



Half Dome Trail Visitor Use Monitoring Report

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Executive Summary

This report details findings from the 2011 study to document visitor use conditions on Half Dome. The purpose of this study was to examine the effects of the new seven day a week permit system on Half Dome, previously a weekend only permit system in 2010. Specifically, this study collected data to answer the following research questions: 1) What are the changes in visitor use conditions on the Half Dome Trail in 2011 compared to conditions in 2008 and 2010? 2) How are visitor arrivals at the Half Dome trail junction related to average and maximum people at one time (PAOT) on the subdome, cables, and summit? 3) Does the 400 people per day permit system maintain 'free flow' travel conditions on the cable route? 4) Is the seven-day permit system effective in maintaining the 'free flow' standard for the number of PAOT on the cables?

Data were collected on Half Dome from July 9, 2011 to September 18, 2011. The following variables were collected: 1) people at one time (PAOT) on the cable route; 2) PAOT on the subdome and summit; 3) group size; 4) trail encounters with individual people and groups; and 5) overall visitor use levels measured using automated visitor counters.

Results from the 2008 use study on Half Dome showed consistently higher use on weekends than on weekdays. In 2010 with the permit system operating on Fridays, Saturdays, Sundays, and holidays, displacement was observed from 2008 weekend peak visitation to 2010 peak visitation on weekdays. With the implementation of a full time permit system in 2011, results showed use levels to be consistent across weekdays, weekends, and holidays. Evaluative data about safety and visitor experience were estimated in the 2008 study and provide a base from which to consider PAOT on the cables in 2011. Specifically, the 2008 study identifies thresholds of: 1) 30 PAOT to provide for unimpeded visitor travel on the cable route, and 2) 70 PAOT when visitors perceive safety issues and unacceptable experiential conditions on the cable route. In 2011, the 30 PAOT threshold was exceeded 31% of the time, and the 70 PAOT threshold was not exceeded on any sample days. Similarly, regression models were estimated and a strong statistical relationship was found between daily levels of hikers on the Half Dome trail and use on the Half Dome cables. Unfortunately, the automated counter used to record hikers on the Half Dome trail was stolen several weeks after initial deployment, so a portion of the data during the study period was lost.

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1. INTRODUCTION

In 2010, Yosemite National Park (YNP) announced the decision to move to a seven day a week permit system for Half Dome after an interim trial season where permits were required only on weekends (Friday through Sunday) and holidays. Results from the 2010 permit period showed extensive displacement of peak visitation on weekends as observed in 2008 to weekdays in 2010. This displacement resulted in weekday visitation far exceeding the management standards established by YNP managers. Management standards are driven primarily by safety thresholds based on maintaining free flow conditions on the cables used to obtain the summit. Free flow conditions become impeded once the number of people at one time on the cables exceeds 30.

This action was complimented with the initiation of the Half Dome Trail Stewardship Plan Environmental Assessment (EA) to determine a long term management solution for visitor use on the trail, including the cable route. The implementation of the 2011 interim permit system provides an environment where visitors can manage their own risk, and allows YNP managers to understand the efficacy of the permit system in improving safety and visitor experience dimensions on the Half Dome trail and cable route. Equally, this enables the public to experience aspects of a visitor use management system that are likely to be outlined in one or multiple alternatives within the planning process.

The interim permit system was instituted under superintendent's order for reasons pertaining to visitor safety and experience. The number of hikers on the Half Dome cable route has been shown to influence the travel times of visitors both on the ascent and descent of the cable route (Lawson, et al., 2009a). This involuntary restriction of visitor movement has produced what the park views as unacceptable conditions at certain times during peak use conditions. The implementation of the 400 people per day interim permit system was established to ensure 'free flow' conditions. 'Free flow' is defined in this report as visitor movement that is unimpeded by the presence of other visitors on the cables. On Half Dome, this has been documented to average 23 minutes for ascension and 19 minutes to descend the cables (Lawson, et al., 2009a). Maintaining these travel times improves safety measures within this unique wilderness setting, giving visitors the ability to travel on their own terms and manage their own levels of risk.

The 2011 Half Dome Trail Visitor Use Monitoring Program was continued from 2010 to compile new data to compare with the discrete variables that were collected in the 2008 baseline study (Lawson, et al., 2009a) and with data from the 2010 study. The monitoring results serve as a valuable source of knowledge and are key to understanding visitor landscape interactions post permit implementation. Aside from the original variables examined in 2008, additional variables were collected in 2010 and 2011 to identify potential relationships across use levels and inform visitor use simulation modeling scenario analyses (using Extend simulation software) developed by Resource Systems Group (RSG) as outlined in Lawson, et al. (2010). The core questions that YNP managers sought to better understand through monitoring conditions in 2011 include:



- 1) What are the changes in visitor use conditions on the Half Dome Trail in 2011 compared to conditions in 2008 and 2010?
- 2) How are visitor arrivals at the Half Dome trail junction related to average and maximum PAOT on the subdome, cables, and summit?
- 3) Does the 400 people per day permit system maintain 'free flow' travel conditions on the cable route?
- 4) Is the seven-day permit system effective in maintaining the 'free flow' standard for the number of PAOT on the cables?

The data collected during the 2011 field season predominantly included observation variables, methods which have been determined by the National Park Service Social Science Division to not require approval by the Office of Management and Budget according to the Paperwork Reduction Act. Methods for the study components will be outlined in the next section.

