



Recreational Camping Damages Due to the Refugio Beach Oil Spill

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prepared for:

Refugio Beach Oil Spill Natural Resource Damage
Assessment

prepared by:

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CHAPTER 1 | INTRODUCTION

On May 19, 2015 an underground pipeline ruptured just west of Refugio State Beach in Santa Barbara County, California, spilling over 120,000 gallons of crude oil into the soil and onto the ground (hereafter referred to as “the spill”).¹ A significant portion of the oil flowed down a nearby ravine and into the Pacific Ocean. After reaching the ocean, the oil spread primarily southward and eastward. Oil washed up on shore around Refugio and El Capitan State Beaches (Exhibit 1.1), resulting in the closure of those sites. In the weeks following the spill, oil and/or tarballs washed ashore in numerous locations along the coastlines of Santa Barbara, Ventura, and Los Angeles Counties.

EXHIBIT 1.1. OVERVIEW OF ASSESSMENT AREA



¹ The United States Department of Transportation’s failure investigation for the spill indicates that, according to the pipeline owner, 2,934 barrels, or 123,228 gallons of oil were released (USDOT, 2016).

The spill occurred within the undeveloped portion of Santa Barbara County referred to as the “Gaviota Coast.” The Gaviota Coast is widely recognized for its scenic beauty and outdoor recreation opportunities, and the area supports California State Park’s mission of supporting health, inspiration, and education through the preservation of extraordinary biological diversity, protecting valued natural and cultural resources, and creating opportunities for high-quality outdoor recreation. In fact, in the early 2000s, the National Park Service (NPS) undertook a feasibility study to determine if the Gaviota Coast should be added to the National Park System (NPS, 2003).

Federal and state natural resource trustee agencies (“Trustees”), in coordination with Plains All America Pipeline (the pipeline owner and operator), conducted a Natural Resource Damage Assessment (NRDA) to assess the impacts of the spill on natural resources. The Trustees for the natural resources injured by the spill include the United States Department of Commerce represented by the National Oceanic and Atmospheric Administration; the United States Department of the Interior represented by the United States Fish and Wildlife Service (USFWS) and the Bureau of Land Management (BLM); the California Department of Fish and Wildlife; the California Department of Parks and Recreation; the California State Lands Commission; and the Regents of the University of California.

As part of the NRDA, the Trustees assessed the impacts of the spill on recreational users of the coastal and marine environment. Recreational users were potentially impacted due to the direct oiling of natural resources and the reasonable expectation of oiling, shoreline and fishing closures, advisories, and cleanup activities. This report documents the impact of the spill on recreational camping. Economic losses to campers are based on the economic concept of consumer surplus (USDOJ, 1987). An individual’s consumer surplus from a camping trip represents the difference between (1) the maximum amount that the individual would be willing to pay for the trip and (2) the amount that the individual actually paid for the trip (in gasoline, supplies, reservation fees, etc.). Thus, consumer surplus is a measure of the net value of a trip, after all expenses have been paid. Camping damages estimated in this report are measured as the aggregate decline in value across all impacted individuals.

We estimated camping damages in four steps:

- 1) Estimate the number of lost camping nights;
- 2) Estimate the economic value associated with a camping night;
- 3) Multiply the number of lost nights by the value per night; and
- 4) Adjust losses to present value.

Chapter 2 provides a description of camping opportunities in the assessment area and summarizes the spill impacts on these opportunities. Chapter 3 describes our quantification of lost camping nights. Chapter 4 explains our method for estimating the value per camping night and presents total damages.

CHAPTER 2 | OVERVIEW OF SPILL IMPACTS TO CAMPING

This chapter provides an overview of coastal camping opportunities in Santa Barbara and Ventura Counties. It then describes how camping in these counties may have been impacted by the spill. While oil also washed ashore in Los Angeles County, camping impacts in Los Angeles County were deemed negligible based on the absence of impacts in Ventura County (see Chapter 3) and conversations with resource managers.

2.1 CAMPING RESOURCES IN ASSESSMENT AREA

Santa Barbara and Ventura Counties provide a limited number of coastal camping opportunities (Exhibits 2.1 and 2.2). In Santa Barbara County, Jalama Beach County Park is the only coastal campground located north of Point Conception. Three state campgrounds lie between Point Conception and Goleta along the Gaviota Coast: Gaviota State Park, Refugio State Beach, and El Capitan State Beach.² Finally, Carpinteria State Beach is located in eastern Santa Barbara County.

