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# Reductions in National Forest Campground Reservation Demand from Wildfire

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The impacts of wildfire are widely felt across the United States and expected to increase in coming years. However, little is known about the long-term impacts of wildfire on recreation. We evaluate the impact of wildfire on reservations to US Forest Service (USFS) campgrounds and find that wildfires decrease camping reservations up to 6 years after a fire occurs. The impacts vary across USFS regions, and our analysis reveals the important role of forest cover in determining the magnitude and duration of impacts. Our results imply that wildfires reduce benefits to campers, which can translate into less spending in nearby communities.

*Key words*: camping, recreation

## Introduction

Wildfire activity in the western United States has increased in recent decades due to many factors, including lengthening fire seasons, greater levels of fuel accumulation from past suppression strategies, and an expanding wildland–urban interface (Riley et al., 2018; Robichaud, Rhee, and Lewis, 2014). Little is known about the long-term impacts of wildfire on recreation sites, specifically campgrounds. Wildfires are likely to diminish recreation site quality and create unsafe conditions for some time after the fire occurs. At the same time, the number of individuals recreating is expected to increase in the coming years (Bowker et al., 2006). Our objective is to quantify the long-term impacts of wildfire on campground use in the western United States.

We build a dataset of camping reservations covering 2008–2017 and wildfire perimeters dating back to 1984 to investigate how reservations change in response to nearby wildfires. The dependent variable in the empirical analysis is an annual capacity utilization measure for each campground. The results reveal that wildfires significantly decrease reservations up to 6 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 decreases in campground reservations can have negative impacts at aggregate and local levels. Over the 10 years of reservation data, fires impacted 794 campgrounds (average of 60 campgrounds per year). We can expect the negative impact to increase as recreation and wildfire risk increase in the future. Our analysis suggests that wildfires continue to impact rural communities long after the fire is over, as declines in camping translate to reduced spending in local communities.

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## Background

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 often spreading across a large portion of the country. 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 and Walsh, 2018). As more homes are located in areas with greater wildfire risk, suppression activities have placed additional emphasis on reducing structure damage (Bayham and Yoder, 2020). A case study in Montana shows that fire suppression costs sometimes exceed the value of the property at risk from fire (Calkin et al., 2005). The emphasis on preventing structure damage may reduce mitigation and suppression efforts in other areas, potentially leading to increased fire risk near campgrounds and recreation areas.

From 1985 to 2009, the USFS spent 80% of its fire suppression expenditures on the western United States (Gebert and Black, 2012). However, suppression strategies are ever-evolving. After a century of active wildfire suppression, suppression-when-necessary strategies are now more common (Calkin, Thompson, and Finney, 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 most forest ecosystems in the western US. 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). Evolving suppression strategies promoting a short-run increase in fires may conflict with people's preference for unburned forest, necessitating a greater understanding of the relationship between wildfire and recreation.

Projections show that between 2002 and 2050, individual participation in outdoor recreation is expected to increase by 26%, 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 and Franks, 2019). Further, the Outdoor Industry Association reports that consumers spend $887 billion annually in the outdoor recreation economy (Outdoor Industry Association, 2017). With the increase in recreation visits comes an increase in spending to local communities. When a fire occurs near a campground, site managers may close the site until deemed safe to reopen (Garnache and Lupi, 2018). Wildfire may shift recreation demand and, therefore, local spending. However, Englin, Holmes, and Lutz (2008) find that 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 campground reservations in the year the fire takes place as firefighters 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 their potential effect on local economies.

Previous analyses have used travel cost methods to examine the effect 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 study uses a survey instrument initially employed by Loomis, Englin, and González-Cabán (1999), which looks 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 they relate to recreation activity. The analysis in this paper builds off this finding, showing regional differences in how wildfire impacts the demand for camping reservations.

Englin, Holmes, and Lutz (2008) also look at wildfire and the economic value of wilderness recreation using wilderness permit data, socioeconomic data, and wildfire data in the Sierra Nevada Mountains using trips from California and Nevada. The authors find that fires occurring 4–9 years

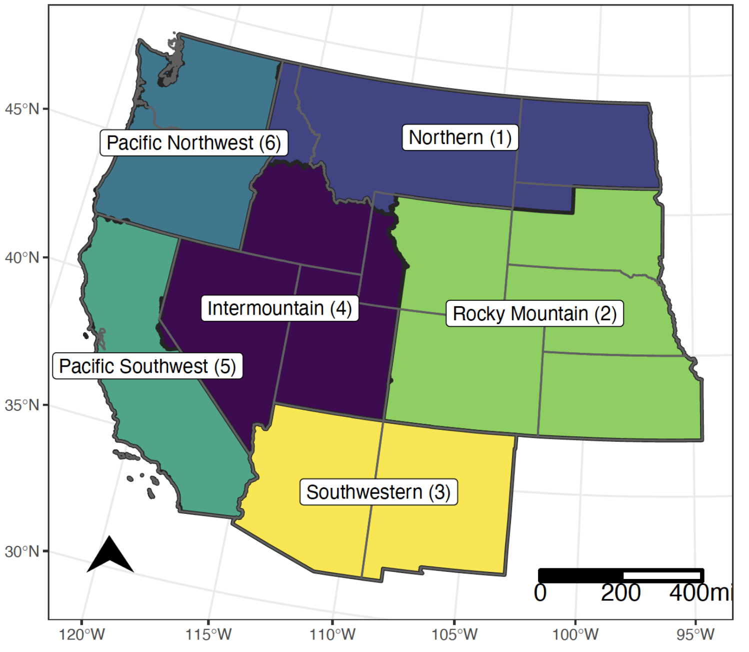


**Figure 1. US Forest Service Regions**

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, Holmes, and Lutz, 2008). Interestingly, our results suggest a persistent negative impact on campground utilization for years after the fire.

