THESIS

BURN SCARS AND BURNT S'MORES: THE IMPACT OF WILDFIRE ON CAMPING DEMAND IN THE YEARS AFTER A FIRE OCCURS

Submitted by

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ABSTRACT

BURN SCARS AND BURNT S'MORES: THE IMPACT OF WILDFIRE ON CAMPING DEMAND IN THE YEARS AFTER A FIRE OCCURS

While the impacts of wildfire are widely felt and expected to increase in the coming years, less is known about the long-term impacts on recreation sites, specifically campgrounds. Wildfires inhibit the ability of individuals to recreate during wildfire season and subsequent years, due to unsafe conditions as the environment recovers. Changing wildfire suppression strategies may also affect households' ability and desire to recreate. At the same time, the number of individuals recreating is expected to increase in the coming years. As people continue to recreate and fires increase in intensity and frequency, we contribute to the discussion on wildfire's impact on recreation.

We evaluate the impact of wildfire on U.S. Forest Service campgrounds in the western United States over the 15 years after a fire occurs. We construct a dataset of camping reservations from 2008-2017 and the percentage of burned area within 10 kilometer of a campground from fires occurring 1984 onward. We find that wildfires significantly decrease reservations up to six years after the fire occurs. Further, we analyze the heterogeneity in the impact of wildfire at the regional level and as a function of the land cover near campgrounds. We observe heterogeneity in impacts across regions, supporting the need for different management strategies across space.

The loss in campground utilization from decreases in reservations have negative impacts at the aggregate and local levels. A typical campground experiencing wildfire has 8% of its buffered area burned. Over the 10 years of reservation data that we evaluate, fires impact an average of 60 campgrounds annually. Summing across the affected campgrounds and fires that occur in a typical year suggests the USFS can expect to lose $50,109 in the years after fires occur at treated campgrounds, not accounting for substitution to other campgrounds. Further, we can expect a typical campground treated by fire to lose 59 campers in the six years after fire. We can expect

the negative impact to increase as recreation and wildfire risk increase in the future. Depressed spending due to a reduction of campers can negatively impact communities that depend on the influx of visitors during the camping season. Reduced camping in these areas can potentially reduce employment, creating larger income gaps between urban and rural communities.

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Chapter 1

Introduction

Wildfires have detrimental impacts on recreational areas, directly impacting recreation demand. Though the immediate effects of fire are widely felt, longer-term impacts are often ignored in calculating total societal costs caused by wildfire. As many individuals choose to explore the outdoors through hiking, biking and camping, burned areas may experience reduced demand long after a fire takes place. Reduced activity may be an unintended cost of wildfire and should be considered in decisions related to fire management.

A fire occurring near a recreation site can have two immediate effects. Initially, the fire can lead to site closures until site managers deem the area safe to reopen (Garnache & Lupi, 2018). Fires also lead to increased quantities of particulate matter from smoke pollution which can cause respiratory issues (Kochi et al., 2010), reducing an individual's ability and preference to recreate. Wildfires can also alter the viewshed, the geographic area that is visible from a given location (Garnache & Lupi, 2018), and it may take multiple years for vegetation to reestablish itself post wildfire (Hilger & Englin, 2009). Increases in rain and snow reaching the ground from reduced precipitation interception increases soil moisture and runoff leading to greater risk for erosion and flash floods (Bladon et al., 2014). These longer-term impacts related to ecological recovery may reduce households' ability to recreate and reduce campsite reservation demand.

We evaluate the effect wildfires have on reservations in subsequent years post fire in the western United States. Specifically, we estimate the impact of fire on campground capacity utilization using campsite reservation made at campgrounds across the country through *recreation.gov*. We then investigate the mechanisms driving the effect on recreation including an exploration of fire size, fire frequency, cumulative burn effects, land cover, and reservation type (local vs. non-local). Our analysis uses a ten-year panel of campsite reservation data from 2008 to 2017 and data on wildfire perimeters from 1984 to 2017. We estimate impacts of wildfire on camping reservations at an aggregate level, encompassing Regions 1-6 of the United States Forest Service (USFS), and separately at the regional level. The analysis estimates the impacts on demand up to fifteen years after a fire occurs near a campground and tests the aforementioned mechanisms at the aggregate and regional levels.

To preview key results, we find that decreases in capacity utilization through six years after a wildfire occurs at the aggregate level. Heterogeneity of wildfire impact is also present across USFS regions and land cover classifications. For instance, we find longer negative impacts in Region 3 after a fire occurs than we do in Region 6. We also find that wildfire has positive impacts in Region 4. These results can inform how forest planners and wildfire managers interact with wildfire in the future, specifically by emphasizing the protection of campgrounds and immediate area around campgrounds. Restoration efforts after a fire could focus specific attention on areas where campgrounds are located. Our research contributes to the literature on wildfire impacting recreation by looking at the entirety of the western United States over multiple decades. The regional analysis can benefit forest managers who have different motivations for suppression efforts. Our analysis is also important to local communities who depend on recreation-based spending. The reduction in campers may have consequences for thesis communities in relation to reduced spending.

Chapter 2

Literature Review

As fires become more prevalent with each passing year, the literature has become more expansive on evaluations of how wildfire impacts recreation. This paper contributes to literature related to changes in recreation demand. Prior research has used case studies at specific recreation sites. This research takes a more comprehensive approach by looking at the campgrounds that fall within the western portion of the United States. This research also explores a large time span. By looking at the effect of fires on campsite reservations up to fifteen years after a fire occurs, we gain a broader understanding of the long-term impacts. The literature review begins by discussing literature that evaluates the general increases of both wildfire and the number of individuals recreating in recent years, then discusses research on the individual health and economic impacts of fire on recreation, and finally discusses research assessing variation in suppression treatments by USFS region to support a regional analysis.

2.1 Increases in Fire and Recreation

From late spring to early winter, fires spread through the western region of the United States, increasing the risk to firefighters and damage to structures. The immediate impacts related to property damage and smoke pollution are widely felt, with smoke pollution expanding across the country. In 2020 alone, smoke from fires in Oregon and California blew across the continent to New York City and Washington, DC (Hirschlag, 2020). The wildland-urban interface, the area of transition between wildland and human development, is also increasing, adding to the difficulty and risk in fire suppression management (Riley et al., 2018). Housing in these fire prone areas also experience fluctuations in pricing due to wildfire risk (McCoy & Walsh, 2018). As more homes are located in areas with greater wildfire risk, suppression activities have placed additional emphasis on reducing structure damage (Bayham & Yoder, 2020). A case study in Montana shows that fire suppression costs sometimes exceed the value of property at risk from fire (Calkin et al., 2005).

Though important, focusing suppression efforts on residential structures in the wildland-urban interface may reduce suppression activities near campgrounds. Our research suggests additional emphasis should be placed on suppression activities near campgrounds.

From 1985-2009, the USFS spent 80% of its fire suppression expenditures on the western U.S. (Gebert & Black, 2012). However, suppression strategies are ever-evolving. Suppression when necessary strategies are now more common, especially after a century of active wildfire suppression (Calkin et al., 2015). These strategies aim to interact with fire in ways that reduce risk to firefighters while also allowing the fire to help restore the land. Fire is an important element of the life cycle in forest ecosystems. The move to suppression when necessary strategies may increase fire occurrence in the short run. However, these strategies may mitigate future fires in terms of fuel breaks and limiting future fire spread (Riley et al., 2018). Because fires are increasing and suppression strategies are changing, wildfire impacts can be felt in ways unrelated to property damage and immediate health risks. Suppression expenditures in the western U.S. guide this paper's analysis of only looking at the western states, though the analysis could easily expand to the rest of the country as the climate continues to change. Evolving suppression strategies promoting the short run increase in fires may conflict with the reasons people choose to recreate, necessitating a greater understanding of the relationship between wildfire and recreation.

The number of individuals participating in recreational activities is also projected to increase in the coming years. Projections show that between 2002 and 2050, individual participation is expected to increase by 26 percent, totaling to almost 20 million visits to recreational areas by the middle of the century (Bowker et al., 2006). In 2016, outdoor recreation accounted for 2.2% of GDP (Highfill & Franks, 2019). Further, the Outdoor Industry Association reports consumers spend $887 billion annually in the outdoor recreation economy (Outdoor Industry Association, 2017). With the increase in recreation visits comes an increase in local spending to local communities. Wildfire may shift recreation demand and therefore local spending, though Englin et al. (2008) shows the influx of fire personnel into areas in the short run may negate the changes associated with decreased recreation demand. The influx of fire personnel during fire season may also impact campsite reservations in the year the fire takes place as fire fighters and managers may stay at campgrounds until a fire is contained. We focus our analysis on the years after a fire to better understand how recreationists change their behavior in response to previous fires and its potential effect on local economies.

2.2 Health Impacts of Fire on Recreation

Recreation has proven to benefit individuals physically, mentally, and socially. Through the activities that take place in national parks and forests, wildland settings are thought to positively contribute to human health (Thomsen et al., 2018). Multiple analyses find individuals derive benefits from recreation including improved physical health through nature-based recreation (Fenton et al., 2017; Lackey et al., 2019; Nordh et al., 2017). Mental health benefits are also created through recreation and have been associated with physical exercise in natural environments (Lackey et al., 2019; Mitchell, 2013). Brymer et al. (2020) discuss dominant themes related to enhanced well being from recreation that are associated with relaxation and restoration of mental functioning. Holland et al. (2018) systematically examined over 200 articles evaluating multiple outcomes associated with wildland recreation participation. Individuals who participated in recreation activities experienced positive pro-social behavior outcomes including relationship enrichment and increased sense of community (Holland et al., 2018). Other positive outcomes included improved quality of life, greater self-respect and self-motivation, and increased physical ability and well being (Holland et al., 2018).

While negative effects from smoke pollution are well documented during fire events (Kochi et al., 2010), our analysis emphasizes longer term affects of fire on recreation in the years after a fire occurs. Fire may reduce the overall health benefits of recreation to individuals in the years after fire occurs. Reduced social interaction and decreased mental health effects may be long term consequences if camping reservations are negatively affected by wildfire. Our research can contribute to the greater literature on the positive impacts of nature-based recreation on human well being. If individuals choose not to camp in response to fire, they are no longer able to receive the benefits of recreation. This loss, while difficult to calculate monetarily, could be included as an unintended consequence of fire.

2.3 Economic Impacts of Fire on Recreation

Many travel cost studies examine the cost of wildfire at specific recreation sites. A case study from New Mexico completes a travel cost study on fire effects, both wildfire and prescribed burning, as they relate to hiking and biking (Hesseln et al., 2003). The survey used in the study was previously used by (Loomis et al., 1999) looking at the same impacts of fire on hiking and biking in Colorado. By comparing results between the two surveys, Hesseln et al. (2003) finds there are different reactions to wildfire effects by both recreation activity and location, implying geographical regions value different elements of the natural environment as it relates to recreation activity. The analysis in this paper builds off this finding showing regional differences in reservation demand. Differences in demand could also relate to the vegetation in each location. Colorado has more forested land than New Mexico and will likely experience different fire characteristics in relation to intensity, size, and duration than the fires in New Mexico. The after-effects of fire will also depend on how the vegetation grows back. Understanding that different regions value natural capital differently can inform regional adjustments to management decisions based on differing recreation demand. Camping demand may also experience different responses to wildfire than both biking and hiking. The research outlined in this paper evaluates camping, a recreational activity not included in these travel cost studies.

Englin et al. (2008) also looked at wildfire and the economic value of wilderness recreation using wilderness permit data, socio-economic data, and wildfire data. Through interacting date of entry permit data and fire data, specifically the fire year, the authors looked at the time of visit compared to the year wildfires took place to see if visits related to certain time frames after the fires took place (Englin et al., 2008). Through this method, the authors find that fires occurring 4-9 years before the wilderness visit date increased demand for recreational site visits, proposing that this increase could be related to hikers curious about how the land adapts after the initial effects of the fire (Englin et al., 2008). These results suggest a potential increase in demand in specific years post wildfire. However, the results outlined by Englin et al. (2008) are localized to the Sierra Nevada Mountains in California using only trips from California and Nevada. Our research takes a broader approach looking at the entire western region of the US as well as accounting for all reservations, not just reservations from individuals that live in nearby states.

To further elaborate on yearly changes post wildfire, Duffield et al. (2013) use time series data on U.S. fire activity and National Park Service recreational visitation data to look at the effect of wildfire on the regional economy surrounding Yellowstone National Park. As with our research, recreational visitations to Yellowstone were expected to decrease with significant fire activity in the park, which was confirmed with negative coefficients of their fire activity variables. Wildfires economically impacted the counties surrounding Yellowstone with reduced visitor spending and reduced willingness to pay to visit the park associated with fewer trips taken (Duffield et al., 2013). The study also finds that marginal per-trip welfare declines immediately after a fire. Welfare begins to recover after the initial drop on a nonlinear path after approximately 35 years of regrowth. While our research will not examine wildfire impacts for as long of a time frame, we will look at the changes in camping demand from a local and non-local reservation perspective. Observing changes by reservation type will help explain the impact on the local economy.

Kim and Jakus (2019) build off the research of Duffield et al. (2013) by looking at the impact of wildfire within certain radii on the five national parks in Utah using monthly visitation data from 1993 to 2015. Results from Kim and Jakus (2019) showed reduced visitation to all five national parks between .51% (Capitol Reef NP) and 1.54% (Bryce Canyon NP) due to fire. Using input-output modeling, the authors show greater economic impacts to rural, tourism-dependent counties than counties that are more diversified and less dependent on the national parks. The research outlined in this paper focuses solely on campgrounds in national forests providing an addendum to research by Duffield et al. (2013) and Kim and Jakus (2019).

While travel cost studies are valuable in estimating economic impacts of wildfires on campsite demand and calculating a demand curve, the approach is limited in comparing the congestion of different campgrounds. Travel cost methods would also be unable to account for campgrounds having different numbers of individual campsites. Like Shartaj and Suter (2020), we choose to focus on capacity utilization as a proxy for changes in recreation demand.

2.4 Suppression Treatment by Region

Wildfire suppression treatments are not equally effective, and effectiveness can vary by region (Robichaud et al., 2014). For instance, USFS Region 6, which encompasses Oregon and Washington, justified fire treatments to protect threatened and endangered species in 59% of fires, greater than any other western region (Robichaud et al., 2014). The Pacific Northwest also contains relatively valuable timber in its forests, so fire suppression activities are prevalent within the region (Hilger & Englin, 2009). Region 4, which encompasses southern Idaho, Nevada, Utah, and part of Wyoming, recorded the greatest percentage of suppression treatments justified through soil productivity compared to other regions (Robichaud et al., 2014). Soil productivity is important to areas that have concerns for the timber industry and protecting municipal water supplies (Robichaud et al., 2014). These varying justifications influence suppression techniques and show a need to look at regional differences in wildfire impacts. If suppression techniques fluctuate by region, this may show up in how regions manage fires near campgrounds. For example, campgrounds in Region 6 may be located in areas with greater forest cover than campgrounds in Region 3, Arizona and New Mexico. Because Region 6 prioritizes protecting endangered species and timber, suppression efforts near campgrounds may differ in strategy than Region 3.

Vegetation also varies by region necessitating different fire suppression activities. The Pacific Northwest has different land cover than the Southwest and fire suppression will differ accordingly. Vegetation not only burns differently but also recovers at differing speeds. Grasslands may recover at a speed that a fire occurring in the same location each year would have little effect on the viewshed from a recreation standpoint. The risk of soil erosion is also present before vegetation returns to the previously burned landscape. As erosion occurs with increased water distribution to waterways, increased sediment loads can decrease water quality increasing the need for restoration strategies (Bladon et al., 2014). These restoration strategies may induce other costs not previously considered in wildfire management. Consistent land cover at the national scale coordinated by multiple federal agencies exists to analyze the differences between regions (Multi-Resolution Land Characteristics Consortium, 2013). This paper will use the satellite imagery provided in the National Land Cover Database to explore these differences in land cover and how they affect recreation demand.

To conclude, the primary focus of this research is understanding the long-term impacts of wildfire on camping demand. This study contributes to the literature by incorporating camping demand into existing recreation demand literature related to hiking and biking. We also contribute by looking at the question from a wide lens whereas prior literature hones into specific recreation sites. Further, our research supports the improved well being of individuals through recreation and the negative effect wildfire can have on the individual gains from recreation. Finally, our results have the ability to assist forest planners and fire managers for future wildfire management. As wildfires continue to ravage national forests and suppression methods evolve, our research advances the discussion of how best to let fires contribute to the life cycle of forest ecosystems while maintaining the elements of natural environments recreationists appreciate and choose to participate in.

