THESIS

CAMPING IN CLEARCUTS
THE IMPACTS OF TIMBER HARVESTING ON USFS CAMPGROUND UTILIZATION

Submitted by

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ABSTRACT

CAMPING IN CLEARCUTS

THE IMPACTS OF TIMBER HARVESTING ON USFS CAMPGROUND UTILIZATION

The United States Forest Service (USFS) governs its lands under multiple-use management, where land is managed for more than one purpose or objective to achieve the greatest possible combination of public benefits. Some objectives are compatible, while others are not (Clawson, 1974; Rose and Chapman, 2003; USFS, 2021c).

This research seeks to inform the site location of future timber harvests relative to existing campgrounds by analyzing how past and current harvests near campgrounds have influenced campground utilization. Beyond this, the research also informs the expected impacts of timber harvesting and recreation on local economies. Previous economic research related to timber harvesting's impact on nearby recreation has been carried out at a smaller spatial scale or outside the U.S., and none have focused on campgrounds specifically (Eggers et al., 2018; Harshaw and Sheppard, 2013). Past studies find that intensive forest management changes the degree of naturalness of a forest and generally negatively impacts recreation. The research we conduct builds on these studies to apply a temporally and spatially explicit model to analyze harvesting's impact on campground utilization on USFS land across the Western U.S.

We find that timber harvests significantly decrease reservations during the year of harvest. Furthermore, the selection method of harvest has the most negative impact, likely due to being the most common harvesting method both overall and near campgrounds. There are regional differences in campground demand during harvesting. Additionally, there is evidence to suggest that campground reservations continue to be impacted one year after a harvest takes place. The loss in campground utilization from the reduction in reservations during harvest years can be expected to have negative impacts on nearby tourism-dependent economies.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

Introduction

The United States Forest Service (USFS) is the overseer of national forests and grasslands in the U.S. They "manage public lands, . . . provide technical and financial assistance to state and private forestry agencies, and make up the largest forestry research organization in the world" (USFS, 2021c).

For much of the nation's history, forest management in the U.S. has been primarily focused on timber supply. However, more holistic management emerged in the latterer half of the 20^{th} century that placed value on both timber and non-timber ecosystem services, such as outdoor recreation. Presently, the USFS governs its lands with multiple-use management. Lands and forests are managed for more than one purpose or objective to achieve the greatest possible combination of public benefits. Some objectives are compatible, while others are not (Clawson, 1974; Rose and Chapman, 2003; USFS, 2021c). Although extractive activities remain important aspects of USFS management and the national economy, demand for recreational space on public lands is on the rise, and must be managed for accordingly. Balancing the competing demands of forests is inherently heterogeneous and requires spatial analysis. Timber production can degrade biodiversity and alter the attractiveness of recreation, while high volumes of outdoor recreation can impede on biodiversity and land available for timber production (Bolund and Hunhammar, 1999). Thus, the choices the USFS makes on the location of timber harvests may have direct influence over the demand of nearby campgrounds, and consequently impact the communities dependent on visitors to those campgrounds.

In this paper, we will address the questions: does timber harvesting on USFS land impact or conflict with nearby campground reservations? Do different types of harvesting methods have different impacts? Are there regional differences to individuals' responses to nearby harvesting activity? Are the potential impacts to campgrounds observed only during the year of harvesting activity, or do they linger in following years?

This study uses temporal and spatial data on campground reservations and timber harvesting on USFS lands. We estimate the impact that timber harvesting activity near campgrounds has on those campgrounds' utilization. The type of timber harvest is also considered. Thus, campground utilization is a function of harvesting activity nearby, harvest characteristics, and campground and year fixed effects. Furthermore, the magnitude of impacts to campgrounds by three other popular management activities undertaken by the USFS are estimated as a comparison to timber harvesting, which would seem more intensive.

This study builds on research by Harshaw and Sheppard (2013) who evaluated the impacts of timber harvesting on recreation opportunities in British Columbia, Canada and Eggers et al. (2018) who studied the relationship between intensive forest management and the recreational value of forests in Sweden. Both studies were based on spatial and temporal forest management and recreation data. This study, to my knowledge, is the first to use historic temporal and spatial data on USFS land to evaluate the relationship between timber harvesting and camping.

This work can inform land managers' decisions on the future locations and types of timber harvesting relative to existing campgrounds and inform implications of current and planned timber harvesting on nearby tourism-dependent communities.

Chapter 2

Background and Literature Review

The background and literature review provides context on relevant USFS policies, a discussion on gateway communities that are impacted by the use of their nearby public lands, trends in recreation on public lands, past research related to the impact of timber harvesting and intensive forest management on recreation opportunities, and finally an overview of how the USFS makes decisions on which parcels of land are suitable for harvesting.

2.1 The Evolution of USFS Policies

The goals of the USFS have evolved throughout its existence to meet the demands of private and public interests. The agency was established in 1905 to provide quality water and timber, and later "[broadened] its management scope for additional multiple uses and benefits and for the sustained yield of renewable resources such as water, forage, wildlife, wood and recreation" (USFS, 2021c). For most of the organization's history, USFS land has been managed mainly for timber production (Rose and Chapman, 2003; USFS, 2021c). Today, the "mission of the Forest Service is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations" (USFS, 2021c). Resource conservation, multiple use mandates, and environmental protection have come to the forefront of public lands policies. Table 2.1 depicts a non-exhaustive list of services that forests can provide that the USFS manages for. Importantly, land, natural resources, human resources, budgets and time are scarce, so the USFS faces complex management decisions on which goods and services to allocate their resources to.

Before the creation of the USFS, public forest management legislation recognized multiple uses of forests (Rose and Chapman, 2003; USFS, 2022c). The Organic Act of 1897 authorized the establishment of national forests for multiple uses including forest protection, forest improvement, timber supply and water supply (USFS, 2022c). Despite this, timber interests dominated public forest management decisions for the early years of the USFS (Rose and Chapman, 2003). There

Table 2.1: Economic benefits of forest lands, adapted from Rose and Chapman (2003).

Extractive goods and services	Non-extractive goods and services
Timber	Recreation
Mining	Wilderness & biodiversity
Plant products	Water supply & quality
Pharmaceuticals	Flood control
Hunting, trapping, fishing	Erosion control
	Pollution control
	Carbon sequestration

were growing public concerns about controlling fire, water systems, wood supply, rural economies and national prosperity. Thus, the focus of the agency in the first half of the twentieth century was resource exploitation and ensuring commodity flows from the land (Kennedy and Quigley, 1998). For example, from 1941 to 1971, timber harvesting jumped from 1.5 to 11.5 billion board-ft/year (Kennedy and Quigley, 1998). Regulations passed during this stage were mainly concerned with acquisition of lands or controlling how the land resources were used. The Weeks Act of 1911 allowed the USFS to acquire private lands previously used for logging or agriculture with the intent of regulating streams and timber harvesting on the land (USFS, 2022c).

Then in the 1960s and 70s, shifting public opinions led to environmental legislation that changed public land management practices (GAO, 1999; Rose and Chapman, 2003; USFS, 2022f). Management decisions still held timber harvesting as an important land use, but now as a part of a more holistic multiple-use management approach (Rose and Chapman, 2003). The USFS broadened its scope of outputs and sought to enhance public lands while taking into account both the environment and local economies. Regulations passed during this era focused on conservation or preservation (the Endangered Species Act of 1973, the National Historic Preservation Act of 1966 and the Wilderness Act of 1964), pollutant control, mitigation or cleanup (the Clean Air Act of 1970, the Clean Water Act of 1972, the Comprehensive Environmental Response Compensation and Liability Act of 1980 and the Resource Conservation and Recovery Act 1976) and outlining the multiple uses of public lands (the Multiple Use Sustained Yield Act of 1960, the National Environmental Policy Act of 1969 and the National Forest Management Act of 1976) (USFS, 2021b).

The multiple-use legislation of the 1960s and 70s is particularly important to this paper. The 1960 Multiple Use-Sustained Yield Act outlines the management of national forests to provide for multiple use and sustained yield of products and services such as recreation, range, timber, watershed, and wildlife and fish (USFS, 2021b). The National Environmental Policy Act (NEPA) of 1969 requires federal agencies to assess the environmental effects of their proposed actions prior to making decisions (USFS, 2021b). Finally, the National Forest Management Act (NFMA) of 1976 recognizes that managing forest resources is complex and changes over time, and public agencies must periodically review and update their management" (USFS, 2021b). NFMA requires the USFS to prepare a land and resource management plan, or "forest plan," which are to be revised at least every 15 years (Riddle, 2018). Together, these policies have shaped the current management of the USFS land examined in this paper.

Today, public opinion and agency values push the USFS in the direction of environmental protection and multiple-use management. Differing values on public forests' purposes, such as balancing economic, environmental or recreational values, and the relationship of timber harvesting levels to forest health shape debates over public land management. Supporters of timber harvesting on public lands cite benefits to local timber industry, rural timber-dependent gateway community economies and beliefs that timber harvesting is a tool for forest health (Riddle, 2018). Opponents to timber harvesting have concerns about its potential negative impacts to ecological (environmental quality or fish and wildlife habitat) or human (recreation, cultural or aesthetic values) resources (Riddle, 2018). Public land is put under pressure as extractive uses and non-extractive uses compete for scarce resources and space.

2.2 Gateway Communities

Gateway communities are towns and cities that border public lands. These communities may be near national or state parks, forests, monuments, grasslands, or bodies of water. They serve as entry points for nearby recreation or natural resource extraction. The economies of these communities are dependent on the use of their nearby public lands. Because of their unique natural attributes, gateway communities face unique issues in terms of development and growth (Howe et al., 1997).

Changes in environmental policy for public lands since the early 1960s have impacted the economies of gateway communities. Communities once dependent on extraction have felt the pressure from USFS conservation and multiple-use policies. A prominent example of this transition that caught national attention was the 1980s northern spotted owl controversy between logging and environmental interests in the Pacific Northwest (Howe et al., 1997; Moore, 1993; Roe, 1996). Many gateway communities in this region depended on high-paying timber industry and supporting service sector jobs for the majority of their economic activity. Environmentalists pushing for the preservation of old growth forests for spotted owl habitat forced timber companies and sawmills to cut their operations in national forests. These communities saw population decline and decreased economic vibrancy. This is a common narrative among gateway communities, though not always so drastic. Many other communities, particularly in the Western U.S., began as mining or forestry towns and have since transitioned to tourism. Examples include Estes Park, Colorado (a mining community), Jackson, Wyoming (a hunting and ranching community) and Leavenworth, Washington (a timber community) (Ford, 2022; Goldmann, 2018; Leavenworth Chamber of Commerce, 2021). These formerly extraction-based communities are now recreational tourism destinations for visitors from all over the world.

Timber production has historically been, and continues to be, an important economic activity in the U.S. (Eggers et al., 2018; Rose and Chapman, 2003; Sorenson et al., 2016). Harvesting involves planning, preparation, removal and transportation of trees. All points along this process, and in the further processing afterward, create jobs and income (Sorenson et al., 2016). For example, the U.S. is the world's leading producer of several wood products, as well as the largest single-consumer of those products (Alderman, 2022). The importance of timber as an economic driver is not homogeneous across the country. The highest levels of employment in forestry and logging occur in the Northwestern U.S., where timber is more desirable due to larger trees and non-homogeneous stands, and more manual methods of harvest are used (Sorenson et al., 2016).

However, recreation is also an important use of public lands and economic driver, especially in rural communities near national forests. Visitors to national forests often spend money in nearby communities while they are on recreation trips. Common things for visitors to spend money on are gasoline, food, lodging and souvenirs. These direct expenditures create further indirect and induced impacts (Thomas and Koontz, 2021; USFS, 2021f). The USFS National Visitor Use Monitoring Survey (NVUM) surveys visitors to national forests to estimate both the number and type of recreation visits based on activity participation, visit duration, visitor demographics and visitor satisfaction. This data is also used to develop estimates of local economic contribution via visitor spending effects. At the time of this writing, the most recent report includes data from fiscal year 2016 through fiscal year 2020 (USFS, 2021f). The NVUM finds that annual spending by recreation visitors in areas near USFS land was about $10 billion in fiscal year 2019. From this direct effect and further indirect and induced effects, about $12.5 billion is reflected in the nation's gross domestic product from visitor spending, and it sustains about 154,000 full and part time jobs.