To further elaborate on yearly changes post wildfire, Duffield et al. (2013) use time series data on US fire activity and National Park Service recreational visitation data to look at the effect of wildfire on the regional economy surrounding Yellowstone National Park. 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 benefits decline immediately after a fire.

Kim and Jakus (2019) build off the research of Duffield et al. (2013) by looking at the impact of wildfire within certain radii of 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 of between 0.51% (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 to counties that are more diversified and less dependent on the national parks.

## Data

To carry out the empirical analysis, we compile data from three sources: 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 datasets for their overall consistency across the study area.

The study area comprises the western US, or USFS Regions 1–6, shown in Figure 1. The western United States experiences higher fire activity and suppression costs than the eastern United States (Gebert and Black, 2012). We also estimate the impact of wildfire on camping for Regions 1–6 individually.

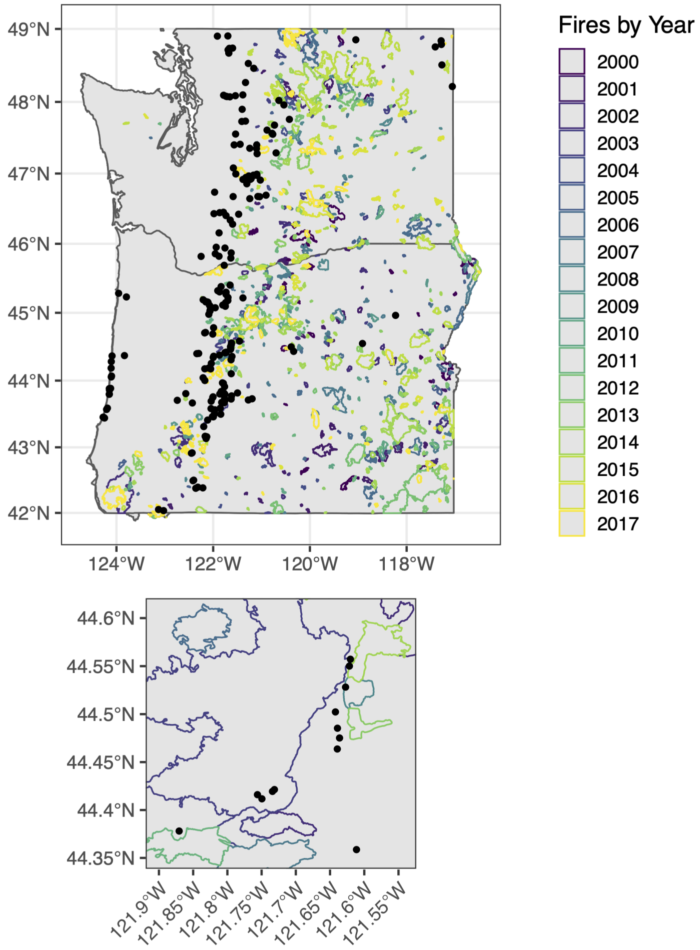


**Figure 2. Wildfire Perimeters and USFS Campgrounds in Region 6, 2000–2017**

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

Monitoring Trends in Burn Severity (MTBS) data provide the spatial boundaries for all fires greater than 1000 acres in the western United States (Monitoring Trends in Burn Severity, 2020). We focus on the subset of MTBS fires in the six USFS regions from 1984 to 2017 to align with the reservation data that end in 2017. We draw a 10-km buffer around each campground and calculate the area of intersection with known fire perimeters. We chose a 10-km radius so as to capture the area of possible use around a given campground. Depending on the topography, viewsheds can extend miles from the campground, and campgrounds often serve as trailheads for recreation opportunities nearby. We expect that higher burned area percentages correspond to decreased campground utilization. Figure 2 illustrates the varying distances between fires and campgrounds in USFS Region 6. When zooming in on a portion of Oregon, we see that some campgrounds occur within fire perimeters, some are touching the edge of fire perimeters, and some are outside of the 10 km buffer of previous fires.

We rely on the National Land Cover Database (NLCD) from the Multi-Resolution Land Characteristics (MRLC) consortium to characterize the land cover in areas near campgrounds (Multi-Resolution Land Characteristics Consortium, 2013). Vegetation information allows us to empirically examine how land cover moderates the impact of wildfire on campground reservations,