In Ventura County, three county campgrounds are located along Highway 101 between Rincon Point and Ventura: Hobson Beach County Park, Rincon Parkway, and Faria Beach County Park. Emma Wood State Beach is located just north of Ventura. McGrath State Beach is located just south of the mouth of the Santa Clara River, and was closed for reasons unrelated to the spill from August 2014 to September 2017.³ Finally, Point Mugu Beach Recreational Vehicle (RV) Park and Point Mugu State Park are located along Highway 101 south of Oxnard.

With limited camping opportunities along the coast in this region, several of these campgrounds are fully booked in late spring and summer. For example, Refugio and El Capitan State Beaches are completely full on most weekend nights in May and June, and are full or nearly full every night of the week in July and August. Further, visitors to these two parks typically need to reserve campsites three to four months in advance for summer visits.

² Two private campgrounds are located a short walk from El Capitan State Beach north of Highway 101, El Capitan Canyon and Ocean Mesa. Impacts to patrons of these two campgrounds are included in the shoreline use assessment since they use the spill area as day users rather than as campers (see Horsch et al., 2018).

³ McGrath State Beach has been closed intermittently since September 2017 due to flooding.

EXHIBIT 2.1. SANTA BARBARA AND VENTURA COUNTY COASTAL CAMPING LOCATIONS



EXHIBIT 2.2. CAPACITY OF COASTAL CAMPING LOCATIONS

LOCATION	INDIVIDUAL CAMPSITES (TENT OR RV)	GROUP CAMPSITES
Jalama Beach County Park	107	0
Gaviota State Park	40	0
Refugio State Beach	68	3
El Capitan State Beach	137	5
Carpinteria State Beach	201	7
Hobson Beach County Park	31	0
Rincon Parkway	127 (RV only)	0
Faria Beach County Park	42	0
Emma Wood State Beach	91	5
McGrath State Beach	NA (Closed)	NA (Closed)
Point Mugu Beach RV Park	86	0
Point Mugu State Park	136	3
Sources: California State Parks System (2016), Santa Barbara County Parks (2016), Hobson Beach Park (2016), Rincon Parkway (2016), Faria Beach Park (2016), Point Mugu RV Park (2016).		

2.2 SPILL IMPACTS TO CAMPING

In Santa Barbara County, Refugio and El Capitan State Beaches (including their campgrounds) were both temporarily closed as a result of the spill. Refugio State Beach, located immediately east of the release point, was evacuated on May 19, 2015 and remained closed for 59 days, reopening on July 17, 2015 (Exhibit 2.3). El Capitan State Beach was evacuated on May 20, 2015 and remained closed for 37 days, reopening on June 26, 2015. In addition, a fisheries closure was established on May 19 for the immediately affected area around the release point (Exhibit 2.4). On May 21, the fisheries closure area was expanded to include the shoreline between Canada de Alegeria and Coal Oil Point, as well as all ocean waters within six miles of this shoreline. The fisheries closure remained in place through June 28 and potentially impacted campers at Gaviota State Beach (throughout the entire closure period) and at El Capitan State Beach (for a three-day period after El Capitan State Beach reopened).