The amount of money spent per party varies by type of trip taken. In general, nonlocals spend more than locals. These visitors typically pay for some kind of lodging, such as a campground or a hotel, while locals and day-trippers do not. Nonlocal visitors also generally purchase more food during their trip than locals. Visitors traveling short distances usually spend less than visitors traveling longer distances, especially on items such as fuel and food. White et al. (2013) estimate USFS visitors' spending impacts and conclude that the lowest average spending of visitors, $33 per party per trip, is from locals on day trips, while the highest average spending, over $983 per party per trip, is from non-locals visiting for skiing and staying overnight nearby.

Partly as a result of changing public lands policy, many gateway community economies have become less dependent on resource extraction and moved toward recreational tourism (Kurtz, 2010). When recreation demand changes due to factors such as population changes, site accessibility, or the amenity value of a resource, gateway communities' economies may be impacted.

2.3 Increases in Recreation Activity

Outdoor recreation is an important use of USFS land. It provides physical challenges, health benefits, lifelong skills and gives people opportunities to connect with nature (USFS, 2021f; White et al., 2016). Participation in outdoor recreation has been steadily increasing over many decades and is forecast to continue to grow (USFS, 2021f; White et al., 2016). The most recent NVUM estimates that in 2020, there were about 168 million recreation visits to national forests. An additional 300 million people traveled on roads near, on or through USFS lands to view the scenery. These numbers are much higher than previous years (for example, 2019 visitation was about 150 million recreation visits). The stark increase from fiscal year 2019 to fiscal year 2020 is a result of peoples' desires to be outdoors in uncrowded, natural settings during the COVID-19 pandemic (USFS, 2021f). The spike in visitation to many USFS sites during the COVID-19 pandemic has been documented through many studies (Barnett, 2021; Ferguson et al., 2022; Shartaj et al., 2022). Although the recent dramatic spike in national forest visitation can be contributed to the pandemic, visitation had been steadily increasing beforehand.

2.4 Impacts of Timber Harvesting on Recreation

Timber harvesting and recreation are in competition for finite forest space. There may be trade-offs of doing one activity rather than another or for doing both activities in close proximity to one another. Harvesting and recreation can be moderately compatible, but only when managed properly (Clawson, 1974). Timber harvesting can alter the amenity value of a forest, both for better or for worse. Depending on the type and intensity of management activity done, wildlife, water supply, and recreation may benefit or suffer. For example, in some cases, clearcutting can benefit wildlife that require the thick cover created by a young regenerating forest (Connecticut Department of Energy and Environmental Protection, nd). However, Eggers et al. (2018) finds that people seeking outdoor recreation prefer mature forests with little sign of human activity, such as clearcuts or ground damage. Harvesting can alter the composition of a forest or a stand, the use of roads, noise levels and forest aesthetics.

Harshaw and Sheppard (2013) study timber harvesting's impacts on outdoor recreation in British Columbia, Canada. Evaluating the temporal dimension of forest management is necessary to understand the dynamic nature of forests, changing societal demands for forest products and visitors' responses to changing resource conditions (Harshaw and Sheppard, 2013). A key insight from this study is that timber harvesting caused a substantial loss of natural settings over several time periods. Once the natural conditions of a forest have been altered, the change may be irreversible. Although individuals engaging in outdoor recreation may seek varying levels of naturalness, if they do seek more natural conditions, it is difficult for a harvested area to appear unchanged from human influence.

Eggers et al. (2018) conducted a similar study in Sweden examining the trade-offs between managing for recreation and wood production. They focus on forests close to urban areas since these forests see the most visitation. They find that longer rotation periods (how long to let a tree grow before harvesting it again) in areas with high recreational demand is beneficial. This practice increases recreational value without banning wood production in prioritized areas.

2.5 USFS Timber Harvesting Decisions

The USFS considers many factors, objectives and policies when deciding which forest parcels are available for timber harvesting. Where the USFS decides to locate timber harvesting has direct impacts on other uses of public land, including recreation. Timber production from federal lands is driven by a complex interaction of environmental factors, market forces and land management policies. The USFS is one of only two federal agencies, the other being the Bureau of Land Management, to conduct timber sales as an authorized use, and the USFS conducts the majority of harvests (Riddle, 2018).

Riddle (2018) details the process and evolution of timber harvesting on federal lands. The USFS oversees approximately 193 million acres of land. Nearly 144.9 million acres of this land are forest and woodland, of which 66% are considered timberland. Timberland is defined as "forest land that is producing or is capable of producing crops of industrial wood. . . in excess of 20 cubic feet per acre per year" (Riddle, 2018). Timber sales, the process in which an entity purchases a contract to harvest timber, are the most common way to allow timber harvesting on federal land.

As stated previously, the NFMA of 1976 requires the USFS to create "forest plans" describing where and how much timber harvesting can occur. These plans designate areas that can support sustainable timber harvest without future impairment. They specify objectives, standards and guidelines for the provision of outdoor recreation, range, wildlife, fish and timber. Forest plans may consider harvesting for various purposes, such as timber production, habitat improvement, fire risk reduction and sanitation. Any timber harvesting that takes place must also be in compliance with other relevant statutes, such as NEPA. Additionally, the USFS establishes a sale schedule and timber sale project plan, or "sale package," which estimates volume offered, acreage and harvest methods. Then, the USFS advertises the package at an appraised starting price, and parties may bid on the package. The highest bidder receives the contract to harvest. These timber sales are available publicly online at fs.usda.gov/managing-land/forest-management/products/timber-sales.

Harvest volume and value is heterogeneous across regions and time. It is a complex interaction between timber type, timber age class, forest condition, ease of operations, land use limitations and local wood production industries. In the Western U.S., Region 6 (the Pacific Northwest) is the largest producing region in both private and public forestry (Riddle, 2018; Sorenson et al., 2016; USFS, 2021e). Riddle (2018) reports that harvest volumes on USFS land in the 1940s were around 1-3 billion board feet per year, then rose in the 1950s-80s to around 10 billion board feet per year and have decreased since the 1990s (a "board foot" is a unit of measure for a piece of lumber 12" wide by 1' long by 1" thick). Harvest volumes have remained between 1.8 and 2.8 billion board feet per year since 2003. The dollar value of timber peaked in 1979 at over $3 billion, and has since decreased to between $100 million and $300 million since 2001. The type of timber harvesting employed has also evolved over time.

Today, less intensive methods of harvest and other management activities are more common (see Figure 3.3 in the following Data section). USFS resources are increasingly dedicated to wildfire mitigation and cleanup (Fox, 2020). Other activities besides timber harvesting, such as brush disposal, hazardous fuel reduction and restoration, are common USFS management strategies. Rather than focusing on earlier goals of meeting targets for volume sold, the agency is now concerned with treating the right acres at the right time by working with state, county and tribal governments and partners in the private sector (Fox, 2020).

Furthermore, the decisions the USFS makes on the location of timber harvests may impact the validity of our results. The models used in this study assume that timber harvesting, our independent variable, occurs randomly. If harvesting occurs in random locations, then the coefficient estimates from our models could reasonably be seen as causal estimates. However, harvesting decisions outlined in each forest plan are likely not random, and the USFS may consider recreation opportunities when deciding which land is suitable for harvesting. If this is the case, our models would have a problem with causal identification. For example, if the USFS chooses to harvest near campgrounds that are expected to have the lowest utilization in the coming years (potentially to avoid high-use recreation areas and keep campgrounds natural-looking), the econometric models would show harvesting is associated with lower utilization. In this case, harvesting did not cause low utilization, rather low utilization caused harvesting. This is an example of upward bias associated with how the harvesting decisions are made because the coefficient estimate would appear larger (more negative) than the causal impact is in reality. However, if, for example, the USFS chooses to harvest near campgrounds that are expected to have the highest utilization (potentially to reduce wildfire risk) then the models would show that harvesting is associated with higher utilization. In this case, harvesting did not cause high utilization, rather high utilization caused harvesting. This is an example of downward bias because the coefficient estimate for timber harvesting would appear smaller (less negative) than the causal impact is in reality. The likelihood of downward bias may be more than that of upward bias, as fire mitigation and campground maintenance become more pressing in the coming years.

Chapter 3

Data

The main empirical estimates are based on two spatial USFS datasets available publicly online: timber harvest data from the FSGeodata Clearinghouse and reservation data from the Recreation Information Database (RIDB) (USFS, 2021d,e). Harvest data includes polygons of harvests since the 1800's and reservation data includes point locations of all campground reservations made through the USFS's reservation website, recreation.gov, since 2006.

We combine these datasets to construct a campground capacity utilization metric using camping reservations from 2008-2018 and the proportion of harvested area within a 5-kilometer radius of a campground from harvests occurring from 1986 to 2018. The buffered area around campgrounds addresses the aesthetics of a forest, as attractiveness can be an important factor in campground visitors' decisions. Campground utilization is determined by comparing the total number of sites available to the average number of sites reserved at each campground. This method was developed by Shartaj and Suter (2020) who used the same RIDB reservation data to explore local determinants of campground utilization.

The impact of three additional management strategies are also estimated. Including these other activities in this study allows us to compare the magnitude of the impact of these activities to the impact of forest harvesting, which would seem more intense. These activities include brush disposal activities, hazardous fuel treatment reduction and integrated resource restoration (USFS, 2022a,b,d). Polygon data on these three activities is similarly collected from the FSGeodata Clearinghouse. These polygons are similarly interacted with the RIDB reservation data to determine the impacted campgrounds and the capacity utilization at those impacted campgrounds.

3.1 Timber Harvest Data

The FSGeodata Clearinghouse is a database provided by the USFS that contains spatial data collected and managed by USFS programs. It is available publicly online, and data is available in a map service and two downloadable file formats. The "Timber Harvests" data includes much of the timber harvesting undertaken in the U.S. since 1820, as well as planned future harvests (USFS, 2021e). However, this layer does not contain all timber harvest activities because although the spatial portion of the activity description is now required, it was not always (USFS, 2021e).

Variables of interest in the harvesting data include the geometry of each harvest, dates of operations, type of harvest and size of harvest in acres. For this research, we subset harvesting data to 1986-2018 and only evaluate harvesting activity in the contiguous Western U.S. (USFS Regions 1-6). We determine which USFS region each harvest is in by overlaying harvesting data with a USFS region boundary. The "Forest Service Regional Boundaries" shapefile from the FSGeodata Clearinghouse contains the geometries of all the USFS lands administered by a region (USFS, 2021a). Figure 3.1 depicts a map of the area of study classified by USFS regions.

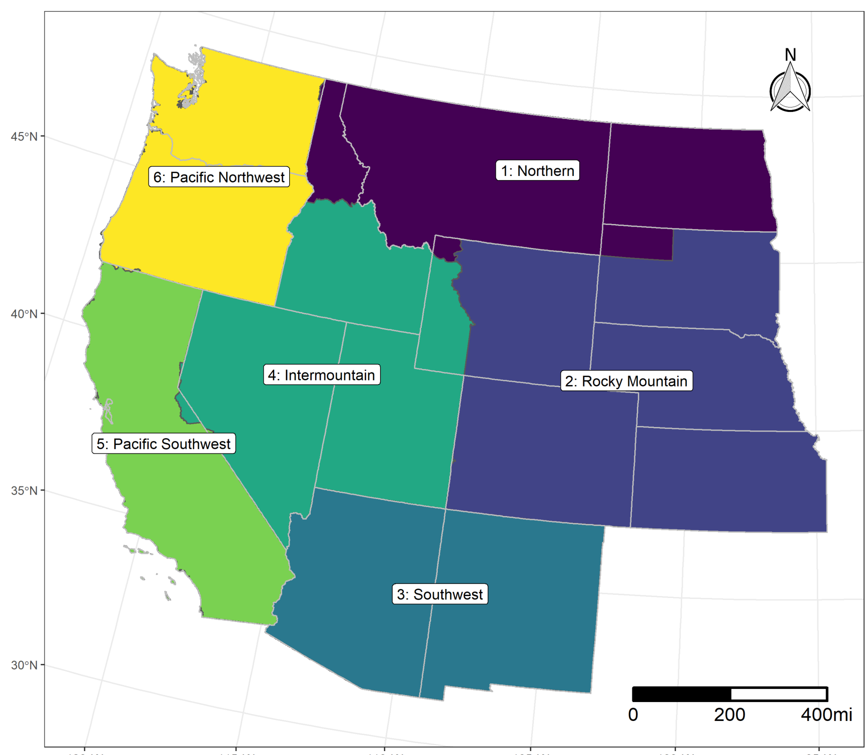

Figure 3.1: Map of the USFS regions included in this study.