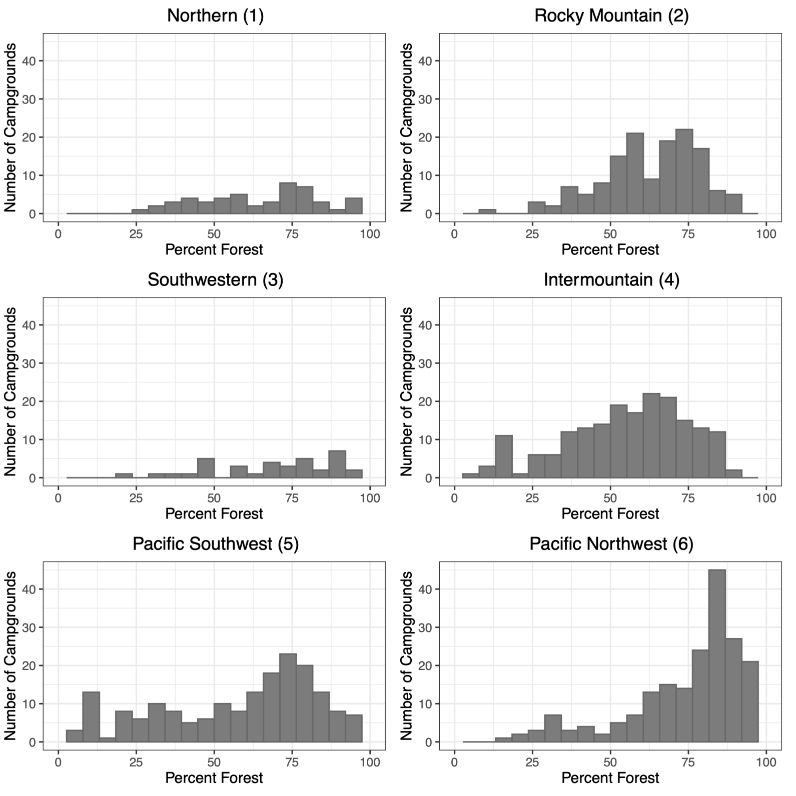


**Figure 3. Percentage Forest Histograms by USFS Region**

*Notes:* Histograms showing the distribution of forested area within 10 km of campgrounds using 2013 National Land Cover Database land cover data (Multi-Resolution Land Characteristics Consortium, 2013) for each region. The figure uses 2017 campground counts.

thus providing feedback on the mechanisms through which wildfire impacts preferences for camping. Specifically, we calculate the fraction of forested land near each campground (10-km buffer) to examine how forest cover moderates the impacts of wildfire.

Land cover data can provide intuition about how landscapes look after fires and the speed at 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 takes longer to recover on forested land. We use the 2013 NLCD because it falls within the campground reservation data window of 2008–2017. Figure 3 shows the distribution of forested area as a percentage of the total area within 10 km of each campground by USFS region. There are more campgrounds in Regions 4–6 than in Regions 1–3, and those campgrounds tend to be surrounded by a higher percentage of forested land.

The camping data are collected from the Recreation Information Database over the years 2008–2017 and include campground 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 campers or dispersed camping. We focus on reservations for only the peak season (May 15–September 15) of a given year. The overwhelming majority camping reservations occur in this time frame (Shartaj and Suter, 2020).

Only campgrounds that are impacted by wildfire at some point between 1984 and 2017 are included in the dataset used in the empirical analysis. The number of campgrounds exposed to fire (within 10 km) in each year of fire data is provided in Table 1 by region. Across the six

**Table 1. Campgrounds Treated by Fire within 10-Kilometer Area by USFS Region and Year**

| | Region | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year** | **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 | 1,433 |

*Notes:* Gap between 2007 and 2008 indicates the starting point from which campground reservation data are available.

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 6 times as many fires as Region 1 and had the highest number of fires per campground across all six regions. Region 5 also had the highest population and the largest wildland–urban interface compared to other regions (Radeloff et al., 2005).

Campground capacity utilization is the primary variable of interest in the empirical analysis. The annual campground utilization value for each campground is calculated using daily reservation data. Each reservation includes information on reservation book date and length of reservation. For each day, the total number of reserved campsites at a given campground is calculated and divided

**Table 2. Increase in Reservable Campground Capacity Utilization, 2008–2017**

| Year | Capacity Utilization (%) |
|---|---|
| 2008 | 28.43 |
| 2009 | 31.70 |
| 2010 | 28.53 |
| 2011 | 31.48 |
| 2012 | 32.60 |
| 2013 | 34.08 |
| 2014 | 35.39 |
| 2015 | 37.02 |
| 2016 | 39.97 |
| 2017 | 40.92 |

**Table 3. Descriptive Statistics by USFS Region**

| USFS Region | No. of Campgrounds Impacted by Fire 1 | Avg. Capacity Utilization (%) (2008–2017) 2 | No. of Treatments (1984–2017) 3 | Avg. Percentage of Buffered Area Burned (1984–2017) 4 | Avg. Percentage of Buffered Area Burned of Treated Campgrounds (1984–2017) 5 |
|---|---|---|---|---|---|
| Northern (1) | 50 | 35.61 | 89 | 0.39 | 7.44 |
| Rocky Mountain (2) | 141 | 37.71 | 102 | 0.23 | 10.59 |
| Southwestern (3) | 36 | 43.42 | 115 | 0.80 | 8.57 |
| Intermountain (4) | 190 | 27.52 | 284 | 0.38 | 8.59 |
| Pacific Southwest (5) | 184 | 37.60 | 593 | 0.70 | 7.43 |
| Pacific Northwest (6) | 193 | 33.95 | 250 | 0.29 | 7.60 |

by the total number of reservable campsites available at that campground. The annual capacity utilization is then calculated as the average daily capacity utilization over a given year for the peak season (May 15–September 15). Campground capacity utilization has been calculated in the same manner in prior research related to the local determinants affecting campground reservations (Shartaj and Suter, 2020). To avoid incomplete observations where campgrounds may have zero capacity utilization because they are unavailable on *recreation.gov*, we subset the data. Specifically, we keep campgrounds with positive capacity utilization values for all years of data and campgrounds where zeros occur initially 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. Over the 10 years of reservation data, average capacity utilization at campgrounds is increasing (Table 2). The increase in utilization is due in part to the increase in the number of campgrounds available on *recreation.gov* and the increase in individuals using the reservation website. We also include descriptive statistics (Table 3) summarizing (i) the number of campgrounds impacted by fire in each region, (ii) the average capacity utilization for each region across the 10 years of reservation data, (iii) the number of fire treatments by region from 1984 to 2017, (iv) the average percentage of the buffered area burned at all campgrounds in the dataset, and (v) the average percentage of the buffered area burned in only the subset of campgrounds that experienced fire.