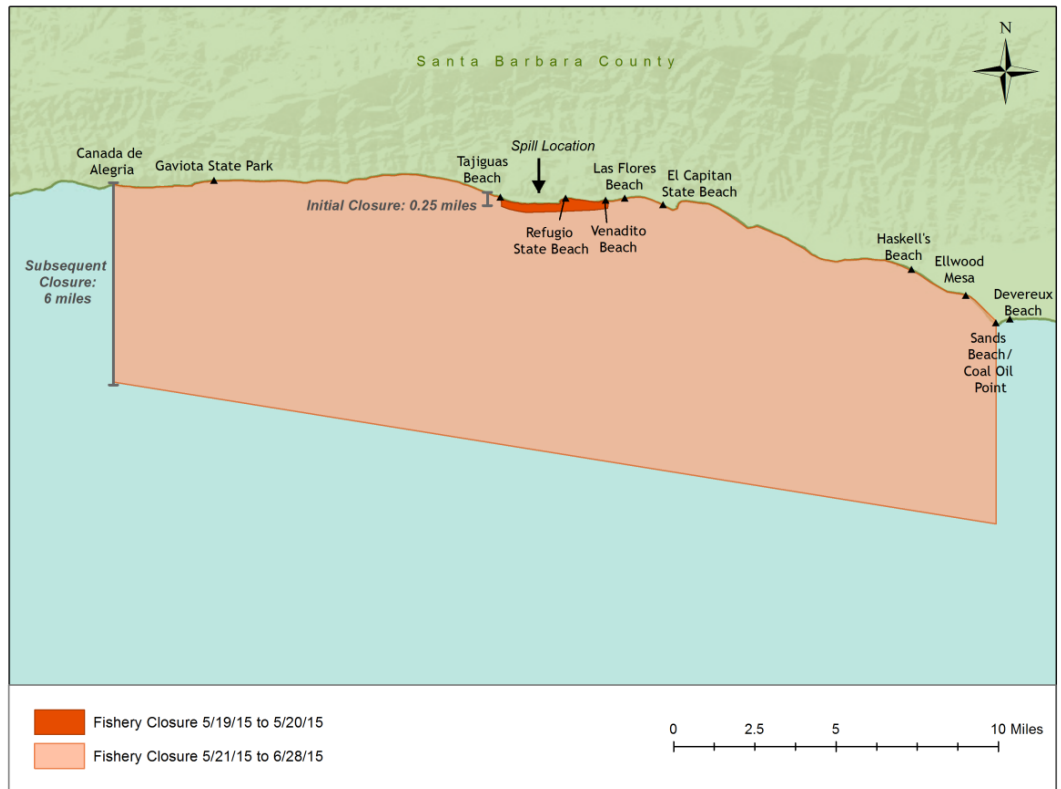
In Ventura County, no campgrounds were closed as a result of the spill, but advisories related to the oil spill—instructing people to avoid contact with tar and oil—were posted on large, electronic highway signs along major coastal access routes throughout the county from May 30 to June 8 (Exhibit 2.3).

EXHIBIT 2.3. CAMPING-RELATED CLOSURES AND ADVISORIES

LOCATION	CLOSURE OR ADVISORY	BEGIN	END	DURATION
Refugio State Beach	Closure	May 19	July 16	59 days
El Capitan State Beach	Closure	May 20	June 25	37 days
Ocean fishing in vicinity of release point ^a	Closure	May 19	June 28	41 days
Beaches and campgrounds in Ventura County	Advisory	May 30	June 8	10 days
Notes: ^a - The fisheries closure only included the area near the release point between May 19 and 20 (Exhibit 2.4). Between May 21 and June 28, it was expanded to include the area up to six miles offshore from Canada de Alegeria (western boundary) to Coal Oil Point (eastern boundary).				

In addition to these advisories and closures, incident-related cleanup crews were present on numerous beaches in Santa Barbara and Ventura Counties in the weeks following the spill, ranging from Gaviota State Beach in the north to Port Hueneme Beach in the south. Oiling was heaviest and persisted longest in areas close to the release point (i.e., in the vicinity of Refugio and El Capitan State Beaches) and downcoast to Coal Oil Point. The oil spread primarily south and east from the release point, though some spread west to Gaviota State Park. Light to moderate oiling was observed at coastal locations throughout the rest of Santa Barbara County and much of Ventura County. During the weeks after the spill, media coverage of the event was pronounced throughout the South Coast region, and to a lesser extent nationally, on television, social media, and in newspapers.

EXHIBIT 2.4. FISHERIES CLOSURE AREA



CHAPTER 3 | NUMBER OF LOST CAMPING NIGHTS

This chapter describes the quantification of lost coastal camping nights in Santa Barbara and Ventura Counties. We begin with an overview of the available data and the methods used to estimate the number of lost camping nights. We then provide estimates for each site.

3.1 OVERVIEW OF DATA AND ANALYSIS APPROACH

The number of lost camping nights equals the reduction in camping relative to baseline, or the level of use that would have existed had the spill not occurred. At coastal campgrounds located in state parks, the number of occupied campsites is tracked on a daily basis. For these locations, the average number of occupied sites in years prior to the spill is compared to the actual number of occupied sites in 2015 to estimate the number of lost camping nights. For the remaining county and private campgrounds, visitation data are limited. To estimate lost camping nights at these sites, we rely on estimates from surrounding state parks and other relevant information, as described in the final section of this chapter.

For state park campgrounds, we obtained daily data on the number of occupied campsites for May through September for the five years prior to the spill (2010-2014) and for the spill year (2015).⁴ We shifted the data series for each pre-spill year to match the days of the week in 2015, beginning with the Tuesday closest to May 19 (the spill date). For example, in 2014 the closest Tuesday to May 19 occurred on May 20, so the 2014 data series was shifted back by one day, such that May 20, 2014 was matched with May 19, 2015, and so on (Exhibit 3.1).