The length of harvesting activity is considered in this study. Harvests lasting over many years may impact camping in more than one year. Harvesting operations lasting for several years are likely to be of larger area or more intensive. However, a minority of harvests in the data last for several decades. It is unlikely that harvest operations lasting this long have significant activity in each year of activity. There may be some years included in these operations where little to no harvesting activity takes place. However, detailed yearly information for harvests is not available in the data used, so longer harvests are excluded. Therefore, only harvests lasting up to five years in length are included in this study. Figure 3.2 depicts a histogram of timber harvests in the Western U.S. classified by the duration of harvesting activity. Only harvests lasting 5 years or less are included in this figure. All of the data fitting these requirements are included, so many of the harvests included in the figure are not near campgrounds. From Figure 3.2, we see that most harvests last 1 year, and Regions 1 (Northern), 5 (Pacific Southwest) and 6 (Pacific Northwest) have the most harvesting activity.

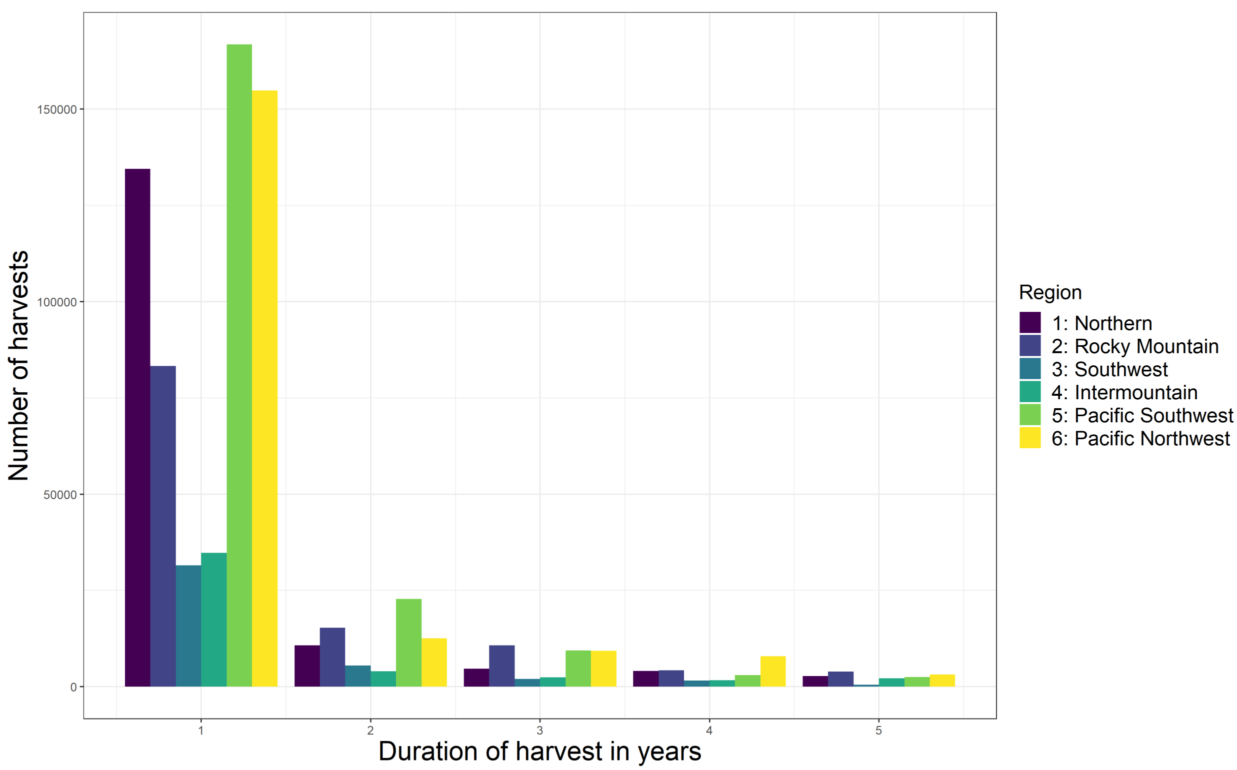

Figure 3.2: Duration of all timber harvests, classified by region.

Furthermore, the type of timber harvest is considered in this study. The main methods of harvesting, ranging from most intensive to least intensive, are clearcut, shelterwood and selection (Table 3.1). There are many types of timber harvests listed in the data which we sort into one of these three main methods.

Table 3.1: Timber harvest methods, adapted from Cook (2014); USFS (2022e).

Clearcut	Shelterwood	Selection
Removes essentially all trees in a stand	Some sheltering trees remain after tree removal	Removes select individual or groups of trees
One operation	Several successive operations	Many individual operations
Produces a new age class	Produces several age classes	Little impact to age classes
Most visually extreme	Moderate visual impact	Least visually extreme
Mainly used for extractive purposes	Used for both extractive purposes and forest health	Mainly used for forest health to remove invasive or unhealthy trees

As mentioned previously, this study only includes harvests that were active up to 20 years before the reservation data starts, (i.e. 1986). It is unlikely we would observe changes in campground demand from harvests occurring more than 20 years prior to the observable reservation data. Any lingering impacts that older harvests have on campground demand are captured in campground fixed effects. Figure 3.3 depicts a count of the number of new USFS harvests each year in the Western U.S. from 1986 to 2018 categorized by type of harvest. There is a general decline in the number of harvests over time. Additionally, the number of clearcut and shelterwood harvests have declined over time, while the selection method remains popular (Figure 3.3).

3.2 Campground Reservation Data

Campground reservation data is gathered from the Recreation Information Database (RIDB) spanning the years 2006 to 2018 (USFS, 2021d). Through recreation.gov, individuals can access recreation site information on federal lands nationwide and make reservations. Historical records of all reservations made through this website are available for download from fiscal year 2006 forward. Although data is available since 2006, there were no reservations to campgrounds with timber harvesting nearby in 2006 and 2007 (likely due to many campgrounds not yet being available on recreation.gov), so reservation data relevant to this study begins in 2008. We subset the RIDB data to include only reservations made between May 15th and September 15th of a given year. Most reservations occur within this time frame (Shartaj and Suter, 2020). The data do not include walk-up reservations. Although the number of walk-up reservations to USFS campgrounds is likely a significant portion of campers, to our knowledge, there is no comparable comprehensive dataset detailing these records.

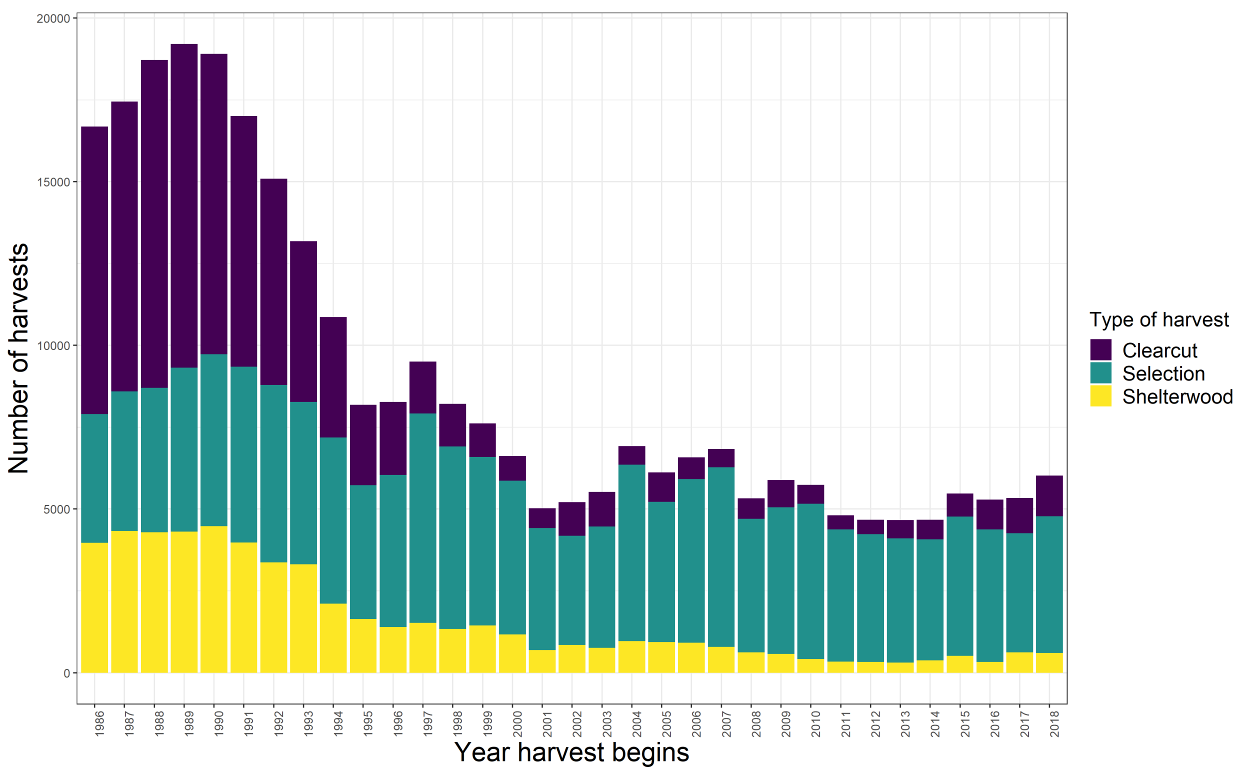

Figure 3.3: Number of harvests per year from 1986-2018 in the Western U.S.

Both the number of campgrounds available for reservation and the number of reservations made are increasing over time. Figure 3.4 depicts the number of campgrounds reserved through recreation.gov in the Western U.S. included in this study (i.e. those that have timber harvesting nearby). The overall number of campgrounds in the dataset has a similar trend. In our main models, campgrounds are allowed to enter the dataset as they enter into the online reservation system. We complete a robustness check where new campgrounds cannot enter the dataset which yields similar results to the base model, implying campgrounds coming online do not significantly impact our results (see Table 5.9 in Robustness Checks). Additionally, as of October 12th, 2018, the data provider and format of the RIDB historical records changed and cannot be directly compared to the previous format (USFS, 2021d). Therefore, data from 2019 and on are excluded from this study. Variables of interest in the reservation data include the geometry of each site, dates of reservations, type of site (only overnight campgrounds are included) and ownership of the site (only USFS sites are included).