The comprehensive list of monitoring components included:

- A) Photographic documentation of people at one time (PAOT) on the cable route
- B) Observation counts of PAOT on the subdome and the summit
- C) Automated visitor counters
- D) Regression modeling
- E) Wilderness encounters

The information presented in this report provides a thorough understanding of visitor use conditions on Half Dome in order to make informed management decisions. Significant levels of understanding have been captured by documenting the effects of visitor use conditions through monitoring and comparing them to the management objectives for this iconic park feature.



2. METHODS

2.1. STUDY AREA

Data were collected at the following locations (Figure 2.1): the summit of Half Dome (large yellow area), the cable route (black line) from the subdome to the summit, the subdome (small yellow area), the trail segment from the Half Dome trail junction to the subdome (orange line), and the trail segment from Nevada Fall to the Half Dome trail junction (brown line).

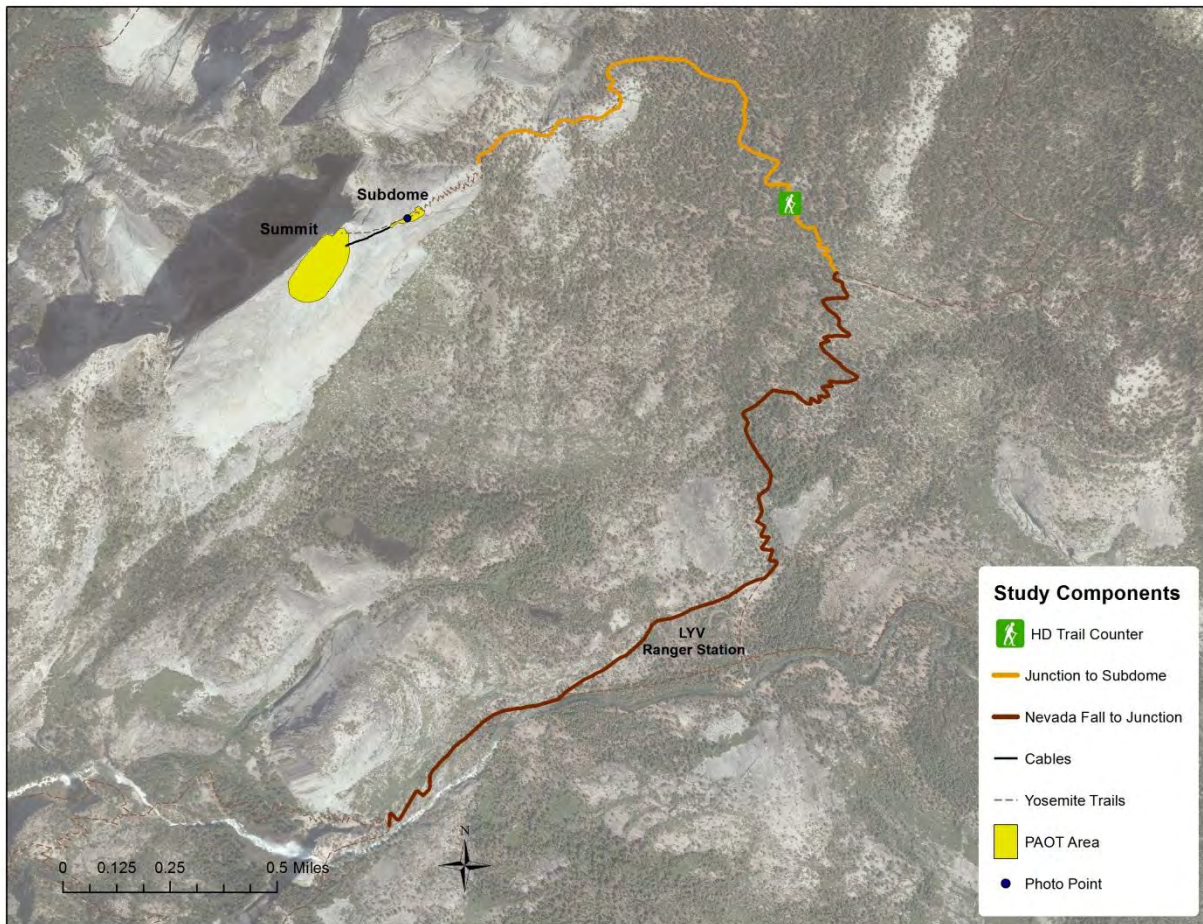


Figure 2.1. Map of Half Dome study area.

2.2. STUDY PERIOD

The study period consisted of 72 days beginning July 9, 2011 and ending September 18, 2011. Sampling days included weekdays, weekend days, and holidays.



2.3. PHOTOGRAPHIC OBSERVATION ON CABLE ROUTE

PAOT on the Half Dome cable route was recorded using repeat photography on 9 sample days, including weekdays and weekend days from July 9, 2011 through August 21, 2011 (Table 2.1). The protocols for photographic documentation of visitor use on the Half Dome cable route were based on previous research conducted by Lawson, et al. (2009a). Photographic observations, recorded to document PAOT on the cable route, were recorded at the subdome and capture visitor use on the 600 foot portion of the cable route visible from that vantage point.

Photographic observations were recorded every 20 minutes from 9:00 AM to 4:00 PM, which produced 22 photographs per day, to estimate PAOT on the cables throughout the busiest seven hour period. On July 13, 2011, the intern arrived late to the subdome and missed the 9:00 AM photo, so there were a total of 197 photographs recorded. Photographic observations were recorded using a digital SLR camera, saved as .jpg files, and catalogued using a photographic observation log sheet.

Table 2.1. Sampling days for Half Dome cable route photographic observation.

