire fighting resources to prevent loss of life and damage to property... fire fighting resources are likely to be allocated where they will be most effective at protecting lives, not necessarily where property losses are most likely” (Conway & Llewellyn, 2012; 5).

The Rural Fire Service found that while 75% of people acknowledged that a bushfire survival plan could save their lives, only 25% of people actually had any form of plan (rfs.nsw.gov, 2009). At the heart of the campaign lies the government’s fundamental approach to how residents should react when unplanned bushfires move into residential areas or the wildland urban interface. For the government, the primary focus is protecting lives (Conway & Llewellyn, 2012). To accomplish this goal, residents must make preparations and ensure plans are in place in case of a bushfire. Residents must then decide, before the fire reaches them, if they wish to stay and defend their property or escape to a safer area before the fire threatens them. The final point of the campaign is survival. Surviving a bushfire is valued above all else.

Prepare, Act, Survive, however, developed out of a similar policy, its predecessor *Prepare, Stay and Defend or Leave Early*:

“Prepare act survive was to replace the catchphrase ‘stay or go’. Because unfortunately over the years ‘prepare *Stay and Defend or Leave Early*’ concept turned into ‘stay or go’. But that’s too simplistic a message given the complexities of what we deal with... *Prepare, Act, Survive* are the three elements that go into all the community messaging across the country. It’s about how you need to prepare and when you hear the information you need to act on it – get out early or whatever – it’s all about survival. The options are there educating people not because we just want you to save your house. We want your house to be a survival mechanism for you.” (Eriksen, 2014)

Nationwide the Australian government has implemented the *Prepare, Act, Survive* approach for when bushfires move into the wildland urban interface at the edge of cities. In this section I will outline the official stance the Australian Government has taken in regards to bushfires moving into residential areas. While this is outlined by the *Prepare, Act, Survive* slogan, I will explain what each section entails and how residents can ensure they are complying with the government program to give their property and themselves the best chance of surviving a bushfire that moves through their city, neighborhood, and possibly their own home.

The *Prepare, Act, Survive* policy clearly has three components: Prepare, Act, and Survive. These components, however, are not as easily understood as one may think. To understand this approach we must start from the beginning, preparation. Contrary to popular belief in Australia, a plan to create a bushfire survival plan is no plan at all and will not offer any protection if a fire moves through a residential area (rfs.nsw.gov, 2009). To assist residents unaware of what they must do to prepare, the New South Wales Rural Fire Service released a guide to outline the *Prepare, Act, Survive* policy. Within this guide, preparation is split into two sections: stay and

defend or leave early. There is little doubt within the scientific community that the safest place to be during a bushfire is far away from the fire, “If it’s {mandatory evacuation} done with enough time, enough forewarning, it’s going to be the safest for the public. There is no doubt if you can get people out of harm’s way then you’re just going to have less people and lives lost” (Stephens, 2014). Dr. Sarah McCaffrey of the U.S. Forest Service shares similar opinions, “you can not argue with the statement, ‘the safest place to be during a fire is far far away from the fire’” (McCaffrey, 2014).

Unfortunately, it is often difficult to notify large groups of people quickly that their neighborhood is in danger. Therefore, for some leaving early is not always an option; most deaths from bushfires actually happen as residents attempt to flee late (Haynes et al., 2008). Even if someone is familiar with the exits from their neighborhood residents are often not mentally prepared to deal with disaster and during a bushfire things can change quickly. Trees or power poles often block roads, smoke is thick and visibility becomes virtually zero feet, and fires do not move in a parallel fashion so just because there is not fire where one is does not mean the road is not blocked by fire ahead (AFAC & Bushfire CRC, 2006).

As an alternative to leaving early, some people decide they would rather stay and defend their property and livelihoods. If someone evacuates once the fire has reached him or her any of the hazards above and more can block their progress. Instead of being protected from radiant heat in their well prepared home, residents are caught in their vehicle and generally die from exposure, the leading cause of

bushfire deaths (Conway & Llewellyn, 2012). To reduce risk residents must first understand what their personal level of risk is and the conditions of the day.

Much of Australia’s fire policy is based on the McArthur Forest Fire Index, which essentially places each day on a scale of 0 (being lowest fire danger) to 100+ (which is highest fire danger). The McArthur forest fire index scale is shown in the Figure 1. This table is an easy to understand visual aid to assist fire departments. They can simply provide residents with either a number representing fire danger or a label of low through catastrophic that shows both how likely a fire is to start but also how the fire will likely act if a fire strikes.

Figure 1.

McArthur Forest Fire Index Categories

Category	Forest Fire Danger Index	Grassland Fire Danger Index
Catastrophic (Code Red)	100 +	150 +
Extreme	75 – 99	100 - 149
Severe	50 – 74	50 – 99
Very high	25 - 49	25 - 49
High	12 – 24	12 – 24
Low to moderate	0 - 11	0 - 11

(rfs.nsw.gov, 2009)

This index essentially takes variables like humidity, temperature, and wind speed to create an exponentially increasing scale of probable harm from fire (Dowdy et al., 2009). It is important to remember that this exponentially increases so an extreme rating is not twice as bad as a severe rating. The forest fire danger index is dictated by this equation:

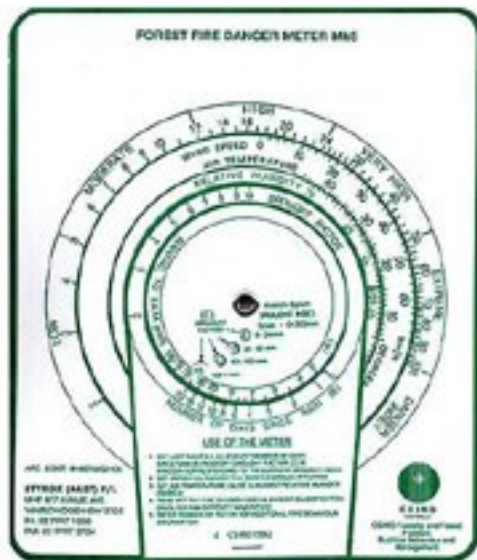
$$\text{FFDI} = 2e^{(-0.45 + 0.987 \ln(\text{DF}) - 0.0345 \text{RH} + 0.0338 \text{T} + 0.0234 \text{v})}$$

DF=Drought Factor
 RH=Relative Humidity
 T=Temperature (°C)
 V=Wind Speed (kmh)

Or can be easily calculated using the meter shown in Figure 2 found on the CSIRO website.

Figure 2.

McArthur Forest Fire Index Meter



The stated purpose of the index is to:

“Give you an indication of the consequences of a fire, if a fire was to start. The rating is based on predicted conditions such as the temperature, humidity, wind and dryness of the landscape. It tells you how a bushfire may act, what impacts there might be on the community if a bush fire were to start and when to implement your Bush Fire Survival Plan” (rfs.nsw.gov, 2009; 8).

This Index is the most widely used predictor of fire conditions within Australia (Sanabria et al., 2013). Essentially the Index offers a way to give huge amounts of information to residents in an easy to read and understandable format.

Under “catastrophic” fire conditions, homes are considered indefensible; building codes are not at a level where a property can withstand the severity of these fires (AFAC, 2012; rfs.nsw.gov, 2009). Under any catastrophic fire, the Australian government suggests everyone leave early even if they have a well-prepared property (AFAC, 2012; rfs.nsw.gov, 2009). The government suggests this because “no structure is ever going to be safe if it’s exposed in catastrophic conditions under current standards so everybody should just get out. It’s much safer” according to Dr. Trent Penman (Bradstock & Penman, 2013). Similarly, under “extreme” fire danger anyone living in a home not up to the current building codes should also leave early because once again the home is unlikely to be defensible. Only specially designed homes can survive an extreme fire (rfs.nsw.gov, 2009). Under other fire conditions, however, it is possible for a resident to save a well prepared home. While there are currently no quantitative levels to define “preparedness” there are some general guidelines. The New South Wales Rural Fire Service emphasizes this by posing questions to homeowners:

1. Is your property well prepared and maintained?
2. Are you physically and emotionally prepared to defend your property?
3. Do you know what to do before, during, and after a bushfire?
4. Do you have well maintained resources and equipment and does everyone planning to Stay and Defend know how to use them?
5. Do you have access to water for firefighting purposes eg a tank, dam, or pool?
Town water supplies can fail during emergencies.
6. Do you have appropriate personal protective clothing?

7. Do you have a backup plan?

Even these questions, however, offer little insight into what physically must be done to prepare a home for a fire. Instead of making a list of preparations, the Rural Fire Service decided to release a diagram shown as Figure 3 in this paper to outline many things residents can do. As you can see from the recommendations, there are many simple things a resident can do to protect his or her property. Clearing flammable materials from around a home reduces risk and installing screens and grates to make sure embers cannot settle under flammable parts of the structure will give a home greater chance of survival. Most measures a resident can take are relatively small and could save a home and lives if properly prepared. Even the best-prepared residents, however, must know what to do when a fire approaches. Preparations are beneficial but without action they are useless. Preparation, however, serves another purpose; residents become engaged and more understanding of the risks they encounter every day living in a fire prone area:

“In preparing the property not only are you reducing the vulnerability of the property but the sociocognitive processes that any resident goes through as they’re doing preparedness behavior brings knowledge into their consciousness that can then be tapped into during the fire, so when shit hits the fan, essentially, people with no knowledge who are most likely to panic, with some knowledge, there’s a likelihood of some rational thinking or behavioral patterns that will, most likely, lead to more rational and more resilient decisions.” (Eriksen, 2014).

Preparation ensures residents are ready to deal with the traumatic experiences of a bushfire.

The second part of the Australian policy is act. Similarly to the prepare section, act has many different categories depending on the severity of a fire. Under the catastrophic level of the fire index it is always recommended that residents

Figure 3.

Preparations for Residents to Comply with Prepare, Act, Survive



(rfs.nsw.gov, 2009)

leave early. For extreme conditions similar recommendations still exist, “Only consider staying if you are prepared to the highest level- such as your home is specially designed, constructed or modified, and situated to withstand a fire, you are well prepared and can actively defend it if a fire starts” (rfs.nsw.gov, 2009; 8). Essentially under extreme fire conditions it can be futile to try to save a home unless it is built to the highest building codes. Staying at a home not well prepared for these conditions will not only likely result in the home being destroyed but also puts the residents at risk. If the structure catches fire then they no longer can use it to protect themselves against radiant heat and smoke.

Once we reach the lower levels of fire danger it becomes plausible for well-prepared residents to protect their property. Under a severe fire danger, and any lower level (Very High, High, or Low Moderate), anyone who has not prepared their structure or any person not physically or mentally prepared to fight the fire, is still suggested that they leave. The New South Wales Rural Fire Service officially suggests, “Leaving early is the safest option for your survival. Well prepared homes that are actively defended can provide safety- but only stay if you are physically and mentally prepared to defend in these conditions” (rfs.nsw.gov, 2009; 8). Even if all preparations are in place, a physical or mental mistake can lead to death and the destruction of structures.

To assist residents, the Rural Fire Service offers basic checklists for residents to understand their role in defending their property and neighborhoods. Figure 4 shows what residents should do after the fire starts but before it has reached an individual’s home. Figure 5, similarly shows how residents should act while the fire

front is upon them and Figure 6 emphasizes the actions necessary for a resident who is defending their property after the fire has passed but before the fire has extinguished. It is important to note that neither wait and see nor shelter in place is acknowledged as viable actions during a bushfire.

Figure 4.

Stay and Defend: Before the Fire Front



(rfs.nsw.gov, 2009)

During the recent fires in NSW in October of 2013 I spoke with one resident who appeared to be in his 80's or 90's. This man had not prepared his house according to the suggestions of the government. Furthermore, while he was mentally prepared to defend his home, physically he was not. While he was mobile with his cane, halfway through the fire he misplaced it. Suddenly he was stuck in

Figure 5.

Stay and Defend: During the Fire Front



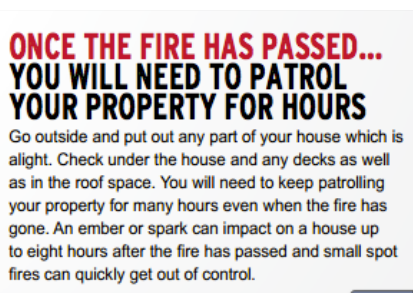
Inside the House

- Continue to drink water so you do not dehydrate.
- Confine pets to one room.
- Close doors, windows, vents, blinds and curtains to prevent flames, smoke and embers from entering.
- Put tape across the inside of the windows so they stay in place if they break.
- Shut off gas at the meter or bottle.
- Move furniture away from the windows to prevent any embers that enter the house from igniting.
- Fill bath, sinks and buckets with water for putting out any fires that may start inside.
- Place wet towels around window and door edges to stop smoke and embers from entering.
- Put a ladder next to the access hole to the roof space so you can check for spot fires.

(rfs.nsw.gov, 2009)

Figure 6.

Stay and Defend: After the Fire Front



(rfs.nsw.gov, 2009)

one spot unable to move. Luckily he was in a position and had enough water

pressure to put out any spot fires that formed:

“A 90-year old guy with a busted leg was very effective at looking after his back deck, but if he had a roof fire, he’s not capable of getting up into his roof space to monitor or suppress it. He wouldn’t be able to reach his eaves; he can’t get up through the manhole in his roof. So if he had an attic fire he’d be in a different situation” (Leonard, 2013).

It very easily could have gone the other way and he could have lost his home and life because of a simple mistake.

It is important to acknowledge that the Australians encourage actively defending but discourage sheltering in place, “if someone’s staying and defending – and it’s staying and *defending*, not staying and sheltering in place. I’ve heard that term used a lot – sheltering in place – sheltering in place is a passive term. Defending is an active term. And that’s a totally different approach” (Morgan & Leonard, 2013).

The final aspect of the Australian policy emphasizes survival. Above all else it is important to protect life over property. While it is tragic for someone to lose everything they own, it is better than losing a life. While survival is not a step specifically outlined in government literature the message is clear; your property is not worth dying for. Leave early to ensure your safety; if you chose to stay, make sure you have a backup plan, “In extreme situations, you reach a point when it’s no longer safe being in a house (certainly the case when it’s caught alight), but it’s horrible outside, and it takes a lot to walk out the door and confront what’s out there, it’s a terrible dilemma” (Morgan & Leonard, 2013). Therefore, prior to a fire you must know what you will do if your home does ignite. Sometimes, simply stepping outside is enough since the fire front has already passed. Staying inside can sometimes be dangerous if residents are not aware of the situation outside :

“A few families retreated in a house during the fire, and one of the owners noticed that his house was starting to catch on fire and tried to convince everybody to get out of the house... the house was losing its tenability and the people decided not to do it. He was the only one to escape and survive. Everyone died in the house.” (Blanchi, 2013).

Tragically, people die too often because of a misunderstanding that they must plan for every contingency.

Fire shelters have been popular in the past but are losing popularity because they are rarely properly maintained. Neighborhoods often combine forces to create a neighborhood safe place, however, either a shelter or a neighborhood safe place should be a last resort. If it is too late to leave and you are not prepared, it may be your last option. These safe places can be buildings or simply large well-irrigated fields that are clear of flammable materials. Essentially it is a place that can protect you while the fire passes but cannot sustain people for long periods of time. Ideally these places would never be utilized. Unfortunately, in a stressful situation plans often break down, “a lot of the people who were defending and their houses were destroyed, we talked about one link in their chain being broken, so, not having a backup generator, running out of water, etc” (Whittaker, 2013). Always have a backup plan and know what your next move is going to be if things get worse or if your property is no longer defensible. In a fire many different things can happen. A tree could fall on your home, a spot fire could get out of control, it has even been reported that fires have caused such strong winds that tornado-like clouds have formed damaging property. Be prepared, know when and how to act, and above all else do what is necessary to survive the fire.

Mandatory Evacuation in the United States

While the United States suffers from similar forest fire issues as Australia, the government has taken a different approach to how residents should respond to an incoming fire. Rather than give residents the legal authority to stay and defend their property, where they are often times safer, the U.S. and many states have taken the “leave or we will make you” approach (Tuttle, 2003). Most states in the U.S. give emergency officials the authority to require residents to evacuate, “It’s simple. It’s straightforward. We’re going to tell you to leave and you leave” (McCaffrey, 2014). The overarching authority for government officials to evacuate residents against their will lies under a government’s sovereign authority coming from *Mandatory Evacuations* in times of extreme circumstances (Bohannon, 2011).

The obligation of the government and the police to protect the people is expanded in a time of emergency. While every state gives their governor specific powers during a state of emergency, it is almost universal throughout the United States to allow emergency personnel to require citizens to evacuate (Bohannon, 2011). Each state, however has different laws surrounding residents refusing to evacuate. In California, for example, ignoring an order to evacuate is a misdemeanor criminal offense punishable by a fine and up to one year in jail (Bohannon, 2011). On the other end of the spectrum, states like Montana do not give emergency personnel the authority to require residents to evacuate even if there is an emergency (Mutch et al., 2011).

Even though many states label staying after a mandatory evacuation has been ordered a crime, it is rarely enforced as a criminal offense and generally it is

not beneficial to waste resources trying to forcefully evacuate people (Bohannon, 2011; Tuttle, 2003; Lacey & Cooper, 2014). Unprepared residents staying in harm's way, however, pose another problem; it puts the responders who may come to save them at risk. To encourage residents to leave, different agencies have different methods. States like North Carolina and Texas inform residents that they are financially responsible to cover any costs of rescue, if rescue is possible (Bohannon, 2011). Virginia utilizes a self-proclaimed "magic marker" tactic where police officers ask residents to write their social security number on their body to help identify any corpses that may be found after the fire (Bohannon, 2011). Still other states ask for the names of next of kin if a resident refuses to leave so they can be contacted if the residents are killed (Tuttle, 2003).

All these methods help convince residents to leave rather than risk their lives but most states will not use force to remove a resident. In an emergency situation they are already short staffed and do not have the resources to force everyone out. Furthermore, approximately 85% of residents will evacuate when ordered while only 15% of residents stay in their home according to a study of Los Angeles County residents (Tuttle, 2003). Even in Colorado, many residents after the Hayman Fire of 2002 stated they would not leave for future fires because of the mental and economic costs (Paveglio et al., 2007). Instead, the time of emergency personnel is better spent helping people that cannot evacuate on their own. As a policy, *Mandatory Evacuation* arose for obvious reasons; a person can no be hurt by a fire if they are not there:

"The safest place to be is where there isn't fire risk. So if you live in a home in the area and we tell you the forecast is that it's very dangerous, your best

option is not to be there. If that's not workable, you need to look at all the other options in your immediate area." (Edwards, 2014)

"The safest action to protect life is for people to be away from the bushfire or threat of bushfire" (Conway & Llewellyn, 2012). It seems that even this logic can sway the opinions of Australian researchers when considering the value of life verse property:

"It seems to be quite effective in achieving the desired outcome of life safety risk reduction. Of course there's this paradigm of humans save houses and houses save people. You remove the human element and of course there's far more of a risk without the human element there. So, you're going to lose significantly larger numbers of houses as a result, but a life is far more valuable than a very large number of houses so maybe the rationale is right." (Leonard, 2013).