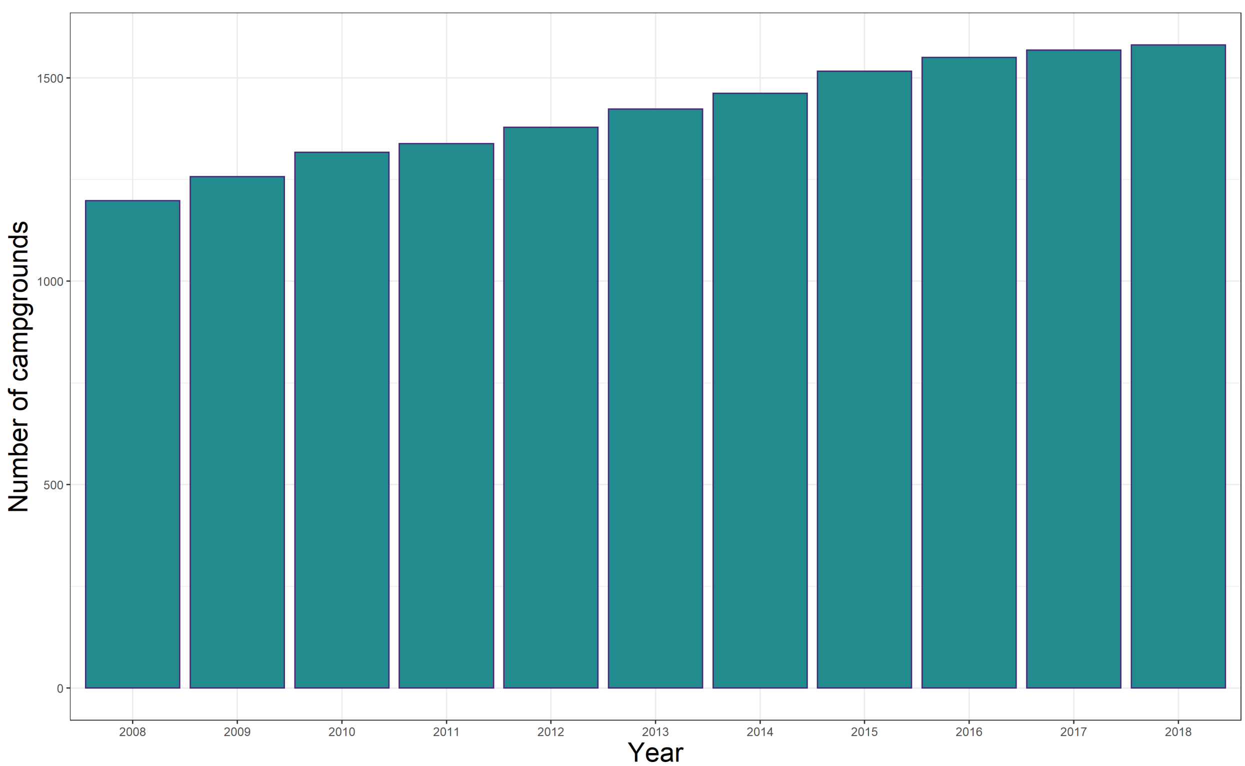

Figure 3.4: Bar plot depicting the number of campgrounds with harvesting nearby reserved through recreation.gov each year from 2008-2018.

To determine which campgrounds may be impacted by timber harvesting, we overlay the campground points and harvest polygons. We create a 5-kilometer buffer around each campground's coordinates to capture what areas of forest are "near" a campground. This buffer captures areas potentially visible by campers when they are moving around their site or recreating nearby. Campers make their decisions on where to camp with several factors in mind, such as proximity to other recreation destinations, campsite amenities and campsite aesthetics. The buffering of campground locations addresses the aesthetics of a campground, because attractiveness is an important choice of outdoor recreation areas (Freimund et al., 1996; Harshaw and Sheppard, 2013). Campgrounds with harvesting activity within their buffer are treated, and those without are untreated. In Figure 3.5, we see an example of the interaction of the reservation data and timber harvesting data. This figure depicts a map of the interaction of timber harvests from 1986-2018 and impacted campgrounds in Larimer County, Colorado.

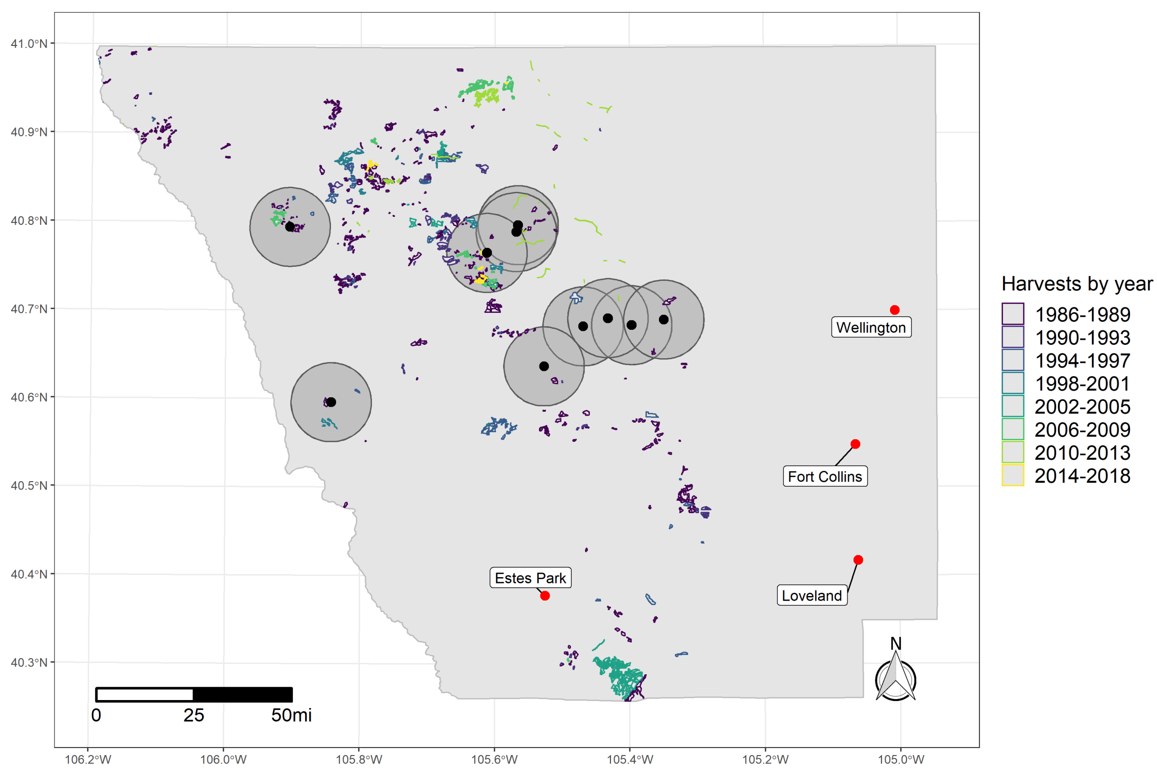

Figure 3.5: Timber harvests and treated campgrounds in Larimer County, Colorado. Black dots indicate treated campgrounds. 5-kilometer buffer areas are represented with gray circles around each campground point. Major cities are labeled.

Table 3.2 shows the number of treated campgrounds from 1986 to 2018 in all regions. From this table, we see that the number of impacted campgrounds decreases over time. This table also shows that Region 6 (the Pacific Northwest) has the most impacted campgrounds, which is intuitive because this region has one of the highest levels of timber harvesting in the Western U.S., as well as many wood mills clustered in this region (Prestemon et al., 2005; Riddle, 2018; Sorenson et al., 2016).

From these impacted campgrounds, we calculate the proportion of harvested area within each buffer, which is our main independent variable. Only the portion of each timber harvest that falls within the buffer is counted toward this total, oftentimes not the entire area of a timber harvest. Both the total proportion harvested and the proportion harvested by type of harvest are calculated. A single timber harvest may impact multiple campgrounds in multiple years. As expected, most campgrounds do not have a large proportion of their buffered area harvested. The distribution of these proportions presented in percentages is depicted in Figure 3.6. The median percent area harvested is approximately 8%.

3.3 Additional Management Activities Data

In addition to the base and several subsequent models that estimate the impact of timber harvesting on campground utilization, the impact of several other management activities on campgrounds are estimated. Estimating the impact of these other activities on camping is relevant to this study to compare the magnitude of less intensive activities to the more intensive activity of timber harvesting. As stated previously, these activities include brush disposal, hazardous fuel reduction and integrated resource restoration. Data on brush disposal activities is taken from the shapefile "Brush Disposal Funded Activities" from the FSGeodata Clearinghouse (USFS, 2022a). Brush disposal pertains to the disposal of "brush and other unwanted debris (slash) resulting from. . . cutting operations on timber sale contracts, stewardship contracts and permits, that are not disposed of by the purchaser" (USFS, 2022a). Data on hazardous fuel reduction treatments is taken from the shapefile "Hazardous Fuel Treatment Reduction: Polygon" from the FSGeodata Clearing-

Table 3.2: Number of campgrounds per year by region with harvesting activity nearby.

	Region						
Year	1	2	3	4	5	6	Total
1986	104	82	8	33	134	197	558
1987	105	91	21	23	109	188	537
1988	101	63	20	33	116	180	513
1989	93	78	29	33	114	178	525
1990	90	68	27	47	132	192	556
1991	98	66	21	24	124	184	517
1992	91	61	18	29	99	169	467
1993	84	54	23	28	73	156	418
1994	75	41	16	28	64	132	356
1995	86	32	12	26	40	110	306
1996	75	37	5	21	52	117	307
1997	79	37	5	28	69	111	329
1998	54	29	13	48	92	110	346
1999	56	32	13	28	92	72	293
2000	45	38	16	28	87	76	290
2001	36	26	14	21	71	63	231
2002	59	29	3	20	68	51	230
2003	48	30	10	17	67	74	246
2004	53	27	15	24	63	105	287
2005	48	28	13	12	52	90	243
2006	38	23	13	25	84	92	275
2007	38	28	11	27	74	82	260
2008	36	38	10	26	54	50	214
2009	37	50	5	39	49	57	237
2010	41	60	19	47	47	69	283
2011	55	55	18	49	61	76	314
2012	45	58	5	63	54	98	323
2013	43	66	17	42	42	93	303
2014	42	56	22	41	23	77	261
2015	49	43	25	35	40	80	272
2016	46	45	21	36	51	79	277
2017	40	54	13	38	54	61	260
2018	30	39	15	27	39	45	195
Total	2020	1564	496	1046	2390	3514	11030

Note: The horizontal line between 2007 and 2008 indicates when impacted campgrounds begin to be observed.

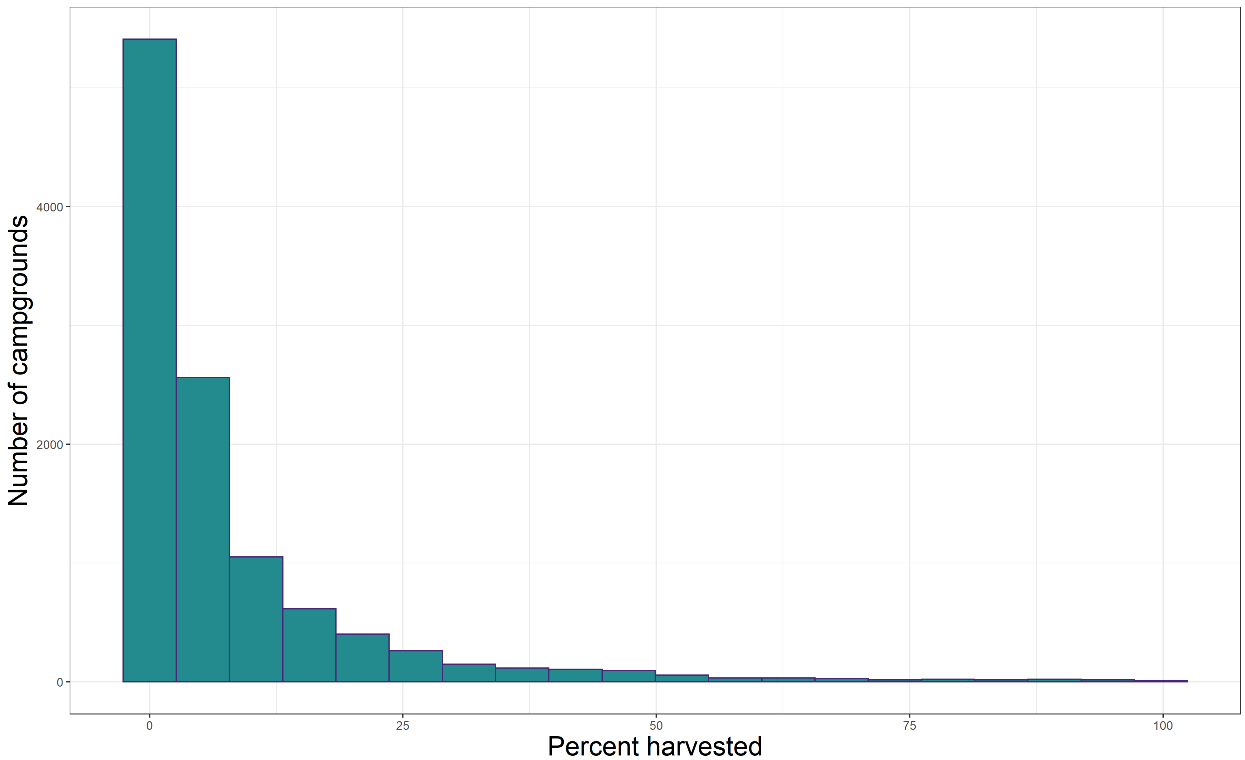

Figure 3.6: Distribution of the proportion of area harvested within impacted campground buffers.

house (USFS, 2022b). Hazardous fuel reduction projects are classified as "vegetative manipulation designed to create and maintain resilient and sustainable landscapes, including burning, mechanical treatments, and/or other methods that reduce the quantity or change the arrangement of living or dead fuel so that the intensity, severity, or effects of wildland fire are reduced within acceptable ecological parameters and consistent with land management plan objectives, or activities that maintain desired fuel conditions" (USFS, 2022b). Finally, data on integrated resource restoration is taken from the shapefile "Integrated Resource Restoration (IRR): Polygon" from the FSGeodata Clearinghouse (USFS, 2022d). Integrated resource restoration projects include "areas treated to sustain or restore watershed function; forestlands treated using timber sales; forestland vegetation improved, forest land vegetation established, rangeland vegetation improved by treatment for noxious weeds or invasive plants; and hazardous fuels treated outside the wildland/urban interface to reduce the risk of catastrophic wildland fire" (USFS, 2022d).