Chapter 3

Methods and Data

To better understand the long term impact of wildfire on campsite utilization, three datasets are used: wildfire perimeter data from Monitoring Trends in Burn Severity, land cover data from the National Land Cover Database, and reservation data from the Recreation Information Database. We select these data sets for their widespread consistency across the western U.S., our area of interest. We also use zipcode data from the U.S. Census Bureau when estimating effects from local and non-local reservations (U.S. Census Bureau, 2013). Merging these data sources allows us to evaluate many factors that can influence changes in campsite reservation demand.

3.1 Fire Data

Monitoring Trends in Burn Severity (MTBS) is an interagency program with the goal of consistently mapping burn severity and large fires across the U.S. (Monitoring Trends in Burn Severity, 2020b). While we opt to use other data sources to understand the effect of wildfire on vegetation, we rely on the Burned Areas Boundaries Dataset as our primary source of fire data (Monitoring Trends in Burn Severity, 2020a). The data include all fires greater than 1000 acres in the western U.S. and greater than 500 acres for the eastern US (Monitoring Trends in Burn Severity, 2020b). This research focuses soley on the western US, or Regions 1-6, shown in Figure 3.1. The western US experiences higher fire activity and suppression costs than the eastern US (Gebert & Black, 2012). We also look at Regions 1-6 individually.

MTBS data include a single shapefile for burned area boundaries for the contiguous U.S. for all years 1984 to 2018. Variables of interest include the geometry of each fire, the region, year, and fire size in acres. For our research, we subset MTBS data to 1984-2017 as the reservation data ends in 2017. When looking at where fires occur, it is beneficial to observe heterogeneity related to proximity of fire to campgrounds. We filter MTBS data by region by intersecting the geometry of each fire with a USFS Regional Boundaries shapefile (U.S. Forest Service, 2020a). We observe

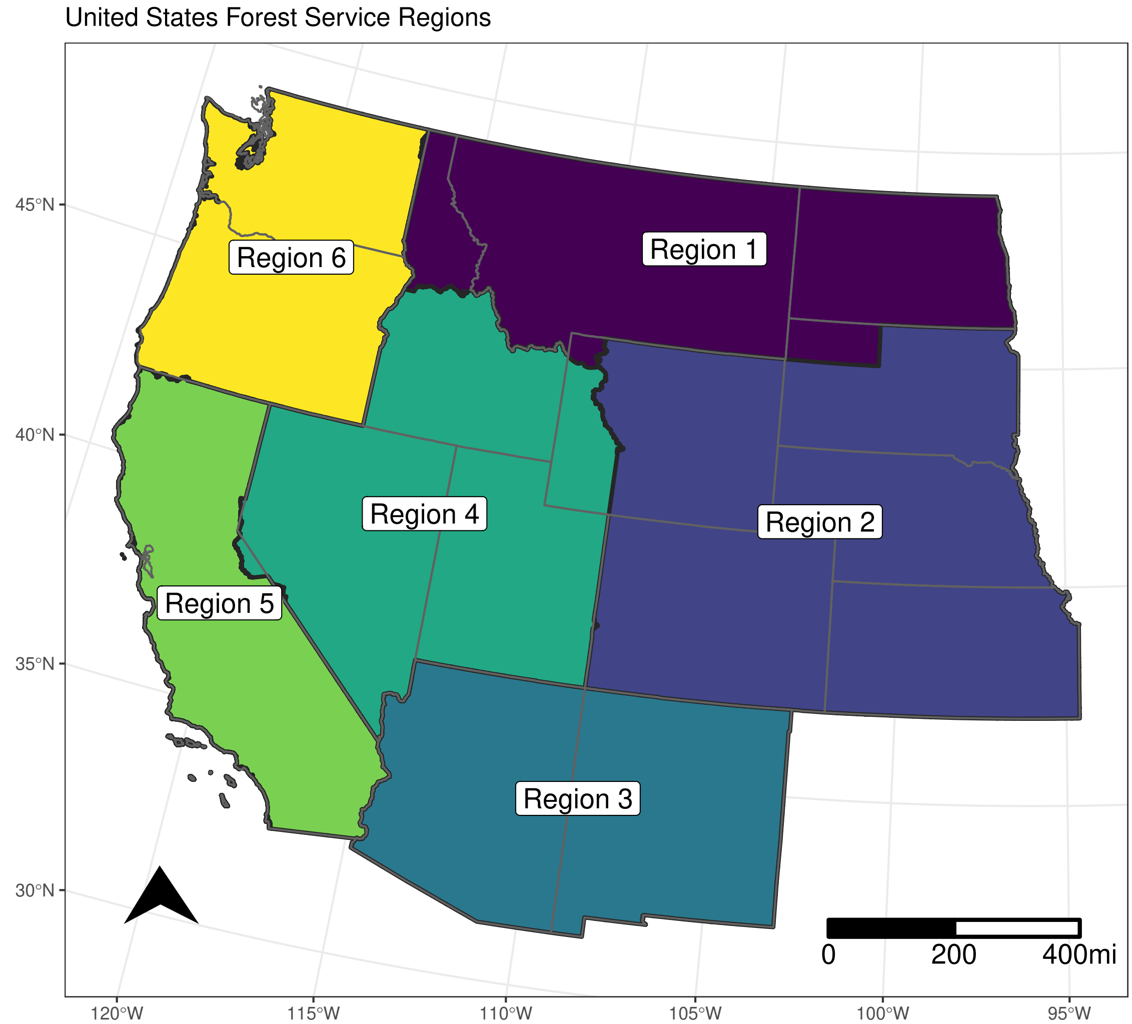

Figure 3.1: A map of the US showing the USFS regions. This research focuses on the western US, specifically Regions 1-6.

varying distances between fires and campgrounds seen in Figure 3.2. When we zoom in on part of Oregon, we see that some campgrounds occur within fire perimeters, some are touching the edge of fire perimeters, and some are unaffected by previous fires. From this, we are able to examine the difference between campgrounds treated by fire and those untreated in our time frame of interest. Areas with campgrounds affected by fire could be considered a risky investment in terms of improving campground infrastructure.

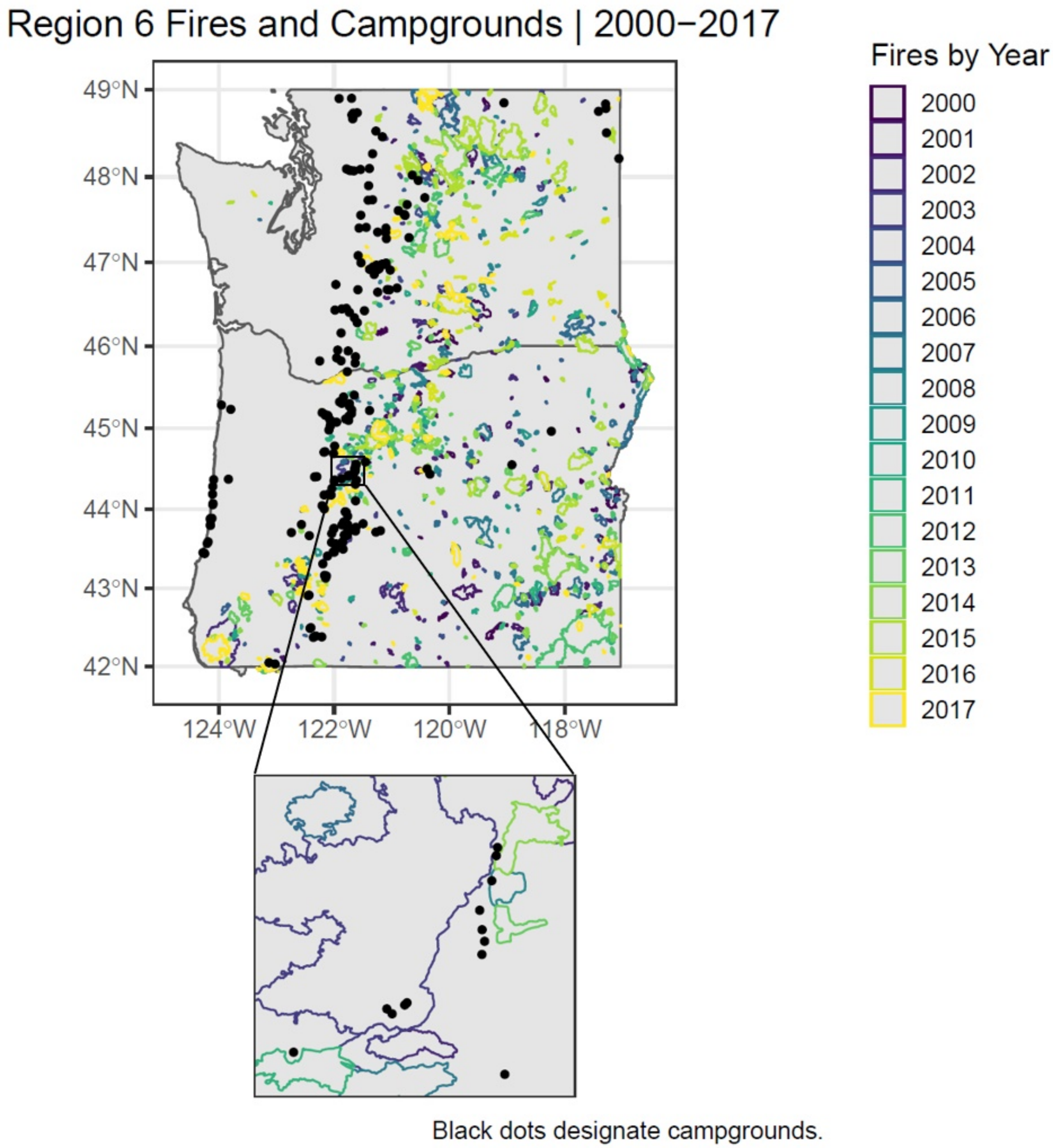

Figure 3.2: A map of all wildfires within USFS Region 6 from 2000-2017 in relation to campgrounds including a zoomed in part of Oregon below main map showing heterogeneity within the data. Some campgrounds fall within fire perimeters, some are proximate to perimeters, and some are unaffected.

3.2 Measuring Wildfire Damage

Multiple fire measurements exist to help define the scope of a wildfire and its impact on the environment. An important distinction between fire intensity, fire severity, and burn severity is pertinent not only to our research but to all studies on wildfire. Fire intensity is refers to the rate of heat released during a fire event (Heward et al., 2013). Many articles refer to fire severity in relation to vegetation and soil changes that occur within minutes or hours of wildfire presence (Heward et al., 2013). Burn severity relates to the ecosystem changes brought on by wildfire over an extended time period (Robichaud et al., 2014). Parameters used in measuring severity include soil color, amount of fuel consumed, depth of burn in soil, resprouting of burned plants, and more (Heward et al., 2013). Because we are concerned with longer term impacts of fire on camping demand, burn severity is more relevant to our research than fire intensity.

However, burn severity measures have limitations. Data from MTBS measure burn severity using satellite imagery to quantify different times relative to the wildfire, including pre-fire growth and post-fire growth approximately one year after the fire took place (Robichaud et al., 2014). While the satellite imagery from different frames provides quality data, the main limitation in using burn severity from MTBS is subjectivity leading to inconsistent reporting. MTBS was developed for fire management needs and has not undergone systematic evaluation to quantify fire accuracy for scientific purposes (Kolden et al., 2015). The burn severity classification is also developed on a per fire basis. Since an analyst visually interprets maps and assigns threshold values on burn severity, this measure lacks objectivity needed for wide-scale use (Kolden et al., 2015). The end burn severity maps provided by MTBS are useful in understanding the general burn patterns of fires but lacks sufficient accuracy to use at the scale we need.

We rely on using the National Land Cover Database (NLCD) from Multi-Resolution Land Characteristics (MRLC) consortium to characterize the land cover in areas near campgrounds and how land cover moderates the impact of wildfire on reservations (Multi-Resolution Land Characteristics Consortium, 2013). While the NLCD is imperfect for use in this research, due to a lack of yearly reporting across all years of interest, it does provide the necessary consistency across the western U.S. in terms of land cover classifications. We rely on this data to calculate the amount of forested land near each campground to observe how land cover moderates the impacts of wildfire on camping.

The MRLC NLCD has the primary objective of providing complete, current, consistent, and public land cover information for the nation (Multi-Resolution Land Characteristics Consortium, 2020a). Land cover data can provide intuition behind how landscapes look after fires and the speed in which vegetation recovers post fire. Common vegetated land cover in the database include deciduous forest, evergreen forest, herbaceous wetlands, and grasslands (Bar Massada et al., 2009). Post-fire vegetation will recover quickly in grassland areas but take longer in forested land. Since we focus on the entire western U.S., NLCD data can provide what MTBS lacks as it relates to burn severity subjectivity. Since NLCD data is processed every few years, data from 2013 will be used as it falls within the campsite reservation data window of 2008-2017. The distribution of forested area within the buffered area around each campground by USFS region is shown in Figure 3.3, potentially explaining some of the variation in camping demand and fire suppression techniques. Campgrounds in Regions 4, 5, and 6 have greater numbers of campgrounds with higher percentages of forested land nearby than Regions 1, 2, and 3. They also have greater numbers of campgrounds in general, supported by Table 3.1 which includes counts of campgrounds available in each region based on 2017 counts.

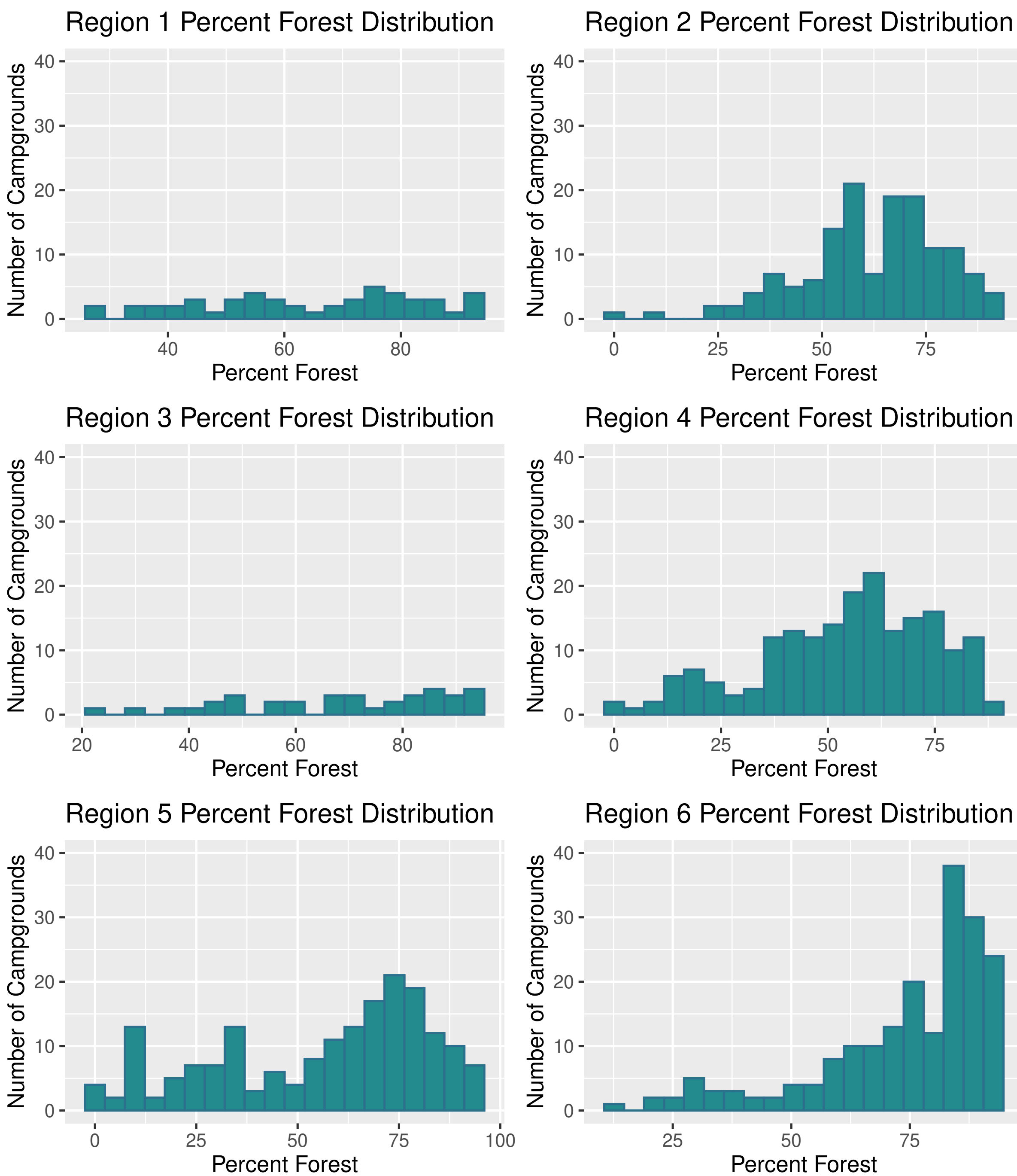

Figure 3.3: Histograms showing the distribution of forested area within 10 km buffer around campgrounds using 2013 NLCD land cover data by each region. Accounts for number of campgrounds in each year using 2017 campground counts.