The advantages, however, are not limited to protecting residents, in fact, most fire personnel in the United States support mandatory evacuation because it allows them to work more effectively without worrying about the life safety factor:

"That decision for mandatory evacuation comes from the fact that obviously you want people out of harm's way... depending on the road networks and topography in a lot of those areas {wildland urban interface} it's very problematic when suddenly people are trying to leave and you're trying to come in...tactically we {firefighters} we can be more fluid and dynamic in our response if everyone is out of the way... plus we don't have the life-safety factor... if we suddenly find someone is trapped {because they ignored the evacuation order}... we have to reduce our firefighting or protection capabilities... the fire services mission is life safety then property protection... so you take the life safety factor out, that makes it a lot easier for us to concentrate on other things that have to do with property." (Lacey & Cooper, 2014).

Fire crews in the U.S. support evacuations; not worrying about resident's well-being allows them to focus on fighting the fire safely. While laws and procedures differ from state to state, any evacuation in the U.S. will likely go through the same four stages: pre-planning, decision to evacuate, evacuation, and re-entry (Tuttle, 2003).

Firefighters in Australia, however, seem to feel the opposite way, “In Australia, I’ve talked to many firefighters who have been like ‘No, they have actually helped me out’ or ‘I like going into a community where homeowners are staying because they can tell me where things are. They can help me out’” (McCaffrey, 2014). It seems that the culture of firefighting in the U.S. has led firefighters to see residents as a hindrance while in Australia they are viewed as an asset and firefighters gladly work aside residents to protect structures and lives.

The pre-planning stage is similar to the Australian preparation stage except on a city, county, or state level. Pre-planning involves any agency that might be needed during a fire including law enforcement, elected officials, and animal control as well as the more obvious firefighting organizations (Tuttle, 2003). Essentially, there must be a plan in place for any contingency. The pre-planning stage can take years to set up procedures for each and every person who may be involved in a forest fire. The finalized plans generally include:

- Incident command posts and staging sites for fire apparatus, designated on a common map base
- Protocols for communications, command and control between fire and law enforcement authorities
- Zones and trigger points for phasing evacuation stages
- Designated evacuation routes and alternates to separate ingress of firefighters from egress of residents. Intersections for traffic control points are identified and adjusted as the fire advances
- Delineated areas with entrapment potential, such as neighborhoods with narrow, dead end roads
- Locations of hydrants and water supplies, cell phone reception, stockpiles of detour signs, tape and traffic cones etc.
- Plans for *Shelter in Place* or evacuation of schools, organized camps, hospitals and senior homes
- Contingency plans for dealing with injuries, providing heavy equipment for pushing abandoned cars off roads, and temporary morgues
- Public information networks and communication centers for keeping the public and media informed

- Single ordering points designated to avoid duplicate resource orders being placed and to assist in after-action documentation and cost recovery (Tuttle, 2003)

In congruence with the Australian stance that planning to make a plan is no plan at all, the U.S. government attempts to make plans for all their residents to reduce the probability of harm. In highly populated areas with millions of people exposed to fire prone areas the pre-planning stage can take years. Even with these plans in place, there is still more work to be done. Inter-agency training must be regularly practiced to ensure the agencies will work together effortlessly in a time of emergency (Tuttle, 2003). With thorough preparations in place and agencies up to date on training, the government must wait until a fire sparks and grows to an uncontrollable strength before implementing the next three stages.

The second and third stages of an evacuation are the decision to evacuate and the implementation of the evacuation. No matter if the fire response is controlled on the federal, state, or local level, any fire will have a chain of command with an Incident Commander or Operations Chief (Tuttle, 2003). Fire authorities try to predict the spread of the fire to ensure there is enough warning for residents to evacuate (Stephens et al., 2009). When the fire moves into a certain pre-designated zones, the Commander orders the initial evacuation. At this stage, however, there are still two different evacuation orders, which may be given: voluntary evacuation or mandatory evacuation (Tuttle, 2003). The purpose of the two stage evacuations is, “when we [emergency personnel] say pre or voluntary evacuation you should be ready. When we say mandatory you should be gone” (Lacey & Cooper, 2014). It is difficult, however, to know when to issue those orders, “you’ve got to weigh a lot of

different considerations as to when you're going to pull the trigger {issue an evacuation}. You sure don't want to do it too late" said Brett Lacey of the Colorado Springs Fire Department (Lacey & Cooper, 2014).

Voluntary evacuations are generally ordered when a fire is expected to reach an area within the next 24 hours (Tuttle, 2003). The general purpose of these evacuations is to clear out residents who have decided to leave as early as possible. This not only makes it easier for officials to focus efforts on evacuating others later but also lessens the burdens on roads and other infrastructure not designed to support mass migrations. When a voluntary evacuation is ordered, a neighborhood or area is not in imminent danger; fire behavior may still change and the evacuation may have been unnecessary but it is designed to prolong the evacuation and decrease the significance of the mandatory evacuation if a mandatory evacuation is ordered.

Once the fire has moved to within 1-4 hours from a residential area, a mandatory evacuation order is generally given by the Fire Chief or sometimes by law enforcement officers depending on the region (Tuttle, 2003). At this point, law enforcement steps in as a major player in evacuating residents to implement the evacuation. The first step of a mandatory evacuation is setting up traffic controls to regulate who may enter and leave an at risk area followed by television and radio stations sending out emergency alerts and if possible, reverse 911 calls are made to any telephone within the designated zone (Tuttle, 2003). Police officers are then sent to disperse through the evacuation zone to make contact with anyone still present and inform them that they are required to leave immediately and to offer

assistance if the residents are not able to evacuate on their own (Tuttle, 2003). With roadblocks in place to ensure residents cannot make their way back into harm's way, the evacuation stage has been completed.

Once people are directly out of danger the government is still responsible for their well being until re-entry. Evacuation centers are already set up at pre determined locations such as schools, town halls, or other large buildings with space to temporarily house as many people as were evacuated. At these centers there must be food, water, medical facilities, sleeping areas, and everything else for the comfort of the evacuees. Representatives of the fire department should also be present to answer any questions and keep the evacuees up to date on the fire's progression (Tuttle, 2003).

Humans, however, are not the only evacuees. Animal control organizations are often involved in evacuations to transport pets and sometimes even livestock out of harm's way. Smaller animals can generally go to the Humane Society temporarily while larger livestock are directed towards fairgrounds or other large patches of land that are safe and suitable for grazing and temporary placement (Tuttle, 2003). With the people and animals of an evacuated area safely out of danger, everyone involved essentially has to play a waiting game to see if the fire will be controlled or if more evacuations are necessary.

The final stage of an evacuation is re-entry once the fire has passed or has been brought under control. To ensure the safety of residents, re-entry must be carefully planned. A mass migration of people back into a fire ravaged area is stressful for everyone involved; emergency officials have been working long hours

dealing with destruction and residents fear they may be returning to a destroyed home with all of their possessions and livelihoods in ashes. As in the evacuation, police officers posted at roadblocks allow cars to pass and designated streets are used for the residents to return home. Emergency responders must be on scene in case the area is put in peril again (Tuttle, 2003).

The United States government, however, also emphasizes mutual responsibility on the state, local, and individual level. One such example is the Fire Adapted Community program developed by the United States Forest Service in 2009 (Quarles, 2013). This program was developed to help communities work with, rather than against wildfires, within wildfire prone areas and has been deemed, “the best alternative to escalating wildfire in the Wildland Urban Interface” (Quarles, 2013; 4). The goals of these communities are to increase community participation in mitigation and preparation for a major fire event. Other specific stated goals of the Fire Adapted Community program as listed in their literature include:

1. An informed and active community that shares responsibility for mitigation practices.
2. A collaborative developed and implemented Community Wildfire Protection Plan.
3. Structures hardened to fire and including adequate defensible space practices; advocated by Firewise Communities, IBHS and others.
4. Local response organizations with the capability to help the community prepare and can respond to wildfire; advocated by Ready, Set, Go!
5. Local response organizations with up-to-date agreements with others who play a role in mitigation and response.
6. WUI Codes, Standards and Ordinances, where appropriate, which guide development.
7. A visible wildfire reduction prevention program that educates the public about the importance of a communitywide approach and the role of individual homeowners.

8. Adequate fuels treatment conducted in and near the community, including development and maintenance of a fuels buffer or firebreak around the community.
9. Established and well-known evacuation procedures and routes.

In many ways this is a community approach to the Prepare aspect of the Australian policy. A community approach encourages communities to take responsibility for themselves since they acknowledge that asking residents to depend on, “suppression and protection resources that are not always available” (Quarles, 2013; 4). While this is a step towards mutual responsibility, the responsibility ends as soon as a fire sparks. Residents are expected to prepare and evacuate when ordered to do so.

While emergency authorities acknowledge residents are a key component in preparing for a fire, they completely miss that residents can be assets during a fire as well. Another program that encourages preparation is the *Ready, Set, Go* initiative. This initiative was developed to increase dialogue between residents and emergency service personnel who serve them (wildlandfirersg.com, 2014). Other than the obvious similarities in the names between *Ready, Set, Go* and *Prepare, Act, Survive*, both programs encourage individuals to prepare their properties.

“Ready” encourages residents to take personal responsibility for preparing their property before a fire ignites in the same way “Prepare” does within the Australian policy (wildlandfirersg.com, 2014). Even the suggestions are similar including the clearing of brush, use of fire resistant landscape, use of non-flammable building materials, and stocking supplies that may be necessary (wildlandfirersg.com, 2014). “Ready” even suggests that residents plan escape routes and asks for residents to ensure every member of the family or home is

prepared to initiate action when necessary (wildlandfirersg.com, 2014). In fact, the two different policies include almost the exact same suggestions for preparation.

“Set” requires residents to be situationally aware and stay up to date with current information on burns including what evacuation orders have been issued (wildlandfirersg.com, 2014). Once again the Australian and American policies are very similar. Both encourage residents to stay up to date to know when to act whether it be to stay and defend in Australia or evacuate in either nation. Finally, “Go” encourages residents to leave early, once again in compliance with the Australian *Prepare, Act, Survive* policy (wildlandfirersg.com, 2014). The stated reasons for leaving early are both to ensure a residents safety but also to ensure firefighters have the ability to move freely within the community when they are needed (wildlandfirersg.com, 2014).

At first glance the two policies seem to be almost identical. Even the *Ready, Set, Go* policy acknowledges, “Residents {can} become an active part of the solution to the problem of increasing fire losses (wildlandfirersg.com, 2014).” This policy, however, ignores the most unique, and beneficial, aspect of *Prepare, Act, Survive*; residents can be assets during the fire not just prior to the fire. For many residents, evacuation is the only option. It is foolish, however, to assume that residents can only help prior to the fire. In the next section I will explore both why and how residents can be beneficial during a fire and how staying to defend ones property may in fact be safer than evacuating.

Evidence in Support of and Against *Prepare, Act, Survive*

The Australian *Prepare, Act, Survive* policy, specifically allowing residents to stay and defend their property, thrives under specific fire conditions when residents are prepared. Since the focus of this research is looking at the effects of allowing residents to stay and defend their property, in this section I will focus on information that supports residents' abilities to stay and defend their property and data that emphasizes problems that are often encountered by residents when implementing their plans to defend their property or leave early. Furthermore, I will explore how homes are destroyed and how most deaths occur to contrast their activities with the activities outlined by the *Prepare, Act, Survive* approach. As stated by John McLennan:

“(a) Civilians were most likely to die because of either the effects of radiant heat or as a result of a motor vehicle accident while fleeing at the last moment, and (b) suitably prepared homes could be defended against bushfires while providing a safe refuge for the people during the passage of the main fire front” (McLennan et al., 2013).

Furthermore, Australians acknowledge the sad reality of emergency services during a bushfire and how residents can alter the outcome of these fires:

“There’s never going to be enough resources to protect every single property out there, and the research from Australia clearly shows that in non-catastrophic conditions, a property that’s been prepared and has residents present that are rational thinking and know what they’re doing, that property is much more likely to survive, which means that agencies can put their resources and emphasis elsewhere.” (Eriksen, 2013)

Therefore, the evidence in support of a policy that allows residents to stay and defend is not only present and plentiful but clearly shows two distinct trends outlined by McLennan. Defending a well prepared home can be done safely and

increase a structures likelihood of survival and conversely, fleeing late is dangerous and likely to put someone in harm's way with no protection from radiant heat (McLennan et al., 2013; Whittaker et al., 2013; Handmer et al., 2010; Tibbits & Whittaker, 2007; McLennan, 2012; Handmer & Tibbits 2005; Mutch et al., 2011; Conway & Llewellyn, 2012). There is no reason that well prepared and able bodied residents should not be given the option to protect their lives and property as stated by Mike Leonard, "a well prepared, healthy people who knew what they are doing, are better off sheltering from the radiant heat and doing what they could to save their property" (Morgan & Leonard, 2013). American researchers such as Scott Stephens support this claim:

"There is considerable evidence that well-prepared houses can provide a safe place for people during wildfires, based on the key assumption that a fire front passes quickly and that houses can survive this period and protect occupants from radiant heat, smoke and embers." (Stephens et al., 2009)

While no particular action during a bushfire is completely risk free, knowledge about past actions and consequences can lead to future policy shifts to encourage safer behavior. Homes can offer protection because they are designed to withstand the first wave of heat from the fire:

"The whole policy is based on the fact that the structure is able to withstand that initial hit from the fire front and the Black Saturday that Ross was mentioning that didn't always and that's what's catastrophic is structures can't withstand that first blast and if it can't withstand the first blast, you can't stay because you're too exposed." (Bradstock & Penman, 2013)

As mentioned in previous sections, staying and defending a property should only be considered if it is not a day of catastrophic fire danger on the McArthur Forest Fire Index (rsf.nsw.gov, 2013). During days of extreme or catastrophic fire danger, emergency personnel need to prepare different messages and plans to

ensure the safety of themselves and residents who may be in danger (Beatson & McLennan, 2011). Therefore, if the fire danger is in the catastrophic range, the only safe option is to leave early. A study conducted by Blanchi in 2010 shows that:

“Less than 1% of house losses occurred when the FFDI was less than 25, roughly 7% occurred when the FFDI was between 25 and 50 and 38% occurred when the FFDI was between 50 and 100. The remainder (64%) occurred when the FFDI exceeded 100.” (Blanchi et al., 2010)

This means that as fire conditions worsen as many as two thirds of homes will be destroyed. Data like this offers sufficient evidence that it is unsafe to stay and defend a property under higher levels of fire danger on the McArthur Forest Fire Index. Furthermore, Australasian Fire and Emergency Services Authorities Services Council (AFAC) acknowledges that “in limited cases, some buildings, due to their construction methods, construction materials, the site they are located on or their proximity to high and unmanageable fuel loads, cannot for all practical purposes be defended against high intensity bushfires” (AFAC & Bushfire CRC, 2006). In Australia, two thirds of fire deaths have been from ten fires all of which occurred under extreme fire danger (some may have been classified as catastrophic however that level was not added until 2009) (Haynes et al., 2008).

Furthermore, homes are only considered defensible if preparations have been made. Statistically, however, staying and actively defending one’s property is a safe and viable option under lower fire danger ratings if the resident is well prepared. In 2001 AFAC coined the catch phrase, “houses protect people and people protect houses” (AFAC, 2001 as cited in Handmer & Tibbits, 2005). This conclusion has been reached for two main reasons: 1. homes are likely to ignite by embers not direct flame or radiant heat and 2. historically few people have died defending a

prepared property (Stephens et al., 2009; McLennan et al., 2013; Whittaker et al., 2013). According to Dr. Justin Leonard, “so it’s something like high 80’s and 90 percent of houses in Australia are lost in absence of the fire front itself so that’s ember attack on vulnerable features of the house” (Leonard, 2013).

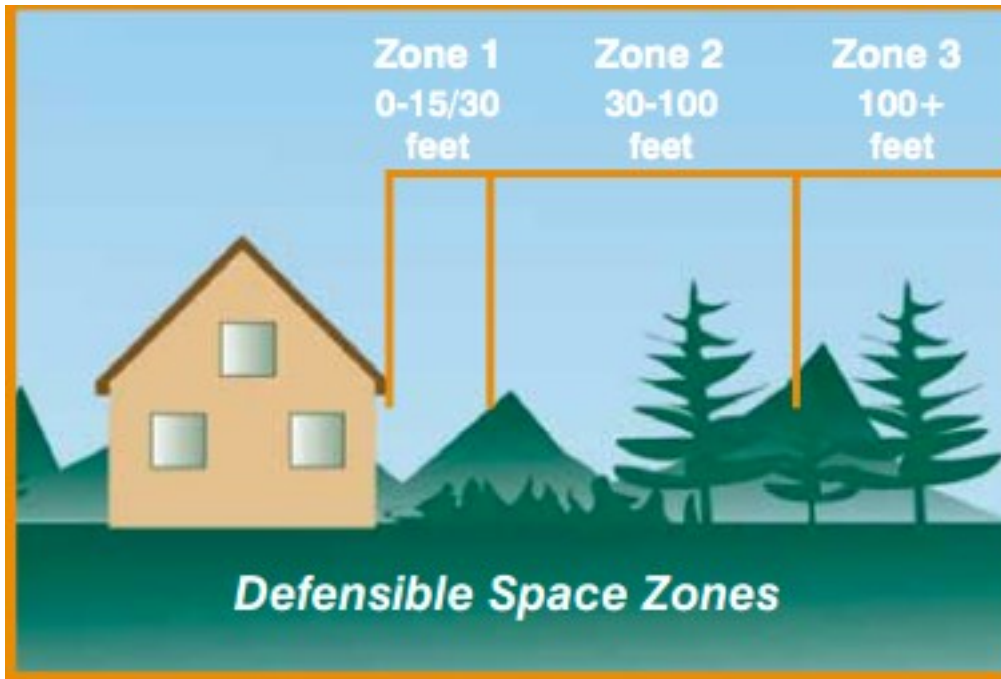
In 1945, Barrow published work based on observations that homes generally ignite by embers becoming lodged in small crevasses of flammable material (Barrow, 1945 as cited in Handmer & Tibbits, 2005). These embers can ignite homes before the fire-front has reached the property, while it is passing, or for several hours after the fire has gone (AFAC & Bushfire CRC, 2006). Homes generally will not ignite from the fire front directly but from these wind blown embers (AFAC & Bushfire CRC, 2006; McLennan et al., 2013; Whittaker et al., 2013). In fact, wind blown embers are the most common ignition source during a bushfire (Leonard, 2003 as cited in Tibbits & Whittaker, 2007). Because of the plethora of evidence to suggest the impact of embers on igniting homes, fuel treatment or mitigation is often used to reduce the probability of an unplanned ignition, reduce the rate of spread, and decrease the intensity of a fire (Price & Bradstock, 2012).