Similar to timber harvesting data, variables of interest in these datasets include the geometry of each activity and dates of operations. These management activities are similarly subset to 1986-2018 and only include those located within the contiguous Western U.S. Again, campgrounds impacted by these activities are determined, and the proportion of impacted area within each buffer is calculated.

3.4 Capacity Utilization

Campground capacity utilization is an integral element to investigate timber harvesting's impact on recreation. To create a utilization measure for each campground and year, reservation data for each campsite within the study area is compiled by year (between May 15th and September 15th). Average utilization is calculated by determining the total number of sites available at a given campground compared to the average number of sites reserved per day. Thus, each campground has one capacity utilization number per year. This method was developed by Shartaj and Suter (2020) who used the same RIDB dataset to explore local determinants affecting campsite reservations.

Average campsite capacity utilization for campground i in year t is:

$$Capacity\ utilization_{it} = \frac{Campsites\ reserved_{it}}{Campsites\ available_{it}}$$

Campground utilization is a proportion between 0 (no campsites were booked through recreation.gov all season) and 1 (the campground was full every night of the season from recreation.gov reservations). Figure 3.7 depicts the average daily capacity utilization of campgrounds in the Western U.S., both treated and untreated. Most campgrounds are approximately one-third full on an average day from recreation.gov reservations. As shown in Figure 3.7, in over half of the regions, average daily capacity utilization is higher in campgrounds without harvesting nearby (Regions 2: Rocky Mountain, 4: Intermountain, 5: Pacific Southwest, and 6: Pacific Northwest).

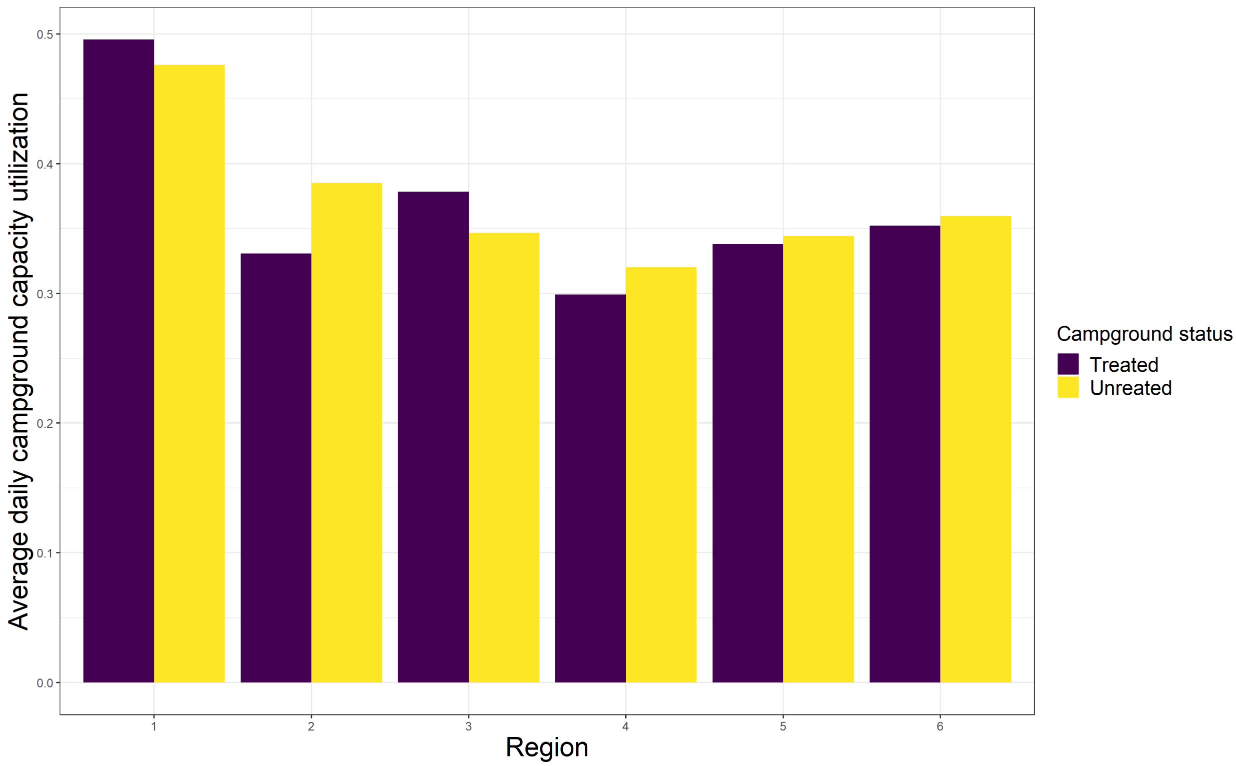

Figure 3.7: Average daily campground capacity utilization across all regions and all campgrounds, treated vs. untreated.

Furthermore, campground utilization from recration.gov users has been increasing over the study period. Figure 3.8 depicts the evolution of average campground capacity utilization over time in each region. In every region, utilization has increased from 2008 to 2018.

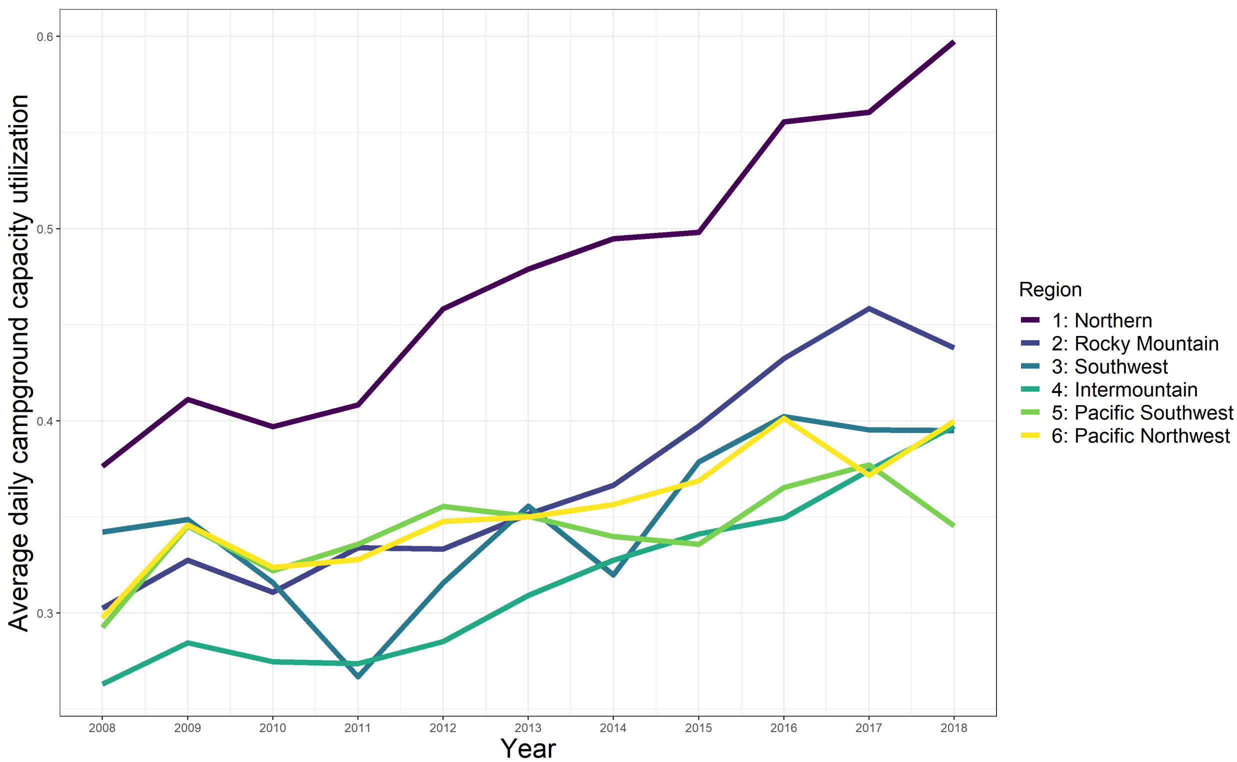

Figure 3.8: Average daily campground capacity utilization across all regions and all campgrounds (both treated and untreated) over time.

Chapter 4

Model

To estimate how timber harvests impact changes in individual campground capacity utilization over time, we use several panel fixed effects linear models with clustered standard errors. For each model, we include campground and year fixed effects. Since we are investigating how timber harvesting impacts campground demand in a given year, other unobservable factors affecting capacity utilization are accounted for with the inclusion of the individual campground and year fixed effects. Furthermore, standard errors are clustered by campground. The clustering accounts for the fact that campgrounds are independent of one another, but capacity utilization at each campground is correlated with itself from year to year.

First, a base model is estimated using all harvests in all regions (4.1). This econometric equation is:

$$Y_{it} = \beta_1 X_{it} + \alpha_i + \gamma_t + \epsilon_{it} \tag{4.1}$$

where Y_{it} is the capacity utilization of campground i in year t, X_{it} is the proportion of the area near campground i that contains a timber harvest in year t, β_1 is the coefficient for the proportion of buffer harvested variable, α_i is a campground fixed effect, γ_t is a year fixed effect, and ϵ_{it} is the error term.

Next, we separate harvesting impacts by harvest type (clearcut = *CC*, shelterwood = *SW*, selection = *SL*) (4.2). This econometric equation is:

$$Y_{it} = \beta_{CC} X_{it,CC} + \beta_{SW} X_{it,SW} + \beta_{SL} X_{it,SL} + \alpha_i + \gamma_t + \epsilon_{it} \tag{4.2}$$

where Y_{it} is the capacity utilization of campground i in year t, $X_{it,CC}$ is the proportion of the area near campground i that contains a clearcut harvest in year t, $X_{it,SW}$ is the proportion of the area near campground i that contains a shelterwood harvest in year t, $X_{it,SL}$ is the proportion of the area near campground i that contains a selection harvest in year t, β_{CC} is the coefficient for the clearcut variable, β_{SW} is the coefficient for the shelterwood variable, β_{SL} is the coefficient for the selection variable, α_i is a campground fixed effect, γ_t is a year fixed effect, and ϵ_{it} is the error term.