3.3 Camping Data

Campsite data is collected from *https://ridb.recreation.gov* over the years 2008 to 2017 and includes campsite characteristics and reservation information including the specific location of the campground (Recreation Information Database, 2020). Reservation data include all reservations made through *recreation.gov* for a given year. Data do not include walk-up reservations. Reservations are also subset to May 15th through September 15th of a given year. Most camping reservations made through the site occur in this time frame (Shartaj & Suter, 2020). Because our analysis is on the differences between campground reservations after wildfire, we selected data from *recreation.gov* for its completeness and quantity of data over other data sources like the National Visitor Use Monitoring (NVUM) System. NVUM data compiles estimates to recreation visits to national forests and grasslands across many forms of recreation (U.S. Forest Service, 2020b). Our research focuses solely on camping and having reservation data like fees paid and zip codes for visitors is informative for our analysis.

We create a 10 kilometer buffer around the longitude and latitude reference for each campground. We take all years of fire perimeter data, 1984-2017, and intersect the fire geometries with the campsite buffer. This provides information relating to campgrounds that have been treated by wildfire in the specified buffered region and provides the necessary values to calculate the percentage burned area within the buffered area of each campground. This calculation helps frame the thought process of this research. If a greater percentage of burned area occurs within a buffer around a campsite, it is expected that campsite utilization would fall, ceteris paribus. The burn percentage within the 10 kilometer buffer is calculated by dividing the burn area within the buffer by the total buffered area. The distribution of burned area within the buffered area that is greater than zero is shown in in Figure 3.4. Burned areas are calculated for all years of fire data. A 100% burn percentage would mean the entire buffered area around the campground burned in a fire, which is an area of 314 square kilometers (121 square miles or 77591.1 acres). Since the likelihood of a wildfire burning the entirety of the buffered area around a campground is low, we expect to find a greater number of campgrounds with lower burn percentages. This is confirmed in Figure 3.4.

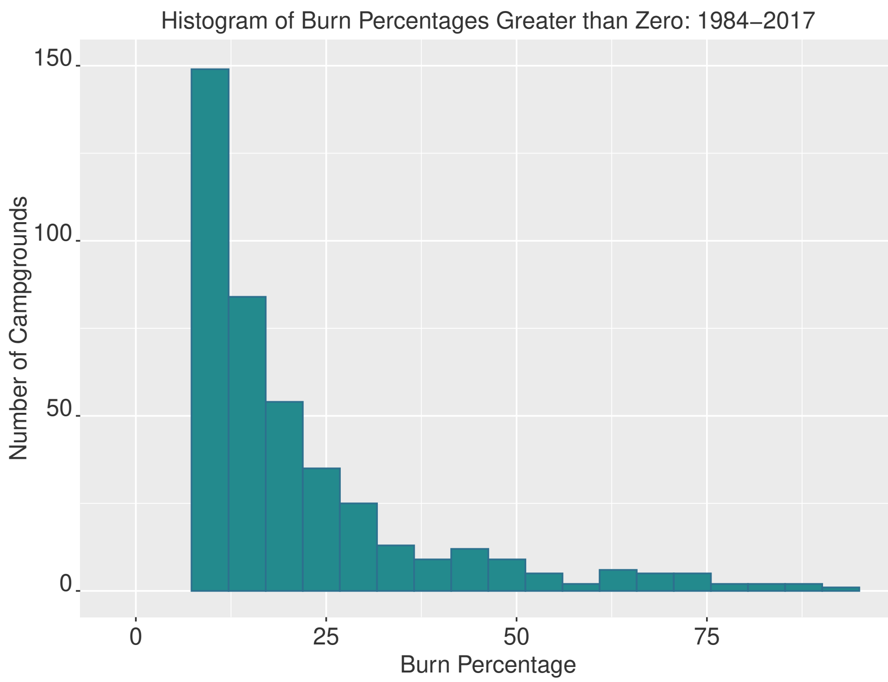

Figure 3.4: Histogram showing the distribution of burned area within buffer that is greater than zero around campgrounds.

We summarize the number of campgrounds treated by fire in each year of fire data. Across the six regions, heterogeneity exists in the total number of treated campgrounds by region and the number of treatments in a given year. Over the 34 years of wildfire data, Region 5 (California) experienced six times more fires than Region 1. Region 5 also has the highest population largest wildland urban interface in number of housing units than the other regions (Radeloff et al., 2005). Region 6 has the highest number of campgrounds, using 2017 counts for campground data, compared to the other five regions (Table 3.1). Because of existing heterogeneity, we include a cumulative burn frequency variable in later regressions to parse out the effect of wildfire on campground capacity utilization. Intuitively, with a campground that experiences burns more frequently, we would expect to find greater impacts to capacity utilization if fires do negatively influence households' desire to recreate.

Table 3.1: Campgrounds Treated by Fire within Buffered Area by USFS Region and Year

Year	*Region* 1	2	3	4	5	6	Total
1984	0	0	0	1	14	0	15
1985	1	0	0	2	11	0	14
1986	0	0	0	2	2	1	5
1987	0	0	1	6	24	4	35
1988	3	14	0	20	3	4	44
1989	0	1	0	17	8	1	27
1990	0	1	2	2	16	1	22
1991	3	2	0	1	3	1	10
1992	0	0	0	0	13	2	15
1993	0	0	2	2	1	0	5
1994	1	1	1	13	36	15	67
1995	0	0	1	5	8	0	14
1996	0	3	1	11	20	10	45
1997	0	0	0	1	18	0	19
1998	1	0	2	2	0	2	7
1999	1	0	4	1	30	0	36
2000	14	3	0	11	6	2	36
2001	6	2	0	10	20	7	45
2002	0	16	14	19	41	13	103
2003	11	4	2	12	10	26	65
2004	0	1	6	5	19	4	35
2005	0	1	1	1	11	1	15
2006	7	0	4	15	26	14	66
2007	5	5	9	26	34	14	93
2008	4	7	1	5	22	10	49
2009	0	0	4	12	10	2	28
2010	0	1	3	7	16	5	32
2011	6	3	12	7	9	12	49
2012	10	13	3	24	17	16	83
2013	2	4	5	12	27	10	60
2014	1	0	6	2	27	26	62
2015	7	0	9	6	27	7	56
2016	1	11	14	20	31	2	79
2017	5	9	8	4	33	38	97
Total	89	102	115	284	593	250	1433
2017 CGs in Region	50	141	36	190	184	193	794

Note: Horizontal line between 2007 and 2008 indicates the starting point from which campsite reservation data is available.

Campsite capacity utilization is our primary variable of interest. As noted earlier, utilization only refers to reservations made through *recreation.gov*, meaning walk-up reservations are not included. Campsite capacity utilization is expected to increase as aggregate recreation levels increase over time noted by Bowker et al. (2006) previously. Though we find an overall increase in campsite utilization, various factors can impact this value. To create a campsite utilization value, yearly data was compiled based on campsite identification number. Each reservation included information on reservation book date and length of reservation. This information was compiled and a calculation was made to determine the number of sites reserved compared to the sites available at each campground. Campsite capacity utilization has been calculated in the same manner in prior research related to local determinants affecting campsite reservations (Shartaj & Suter, 2020). The capacity utilization equation is formally defined below:

$$Capacity\,Utilization_{it} = \frac{Campsites\,reserved_{it}}{Total\,campsites\,available_{it}} \tag{3.1}$$

where i is the individual campground and t is the year. For instance, if a camping area has ten individual sites and three are booked every day during the peak season, then the capacity utilization at this campsite is 30%. When comparing capacity utilization percentages in 2008 and 2017, we observe capacity utilization has increased over the 10 years of reservation data as shown in Figure 3.5.

Originally, many zeros occur in early years of reservation data for capacity utilization. This is because all campgrounds were not fully integrated into the *recreation.gov* website for making online reservations. Additional observation of the capacity utilization measure across campgrounds and years show zero values in various years, not just the beginning of reservation data. Since our primary focus is on change in campground reservations and not decisions related to when campgrounds are available online, we look at zeros in the capacity utilization measure to see if they occur in the same year as wildfire. We start by creating a buffered area of one kilometer around a campground using the same methods described earlier. A fire occurring in the one kilometer buffer

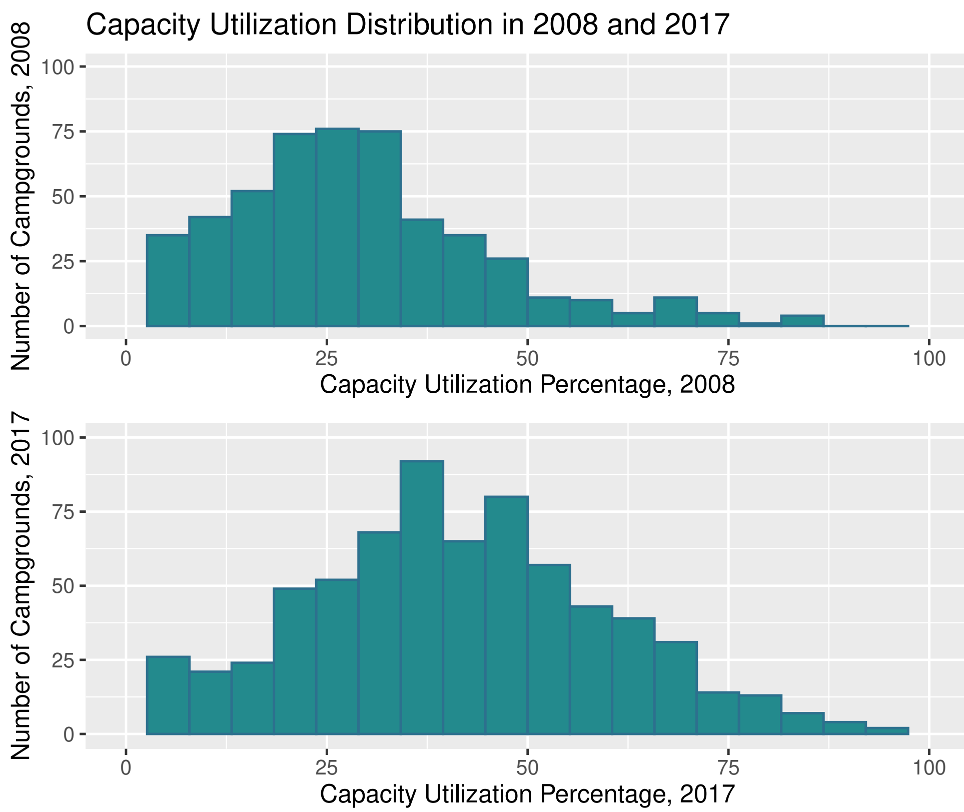

Figure 3.5: Capacity utilization across all campgrounds in 2008 and 2017. Note that more campgrounds are available through *recreation.gov* in 2017 than 2008.

has a better chance of burning the campground or surrounding area enough that the campground may need to close in the following year for restoration.

We take the campgrounds where fires burned within one kilometer and compare the year the fire occurred to the zeros present in the capacity utilization data. If a zero occurs in the year after a fire occurs, it may be reasonable to believe that the zero was caused by wildfire in the year prior and not another reason. The distribution of zeros throughout the camping data did not consistently align with when fires occurred to confidently say zeros values are solely related to fire. Ultimately, we choose to only keep campgrounds in the data set where all ten years of capacity utilization are greater than zero and campgrounds where zeros occur and are then followed by positive values for capacity utilization. This subset allows us to observe the effect of wildfire on capacity utilization while accounting for campgrounds showing up on recreation.gov in different years. To support our analysis, a robustness check using only campgrounds with ten years of positive data, omitting the campgrounds with zeros at the beginning of reservation data.

Another variable of interest in this research is the impact of wildfire on local reservations. Because we have zip code data with every reservation, an additional benefit of using *recreation.gov* data compared to other sources, we calculate the percentage of local reservations for a campground in a given year. U.S. Census data from 2013 provide the centroid for each zip code (U.S. Census Bureau, 2013). The Euclidean distance between this point and the unique point of each campground is then calculated. Local reservations are defined as those that occur within 80 kilometers (roughly 50 miles) of the campground. Multiple studies on recreation use 50 miles to define local activity (Flores et al., 2018; Highfill & Franks, 2019). The local reservation percentage is then calculated by dividing the reservations defined as local by the total reservations for a given campground in a given year as formally shown below:

$$Percentage\ of\ Local\ Reservations_{it} = \frac{Local\ Reservations_{it}}{Total\ Reservations_{it}} \tag{3.2}$$

where i is the individual campground and t is the year. Again, the calculation for local reservations is subset to May 15 to September 15 of each year. Local reservations have decreased on average over the time period of interest as seen in Table 3.2. If reservations are becoming increasingly non-local and capacity utilization falls because of wildfire, local economies dependent on campers may experience depressed spending. For ease interpreting results, we multiply the percentage of local reservations by capacity utilization for each campground in each year. This allows us to focus in on the effect of fire on local reservations.

To summarize, our cross-sectional time series data on campgrounds encompasses the western regions of the U.S. as defined by the USFS. We have ten years of reservation data ranging from 2008 to 2017 with observations for each campground for each year. While our data for fires extends back to 1984, we only use fires from 1994 onward as this is fifteen years before our reservation data begins. Future analysis could easily extend further back, testing the effect of fires on capacity utilization 25 years after a fire takes place.

Table 3.2: Percentage of Local Reservations 2008-2017

Year	Local Reservations (%)
2008	26.47
2009	26.25
2010	25.75
2011	24.99
2012	25.32
2013	24.60
2014	24.31
2015	23.78
2016	22.75
2017	21.60

Note: A decrease in percentage of local reservations across all campgrounds in all regions from 2008 to 2017. Note that more campgrounds are added to *recreation.gov* over time.

3.4 Econometric Model

We use a panel fixed effects linear model to account for the changes in capacity utilization and change in local reservations over time at individual campsites. Since we are concerned with how demand changes in subsequent years after fire, we create yearly lags of the fire occurrence for fifteen years post fire occurrence. For example, a burn lag of two would calculate the effect of the burn percentage two years after the fire burns part of the buffered area. We then estimate the regression looking at the impact of the area of burn within the ten kilometer buffer of a campsite including this area lagged for fifteen years, on capacity utilization.

Since we are specifically looking at how fire in previous years impacts campsite demand in a given year, other unobservable factors affecting capacity utilization are accounted for with the inclusion of individual campground and time fixed effects in each regression.

We estimate the following regression,

$$Y_{it} = \sum_{j=0}^{15} \beta_j X_{it-j} + \gamma_i + \delta_t + \varepsilon_{it} \tag{3.3}$$

where Y_{it} is the capacity utilization of campground i in year, t, X_i is the proportion burned near a campground, and β_j is a series of lagged variables to account for years after wildfire occurrence. γ_i is the individual campground fixed effect and δ_t is a time fixed effect for each year of interest. We cluster standard errors at the campground level to account for correlation. We run this regression at the aggregate level encompassing Regions 1 through 6 and then at the region level as designated by the USFS.

3.5 Additional Analyses

We estimate several alternative specifications to estimate the mechanisms affecting the change in camping reservation demand in the years after fires occur. To parse out the changes in capacity utilization, further regressions are run to look at burn frequency at the campground and regional levels, fire size, land cover, and the percentage of local reservations.