In fact, homes generally can only catch fire from direct flame if there is significant fuel load within 40 meters of the structure but can ignite from embers blowing from as far away as 10 kilometers (Gibbons et al., 2012). In Australia the 10/30 rule was implemented to ensure there are no trees or shrubs within 10 meters and another 30 meters of land have been cleared to ensure adequate defensible space (Gilbert, 2013). The Colorado State Forest Service actually suggests clearing over 100 feet from a home by using three different zones shown in

Figure 7 (Colorado State Forest Service, 2012).

Figure 7.

Defensible Space Zones



(Colorado State Forest Service, 2012)

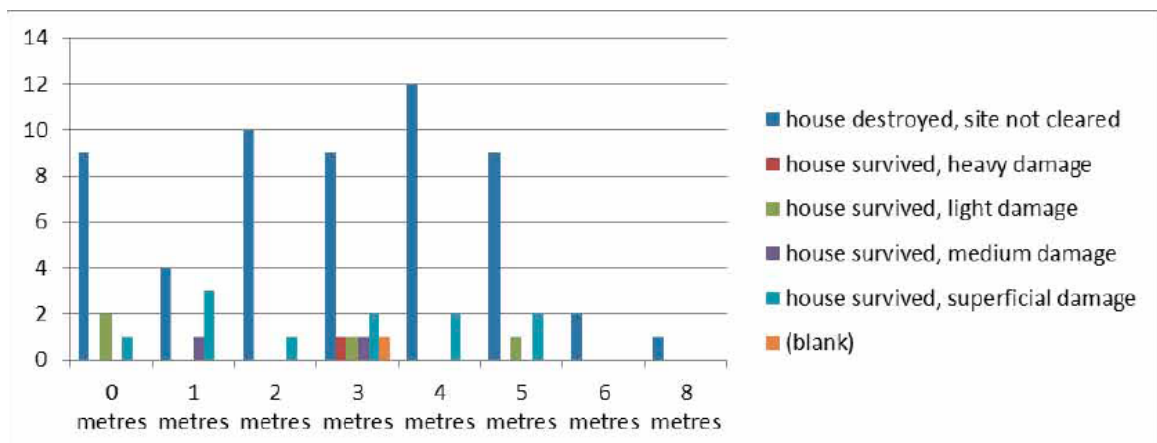
Zone 1 is within 30 feet and requires the elimination of all fuels. Zone 2 goes from 30-100 feet and allows smaller fuels such as bushes. From there, Zone 3 extends over 100 feet from a home and allows larger trees but should still be mitigated regularly to ensure adequate defensible space (Colorado State Forest Service, 2012).

The reduction of fuel within 40 meters of a structure from 90% coverage to 5% coverage increases the likelihood of the structure surviving by 43% or a 5% risk reduction for 10% clearance (Gibbons et al., 2012). Clearing flammable materials from within 40 meters of a home is the single preparation that increases the likelihood of survival the most. As shown in Figure 8, clearing flammable materials from close proximity to a home significantly reduces the probability of a structure

being damaged or destroyed by a fire especially if there is more than 5 meters of defensible space (Smith, 2011).

Figure 8.

Destruction of Homes with Different Defensible Space



(Smith, 2011)

Statistical evidence, however, is not only available for survival rates of structures. In fact, there is just as much evidence to support the claim that staying and defending a property is relatively safe compared to any other activity. This evidence shows a major trend: people are more likely to be killed when evacuating than when staying and defending a well prepared home (Haynes et al., 2008). A comprehensive study of bushfire deaths in Australia shows the activities at time of death of all 552 people who were killed between 1900 and 2007 in Figure 9.

It is important to note that during this time period only one person died while inside a structure actively defending a property; the cause of death was later ruled a heart attack (Haynes et al., 2008). In other words, not a single person between 1900 and 2007 died when strictly following the *Prepare, Act, Survive* policy.

Figure 9.

Activity at Time of Death in Australia between 1900-2007

Table 8: Activity at time of death

Activity	1900 to 2007/08	1900 to 1955	1956 to 2007
Late evacuation	176 (31.9%)	110 (37.3%)	66 (25.7%)
Of these:			
- from shelter	100 (56.8%)	42 (38.2%)	58 (87.9%)
- from a place of work outside	53 (30.1%)	51 (46.4%)	2 (3.0%)
- destination or origin unknown	20 (11.4%)	16 (14.5%)	4 (6.0%)
- from an undefendable shelter	3 (0.8%)	1 (0.9%)	2 (3.0%)
Defending property outside	145 (26.3%)	82 (27.8%)	63 (24.5%)
Of these:			
- In a suburban location	42 (29%)	14 (17.1%)	28 (44.5%)
- In a rural location	103 (71%)	68 (83%)	35 (55.6%)
Inside defendable property	46 (8.3%)	11 (3.7%)	35 (13.6%)
Of these:			
- Actively defending	1* (2.2%)	0 (0.0%)	1* (2.9%)
- Meagre and unsuccessful attempts to defend	5 (10.9%)	1 (9.1%)	4 (11.5%)
- Passively sheltering	35 (76.1%)	9 (81.8%)	26 (74.3%)
- Activities unknown	5 (10.9%)	1 (9.1%)	4 (11.5%)
Activity	1900 to 2007/08	1900 to 1955	1956 to 2007
Travelling through the area unaware	35 (6.3%)	7 (2.4%)	28 (10.9%)
Of these:			
- Travelling for work	29 (82.9%)	5 (71.4%)	24 (85.7%)
- Travelling for pleasure			
En route to defend or rescue	25 (4.5%)	10 (3.4%)	15 (5.8%)
Waiting rescue	8 (1.4%)	1 (0.3%)	7 (2.7%)
Assisting fire fighting operations eg forestry worker	12 (2.1%)	2 (0.7%)	10 (3.9%)
Returned into burning building	8 (1.4%)	2 (0.7%)	6 (2.3%)
In an undefendable shelter	8 (1.4%)	8 (2.7%)	0 (0.0%)
Unknown activity at time of death	89 (16.1%)	62 (21.0%)	27 (10.5%)
Total	552	295	257

(Haynes et al., 2008)

In compliance with the *Prepare, Act, Survive* policy, residents should go inside their property when the fire front is passing. While 26.3% of deaths occurred outside a structure while defending the property, if residents retreat inside the structure to protect themselves from radiant heat, then they will likely survive unharmed (Haynes et al., 2008). Furthermore, even if a resident decides to stay outside, statistically they are still more likely to be killed fleeing late. Thirty one point nine percent of fire deaths occurred during a late evacuation, which compromises the riskiest activity for residents to engage in during a bushfire

(Haynes et al., 2008; McLennan et al., 2013; Whittaker et al., 2013; Tibbits & Whittaker, 2007). The most common, preventable, cause of death during a bushfire is being caught outside and exposed to radiant heat and smoke (Stephens et al., 2009). There are many reasons why it is dangerous to flee late during a bushfire including “smoke, noise, heat, flames, firefighting vehicles, and panic all make fleeing in a vehicle or on foot dangerous” and therefore, “the risk of being overrun by fire is very real and has resulted in numerous fatalities” (AFAC & Bushfire CRC, 2006).

This point is emphasized by the 2005 Eyre Peninsula Fires where there were nine fatalities eight of which were residents in or near cars who tried to evacuate too late (Whittaker et al., 2013). Many Australian fires have shown how effective residents can be at defending their properties. Specifically, during the 1983 Ash Wednesday Fires, residents “were able to save their houses by extinguishing small ignitions of the house itself before the fire became uncontrollable” (Ramsay, 1987 as cited in Whittaker et al., 2013) and a post fire study found a 90% survival rate for homes that were actively defended by residents compared to an 82% survival rate for homes that were occupied but not actively defended and only a 44% survival rate for structures that were unattended (Wilson and Ferguson, 1984 as cited in Whittaker et al., 2013).

Similarly, other studies have shown a three to six time greater likelihood of survival for a structure if a resident is there to defend (Blanchi, 2013). In essence, “the critical factor in building survival is the presence of people” (Stephens et al., 2009) and therefore it is important to allow residents to stay and defend their property. Furthermore, “the removal of able-bodied residents can often be

detrimental to structural survival and public safety” (Mutch et al., 2011). Fire crews can focus on the fire rather than homes and roads are clear for easy movement in and out of dangerous areas quickly (Mutch et al., 2011). Well-prepared residents can be assets to firefighters rather than a hindrance to their progress (Mutch et al., 2011).

It is important to acknowledge that there are many factors that may put residents at risk if they decide to stay and defend. Unfortunately, it took the deaths of 172 (some estimates claim 173) people and over 2000 structures lost and more than 4000 other homes directly affected during the 2009 “Black Saturday” Fires to emphasize some shortcomings in Australian fire policies (McLennan et al., 2013; Whittaker & Handmer, 2010). On February 7th, 2009, Australians experienced some of the worst fire conditions ever recorded and the worst single day of bushfires in recorded history with the Premier of Victoria, John Brumby calling it “the worst day in the history of the State.” The temperature of the day was 111° F (44° C) with less than 10% relative humidity and winds over 62 mph (100kph) (McLennan et al., 2013; Whittaker & Handmer, 2010). Furthermore, the state of Victoria had been in a decade long drought with worsening conditions in the previous year (McLennan et al., 2013). This combination of factors left dry fuel on the ground and prime conditions for a major unplanned fire to spark.

The severity of this fire even caused the Australians to consider a *Mandatory Evacuation* policy at times, “There’s been a big swing almost towards evacuation is the only safe option” said Gary Morgan, CEO of Bushfire CRC. Even some researchers believe that at some point a mandatory evacuation may be necessary,

“I’m coming to the conclusion that there should be evacuation quite frankly. Yeah, when the threat is really real... I think there’s a great deal of merit” (Bradstock & Penman, 2013).

While this event was a tragic look at how damaging fires can be, it offers researchers insight into weaknesses of the *Stay and Defend or Leave Early* policy which paved the way for the current *Prepare, Act, Survive* approach:

“I mentioned the word awakening – I think up until February 2009 there was a sense of trust, confidence, support in the Fire and Emergency services... what happened was a fundamental disconnect between community expectations, government policy in relation to those expectations, and directions sent to the service providers about how to meet those expectations... the expectation from the public was that services will be there, it’s not my responsibility it’s theirs... Because the emergency service providers know we can’t do it all alone, and there has to be some responsibility taken by the individuals and community groups, by industry and by governments.”
(Edwards, 2014)

Prepare, Act, Survive emphasizes the importance of different actions, in reality the two policies are grounded on the same general beliefs that it can be safe to stay and defend a property if well prepared as stated by Dr. Christine Eriksen of the Australian Centre for Cultural Environmental Research:

“The royal commission approved of the essential components of the policy, so they still estimated that a prepared property with or without people present always has a higher chance of survival, not only because it assists the fire services if they do get there, but also because it’s less likely to ignite in the first place.” (Eriksen, 2014)

Similarly expressed by Dr. Raphael Blanchi of CSIRO:

“The fact that the policy is not completely put in question that they recognized there were some good aspects of the policy but it has to be changed to take into account some other problems linked to this implementation of the policy” (Blanchi, 2013).

I believe many strengths and weaknesses emphasized by the Black Saturday Fires offer insights into how residents will react under the new *Prepare, Act, Survive* policy.

The Black Saturday Fires, however, show drastically different trends than previous fires in regards to human deaths. Not only do the Black Saturday Fires offer insight into the differences between fires on days of a lower fire danger but also they represent a transitional period from *Stay and Defend or Leave Early* to *Prepare, Act, Survive*. In Figure 10, a table showing activity at time of death, it is clear that most residents died while sheltering in their home (McLennan et al., 2013).

Figure 10.

Black Saturday Fire Activity at time of Death

Activity at time of death	%
Sheltering inside/near a structure	65
Fleeing: car and/or foot	17
Defending a dwelling	9
Caught in the open on foot	3
Other (e.g., camping, subsequent heart attack)	5

(McLennan et al., 2013)

In fact, 40% of the 200 fire deaths inside structures in the last 200 years were in places like bathrooms where it is impossible to properly monitor the progression of the fire (Blanchi, 2013). While few residents died actively defending, a much higher percentage of residents died inside their homes than national averages over the last 100 years. The data, however, are not necessarily contradictory to the evidence in support of *Prepare, Act, Survive*. Of the deaths within structures, 69% of people

were passively sheltering, another activity, which *Prepare, Act, Survive* acknowledges as a dangerous activity. There were, however, nine deaths while defending a structure, which had never been seen in the past (McLennan et al., 2013).

One study conducted by the Center for Risk and Community Safety at RMIT University and Bushfire CRC found that of the 172 deaths, 58% of people had not made any preparations while only 14% of people had made any preparations to stay and defend their property and only 20% were well prepared to enact their plans to stay and defend (Handmer et al., 2010). Furthermore, because the fire killed these people it is fair to say that they had not prepared to leave early or did not effectively initiate their plans (Handmer et al., 2010). Twenty five percent of the residents whom were killed seemed to not know they were living in a fire prone area and 39% did not know how to react to a fire while 30% were caught by surprise and did not have time to initiate plans (Handmer et al., 2010). Of these deaths:

“Evidence suggests that 34% of fatalities intended to stay and defend their properties, a further 26% intended to wait and see before committing to a course of action which may, or may not, have been to defend their properties. In a further 15% of fatalities, there was no evidence of any intentions; and eight percent of fatalities intended to stay at their property but to seek shelter rather than actively defend. Sixteen percent of fatalities had intentions to leave, and 1% had made a conscious decision to do nothing (i.e. to deny the fire risk).” (Handmer et al., 2010)

Of the 34% who planned to stay and defend their property, only 5% showed any evidence of actively defending which is a fundamental requirement of staying and defending while 26% appeared to be waiting to see what measures they should take (Handmer et al., 2010). Almost 70% of deaths were of people passively sheltering and 14% were fleeing late both of which are considered dangerous activities and

not suggested by experts (Handmer et al., 2010). Therefore, almost all deaths occurred when residents were acting against the suggestions of the Australian fire authorities

This data shows that the populations killed were not representative of greater Australian societal trends in regards to preparation and actions. In general, those who perished were not as aware of the dangers associated with living in the wild land urban interface and furthermore were not prepared for a fire which inevitably would effect them at some point. In fact, only 20% of residents who died were acting in compliance with the suggestions of the *Stay and Defend or Leave Early* policy of the time.

One concerning piece of information is that residents fundamentally fail to act even though they appear to understand the risks involved with living in fire prone ecosystems. One study conducted by The Bushfire CRC found that 78% of respondents believed a bushfire could occur in their neighborhood and 67% acknowledged a high level of threat to their property and selves (Whittaker et al., 2013). Australian residents surveyed seem to generally acknowledge the risk of bushfires, which resulted in a high level of preparedness.

Seventy eight percent of residents had discussed how they planned to respond with their families and 68% of residents had specific plans in place for each member of the family in case of a bushfire but only 20-25% of residents have a formal written plan (Whittaker et al., 2013; Whittaker & Handmer, 2010; Whittaker et al., 2010). Preparation, however, goes much further than simply having a bushfire plan:

The most common preparations were actions normally undertaken as part of general property maintenance; such as clearing leaves, grass and other debris from around the house (92%), clearing leaves from gutters (88%) and obtaining and preparing equipment such as ladders, buckets and mops (73%). Many residents had moved combustible materials such as firewood and garden furniture away from their homes (70%) and obtained and prepared firefighting equipment such as water pumps and hoses (66%). Less common were actions to protect vulnerable points on houses from ember attack; such as installing seals and draft protectors around windows and doors (35%), covering gaps and vents (31%), installing gutter protection (25%) and covering under floor spaces (20%).” (Whittaker et al., 2013)

It is clear that most residents had participated in some level of preparation, however, most preparation was simple tasks generally thought of as regular housework rather than fire preparation. In reality, with embers igniting most homes, it is important to cover any area where embers may enter a home or become lodged in flammable materials and only about one third of residents made these changes to their homes to prepare for a bushfire. Even with many residents preparing, more must do so, “A lot of the evidence from my research shows that people have kind of good awareness of the risks they’re dealing with but they don’t translate that into preparedness behavior. There’s a gap -- the issue is how do we connect that gap better (Eriksen, 2013). Simply having a fire plan does not appear to be linked to better decision-making. The plan may have been insufficient by not having contingency plans if the primary action was impossible (Handmer et al., 2010). “*{Prepare, Act, Survive}* doesn’t emphasize that you need a contingency plan for every possible contingency, so you’re prepared and ready” stated Dr. Justin Leonard (Leonard, 2013).

During the Black Saturday Fires, only 2% of residents reacted to the fires when warned by authorities to leave the day before the fire (McLennan et al., 2013).

This is consistent with responses from a Bushfire CRC study that found only 2% of residents plan to leave on any day of catastrophic fire danger (Whittaker et al., 2013; Whittaker et al., 2010). However, more generally, 50-60% of residents plan to leave well before a fire is even reported on days of catastrophic fire danger when in reality, during the Black Saturday fires, two thirds of residents were at home and of the third that were not present at the time of the fire only 1.5% had left because of the fire danger (Whittaker & Handmer, 2010).

From here the survey responses split into two categories as both *Prepare, Act, Survive* and *Stay and Defend or Leave Early* indicate: residents can stay and defend their property or leave before threatened by the fire. Fifty percent of residents plan to stay and defend their property while 19% plan to leave before warning signs of danger (Whittaker et al., 2013; Whittaker et al., 2010). This means that 31% of residents are undecided on their plans with 17% planning to see what fire conditions are like that day and 9% planning to wait and see if the fire will effect them therefore evacuate late putting them in danger (Whittaker et al., 2013; Whittaker & Handmer, 2010). Residents often wait and see what will happen for a few reasons: 1. falsely perceived low risk, 2. their expectation of a warning, 3. belief that they can safely defend their home, and 4. the potential risks and costs of relocation (McLennan, 2012). Even with Australian fire authorities emphasizing the danger of late evacuation, one quarter of residents do not have a plan or plan to participate in the riskiest action during a bushfire, leaving late and therefore putting themselves in harm's way (Whittaker et al., 2013).