Then, we separate harvesting impacts by region (4.3). This econometric equation is:

$$Y_{it} = \sum_{n=1}^{6} \beta_n X_{it\,n} + \alpha_i + \gamma_t + \epsilon_{it} \tag{4.3}$$

where $n = 1, 2, 3, 4, 5, 6$ for Regions 1-6, Y_{it} is the capacity utilization of campground i in year t, $X_{it\,n}$ is the proportion of the area near campground i that contains a timber harvest in year t in Region n, β_n is the coefficient for the timber harvesting variable for each Region n, α_i is a campground fixed effect, γ_t is a year fixed effect, and ϵ_{it} is the error term.

We then model the lagged impacts of timber harvesting activity to investigate if impacts linger in the years following harvesting activity (4.4). This econometric equation is:

$$Y_{it} = \sum_{j=0}^{N} \beta_j X_{it-j} + \alpha_i + \gamma_t + \epsilon_{it} \tag{4.4}$$

where Y_{it} is the capacity utilization of campground i in year t, X_{it} is the proportion the area near campground i that contains a timber harvest in year t, β_j are a series of coefficients for the lagged timber harvest variables to account for up to N years after a timber harvest, α_i is a campground fixed effect, γ_t is a year fixed effect, and ϵ_{it} is the error term.

Next, we investigate timber harvesting's impact on campground utilization at a more aggregate level. First, a binary model where campgrounds either have harvesting nearby or not is estimated (4.5). This allows us to compare the average utilization of campgrounds with harvesting activity to those without. Then, we estimate a model where campgrounds are sorted into five buckets classified by buffer area harvested (0-5% harvested, 5-10% harvested, 10-15% harvested, 15-20% harvested, and over 20% harvested) (4.6). This model allows us to estimate how specific levels of the proportion of a buffer harvested impacts utilization differently. The binary model is:

$$Y_{it} = \beta_1 Z_{it} + \alpha_i + \gamma_t + \epsilon_{it} \tag{4.5}$$

where Y_{it} is the capacity utilization of campground i in year t, Z_{it} is a dummy variable indicating harvesting activity ($Z_{it} = 1$ if campground i has harvesting in its buffer in year t, $Z_{it} = 0$ if campground i does not have harvesting in its buffer in year t), β_1 is the coefficient for the dummy variable, α_i is a campground fixed effect, γ_t is a year fixed effect, and ϵ_{it} is the error term.

The econometric equation for the model separating campgrounds into buckets is:

$$Y_{it} = \sum_{k=1}^{5} \beta_k Z_{k,it} + \alpha_i + \gamma_t + \epsilon_{it} \tag{4.6}$$

where $k = 1, 2, 3, 4, 5$ for the 5 buckets of area harvested, Y_{it} is the capacity utilization of campground i in year t, $Z_{k,it}$ is a dummy variable indicating harvesting activity ($Z_{k,it} = 1$ if campground i has k amount of harvesting in its buffer in year t, $Z_{k,it} = 0$ if campground i does not have k amount of harvesting in its buffer in year t), β_k is the coefficient for the dummy variable for each bucket j, α_i is a campground fixed effect, γ_t is a year fixed effect, and ϵ_{it} is the error term.

Finally, the impact of three additional USFS management activities are estimated using a similar model to the base regression (brush disposal = *B*, hazardous fuel = *H*, integrated resource restoration = *R*) (4.7). These models are included to compare the magnitude impacts to campgrounds by other management activities to the impacts of timber harvesting. This econometric equation is:

$$Y_{it} = \beta_B X_{it,B} + \beta_H X_{it,H} + \beta_R X_{it,R} + \alpha_i + \gamma_t + \epsilon_{it} \tag{4.7}$$

where Y_{it} is the capacity utilization of campground i in year t, $X_{it,B}$ is the proportion of the area near campground i that contains a brush disposal activity in year t, $X_{it,H}$ is the proportion of the area near campground i that contains a hazardous fuel treatment reduction activity in year t, $X_{it,R}$ is the proportion of the area near campground i that contains an integrated resource restoration activity in year t, β_B is the coefficient for the brush variable, β_H is the coefficient for the hazardous fuel variable, β_R is the coefficient for the integrated resource restoration variable, α_i is a campground fixed effect, γ_t is a year fixed effect, and ϵ_{it} is the error term.

We also complete several robustness checks included in the following section. These checks investigate the assumptions we made about which campgrounds are included in the study, the size of buffer selected impacted our results and the harvests included in the lag model.

Chapter 5

Results and Discussion

The following section includes a discussion of the results of the base and subsequent models. Results from these models show the effect of timber harvesting on campground reservations, revealing reductions in capacity utilization.

In the base model, we estimate the impact that nearby timber harvesting has on campground reservations during years of harvesting activity. Treated campgrounds contain harvests within a 5-kilometer buffer, and harvests may last multiple years and impact multiple campgrounds. From this model, we find that the proportion of harvested area within the buffer around a campground reduces capacity utilization in the year a harvest takes place (Table 5.1). In Table 5.1, a negative and significant coefficient during the year a harvest takes place is observed. These results can be interpreted as a 1 percentage point increase in area harvested within a campground's buffered area would have a 0.2 percentage point decrease in daily average campground capacity utilization during the year of harvest. For example, if a timber harvest takes place near a campground and harvests 10% of its buffered area, the campground's average daily capacity utilization would decrease by 2 percentage points. In other words, because capacity utilization is a proportion between 0 and 1, if utilization is at 0.5 (the campground is half full on average) and 10% of a buffer around the campground is harvested, then utilization would be reduced by 0.02 (0.2*0.1). Therefore, utilization would decrease from 0.5 to 0.48. The base model shows that at the aggregate level, visitors to national forests are changing their camping behavior as a result of nearby timber harvesting. Again, the median area harvested of a campgrounds buffer is approximately 8%.

Next, we model if timber harvesting's impact on campground reservations varies by type of harvest. We divide harvesting activity into three types of harvest: clearcut, shelterwood and selection. Results from the model separated by harvest type show that only the selection method has a significantly negative impact on campground utilization (Table 5.2). Additionally, the clearcut point estimate is the largest, although it also has a high standard error given the relatively small

Table 5.1: Campground capacity utilization, harvesting nearby.

	Dependent variable:
	Capacity utilization
Proportion harvested	-0.204^{**}
	(0.080)
Observations	2,940
R^2	0.004
Adjusted R^2	-0.367
F Statistic	7.622^{***} (df = 1; 2143)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

number of observations (less than half of impacted campgrounds have a clearcut nearby, while over 75% of impacted campgrounds have a selection cut nearby). The results for the selection method are similar to the base regression results, but of slightly smaller magnitude and less significant. Compared to the base regression, separating operations by harvest type shows us that campers are responsive to selection cuts, but do not have a significant response to other methods. This result may be observed because selection cutting is the most common method of harvest both overall (see Figure 3.3) and near campgrounds. The large point estimate on the clearcut method may be observed because clearcutting has the most visual impact on a forest or operations.

Next, we separate campgrounds and harvests by USFS regions to see if there are regional differences in campground demand. We estimate this model both with and without controlling for the type of harvesting done by region. Controlling for the type of harvesting done by region can inform us if any differences observed between regions are driven by regional harvesting trends or by something else. Results from these models separated by region reveal timber harvesting's impact on campground utilization is heterogeneous across the Western U.S. The results without the clearcut control variable in Table 5.3 show that timber harvests in Regions 1 (Northern) and 2 (Rocky Mountain) have the most negative impacts on campground utilization. No other region has

Table 5.2: Capacity utilization, separated by harvest type.

	Dependent variable:
	Capacity utilization
Clearcut	−0.638
	(0.434)
Shelterwood	−0.189
	(0.662)
Selection	−0.146*
	(0.085)
Observations	2,940
R^2	0.004
Adjusted R^2	−0.367
F Statistic	3.201** (df = 3; 2141)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

significant coefficient estimates. Separating by region reveals that campers' responses to nearby harvesting varies by region.

When the variable controlling for type of harvesting done by region is included, there is very little change to the point estimates, though the impacts to campgrounds in Region 5 (Pacific Southwest) become significant. This suggests that the regional differences in campground capacity utilization are due to something other than the type of harvesting done by region.

Next, we estimate the model to see if impacts to campground demand linger in the years following harvesting activity. If reductions in campground demand do linger, gateway communities dependent on the economic stimulation from visitors will miss out on that stimulation for longer. For this model, each timber harvest is counted only as the fiscal year a timber harvest is awarded, rather than allowing harvests to impact multiple years. Results reveal that there is a significant negative response to campground utilization during the year of harvesting operations and strong

Table 5.3: Capacity utilization, separated by region.

	Dependent variable:	
	Capacity utilization	
	Without clearcut control	With clearcut control
Region 1	-1.133^{**}	-1.130^{**}
	(0.527)	(0.525)
Region 2	-0.207^{*}	-0.207^{*}
	(0.118)	(0.118)
Region 3	-0.114	-0.116
	(0.103)	(0.103)
Region 4	-0.036	-0.034
	(0.153)	(0.153)
Region 5	-0.726	-0.719^{**}
	(0.527)	(0.527)
Region 6	0.181	0.183
	(0.283)	(0.283)
Proportion clearcut	–	-0.003
		(0.015)
Observations	2,940	2,940
R^2	0.008	0.008
Adjusted R^2	-0.364	-0.365
F Statistic	2.771^{**} (df = 6; 2138)	2.389^{**} (df = 7; 2137)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

evidence suggesting lasting impacts in the year following harvesting activity (Table 5.4). Table 5.4 shows several iterations of the lagged impacts model, starting with a model that includes only the year a harvest occurs, then adding on one year lagged impacts, three year lagged impacts, five year lagged impacts and finally seven year lagged impacts. These results can be interpreted as a 1 percentage point increase in area harvested within a campground's buffered area would have a roughly 0.2 percentage point decrease in daily average campground capacity utilization during the year of harvest. These results are similar to the base model that allowed harvesting activities lasting multiple years to impact campgrounds during each year of operations. Table 5.4 also shows evidence that the negative impacts to campground capacity utilization linger for a one year lag. These results are similar to the impacts observed during the year of harvest. This suggests that individuals' demand for campgrounds continues to be impacted even after operations have ceased. However, as stated previously, harvests are only counted as the year they are awarded, so any operations in subsequent years are unaccounted for. Thus, the results may be driven by the unaccounted for years a harvest continues to operate. We examine this possibility in Table 5.10 in the following Robustness Checks section.

The next two models estimate harvesting's impact on campground utilization at a more aggregate level. The utilization of campgrounds with and without harvesting nearby is compared. Thus, all campgrounds in the RIDB data are included. In contrast to the previous regressions where the impact of nearby harvesting activity on campground utilization is estimated by continuously increasing the proportion of a campground's buffer harvested, these models compare campgrounds with harvesting nearby to those without. Furthermore, placing campgrounds into several buckets classified by the proportion of their buffers harvested allows us to estimate how specific levels of harvesting nearby impact utilization differently. We can compare the utilization of campgrounds with little harvesting in their buffers to those with more harvesting in their buffers.

First, a binary model is constructed that compares the capacity utilization of campgrounds with harvesting activity nearby to those without harvesting activity nearby. Table 5.5 shows that campgrounds with harvesting activity nearby have a lower average daily utilization than those without harvesting nearby. Campgrounds with harvesting in their buffer can be expected to have a 0.5 percentage point lower daily campground capacity utilization. In other words, if the average utilization of campgrounds without harvesting nearby is 0.5, the average utilization of campgrounds with harvesting nearby would be 0.495. Compared to the base model, the magnitude of the re-

Table 5.4: Capacity utilization, including several year lags.

	Dependent variable:				
	Capacity utilization				
	No lags	1 year	3 years	5 years	7 years
Harvest year	-0.248^{***}	-0.255^{***}	-0.255^{**}	-0.220^{**}	-0.201^{**}
	(0.093)	(0.095)	(0.102)	(0.095)	(0.094)
1 lag	–	-0.227^{***}	-0.241^{***}	-0.213^{**}	-0.200^{**}
		(0.086)	(0.086)	(0.089)	(0.088)
2 lags	–	–	0.075	0.099	0.111
			(0.106)	(0.102)	(0.102)
3 lags	–	–	−0.091	−0.108	−0.104
			(0.155)	(0.150)	(0.146)
4 lags	–	–	–	0.218	0.221^{*}
				(0.134)	(0.128)
5 lags	–	–	–	0.333	0.198
				(0.240)	(0.285)
6 lags	–	–	–	–	0.814
					(0.502)
7 lags	–	–	–	–	0.247
					(0.384)
Observations	2,157	2,157	2,157	2,157	2,157
R^2	0.003	0.006	0.007	0.009	0.013
Adjusted R^2	−0.675	−0.671	−0.673	−0.672	−0.668
F Statistic	4.497^{**}	3.961^{**}	2.102^{*}	1.931^{*}	2.032^{**}
	(df = 1; 1283)	(df = 2; 1282)	(df = 4; 1280)	(df = 6; 1278)	(df = 8; 1276)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

sults from the binary model are smaller, but supplement predictions that timber harvesting near campgrounds reduces their utilization.