Date	Day of Week	Period of Observation	Number of Observations
7/9/2011	Saturday	9:00 AM – 4:00 PM	22
7/11/2011	Monday	9:00 AM – 4:00 PM	22
7/13/2011*	Wednesday	9:20 AM – 4:00 PM	21
7/17/2011	Sunday	9:00 AM – 4:00 PM	22
7/19/2011	Tuesday	9:00 AM – 4:00 PM	22
8/6/2011	Saturday	9:00 AM – 4:00 PM	22
8/14/2011	Sunday	9:00 AM – 4:00 PM	22
8/19/2011	Friday	9:00 AM – 4:00 PM	22
8/21/2011	Sunday	9:00 AM – 4:00 PM	22
			Total = 197

*No photo taken at 9:00 AM

There were a total of 72 days in the sampling period from July 9 – September 18. Observations for this study were collected on 9 days (12.5% of all sampling days). Descriptive statistics were calculated using Microsoft Excel and statistical comparisons were estimated using SPSS 19 statistical software.

2.4. ARRIVALS AT CABLE ROUTE

Arrivals at the cable route were recorded by direct observation on 11 sample days, including weekdays and weekend days, from July 10 through August 26 (Table 2.2). The observations were recorded in 20 minute intervals from 9:00 AM to 4:00 PM, producing 22 counts per day, to estimate the number of arrivals during the busiest seven hour period. A total of 242 counts were recorded. The protocol involved observers counting the total number of people to arrive at the first set of stanchions at the



base of the cables for 20 minutes at a time. Observers recorded the date and time of the observation along with the total number of people to arrive at the cables.

There were a total of 72 days in the sampling period from July 9, 2011 – September 18, 2011. Observations for this study were collected on 11 days (15.3% of all sampling days). Descriptive statistics were calculated using Microsoft Excel and statistical comparisons were estimated using SPSS 18 statistical software.

Table 2.2. Sampling days for Half Dome cable arrivals.

Date	Day of Week	Period of Observation	Number of Observations
7/10/2011	Sunday	9:00 AM – 4:00 PM	22
7/12/2011	Tuesday	9:00 AM – 4:00 PM	22
7/16/2011	Saturday	9:20 AM – 4:00 PM	21
7/18/2011	Monday	9:00 AM – 4:00 PM	22
8/5/2011	Friday	9:00 AM – 4:00 PM	22
8/7/2011	Sunday	9:00 AM – 4:00 PM	22
8/9/2011	Tuesday	9:00 AM – 4:00 PM	22
8/12/2011	Friday	9:00 AM – 4:00 PM	22
8/13/2011	Saturday	9:00 AM – 4:00 PM	22
8/20/2011	Saturday	9:00 AM – 4:00 PM	22
8/26/2011	Friday	9:00 AM – 4:00 PM	22
			Total = 242

2.5. PAOT ON SUBDOME

PAOT observations on the subdome were recorded in 2011 by direct observation on 9 sample days, including weekdays and weekend days, from July 9 to August 21 (Table 2.3). The PAOT observations on the subdome were recorded in 20 minute intervals from 9:00 AM to 4:00 PM, producing 22 PAOT counts per day, to estimate the number of PAOT on the subdome throughout the busiest seven hour period. A total of 198 counts were recorded. The protocol involved observers counting the total number of people on the subdome while walking from the base of the cables to the northeast end of the subdome. Observers recorded the date and time of the observation along with the total number of people on the subdome.

The sampling period consisted of a total of 72 days, from July 9, 2011 – September 18, 2011. Observations for this study were collected on 9 days (12.5% of all sampling days). Descriptive statistics were calculated using Microsoft Excel and statistical comparisons were estimated using SPSS 18 statistical software.



Table 2.3. Sampling days for subdome PAOT observations.

Date	Day of Week	Period of Observation	Number of Observations
7/9/2011	Saturday	9:00 AM – 4:00 PM	22
7/11/2011	Monday	9:00 AM – 4:00 PM	22
7/13/2011	Wednesday	9:00 AM – 4:00 PM	22
7/17/2011	Sunday	9:00 AM – 4:00 PM	22
7/19/2011	Tuesday	9:00 AM – 4:00 PM	22
8/6/2011	Saturday	9:00 AM – 4:00 PM	22
8/14/2011	Sunday	9:00 AM – 4:00 PM	22
8/19/2011	Friday	9:00 AM – 4:00 PM	22
8/21/2011	Sunday	9:00 AM – 4:00 PM	22
Total = 198			

2.6. PAOT ON SUMMIT

PAOT observations on the Half Dome summit were recorded in 2011 by direct observation on 9 sample days, including weekdays and weekend days, from July 9 through August 21 (Table 2.4). The PAOT observations on the summit were recorded in 20 minute intervals from 9:00 AM to 4:00 PM, producing 22 PAOT counts per day, to estimate the number of PAOT on the summit throughout the busiest seven hour period. A total of 198 counts were recorded. The protocol involved observers counting the total number of people on the summit of Half Dome while walking from the northeast corner to the southwest corner across the summit. Observers recorded the date and time of the observation along with the total number of people on the summit.

Table 2.4. Sampling days for Half Dome summit PAOT observations.