Of the residents who planned to stay and defend, 80% stuck with their plan while 20% of residents who planned to stay, left (McLennan et al., 2013). These statistics slightly conflict with Bushfire CRC data stating that one third of residents who planned to stay left at some point during the fire (Whittaker et al., 2013; Whittaker et al., 2010). Many people who planned to stay and defend their property were not fully committed to do so (Whittaker et al., 2013; Tibbits & Whittaker, 2007). While 43% of people who planned on staying left safely before the fire reached them, 33% of this group left only after some trigger such as a home catching fire or firefighting equipment failing which implies that these residents likely left at a dangerous time (Whittaker et al., 2013). Residents varied greatly on reasons for leaving after plans to stay and defend:

“One-third (38%) of those who stayed to defend left at some stage while their property was under threat. The most commonly cited reason for leaving a house or property was that it was too dangerous to stay and defend (44%). Other reasons were that there were flames in the immediate vicinity of the property (33%) and to remove other household members or visitors from danger (26%). One-quarter left because utilities or equipment failed (26%) or because their house caught fire (18%)” (Whittaker et al., 2013).

All of these people, however, unnecessarily put themselves in peril and there still seems to be a misunderstanding by residents of when it is acceptable and safe to leave and when fleeing will put them in even more danger. Essentially, there were large numbers of people who evacuated late and in a dangerous way even though the *Prepare, Act, Survive* policy explicitly condemns those actions.

Of the residents who planned to leave early, only 65% left while it was safe to do so while 24% placed themselves in harm's way by fleeing late even though both policies explicitly condone the action and 11% decided to stay and defend since they

felt it was too dangerous to leave (McLennan et al., 2013). Similar statistics from Bushfire CRC confirms these claims finding that 12% of people stayed and defended their property because it was perceived as too dangerous to leave or their attempts to leave were thwarted by the fire or other circumstance (Whittaker et al., 2013). The Bushfire CRC statistics listed in the prior paragraphs are visually represented in Figure 11.

Figure 11.

Action vs. Intended Action During the “Black Saturday” Fires

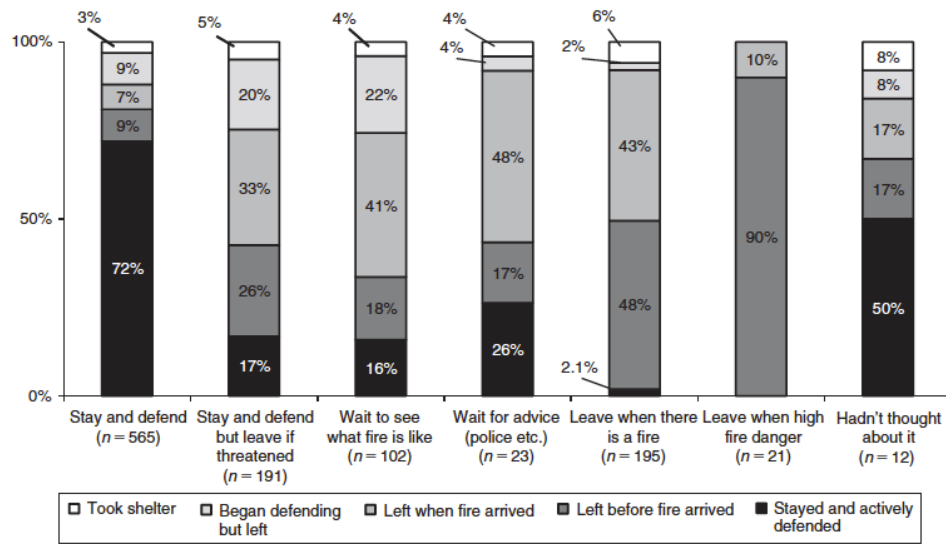


Fig. 2. Action taken by residents during the 2009 Black Saturday bushfires, compared to their intended action. Percentages may not total 100% due to rounding.

(Whittaker et al., 2013)

Forty four percent of homes of residents who left were destroyed while only 20% of homes were destroyed if a resident stayed to defend (McLennan et al., 2013). Even under catastrophic fire danger, over twice as many homes survived if there was a resident there to defend the structure (McLennan et al., 2013). Interestingly, a prior plan to stay and defend did not increase a home’s likelihood of

survival over residents who planned to leave but decided at the last moment to stay and defend (McLennan et al., 2013). Once again, this statistic contradicts Bushfire CRC statistics that 16% of homes were destroyed when residents were planning to stay and did so compared to 31% of homes destroyed if the residents had planned to leave but ended up staying (Whittaker et al., 2013).

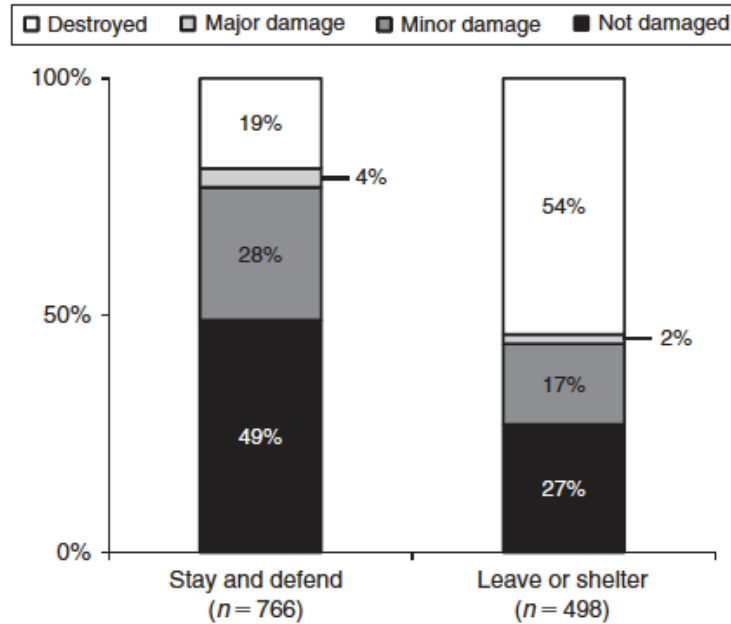
This evidence, however, should not overshadow data that support staying and defending and the relationship to the survival of homes. As shown in Figure 12, Nineteen percent of homes were destroyed where residents were present to defend the property compared to 54% of homes where no one was present (Whittaker et al., 2013). Furthermore, more houses experienced minor or major damage when there were no residents present (Whittaker et al., 2013). While both studies show higher survival rates when residents are present, the evidence is inconclusive as to what role planning to stay and defend plays in preparations and therefore survival rates of structures. Overall, during the Black Saturday Fires there was a 77% survival rate for attended homes and a 44% survival rate for unattended homes (Whittaker et al., 2013).

While many people successfully defended their property, there were major problems that residents experienced during the fire that added significant difficulty to acting safely. For residents who wanted to leave early, common problems reported were: 1. vague understanding of when is “late” evacuation, 2. residents often do not receive an official warning to leave (if that is part of their plan) (Whittaker et al., 2013; Whittaker & Handmer, 2010; Tibbits & Whittaker, 2007).

Figure 12.

Homes Damaged and Destroyed of Stay and Defend vs. Leave Early Action

Taken



(Whittaker et al., 2013).

For residents who were staying and defending their property, some of the most common problems were: 1. failure of plastics and fittings of firefighting equipment, 2. lack of stored water and low water pressure from city sources or reliance on grid electricity for pumps, and 3. the mental and physical preparedness of residents to deal with a traumatic experience (McLennan et al., 2013; Tibbits & Whittaker, 2007). Furthermore, for some residents in rural areas, leaving early is not considered a viable option because they are located so far from any safe place and would spend no time at home if they left during every day of heightened fire danger (Tibbits & Whittaker, 2007).

During the fires, only 38% of residents received an official warning that they were in danger or that if they were planning to leave, they should evacuate (Whittaker et al., 2013; Whittaker et al., 2010). This is problematic because 25% of residents have stated they will wait to leave until told to do so by emergency officials (Whittaker & Handmer, 2010). Furthermore, 72% of residents expected to receive an official warning if there was a fire threatening them (Whittaker et al., 2010). Even for those residents who did receive an official warning, 68% stated they had just enough time to respond safely (Whittaker et al., 2010). Fifty one percent of residents who left reported that they felt they left either late or very late (Whittaker et al., 2010). In fact, half of the residents only became aware of the fire when noticing sensory cues such as smoke, embers, or flames (Whittaker et al., 2010). Only 9% of people who died in the blaze likely received any official warning and it is believed that 30% were caught completely by surprise (Handmer et al., 2010). Therefore, the communication between fire authorities and residents must be enhanced to ensure that residents have the information available to make an informed decision of when to leave and when to stay and defend (McLennan et al., 2013).

There is also significant evidence to suggest residents who plan to leave will likely wait until there are signs of the fire approaching to react. These triggers can be smoke, embers, or flames, which often imply that since the fire is too close, it is more dangerous at this point to leave than stay and defend (McLennan et al., 2013; Stephens et al., 2009). Unfortunately, there seems to be a fundamental disconnect between knowledge and actions; residents still often leave when these warning

signs arise even though Australian fire authorities emphasize the dangers of late evacuation (McLennan et al., 2013). While 80% of residents who fled late acknowledged the risks of doing so, they still made the decision to put themselves in harm's way (Whittaker et al., 2013). Half of these residents encountered dangers varying from smoke and embers to fallen trees (Whittaker et al., 2013). The residents who evacuated reported problems with 44% mentioning smoke, 26% stating poor visibility, 24% reporting traffic, 24% reporting embers, 17% reporting flames, and 12% mentioning fallen trees as hindering their evacuation (Whittaker et al., 2010).

It is important to acknowledge that while preparations and general fire knowledge is valuable and on a large scale increases a structure's and person's likelihood of survival, there is some level of randomness (or there are variables not currently understood), which can lead to the destruction of homes. During the Black Saturday Fires it was found that:

“There was no significant difference between those who defended their homes successfully and those whose homes were destroyed on: (a) overall ratings of long-term preparation; (b) knowledge of bushfires; or (c) preparation on the day” (McLennan et al., 2013).

While fire researchers play an important role in gaining information about how structures and people are harmed during fires, we are far from having a perfect understanding of fires and a fires interaction with the developed world. There are clear trends, however that preparation and knowledge of fires increases both personal survival and structural survival. This science, however, is not perfect and sometimes cannot explain why one well prepared and defended home survives while another one does not. Regardless, 77% of residents who fled stated they

would do so again and 78% of residents who stayed to defend also believed they would act in the same way again (Whittaker et al., 2010).

While most of the statistics and information in this section pertains more to the *Stay and Defend or Leave Early* policy since it was in place during the 2009 Black Saturday Fires, I believe many of the shortcomings are transferrable to the current *Prepare, Act, Survive* policy since they both have the same fundamental standing in regards to allowing resident to stay and defend their property. One major goal of the policy shift was to emphasize the dangers of “wait and see” which is the primary reason for the “Act” component of *Prepare, Act, Survive* as discussed in previous sections (McLennan, 2012). Unfortunately, since the *Prepare, Act, Survive* policy is so new, there is little information on how it has changed residents’ actions during a major fire. Furthermore, Australia has not seen many major fires since the policy’s enactment meaning there are limited data currently available.

Therefore, for the purposes of this research, I will assume that while the policy has changed many of the same issues are still present, “I think the name’s changed, but ultimately has anything else? I don’t think so” (Haynes, 2013). While there will most certainly be changes in residents’ actions in the future, as of now I have not seen any data to indicate that those changes are actually occurring and therefore will assume that residents have not yet significantly altered their bushfire plans or actions during a fire. Furthermore, I believe that residents prefer a “wait and see” method of reaction because of simple convenience and therefore even with a policy shift, it will not likely significantly alter their behavior. While these

assumptions may be false, only time will tell if the policy shift effectively changes human behavior.

Would *Prepare, Act, Survive* Work in the United States?

On November 26th, 2007 a fire just outside of Los Angeles, California threatened dozens of homes in the El Nido neighborhood (Pool, 2007). Against orders from the Los Angeles County Sheriff's Department, Matt Haines stayed in his home and began to prepare his 31-year-old pumper truck for action (Pool, 2007). As residents of the neighborhood began spraying down homes and extinguishing embers, others set up pumps and hoses to increase their defenses against the oncoming fire (Pool, 2007). For a \$6000 investment in the trucks, pumps, and hoses, the neighborhood fire crew saved millions of dollars in houses (Pool, 2007). Stories like this one are becoming more common as fires worsen and residents living in fire prone regions continue to fight back. This is just one success story of many throughout the United States where residents are implementing Australian-like policies to protect themselves and their property against wildfires.

While the Australians have seen clear successes using the *Prepare, Act, Survive* policy it is not clear that it would be plausible or even possible to formally implement a similar policy within the United States on a large scale. With fire problems worsening in the U.S., forest managers are looking at the Australians as an example of alternative approaches to fighting wildfires:

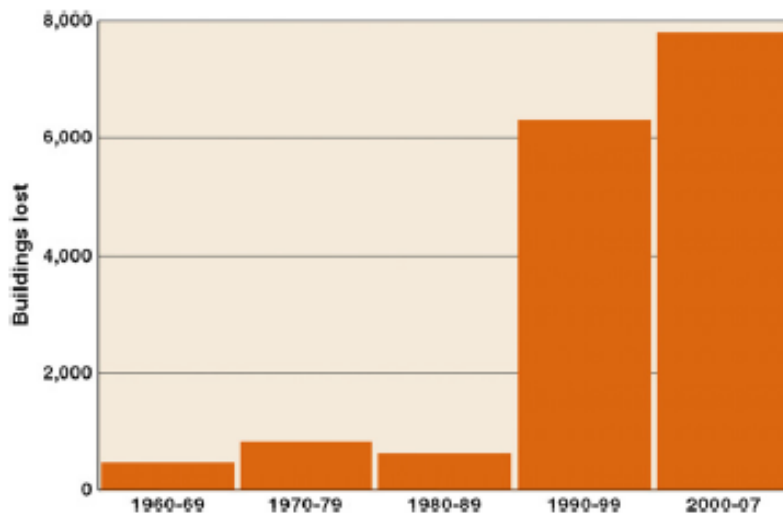
“The increased costs and negative impacts of wildfires are causing fire managers and policymakers to reexamine the traditional approaches to fire management including whether mass evacuation of populations threatened by wildfire is always the most appropriate option.” (McCaffrey & Rhodes, 2009)

Fire managers around the United States are feeling the pressure of increased fire danger. With fire conditions changing, policies must adapt as well. This is

represented in funding for fire management, which in 2007 alone was \$1.8 billion and has grown from 25% of the forest service's budget to 44% from 2000 to 2008 (McCaffrey & Winter, 2011). Most money, however, goes to fire suppression and ignores the need for education (Stephens et al., 2009). Even with the increase in funding, states like California have seen sharp increases in damage to structures over the last three decades as shown in Figure 13 implying mandatory evacuations do nothing to prevent damage to buildings (Stephens et al., 2009). Recently, more Americans are refusing to leave their property during emergencies also forcing fire managers to look into alternative policies (Cohn, 2006 as cited in McCaffrey & Winter, 2011).

Figure 13.

Building Loss in California 1960-2007



(Stephens et al., 2009)

While a *Mandatory Evacuation* policy is effective at saving lives if implemented well, it does nothing to protect buildings and unfortunately is not

always ordered early enough to ensure residents are not put in peril (Stephens et al., 2009). The problem is, “it assumes a) people will always be able to evacuate and b) that they will” (McCaffrey, 2014). Furthermore, a few failed mandatory evacuation attempts in the United States have emphasized the need for an adaptive and variable approach when residents are dealing with wildfires.

One such event occurred in 2003 during the Cedar Fire in Southern California when 22 people were killed while evacuating at the last minute under orders from police and fire officials (Mutch, 2007 as cited in McCaffrey & Rhodes, 2009). Thousands of residents spent two to three hours in traffic trying to evacuate; a shift in the wind would have resulted in hundreds and possibly thousands of deaths (Mutch et al., 2011). A similar event occurred during the 2001 Oakland Hills Fire when 25 residents were killed, 24 of whom while evacuating (Ewell, 1995; Mutch et al., 2011). With 100,000 residents evacuating through thick smoke, traffic, and flames, many people were lucky that they made it out alive (Ewell, 1995). Almost 2,500 homes were also destroyed during the fire (Ewell, 1995; Mutch et al., 2011). While these events are relatively rare, they emphasize the importance of alternative approaches to ensure residents are not being put in more peril while trying to get them out.

The United States and Australia suffer from many of the same wildfire problems. To start, both nations have vast regions susceptible to wildfires (McCaffrey & Winter, 2011). Both nations are currently expanding metropolitan areas further into wildfire prone areas of the wildland urban interface making it more rare for wildfires to burn without intersecting with structures or people

(McCaffrey & Winter, 2011; Mutch et al., 2011; Stephens; 2009). Furthermore, growth rates in the wildland urban interface are only expected to increase in the future in both the United States and Australia (Stephens et al., 2009). In 2011 it was estimated that almost 45 million homes are located in the wildland urban interface throughout the U.S. (Schorow, 2011). Most people moving to the wildland urban interface are from cities and likely do not have much knowledge about fires and the associated risks of living in fire prone areas (Stephens et al., 2009). The United States and Australia have both experienced destructive fires on a large scale with numerous deaths and billions of dollars in damage to structures (McCaffrey & Winter, 2011; Mutch et al., 2011).

A study conducted by the Natural Resources Defense Council found that on average it only costs \$2510 per home to retrofit them with vent screening and box eaves which significantly reduce a structure's potential to catch fire from embers (Mall & Matzner, 2007 as cited in Stephens et al., 2009). Even if every home in the wildland urban interface in fire prone areas was retrofitted to these standards, the decrease in damage from fires would pay for itself after a few major events (Stephens et al., 2009). The intermix of wooded areas and homes causes an increase ignitions and makes it more difficult to protect homes since there are massive amounts of fuel located near homes (Stephens et al., 2009). Furthermore, worsening fire conditions from climate change are exacerbating the problem (McCaffrey & Winter, 2011).

Essentially, the wildfire problem is both increasing the likelihood of harm while simultaneously increasing the magnitude of harm therefore increasing the

probability of major disasters; there are larger fires more often causing more destruction. Even more concerning, since humans start most fires in the U.S., there will likely be more unplanned fires purposefully or accidentally lit if more people are spending time in fire prone areas (Stephens; 2009). Furthermore, legal authority surrounding mandatory evacuation is similar in both nations; in both Australia and the U.S. some states give the police the authority to issue a mandatory evacuation while some do not (McCaffrey & Winter, 2011).