We calculate a burn frequency measure to interact with the burn percentage lags and parse out the effect of cumulative burns on campgrounds. MTBS fire perimeter data include 34 years of fire, from 1984 through 2017, at the time of this research. We count each year in which a fire occurs within the 10 km buffer around a campground as having a burn frequency of one. The number of years a fire occurs within the buffered area is divided by the total number of years of data available, 34. This value gives us the burn frequency measure for each campground, which is then interacted with the year of burn percentage and subsequent burn lags for a given campground. Campgrounds with higher percentages of burn years may experience greater negative effects in the years after fire occurrence. We also look at the burn frequency using regional values as a proxy for saliency. We take the total number of campgrounds treated by fire over the 34 years of fire data from Table 3.1. We then divide this value by 34 to get a regional burn frequency measure. For instance, Region 1 would have a burn frequency calculated by dividing the 89 treated campgrounds by 34 years to get 2.62. Again, this regional burn frequency measure is interacted with the percentage of burned area in the year of fire and the burn lags. We aggregate this analysis up to a single regression including all six regions.

Fire size as a contributing factor to reduced capacity utilization was also tested at the aggregate and regional levels. Larger fires typically experience greater awareness across the country than smaller, local fires. Reporting on the Cameron Peak Fire of 2020 extended past local news outlets to CNN as the fire progressed (Moshtaghian & Maxouris, 2020)). Fires can also spread quickly depending on the fuel type. Larger fires may also be more intense and cause greater damage. MTBS data provide fire size, in acres, that we interact with the burn lags.

Further, we calculate the impact of forested land on capacity utilization. We do so by extracting the pixels from 2013 NLCD raster data that fall within each buffered area of a campground. Each pixel is labeled with a numerical classification. These numbers match extended classifications from the NLCD. Since we are concerned with the percentage of forested land, we group the three land cover classifications that relate to forests together. We divide the percentage of pixels that fall into the forest categories by the total pixels in the buffered area to create a percent forest value. We expect to find the percentage of forested land around a campground correlate to larger negative impacts on capacity utilization.

When analyzing the potential change in percentage of local reservations due to fire, we multiply the percentage of local reservations by capacity utilization for each campground in each year of data. This makes for an easier interpretation of coefficients from the regression. Again, capacity utilization remains the dependent variable in these regressions. We expect to find a greater decrease in local reservations as individuals who live nearby will have greater knowledge on fires in their area. Observing a decrease in non-local reservations would have the negative effect of not only reduced income to the USFS in terms of lost reservation fees but also reducing local spending.

Chapter 4

Results and Discussion

Results from the base and subsequent models illuminate the effect of wildfire on campsite reservations showing long term decreases in capacity utilization. The results and discussion continue in the following order: examination of the base model results at the aggregate level, exploration of model outcomes at the regional level, and finally, key results from mechanism analyses.

We find that the percentage of burned area within the buffer around a campground reduces capacity utilization by -0.916 in the first year after fire and continues to reduce capacity utilization through year 6 (Figure 4.1). In Figure 4.1, we observe negative coefficients with standard errors maintaining negativity through six years post wildfire. We also observe a negative coefficient twelve years post wildfire. Standard errors for each coefficient are shown numerically in Table 4.1. To provide intuition for the coefficients, a 1% increase in the burned area within the buffered area of a campground would decrease campsite capacity utilization by nearly 10% the year after the wildfire occurred. A 1% increase in burned area is 3.14 square kilometers or roughly 1.21 square miles. We do not place much value in the effect on capacity utilization in the year a fire takes place as it is not well identified. Our primary focus is the long term, so we do not account for the month and day a fire occurs in a given year that could effect reservations in the fire year[1].

A conservative robustness check at the aggregate level using only campgrounds with positive capacity utilization values for all ten years of data are shown in Table 4.2. Results in Table 4.2 indicate decreases in capacity utilization are negative through five years after a wildfire occurs. This specification shows the impacts are a result of the changes in camping behavior and not USFS decisions about closing campgrounds. Changes in individual camping demand impacts the

[1] We also test our regression using a 5 kilometer and 20 kilometer buffer. Results are qualitatively similar with the same sign and significance of coefficients. Using a 5 kilometer buffer, we find a greater length of impacts with significant negative effects present through 8 years after wildfire and again in years 12-15 (Table B.2). Using a 20 kilometer buffer, we find similar results of significant negative impacts through six years after fire and again in year 13 (Table B.4).

individual in terms of reduced health outcomes from nature-based recreation. These changes can also influence forest managers in charge of fire suppression or campground management. We also estimate the effect of pretreatment trends by including five leads before a fire occurs, both in the aggregate model and the regional models. We expect to see minimal changes in capacity utilization in the years before fires occur. While no significant effect is observed in the years before a fire takes place at the aggregate level, positive effects occur in Region 3 and Region 4 five years and one year before fire, respectively. We include the tables for reference in the appendix (Table A.1 and Table A.2).

To quantify the effect of decreased capacity utilization over the six years after a fire occurs, we calculate the cumulative effect of the coefficients for the lags and multiply this value by the loss in fees paid for reservations. The cumulative effect can be written as $\sum_{j=0}^{6} \beta_j$ in a distributed lag model (Parker, n.d.). We sum the six lag coefficients to get -0.5018. For the representative campground impacted by wildfire, we expect to see 8% of its buffered area burned. For campgrounds affected by fire, the average yearly revenue is roughly $20,804. Multiplying these values together, a typical campground treated by fire can expect to lose $835 in the years after fire treatment. Across all years, we observe an average of 60 campgrounds affected by fire annually. When we multiply the loss at each campground by the 60 campgrounds treated, we find that the USFS can expect to lose $50,109 in the years after fire treatments. Lost revenue to the USFS is only part of the economic cost. Mentioned previously, individuals derive many benefits from nature-based recreation. Future research could evaluate lost economic benefits by calculating lost consumer surplus to campers from fires near campgrounds.

This lost revenue to the USFS does not account for the potential of individuals to substitute for unaffected campgrounds. We would expect to see bigger effects on reduced reservation fees at campgrounds that have available substitutes nearby, like campgrounds unaffected by fire. Future research could look at the number of available substitutes for fire-impacted campgrounds. This could potentially be calculated at the national forest level by referencing the closest campgrounds unaffected by fire in the same year as affected campgrounds. If capacity utilization values increased at unaffected campgrounds by the same amount that reductions occur at treated campgrounds, we may be able to attribute some of those increases in part due to substitution.

Another way to think about the decrease in capacity utilization is the decrease in the number of camping participants. We sum the party size of reservations for all campgrounds in our study for all years of data to get the total number of campers. The average campground will have 1,447 campers during the peak season in a given year. Again, the sum of the six negative coefficients is -.5018. When we multiply the loss in capacity utilization and the average burn percentage of 8% by the number of visitors, campgrounds affected by fire can expect to lose 59 visitors. This loss of visitors has implications for local communities who are dependent on the additional spending made by camping participants.

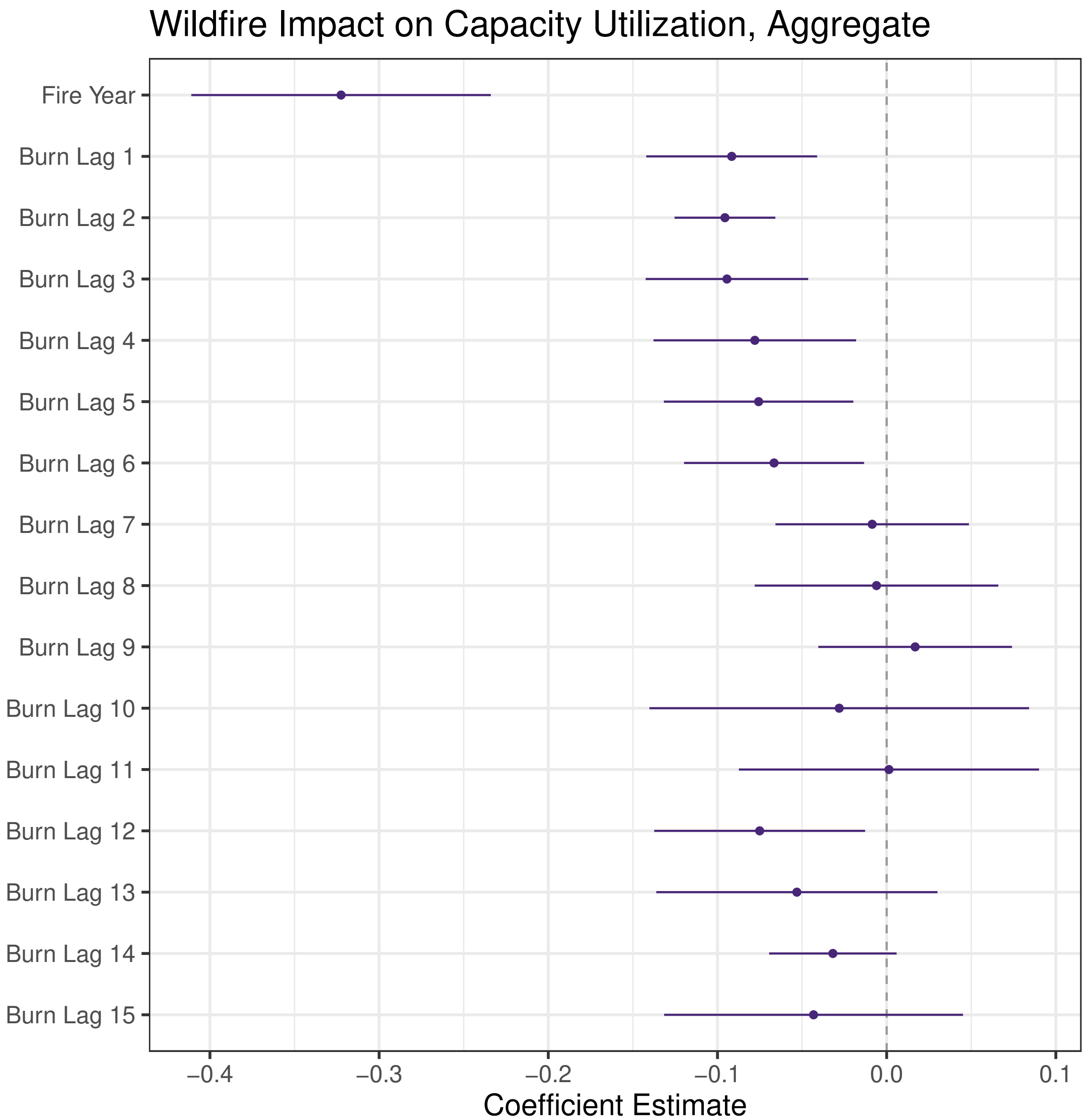

Figure 4.1: A visual representation of the long term impacts of wildfire on camping reservation demand

Table 4.1: Base Model: Aggregate, 15 lags, Individual and Time FE

Dependent Variable:	capacity_booked
Variables	
fire_year	-0.3225***
	(0.0352)
burnlag1	-0.0916***
	(0.0196)
burnlag2	-0.0956***
	(0.0233)
burnlag3	-0.0944***
	(0.0260)
burnlag4	-0.0779**
	(0.0315)
burnlag5	-0.0757**
	(0.0351)
burnlag6	-0.0666*
	(0.0381)
burnlag7	-0.0086
	(0.0379)
burnlag8	-0.0060
	(0.0367)
burnlag9	0.0168
	(0.0408)
burnlag10	-0.0280
	(0.0407)
burnlag11	0.0014
	(0.0388)
burnlag12	-0.0751*
	(0.0434)
burnlag13	-0.0531
	(0.0407)
burnlag14	-0.0318
	(0.0371)
burnlag15	-0.0432
	(0.0376)
Fixed-effects	
Year	Yes
Campground	Yes
Fit statistics	
Observations	6,081
R^2	0.88484
Adjusted R^2	0.86938
F-test	57.202

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 4.2: Aggregate Model: Campgrounds with Capacity Data for all years (2008-2017)

Dependent Variable:	capacity_booked
Model:	(1)
Variables	
fire_year	-0.3279***
	(0.0381)
burnlag1	-0.0851***
	(0.0194)
burnlag2	-0.0887***
	(0.0233)
burnlag3	-0.1000***
	(0.0250)
burnlag4	-0.0829***
	(0.0309)
burnlag5	-0.0733**
	(0.0359)
burnlag6	-0.0592
	(0.0392)
burnlag7	0.0055
	(0.0401)
burnlag8	-0.0062
	(0.0386)
burnlag9	0.0256
	(0.0421)
burnlag10	-0.0161
	(0.0419)
burnlag11	-0.0065
	(0.0395)
burnlag12	-0.0472
	(0.0416)
burnlag13	-0.0606
	(0.0408)
burnlag14	-0.0469
	(0.0385)
burnlag15	-0.0509
	(0.0394)
Fixed-effects	
Year	Yes
Campground	Yes
Fit statistics	
Observations	5,130
R^2	0.88875
Adjusted R^2	0.87574
F-test	68.313

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

To better understand the decrease in capacity utilization caused by wildfire, we also estimate the base model at the USFS regional level. As noted earlier, heterogeneity exists in suppression treatment by region and the number of campgrounds impacted by fire by region, shown in Table 3.1. To visualize how results differ across regions, we provide the results for the lagged burn percentages for the year of, year after, 5 years after, 10 years after, and 15 years after a fire takes place shown in Figure 4.2. Regionally, results compare to the aggregate level although some regions do not experience as persistent of negative impact of wildfire events over time. Some regions are positively impacted by wildfire while others experience minimal effects. Points below the dashed line at zero, indicate negative effects in the selected years. In Table 4.3, we can see coefficients and standard errors for each burn lag[2]. We observe negative impacts in the year of fire for all regions. Regions 2 and 3 experience negative impacts on capacity utilization in earlier years post wildfire. Region 2 also experiences a positive effect on capacity utilization in later years. Region 4 has seven years where wildfires have positive and significant impacts on capacity utilization.

These results are important in guiding additional analyses. The observation of regional differences supports the need for different suppression strategies. A one-size-fits all method to manage fire near campgrounds may not reap the same rewards in each region. A conservative robustness check at the regional level using only campgrounds with positive capacity utilization values for all ten years of data are shown in Table B.1 in the appendix. Results in Table B.1 again show the variation across regions and are consistent with the primary model for regional analysis. Results suggest that decreases in capacity utilization are from individuals choosing not to make reservations at campgrounds affected by fire rather than when campgrounds are made available for bookings on *recreation.gov*.

[2]Again, we test our regression using 5 kilometer and 20 kilometer buffered areas. Regionally, results confirm the primary specification. For the 5 kilometer buffer, results become more significant for longer stretches of time post fire. Region 6 specifically experiences negative and significant reductions in capacity utilization for years 5-14 after a wildfire takes place where no significant results occur. In the 20 kilometer buffer, Region 4 experiences greater positive effects for years 6-12 after fire.