## Empirical Methods

We use a panel fixed effects model to assess how annual capacity utilization at individual campgrounds responds to nearby wildfire activity. Since we are concerned with how reservations change in subsequent years after fire, we create yearly lags of the fire occurrence (percentage of area within 10 km of campground burned) for 15 years post-fire occurrence[1]. For example, the coefficient on a burn lag of 2 represents the effect of the burn percentage 2 years after the fire burns part of the 10 km area. We then estimate the regression looking at the impact of the burn area within 10 km of a campground including this area lagged for 15 years, on capacity utilization. Since we are specifically looking at how fire in previous years impacts campground demand in a given year, other unobservable factors affecting capacity utilization are accounted for with the inclusion of individual campground and year fixed effects in each regression. The regression equation is formalized as

$$(1) \qquad Y_{it} = \sum_{j=0}^{15} \beta_j X_{it-j} + \gamma_i + \delta_t + \varepsilon_{it},$$

where $Y_{it}$ is the capacity utilization of campground $i$ in year $t$, $X_i$ is the proportion burned near campground $i$, and $\beta_j$ is a series of contemporaneous and lagged coefficients to account for the impact of wildfire $j$ years after the wildfire occurrence. $\gamma_i$ is the individual campground fixed effect and $\delta_t$ is a time fixed effect for each year of interest. We cluster standard errors at the campground level to account for correlation within a campground over time. The econometric model is estimated using all data and then individually by USFS region.

To better understand the mechanisms through which wildfires impact campground reservations, we evaluate whether land cover changes the relationship between wildfire and capacity utilization. We do so by extracting the pixels from the 2013 NLCD raster data that fall within 10 km of each campground. The three forest land cover classifications from the NLCD are then grouped together, and we divide the number of forested pixels by the total pixels within 10 km to create a percentage forest value. We hypothesize that the impact of fire on capacity utilization increases with the percentage of forested land around a campground.

## Results and Discussion

Table 4 contains the coefficient estimates for the contemporaneous and lagged fire variables on campground utilization. The results are also plotted in Figure 4. The results reveal that a marginal increase in the percentage of burned area within 10 km of a campground reduces capacity utilization by 0.32 (95% CI, −0.3602, −0.2873) in the year that the fire occurs. The marginal effect of wildfire is −0.09 (−0.1112, −0.0720) in the first year after the fire and wildfire is found to significantly reduce capacity utilization through year 6. The majority of the burn lags beyond 6 years are also negative but not statistically different from 0, with the exception of the 12-year burn leg, which is statistically significant and negative. We expect that the lagged effect of wildfire on campground utilization is due in part to local awareness of burn scars and online campground information describing the fire impacts. Future research could further investigate these mechanisms through which past fires impact recreation activities.

To provide intuition for the coefficients, a 10-percentage-point increase in the burned area within the buffered area of a campground is predicted to decrease campground capacity utilization by nearly 1 percentage point the year after the wildfire occurs. A 10-percentage-point increase in burned area is 31.4 square km (12.1 square miles). We also conduct a sensitivity analysis using alternative buffer

[1] A dynamic panel specification that includes the lagged dependent variable, such as that proposed by Arellano and Bond (1991), could be useful for identifying the impact of wildfire on campground utilization in the year that the fire occurs. However, such a model would make it more difficult to analyze the impact of fire on utilization in the years after the fire occurs.

**Table 4. Base Model: Aggregate, 15 lags, Individual and Time FE ($N$ = 6,081)**

| | Dependent Variable: Capacity Utilization | | |
|---|---|---|---|
| **Variables** | **10 km** | **5 km** | **20 km** |
| Fire Year | −0.3225*** | −0.2458*** | −0.3683*** |
| | (0.0352) | (0.0361) | (0.0421) |
| Burn Lag 1 | −0.0916*** | −0.0610*** | −0.1083*** |
| | (0.0196) | (0.0162) | (0.0249) |
| Burn Lag 2 | −0.0956*** | −0.0592*** | −0.1393*** |
| | (0.0233) | (0.0186) | (0.0335) |
| Burn Lag 3 | −0.0944*** | −0.0677*** | −0.1294*** |
| | (0.0260) | (0.0209) | (0.0345) |
| Burn Lag 4 | −0.0779** | −0.0630** | −0.1293*** |
| | (0.0315) | (0.0248) | (0.0408) |
| Burn Lag 5 | −0.0757** | −0.0714*** | −0.1174** |
| | (0.0351) | (0.0263) | (0.0467) |
| Burn Lag 6 | −0.0666* | −0.0690** | −0.0880* |
| | (0.0381) | (0.0278) | (0.0524) |
| Burn Lag 7 | −0.0086 | −0.0452 | −0.0287 |
| | (0.0379) | (0.0282) | (0.0476) |
| Burn Lag 8 | −0.0060 | −0.0404 | −0.0307 |
| | (0.0367) | (0.0298) | (0.0484) |
| Burn Lag 9 | 0.0168 | −0.0253 | 0.0348 |
| | (0.0408) | (0.0282) | (0.0549) |
| Burn Lag 10 | −0.0280 | −0.0343 | −0.0553 |
| | (0.0407) | (0.0274) | (0.0570) |
| Burn Lag 11 | 0.0014 | −0.0332 | 0.0008 |
| | (0.0388) | (0.0273) | (0.0554) |
| Burn Lag 12 | −0.0751* | −0.0916*** | −0.0707 |
| | (0.0434) | (0.0316) | (0.0598) |
| Burn Lag 13 | −0.0531 | −0.0730** | −0.1037 |
| | (0.0407) | (0.0321) | (0.0772) |
| Burn Lag 14 | −0.0318 | −0.0520* | −0.0606 |
| | (0.0371) | (0.0293) | (0.0524) |
| Burn Lag 15 | −0.0432 | −0.0638** | −0.0459 |
| | (0.0376) | (0.0287) | (0.0474) |
| Year fixed effects | Yes | Yes | Yes |
| Campground fixed effects | Yes | Yes | Yes |
| $R^2$ | 0.88484 | 0.88430 | 0.88371 |
| Adjusted $R^2$ | 0.86938 | 0.86876 | 0.86809 |
| $F$-test | 57.202 | 56.900 | 56.572 |