Americans, however, seem to have many misconceptions about how people are harmed during a wildfire including but not limited to, “expectations that fire agencies will be at every house, belief that houses explode in fires, confidence, commitment, and high risk decisions” (Stephens et al., 2009). Another example is Americans believe smoke inhalation is the most common cause of death and traffic accidents are least common with radiant heat in the middle (McCaffrey & Winter, 2011). Australian data shows that of the three, radiant heat is the leading cause of death followed by car accidents and then smoke inhalation (Haynes et al., 2008). In both the U.S. and Australia late evacuation is the leading cause of death during wildfires (Mutch et al., 2011). This is partially because “western communities in areas with frequent fires often do not have sufficient traffic infrastructure to facilitate timely evacuation” (Paveglio et al., 2007). Therefore, residents of the U.S. do not seem to have a clear understanding of common causes of death and therefore do not accurately perceive the risks of a wildfire.

Similar to data from Australia, in the United States, have also shown that embers are also a common ignition source of homes during forest fires (Cohn, 2006

as cited in McCaffrey & Winter, 2011). Residents in fire prone areas of the United States often behave in similar ways to Australians. In 2009 Sarah McCaffrey of the USDA Forest Service conducted a survey of residents in the wildland urban interfaces of California, Florida, and Montana to help determine the level of preparedness of residents in fire prone areas. According to this survey, over 89% of respondents said they had done some degree of fuel management on their property meaning only 11% of residents have not made any preparation to protect themselves from wildfires (McCaffrey & Rhodes, 2009). Fuel management to mitigate fire risk reduces both the probability of harm and the magnitude of harm therefore decreasing the risk to homeowners. Furthermore, 74% of residents had made their homes more resistant to fire (McCaffrey & Winter, 2011). Most residents of the U.S. manage vegetation and fuel loads near their homes prior to investing in costly structural upgrades and believe that vegetation management is more effective than structural changes which is supported by Australian evidence provided by Gibbons discussed in the previous section (McCaffrey & Winter, 2011).

Contrary to Australia where 78% of residents have discussed plans for forest fires, only 38% of residents actually had a plan for a fire threatening their home and lives (Whittaker et al., 2013; McCaffrey & Winter, 2011). As shown in Figure 14, when asking respondents who had been threatened by a fire how they reacted, 48% indicated they decided to see for themselves how bad it was going to be and then decide if they should leave, while only 38% of residents left when the mandatory evacuation order was given, and 20% of residents stayed and attempted to save their property (McCaffrey & Winter, 2011). Of the same group of residents

surveyed, only one third said that in the future they would leave when the mandatory evacuation order is given while half said they would stay to make preparations and leave if they felt they were in danger with 11% planning to stay throughout and 6% undecided (McCaffrey & Winter, 2011).

Once again, this contrasts with the Australian statistics where only 19% said they would leave, 50% would stay and defend, 29% were undecided and 17% would wait and see (Whittaker et al., 2013; Whittaker et al., 2010). Interestingly, people who have defended their property in the past are more likely to do so again (Bradstock & Penman, 2013). This statistic emphasizes a fundamental misunderstanding of risk. The U.S. has a much larger percentage of people who will wait and see what happens, which is well known to be a risky activity (McLennan, 2012). Interestingly, however, even with the major emphasis on fire plans in Australia, and a higher percentage of people stating they have plans in Australia, there are more people who are undecided about their actions in Australia than in the United States according to this survey. Just having a culture around residents preparing for fires is beneficial as mentioned by Dr. Scott Stephens:

“Community fire brigades...where people rally around trailers where they have equipment. They have nomex {fire resistant clothing}. They have fire hydrant hookups. They have radios. They go out maybe 2 or 3 times a year to discuss plans and not everybody shows up... but there was a substantial number ... just having that dialogue with your neighbors and bringing in the fire services... They {Australians} are just so heads and tails above anything I've seen in California” (Stephens, 2014).

Even with a formal evacuation policy, many residents stay anyways.

Therefore, it may be logical to formalize the de facto policy since it appears to

already be prevalent. There does, however, seem to be a misconception that “wait and see” is a safe and acceptable response.

Figure 14.

Preparation for Wildfires by Residents in the United States

	A great deal (%)	Somewhat (%)	Only a little or Not at all (%)	
Managed vegetation (e.g., cleared or pruned weeds, brush, and trees; used fire-resistant plants or landscaping)	58	31	11	
Made my house more fire-resistant (e.g., installed non-flammable roofing; installed dual pane windows; enclosed the space under my deck)	38	38	24	

	Have done a lot of work (%)	Have done to some degree (%)	Haven't done at all (%)	Not applicable to my home (%)
Removed dead or dying vegetation within 30 feet of my home	68	24	2	6
Removed leaf litter (dry leaves/pine needles) from yard, roof, and rain gutters	53	35	5	7
Relocated woodpiles or other combustible materials 30 feet from the house	46	26	9	19
Removed or pruned vegetation near windows	42	29	6	23
Removed combustible material and vegetation from around and under decks	40	22	6	22
Removed "ladder fuels" (low-level vegetation that allows the fire to spread from the ground to the tree canopy)	39	38	9	14
Trimmed tree canopies to keep their branches a minimum of 10 feet from structures and other trees	36	43	12	9

(McCaffrey & Winter, 2011)

While the United States and Australia differ in many regards, building styles and materials, vegetation types, social structures, and legal systems vary greatly between the two countries and even within each state of both countries.

Structurally, homes in the United States are often built from flammable materials, specifically wooden shingled roofs while most structures in fire prone areas of Australia have corrugated iron roofs (McCaffrey & Winter, 2011). This structural

difference is significant knowing that most homes catch fire from embers (Stephens et al., 2009; Leonard, 2003 as cited in Tibbits & Whittaker, 2007). Wooden shingled roofs offer the perfect opportunity for embers to become lodged in a crevasse between shingles and catch the roof on fire destroying the entire home.

While this roof type is more common in the U.S., it is estimated that only 10% of homes in fire prone areas have flammable roofs so in reality a small proportion of homes are effected by this (McCaffrey & Winter, 2011). More significant, however, 30% of residents rejected the idea of boxing their eaves, enclosing decks, or covering walls with fire-resistant materials that are suggested preparations under the *Prepare, Act, Survive* policy (McCaffrey & Winter, 2011). Eighty seven percent of residents reported making changes for protection against direct flames while 86% did so to protect against ember ignition (McCaffrey & Winter, 2011). This statistic implies that there are misconceptions around the relative dangers and causes of house loss in regards to embers versus direct flames. With preparation, however, even officials from the Colorado Springs Fire Department acknowledge that some residents could successfully stay and defend if their structures are prepared:

“If you have a smaller flat built out of non-combustible materials, then that person with a garden hose is probably going to be extremely successful in putting out a mulch fire moving up towards his house or one bush or two it its on his house because the exposure is relatively small, that won’t be a problem... that can reduce those {structure loss} numbers.” (Lacey & Cooper, 2014).

Another common difference is the population density of developments in the wildland urban interface. The United States, generally, has a greater population density in wildfire prone areas making evacuation more difficult but also increasing the likelihood of house-to-house ignitions (Cova, 2005 as cited in McCaffrey &

Rhodes, 2009). Therefore, it is unclear how the *Prepare, Act, Survive* policy would work in areas with a high population density.

Australian residents of rural fire prone areas are often volunteers with the local fire brigade and have a culture of self-reliance and value the protection of personal property (McCaffrey & Winter, 2011). Australia has always had active volunteer fire brigades (McCaffrey & Winter, 2011). Interestingly, when asked who is responsible for protecting private residences (firefighters or homeowners), only 2% of respondents believed it was the sole responsibility of firefighters with 98% acknowledging homeowners played at least a minor responsibility in protecting their property (McCaffrey & Winter, 2011). Furthermore, about two thirds of residents had undergone preparations to assist firefighters or increase their chances of firefighters defending their home emphasizing the acceptance of mutual responsibility (McCaffrey & Winter, 2011).

The Australians emphasize education as part of the *Prepare, Act, Survive* policy (McCaffrey & Winter, 2011). They are, after all, responsible for ensuring residents are informed so they understand the risks associated with staying and defending or leaving their property (McCaffrey & Winter, 2011). While Australian authorities emphasize that a fire truck may not come to assist you, in the U.S. residents expect firefighters to protect them and their property even if residents accept some responsibility; if firefighters are requiring you to leave, they must protect the property since you cannot (McCaffrey & Winter, 2011):

“It’s something that really has to be implemented from the ground up, so people need to realize they’re taking on responsibility and just what that means. So it’s about having all the knowledge needed, doing the preparedness, thinking it through – which is the same problem we have in

Australia, which is that not enough people think through each and every detail.” (Eriksen, 2013)

Overall, while some differences are significant, especially around perceived risk, they do not completely disqualify *Prepare, Act, Survive* from working in many regions of the U.S.:

“Differences between the United States and Australia mean there are likely to be locations in the United States where it would be unwise for homeowners to stay and defend their property, but the differences are not systemic enough to mean that such an approach would not be a viable option in many US localities” (McCaffrey & Winter, 2011)

“There may be some regions where the local climate, topography, and infrastructure may render a ‘Prepare, *Stay and Defend or Leave Early*’ option to be inadvisable. In these locations, a focus on preparing your property to resist ignitions and leaving early may be the only viable option.” (Stephens et al., 2009)

While there are many differences, there is also a clear need to create adaptive fire policies to ensure the safety of residents. Because some locations may not be suitable for the *Prepare, Act, Survive* policy does not mean it would not be effective in other regions of the United States. Unfortunately, it often takes major events to spur residents to prepare, “we have a lot of people that are very aware... we had 62 homeowners associations involved with us... prior to Waldo {Canyon Fire}. After Waldo {Canyon Fire} and Black Forest {Fire} we now have 106... that’s double in the course of a year... because there was smoke in the air” (Lacey & Cooper, 2014).

With a growing number of people living and recreating in the wildland urban interface, mandatory evacuations are harder to implement not to mention the huge economic and social costs associated with evacuations (McCaffrey & Winter, 2011). These residents could be utilized to assist firefighters:

“If you’ve got a number of residents up there {in the wildland urban interface} with several thousand people who can remain based on construction type and some of... those other factors are in place and they stay to take care of their own house then we’ve maximized our firefighting force from 150 folks on duty today in the city of Colorado Springs to maybe 1300-1500 people actively fighting the fire” (Lacey & Cooper, 2014).

With more people moving into the wildland urban interface, implementing a *Prepare, Act, Survive* policy would maximize the firefighting potential of those individuals who wish to stay.

Furthermore, with the development of these new regions, certain neighborhoods cannot practically be defended by fire departments, leaving the residents to fend for themselves during an unplanned forest fire (McCaffrey & Winter, 2011). More regions around the U.S. are implementing alternative policies to *Mandatory Evacuation* in order to protect residents and reduce damage to property (McCaffrey & Winter, 2011). If people are not going to leave their property during a wildfire they have two options: 1. shelter in place or 2. stay and defend (McCaffrey & Winter, 2011).

Various communities throughout the United States have implemented a *Shelter in Place* policy if a mandatory evacuation is deemed impossible or dangerous by the local fire authorities (McCaffrey & Winter, 2011). *Shelter in Place*, which is explicitly denounced in the Australian policy is considered a backup if residents cannot safely leave (McCaffrey & Winter, 2011). Rancho Santa Fe, a neighborhood in Southern California just outside of San Diego has implemented a *Shelter in Place* policy as a backup measure if evacuation is not possible (Mutch et al., 2011). Similar to Australia’s policies, residents are required to prepare their homes by retrofitting them with fire resistant materials and defensible space (Mutch et al., 2011). Unlike

Australia's policies, however, residents are told to shelter in place and not actively defend (Mutch et al., 2011).

This policy developed when Fire Marshall Erwin Willis noted, "it made no sense that so many residents were losing their lives fleeing structures that we were teaching our firefighters to seek shelter if trapped by a firestorm." The policy was tested in 2007 when the Witch Creek Fire moved through the area (Mutch et al., 2011). The structures were so well prepared that no structures or lives were lost while adjacent neighborhoods with more relaxed standards suffered significant losses but even those houses stayed standing long enough for the fire front to pass and residents to safely escape outside (Mutch et al., 2011).

The other approach used in various parts of the United States is a strict imitation of the Australian *Stay and Defend or Leave Early* policy (Mutch et al., 2011). Montana state law does not give emergency officials the authority to force residents to evacuate, even during an emergency situation (Mutch et al., 2011). In 2000, forest fires threatened the West Fork and Bitterroot River regions of Montana (Mutch et al., 2011). Residents, including Robert Mutch, a prominent fire researcher and consultant with decades of experience, took measures to protect their properties including clearing vegetation, installing sprinklers, and fighting the fire when it arrived (Mutch et al., 2011). No homes or lives were lost and the Painted Rocks Fire District was born formalizing the Australian policy in the United States for the first time (Mutch et al., 2011).

Residents regularly go through trainings and are issued identification cards, which allow them to pass through roadblocks to return home to defend their

property (Mutch et al., 2011). This is another example of a region implementing an alternative policy to the standard *Mandatory Evacuation* approach. Since these policies have been implemented and successful, their model could be scaled to implement the policies state or even nation wide.

Even with strong evidence supporting the legitimacy of the *Prepare, Act, Survive* policy, many researchers are not optimistic that it would be beneficial in the United States. One such skeptic is Jack Cohen a fire researcher out of Forest Services Fire Science Laboratory (Schorow, 2011). Because most homes catch fire from embers, Cohen believes homes should be retrofitted to survive a fire and therefore there is no reason to stay since the home will likely survive without the presence of a resident defending the structure stating, “if you do everything right, there’s no reason to stay because your house should withstand the event” (Schorow, 2011). Others such as Randy Bradley, a Fire Chief in California, agree with Cohen, and fears the Australian policy would confuse residents into thinking they are professional firefighters and therefore encourages them to take unnecessary risks (Schorow, 2011). Bob Roper, another Californian Fire Chief agrees as well stating that no fires are alike and he does not believe the public is capable of acting in an educated manner to safely defend their homes (Schorow, 2011).

Still, other researchers propose different policies that are completely original and untested. Phillip Queen, a firefighter and author suggests late evacuations can still save lives if properly implemented believing residents, with the assistance of firefighters can safely shelter in a home and escape the danger after the fire front has passed (Queen, 1995). Queen cites a personal experience as evidence to support

his claim, “in one case, firefighters herded residents into a house and poured water on it until the fire passed. Six people were saved in this manner... we, as firefighters, are so conditioned to attack fires and rescue people aggressively that we forget to change those behaviors even when the situation becomes hopeless” (Queen, 1995). The hopeless situation he is referring to is both putting out burning homes and evacuating people. At some point, Queen believes firefighters must readjust and protect residents where they are and focus on protecting them rather than evacuating them.

Others such as Doug Decker suggest residents prepare, specifically by creating defensible space and then leave when the mandatory evacuation order is given. Decker references personal experiences as well, telling the story of a man whom he argued with for 30 minutes in the middle of a fire trying to get him to evacuate (Decker, 1995). The man had created defensible space and because of that preparation firefighters stopped at his home and fought the fire from his yard, saving his home in the process (Decker, 1995).

One concern of fire officials is the liability of allowing residents to stay during a inherently risky situation, “I think one of the biggest issues is liability... our court systems are a little more open to potential lawsuits” states Dr. Scott Stephens (Stephens, 2014). When something goes wrong, people in the U.S. look for someone to blame, “Well you’ve got a culture that likes to sue each other very often so I think if a family died and they were encouraged to stay and defend, then the government or whoever’s going to get sued so I think that would be a massive issue” (Haynes, 2013). Dr. Sarah McCaffrey, however offers an alternative view, “I’ve heard the

liability argument all the time but what about the inverse? You are not held liable when you tell people to evacuate and they die evacuating” (McCaffrey, 2014).

Therefore, it seems that allowing residents to make decisions for themselves and participate in a statistically less dangerous activity would not increase the liability for fire crews in the U.S.

While the *Mandatory Evacuation* policy is still the primary policy throughout the United States, worsening fire conditions are forcing firefighters and land managers to reconsider the approach. While the two policies suggested by Queen and Decker have anecdotal evidence to support them, the *Prepare, Act, Survive* policy has years of sound scientific research to support it. Furthermore, the policy has already been implemented on a small scale in Montana without difficulty. The successful implementation of the *Prepare, Act, Survive* policy is contingent on a few factors including: education of the community, preparation (mental, physical, and structural), and an effective warning system (Stephens et al., 2009). While the physical characteristics necessary for the successful implementation of *Prepare, Act, Survive* are well known, more research must be conducted on what social programs must complement the physical preparedness (Paveglio et al., 2007). The implementation of the Australian *Prepare, Act, Survive* policy is not only possible in the United States but also probable if fire conditions continue to worsen and more lives and property are lost to fires. As stated by Fire Marshall Brett Lacey, “In the United States the public are the creators of public policy so if they as a populace want that {*Prepare, Act, Survive*} as a law or prescribe then they have the ability to pass or enact that” (Lacey & Cooper, 2014).

Waldo Canyon Fire and *Prepare, Act, Survive*

To fully understand the effects of the *Prepare, Act, Survive* policy within the United States, it is important to understand how it might have altered the outcomes of specific past fires. At this point, I would like to emphasize that this section is purely an educated estimate and the data cannot be confirmed; it is impossible to retrospectively say what would have happened if things had been different. I, however, will use the best data currently available to me to assess how many homes likely would have been destroyed in the Waldo Canyon Fire if the *Prepare, Act, Survive* policy had been in place. While at times I will make underlying assumptions, I will explain the assumptions I have made and why I chose to do so. I believe this is the most effective way to retrospectively look at the Waldo Canyon Fire through a different lens to help protect lives and property in the future.

Colorado Springs is a large metropolitan area located approximately 70 miles directly south of Denver, Colorado. Within the city limits there are around 650,000 residents covering about 200 square miles of land (Quarles et al., 2013). Almost a quarter of Colorado Springs residents live within the 28,000 acres of wildland urban interface (Quarles et al., 2013). The wildland urban interface is primarily forested foothills with slopes up to 45°, 17 inches of precipitation annually and temperatures up to 100°F in the summer months (Quarles et al., 2013). Throughout Colorado, a disproportionate number of people live within the wildland urban interface. Estimates claim as many as 40% of Colorado residents live in the wildland urban interface even though it only covers 4% of the state's area (Udall & Bennet, 2012). Colorado Springs is in an ecological region with natural fire regimes burning

regularly. Now that we understand the setting of the fire, we can look to the response to the Waldo Canyon Fire.