Date	Day of Week	Period of Observation	Number of Observations
7/9/2011	Saturday	9:00 AM – 4:00 PM	22
7/11/2011	Monday	9:00 AM – 4:00 PM	22
7/13/2011	Wednesday	9:00 AM – 4:00 PM	22
7/17/2011	Sunday	9:00 AM – 4:00 PM	22
7/19/2011	Tuesday	9:00 AM – 4:00 PM	22
8/6/2011	Saturday	9:00 AM – 4:00 PM	22
8/14/2011	Sunday	9:00 AM – 4:00 PM	22
8/19/2011	Friday	9:00 AM – 3:40 PM	22
8/21/2011	Sunday	9:00 AM – 4:00 PM	22
Total = 198			



There were a total of 72 days in the sampling period from July 9, 2011 – September 18, 2011. Observations for this study were collected on 9 days (12.5% of all sampling days). Descriptive statistics were calculated using Microsoft Excel and statistical comparisons were estimated using SPSS 18 statistical software.

2.7. AUTOMATED VISITOR COUNTERS

Trail use volumes were measured using a TRAFx (Canmore, Canada) active infrared monitor on the Half Dome trail approximately ¼ mile beyond the junction with the John Muir Trail (Figure 2.2). The TRAFx monitor system is comprised of a single infrared scope connected to a small memory unit and stores up to 14,000 hourly counts. The monitor registers a count when the scope detects the infrared signature of a warm moving object. The Half Dome trail TRAFx monitor was installed on July 9, 2011, but was stolen before any data could be retrieved. The replacement Half Dome trail monitor was installed on July 22, 2011 and collected data until September 18, 2011.



Figure 2.2. TRAFx visitor counter in lock-box (left) and conceptual example of counter in operation (right).

2.8. WILDERNESS TRAIL ENCOUNTERS

Wilderness encounter data were collected by trained Yosemite NP Student Conservation Association (SCA) interns to describe and understand wilderness encounter conditions on trails in the vicinity of Half Dome. Observers hiked trail segments within the study area and recorded their encounters with other parties in a standardized data collection pocket notebook. Observers were instructed to hike at the pace of the average hiker, approximately two miles per hour and to begin data collection for each trail segment by noting the date, time, and trail segment (Table 2.5).

Upon completion of the trail segment, the time was recorded. The attributes recorded about each encounter were: 1) reference number, 2) time of encounter, 3) number of people, 4) number of stock, 5)



direction of travel, 6) day or overnight visitor, 7) whether the group was outside of speaking distance (25 feet), and 8) whether the group had been seen previously during the observation period. Observations lasted from a half hour to one and a half hours on each trail segment each day and encounter results were standardized into encounters per hour. Data collection protocols were based on previous wilderness encounter research in Yosemite NP conducted by Broom and Hall (2010). Observers were instructed to conduct observations between 8:00 AM and 6:00 PM. Data were collected from July 10, 2011 – September 18, 2011, which included weekdays, weekend days, and holidays. Observations for this study were collected on 18 days (25.0% of all sampling days), equaling 36.14 hours. Descriptive statistics were calculated using Microsoft Excel and statistical comparisons were estimated using SPSS 18 statistical software.



Table 2.5. Dates of trail encounter observations.

Date	Time Begin	Time End	Total Hours
Nevada Fall – Half Dome trail junction			
Sunday, July 10	9:05 AM	10:15 AM	1.17
Tuesday, July 12	2:40 PM	3:26 PM	0.77
Saturday, July 16	9:30 AM	11:10 AM	1.67
Monday, July 18	8:11 AM	8:57 PM	0.77
Wednesday, July 20	11:00 AM	11:56 AM	0.93
Wednesday, July 20	2:05 PM	2:55 PM	0.83
Friday, August 12	11:00 AM	11:58 AM	0.97
Saturday, August 13	12:50 PM	1:58 PM	1.13
Saturday, August 20	8:40 AM	9:27 AM	0.78
Monday, August 22	1:35 PM	2:47 PM	1.20
Sunday, August 28	11:24 AM	12:11 PM	0.78
Monday, September 5	10:30 AM	11:21 AM	0.85
Tuesday, September 6	10:10 AM	11:06 AM	0.93
Saturday, September 10	10:45 AM	11:40 AM	0.91
Sunday, September 11	12:00 PM	12:48 PM	0.80
Saturday, September 17	12:00 PM	1:05 PM	1.08
Sunday, September 18	10:30 AM	11:42 AM	1.20
Sunday, September 18	2:00 PM	3:03 PM	1.05
Half Dome trail junction - subdome			
Sunday, July 10	10:55 AM	11:43 AM	0.80
Sunday, July 10	3:35 PM	4:18 PM	0.72
Tuesday, July 12	9:00 AM	10:27 AM	1.45
Saturday, July 16	11:45 AM	12:40 PM	0.92
Saturday, July 16	1:23 PM	2:03 PM	0.67
Monday, July 18	12:00 PM	12:35 PM	0.58
Wednesday, July 20	10:20 AM	10:59 AM	0.65
Wednesday, July 20	12:00 PM	12:33 PM	0.55
Thursday, August 4	10:50 AM	11:32 AM	0.70
Thursday, August 4	1:10 PM	2:16 PM	1.10
Friday, August 12	10:25 AM	11:00 AM	0.58
Saturday, August 13	2:00 PM	2:51 PM	0.85
Saturday, August 20	12:30 PM	12:58 PM	0.47
Monday, August 22	1:00 PM	1:35 PM	0.58
Sunday, August 28	2:00 PM	2:25 PM	0.42
Saturday, September 3	10:15 AM	10:44 AM	0.48
Saturday, September 3	1:12 PM	1:58 PM	0.77
Monday, September 5	12:50 PM	1:32 PM	0.70
Tuesday, September 6	12:00 PM	12:24 PM	0.40
Saturday, September 10	12:30 PM	1:03 PM	0.55
Sunday, September 11	10:40 AM	11:15 AM	0.58
Saturday, September 17	8:30 AM	9:20 AM	0.83
Saturday, September 17	10:00 AM	10:42 AM	0.70
Saturday, September 17	12:20 PM	1:03 PM	0.72
Sunday, September 18	12:20 PM	1:03 PM	0.72
Sunday, September 18	1:10 PM	2:00 PM	0.83