For every day in 2015, we calculate the deviation from baseline as the number of occupied campsites on that day in 2015 minus the average number of occupied campsites on the five matched days in 2010-2014:

$$(3.1) \quad D_t = N_t^{2015} - (N_t^{2010} + N_t^{2011} + N_t^{2012} + N_t^{2013} + N_t^{2014})/5$$

⁴ For Point Mugu State Park, we were unable to obtain data for August and September of 2010 and September of 2011-2014.

where:

D_t = Deviation on matched day t

N_t^y = Total number of occupied individual campsites on matched day t of year y .⁵

EXHIBIT 3.1. ILLUSTRATION OF APPROACH TO MATCHING DAYS

MATCHED DAY NUMBER	DAY OF WEEK	PRE-SPILL YEARS					SPILL YEAR
		2010	2011	2012	2013	2014	2015
1	Tuesday	5/18/2010	5/17/2011	5/22/2012	5/21/2013	5/20/2014	5/19/2015 ^a
2	Wednesday	5/19/2010	5/18/2011	5/23/2012	5/22/2013	5/21/2014	5/20/2015
3	Thursday	5/20/2010	5/19/2011	5/24/2012	5/23/2013	5/22/2014	5/21/2015
4	Friday	5/21/2010	5/20/2011	5/25/2012	5/24/2013	5/23/2014	5/22/2015
5	Saturday	5/22/2010	5/21/2011	5/26/2012	5/25/2013	5/24/2014	5/23/2015
6	Sunday	5/23/2010	5/22/2011	5/27/2012	5/26/2013	5/25/2014	5/24/2015
7	Monday	5/24/2010	5/23/2011	5/28/2012	5/27/2013	5/26/2014	5/25/2015
8	Tuesday	5/25/2010	5/24/2011	5/29/2012	5/28/2013	5/27/2014	5/26/2015
9	Wednesday	5/26/2010	5/25/2011	5/30/2012	5/29/2013	5/28/2014	5/27/2015
Etc.							
Notes: a -Day of the spill.							

The daily deviations estimated using Equation 3.1 are summed over two-week periods, beginning with May 20, 2015, the first full day after the spill.⁶ Aggregating by two-week periods smooths the results and ensures that major holidays fall within the same time blocks.

Our “matched days” approach to calculating lost camping nights is preferable to using a parametric model (i.e., modeling camping nights as a function of various factors) given that these campgrounds are at or near capacity throughout much of the summer. With the campgrounds at or near capacity, the impact of weather and other factors would be muted in a parametric model, and obtaining accurate predictions for 2015 would be challenging.⁷

⁵ Group camping is excluded when calculating these deviations, but it is incorporated in our final estimate of lost camping nights.

⁶ Since the closure at Refugio State Beach began on May 19, 2015, the first period for this site includes 15 rather than 14 days.

⁷ Censored models were explored, but ultimately were not used due to estimation difficulties.

3.2 RESULTS FOR STATE PARKS AND BEACHES

Exhibit 3.2 presents the estimated percentage deviation from baseline for each site and two-week period. Spill impacts occur when the initial deviation at a site is negative and continue until the first period with a non-negative deviation or until the first full period after Labor Day.⁸ We find a decline in camping associated with the spill for two weeks at Gaviota State Park, and through early September at Refugio and El Capitan State Beaches. We do not observe a spill-related decline in camping at any other site. While a modest decline was observed in the data for Carpinteria State Beach, conversations with resource managers indicate that this decline is likely due to a temporary reduction in the number of campsites available to visitors at Carpinteria State Beach in 2015. The highlighted periods in Exhibit 3.2 depict the sites and time periods with spill impacts.

EXHIBIT 3.2. PERCENTAGE DEVIATION BY SITE AND PERIOD^A

Site	May	June		July			August		September	
Gaviota State Park		-16.1%	34.6%	10.3%	-20.9%	-6.4%	-9.0%	-9.0%	-10.2%	-2.8%
Refugio State Beach ^b		-100.0%	-100.0%	-100.0%	-100.0%	-17.5%	-2.5%	-3.1%	-3.9%	-4.4%
El Capitan State Beach		-100.0%	-100.0%	-66.3%	-4.5%	-0.3%	-0.7%	-3.1%	-7.3%	-1.4%
Carpinteria State Beach		-3.3%	-7.5%	-5.1%	-5.8%	-6.7%	-5.1%	-4.5%	-8.1%	2.2%
Emma Wood State Beach		13.8%	18.2%	11.9%	1.7%	-1.2%	0.8%	6.4%	12.5%	38.4%
Point Mugu State Park		6.2%	-18.6%	-14.1%	-15.5%	-6.8%	1.5%	3.8%		

Notes:

^a - Sites and time periods with a spill impact are highlighted.