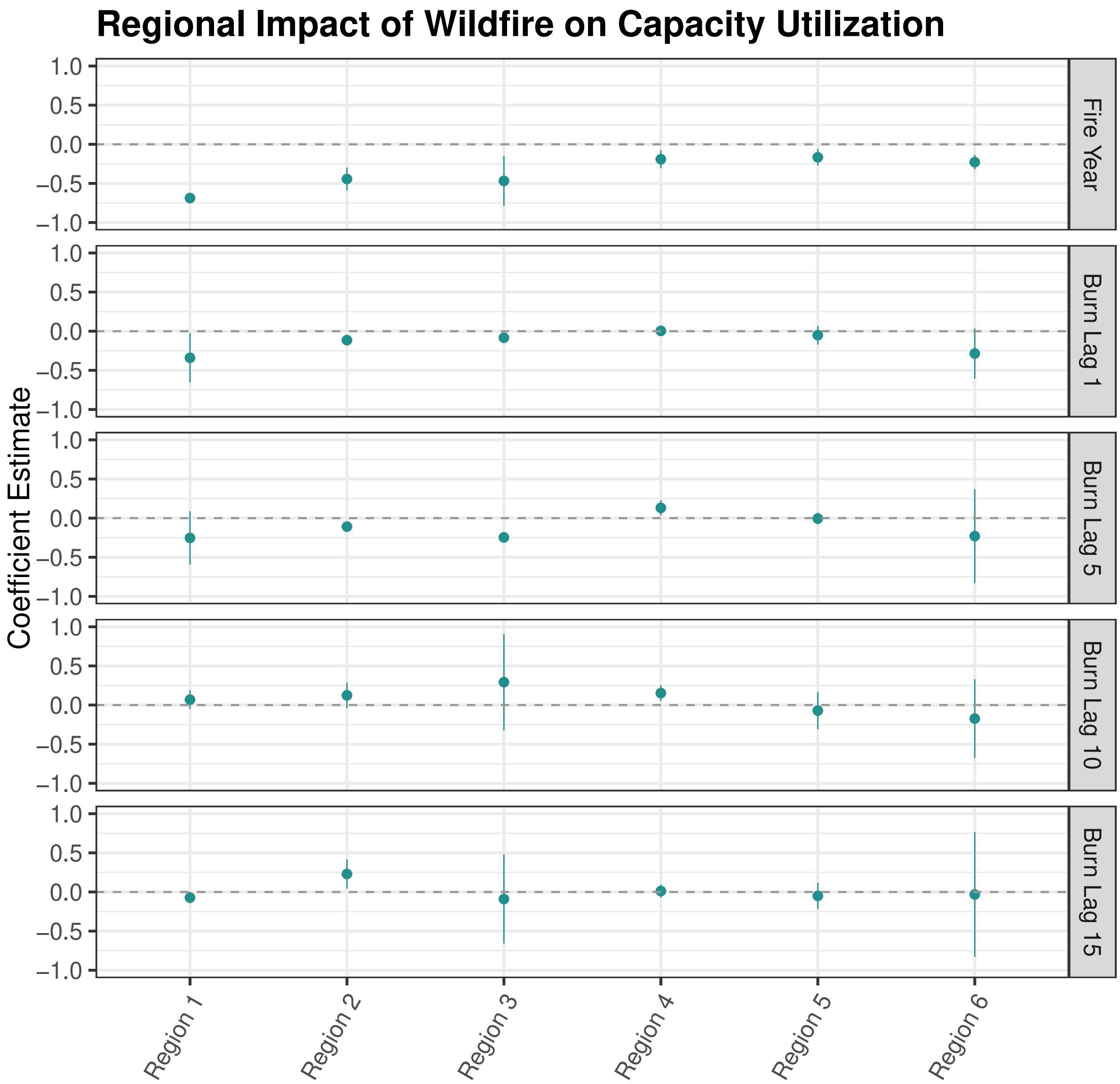

Figure 4.2: A visual representation of the impact of wildfire on camping reservation demand by regions in year of, one year after, 5 years after, 10 years after, and 15 years after fire takes place.

Table 4.3: Base Model: Regional, 15 lags, Individual and Time FE

Dependent Variable:	capacity_booked					
Region:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
fire_year	-0.6871***	-0.4434***	-0.4679***	-0.1913***	-0.1662***	-0.2282***
	(0.1778)	(0.0879)	(0.1114)	(0.0502)	(0.0473)	(0.0704)
burnlag1	-0.3402***	-0.1144***	-0.0835	0.0040	-0.0507	-0.2847*
	(0.1209)	(0.0418)	(0.0743)	(0.0340)	(0.0551)	(0.1638)
burnlag2	-0.2387	-0.0805**	-0.1747**	0.0161	-0.0371	-0.2135
	(0.2087)	(0.0378)	(0.0729)	(0.0507)	(0.0439)	(0.2320)
burnlag3	-0.2429**	-0.1018***	-0.1444	0.0591	-0.0583	0.2672
	(0.1085)	(0.0373)	(0.0926)	(0.0605)	(0.0547)	(0.1993)
burnlag4	0.0857	-0.0877**	-0.2469***	0.0998*	-0.0188	0.1053
	(0.2023)	(0.0397)	(0.0715)	(0.0554)	(0.0782)	(0.2586)
burnlag5	-0.2529*	-0.1084**	-0.2461***	0.1310**	-0.0053	-0.2304
	(0.1367)	(0.0512)	(0.0680)	(0.0594)	(0.0575)	(0.2768)
burnlag6	-0.1705	0.0679	-0.1954***	0.1513**	0.0188	-0.3285
	(0.1479)	(0.1386)	(0.0658)	(0.0609)	(0.0625)	(0.2762)
burnlag7	-0.4246*	0.0823	0.4065	0.2354***	0.0141	-0.3595
	(0.2476)	(0.1161)	(0.5375)	(0.0661)	(0.0552)	(0.2663)
burnlag8	0.0313	0.1256	0.1126	0.1709***	0.0214	-0.2729
	(0.1077)	(0.1113)	(0.4983)	(0.0535)	(0.0549)	(0.2602)
burnlag9	0.0165	0.2407**	-0.1120	0.1692***	0.0210	-0.1917
	(0.0922)	(0.1180)	(0.5152)	(0.0445)	(0.0581)	(0.2365)
burnlag10	0.0688	0.1244	0.2920	0.1525**	-0.0709	-0.1735
	(0.0979)	(0.1276)	(0.4039)	(0.0616)	(0.0741)	(0.2327)
burnlag11	0.0213	0.1485	0.1810	0.1503**	-0.0099	-0.1817
	(0.0982)	(0.1419)	(0.4074)	(0.0660)	(0.0779)	(0.2286)
burnlag12	-0.0341	0.2698*	0.0200	0.0805	-0.0774	-0.3143
	(0.0980)	(0.1435)	(0.3749)	(0.0743)	(0.0817)	(0.2375)
burnlag13	-0.0551	0.2283	-0.0857	0.0297	-0.0614	-0.2738
	(0.0787)	(0.1505)	(0.3885)	(0.0872)	(0.0758)	(0.2444)
burnlag14	0.0334	0.2664	-0.0435	0.0289	-0.0952	-0.2834
	(0.0634)	(0.1627)	(0.3946)	(0.0335)	(0.0656)	(0.2423)
burnlag15	-0.0717	0.2302	-0.0899	0.0118	-0.0495	-0.0322
	(0.0617)	(0.1778)	(0.4118)	(0.0380)	(0.0476)	(0.2842)
Fixed-effects						
Year	Yes	Yes	Yes	Yes	Yes	Yes
Campground	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	404	1,205	237	1,519	1,344	1,372
R^2	0.87991	0.91206	0.85056	0.92176	0.86949	0.87856
Adjusted R^2	0.85511	0.89867	0.80515	0.91097	0.85032	0.85770
F-test	35.469	68.161	18.730	85.419	45.358	42.111

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Because Region 4 appears to be an outlier compared to the other regions with years of positive and significant changes in capacity utilization, we opt to rerun the aggregate base model without Region 4. Based on previous results, we expect the sign and size of the coefficients to become more negative without the inclusion of Region 4. Shown in Table A.3 in the appendix, coefficients are indeed more negative over the 15 years post wildfire. The significance of coefficients increases for year six. The coefficient for thirteen years after a fire also becomes significant in this model. Region 4's effect on the aggregate result further supports regional differences in suppression strategies. If individuals are less affected by fire in Region 4 in relation to camping demand, suppression efforts could place more focus on letting fires benefit the land. This would allow new methods of management, like the use of potential wildland operation delineations (PODs) to expand into more USFS areas in Region 4.

Additional analyses in the main text and appendix may help in explaining the positive effects of fire on camping reservations experienced by Region 4. To build off the observed regional difference of wildfire on capacity utilization, we also calculated multiple variables to better understand the mechanism affecting capacity utilization. We analyze cumulative burn frequency, the number of times a campground experiences any burn within the 10 km buffer, regional saliency, fire size, land cover, specifically the percent of forested land within the buffered area, and reservation type (local vs. non-local). Of the five mechanisms, we choose to expand discussion on the land cover classification and percentage of local reservations. Results for burn frequency at the aggregate and regional level are shown in Tables A.5 and A.6 in the appendix. Results for regional saliency are shown in Table A.7. Results for fire size are shown in Tables A.8 and A.9 for the aggregate and regional levels, also in the appendix.

Worth discussing are the results from testing the percentage of forested land on capacity utilization (Table 4.4). The table includes two columns: the left column shows the burn percentage in the year the fire takes place and the 15 consecutive lags. The right column shows the interaction between the percentage of forested land in the buffer around a campground with the left column variables. This display allows for easier viewing of the effects over time. We observe that areas with greater forested buffer areas see a greater negative impact in the year of and year after a fire occurs. We find that in later years, the interaction effect between the burn lag and the percentage of forested area become positive for years 10 through 15 (Table 4.4). This positive effect could signal the return of grasses, shrubs and small trees that make a recreation site more desirable. We know that campgrounds in Regions 4, 5, and 6 have greater percentages of forested land in their buffers (Figure 3.3) again indicating the need for regional management of campgrounds as it relates to impacts from wildfires. Region 4 may have the perfect balance of vegetation to increase capacity utilization in the years after fire treatment. When looking at the NLCD interactive viewer using 2013 land cover data, Region 4 has a greater amount of its area defined by shrub and grassland vegetation (Multi-Resolution Land Characteristics Consortium, 2020b). Grasslands will recover faster than areas with higher percentages of forest. Future research should do more to analyze the mechanisms that underlie the positive effects of fire experienced in Region 4.

Table 4.4: Aggregate Model: Percentage of Forested Land, 15 lags, Individual and Time FE

Dependent Variable:	capacity_booked	capacity_booked*percent_forest
Variables		
fire_year	-0.1940*	-0.2360
	(0.1051)	(0.2259)
burnlag1	0.0246	-0.2346**
	(0.0545)	(0.1060)
burnlag2	-0.0105	-0.1703
	(0.0558)	(0.1068)
burnlag3	-0.0640	-0.0494
	(0.0709)	(0.1476)
burnlag4	-0.0442	-0.0502
	(0.0867)	(0.1883)
burnlag5	-0.0391	-0.0457
	(0.0935)	(0.2057)
burnlag6	-0.0386	-0.0190
	(0.1042)	(0.2292)
burnlag7	-0.0562	0.1801
	(0.1139)	(0.2851)
burnlag8	-0.0995	0.2656
	(0.1144)	(0.2943)
burnlag9	-0.1499	0.4286
	(0.1122)	(0.2778)
burnlag10	-0.2229*	0.5070*
	(0.1322)	(0.2990)
burnlag11	-0.3017***	0.7118**
	(0.1147)	(0.2797)
burnlag12	-0.3607***	0.6812**
	(0.1249)	(0.3011)
burnlag13	-0.4055***	0.8300***
	(0.1205)	(0.2940)
burnlag14	-0.3702***	0.8187***
	(0.1058)	(0.2629)
burnlag15	-0.2454**	0.5204*
	(0.1141)	(0.2872)
Fixed-effects		
Year	Yes	
Campground	Yes	
Fit statistics		
Observations	6,081	
R^2	0.88589	
Adjusted R^2	0.87018	
F-test	56.372	

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

At the aggregate level, the impact of fire on the percent local reservations is negative and significant in many years after a fire takes place, as shown in Table 4.5. Negative and significant effects occur in years one, two, six through ten, and thirteen after a fire occurs. Decreases in local reservations could be attributed to greater knowledge of fires in the area and choosing to go elsewhere to camp. At the regional level, shown in Table A.4 in the appendix, a couple years are positive in each region over the fifteen years except for Region 5. The positive effects are possibly related to individuals wanting to see the landscape as it restores. Knowing results are mostly negative in relation to local reservations can influence how campgrounds are advertised or marketed in the future. To make up for the lost capacity utilization from local reservations, campgrounds could work to increase out-of-town visitors. Increases in non-local campers may also benefit the recreation-dependent local communities.

Table 4.5: Aggregate Model: Percentage of Local Reservations, 15 lags, Individual and Time FE

Dependent Variable:	capacity_booked_local
Variables	
fire_year	-0.0683***
	(0.0126)
burnlag1	-0.0165**
	(0.0076)
burnlag2	-0.0157*
	(0.0085)
burnlag3	-0.0042
	(0.0109)
burnlag4	-0.0013
	(0.0119)
burnlag5	-0.0127
	(0.0113)
burnlag6	-0.0362***
	(0.0091)
burnlag7	-0.0443***
	(0.0117)
burnlag8	-0.0370***
	(0.0131)
burnlag9	-0.0336**
	(0.0156)
burnlag10	-0.0276*
	(0.0152)
burnlag11	-0.0117
	(0.0177)
burnlag12	-0.0249
	(0.0164)
burnlag13	-0.0254**
	(0.0124)
burnlag14	-0.0154
	(0.0112)
burnlag15	-0.0145
	(0.0127)
Fixed-effects	
Year	Yes
Campground	Yes
Fit statistics	
Observations	6,080
R^2	0.94138
Adjusted R^2	0.93351
F-test	119.54

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Chapter 5

Conclusion

Our research supports the continued exploration of the impacts of wildfire on recreation demand and how these effects are experienced in the long run. Through the use of MTBS fire perimeter data, NLCD land cover classifications, and RIDB reservation data, we explored many of the variables that can negatively influence camping demand because of wildfire. We find negative effects over six years after a fire occurs for the western U.S. as a whole given the 10 kilometer buffer around campgrounds. These results not only contribute to expanding the literature on wildfire and recreation demand but also have real world implications. Individuals are changing their camping reservations in response to fire indicating potential decreases in well being. Decreases in camping may also effect local communities who are dependent on the seasonal revenue recreation brings to their areas.

The evidence in the aggregate model is useful to wildfire managers before a fire incident occurs and during the management process. ICS-209 reports indicate that fire managers take effort to protect campgrounds when possible noting, "Burnout indirect lines and roads to keep the fire out Phon D Sutton campground and provide a secure line" in Region 3 (Fire and Aviation Management Web Applications, 2017). Managers also indicate that "Infrastructure to a recreational campground damaged" (Fire and Aviation Management Web Applications, 2017). Our analysis provides additional support in the form of observing changing preferences because of physical changes to or near campgrounds caused by fire. The physical attributes of the land affected by wildfire in the buffered area around a campground is reducing capacity utilization for many years after the fire occurs.

We also observed a distinct difference by region in terms of capacity utilization effects. This fact alone supports varying degrees of forest management strategies as they relate to fire. A one size fits all strategy is unlikely to benefit all regions equally as wildfires continue to increase in intensity and frequency. The USFS could use the results in preparation for future fire seasons. Since fire suppression efforts already exceed yearly budgets, the USFS could work to better allocate their resources to protecting campgrounds that receive more reservations when fires are a threat. In this way, more funds would be allocated to more valuable resources. The USFS could also reduce risk at these sites before a fire occurs nearby. Creating a defensible space and removing dead plants could reduce fire risk in the buffered area around a campground and increase the health and visual appeal of the surrounding area.

While the base model and subsequent specification models describe multiple factors relating to a wildfire's negative impact on campsite reservations including percent of forested land or local reservations, economic and social impacts are important to discuss. Wildfires are in fact changing individual behavior related to making camping reservations. Individuals derive many benefits from nature-based recreation including positive physical and mental health benefits as well as an improved sense of community. When individual's choose not to recreate, spillover effects can occur. Buckley (2020) states that poor mental health costs global GDP roughly 10%. Decreases in camping may lead to decreased balance across all aspects of life for individuals and potential financial losses to businesses.

The length of time in which fires reduce campsite reservations may impact local spending. An appeal of camping is getting away from the busyness of life and enjoying the outdoors. Noted earlier, individuals derive multiple benefits from recreation. A reduction in individuals desiring to recreate may decrease local spending in the small towns and communities near campgrounds. This decrease in local spending reduce demand in these areas potentially reducing employment. In communities that are dependent on recreation, reduced capacity utilization could greatly affect their livelihood. The negative impact of wildfires on camping reservations represents a persistent cost to the local communities.

While the analysis described in this thesis covers multiple aspects of fire and their impacts on camping demand, further analysis can benefits multiple groups concerned about the future effects of fire. Future extensions of this research include expanding regressions to the eastern United States, evaluating other mechanisms related to fire that effect capacity utilization, and assessing impacts on recreation demand under different fire scenarios. One mechanism to analyze could be fire type. MTBS data include three fire types: prescribed, wildland fire use, and complex. The majority of the fires are designated wildland fire use leaving little variation to analyze. Incorporating fire type data from an additional data source could provide clarity to the question. Prescribed burns may have different impacts on camping compared to other ignition types like human or natural causes. Another direction could be to incorporate data on walk-up reservations and dispersed camping that are currently not available through *recreation.gov*. If campgrounds are impacted by fire, individuals may choose to camp in dispersed areas nearby that do not have observable fire impacts and vice versa. Proximity to national park boundaries could also be included in future research. Many USFS campgrounds are located near NP boundaries and the impact of wildfire may be different at these popular campgrounds. National parks themselves see large quantities of visitors each year. Analyzing the effect of wildfire on national park campgrounds and visitation could prove useful to the National Park Service. Analysis at the national forest level instead of the USFS regional level may also prove beneficial, especially in relation to reductions in local spending. While this project contributes to the literature though its wide scale analysis, more can still be known about how fires impact recreation in the future. The impact of wildfire on recreation is important to research as the number of recreation participants and wildfires continue to increase.