2.9. REGRESSION MODELING

Statistical relationships among visitor use data: a) collected via automated counters along the trail to Half Dome, b) PAOT on the Half Dome cable route, c) PAOT on the Half Dome summit, and d) wilderness encounters, were explored using various regression techniques. This approach was successfully applied in YNP to estimate visitor use at attraction sites from inbound vehicles measured at entrance gates (Lawson, et al., 2009b, Pettebone, 2009), and in Devils Postpile National Monument (NM) (Pettebone, et al., 2010). For the Half Dome Trail Visitor Use Monitoring study, models at different time scales (i.e., hourly and daily) were estimated to understand how overall use levels are related to PAOT on the cable route and on the summit. The simplest models (i.e., least number of independent variables) that explained the most variability in the dependent variable (e.g., PAOT on the cable route and the summit) were identified and reported. These statistical relationships were estimated using SPSS 18 statistical software.



3. RESULTS

3.1. PHOTOGRAPHIC OBSERVATIONS ON CABLE ROUTE

PAOT on the Half Dome cables was variable throughout the course of a day. Figure 3.1 graphically depicts the changes in PAOT during the hours of highest use. The standard for unimpeded travel conditions on the cable route of 30 PAOT and visitor perceptions of safety and experiential acceptability of 70 PAOT (Lawson, et al., 2009a) are included in Figure 3.1.

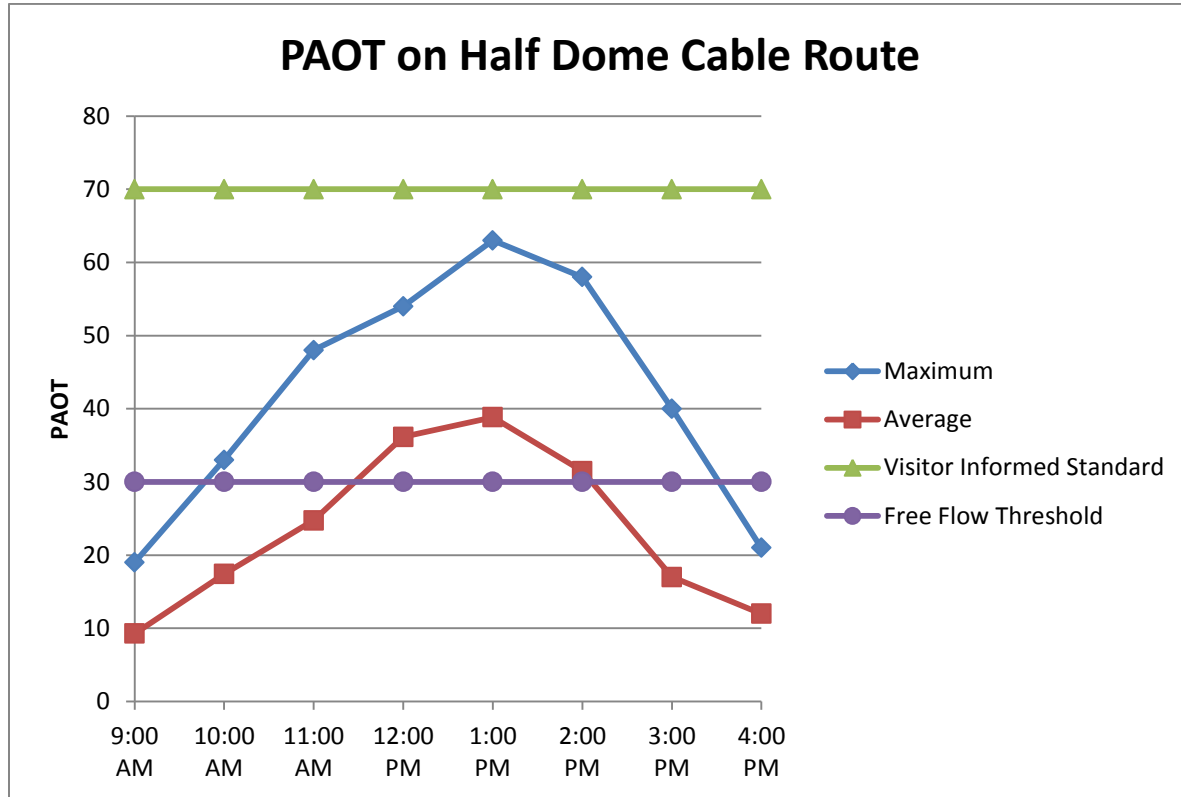


Figure 3.1. PAOT results on the Half Dome cable route.

PAOT on the cable route peaks approximately during the 1:00 PM – 2:00 PM hour. Maximum observed PAOT was 63, which occurred on Sunday, July 17 at 1:40 PM. Figure 3.2 displays the photographic documentation of PAOT on the cable route during this time period. Descriptive statistics of hourly PAOT on the Half Dome cables during the 2011 study are presented in Table 3.1. Weekend (n = 5) and weekday (n = 4) averages show little difference throughout the day; however, due to the small sample size, results should be interpreted with caution.