*Notes:* One-way (campground) standard errors in parentheses. Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level, respectively.

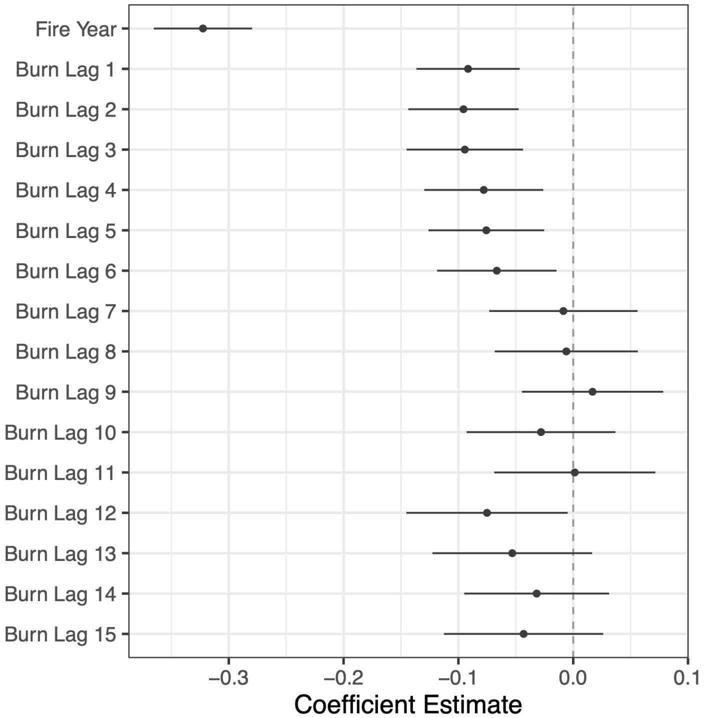


**Figure 4. Long-Term Impacts of Wildfire on Campground Capacity Utilization**
*Notes:* A visual representation of the long term impacts of wildfire on campground capacity utilization.

specifications of 5 km and 20 km following the same steps as the primary specification and include the estimates in Table 4. Overall, the coefficient results at the alternative buffer distances are consistent with the 10-km buffer specification.

To quantify the effect of decreased capacity utilization over the 6 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 $\sum_{j=1}^{6} \beta_j$ in a distributed lag model (Parker, n.d.). We sum the 6 lag coefficients to get −0.5018. For the representative campground impacted by wildfire, the mean fraction of buffered area burned is 8%, which translates to a cumulative effect on capacity utilization of $-0.04 = -0.5018 \times 0.08$. For campgrounds affected by fire, the average yearly revenue is roughly $20,804. Multiplying these values, a typical campground treated by fire can expect to lose $835 per year in the years after being treated by wildfire. 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 6 years after wildfire occurrence.

This lost revenue to the USFS does not account for the potential for individuals to substitute to unaffected campgrounds or the potential benefit some campers experience from reduced congestion. We would expect to see larger effects on reduced reservation fees at campgrounds that have available substitutes nearby, like campgrounds unaffected by fire. 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. Lost revenue to the USFS is only part of the direct economic cost. Future research could evaluate lost economic benefits by calculating lost consumer surplus to campers from fires near campgrounds. The loss of campground visitors also has implications for local communities that that depend on campers' additional spending.

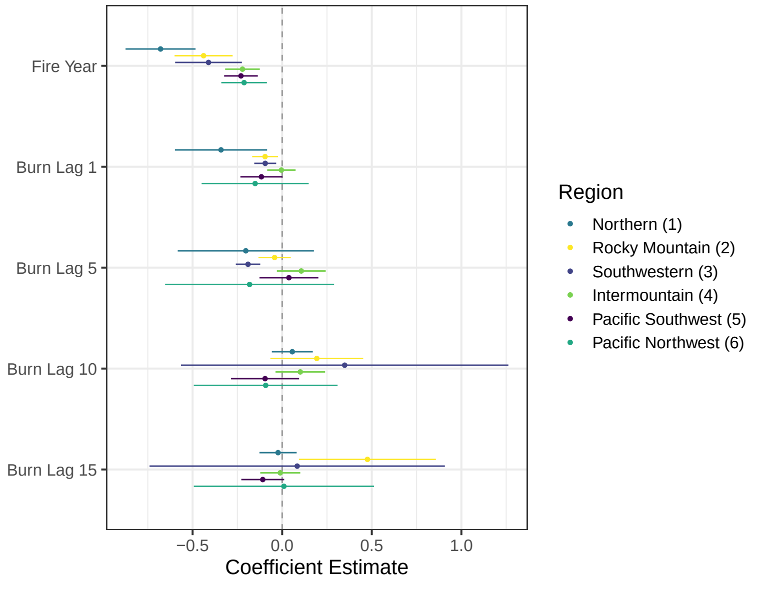


**Figure 5. Regional Dot-Whisker Plot**

*Notes:* A visual representation of the impact of wildfire on campground capacity utilization by region in the year of, 1 year after, 5 years after, 10 years after, and 15 years after fire takes place.