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Appendix A

Additional Mechanism Regressions

The appendix for additional mechanism regressions includes important fire characteristics we considered when analyzing the effect of wildfire on camping reservations that may not be as indicative of changes in capacity utilization. While important in our process, these results are briefly touched upon in the main text and are included here for those who are interested. This appendix includes regressions for the primary model including leads (Tables A.1 and A.2). aggregate base model without Region 4 (Table A.3), regional effects from the percent of local reservations (Table A.4), cumulative fire frequency effects at the aggregate and regional levels (Tables A.5 and A.6), saliency effects at the aggregate level (Table A.7), and fire size effects at the aggregate and regional levels (Tables A.8 and A.9). Each step we took in analyzing various fire characteristics benefited the results outlined in the main text.

Table A.1: Base Model: Aggregate, 5 leads and 15 lags, Individual and Time FE

Dependent Variable:	capacity_booked
Model:	(1)
Variables	
lead5	0.0337
	(0.0323)
lead4	0.0096
	(0.0332)
lead3	0.0181
	(0.0297)
lead2	0.0120
	(0.0309)
lead1	-0.0165
	(0.0284)
burn_pcts	-0.3170***
	(0.0394)
burnlag1	-0.0868***
	(0.0309)
burnlag2	-0.0911***
	(0.0314)
burnlag3	-0.0906***
	(0.0329)
burnlag4	-0.0750**
	(0.0375)
burnlag5	-0.0721*
	(0.0393)
burnlag6	-0.0623
	(0.0418)
burnlag7	-0.0037
	(0.0421)
burnlag8	-0.0020
	(0.0401)
burnlag9	0.0201
	(0.0442)
burnlag10	-0.0254
	(0.0438)
burnlag11	0.0043
	(0.0413)

burnlag12	-0.0721
	(0.0454)
burnlag13	-0.0498
	(0.0426)
burnlag14	-0.0286
	(0.0382)
burnlag15	-0.0416
	(0.0379)
Fixed-effects	
Year	Yes
LegacyFacilityID	Yes
Fit statistics	
Observations	6,080
R^2	0.88488
Adjusted R^2	0.86932
F-test	56.854

One-way (LegacyFacilityID) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.2: Base Model: Regional, 5 leads and 15 lags, Individual and Time FE

Dependent Variable:	capacity_booked					
Region:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
lead5	0.4782	-0.0311	0.3893*	0.0197	-0.0066	-0.0298
	(0.2864)	(0.1185)	(0.2017)	(0.0299)	(0.0473)	(0.0703)
lead4	-0.2604	-0.0459	0.1170	0.0342	-0.0240	0.0662
	(0.2446)	(0.0799)	(0.2541)	(0.0290)	(0.0524)	(0.0690)
lead3	0.2380	-0.0008	0.0826	0.0299	-0.0759	0.0398
	(0.2117)	(0.0834)	(0.4983)	(0.0203)	(0.0492)	(0.0906)
lead2	-0.1048	-0.0500	0.1093	0.0251	-0.0053	-0.0218
	(0.1990)	(0.0857)	(0.5117)	(0.0244)	(0.0415)	(0.0981)
lead1	-0.2990	-0.0185	-0.0140	0.1008**	-0.0317	-0.1339
	(0.1826)	(0.0893)	(0.5226)	(0.0410)	(0.0442)	(0.0866)
burn_pcts	-0.6347***	-0.4712***	-0.4054	-0.1658***	-0.1844***	-0.2440***
	(0.2185)	(0.1285)	(0.5682)	(0.0531)	(0.0472)	(0.0923)
burnlag1	-0.3323*	-0.1416	-0.0215	0.0283	-0.0676	-0.3196*
	(0.1675)	(0.0937)	(0.5084)	(0.0380)	(0.0578)	(0.1851)
burnlag2	-0.2235	-0.1089	-0.1149	0.0410	-0.0487	-0.2501
	(0.2525)	(0.0950)	(0.5208)	(0.0528)	(0.0467)	(0.2480)
burnlag3	-0.2461*	-0.1298	-0.0835	0.0829	-0.0667	0.2473
	(0.1421)	(0.0926)	(0.4998)	(0.0620)	(0.0562)	(0.2205)
burnlag4	0.0842	-0.1150	-0.1926	0.1246**	-0.0255	0.1170
	(0.2276)	(0.0995)	(0.5429)	(0.0561)	(0.0757)	(0.2776)
burnlag5	-0.2524	-0.1365	-0.1905	0.1523**	-0.0067	-0.2627
	(0.1545)	(0.1011)	(0.5497)	(0.0589)	(0.0588)	(0.2929)
burnlag6	-0.1748	0.0437	-0.1351	0.1718***	0.0188	-0.3575
	(0.1636)	(0.1470)	(0.5561)	(0.0605)	(0.0633)	(0.2918)
burnlag7	-0.4266	0.0606	0.5379	0.2534***	0.0087	-0.3817
	(0.2576)	(0.1328)	(0.8427)	(0.0661)	(0.0562)	(0.2826)
burnlag8	0.0306	0.1015	0.1430	0.1928***	0.0160	-0.3077
	(0.1123)	(0.1272)	(0.9177)	(0.0537)	(0.0550)	(0.2769)
burnlag9	0.0250	0.2201	-0.0538	0.1873***	0.0177	-0.2192
	(0.0956)	(0.1378)	(0.8754)	(0.0447)	(0.0592)	(0.2539)
burnlag10	0.0823	0.1013	0.2415	0.1734***	-0.0705	-0.1978
	(0.0995)	(0.1468)	(0.7668)	(0.0629)	(0.0753)	(0.2510)

burnlag11	0.0166	0.1264	0.2049	0.1705**	-0.0100	-0.2093
	(0.0998)	(0.1612)	(0.7385)	(0.0656)	(0.0785)	(0.2469)
burnlag12	-0.0246	0.2472	0.0580	0.0986	-0.0792	-0.3435
	(0.1012)	(0.1653)	(0.5925)	(0.0751)	(0.0830)	(0.2556)
burnlag13	-0.0596	0.2064	-0.0515	0.0534	-0.0672	-0.3055
	(0.0825)	(0.1709)	(0.6377)	(0.0878)	(0.0767)	(0.2621)
burnlag14	0.0301	0.2439	0.0020	0.0331	-0.0980	-0.3145
	(0.0648)	(0.1810)	(0.6354)	(0.0338)	(0.0661)	(0.2608)
burnlag15	-0.0692	0.2075	-0.0500	0.0160	-0.0539	-0.0542
	(0.0630)	(0.1909)	(0.6430)	(0.0357)	(0.0472)	(0.2923)
Fixed-effects						
Year	Yes	Yes	Yes	Yes	Yes	Yes
LegacyFacilityID	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	402	1,204	236	1,517	1,343	1,371
R^2	0.88239	0.91213	0.85204	0.92196	0.86951	0.87889
Adjusted R^2	0.85621	0.89836	0.80244	0.91091	0.84981	0.85758
F-test	33.710	66.234	17.178	83.452	44.145	41.241

One-way (LegacyFacilityID) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Tables A.1 and A.2 support the lack of effect in the years before fires treat campgrounds. Capacity utilization should not change in the years before fires take place.

Table A.3 removes Region 4 which seems to be an outlier in the main specification. Region 4 experiencing a positive effect supports all the additional mechanisms we test in determining what characteristics of fire are influencing capacity utilization.

Table A.3: Base Model: Aggregate Less Region 4, All Campgrounds, 15 lags, Individual and Time FE

Dependent Variable:	capacity_booked
Variables	
fire_year	-0.3492***
	(0.0406)
burnlag1	-0.1097***
	(0.0242)
burnlag2	-0.1086***
	(0.0249)
burnlag3	-0.1142***
	(0.0271)
burnlag4	-0.1019***
	(0.0330)
burnlag5	-0.1027***
	(0.0371)
burnlag6	-0.0982**
	(0.0403)
burnlag7	-0.0554
	(0.0446)
burnlag8	-0.0314
	(0.0444)
burnlag9	-0.0003
	(0.0505)
burnlag10	-0.0506
	(0.0499)
burnlag11	-0.0154
	(0.0461)
burnlag12	-0.1014**
	(0.0500)
burnlag13	-0.0784*
	(0.0471)
burnlag14	-0.0634
	(0.0444)
burnlag15	-0.0662
	(0.0435)
Fixed-effects	
Year	Yes
Campground	Yes
Fit statistics	
Observations	4,562
R^2	0.86945
Adjusted R^2	0.85118
F-test	47.583

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.4: Regional Model: Percentage of Local Reservations Effects 15 lags, Individual and Time FE

Dependent Variable:	capacity_booked_local					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
fire_year	-0.2436**	-0.1561***	-0.0122	-0.0641***	-0.0383***	-0.0681**
	(0.1033)	(0.0253)	(0.0095)	(0.0182)	(0.0090)	(0.0287)
burnlag1	-0.0879*	-0.0272	0.0145	-0.0045	-0.0096	0.0794
	(0.0450)	(0.0253)	(0.0128)	(0.0191)	(0.0117)	(0.1055)
burnlag2	-0.1212*	0.0054	0.0066	0.0071	-0.0274*	0.1170
	(0.0694)	(0.0207)	(0.0069)	(0.0261)	(0.0158)	(0.1186)
burnlag3	-0.2011	0.0092	0.0011	0.0487	-0.0104	0.1921
	(0.1643)	(0.0232)	(0.0079)	(0.0327)	(0.0185)	(0.1505)
burnlag4	-0.0156	0.0505**	0.0012	0.0281	-0.0374**	0.1260
	(0.0515)	(0.0222)	(0.0093)	(0.0237)	(0.0179)	(0.1426)
burnlag5	-0.1979	0.0304	0.0027	0.0155	-0.0349	0.0985
	(0.1933)	(0.0243)	(0.0062)	(0.0249)	(0.0240)	(0.1362)
burnlag6	-0.1555	-0.0595**	-0.0021	-0.0094	-0.0517*	0.0781
	(0.1244)	(0.0280)	(0.0047)	(0.0220)	(0.0264)	(0.1279)
burnlag7	-0.2492*	-0.0417*	0.0049	0.0031	-0.0639**	0.0787
	(0.1279)	(0.0226)	(0.0204)	(0.0218)	(0.0282)	(0.1277)
burnlag8	0.0126	-0.0790**	0.0284	0.0187	-0.0490**	0.0637
	(0.0422)	(0.0309)	(0.0477)	(0.0287)	(0.0247)	(0.1205)
burnlag9	0.0470	-0.0372	-0.1385	-0.0107	-0.0547**	0.0825
	(0.0466)	(0.0407)	(0.1037)	(0.0245)	(0.0246)	(0.1104)
burnlag10	0.0702*	-0.0607	0.1005	0.0058	-0.0830***	0.0994
	(0.0357)	(0.0375)	(0.0864)	(0.0245)	(0.0295)	(0.1093)
burnlag11	0.0838**	0.0017	0.1393	-0.0077	-0.0771**	0.0758
	(0.0389)	(0.0339)	(0.1173)	(0.0236)	(0.0385)	(0.1096)
burnlag12	0.0353	0.0872**	0.0863	-0.0200	-0.0954**	0.0663
	(0.0391)	(0.0386)	(0.0652)	(0.0280)	(0.0426)	(0.1085)
burnlag13	0.0260	0.0642	0.0541	-0.0105	-0.0764**	0.0499
	(0.0258)	(0.0397)	(0.0419)	(0.0330)	(0.0354)	(0.1081)
burnlag14	0.0250	0.1037**	0.0809	-0.0054	-0.0690***	0.0630
	(0.0273)	(0.0410)	(0.0578)	(0.0107)	(0.0253)	(0.1145)
burnlag15	-0.0063	0.1417***	0.0354	-0.0418***	-0.0196	0.0262
	(0.0180)	(0.0378)	(0.0340)	(0.0147)	(0.0178)	(0.0876)
Fixed-effects						
Year	Yes	Yes	Yes	Yes	Yes	Yes
Campground	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	404	1,205	237	1,519	1,343	1,372
R^2	0.90403	0.95497	0.95281	0.96426	0.93763	0.93777
Adjusted R^2	0.88421	0.94811	0.93848	0.95934	0.92846	0.92708
F-test	45.599	139.37	66.453	195.63	102.27	87.719

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

We include Table A.4 in the appendix to show variation by region in response to the decrease in local reservations. Region 5 seems to have the most persistent effects in the years after fire. Regions 3 and 6 have no significant effects after fire. Future analysis could look at only non-local reservations to understand if capacity utilization reductions are caused by both types of reservations.

Table A.5: Aggregate Model: Burn Frequency Effects, 15 lags, Individual and Time FE

	Dependent variable:
	capacity_booked
fire_year	-0.3297***
	(0.0493)
burnlag1	-0.0909**
	(0.0355)
burnlag2	-0.1680***
	(0.0487)
burnlag3	-0.1631***
	(0.0511)
burnlag4	-0.1389**
	(0.0563)
burnlag5	-0.1965***
	(0.0673)
burnlag6	-0.1734**
	(0.0816)
burnlag7	-0.0379
	(0.1153)
burnlag8	-0.1054
	(0.1202)
burnlag9	-0.0139
	(0.1233)
burnlag10	-0.1330
	(0.1289)
burnlag11	-0.0441
	(0.1184)
burnlag12	0.0269
	(0.1316)
burnlag13	-0.0407
	(0.1246)
burnlag14	-0.0086
	(0.1032)
burnlag15	-0.0274
	(0.0853)
fire_year:burn_freq	0.0366
	(0.6258)
burnlag1:burn_freq	0.0027
	(0.4704)

burnlag2:burn_freq	0.8775
	(0.6595)
burnlag3:burn_freq	0.8629
	(0.7223)
burnlag4:burn_freq	0.7919
	(0.7755)
burnlag5:burn_freq	1.3885
	(0.9111)
burnlag6:burn_freq	1.1580
	(0.9954)
burnlag7:burn_freq	0.5305
	(1.1946)
burnlag8:burn_freq	1.1419
	(1.2630)
burnlag9:burn_freq	0.5374
	(1.2403)
burnlag10:burn_freq	1.1086
	(1.2370)
burnlag11:burn_freq	0.6305
	(1.2035)
burnlag12:burn_freq	-0.5529
	(1.3105)
burnlag13:burn_freq	0.1286
	(1.2504)
burnlag14:burn_freq	-0.0023
	(1.1406)
burnlag15:burn_freq	-0.0379
	(0.9024)
Fixed-effects	
Year	Yes
Campground	Yes
Fit statistics	
Observations	6,081
R^2	0.88547
Adjusted R^2	0.86969
F-test	56.135

Note: *One-way (Campground) standard-errors in parentheses*
$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table A.6: Regional Model: Burn Frequency Effects, 15 lags, Individual and Time FE