Figure 3.2 Photographic documentation of maximum PAOT (63) on the Half Dome cable route on Sunday, July 17 at 1:40 PM.



Table 3.1. Descriptive statistics of hourly PAOT on the Half Dome cable route.

Hour		Average	Median	Min	Max
9:00 AM	Weekend	11.47	13.0	0	19
	Weekday	6.27	6.0	2	13
10:00 AM	Weekend	16.47	15.0	2	31
	Weekday	18.58	21.0	5	33
11:00 AM	Weekend	25.20	21.0	10	48
	Weekday	24.17	22.0	11	44
12:00 PM	Weekend	35.33	36.0	10	53
	Weekday	37.17	35.0	21	54
1:00 PM	Weekend	37.40	39.0	2	63
	Weekday	40.67	37.5	26	60
2:00 PM	Weekend	32.13	34.0	5	58
	Weekday	30.67	28.5	17	56
3:00 PM	Weekend	19.80	21.0	2	40
	Weekday	13.50	12.5	3	26
4:00 PM	Weekend	15.00	12.0	10	21
	Weekday	8.25	8.0	6	11

Finally, estimations were calculated for the proportion of time that PAOT standards on the Half Dome cables were violated (Table 3.2). Results indicate that visitor travel on the cable route is unimpeded 69% of the time, and the visitor standard for perceptions of safety and acceptability was not exceeded.

Table 3.2. Proportion of time that PAOT standards on the Half Dome cables are violated.

Variable	Proportion
PAOT on cables	
>30 PAOT	31%
>70 PAOT	0%

3.2. ARRIVALS AT CABLE ROUTE

Table 3.3 shows descriptive statistics of hourly arrivals at the Half Dome cables; average arrivals (n = 11) peak during the 12:00 PM – 1:00 PM hour. Average hourly arrivals over the course of a day at the Half Dome cable route were estimated (Table 3.4). Due to the small sample size, results should be interpreted with caution.



Table 3.3. Descriptive statistics of hourly arrivals at the Half Dome cable route.

Hour	Average	Median	Min	Max
9:00 AM	7.42	6.0	0	20
10:00 AM	12.85	11.0	4	29
11:00 AM	16.36	17.0	1	32
12:00 PM	17.39	16.0	2	35
1:00 PM	15.12	15.0	5	27
2:00 PM	8.91	7.0	0	32
3:00 PM	3.97	3.0	0	16
4:00 PM	1.82	2.0	0	5

Table 3.4. Descriptive statistics of hourly arrivals over the course of a day at the Half Dome cable route.

Variable	Average	Median	Min	Max
Hourly arrivals	11.27	11.0	0	35

3.3. PAOT ON SUMMIT

Similar to the Half Dome cable route, PAOT on the Half Dome summit was variable throughout the course of a day. Figure 3.3 graphically depicts the changes in PAOT during the hours of highest use. Average PAOT on the summit peaks approximately during the 1:00 PM – 2:00 PM hour. Maximum observed PAOT was 101, which occurred on Wednesday, July 13 at 11:40 AM. Descriptive statistics of hourly PAOT on the Half Dome summit (n = 9) during the 2011 study are presented in Table 3.5. Average hourly PAOT over the course of a day on the Half Dome summit was also estimated (Table 3.6).

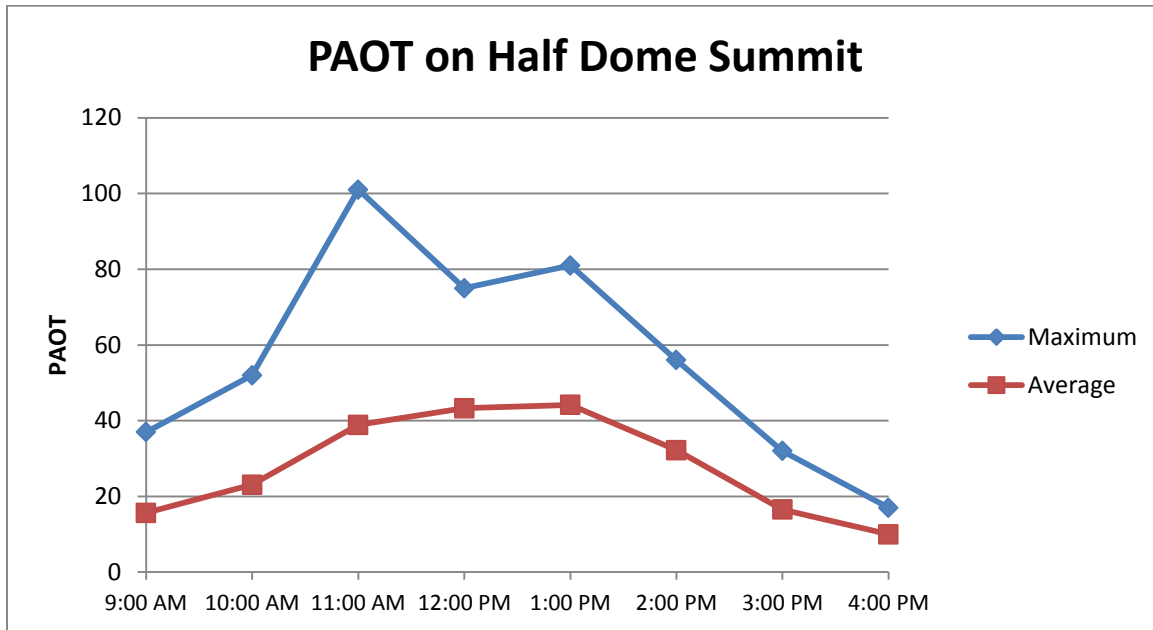


Figure 3.3. PAOT results on the Half Dome summit.