^b - Since the closure at Refugio State Beach began on May 19, 2015, the first period for this site includes 15 rather than 14 days.

Estimates of baseline camping nights are presented in Exhibit 3.3 for sites and periods where a decline in use due to the spill was observed. These estimates were developed by multiplying our baseline estimates of occupied campsites by the average number of persons per occupied site (as estimated by the California Department of Parks and Recreation), then adding the average number of persons observed at group camping sites during the baseline period.

Lost camping nights are calculated by multiplying the percentage decline for a particular site and period (Exhibit 3.2) by the corresponding baseline nights (Exhibit 3.3). The lost camping night estimates are summarized in Exhibit 3.4. In total we estimate 49,188 lost camping nights, with the vast majority occurring at Refugio and El Capitan State Beaches.

⁸ Any impacts after Labor Day were likely very small for two reasons: 1) the amount of baseline camping nights declines significantly after Labor Day, relative to the summer season, and 2) percentage declines were small relative to the summer season and diminishing.

EXHIBIT 3.3. BASELINE CAMPING NIGHTS BY SITE AND PERIOD

Site	May	June	July	August	September
Gaviota State Park					
Refugio State Beach ^a					
El Capitan State Beach					

Notes:

^a - Since the closure at Refugio State Beach began on May 19, 2015, the first period for this site includes 15 rather than 14 days.

EXHIBIT 3.4. SUMMARY OF LOST CAMPING NIGHTS

SITE	LOST CAMPING NIGHTS
Gaviota State Park	189
Refugio State Beach	23,009
El Capitan State Beach	25,989
Total	49,188

3.3 RESULTS FOR OTHER SITES

This section describes our assessment of impacts to camping at Jalama Beach County Park, Hobson Beach County Park, Rincon Parkway, Faria Beach County Park, and Point Mugu Beach RV Park.

For Jalama Beach County Park, we compared May-September occupancy rates in 2015 with May-September occupancy rates in pre-spill years. Based on this analysis, 2015 did not exhibit spill-related impacts. Although intra-month declines due to the spill may be masked in these monthly data, Jalama Beach County Park was relatively far from the spill.

Managers for Hobson Beach County Park, Rincon Parkway, Faria Beach County Park, and Point Mugu Beach RV Park reported that the spill did not have an impact on camping at their sites. While data were not available for these locations, these statements are consistent with results for surrounding sites (Carpinteria State Park and Emma Wood State Beach; Exhibit 3.2).

CHAPTER 4 | VALUE OF A CAMPING NIGHT AND SUMMARY OF DAMAGES

The value of a camping night was estimated using travel cost models for Refugio and El Capitan State Beaches. The analysis was implemented in three steps. First, we used campsite reservation data to estimate baseline demand functions. Second, we adjusted these baseline demand functions to reflect the impact of capacity constraints at the two sites. Third, we used these adjusted baseline demand functions to calculate the value of a camping trip. Each step of the analysis is described in detail below.

4.1 BASELINE DEMAND FUNCTIONS

We estimated baseline demand functions using single-site, zonal travel cost models for Refugio and El Capitan State Beaches. Single-site models were chosen over multiple-site models because data for multiple-site models were not available. In addition, the camping closures occurred during the peak camping season, when vacancies at substitute coastal campgrounds are scarce. Zonal travel cost models relate population trip rates (e.g., camping nights per person) to the cost of traveling to a recreation site, controlling for relevant demographic characteristics (Hellerstein 1992; Hellerstein and Mendelsohn 1993). The cost of traveling to the site is treated as a proxy for price, and the relationship between trip rate and price is used to derive baseline demand.

The unit of analysis for the zonal travel cost models was a zip code tabulation area (ZCTA), a geographic region defined by the U.S. Census Bureau that is largely consistent with U.S. Postal Service ZIP codes.⁹ Our analysis focuses on the subset of ZCTAs within 500 driving miles of Refugio State Beach.¹⁰

For each ZCTA, we used reservation data provided by California State Parks to calculate the total number of reserved camping nights at Refugio and El Capitan State Beaches originating from the ZCTA. We then divided total reserved camping nights by the population of the ZCTA to produce a ZCTA-specific trip rate for each site. In calculating the total number of reserved camping nights, we focused on the 2015 closure dates during the five calendar years prior to the spill. That is, for Refugio State Beach, we focused on

⁹ Approximately 2.7 percent of camping nights in the reservation data did not have a ZCTA match for the ZIP code provided, and were therefore excluded from the model. This is likely due to a combination of factors, including the use of P.O. boxes and ZIP code reporting errors.