To better understand the heterogeneity in changes in capacity utilization caused by wildfire, we also estimate a model similar to equation (1) that interacts the burn percentage and lags with indicator variables for each individual USFS region, with results reported in Figure 5 and Table 5. Visually, we provide the results for the lagged burn percentages for the year of, 1 year after, 5 years after, 10 years after, and 15 years after a fire takes place (Figure 5).

We observe negative and statistically significant impacts on capacity utilization in the year of fire for all regions. These negative effects also persist in the first 2 years after a fire occurs in nearly all of the regions, with negative point estimates on the burn lag 1 variable in all regions and negative point estimates on the burn lag 2 variable in all regions except for the Intermountain region. In later years after a fire occurs, there is more heterogeneity in impacts across regions. This heterogeneity likely derives from differences in a host of biophysical, management, and demand-side characteristics that are unique to campgrounds in each region. The Northern, Rocky Mountain, and Southwestern regions generally display impacts over time that are consistent with the aggregate model, with negative impacts in the first 5–6 years after a fire occurs and some positive impacts in later years post fire. By comparison, the Intermountain region sees negligible impacts of fire in the initial years after a fire occurs, with positive and significant impacts for lags 6–9. These positive impacts of fire observed in the Intermountain region may be driven by the rate of habitat recovery that occurs in this region. Finally, in the two Pacific regions (Pacific SW and Pacific NW), we generally observe negative point estimates on the lagged impacts of fire that are not statistically different from 0. The exception to this is the positive and significant point estimate for burn lag 3 in the Pacific NW region. While this impact may be due to reforestation efforts that occur in this region, we hesitate to draw strong inferences from one out of the 96 coefficient estimates presented in Table 5.[2]

Differences in wildfire impacts across regions may also be due to differences in demand for the individual campgrounds. For example, we note that the biggest negative impacts in the immediate years after a fire occurs are in the Southwestern region, where campgrounds impacted by wildfire have the highest average capacity utilization (Table 3). The Intermountain region sees negligible

[2] For completeness, in the appendix we compare the results of the main specification (Table 4) to the treatment-weighted average of the regional model (Table 5).

**Table 5. Interaction Model: Regional, 15 lags, Individual and Time FE ($N$ = 6,081)**

| | Dependent Variable: Capacity Utilization by Region | | | | | |
|---|---|---|---|---|---|---|
| **Region** | **Northern** | **Rocky Mountain** | **South-western** | **Inter-mountain** | **Pacific SW** | **Pacific NW** |
| Fire Year | −0.6789*** | −0.4387*** | −0.4112*** | −0.2216*** | −0.2300*** | −0.2126*** |
| | (0.0997) | (0.0827) | (0.0950) | (0.0493) | (0.0479) | (0.0649) |
| Burn Lag 1 | −0.3414*** | −0.0955*** | −0.0947*** | −0.0044 | −0.1160* | −0.1509 |
| | (0.1312) | (0.0368) | (0.0312) | (0.0404) | (0.0598) | (0.1525) |
| Burn Lag 2 | −0.1907 | −0.0573 | −0.1380*** | 0.0168 | −0.0813 | −0.0919 |
| | (0.1185) | (0.0369) | (0.0402) | (0.0603) | (0.0534) | (0.2207) |
| Burn Lag 3 | −0.3302*** | −0.0564* | −0.1677*** | 0.0641 | −0.0927 | 0.3600** |
| | (0.1002) | (0.0341) | (0.0377) | (0.0684) | (0.0642) | (0.1713) |
| Burn Lag 4 | 0.0506 | −0.0446 | −0.1815*** | 0.0854 | −0.0223 | 0.2594 |
| | (0.1900) | (0.0370) | (0.0345) | (0.0678) | (0.0798) | (0.2542) |
| Burn Lag 5 | −0.2030 | −0.0424 | −0.1906*** | 0.1066 | 0.0376 | −0.1819 |
| | (0.1939) | (0.0461) | (0.0348) | (0.0696) | (0.0838) | (0.2406) |
| Burn Lag 6 | −0.1696 | 0.1301 | −0.1507*** | 0.1369* | 0.0356 | −0.2575 |
| | (0.1503) | (0.1398) | (0.0496) | (0.0746) | (0.0809) | (0.2461) |
| Burn Lag 7 | −0.4575** | 0.1649 | 0.4734 | 0.2209*** | −0.0103 | −0.2974 |
| | (0.2193) | (0.1171) | (0.5401) | (0.0761) | (0.0716) | (0.2363) |
| Burn Lag 8 | −0.0363 | 0.2194* | 0.1946 | 0.1616** | −0.0304 | −0.2103 |
| | (0.0676) | (0.1156) | (0.5275) | (0.0628) | (0.0690) | (0.2291) |
| Burn Lag 9 | −0.0298 | 0.3524*** | 0.1489 | 0.1349** | −0.0138 | −0.1063 |
| | (0.0675) | (0.1276) | (0.5544) | (0.0543) | (0.0729) | (0.2096) |
| Burn Lag 10 | 0.0565 | 0.1930 | 0.3487 | 0.1012 | −0.0955 | −0.0921 |
| | (0.0583) | (0.1322) | (0.4661) | (0.0707) | (0.0969) | (0.2047) |
| Burn Lag 11 | −0.0175 | 0.2506* | 0.3666 | 0.0900 | −0.0411 | −0.0790 |
| | (0.0665) | (0.1475) | (0.4631) | (0.0733) | (0.0900) | (0.2012) |
| Burn Lag 12 | −0.0661 | 0.3863** | 0.0803 | 0.0347 | −0.1393 | −0.2082 |
| | (0.0736) | (0.1524) | (0.4014) | (0.0804) | (0.0945) | (0.2067) |
| Burn Lag 13 | −0.0395 | 0.4028** | 0.1347 | −0.0208 | −0.1525 | −0.1607 |
| | (0.0719) | (0.1621) | (0.4179) | (0.0894) | (0.0955) | (0.2134) |
| Burn Lag 14 | 0.1062 | 0.4522** | 0.1554 | 0.0246 | −0.1768** | −0.1928 |
| | (0.1072) | (0.1764) | (0.4133) | (0.0421) | (0.0733) | (0.2068) |
| Burn Lag 15 | −0.0231 | 0.4758** | 0.0838 | −0.0107 | −0.1085* | 0.0096 |
| | (0.0530) | (0.1948) | (0.4205) | (0.0570) | (0.0610) | (0.2565) |
| Year fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Campground fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.88783 | | | | | |
| Adjusted $R^2$ | 0.87084 | | | | | |
| F-test | 52.392 | | | | | |