Table 3.5. Descriptive statistics of hourly PAOT on the Half Dome summit.

Hour	Average	Median	Min	Max
9:00 AM	15.67	15.0	0	37
10:00 AM	23.11	25.0	0	52
11:00 AM	38.89	34.0	12	101
12:00 PM	43.30	42.0	19	75
1:00 PM	44.19	44.0	16	81
2:00 PM	32.22	35.0	6	56
3:00 PM	16.52	14.0	2	32
4:00 PM	10.00	10.0	2	17

Table 3.6. Descriptive statistics of hourly PAOT over the course of a day on the Half Dome summit.

Variable	Average	Median	Min	Max
PAOT on summit	29.62	28.0	0	101



3.4. PAOT ON SUBDOME

Average hourly PAOT on the subdome (n = 9) was estimated (Table 3.7), and shows that PAOT on the subdome peaked during the 12:00 PM – 1:00 PM hour. Table 3.8 shows descriptive statistics of average hourly PAOT on the subdome over the course of a day.

Table 3.7. Descriptive statistics of hourly PAOT on the subdome.

Hour	Average	Median	Min	Max
9:00 AM	10.23	9.5	0	35
10:00 AM	16.89	16.0	3	35
11:00 AM	21.96	22.0	5	37
12:00 PM	30.11	28.0	11	53
1:00 PM	22.56	21.0	8	47
2:00 PM	20.33	21.0	6	40
3:00 PM	11.59	9.0	0	29
4:00 PM	3.44	4.0	0	8

Table 3.8. Descriptive statistics of hourly PAOT over the course of a day on the subdome.

Variable	Average	Median	Min	Max
PAOT on subdome	18.43	19.0	0	53

3.5. AUTOMATED VISITOR COUNTERS

As explained above, early on in the study period, the TRAFx counter was stolen. While the study period began on July 9, 2011, there are no TRAFx counter data until July 22, 2011 when the counter was replaced. Implications of this will be discussed in the regression analyses section below.

While most people who hike the Half Dome trail intend to ascend Half Dome via the cables, there are many who do not make it to the top of Half Dome for various reasons. With this in mind, the Half Dome trail may become the destination for many people rather than Half Dome itself. This may limit the counter’s ability to estimate total Half Dome use at its current location, demonstrating that TRAFx counter data should be interpreted with caution.

3.5.1 Total Visitor Use

Total visitor use for the automated counter was estimated at 18,447(±1529). This number represents the total number of people who arrived at the Half Dome trail junction during the study period, July 22, 2011 – September 18, 2011. Of this total, approximately 34%, 6,273 (±520), arrived on weekend days and 66%, 12,174 (±1009), arrived on weekdays.



3.5.2 Daily Visitor Use

Results from the automated counters placed at the junction of the Half Dome Trail and the John Muir Trail show that use was variable throughout the week, with the highest use on Saturdays and the lowest use on Mondays. The busiest day was Saturday, August 20 with 450 visitors, and the lowest use day was Tuesday, August 30 with 208 visitors. Figure 3.4 shows total daily use, as estimated from the TRAFx counter data, beginning July 22, 2011 and ending September 18, 2011.