¹⁰ Five hundred miles was selected as a reasonable upper bound driving distance for the travel cost model. While some campers travel further than 500 miles to visit these sites, we do not know if visitors from these distant origins drive or fly to the site. Minor modifications to the distance cutoff had very little impact on the camping night value.

camping reservations between May 19 and July 16 during the 2010 to 2014 period, and for El Capitan State Beach we focused on camping reservations between May 20 and June 25 for the same five-year period.

The round-trip cost of driving to each site was calculated as the out-of-pocket cost per mile times the total number of miles traveled, plus the opportunity cost of time per hour times the total number of hours spent traveling, plus any tolls. Total miles, hours, and tolls associated with driving to each site were calculated using PC Miler, assuming all trips originate at the geographic centroid of each ZCTA.

The assumed out-of-pocket cost per vehicle mile was \$0.418 for Refugio State Beach and \$0.334 for El Capitan State Beach. These cost assumptions reflect weighted average out-of-pocket costs for standard vehicles, vehicles pulling trailers, and RVs, with weights determined by the percentage of reservations at each site using each type of transportation. We use \$0.243, \$0.456, and \$0.763 to represent the out-of-pocket cost per vehicle mile for standard vehicles, vehicles pulling trailers, and RVs, respectively.¹¹ Out-of-pocket and toll costs were divided by 3.2 to reflect cost sharing among vehicle occupants.¹² The opportunity cost of time per hour was calculated as one-third the mean annual income of the ZCTA divided by 2,080 hours (52 weeks times 40 hours per week).¹³

We estimate the parameters of separate Poisson count models for each park. Letting y_i represent the park-specific trip rate associated with the i th ZCTA, the Poisson probability of observing y_i is given by

$$(4.1) \quad P(y_i) = \frac{e^{-\mu_i} \mu_i^{y_i}}{y_i!},$$

where μ_i , the expected trip demand, is a function of travel cost (p_i), a set of demographic controls (z_i), and parameters to be estimated (γ and β):

$$(4.2) \quad \mu_i(p_i, z_i) = \exp(\gamma p_i + z_i' \beta).$$

The demographic controls used in estimating the models are provided in Exhibit 4.1.

¹¹ The per-mile cost for standard vehicles was calculated as the average operating cost (including gasoline, maintenance and depreciation) for small, medium, and large sedans based on the American Automobile Association's 2012 edition of "Your Driving Costs." The per-mile cost for vehicles pulling trailers was developed by adjusting the per-mile cost for standard vehicles using fuel efficiency calculations reported in Table 2 of Thomas, Huff, and West (2014). The per-mile cost for RVs was developed by adjusting the per-mile cost for standard vehicles to reflect a fuel efficiency ratio of approximately 3.14 (29.8 mpg for standard vehicles versus 9.5 mpg for RVs).

¹² California State Parks assumes an average of 3.2 persons per day use vehicle at these sites.

¹³ One-third of hourly household income is often used by economists to represent the opportunity cost of time in travel cost models (e.g., Parsons et al., 2009).

EXHIBIT 4.1. DEMOGRAPHIC VARIABLES

VARIABLE DESCRIPTION
Median age
% of population living in Census-designated urban areas
% of adults with a high school diploma or less
% of adults with a 4-year college degree
% of adults unemployed
% white
% male
% of households with members less than 18
Mean household size
Source: 2012 American Community Survey (ACS) five-year averages.

These demographic variables are identical to those used in the Deepwater Horizon infield valuation model (von Haefen, 2015).

4.2 ADJUSTMENTS TO BASELINE DEMAND TO REFLECT CAPACITY CONSTRAINTS

The campgrounds at Refugio and El Capitan State Beaches are frequently filled to capacity during the summer months, even on many weekdays (Exhibit 4.2). As a result, not everyone who would like to camp at these sites can secure a reservation. All else equal, individuals who have a higher willingness to pay to camp at these locations are more likely to exert the effort required to secure a reservation. For this reason, we would underestimate campers' true willingness to pay by calculating the value per camping night using the baseline demand curves described in the previous section. We therefore adjust the baseline demand curves to reflect this capacity constraint prior to calculating a camping night value.