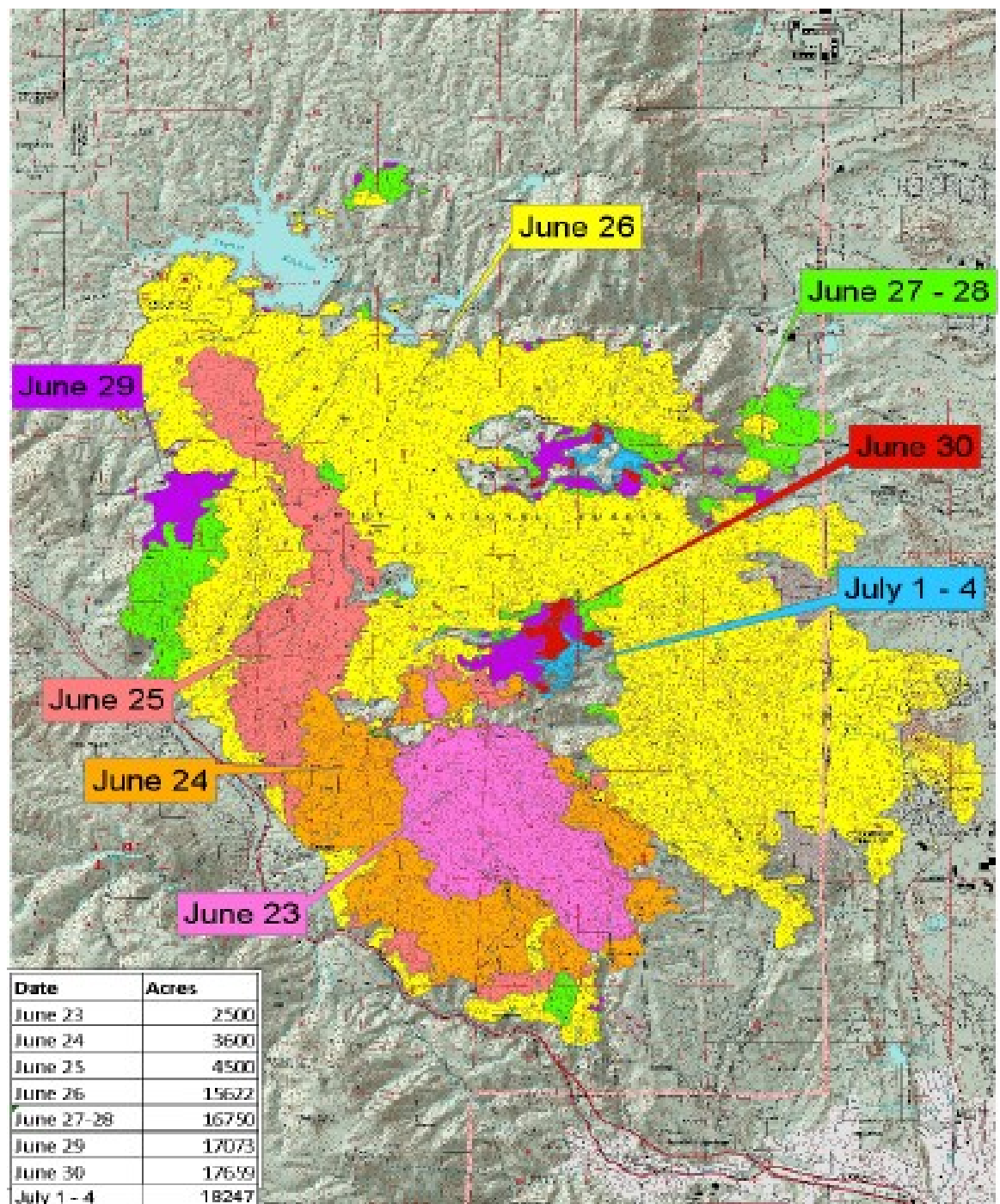
First, we must understand the Waldo Canyon Fire and the official response to move forward with predictions of how structure loss could have been different if residents had been allowed to stay and defend their property. On June 14th 2012, the U.S. Forest Service issued fire and smoking restrictions on land adjacent to Colorado Springs (Waters, 2013). The same day, Governor Hickenlooper of Colorado issued an executive order banning open burning throughout the state (Waters, 2013). At this point in time, Colorado had already experienced one of the worst fire seasons in the states history; 344 other wildfires had already sparked in the state (Waters, 2013). As stated by Senator Mark Udall, “This was a historic year for Colorado; twice within three weeks we broke the previous record for the most destructive wildfire in state history.”

The next two pages are maps showing respectively the progression of the Waldo Canyon Fire (Figure 15) and a map outlining different evacuation zones (Figure 16). Throughout the rest of this paper these maps will be referenced and should be utilized to visualize both how the fire moved and how officials evacuated areas that were threatened by the fire.

At around noon on June 22nd 2012 the Manitou Springs Fire Department (MSFD) and the Colorado Springs Fire Department (CSFD) received the first calls reporting smoke from a fire in the Waldo Canyon area. Over the next 18 days, the fire burned 18,247 acres, destroyed 347 homes and tragically killed two people (Waters, 2013). The total cost to the city of Colorado Springs was \$1,432,126 for

Figure 15.

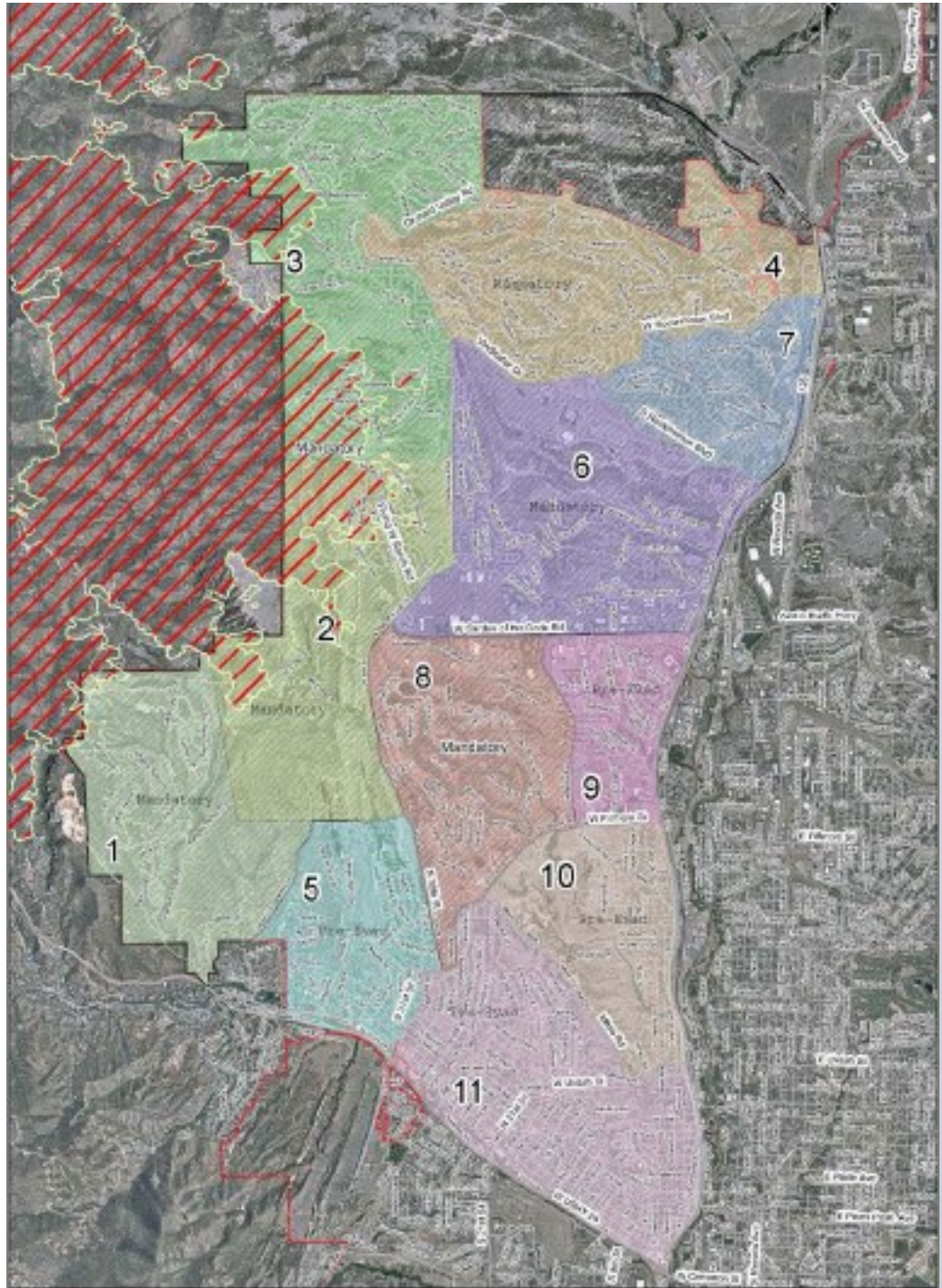
Evacuation Zones for the Waldo Canyon Fire



(Waters, 2012)

Figure 16.

Waldo Canyon Fire Progression Map



(Waters, 2012)

public assistance and an additional \$1,280,384 for suppression activities not including the cost of any structures lost (Waters, 2013). By June 23rd, fire crews verified a quick burning fire within the Pike National Forest (Waters, 2013). By 2:00 pm that same day, an evacuation order was issued for Zone 1 which is the Cedar Heights neighborhood because “a quick-moving crown fire could be seen moving south and west of Cedar Heights” as stated by CSFD (Waters, 2013; pg 12). Battalion Chief Randy Royal later stated, “My first thought was, ‘Oh no. This is bad’”.

By 2:22 pm, the Colorado Springs Police Department (CSPD) had dispatched 15 officers to go door to door to assist residents with evacuation while other officers used vehicle mounted PA systems to inform residents of the evacuation (Waters, 2013). While few residents resisted officers, the after action report states that some residents did in fact refuse to leave and were allowed to stay even though it could result in a misdemeanor charge under Colorado State Law; no arrests were made (Waters, 2013). CSPD officers visited over 200 homes and contacted 400 residents whom were safely evacuated (Waters, 2013). At approximately 3:00 pm, voluntary evacuation orders were issued for the Mountain Shadows neighborhood (Waters, 2013). Only 17 minutes later, the Waldo Canyon Fire crossed Rampart Range Road, breaching Zone 2, and upgrading the voluntary evacuation to mandatory (Waters, 2013). In a similar fashion to the first evacuation, another 15 uniformed CSPD officers were dispatched to evacuate 840 homes and 1,875 residents over the next eight hours (Waters, 2013). The first day of the fire resulted in the evacuation of 2,281 residents from Zone 1 and 2 (Waters, 2013).

Approximately 2,500 acres had burned during the first day of the fire (Waters, 2013).

On June 24th, the wind direction shifted pushing the fire southwest threatening the cities of Woodland Park and Ute Pass (Waters, 2013). The fire continued to threaten the Cedar Heights Neighborhood and at this point CSFD designated units to provide structure protection within the neighborhood according to the after action report (Waters, 2013). Once again, 12 officers moved through the neighborhood to contact and encourage residents to evacuate; refusals were noted and called into dispatch but no arrests were made (Waters, 2013). The fire grew to 3,600 acres on this day (Waters, 2013).

High temperatures and erratic winds on June 25th caused the fire to rapidly grow and continue to shift directions. The Waldo Canyon Fire grew on the north front but did not threaten any new structures but grew to 4,500 acres (Waters, 2013). CSPD once again moved through the Mountain Shadows Neighborhood to contact residents and encourage them to evacuate (Waters, 2013). On June 26th the fire continued to grow to the north threatening the Northern Mountain Shadows and Peregrine Neighborhoods (Waters, 2013). By 8:00 am the fire was 5% contained and the city decided to allow evacuated residents from Cedar Heights and Southern Mountain Shadows to return home with an escort to retrieve emergency items (Waters, 2013). By 10:00 a.m., however, the plans to reenter Cedar Heights were scrapped completely and only 45 minutes after the first residents were allowed back into Mountain Shadows they were evacuated again because of fire behavior (Waters, 2013). "They are just incensed, a lot of the people who live there,

so we allowed sequential reentry for 30 minutes at a time and then... fire behavior picked up... things started to get dicey up top...so we cancelled that” stated Fire Marshall Brett Lacey (Lacey & Cooper, 2014).

At approximately 12:30 p.m., voluntary evacuation orders were issued for Zone 3, which includes Northern Mountain Shadows and Peregrine (Waters, 2013).

At 3:00 p.m., a pyro-cumulous cloud developed above the fire, which quickly collapsed pushing the fire east towards the United States Air Force Academy with 65 mph winds recorded (Waters, 2013). As stated by Fire Marshall Brett Lacey:

“With Waldo Canyon we had predicted we would have about four hours with the way the fire had been behaving when that cloud collapsed and everything went out the window... the wind just pushed that whole front... the wind obviously picked up. The heat from the fire was pre-heating the vegetation in front of it... so then when it hit the Front Range it boiled down at 60 to 65 miles per hour... blowing like a freight train” (Lacey & Cooper, 2014).

By 4:08 p.m., the fire had breached the ridge above Zone 3 prompting the mandatory evacuation order to be issued (Waters, 2013). At this point, many residents expressed the need to enter evacuation zones to retrieve children or pets; CSPD complied with these needs and allowed individuals to enter and were ordered to leave as soon as those tasks were completed (Waters, 2013). It is also noted that at this time CSFD personnel were active in mitigating risk in the Mountain Shadows neighborhoods by removing brush close to structures and dismantling wooden decks that potentially could ignite homes (Waters, 2013).

At 5:23 p.m., firefighters were ordered to leave the Mountain Shadows Neighborhood because of hazardous conditions but had returned to fight structure fires by 6:00 p.m. since the fire front had passed (Waters, 2013). Furthermore, only 20 minutes later, mandatory evacuations were ordered for Zone 4, North

Rockrimmon, and soon after Zone 7, 6, and 8 which respectively were the Southeast Rockrimmon, South Pope's valley combined with Woodman Valley, Pinon Valley, and Pine Cliffs and finally Kissing Camels (Waters, 2013). These evacuations displaced more than 20,000 Colorado Springs residents (Waters, 2013). Late in the evening, at approximately 10:00 p.m., CSPD entered effected areas and determined two residents had been killed by the blaze (Waters, 2013). On June 26th, the Waldo Canyon Fire grew to 15,622 acres, 1,516 of which were located within the city limits of Colorado Springs and the total number of evacuees grew to 26,500 residents (Waters, 2013).

From June 26th to 27th firefighters continued to battle structure fires while simultaneously attempting to control the fire's spread. Initial reports found that almost 700 structures had been affected the previous day (Waters, 2013). CSFD ordered 15 fire engines to the Peregrine neighborhood to protect structures while other crews continued to extinguish spot fires in Mountain Shadows (Waters, 2013). Pre-evacuation orders were given for Zone 5, Pleasant Valley, and Zone 9, Holland Park (Waters, 2013). CSFD, at this point, began surveying the damage in Mountain Shadows. Simultaneously, a similar storm to the previous day pushed the fire into Peregrine. Fire crews were forced to evacuate but quickly returned and extinguished spot fires and embers after the fire front had passed preventing any further structure loss (Waters, 2013).

On June 28th CSFD continued to deploy personnel to both Mountain Shadows and Peregrine to defend homes against ember attack (Waters, 2013). Initial reports were released to the public stating that 346 homes had been destroyed two days

earlier all of which were in the Mountain Shadows Neighborhood (Waters, 2013). By 8:00 p.m., the City of Colorado Springs began to lift mandatory evacuation orders and by the 29th the order for Cedar Heights allowed those residents to return six days after they had left (Waters, 2013). Over the next few days the fire continued to grow but at a slow rate; since the 26th there had been little growth and evacuations orders were steadily lifted (Waters, 2013). On the 30th, residents were allowed back into damaged areas for the first time after being briefed on hazardous conditions and residents were encouraged to wear protective clothing (Waters, 2013). By July 5th, the Waldo Canyon Fire was 95% contained and by July 8th, all evacuation orders had been lifted (Waters, 2013). On July 10th, 2012 the fire was determined to be 100% contained marking the end to the worst fire in Colorado history (Waters, 2013). The Waldo Canyon fire affected over 50,000 residents through mandatory, voluntary, or pre-evacuations and over 25,000 buildings were in areas that were zoned for evacuation (Waters, 2013). For ease of reference, the evacuations are listed in Figure 17 with pertinent information about them.

Some residents, however, ignored mandatory evacuation orders from the beginning. When asked about if residents stayed to defend their property, Fire Marshall Brett Lacey mentioned, "I only know of one guy... he stayed behind for the purposes of defending his house and in fact his house survived... but all others adjacent to him were lost" Deputy Fire Marshall Kris Cooper added, "when firefighter went to evacuate he said 'no I'm not leaving...I'm going to stay and defend my house or I'm going down with it' He was one of the fortunate ones whose house didn't burn" (Lacey & Cooper, 2014).

Figure 17.

Evacuations During the Waldo Canyon Fire

Evac Zone	Neighborhood(s)	Evac Date	Return Date	Residents Affected	Buildings Affected	Notes
1	Cedar Heights	6/23	6/29	406	213	
2	Southern Mountain Shadows	6/23	Multiple	1,875	840	Streets in Mountain Shadows were released street by street, day by day, until 8 July.
3	Northern Mountain Shadows/Peregrine/Oak Valley	6/26	Multiple	7,090	2,565	Peregrine: 7/1 Oak Valley: 7/1 N. Mountain Shadows: See above.
4	Northern Rockrimmon	6/26	6/29	8,250	2,987	
5	Pleasant Valley	N/A	N/A	2,865	2,178	Pre-Evacuation Only
6	Woodmen Valley/Pinon Valley/Pine Cliff	6/26	Multiple	5,114	1,955	Pine Cliff: 6/28 Woodmen Valley: 6/29 Pinon Valley: 7/1
7	Southeast Rockrimmon	6/26	6/28	3,820	1,434	
8	Kissing Camels	6/26	6/28	2,215	1,314	
9	Holland Park	N/A	N/A	3,995	1,601	Pre-Evacuation Only
10	Old Colorado City	N/A	N/A	3,156	1,686	Pre-Evacuation Only
11	Mesa/Indian Heights	N/A	N/A	13,270	9,558	Pre-Evacuation Only
Total				52,056	26,331	

(Waters, 2012)

Fortunately for everyone involved, the Colorado Springs Fire Department, with the help of other local, state, and federal agencies skillfully reduced losses of both lives and property through their valiant efforts by successfully evacuating over 26,000 residents safely and saving 82% of homes in effected areas (Waters, 2013). Overall around 30,000 residents evacuated their homes, 18,247 acres of land were burned and two residents were killed over 18 days (Quarles et al., 2013). Without the expertise and preparation of CSFD, CSPD, and the other agencies involved, the Waldo Canyon Fire would have caused even more damage and threatened even more lives. This, however, does not mean that the utilization of prepared residents could not have reduced losses even further.