	Dependent variable:					
	capacity_booked					
	(1)	(2)	(3)	(4)	(5)	(6)
fire_year	-0.8725*	-0.6687***	0.1340	-0.4499***	-0.0743	-0.2331**
	(0.4592)	(0.2266)	(0.3244)	(0.1293)	(0.1104)	(0.1158)
burnlag1	-0.8201	-0.1904**	-0.0216	-0.1360	0.0315	-0.0724
	(0.4924)	(0.0912)	(0.1241)	(0.0827)	(0.1272)	(0.2274)
burnlag2	-0.3782	-0.2010***	-0.0737	-0.0630	0.0118	-0.3754
	(0.6238)	(0.0705)	(0.1301)	(0.1881)	(0.1043)	(0.2828)
burnlag3	-0.3128	-0.1880***	-0.1569	0.1628	0.0112	0.2828
	(0.4300)	(0.0477)	(0.2417)	(0.1420)	(0.1432)	(0.2892)
burnlag4	-0.2609	-0.1627***	-0.2593	0.1281	0.2745*	-0.4945
	(0.7136)	(0.0463)	(0.1821)	(0.1930)	(0.1552)	(1.1660)
burnlag5	-1.1561**	-0.2461***	-0.5728	0.3182**	0.1243	1.4238
	(0.5383)	(0.0552)	(0.4352)	(0.1554)	(0.2073)	(0.9540)
burnlag6	-1.3334**	-0.2247	-0.2487	0.3915**	0.2944	1.1787
	(0.6051)	(0.4712)	(0.2465)	(0.1549)	(0.2025)	(0.9283)
burnlag7	-1.3313*	-0.0332	-0.9036	0.4426***	0.2720	1.6390*
	(0.7872)	(0.4347)	(1.4972)	(0.1485)	(0.1865)	(0.8735)
burnlag8	-0.5765	-0.1592	-0.0340	0.3291**	0.1824	1.2622
	(0.4678)	(0.4421)	(2.3746)	(0.1419)	(0.2060)	(0.8615)
burnlag9	-0.7650	-0.1646	-1.5807	0.2927**	0.3985**	1.4131*
	(0.4824)	(0.4506)	(1.5529)	(0.1209)	(0.1898)	(0.8334)
burnlag10	-0.5031	-0.3438	-0.7921	0.0698	0.0436	1.3514*
	(0.4140)	(0.4579)	(2.5405)	(0.2209)	(0.2100)	(0.7894)
burnlag11	-0.4279	-0.3810	-2.0164	0.6091***	0.2758	1.3946*
	(0.3480)	(0.4502)	(1.6941)	(0.1633)	(0.1979)	(0.7676)
burnlag12	-0.5669	-0.2535	-2.2953	0.3173	0.3726*	1.7551**
	(0.4457)	(0.4500)	(2.2458)	(0.2740)	(0.2151)	(0.7521)
burnlag13	-0.3567	-0.2710	-3.1282	0.1103	0.2951	1.3567*
	(0.3190)	(0.4580)	(2.2529)	(0.2480)	(0.2003)	(0.7113)
burnlag14	-0.1952	-0.2295	-2.9994	0.4411**	-0.1120	1.2602*
	(0.2404)	(0.4658)	(2.3201)	(0.1796)	(0.1337)	(0.6756)
burnlag15	-0.4183*	-0.3112	-2.8041	0.5583**	-0.0394	1.7870**
	(0.2116)	(0.4790)	(2.2192)	(0.2146)	(0.1019)	(0.7423)
fire_year:burn_freq	1.1036	4.5635	-8.9623	3.2458**	-0.6048	0.2164
	(5.1321)	(3.0465)	(6.5592)	(1.3768)	(0.5891)	(2.4148)
burnlag1:burn_freq	6.1486	1.6314	-0.4929	1.2817	-0.5554	-2.8114
	(4.5961)	(1.1219)	(2.8267)	(1.0200)	(0.6894)	(4.0697)

burnlag2:burn_freq	1.1925	2.4431**	-0.8290	0.7199	-0.3685	2.3311
	(6.6794)	(1.1271)	(1.6412)	(1.5110)	(0.5701)	(4.6491)
burnlag3:burn_freq	0.5587	1.7305***	0.7693	-0.8524	-0.4689	-0.2718
	(4.7492)	(0.6058)	(3.2099)	(1.3283)	(0.7127)	(4.0132)
burnlag4:burn_freq	4.2975	1.5536*	1.8005	-0.3928	-1.6868*	3.5088
	(7.8514)	(0.8470)	(3.1321)	(1.5280)	(0.8776)	(8.1435)
burnlag5:burn_freq	12.4493**	2.7296***	7.5617	-1.4409	-0.7686	-13.2047
	(6.0472)	(0.8668)	(7.4460)	(1.3738)	(1.0000)	(8.2988)
burnlag6:burn_freq	14.8165**	4.5638	2.6168	-1.9090	-1.5358	-12.6798
	(6.2252)	(7.2374)	(4.3630)	(1.3991)	(0.9888)	(8.2031)
burnlag7:burn_freq	11.6800	1.5579	9.9338	-1.3321	-1.4526	-15.8535**
	(7.9712)	(6.0825)	(11.1706)	(1.3454)	(0.8970)	(7.9950)
burnlag8:burn_freq	8.0029*	4.3226	0.4524	-1.0625	-0.8614	-12.6316
	(4.4111)	(6.0339)	(18.4798)	(1.2651)	(1.0096)	(7.9063)
burnlag9:burn_freq	10.2522**	6.5378	12.3222	-0.8789	-2.0864**	-12.7481
	(4.8201)	(5.8988)	(12.1931)	(1.2124)	(0.9787)	(7.8276)
burnlag10:burn_freq	7.6320*	8.8501	8.9971	1.1658	-0.7009	-12.2469*
	(3.8358)	(6.9632)	(21.7155)	(1.6310)	(1.0478)	(7.1828)
burnlag11:burn_freq	5.9166*	10.1512	18.2763	-5.4473***	-1.6941*	-12.6495*
	(3.1514)	(6.7502)	(14.4932)	(1.7450)	(0.9762)	(6.8440)
burnlag12:burn_freq	6.9261	10.2210	20.6792	-2.8398	-2.6983**	-15.7926**
	(4.2341)	(6.5788)	(19.4660)	(3.8363)	(1.0615)	(6.7097)
burnlag13:burn_freq	3.9329	9.6809	25.3835	-0.6555	-2.0866**	-13.0367**
	(3.1359)	(6.9465)	(19.7875)	(3.1150)	(1.0271)	(6.5321)
burnlag14:burn_freq	2.9166	9.6219	25.0264	-6.5885**	-0.0959	-12.4841**
	(2.5750)	(7.4068)	(20.0349)	(2.8138)	(0.7091)	(6.1345)
burnlag15:burn_freq	4.4750**	10.5333	23.6995	-8.7748**	0.0110	-12.6578**
	(1.8655)	(8.3140)	(19.4430)	(3.4212)	(0.5343)	(5.6235)
Fixed-effects						
Year	Yes	Yes	Yes	Yes	Yes	Yes
Campground	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	404	1,205	237	1,519	1,344	1,372
R^2	0.88548	0.91357	0.89261	0.92325	0.87124	0.88026
Adjusted R^2	0.85487	0.89887	0.84640	0.91161	0.85029	0.85775
F-test	28.926	62.154	19.316	79.275	41.572	39.096

Note: *One-way (Campground) standard-errors in parentheses*
*p<0.1; **p<0.05; ***p<0.01

Tables A.5 and A.6 analyze the effects of frequent burns on campground buffers. We observe negative coefficients in later years for Regions 4, 5, and 6. The coefficients in the later years are also larger in magnitude supporting the idea that increases in frequency of fires treating campground buffers reduce capacity utilization. Region 1 experiences some positive effects in later years related to burn frequency.

Table A.7: Aggregate Model: Saliency Effects, 15 lags, Individual and Time FE

	Dependent variable:
	capacity_booked
fire_year	-0.3154***
	(0.0625)
burnlag1	0.0316
	(0.0858)
burnlag2	0.0284
	(0.0918)
burnlag3	0.0243
	(0.0910)
burnlag4	-0.0406
	(0.0858)
burnlag5	-0.0499
	(0.0682)
burnlag6	-0.0113
	(0.0746)
burnlag7	0.2176*
	(0.1194)
burnlag8	0.0914
	(0.1228)
burnlag9	0.1111
	(0.1281)
burnlag10	0.1708
	(0.1302)
burnlag11	0.1601
	(0.1413)
burnlag12	-0.0677
	(0.1280)
burnlag13	-0.0183
	(0.1052)
burnlag14	-0.1443
	(0.1075)
burnlag15	-0.1565
	(0.1280)
saliency	0.0016
	(0.0012)
fire_year:saliency	0.0127*
	(0.0075)

burnlag1:saliency	0.0013
	(0.0095)
burnlag2:saliency	-0.0014
	(0.0101)
burnlag3:saliency	-0.0066
	(0.0106)
burnlag4:saliency	0.0029
	(0.0136)
burnlag5:saliency	0.0049
	(0.0096)
burnlag6:saliency	0.0038
	(0.0079)
burnlag7:saliency	-0.0105
	(0.0092)
burnlag8:saliency	-0.0074
	(0.0089)
burnlag9:saliency	-0.0115
	(0.0092)
burnlag10:saliency	-0.0138
	(0.0093)
burnlag11:saliency	-0.0131
	(0.0095)
burnlag12:saliency	-0.0075
	(0.0090)
burnlag13:saliency	-0.0112
	(0.0091)
burnlag14:saliency	-0.0047
	(0.0089)
burnlag15:saliency	-0.0066
	(0.0114)
Fixed-effects	
Year	Yes
Fit statistics	
Observations	4,799
R^2	0.06469
Adjusted R^2	0.05643
F-test	7.8319

One-way (LegacyFacilityID) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table A.7 shows minimal effects related to regional treatments. For instance, Region 5 having more treated campgrounds than Region 1 seems to have no significant effect on capacity utilization. There are likely other factors that are more important to campers.

Tables A.8 and A.9 also show minimal effects, this time relating to fire size. While some significant effects are observable at the aggregate and regional levels, the scale in which fire size effects capacity utilization is minimal. Still, fire size effects vacillate between positive and negative effects on capacity utilization.

Table A.8: Aggregate Model: Fire Size Effects, 15 lags Individual and Time FE

	Dependent variable:
	capacity_booked
fire_year	-0.4551***
	(0.0690)
burnlag1	-0.0815***
	(0.0186)
burnlag2	-0.0928***
	(0.0229)
burnlag3	-0.0930***
	(0.0254)
burnlag4	-0.0692**
	(0.0313)
burnlag5	-0.0708**
	(0.0348)
burnlag6	-0.0571
	(0.0385)
burnlag7	0.0006
	(0.0382)
burnlag8	0.0420
	(0.0376)
burnlag9	0.0341
	(0.0412)
burnlag10	-0.0191
	(0.0400)
burnlag11	0.0099
	(0.0398)
burnlag12	-0.0754*
	(0.0440)
burnlag13	-0.0486
	(0.0414)
burnlag14	-0.0166
	(0.0362)
burnlag15	-0.0424
	(0.0376)
acres	0.0000
	(0.0000)
fire_year:acres	0.0000**
	(0.0000)

burnlag1:acres	-0.0000
	(0.0000)
burnlag2:acres	0.0000
	(0.0000)
burnlag3:acres	0.0001***
	(0.0000)
burnlag4:acres	0.0000
	(0.0000)
burnlag5:acres	0.0000*
	(0.0000)
burnlag6:acres	0.0000
	(0.0000)
burnlag7:acres	-0.0000**
	(0.0000)
burnlag8:acres	-0.0000**
	(0.0000)
burnlag9:acres	-0.0000
	(0.0000)
burnlag10:acres	-0.0000
	(0.0000)
burnlag11:acres	0.0000
	(0.0000)
burnlag12:acres	0.0000
	(0.0000)
burnlag13:acres	0.0000
	(0.0000)
burnlag14:acres	-0.0000**
	(0.0000)
burnlag15:acres	0.0000
	(0.0000)
Fixed-effects	
Year	Yes
Campground	Yes
Fit statistics	
Observations	6,081
R^2	0.88596
Adjusted R^2	0.87023
F-test	56.322

Note: *One-way (Campground) standard-errors in parentheses*
*p<0.1; **p<0.05; ***p<0.01

Table A.9: Regional Model: Fire Size Effects, 15 lags Individual and Time FE

	Dependent variable:					
	capacity_booked					
	(1)	(2)	(3)	(4)	(5)	(6)
fire_year	-0.7618**	-1.6923***	-2.4659**	-0.2717	-0.1275*	-0.3420
	(0.3055)	(0.3805)	(0.9303)	(0.1777)	(0.0664)	(0.3160)
burnlag1	-0.3335**	-0.1034***	-0.0953	0.0095	-0.0156	-0.2600*
	(0.1498)	(0.0381)	(0.0726)	(0.0359)	(0.0641)	(0.1548)
burnlag2	-0.1644	-0.0670*	-0.1521**	0.0175	-0.0380	-0.1232
	(0.2257)	(0.0376)	(0.0675)	(0.0509)	(0.0456)	(0.2179)
burnlag3	-0.1545	-0.0899***	-0.2066***	0.0629	-0.0640	0.2757
	(0.1135)	(0.0342)	(0.0743)	(0.0604)	(0.0593)	(0.2068)
burnlag4	0.1332	-0.0754**	-0.2243***	0.0940	0.0201	0.5100
	(0.2117)	(0.0363)	(0.0654)	(0.0573)	(0.0748)	(0.3184)
burnlag5	-0.2067	-0.0903*	-0.2145***	0.1335**	-0.0070	-0.1587
	(0.1355)	(0.0497)	(0.0671)	(0.0595)	(0.0568)	(0.2695)
burnlag6	-0.1381	0.0689	-0.1854**	0.1478**	0.0485	-0.2625
	(0.1542)	(0.1331)	(0.0730)	(0.0595)	(0.0626)	(0.2678)
burnlag7	-0.3892	0.0836	0.4548	0.2386***	0.0388	-0.2915
	(0.2560)	(0.1060)	(0.5096)	(0.0668)	(0.0569)	(0.2510)
burnlag8	0.0507	0.1201	0.3750	0.2185***	0.0681	-0.0711
	(0.1060)	(0.1085)	(0.5010)	(0.0534)	(0.0598)	(0.2545)
burnlag9	0.0199	0.0844	-0.0339	0.1749***	0.0869	-0.1452
	(0.0910)	(0.1259)	(0.4689)	(0.0454)	(0.0654)	(0.2211)
burnlag10	0.0779	0.0821	0.2125	0.1555**	-0.0057	-0.1147
	(0.0923)	(0.1238)	(0.3250)	(0.0633)	(0.0715)	(0.2161)
burnlag11	0.0262	0.0977	0.1999	0.1713**	0.0391	-0.1556
	(0.0997)	(0.1409)	(0.3829)	(0.0708)	(0.0839)	(0.2266)
burnlag12	-0.0322	0.2218	-0.0595	0.1047	-0.0672	-0.2809
	(0.1009)	(0.1434)	(0.3910)	(0.0719)	(0.0880)	(0.2262)
burnlag13	-0.0488	0.1825	-0.0118	0.0228	-0.0486	-0.1915
	(0.0775)	(0.1513)	(0.4152)	(0.0897)	(0.0784)	(0.2206)
burnlag14	0.0348	0.2088	-0.2370	0.0301	-0.0601	-0.2208
	(0.0632)	(0.1630)	(0.3015)	(0.0335)	(0.0735)	(0.2408)
burnlag15	-0.0670	0.1951	-0.0031	0.0112	-0.0593	-0.0872
	(0.0606)	(0.1751)	(0.4353)	(0.0385)	(0.0466)	(0.2367)
acres	-0.0000	0.0000	-0.0000	-0.0000***	-0.0000	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
fire_year:acres	-0.0000	0.0000***	0.0000	0.0000	-0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

burnlag1:acres	0.0000	-0.0013***	-0.0000	-0.0001***	-0.0000*	0.0003
	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0002)
burnlag2:acres	-0.0019***		-0.0000	-0.0001**	0.0000***	-0.0004
	(0.0004)		(0.0001)	(0.0000)	(0.0000)	(0.0003)
burnlag3:acres	0.0019***		-0.0000	-0.0015***	0.0000	-0.0000
	(0.0005)		(0.0004)	(0.0001)	(0.0000)	(0.0001)
burnlag4:acres		-0.0027	0.0002	0.0000**	-0.0001***	-0.0004***
		(0.0024)	(0.0004)	(0.0000)	(0.0000)	(0.0001)
burnlag5:acres		0.0001***	0.0002	-0.0002***	0.0001**	0.0001
		(0.0000)	(0.0003)	(0.0001)	(0.0000)	(0.0001)
burnlag6:acres	-0.0001		0.0002**	0.0000**	-0.0000***	0.0005***
	(0.0001)		(0.0001)	(0.0000)	(0.0000)	(0.0001)
burnlag7:acres	-0.0001		-0.0000	0.0004	-0.0000	-0.0014***
	(0.0001)		(0.0000)	(0.0009)	(0.0000)	(0.0002)
burnlag8:acres	0.0004***	-0.0000	-0.0002	-0.0000**	-0.0000	0.0001**
	(0.0001)	(0.0000)	(0.0002)	(0.0000)	(0.0000)	(0.0000)
burnlag9:acres	0.0000***	0.0004***	0.0005**	-0.0000	0.0000	-0.0000
	(0.0000)	(0.0001)	(0.0003)	(0.0001)	(0.0000)	(0.0000)
burnlag10:acres		0.0000	0.0001	-0.0000	0.0000	0.0000
		(0.0000)	(0.0001)	(0.0000)	(0.0000)	(0.0000)
burnlag11:acres	0.0000*	0.0002***	0.0003*	0.0001***	-0.0002***	-0.0000
	(0.0000)	(0.0000)	(0.0002)	(0.0000)	(0.0001)	(0.0000)
burnlag12:acres	0.0000		0.0006	-0.0001	0.0000**	0.0000*
	(0.0000)		(0.0007)	(0.0002)	(0.0000)	(0.0000)
burnlag13:acres			-0.0006	0.0004***	0.0000	-0.0035***
			(0.0005)	(0.0001)	(0.0000)	(0.0001)
burnlag14:acres		-0.0040***	0.0001*	-0.0119***	-0.0000	0.0000
		(0.0003)	(0.0001)	(0.0011)	(0.0000)	(0.0000)
burnlag15:acres	-0.6607***	0.0022***	0.0001***	0.0007***	0.0000***	0.0007*
	(0.1838)	(0.0004)	(0.0000)	(0.0001)	(0.0000)	(0.0004)
Fixed-effects						
Year	Yes	Yes	Yes	Yes	Yes	Yes
Campground	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	404	1,205	237	1,519	1,344	1,372
R^2	0.88336	0.91592	0.90619	0.92311	0.87306	0.88528
Adjusted R^2	0.85402	0.90209	0.86500	0.91138	0.85227	0.86359
F-test	30.108	66.255	22.002	78.666	41.994	40.814

Note: *One-way (Campground) standard-errors in parentheses*
*p<0.1; **p<0.05; ***p<0.01

Appendix B

Robustness Checks

The appendix for robustness checks includes two checks at the aggregate and regional levels. One check relates to the capacity utilization measurement. As noted in the text, we choose to omit campgrounds with zero values at random intervals within the data, choosing only to keep campgrounds that have zeros at the beginning of the data, implying late additions to *recreation.gov*, and campgrounds with capacity utilization values greater than zero for all years of data. To ensure the validity of our results, we also run the aggregate and regional regressions using only campgrounds with capacity utilization values greater than zero for all years 2008-2007. Using this method, we lose 951 observations. Our results are qualitatively similar to the base models, shown in Table 4.2 in the main text and Table B.1 with same significance levels and signs for the six years after a fire takes place.