Table 5.5: Capacity utilization, binary: harvesting nearby or not.

	Dependent variable:
	Capacity utilization
Harvesting nearby	-0.005^{**}
	(0.003)
Observations	15,588
R^2	0.0003
Adjusted R^2	-0.124
F Statistic	4.512^{**} (df = 1; 13867)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5.6 shows results from the model containing several buckets of campgrounds separated by the the proportion of harvested area nearby. Compared to campgrounds with no harvesting activity nearby, campgrounds with harvesting activity nearby in general have lower daily capacity utilization (Table 5.6). As the proportion harvested of a campground's buffer increases, campground capacity utilization generally decreases. Campgrounds with the lowest level of harvesting in their buffer (0-5%) can be expected to have a 0.4 percentage point lower daily campground capacity utilization, which is similar to the findings from the binary model. Thus, if the average utilization of campgrounds without harvesting nearby is 0.5, the average utilization of campgrounds with 0-5% of their buffer harvested would be 0.496. Conversely, campgrounds with the highest level of harvesting in their buffer (20% or greater) can be expected to have a 5.1 percentage point lower daily campground capacity utilization. For these campgrounds, if the average utilization of campgrounds without harvesting nearby is 0.5, the average utilization of campgrounds with 20% or more of their buffer harvested would be 0.449. This is a larger change in average utilization compared to the base results (utilization drops from 0.5 to 0.48). Thus, this model further confirms that compared to campgrounds with no harvesting activity nearby, campgrounds with harvesting activity nearby can be expected to have lower demand. Furthermore, campgrounds with higher proportions of their buffers harvested have lower demand than those with less of their buffers harvested.

Figure 5.1 shows a visual representation of the results from the buckets model (Table 5.6). This graphic shows that the point estimates are relatively linear as we compare campgrounds within different buckets of harvested area. This apparent linearity shows us that the base and subsequent model specifications are appropriate, which estimated the impact of marginal linear increases in the proportion of a campground's buffer that is harvested on campground utilization.

Table 5.6: Capacity utilization, buckets: 5% increments.

	Dependent variable:
	Capacity utilization
0-5% harvested	-0.004
	(0.003)
5-10% harvested	-0.016^{*}
	(0.010)
10-15% harvested	-0.021
	(0.013)
15-20% harvested	-0.060^{**}
	(0.024)
20% or greater harvested	-0.051^{***}
	(0.018)
Observations	15,588
R^2	0.001
Adjusted R^2	-0.123
F Statistic	2.585^{**} (df = 5; 13863)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

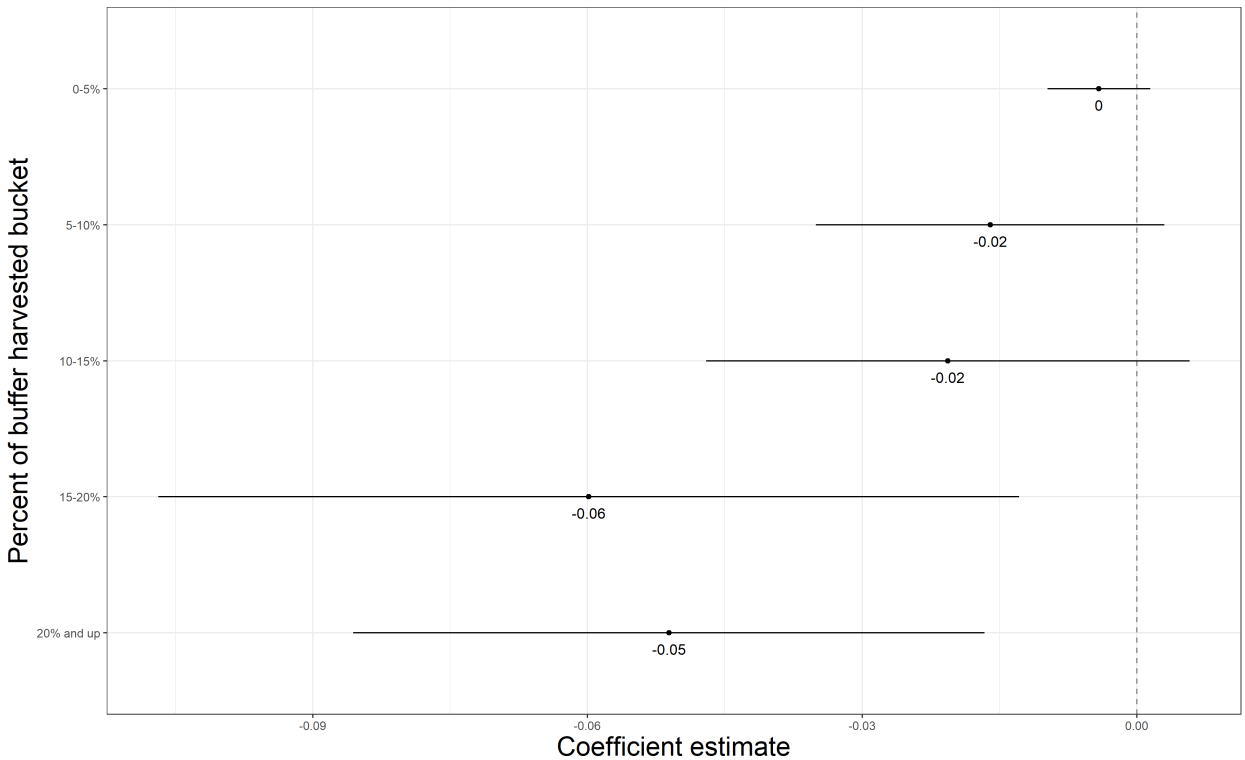

Figure 5.1: A visual representation of the coefficient estimates from the model categorizing campgrounds into several buckets of percentage of their buffer harvested.

Finally, we test the impact of three other USFS activities on campground demand. As stated previously, the USFS conducts many other forestry activities besides timber harvesting. Including these other activities allows us to compare the magnitude of the impact of these activities to the impact of forest harvesting. In Table 5.7, the impacts of brush disposal activities, hazardous fuel reduction treatments and integrated resource restoration (IRR) on nearby campground capacity utilization are estimated.

Activities are counted as the year they are awarded. The results from these models show that hazardous fuel reduction treatments and integrated resource restoration activities negatively impact nearby campground capacity utilization (Table 5.7). The coefficient on brush disposal is not statistically significant from zero, so we can conclude that this activity does not have a significant impact on campground demand (Table 5.7). These USFS activities may not be mutually exclusive to timber harvesting. For instance, brush disposal activities often take place after a harvest has been completed and debris remains in the impacted area. Compared to timber harvesting, the magnitude of impacts to campgrounds by these other activities is much smaller. Timber harvesting appears to impact campground demand more than these other USFS activities.

Table 5.7: Capacity utilization, other activities nearby: brush disposal activities, hazardous fuel treatment reduction and integrated resource restoration.

	Dependent variable:
	Capacity utilization
Brush disposal	0.046
	(0.057)
Hazardous fuel	-0.060^{***}
	(0.021)
IRR	-0.034^{***}
	(0.010)
Observations	8,648
R^2	0.003
Adjusted R^2	-0.204
F Statistic	6.462^{***} (df = 3; 7164)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

5.1 Robustness Checks

We complete several robustness checks to test if the assumptions we have made in the selection of the buffer size and campgrounds included impact results. These checks and alternate specifications test if the results are robust to the possibility that one of these assumptions might not be true. First, we change the size of the buffered area included around campgrounds. The 5-kilometer buffer was chosen somewhat arbitrarily to capture the area that campers are likely to consider when considering the aesthetics of their campground. However, depending on land cover, location, recreation opportunities nearby, individual preferences and other factors, campers may explore a larger or smaller area around their campsite. Therefore, we both contract the buffer to 2 kilometers and expand it to 10 kilometers (Table 5.8). Then, we investigate if the campgrounds included in the study impact the findings. The number of campgrounds included in the RIDB data is increasing over time. This may be due to many factors, such as new campgrounds being constructed or existing campgrounds that previously did not use recreation.gov for reservations going online. Therefore, it is necessary to test if including every campground in the RIDB data impacts the findings (Table 5.9). Finally, we test the assumptions of which harvests are included in the lag model. In the base lag model (Table 5.4), all timber harvests are included, but they can only impact the year they are awarded, rather than the full length of their duration. To test if results from this model are driven by harvests lasting multiple years, we estimate a model that includes only harvests lasting one year (Table 5.10).

First, we contract the buffer to a 2-kilometer radius. Table 5.8 shows that the coefficient on nearby harvesting within a 2-kilometer buffer is not statistically significant from zero. Thus, individuals' demand for campgrounds is not found to be significantly impacted by nearby harvesting when area considered is contracted to 2 kilometers. These results may be in part driven by fewer harvests taking place within a 2-kilometer buffer than a 5-kilometer buffer (1,521 versus 2,940 impacted campgrounds, respectively). Furthermore, a 1% change in a 2-kilometer buffer is a much smaller area than a 1% change in a 5-kilometer buffer. A 1% change in harvested area of the 5-kilometer buffer is 0.7854 square kilometers (1% of 78.54 square kilometers), while a 1% change in harvested area of the 2-kilometer buffer is 0.1257 square kilometers (1% of 12.57 square kilometers). Thus, a 1% change in the 5-kilometer buffer is over six times as large as a 1% change in the 2-kilometer buffer, so it is expected to not necessarily find significant impact to campgrounds using a 2-kilometer buffer.

However, when the buffer is expanded to 10 kilometers, we observe a negative and significant coefficient on campground capacity utilization. In Table 5.8, we find that a 1 percentage point increase in area harvested within the buffer would have a 0.3 percentage point decrease in daily average campground capacity utilization during the year of harvest. This point estimate is larger than the base regression estimate of a 0.2 percentage point decrease. This makes intuitive sense because there are both more impacted campgrounds (5,312 impacted campgrounds versus 2,940 impacted campgrounds for the 10 and 5-kilometer buffers, respectively) and a larger area of change. A 1% change in a 10-kilometer buffer is a much larger area than a 1% change in a 5-kilometer buffer. Again, a 1% change in harvested area of the 5-kilometer buffer is 0.7854 square kilometers, while a 1% change in harvested area of the 10-kilometer buffer is 3.142 square kilometers (1% of 314.2 square kilometers). A 1% change in the 10-kilometer buffer is over four times as large as a 1% change in the 5-kilometer buffer. These results show that a larger negative response to campground demand is observed when a larger area of impact is included. The localized campground aesthetics are not necessarily the largest driving factor of individuals' decisions.

Additionally, the base model is estimated including only campgrounds that have existed in the data since the start of reliable reservation data, i.e. since 2008 (Table 5.9). This model allows us to look at only campgrounds that have reservations each year and exclude those that came online at some point. The coefficient on harvesting activity in this model is similar to the estimate from the base regression. We can conclude that results are not significantly driven by campgrounds coming online, rather they are driven by individuals' responses to nearby harvesting.

Finally, the lag model is estimated including only harvests that last one year (Table 5.10). In this model, harvests that impact campgrounds for multiple years are excluded. In the base lagged model, we found negative impacts to campgrounds during the year a harvest is awarded as

Table 5.8: Capacity utilization, harvesting within a 2-kilometer and 10-kilometer buffer.