To begin, it is necessary to ensure that the conditions during the Waldo Canyon Fire were not of catastrophic danger since that is an automatic disqualifier

to stay and defend according to AFAC Position 5.0 and the New South Wales Rural Fire Service. Therefore I will first calculate the fire severity on the McArthur Forest Fire Index. As previously explained, the McArthur Forest Fire Index is “based on the temperature (°C), T, wind speed (kmh), v, relative humidity (%), RH, and a component representing fuel availability called the drought factor, DF” (Dowdy et al., 2009). This is represented in the equation below:

$$\text{FFDI} = 2e^{(-0.45 + 0.987 \ln(\text{DF}) - 0.0345 \text{RH} + 0.0338 \text{T} + 0.0234 \text{v})}$$

DF=Drought Factor
RH=Relative Humidity
T=Temperature (°C)
V=Wind Speed (kmh)

Therefore, with all the variable readily available from websites like www.wunderground.com it is possible to calculate the fire danger rating for the day which is shown in the Table 1. It is important to mention that for each date, the top line labeled “Max” was calculated using each individual rating at the worst point during the day. Therefore, it is rare for every factor to present itself in its worst condition at the same time. Therefore, the “Max” line over represents the fire danger of the day. Similarly, the “Avg” line was calculated using the average of each variable for the day. Therefore, during the day when fire conditions were worse because of higher temperatures and generally lower humidity causing the “Avg” fire index rating under represent what the level actually may have been that day.

Table 1.

McCarthy Forest Fire Index During the Waldo Canyon Fire

Date	T (°F)	T(°C)	V (MPH)	V (KPH)	RH (%)	DF	FFID
6/23 Max	100	38	28	45	6	10	104
6/23 Avg	82	28	8	13	16	10	25
6/24 Max	100	38	29	47	7	10	105
6/24 Avg	84	29	9	14	17	10	25
6/25 Max	98	37	28	45	3	10	112
6/25 Avg	83	28	11	18	19	10	25
6/26 Max	101	38	28	45	15	10	76
6/26 Avg	82	28	9	13	24	10	19
6/27 Max	95	35	37	59	14	10	99
6/27 Avg	81	28	10	17	26	10	19
6/28 Max	93	34	26	42	15	10	62
6/28 Avg	78	26	8	13	30	10	14
6/29 Max	95	35	35	56	11	10	102
6/29 Avg	77	25	9	14	31	10	14
6/30 Max	97	36	35	56	9	10	114
6/30 Avg	80	27	7	11	26	10	16

Luckily, CSFD supplied the date and time that different evacuation orders were issued and therefore it is possible to calculate what level on the Forest Fire Index was present at the time the evacuations were ordered. Because the

properties destroyed and damaged were located in the Mountain Shadows neighborhood, I will focus on the time when this neighborhood was evacuated. As stated before, a voluntary evacuation order was given for Southern Mountain Shadows on June 23rd at 3:00 p.m. and was upgraded to mandatory only a few short minutes later (Waters, 2013). Northern Mountain Shadows was evacuated on June 26th with the voluntary order issued at 12:30 p.m. and the mandatory evacuation at 4:08 p.m. (Waters, 2013).

Table 2.

McCarthy Forest Fire Index at Time of Evacuations During the Waldo Canyon Fire

Date/Time	T (°F)	T(°C)	V (MPH)	V (KPH)	RH (%)	DF	FFID
6/23 3:00 pm	98	37	23	37	7	10	81
6/26 12:30pm	98	37	22	35	7	10	77
6/26 4:00pm	98	37	15	24	6	10	65

Therefore, even though some “Max” values would have disqualified residents from staying and defending their properties (although not on 6/26, 6/27, or 6/28) when each mandatory evacuation order was given, as shown in Table 2, the fire danger was well below what it must be to disqualify residents from staying and defending under the AFAC and government policies and suggestions. This means that it would have been plausible for residents to stay and defend their property, which could have prevented some damage that was caused by the Waldo Canyon Fire.

It is well known and accepted that Colorado Springs, and especially the wildland urban interface, is in an ecological zone where forest fires regularly burn. Because of this ever-present risk, the CSFD and many residents have attempted to prepare for a catastrophic event such as the Waldo Canyon Fire. Since the first aspect of the Australian *Prepare, Act, Survive* policy is prepare, it is a logical place to start when applying the Australian policy to the Waldo Canyon Fire.

Colorado Springs has participated in the USDA Forest Service's Fire Adapted Communities Program and to comply with their goals, the city has devoted \$300,000 annually to wildfire mitigation as well as employing two full-time fire mitigators. These fire mitigators work with eighty-six Homeowners Associations in the region to reduce their wildfire risk through altering the landscape without simply clear cutting (Waters, 2013). Fuel management in the Colorado Springs region is expected to have a \$12-\$24 return for every \$1 invested (Quarles et al., 2013). In the Cedar Heights neighborhood it was later determined that the cost benefit ratio was 1/517 meaning for a \$300,000 investment over \$77,000,000 in losses were prevented (Quarles et al., 2013). Because of these returns, Colorado Springs mitigates approximately 1000 acres annually at a cost of \$800-\$2500 per acres to, "moderate the behavior of wildfires and allow firefighters to extinguish fires before they damage structures" (Quarles et al., 2013; pg 7). By controlling the landscape, firefighters can control the fire and have a chance to defend structures in a similar way that Australians encourage residents to prepare their homes for defense.

Colorado Springs developed an appendix to their Emergency Operations Plan in 2008 specifically focused on the wildland urban interface (Waters, 2013). This

plan was updated in June of 2012 only days before the Waldo Canyon Fire providing an excellently coordinated response to the event (Waters, 2013). Because of this preparation, many of the evacuation zones and plans were in place prior to the fire's ignition meaning the event triggered standing operating procedures to be initiated rather than forcing emergency response officials to struggle to develop plans for the safe evacuation of residents. Furthermore, the city of Colorado Springs conducts trainings for residents four times a year to help residents understand both how they can prepare for events like forest fires and what residents can do to safely evacuate if or when the time comes to do so (Waters, 2013).

These mitigation practices proved to be effective during the Waldo Canyon Fire. The Cedar Heights neighborhood is adjacent to Solitude Park, a 300 acre park that received mitigation treatment in 2010 (Quarles et al., 2013). On June 24th, the Waldo Canyon Fire burnt through the park but the mitigation allowed firefighters to work from a safe zone and construct a dozer line between the park and neighborhood (Quarles et al., 2013). Furthermore, firefighters commented that discontinuous fuels allowed easier access to spot fires, which could easily be extinguished (Quarles et al., 2013). The result of this mitigation was "ultimately no homes were lost in the Cedar Heights neighborhood which is adjacent to the treatment area, partially due to the fuels treatment, firefighters anchored in a safe zone that put out spot fires" (Quarles et al., 2013; pg 8). Even American authorities comment on the "safe zone" which can be created by fuel mitigation. It seems that if these zones can be created for firefighters, it would be plausible for residents to behave in the same way; retreat to the safe zone while the fire front passes and

continue to fight spot fires both before and after the fire has passed as the Australian policy calls for. Similar to Australian practices, Colorado Springs officials call for residents to take responsibility for their safety instead of relying on state operated mitigation practices and firefighting resources.

As part of the “Sharing the Responsibility” campaign, Colorado Springs officials are encouraging residents to actively participate in mitigation activities (Quarles et al., 2013). One such tool provided by CSFD is the interactive Firewise website which allows residents to view the personalized hazard rating of their property as well as their neighbors’ property (Quarles et al., 2013). This map is essentially designed to show residents how prepared they, and their neighbors are, for a forest fire.

While the specific factors that go into a property’s hazard rating are withheld from the public, many of those factors are similar to what the Australians encourage residents to do to prepare their property, “The office of the Fire Marshall provides free Hazard Risk Assessments for developments planned in the WUI. The review includes vegetation and landscape as well as building components” (Quarles et al., 2013; 6). Colorado Springs has also increased city codes for new developments in the wildland urban interface for example disallowing cedar or other flammable roofing materials and requiring defensible space of at least 10 feet directly around the structure with 30 feet of mitigated vegetation (Quarles et al., 2013). These updated codes have been linked to reducing loss from fires such as Waldo Canyon:

“Replacement of 55,000 cedar shake roofs over the last six years had a significant impact on ember starts as did the use of fire resistant materials, home design and placement, and landscaping. Mitigation measures, building siting and location, fuels reductions, and building materials all were

addressed. The Waldo Canyon Fire was responsible for igniting homes in close proximity to the blaze and igniting combustible building materials on or near other homes that ultimately resulted in the homes being damaged or destroyed.” (Quarles et al., 2013; 6).

In accordance with Australian policies and suggestions, structures must be prepared to withstand ember attack and flammable materials must be well away from homes to create defensible space. Essentially, Prepare still applies to residents in the wildland urban interface of the United States; even if residents do not plan to stay and defend their property, preparing a structure significantly increases its likelihood of survival. The Australians agree with this sentiment calling for everyone to prepare whether they plan to stay and defend or not.

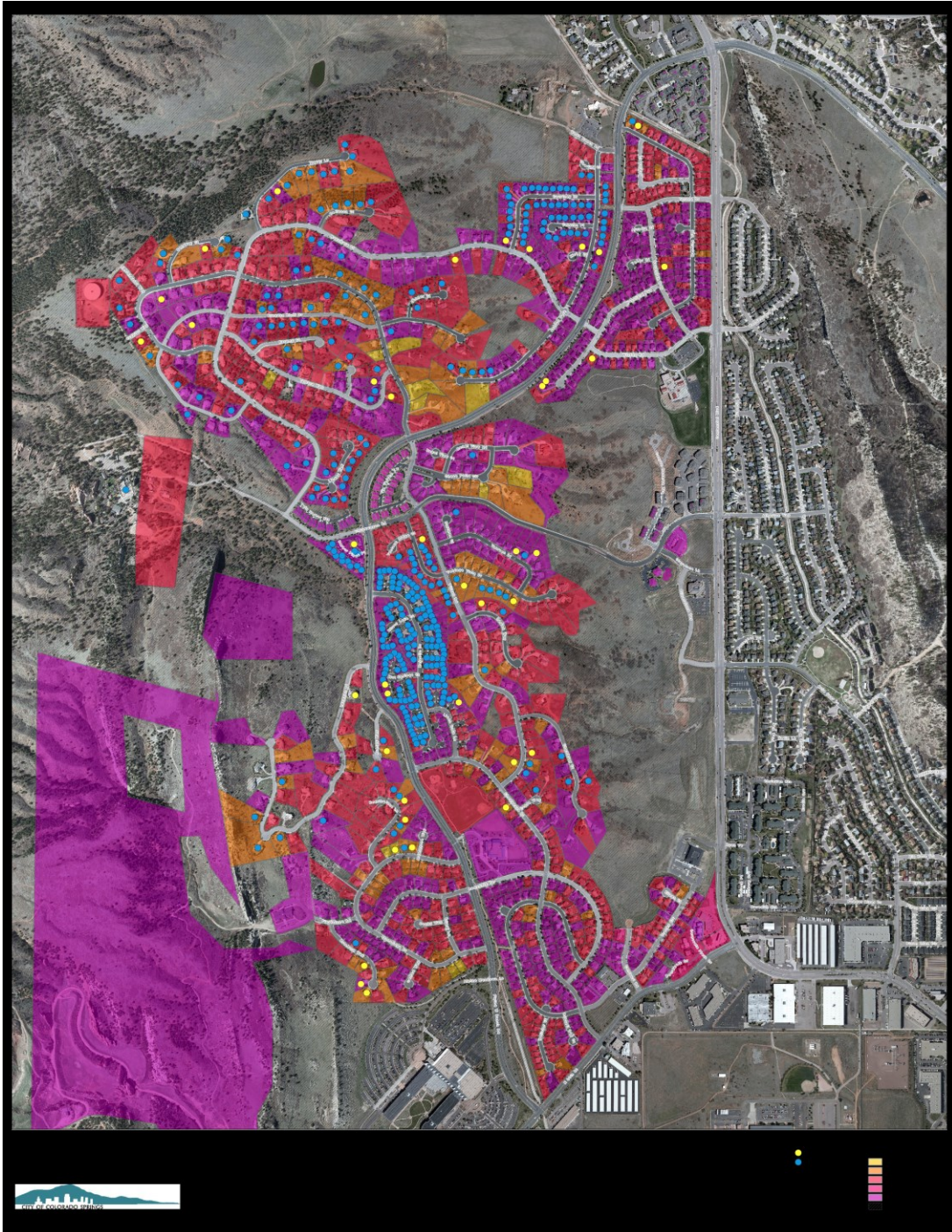
Colorado Springs’ residents and emergency personnel alike participated in varying other activities to prepare for a large uncontrollable fire such as the Waldo Canyon Fire. One such example of this preparation is shown by wildland urban interface evacuation drills conducted in the Mountain Shadows and Cedar Heights neighborhoods in 2009 and 2011 (Waters, 2013). It is important to note that these were the two neighborhoods most directly effected by the Waldo Canyon Fire and they had practiced evacuating within the last three years of the fire. These drills, conducted by CSFD and CSPD as well as Homeowners Associations, prepared residents to evacuate during an event like Waldo Canyon. This mock evacuation included testing systems to inform residents of evacuation, mock evacuations, and a debrief of residents to ensure safer and more efficient evacuations in the future; drills like these can be credited for the effectiveness and safe evacuation of thousands of residents in a short period of time (Waters, 2013).

Nonetheless, even with mitigation practices in place and prepared residents, not every home will survive a forest fire. Of the homes that ignited during the Waldo Canyon Fire, approximately 90% were completely destroyed and firefighter intervention is credited for saving the other 10% (Quarles et al., 2013). If residents had been allowed to stay and defend their property would this be different? Figure 18 shows the Mountain Shadows neighborhood and individual properties risk prior to the Waldo Canyon Fire. Yellow lots are those with extreme risk while pink shows low risk. Each dot represents a home that caught fire and they are color coded where blue represents a structure that was completely destroyed and yellow represents a home with visible damage.

This map not only shows which structures were at risk but also offers insight into how well the structures and landscape were prepared. As mentioned before CSFD does not release specific factors that influence a property's risk. The connection between risk and preparedness, however, offers insight into which properties were potentially defensible by residents who may have decided to stay and defend. For the purposes of this research, I will assume that only those who were at the levels of low or moderate risk qualify as prepared under the Australian policy. While the Australians do not have formal definitions of "Prepare", I believe that residents who were in the low or moderate categories have shown some level of preparedness and therefore would feel they could successfully defend their property. Nonetheless, "in Waldo over 80% of homes that burnt had combustible siding or roofs or both" said Deputy Fire Marshal Kris Cooper with the Colorado Springs Fire Department.

Figure 18.

Risk Map of Homes Damaged and Destroyed During the Waldo Canyon Fire



(Smith, 2014)

Therefore, even many residents with moderate or low risk still used flammable materials in the construction of their homes.

Of the structures that were lost in the Waldo Canyon Fire, 0 were listed as extreme risk, 39 were very high risk, 112 were high risk, 191 were moderate risk and not a single loss occurred for a home that was low risk (Smith, 2014). Similar proportions apply to homes that were damaged but not destroyed with 1 damaged home having extreme risk, 6 with very high risk, 20 at high risk, 18 moderate risk homes and only 1 low risk home damaged (Smith, 2014). The data are represented in the Table 3. *Prepare, Act, Survive* clearly encourages all residents to prepare but only encourages residents to stay and defend their property if they are well prepared. Using my definitions of prepared in regards to the risk hazard map, residents potentially could have stayed to defend 191 homes that were destroyed and 19 homes that were visibly damaged.

Table 3.

Structure Loss from Different Risk Categories during the Waldo Canyon Fire

	Extreme	Very High	High	Moderate	Low	Not Rated	Total
Total Loss	0	39	112	191	0	2	344
Visible Damage	1	6	20	18	1	0	46
N/A	8	60	302	332	6	1	709
Total	9	105	434	541	7	3	1099

Using the methodology explained above, I have concluded that it would have been plausible for residents to stay at 191 homes that were destroyed and 19 damaged homes. This gives us a base number of structures that potentially could be

saved. The next step is looking at how the homes caught fire. As expressed in prior sections, the Australian *Prepare, Act, Survive* partially developed out of observations of how homes ignite during a forest fire; homes primarily ignite from embers becoming lodged in flammable material near or on a home and therefore igniting the structure, which can completely burn to the ground. This reasoning not only prompted a policy with stay and defend as an option but also can be used to look at what homes could have been saved if a resident could put out these embers. While residents have successfully defended their properties against direct flame from the fire, adjacent vegetation, or neighboring structures, the approach was developed to defend mainly against embers and therefore those homes will be my focus.

The CSFD classifies how homes ignited by four different categories: fire front, exposure, vegetation, and fire brand. Fire front refers to homes igniting from the main body of the fire as it passes. Exposure represents homes that caught fire from adjacent structures. Vegetation clearly refers to homes that caught from nearby vegetation that was burning. Finally, fire brand is any home that ignited because of embers becoming lodged within flammable materials on the home or structure itself. Of the homes that were either damaged or destroyed 21 ignited from the fire front, 179 from exposure, 54 from vegetation, and 136 from fire brand or embers (Smith, 2014). Interestingly, and different than what most Australian evidence suggests, more homes caught fire because of exposure to other burning structures than from embers. This may be because of different building and development patterns within each country.

It is important, however, to acknowledge how the first structure caught fire causing others to ignite around it. One such example of house to house ignition is during the Waldo Canyon Fire, one home caught fire which subsequently spread to six other homes that were ultimately destroyed (Quarles et al., 2013).

Unfortunately, the data are currently not available for every home. If one home, however, caught fire from embers and ignited multiple adjacent homes, one resident defending that initial home could potentially have saved dozens of structures. Since there is little evidence to support this claim, however, for the purposes of this paper those homes will be discounted.

With 136 structures igniting from embers it is once again clear that allowing residents to stay and defend their property would likely result in lower property loss within the United States as it has proven to be effective in Australia. At least 136, and most likely significantly more homes, would have stood a chance of surviving if residents had been there to defend their property.

Possibly even more significant is how many homes caught fire from the fire front, 21. Only 21 homes damaged while the fire was passing, offers anecdotal evidence in support of a policy with the option to stay and defend. The vast majority of homes were not damaged while the fire was present in a form that was deadly to humans. Therefore, even if a structure was lost later, it would be possible for residents to safely shelter in the homes while the fire front passes and then fight embers, adjacent vegetation, or buildings that were burning. While this is anecdotal evidence at best, the relatively small number of homes that caught fire from the fire

front implies that residents could have safely stayed and defended their homes during the Waldo Canyon Fire.