Specifically, we shift each demand curve outward to reflect demand at each site in the absence of the capacity constraint. As day use visits at the two sites are relatively unrestricted, we use information on variation in day use visitation during the baseline years (2010 to 2014) to predict unrestricted demand for camping. We assume that without the capacity constraint, the percentage increase in camping between the pre-closure period and the closure period would mirror the percentage increase in day use between the same two time periods. We specify May 1 to 18 as the pre-closure period for Refugio, and we specify May 1 to 19 as the pre-closure period for El Capitan.

Let d_1 and c_1 represent observed total day use and camping, respectively, during the pre-closure period from 2010 to 2014, and let d_2 and c_2 represent observed total day use and camping, respectively, during the closure period from 2010 to 2014. The percentage increase in camping (δ) without the capacity constraint is estimated as the ratio of day use to camping in the closure period to the ratio of day use to camping in the pre-closure period:

$$(4.3) \quad \hat{\delta} = \frac{(d_2/c_2)}{(d_1/c_1)}$$

This percentage increase is estimated separately for weekdays and weekends at each park. A park-specific weighted average percentage increase is then calculated, where the weights are equal to the proportion of use occurring on each type of day.¹⁴ The overall estimated percentage increase in camping demand is 50.0 percent for Refugio and 27.8 percent for El Capitan.

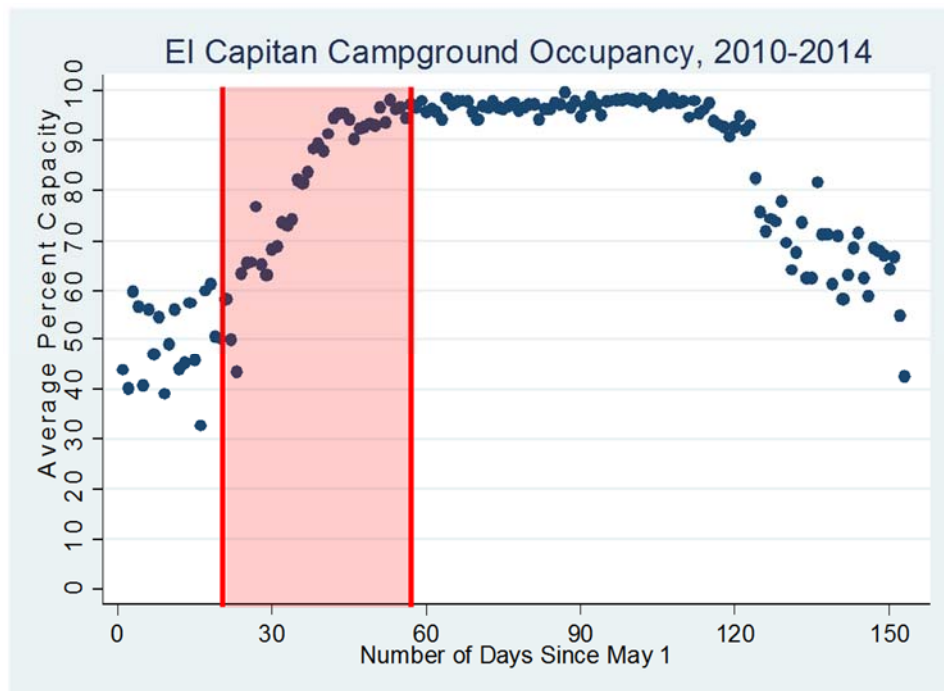
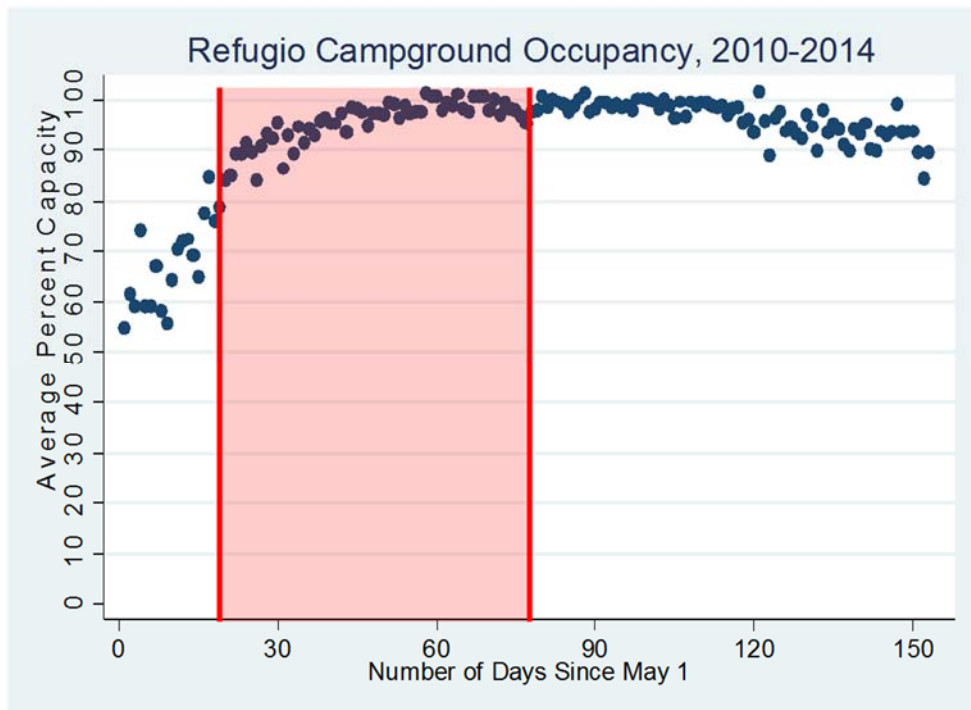
Given these estimated increases, the unrestricted camping demand at each site is given by:

$$(4.4) \quad \tilde{\mu}_i(p_i, z_i) = \hat{\delta} \exp(\hat{\gamma} p_i + z_i' \hat{\beta}),$$

where $\hat{\gamma}$ and $\hat{\beta}$ are the estimated parameters from Equation 4.2. This is the shifted camping demand curve from Equation 4.2 that would result if demand were allowed to increase to $\hat{\delta}$ times current levels.

¹⁴ Camping at El Capitan does not appear to be capacity constrained on weekdays during the closure period, so the weekday adjustment ratio was 1.0 for El Capitan.

EXHIBIT 4.2. OCCUPANCY RATES AT REFUGIO AND EL CAPITAN STATE BEACHES (2015 CLOSURE PERIODS HIGHLIGHTED)



4.3 VALUE PER CAMPING NIGHT

We use the unrestricted camping demand curves for each park to calculate the value of a camping night. Specifically, for each ZCTA, we calculate the total consumer surplus as the area under the unrestricted demand curve (Equation 4.4) above the price, up to the number of camping trips predicted with the capacity constraint imposed. We then sum consumer surplus across all ZCTAs and divide by the total number of predicted trips to estimate the value per camping night.

Let $\tilde{p}_i(\mu_i, z_i)$ represent the unrestricted inverse demand curve for the i th ZCTA. The camping night value for each park is calculated as:

$$(4.5) \quad V = \frac{\sum_{i=1}^n \int_0^{\mu_i(p_i, z_i)} (\tilde{p}_i(x_i, z_i) - p_i) dx}{\sum_{i=1}^n \mu_i(p_i, z_i)}$$

The estimated camping value for Refugio State Beach is \$22.99 per night and \$30.45 per night for El Capitan State Beach (both in 2012 dollars). We calculate an overall camping night value as the weighted average of the values for the two parks, with weights equal to the number of lost camping nights at each location. The weighted average camping night value is \$26.94. We adjust this estimate to July 2018 dollars using the consumer price index (CPI) (Bureau of Labor Statistics, 2018) to obtain an estimated value per camping night of \$29.57.

4.4 SUMMARY OF DAMAGES

We combine our estimate of lost camping nights (49,188) with the estimated value per night (\$29.57) to calculate damages.¹⁵ Present value damages as of July 2018 are calculated using monthly discounting at an annual rate of three percent (NOAA, 1999). To implement monthly discounting, we assign the two-week loss periods (Exhibit 3.2) to the month that includes the majority of the period. Exhibit 4.3 presents the distribution of losses by month.

EXHIBIT 4.3. TEMPORAL DISTRIBUTION OF CAMPING LOSSES

MAY	JUNE	JULY	AUGUST	SEPTEMBER
25%	57%	15%	1%	2%

Our estimate of camping damages as of July 2018 is \$1,593,571.

¹⁵ Some camping nights that occurred after the spill may have been diminished. However, we do not have sufficient data to estimate the number of diminished camping nights. Therefore, diminished camping use impacts are excluded from our damages estimate.

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