*Notes:* Clustered standard errors in parentheses. Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level, respectively.

**Table 6. Aggregate Model: Percentage of Forested Land, 15 Lags, Individual and Time Fixed Effects ($N$ = 6,081)**

| Variables | Capacity Utilization | Capacity Utilization × Percentage Forest |
|---|---|---|
| Fire Year | −0.1940* | −0.2360 |
| | (0.1051) | (0.2259) |
| Burn Lag 1 | 0.0246 | −0.2346** |
| | (0.0545) | (0.1060) |
| Burn Lag 2 | −0.0105 | −0.1703 |
| | (0.0558) | (0.1068) |
| Burn Lag 3 | −0.0640 | −0.0494 |
| | (0.0709) | (0.1476) |
| Burn Lag 4 | −0.0442 | −0.0502 |
| | (0.0867) | (0.1883) |
| Burn Lag 5 | −0.0391 | −0.0457 |
| | (0.0935) | (0.2057) |
| Burn Lag 6 | −0.0386 | −0.0190 |
| | (0.1042) | (0.2292) |
| Burn Lag 7 | −0.0562 | 0.1801 |
| | (0.1139) | (0.2851) |
| Burn Lag 8 | −0.0995 | 0.2656 |
| | (0.1144) | (0.2943) |
| Burn Lag 9 | −0.1499 | 0.4286 |
| | (0.1122) | (0.2778) |
| Burn Lag 10 | −0.2229* | 0.5070* |
| | (0.1322) | (0.2990) |
| Burn Lag 11 | −0.3017*** | 0.7118** |
| | (0.1147) | (0.2797) |
| Burn Lag 12 | −0.3607*** | 0.6812** |
| | (0.1249) | (0.3011) |
| Burn Lag 13 | −0.4055*** | 0.8300*** |
| | (0.1205) | (0.2940) |
| Burn Lag 14 | −0.3702*** | 0.8187*** |
| | (0.1058) | (0.2629) |
| Burn Lag 15 | −0.2454** | 0.5204* |
| | (0.1141) | (0.2872) |
| Year fixed effects | Yes | |
| Campground fixed effect s | Yes | |
| $R^2$ | 0.88589 | |
| Adjusted $R^2$ | 0.87018 | |
| F-test | 56.372 | |

*Notes:* One-way (campground) standard errors in parentheses. Signif. Codes: ***: 0.01, **: 0.05, *: 0.1. The mean forest area for all campgrounds in the model is 0.62. The standard error for the combined effect coefficients are calculated as linear combination of coefficients, $se(\beta_j^c) = \left(V(\beta_j) + (0.62)^2 * V(\beta_{f,j}) + 2 \times 0.62 \times cov(\beta_j, \beta_{f,j})\right)^{1/2} \quad \forall \; j = [0, 15]$, where $\beta_j$ is the main effect for lag $j$ and $\beta_{f,j}$ is the coefficient on the interaction of percentage of forested area and lag $j$.

impacts of fire in the years after the fire occurs, which may be due in part to the fact that impacted campgrounds in this region experience the lowest capacity utilization. Fires have less of an opportunity to reduce demand for reservations if demand is already relatively low.

Results from an econometric model that evaluates how the percentage of forested land impacts the relationship between wildfire and capacity utilization help to shed some additional light on the mechanisms that may be driving regional differences. Specifically, the model that is estimated includes interactions between the burn lags and the percentage of forested area within 10 km of a campground. The results of this empirical model are provided in Table 6, which includes two columns: The left column shows the coefficients on the variable that quantifies the burn percentage in the year the fire takes place and the 15 consecutive lags and the right column shows the coefficients on the interaction between the percentage of forested land and each burn lag. By summing the coefficients for the burn lag and the burn lag interacted with the percentage of forested land, the results show that campgrounds with greater forested areas surrounding them see a greater negative impact in the year of and year after a fire occurs. In later years, however, the interaction between the burn lag and the percentage of forested area becomes positive for years 10–15 (Table 6). This positive effect could signal the return of grasses, shrubs and small trees that make a recreation site more desirable.