We also complete a robustness check on the size of the buffered area surrounding the campgrounds at the aggregate and regional levels. We follow the same steps in calculating a 10 km buffer, instead creating both 5 and 20 km buffers. Results are qualitatively similar with the same sign and significance of coefficients. Coefficients are slightly larger in the 20 km buffer estimates compared to the 10 km specification. Coefficients are slightly smaller in the 5 km buffer estimates compared to the 10 km specification. This makes sense as a 1% increase in burned area within the buffer is a much larger area in a 20 km buffer than a 5 km buffer.

Table B.1: Regional Model: Campgrounds with Capacity Data for all years (2008-2017)

Dependent Variable:	capacity_booked					
Region:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
fire_year	-0.6937***	-0.4428***	-0.4686***	-0.1996***	-0.1605***	-0.2590***
	(0.1811)	(0.0886)	(0.1114)	(0.0508)	(0.0520)	(0.0811)
burnlag1	-0.3533***	-0.1254***	-0.1254*	0.0129	-0.0543	-0.1832
	(0.1144)	(0.0424)	(0.0645)	(0.0362)	(0.0637)	(0.2032)
burnlag2	-0.2292	-0.0813**	-0.1995**	0.0426	-0.0333	-0.3924
	(0.2065)	(0.0384)	(0.0733)	(0.0498)	(0.0422)	(0.2791)
burnlag3	-0.2822***	-0.1022**	-0.1135	0.0792	-0.1322**	0.2328
	(0.0956)	(0.0393)	(0.1089)	(0.0616)	(0.0571)	(0.2050)
burnlag4	0.0846	-0.0610*	-0.2657***	0.1236**	-0.1227	0.0258
	(0.1991)	(0.0347)	(0.0743)	(0.0578)	(0.1030)	(0.2427)
burnlag5	-0.2441*	-0.0883*	-0.2820***	0.1544**	-0.0296	-0.1311
	(0.1255)	(0.0500)	(0.0740)	(0.0651)	(0.0640)	(0.2229)
burnlag6	-0.1685	-0.0241	-0.1728**	0.1862***	-0.0089	-0.1032
	(0.1953)	(0.0990)	(0.0684)	(0.0672)	(0.0749)	(0.2172)
burnlag7	-0.5427*	0.0274	0.4941	0.2748***	-0.0293	-0.2205
	(0.2847)	(0.1010)	(0.5566)	(0.0716)	(0.0633)	(0.2165)
burnlag8	0.0692	0.0776	0.2168	0.1974***	-0.0193	-0.1383
	(0.0868)	(0.0966)	(0.5107)	(0.0558)	(0.0608)	(0.2039)
burnlag9	0.0113	0.2059*	-0.0361	0.1864***	-0.0186	-0.0698
	(0.0772)	(0.1126)	(0.5263)	(0.0455)	(0.0641)	(0.1833)
burnlag10	0.1152*	0.0452	0.3830	0.1713**	-0.1225	-0.0606
	(0.0675)	(0.1078)	(0.4632)	(0.0671)	(0.0815)	(0.1836)
burnlag11	0.0539	0.0527	0.2340	0.1137*	-0.0227	-0.1158
	(0.0891)	(0.1195)	(0.4301)	(0.0679)	(0.0861)	(0.1904)
burnlag12	0.0505	0.2092	0.4345	0.1022	-0.1192	-0.1860
	(0.0636)	(0.1315)	(0.4399)	(0.0735)	(0.0865)	(0.1975)
burnlag13	-0.0233	0.1674	-0.1102	0.0699	-0.0973	-0.1712
	(0.0650)	(0.1385)	(0.3879)	(0.0868)	(0.0811)	(0.1941)
burnlag14	0.0481	0.2110	-0.1006	0.0380	-0.1147	-0.1846
	(0.0609)	(0.1552)	(0.3900)	(0.0340)	(0.0695)	(0.2114)
burnlag15	-0.0668	0.1743	-0.0682	0.0208	-0.0747	-0.2306
	(0.0488)	(0.1708)	(0.4316)	(0.0335)	(0.0469)	(0.1441)
Fixed-effects						
Year	Yes	Yes	Yes	Yes	Yes	Yes
Campground	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	330	1,000	200	1,410	1,090	1,100
R^2	0.89378	0.91866	0.84410	0.92010	0.86927	0.88801
Adjusted R^2	0.87152	0.90713	0.79984	0.90951	0.85108	0.87246
F-test	40.154	79.694	19.073	86.825	47.795	57.103

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table B.2: Robustness Model: Aggregate with 5 km buffer, 15 lags, Campground and Time FE

Dependent Variable:	capacity_booked
Variables	
fire_year	-0.2458***
	(0.0361)
burnlag1	-0.0610***
	(0.0162)
burnlag2	-0.0592***
	(0.0186)
burnlag3	-0.0677***
	(0.0209)
burnlag4	-0.0630**
	(0.0248)
burnlag5	-0.0714***
	(0.0263)
burnlag6	-0.0690**
	(0.0278)
burnlag7	-0.0452
	(0.0282)
burnlag8	-0.0404
	(0.0298)
burnlag9	-0.0253
	(0.0282)
burnlag10	-0.0343
	(0.0274)
burnlag11	-0.0332
	(0.0273)
burnlag12	-0.0916***
	(0.0316)
burnlag13	-0.0730**
	(0.0321)
burnlag14	-0.0520*
	(0.0293)
burnlag15	-0.0638**
	(0.0287)
Fixed-effects	
Year	Yes
Campground	Yes
Fit statistics	
Observations	6,081
R^2	0.88430
Adjusted R^2	0.86876
F-test	56.900

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table B.3: Robustness Model: Regional with 5 km buffer, 15 lags, Campground and Time FE

Dependent Variable:	capacity_booked					
Region:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
fire_year	-0.2424**	-0.3497***	-0.4237***	-0.2422***	-0.0938***	-0.1337**
	(0.1177)	(0.0709)	(0.1278)	(0.0472)	(0.0307)	(0.0516)
burnlag1	-0.1593*	-0.0807**	-0.0819	0.0254	-0.0282	-0.0290
	(0.0855)	(0.0335)	(0.0606)	(0.0386)	(0.0364)	(0.0509)
burnlag2	-0.0827	-0.0619**	-0.1489**	0.0303	-0.0335	-0.0823
	(0.1110)	(0.0311)	(0.0576)	(0.0392)	(0.0271)	(0.0903)
burnlag3	-0.1052	-0.0643**	-0.1279*	0.0566	-0.0750***	0.0739
	(0.0815)	(0.0295)	(0.0722)	(0.0455)	(0.0267)	(0.0464)
burnlag4	0.0112	-0.0595*	-0.2130***	0.1028***	-0.0650	0.1270*
	(0.1001)	(0.0350)	(0.0604)	(0.0370)	(0.0399)	(0.0688)
burnlag5	-0.1100	-0.0866*	-0.2210***	0.1299***	-0.0747***	-0.2674**
	(0.0755)	(0.0475)	(0.0638)	(0.0469)	(0.0279)	(0.1238)
burnlag6	-0.0959	0.1155	-0.1804***	0.1465***	-0.0744**	-0.3149**
	(0.0768)	(0.1552)	(0.0591)	(0.0485)	(0.0347)	(0.1243)
burnlag7	-0.1660	0.1181	0.1139	0.1857***	-0.0528*	-0.3178**
	(0.1214)	(0.1347)	(0.3056)	(0.0448)	(0.0288)	(0.1340)
burnlag8	-0.0113	0.1130	-0.2023	0.1646***	-0.0781**	-0.2616**
	(0.0850)	(0.1296)	(0.4743)	(0.0441)	(0.0347)	(0.1238)
burnlag9	-0.0071	0.2167	-0.2902	0.1454***	-0.0697**	-0.2728**
	(0.0729)	(0.1310)	(0.2874)	(0.0377)	(0.0347)	(0.1289)
burnlag10	0.0084	0.1385	-0.0539	0.1653***	-0.0742*	-0.2713**
	(0.0822)	(0.1291)	(0.2286)	(0.0390)	(0.0384)	(0.1281)
burnlag11	0.0135	0.1352	-0.1272	0.1262**	-0.0694	-0.2622**
	(0.0805)	(0.1336)	(0.2203)	(0.0517)	(0.0541)	(0.1227)
burnlag12	-0.0526	0.2208*	-0.2341	0.0954	-0.1249**	-0.3507***
	(0.0798)	(0.1302)	(0.2187)	(0.0583)	(0.0522)	(0.1299)
burnlag13	-0.0499	0.1839	-0.3017	0.1036*	-0.0873*	-0.3422**
	(0.0532)	(0.1310)	(0.2426)	(0.0549)	(0.0485)	(0.1606)
burnlag14	-0.0175	0.2040	-0.2678	0.0615*	-0.1267***	-0.2961**
	(0.0464)	(0.1309)	(0.2432)	(0.0330)	(0.0304)	(0.1270)
burnlag15	-0.0744	0.1728	-0.3371	0.0452	-0.0688**	-0.2162**
	(0.0555)	(0.1382)	(0.2591)	(0.0315)	(0.0311)	(0.1025)
Fixed-effects						
Year	Yes	Yes	Yes	Yes	Yes	Yes
Campground	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	404	1,205	237	1,519	1,344	1,372
R^2	0.87579	0.91136	0.85266	0.92225	0.86912	0.87845
Adjusted R^2	0.85013	0.89788	0.80789	0.91153	0.84989	0.85757
F-test	34.129	67.576	19.045	85.998	45.208	42.068

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table B.4: Robustness Model: Aggregate with 20 km buffer, 15 lags, Campground and Time FE

Dependent Variable:	capacity_booked
Variables	
fire_year	-0.3683***
	(0.0421)
burnlag1	-0.1083***
	(0.0249)
burnlag2	-0.1393***
	(0.0335)
burnlag3	-0.1294***
	(0.0345)
burnlag4	-0.1293***
	(0.0408)
burnlag5	-0.1174**
	(0.0467)
burnlag6	-0.0880*
	(0.0524)
burnlag7	-0.0287
	(0.0476)
burnlag8	-0.0307
	(0.0484)
burnlag9	0.0348
	(0.0549)
burnlag10	-0.0553
	(0.0570)
burnlag11	0.0008
	(0.0554)
burnlag12	-0.0707
	(0.0598)
burnlag13	-0.1037
	(0.0772)
burnlag14	-0.0606
	(0.0524)
burnlag15	-0.0459
	(0.0474)
Fixed-effects	
Year	Yes
Campground	Yes
Fit statistics	
Observations	6,081
R^2	0.88371
Adjusted R^2	0.86809
F-test	56.572

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table B.5: Robustness Model: Regional with 20 km buffer, 15 lags, Campground and Time FE

Dependent Variable:	capacity_booked					
Region:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
fire_year	-0.4979	-0.8027***	-0.4774***	-0.1637***	-0.1698**	-0.5129***
	(0.3783)	(0.1515)	(0.0688)	(0.0618)	(0.0663)	(0.1640)
burnlag1	-0.0980	-0.2150***	-0.0844	-0.0047	-0.0238	-0.4816
	(0.3432)	(0.0699)	(0.0637)	(0.0410)	(0.0673)	(0.4288)
burnlag2	-0.2914	-0.1960**	-0.2063**	0.0348	-0.0495	0.0439
	(0.3593)	(0.0785)	(0.0880)	(0.0633)	(0.0670)	(0.5336)
burnlag3	-0.1708	-0.2374***	-0.1438	0.0799	-0.0366	0.9635
	(0.3030)	(0.0773)	(0.1456)	(0.0753)	(0.0655)	(0.6930)
burnlag4	-0.0800	-0.2173**	-0.2942***	0.0502	-0.0194	0.6644
	(0.3303)	(0.0868)	(0.0985)	(0.0805)	(0.1248)	(0.5440)
burnlag5	-0.3448	-0.2604**	-0.3180***	0.1146	0.0319	-0.0751
	(0.3838)	(0.1055)	(0.0925)	(0.0766)	(0.0790)	(0.5694)
burnlag6	-0.2533	0.0061	-0.2500**	0.1484**	0.0569	-0.4090
	(0.3042)	(0.1637)	(0.1052)	(0.0731)	(0.1041)	(0.5115)
burnlag7	-0.3666	0.0286	0.1584	0.2711***	-0.0252	-0.3719
	(0.3398)	(0.1376)	(0.6506)	(0.0953)	(0.0791)	(0.4688)
burnlag8	0.1180	0.0918	0.1199	0.1930**	0.0048	-0.2432
	(0.1959)	(0.1494)	(0.6836)	(0.0767)	(0.0779)	(0.4424)
burnlag9	0.1350	0.1487	0.1425	0.2093***	0.0507	0.0113
	(0.1832)	(0.1663)	(0.6879)	(0.0709)	(0.0824)	(0.4345)
burnlag10	0.2176	-0.0015	0.4475	0.1260	-0.1753*	0.0404
	(0.1633)	(0.1574)	(0.7304)	(0.1002)	(0.0978)	(0.4334)
burnlag11	0.1541	0.0300	0.1996	0.3373**	-0.0831	0.0391
	(0.1658)	(0.1697)	(0.7159)	(0.1327)	(0.1097)	(0.4398)
burnlag12	0.1139	0.1332	0.0246	0.3854***	-0.0994	-0.1959
	(0.1640)	(0.1783)	(0.7345)	(0.1231)	(0.1132)	(0.4388)
burnlag13	0.1033	0.0319	-0.1660	-0.0747	-0.2762	-0.1135
	(0.1150)	(0.1843)	(0.7085)	(0.1540)	(0.2060)	(0.4192)
burnlag14	0.2052	0.0500	-0.0630	0.0497	-0.2214**	-0.2237
	(0.1280)	(0.1899)	(0.7116)	(0.0679)	(0.1073)	(0.4386)
burnlag15	-0.0043	0.0323	-0.1894	0.0224	-0.0622	0.5165
	(0.0756)	(0.1788)	(0.7381)	(0.0597)	(0.0881)	(0.4575)
Fixed-effects						
Year	Yes	Yes	Yes	Yes	Yes	Yes
Campground	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	404	1,205	237	1,519	1,344	1,372
R^2	0.87442	0.90994	0.84172	0.92145	0.87047	0.88078
Adjusted R^2	0.84847	0.89623	0.79362	0.91062	0.85145	0.86030
F-test	33.704	66.402	17.501	85.048	45.753	43.004

One-way (Campground) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*