Using the data listed above, *Prepare, Act, Survive* might potentially have saved 210 homes from destruction or damage based on preparedness and 136 structures from ignition due to embers. While these may overlap, the data are not available at this time to compare how those statistics interact. Either statistic, however, shows that a significant number of homes might have been saved if residents had been there to defend the structure instead of forced to leave by emergency personnel. When comparing this information to statistics from Australia, the realistic number of structures that might have been saved changes.

First of all, we already know that around 50% of Australians plan to stay and defend their property in the event of a large bush or forest fire (Whittaker, 2011). I chose to use the Australian statistic for this rather than the American statistic because if the *Prepare, Act, Survive* policy had been in place within the United States at the time of the Waldo Canyon Fire, people would likely have behaved differently. The shortcomings of this approach were discussed above as well as the differences between American and Australian's plans to stay and defend. While it is probable that those who plan to stay are shifted towards the prepared side, it is impossible to say with certainty that is true without further research. Therefore, of the 210 prepared properties and of the 136 ember ignition structures respectively 105 and 68 would likely have had residents present to defend their property.

Using statistics from the Black Saturday Fires of 2009, we can step even further into predicting alternative outcomes. The conditions during the Black

Saturday Fires were slightly worse than those experienced during the Waldo Canyon Fire. During Black Saturday, the temperature was 111°F with relative humidity below 10% and wind speeds of 62 mph reported (McLennan et al., 2013; Whittaker & Handmer, 2010). This is compared to Colorado Springs temperatures hovering around 100°F relative humidity varying from single digits to mid 30's and much lower wind speeds maxing out in the mid 30's as well. On the McArthur Forest Fire index, Waldo Canyon was generally in the extreme range while Black Saturday was well within to the catastrophic category. Therefore, using the data from Black Saturday should give us conservative estimates into likely property damage during the Waldo Canyon Fire without controlling for cultural and structural differences mentioned in pervious sections.

Two studies post- Black Saturday offered different but similar statistics on the numbers of homes that survived with and without residents defending them. A study by Dr. Joshua Whittaker found 54% of homes were destroyed if no resident was present while only 19% were destroyed when residents were defending the structure (Whittaker & Handmer, 2010). Similarly, another study found that 44% of structures were destroyed without a resident present and 20% were destroyed if a resident defended the property (McLennan et al., 2013).

Using these two statistics we can step forward with out predictions. Therefore, these statistics show between 35% and 45% more structures survive if residents are present to stay and defend the homes. Therefore, if only looking at the homes that were prepared and had either low or moderate risk, between 37 and 47 homes would have been saved if 50% of residents had chosen to stay. If we look

solely at homes that caught fire from ember ignitions, between 23 and 30 homes would have been saved once again if 50% of residents had chosen to stay and defend their property. Essentially, I predict that between 23 and 47 homes could have been saved if residents had been allowed to stay and defend their property during the Waldo Canyon Fire.

We must understand that events like this are not over; more fires will effect the wildland urban interface, “ The Oakland Hills Fire there were people burned in their cars because the congestion and that’s going to happen in parts of our community... Broadmoor Bluffs... there’s very poor road networks and narrow roads. You try to dump everyone out of that community at once and you’re going to get traffic jams. If that fire burns through, people have no where to go” (Lacey & Cooper, 2014). Colorado Springs must consider alternative policies such as *Prepare, Act, Survive* to ensure we are best protected against fires.

Conclusion

In conclusion, there is clearly a reason the Australians have developed policies to allow residents to share the responsibility and make an informed decision about whether they are capable of staying at their homes during a disaster to defend their property. While my calculations are far from exact, they offer an approximation of how damage might have changed if a different policy had been in place in Colorado Springs. To the extent of my knowledge, this is the first study of its kind, however, it could be reproduced with any fire. In the coming years, the United States will be forced to reexamine evacuation policies. In fact, many regions are already experimenting with alternatives to *Mandatory Evacuation*.

Whether a *Prepare, Act, Survive* type policy will be implemented in the United States is unknown, however the evidence presented shows that it plausibly could be implemented and potentially could significantly reduce the damage to structures during unplanned fires. One thing however is clear, to stay and defend the government must increase and continue to enforce building codes and the usage of defensible space. These factors, paired with residents defending their property have the potential to significantly alter the outcomes of forest fires without putting residents in danger. While the data are currently limited, unfortunately, more information is constantly presenting itself as fires continue to worsen around the world. While plausibly dozens of homes could have been saved during the Waldo Canyon Fire, the careful implementation of a policy that allows residents to stay and defend their property could significantly alter the way Americans

Acknowledgements

I would like to acknowledge the role that many people played in making this project possible. First of all, I would like to thank Distinguished Lecturer and Legal Scholar in Residence Phillip Kannan of Colorado College Environmental Science Program for advising me throughout this process. Dr. Eric Perramond was also influential in the development and success of this research. Thank you to the Colorado College Social Science Executive Committee for providing funding for this collaborative research project. I would also like to thank the researchers, professors, government officials, and firefighters who took the time to speak with me both in Australia and the United States. Each played a unique role in making this project possible and successful. Thank you Fire Marshall Brett Lacey, Dr. Christine Eriksen, Gary Morgan, Jill Edwards, John Gilbert, Dr. John Handmer, Dr. Josh Whittaker, Dr. Justin Leonard, Dr. Katharine Haynes, Deputy Fire Marshall Kris Cooper, Dr. Malcolm Gill, Mike Leonard, Dr. Raphael Blanchi, Dr. Ross Bradstock, Dr. Sarah McCaffrey, Dr. Scott Stephens, and Dr. Trent Penman. Each of these individuals took the time to either meet with me in person or speak with me over the phone to provide me with crucial information about Australian policies or the Waldo Canyon Fire. Finally, I would like to thank everyone who edited this work and offered alternative thoughts on my work.

Works Cited

- Australian Fire Authorities Council "Position paper on community safety and evacuation during bushfires." (2001)
- Barrow, G.J."A survey of houses affected in the Beaumaris Fire, January 14, 1944." *Journal of the Council for Scientific and Industrial Research* (1945).
- Beatson, Ruth, and Jim McLennan. "What Applied Social Psychology Theories Might Contribute to Community Bushfire Safety Research After Victoria's "Black Saturday"." *Australian Psychologist* 46 (2011): 171-82. Web.
- Blanchi, Raphael. Personal interview. 25 Oct. 2013.
- Blanchi, Raphael, Chris Lucas, Justin Leonard, and Klara Finkele. "Meteorological Conditions and Wildfire-related House Loss in Australia." *International Journal of Wildland Fire* 19 (2010): 914-26. Web.
- Bradstock, R. A., and B. J. Kenny. "An Application of Plant Functional Types to Fire Management in a Conservation Reserve InSoutheastern Australia." *International Association for Vegetation Science* 14.3 (2003): 345-54. Web.
- Bradstock, R. A. "A Biogeographic Model of Fire Regimes in Australia: Current and Future Implications." *Global Ecology and Biogeography* 19.2 (2010): 145-58. Print.
- Bradstock, R. A., M. Beward, and J. S. Cohn. "The Modeled Effects of Differing Fire Management Strategies on the Conifer *Callitris Verrucosa* within Semi-arid Mallee Vegetation in Australia." *Journal of Applied Ecology* 43.2 (2006): 281-92. Web.
- Bradstock, Ross, Trent Penman. Personal interview. 21 Oct. 2013.
- Brown, Timothy J., Beth L. Hall, and Anthony L. Westerling. "THE IMPACT OF TWENTY-FIRST CENTURY CLIMATE CHANGE ON WILDLAND FIRE DANGER IN THEWESTERN UNITED STATES: AN APPLICATIONS PERSPECTIVE." *Climatic Change* 62 (2004): 365-88. Web.
- "Bush Fire Survival Plan." *Royal Fire Service New South Wales* (2009): n. pag. Web.
- "Bushfires and Community Safety Version 5.0." Australasian Fire and Emergency Service Authorities Council, Nov. 2012. Web.
- Cohen, Jack. "The Wildland- Urban Interface Fire Problem a Consequence of the Fire Exclusion Paradigm." *Forest History Today* (2008): n. pag. Web.
- Cohn, P.J.; Carroll, M.S. 2006. Evacuation behavior during wildfires: Results of three case studies. *Western Journal of Applied Forestry*. 21(1): 39-48
- Conway, Geoff, and Rob Llewellyn. "Bushfires and Community Safety: This Version 5.0 of November 2012 Replaces Version 4.1 of September 2010." *Austrasian Fire and Emergency Service Authorities Council* (2012): n. pag. Web.

- COVA, T.J. 2005. Public safety in the urban-wildland interface: Should fire-prone communities have a maximum occupancy? *Nat. Hazards Rev.* 6(3):99 -108.
- Decker, Doug. "Last-Minute Evacuations Save Lives." *Wildfire* 4.2 (1995): 31. Web.
- Dowdy, Andrew J., Graham A. Mills, Klara Finkele, and William De Groot. "Australian Fire Weather as Represented by the McArthur Forest Fire Danger Index and the Canadian Forest Fire Weather Index." *CAWCR Technical Report* 10 (2009): 1-84. Web.
- Edwards, Jill. Personal interview. 8 Oct. 2013.
- Eriksen, Christine. Personal Interview. 21 Oct. 2013.
- Ewell, R. Lamont. "The Oakland-Berkeley Hills Fire of 1991." *The Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems* (1995): 6-10. Web.
- Gibbons, Philip, Linda Van Bommel, A. Malcolm Gill, Geoffrey J. Cary, Don A. Driscoll, Ross A. Bradstock, Emma Knight, Max A. Moritz, Scott L. Stephens, and David B. Lindenmayer. "Land Management Practices Associated with House Loss in Wildfires." Ed. Rohan H. Clarke. *PLoS ONE* 7.1 (2012): E29212. Print.
- Gilbert, John. Personal interview. 23 Oct. 2013.
- Gill, A. Malcolm, Scott L. Stephens, and Geoffrey J. Cary. "The Worldwide "wildfire" Problem." *Ecological Applications* 23.2 (2013): 438-54. Print.
- Guyette, R. P., R. M. Muzika, and D. C. Dey. "Dynamics of an Anthropogenic Fire Regime." *Ecosystems* 5.5 (2002): 472-86. Web.
- Handmer, John, and Amalie Tibbits. "Is Staying at Home the Safest Option during Bushfires? Historical Evidence for an Australian Approach." *Environmental Hazards* 6.2 (2005): 81-91. Print.
- Handmer, John, Saffron O'Neil, and Damien Killalea. "Review of Fatalities in the February 7, 2009, Bushfires." *Prepared for the Victorian Bushfires Royal Commission* (2010): 1-38. Web.
- Haynes, Katharine, Amalie Tibbits, Lucinda Coates, Gaminda Ganewatta, John Handmer, and John McAneney. "100 Years of Australian Civilian, Bushfire Fatalities: Exploring the Trends in Relation to the 'stay or Go Policy'" *Reports for Bushfire CRC* (2008): 1-32. Web.
- Haynes, Katharine. Personal interview. 8 Oct. 2013.
- Kannan, Phillip M. "Mitigating Global Climate Change: Designing A Dynamic Convention To Combat A Dynamic Risk." *William & Mary Environmental Law Review* 36.2 (2012): 491-527. Web.

- Lacey, Brett, and Kris Cooper. Personal interview. 13 Jan. 2014.
- "LEARN About Ready, Set, Go!" International Association of Fire Chiefs, The Firewise Communities Program, The Insurance Institute for Business & Home Safety, U.S. Department of the Interior, U.S. Fire Administration, and U.S. Forest Service, n.d. Web. <<http://www.wildlandfirersg.org/learn/index.cfm?navItemNumber=500>>.
- Leonard, J. "People and Property: A Researcher's Perspective." *Australia Burning: Fire Ecology, Policy and Management Issues* (2003): 103-12. Web.
- Leonard, Justin. Personal interview. 22 Oct. 2013.
- Mall A and Matzner F 2007 *Safe at Home: Making the Federal Fire Safety Budget Work for Communities* (New York: Natural Resources Defense Council)
<http://www.nrdc.org/land/forests/safe/safe.pdf>
- McCaffrey, Sarah, and Greg Winter. "UNDERSTANDING HOMEOWNER PREPARATION AND INTENDED ACTIONS WHEN THREATENED BY A WILDFIRE." *Proceedings of the Second Conference on the Human Dimensions of Wildland Fire* (2011): 88-95. Web.
- McCaffrey, Sarah M., and Alan Rhodes. "Public Response to Wildfire: Is the Australian "Stay and Defend or Leave Early" Approach an Option for Wildfire Management in the United States?" *Journal of Forestry* (2009): 9-15. Web.
- McCaffrey, Sarah. Telephone interview. 23 Jan. 2014.
- McLennan, J., and G. Elliot. "'Wait and See': The Elephant in the Community Bushfire Safety Room." *Proceedings of Bushfire CRC & AFAC 2012 Conference Research Forum* (2012): 56-69. Web.
- McLennan, J., G. Elliott, M. Omodei, and J. Whittaker. "Householders' Safety-related Decisions, Plans, Actions and Outcomes during the 7 February 2009 Victorian (Australia) Wildfires." *Fire Safety Journal* 61 (2013): 175-84. Print.
- Morgan, Gary, and Mike Leonard. Personal interview. 8 Oct. 2013.
- Mutch, Robert W., Michael J. Rogers, Scott L. Stephens, and A. Malcolm Gill. "Protecting Lives and Property in the Wildland-Urban Interface: Communities in Montana and Southern California Adopt Australian Paradigm." *Fire Technology* 47.2 (2011): 357-77. Print.
- MUTCH, R.W. 2007. *FACES: The story of the victims of Southern California's 2003 Fire siege*. Wildland Fire Lessons Learned Center. Available online at www.wildfirelessons.net/documents/FACES.pdf; last accessed Jan. 16, 2008.
- Paveglio, Travis, Matthew S. Carroll, and Pamela J. Jakes. "Alternatives to Evacuation—Protecting Public Safety during Wildland Fire." *Journal of Forestry* (2008): 65-70. Web.

- Pool, Bob, "Do-it-Yourself Fire Crew Saves Own Neighborhood." Online Posting. The Christian Science Monitor, 26 Nov. 2007. Web.
- "Protecting Your Home from Wildfire: Creating Wildfire-Defensible Zones." *Colorado State Forest Service* (2012): n. pag. Web.
- Price, Owen F., and Ross A. Bradstock. "The Efficacy of Fuel Treatment in Mitigating Property Loss during Wildfires: Insights from Analysis of the Severity of the Catastrophic Fires in 2009 in Victoria, Australia." *Journal of Environmental Management* 113 (2012): 146-57. Print.
- Quarles, Stephen, Pam Leschak, Chief Rich Cowger, Keith Worley, Remington Brown, and Candace Iskowit. "Lessons Learned from Waldo Canyon: Fire Adapted Communities Mitigation Assessment Team Findings." *FIRE ADAPTED COMMUNITIES COALITION* (2013): 1-48. Web.
- Queen, Phillip L. "Evacuation at a Wildland/Urban Interface Fire." *Wildfire* 4.2 (1995): 22-23. Web.
- Ramsay GC, McArthur NA, Dowling VP (1987) Preliminary results from an examination of house survival in the 16 February 1983 bushfires in Australia. *Fire and Materials* 11, 49-51.
- Sanabria, L. A., X. Qin, J. Li, R. P. Cechet, and C. Lucas. "Spatial Interpolation of McArthur's Forest Fire Danger Index across Australia: Observational Study." *Environmental Modeling & Software* 50 (2013): 37-50. Web.
- Schorow, Stephanie. "Stay or Go?" *NFPA Journal* (n.d.): n. pag. Web. Oct. 2011.
- Smith, Ralph. "Final Report on - "Investigation of the House Losses in the Roleystone / Kelmscott Bushfire 6 February 2011"" *Bushfire Environmental & Protection Branch* (2011): n. pag. Web.
- Smith, Steven. E-mail interview. 11 Mar. 2014.
- Smith, Steven. E-mail interview. 17 Mar. 2014.
- Stephens, Scott L., Mark A. Adams, John Handmer, Faith R. Kearns, Bob Leicester, Justin Leonard, and Max A. Moritz. "Urban-wildland Fires: How California and Other Regions of the US Can Learn from Australia." *Environmental Research Letters* 4.1 (2009): 014010. Print.
- Stephens, Scott. Personal interview. 6 Jan. 2014.
- "FIRE NOTE THE STAY AND DEFEND YOUR PROPERTY OR GO EARLY POLICY." *THE AFAC POSITION AND THE BUSHIFRE CRC'S CURRENT RESEARCH* (2006): n. pag. Web.
- Tibbits, A., and J. Whittaker. "Stay and Defend or Leave Early: Policy Problems and Experiences during the 2003 Victorian Bushfires." *Environmental Hazards* 7.4 (2007): 283-90. Print.

- Tuttle, A. E. "Wildland Fire Evacuation in the U.S.: The Color vs. the Letter of the Law." (2003): n. pag. Web.
- Udall, Mark, and Michael Bennet. Letter to The Honorable Tom Vilsack. 11 Oct. 2012. MS. United States, Colorado Springs, Colorado.
- Wardell-Johnson, Grant. "Prescribed Burning Is No Panacea for the New Extremes of Fire and Weather." *Social Alternatives* 28.1 (2009): 47-48. Web.
- Waters, Bret. "Waldo Canyon Fire 23 June 2012 to 10 July 2012 Final After Action Report." *City of Colorado Springs* (2013): n. pag. Web.
- Whittaker, Joshua, and John Handmer. "Community Bushfire Safety: A Review of Post-Black Saturday Research." *The Australian Journal of Emergency Management* 25.4 (2010): 7-13. Web.
- Whittaker, Joshua, Katharine Haynes, Jim McLennan, John Handmer, and Briony Towers. "Victorian 2009 Bushfire Research Response Household Mail Survey." *Bushfire CRC* (2010): n. pag. Web.
- Whittaker, Joshua, Katharine Haynes, John Handmer, and Jim McLennan. "Community Safety during the 2009 Australian 'Black Saturday' Bushfires: An Analysis of Household Preparedness and Response." *International Journal of Wildland Fire* 22.6 (2013): 841-49. Print.
- Whittaker, Joshua. Personal interview. 25 Oct. 2013.
- Wilson AAG, Ferguson IS Fight or flee? A case study of the Mount Macedon bushfire. *Australian Forestry* 47 (1984): 230-236