The results suggest that landscape regrowth is more likely to generate amenities in the long run after a fire occurs in a more heavily forested area. We know that campgrounds in the Intermountain, Pacific SW, and Pacific NW regions (Regions 4–6) have greater percentages of forested land within 10 km of campgrounds (Figure 3), again indicating the need for regional management of campgrounds as it relates to impacts from wildfires. The Intermountain region appears to have a balance of vegetation that may lead to an increase in capacity utilization in the intermediate years after fire occurs. While these results help to explain some of the variation in fire impacts across regions, future research should do more to analyze the mechanisms that underlie the differences that are observed across regions.

## Conclusion

We investigate the negative effects of proximal wildfire on campground utilization. We find that for every 1-percentage-point increase in area burned within 10 km of the campground, capacity utilization falls by approximately 0.5 over the 6 years after the fire occurs. This effect varies in duration and magnitude across USFS regions. We find evidence that this negative effect of fire on visitation is larger in forested areas the year after a fire occurs but becomes positive in later years as the landscape recovers.

Outdoor recreation is an important service provided by agencies like the USFS that manage public lands. Camping has been growing in popularity, and the COVID-19 pandemic accelerated this growth (Shartaj, Suter, and Warziniack, 2022). At the same time, climate change is expected to increase wildfire activity in the western United States (Abatzoglou and Williams, 2016; Abatzoglou et al., 2021). Our results suggest that wildfire will continue to impact camping opportunities well into the future. Moreover, our results may serve as a lower bound if campground utilization and wildfire activity continue to increase in the future.

Our results may also influence land management decisions. An agency like the USFS manages campgrounds but also directs wildfire mitigation and suppression activities. Our results suggest that investments in fuel treatments near campgrounds to reduce the probability of wildfire occurrence and severity can make campgrounds more resilient in the face of a changing climate. Differences by region also indicate the need for unique suppression strategies across the western United States by land cover.

Campgrounds are often located near rural communities that depend on recreation tourism. Our results suggest that wildfire-induced reductions in campground visitation also reduce visitation and spending in communities located near campgrounds. This linkage highlights the influence of public land managers like the USFS on rural communities, particularly in the western United States. In communities that are dependent on recreation, reduced capacity utilization could greatly affect livelihoods and represent a persistent cost.

Future extensions of this research include expanding regressions to the eastern United States, evaluating other mechanisms related to fire that affect capacity utilization, and assessing impacts on recreation demand under different fire scenarios. Another direction could be to incorporate data on walk-up camping 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. A site-choice model to characterize the substitution between sites when one is impacted by fire could be used to further analyze the decisions of individuals. Proximity to national park boundaries could also be included in future research. Many USFS campgrounds are located near national park boundaries, and the impact of wildfire may be different at these popular campgrounds. The impact of wildfire on recreation is an important topic of research as the number of recreation participants and wildfires continue to increase.

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## Appendix: Comparing the Base Model to the Regional Model

This appendix compares the results of the main specification (Table 4) to the treatment-weighted average of the regional model (Table 5). While the main specification shows that the effect of fire on campground utilization is consistently negative and statistically significant for the 6 years following a fire, the regional model shows heterogeneity in the effect. There are several potential explanations for the heterogeneous effects, as we discuss in the main text. However, it is helpful to compare the main specification to the treatment-weighted averages of the regional model. We calculate the linear combination of the regional coefficients by the number of treatments across the sample period:

$$\beta_j^r = \sum_k \beta_{j,k} \times w_k, \tag{A1}$$

where $w_k$ are the fraction of treatments in each region, $k$, across the entire sample period. We calculate standard errors (and associated 95% confidence intervals) using

$$se(\beta_j^r) = \sqrt{w_j^T V w_j}, \tag{A2}$$

expressed in matrix notation, where $\boldsymbol{w}_j$ is the vector of regional weights corresponding to each set of lags $\boldsymbol{j}$, and $\boldsymbol{V}$ is the variance–covariance matrix.

The results of the main model are compared to the treatment-weighted average of the regional model in Figure A1. We find general agreement between the two models, with the exception of lags 3 and 4, where the treatment-weighted average coefficients are positive although not statistically different from 0. As we discuss in the main text, this heterogeneity likely derives from differences in a host of biophysical, management, and demand-side characteristics that are unique to campgrounds in each region affecting the response to wildfire events.

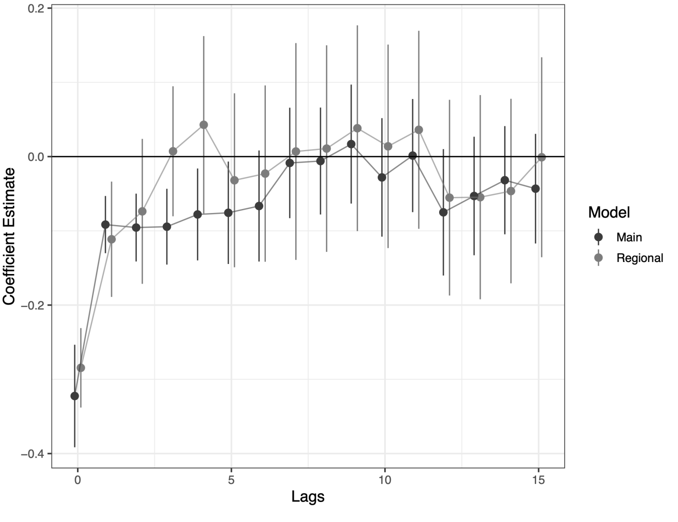


**Figure A1. Base Model and Regional Model Comparison**