	Dependent variable:	
	Capacity utilization	
	2 km buffer	10 km buffer
Proportion harvested	-0.006	-0.342^{***}
	(0.006)	(0.130)
Observations	1,521	5,312
R^2	0.00002	0.002
Adjusted R^2	-0.535	-0.264
F Statistic	0.015 (df = 1; 990)	8.856^{***} (df = 1; 4193)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

well as in a one year lag. It is unclear if the results in the one year lag are driven by the lasting aesthetic impacts from harvesting or by multiple-year harvests that continue to impact campground utilization after the year they are awarded. To test if these lagged results are driven by harvests lasting multiple years, only include harvests lasting. We find no significant impacts to campground utilization from harvests lasting one year in any iterations of this model (Table 5.10). Compared to the base lag model, the predictive power of this model decreased significantly. It would appear that harvests lasting one year are not driving the results observed in the base lagged model. However, this does not answer the question of whether results from the base lagged model were observed because of the lasting aesthetic impacts to campgrounds from harvesting or from harvests lasting multiple years.

Table 5.9: Capacity utilization, campgrounds that have existed in the RIDB data since 2008.

	Dependent variable:
	Capacity utilization
Proportion harvested	-0.185^{*}
	(0.109)
Observations	1,017
R^2	0.004
Adjusted R^2	-0.277
F Statistic	3.475^{*} (df = 1; 792)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

Table 5.10: Capacity utilization, including several year lags. Only timber harvests lasting 1 year are included.

	Dependent variable:				
	Capacity utilization				
	No lags	1 year	3 years	5 years	7 years
Harvest year	−0.202	−0.202	−0.131	−0.123	−0.117
	(0.273)	(0.273)	(0.268)	(0.265)	(0.258)
1 lag	–	−0.044	−0.136	−0.145	−0.090
		(0.242)	(0.293)	(0.297)	(0.300)
2 lags	–	–	0.796	0.743	0.425
			(1.010)	(1.031)	(1.026)
3 lags	–	–	−0.444	−0.108	−0.119
			(1.601)	(1.612)	(1.602)
4 lags	–	–	–	−1.801	−1.759
				(1.821)	(1.763)
5 lags	–	–	–	1.148	1.989
				(1.370)	(1.063)
6 lags	–	–	–	–	−10.737
					(9.294)
7 lags	–	–	–	–	−50.356***
					(6.961)
Observations	973	973	973	973	973
R^2	0.001	0.001	0.002	0.005	0.030
Adjusted R^2	−1.178	−1.183	−1.189	−1.194	−1.147
F Statistic	0.270	0.141	0.264	0.346	1.709*
	(df = 1; 446)	(df = 2; 445)	(df = 4; 443)	(df = 6; 441)	(df = 8; 439)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

Chapter 6

Conclusion

This research adds to the growing body of literature analyzing the interactions of multiple forest uses on public land. Through the interaction of USFS historical timber harvesting data and RIDB reservation data, we explore several variables that can influence campground demand. We find significant negative effects to campground utilization during harvest operations in the Western U.S. with a 5-kilometer buffer around campgrounds. The selection method of harvest significantly negatively influences campground demand, while other methods of harvesting have no identifiable impact. Individuals' responses to harvesting activity is heterogeneous across USFS regions. Furthermore, strong evidence suggests that campground utilization is impacted up to one year after harvesting occurs. Other forest management activities undertaken by the USFS appear to be less impactful to campground utilization than timber harvesting. These results contribute to the expanding body of literature on timber harvesting and recreation demand and provide insight on potential impacts to gateway communities.

Overall, visitors to national forests are changing their camping behavior in response to timber harvesting, indicating potential decreases in welfare. If visitors choose to not to camp because of a timber harvest nearby, they may miss out on the positive benefits derived from outdoor recreation, such as physical challenges, health impacts and connection to nature. This study provides additional support to the existing literature that individuals change their preferences on where to recreate based on the attractiveness and aesthetics of a campground and its surrounding terrain, such as Eggers et al. (2018) and Harshaw and Sheppard (2013). The physical attributes of the land affected by timber harvested in the buffered area around a campground are reducing the capacity utilization of that campground.

Again, decreases in campground visitation may have significant effects on nearby tourism-dependent gateway communities. Due to the reduction in individuals deciding to recreate at certain campgrounds because of timber harvesting, fewer individuals may make recreation trips to the impacted area, and spending in gateway communities near those campgrounds may decrease. This has direct, indirect and induced economic impacts. The negative impact of timber harvesting on camping reservations represents a complex cost to local communities.

With more money and time, this research could be improved and expanded upon to include more data on how the USFS makes decisions on locating harvests. For example, investigating how much weight the USFS places on existing campgrounds or other recreation sites when deciding where to harvest would be informative to this research. Furthermore, the impact of specific activities could be explored, such as cleaning up areas impacted by beetle kill or fire. Similarly, the relationship between USFS management activities and wildfire can be explored further. Wildfire mitigation and cleanup are an increasingly important use of USFS resources, especially as climate change and other factors exacerbate the frequency and intensity of fires (Pausas and Keeley, 2021). The tradeoffs between harvesting and other USFS management activities to control for fire or other natural disasters could be explored. Although hazardous fuel treatment reduction was found to negatively impact campground capacity utilization (Table 10), in the long run, this activity could potentially prevent or deter a fire from burning a campground, which would likely have a larger visual effect. Additionally, rather than a simple circle around each point, the buffers around campgrounds could be altered to include factors such as land cover and hillshade to target areas more likely seen by individuals. Furthermore, we excluded data beginning in fiscal year 2019 to the present. The structure of the data changed in 2018, so data on more recent years is not directly comparable to the data used in this research. However, the methods of analyzing the reservation data could be altered to include these years. Finally, additional models that account for campground amenities and attributes could be included. If a campground has desirable attributes, such as being near a body of water, demand for that campground may be highly inelastic, and the campground's attributes might outweigh the potential effects of harvesting nearby. The inclusion of this campground-specific data can investigate whether campground attributes can influence the impact of harvesting on campground utilization.

The insights provided in this study may help inform land managers, specifically the USFS, on how timber harvesting activities and camping interact. Because timber harvesting does in fact decrease nearby campground utilization, in the future, the USFS could locate harvests further from existing campgrounds or utilize other methods of forest management besides timber harvesting.

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Appendix A

Additional Model Specifications

This section includes additional model specifications not included in the main study. These models inform the main findings, but are not as informative on campground capacity utilization by themselves.

Included are: a model that compares campgrounds with less than one week of harvesting activity nearby per year to campgrounds with over one week of harvesting activity nearby per year (Table A.1), a model that investigates whether the location of a of a campground in proximity to a population center influences the impact of harvesting on campground utilization (Table A.2), and the lag model using year of completion rather than year awarded as the year of harvest (Table A.3).

In the base regression, the length of harvesting activity is only counted by year. However, some harvests may only last one day, while others may last for several months. Harvest activities of different lengths are likely to have differing impacts on nearby campgrounds. We test if the length of harvesting activity within a given year near campgrounds impacts their utilization. Table A.1 shows that the utilization of campgrounds with more than one week of harvesting activity nearby per year is negatively impacted similar to the base results, while the coefficient on campgrounds with harvesting activity lasting one week or less per year is not statistically significant from zero. Thus, the utilization of campgrounds with less than one week of harvesting activity nearby per year is not impacted. Because these harvesting operations are so short, they likely have little visual impact. Conversely, campgrounds that experience longer periods of harvesting operations per year are likely more visually impacted. These findings suggest that within a given year, individuals' demand of campgrounds is reduced when harvesting activity nearby takes place over a long (more than one week) period of time.

We then estimate a model that investigates whether a campground being located near a population center influences the impact of harvesting on campground utilization. Distance to a campground is an important consideration to individuals when making recreation decisions. In general,

Table A.1: Capacity utilization, campgrounds with one week or less & more than one week of harvesting activity nearby per year.

	Dependent variable:	
	Capacity utilization	
	One week or less	More than one week
Proportion harvested	−3.095	-0.193^{**}
	(2.231)	(0.082)
Observations	385	2,580
R^2	0.018	0.004
Adjusted R^2	−2.492	−0.347
F Statistic	1.973 (df = 1; 108)	7.573^{***} (df = 1; 1907)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

as the distance to a recreation area increases, travel costs also increase. There are alternate definitions of what constitutes a recreation area being "nearby," such as walkability (e.g. Ekkel and de Vries, 2017) or travel time (e.g. Kim and Nicholls, 2016). For the purpose of this study, we will define campgrounds as being near a population center if they are within 40 kilometers of a city or town (Kim and Fesenmaier, 1990). Data on U.S. cities is taken from the R package, USAboundaries (Mullen and Bratt, 2018). In this model, the base model is estimated including a dummy variable for campgrounds nearby a population center (within a 40 kilometer radius). Thus, all campgrounds with timber harvesting within a 5-kilometer buffer are included and then classified as being near a population center or not. Approximately 58% of campgrounds with harvesting nearby are also near a population center. In Table A.2, the impact of nearby timber harvesting to campground utilization is separated by campgrounds not near a population center and campgrounds near a population center. From this model, we see that timber harvesting nearby campgrounds both near and not near population centers has negative impacts to utilization. For a campground not near a population center, the impact of a 1 percentage point increase in area harvested would decrease utilization by 0.15 percentage points. For a campground near a population center, a 1 percentage point increase in area harvested would decrease utilization by 0.21 percentage points ($-0.15 - 0.06 = -0.21$). Harvesting near population centers does not have an impact that is statistically significantly different from harvesting that occurs not near population centers. There are a number of reasons why the impact might be larger near population centers. For example, average capacity utilization is higher at campgrounds near population centers, so there is a larger potential for declines in capacity. Alternatively, it may be easier for individuals to substitute a trip to an impacted campground with a stay at a nearby hotel, so reductions in utilization are more common near population centers.

Table A.2: Campground capacity utilization, dummy for proximity to a population center.

	Dependent variable:
	Capacity utilization
Proportion harvested	−0.151
	(0.229)
Proportion harvested ∗ city dummy	−0.061
	(0.246)
Observations	2,940
R^2	0.004
Adjusted R^2	−0.367
F Statistic	3.847** (df = 2; 2142)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01

Finally, we specify the lag model using a different date variable from the dataset than what was used for the main lag model. In Table A.3, the lag model is specified using the fiscal year completed variable (rather than the fiscal year awarded variable) as the year of harvest. These results show no consistently significant impact to individuals' campground utilization decisions from nearby harvesting. This differs from the main findings where the year harvesting operations are awarded was found to significantly and negatively impact camping decisions both during the year harvests are awarded and the following year. These findings may occur because the year of completion in the harvesting data is not indicative of when the intense harvesting activity actually occurs.

Table A.3: Capacity utilization, including several year lags, identified as final year of harvesting.

	Dependent variable:				
	Capacity utilization				
	No lags	1 year	3 years	5 years	7 years
Harvest year	−0.029	−0.048	−0.017	0.032	0.031
	(0.093)	(0.093)	(0.098)	(0.085)	(0.086)
1 lag	–	-0.206^{**}	-0.184^{**}	-0.151^{*}	−0.151
		(0.085)	(0.087)	(0.088)	(0.092)
2 lags	–	–	0.066	0.088	0.087
			(0.097)	(0.093)	(0.095)
3 lags	–	–	0.202^{**}	0.208^{**}	0.205^{**}
			(0.086)	(0.087)	(0.084)
4 lags	–	–	–	0.159	0.144
				(0.116)	(0.120)
5 lags	–	–	–	0.190	0.170
				(0.226)	(0.223)
6 lags	–	–	–	–	−0.054
					(0.185)
7 lags	–	–	–	–	0.399
					(0.643)
Observations	2,292	2,292	2,292	2,292	2,292
R^2	0.00004	0.002	0.004	0.005	0.006
Adjusted R^2	−0.555	−0.553	−0.553	−0.552	−0.554
F Statistic	0.065	1.629	1.365	1.290	1.024
	(df = 1; 1473)	(df = 2; 1472)	(df = 4; 1470)	(df = 6; 1468)	(df = 8; 1466)

Campground and year fixed effects are included

Note: *p<0.1; **p<0.05; ***p<0.01