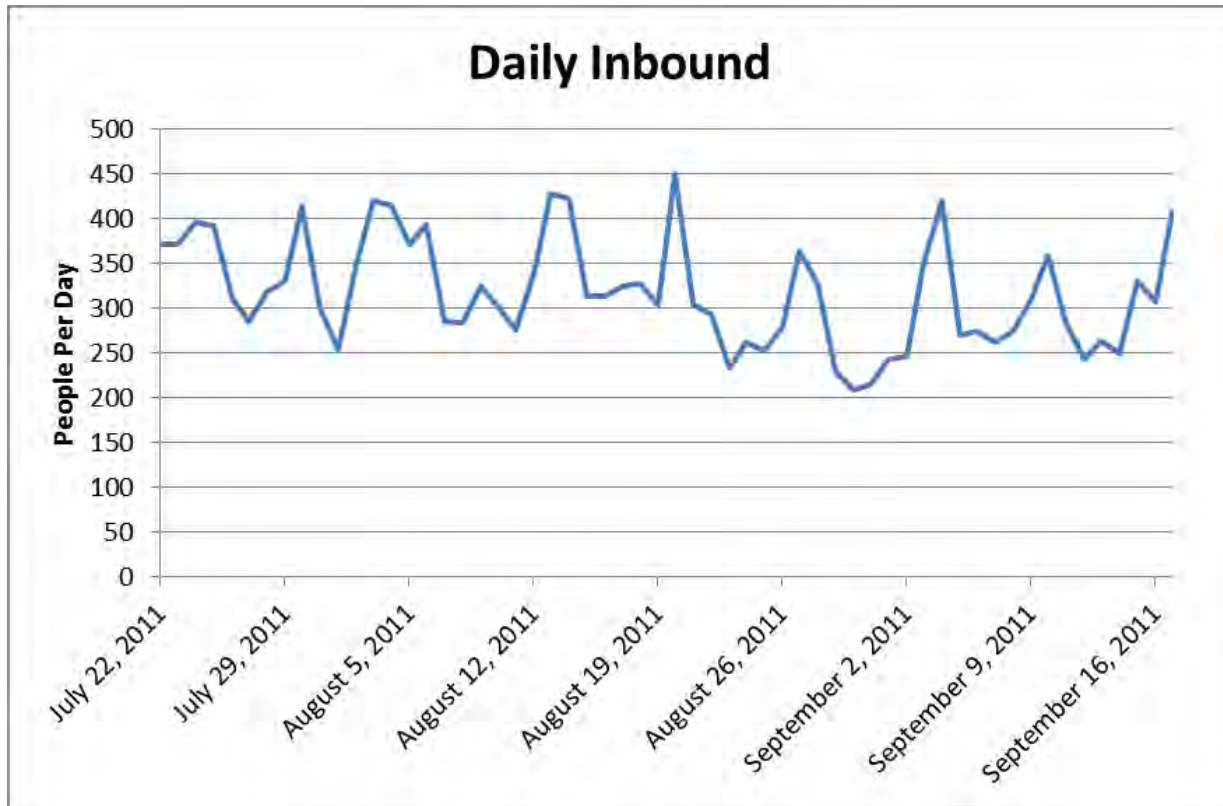


Figure 3.4. Visitor arrivals at Half Dome Trail Junction from July 22, 2011 – September 18, 2011.

Visitor use by weekday varies slightly. Saturdays are the busiest day while Mondays receive the fewest visitors. Weekday use estimated in 2008 and 2010 are compared with use in 2011 in Figure 3.5. The 2010 estimates are based on data collected from June 23 – September 14 and the 2008 data were collected from July 11 – August 10. The 2008 data show substantially higher levels of visitor use on weekends, particularly Saturdays, compared to weekdays. Visitor use on Mondays and Thursdays in 2010 is comparable to visitor use on Saturdays in 2008, while 2011 is more evenly distributed throughout the week with only slightly higher visitation on weekend days. Descriptive statistics of weekday results from 2011 are presented in Table 3.9.

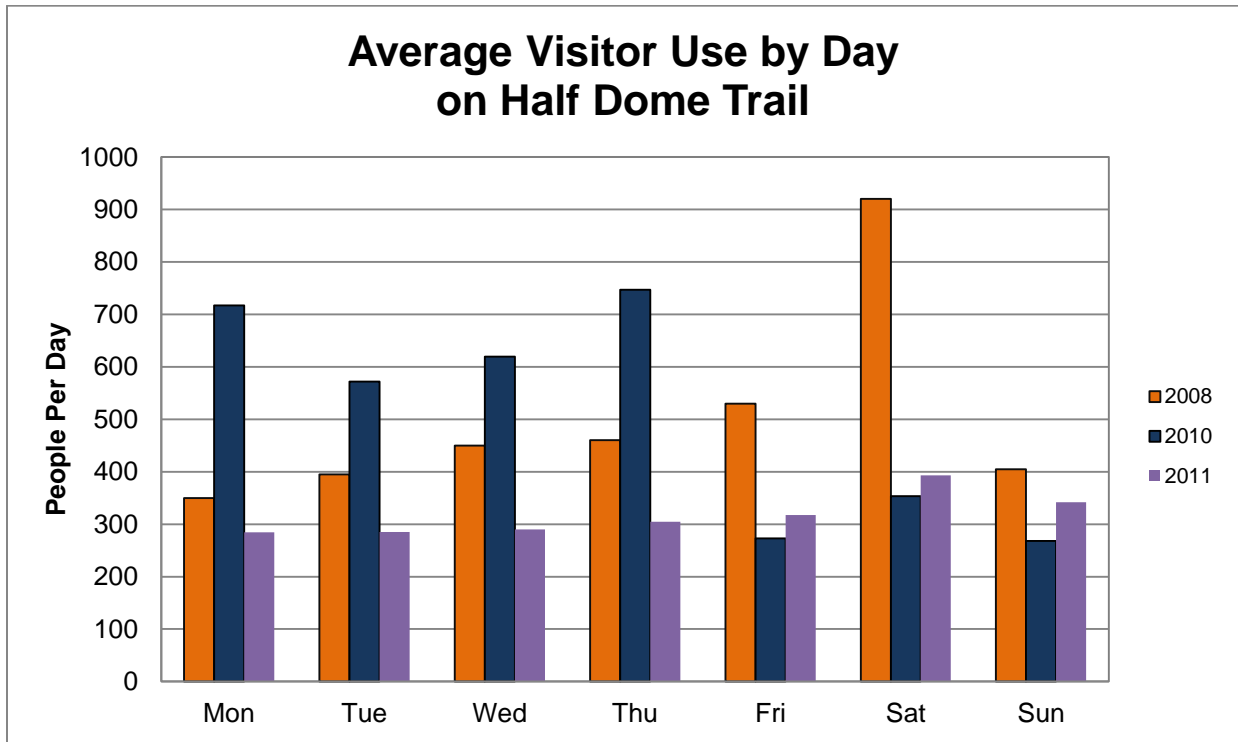


Figure 3.5. Visitor arrivals at Half Dome Trail junction by weekday.

Table 3.9. Descriptive statistics of visitor arrivals at Half Dome trail junction.

Day of Week	n	Average	Min	Max
	58	318	208	450
Monday	8	285	229	391
Tuesday	8	285	208	349
Wednesday	8	290	215	419
Thursday	8	305	244	415
Friday	9	318	246	372
Saturday	9	393	350	450
Sunday	8	342	281	423

3.5.3 Hourly Visitor Use

Visitor arrivals at the Half Dome junction vary greatly throughout the course of a day with peak arrivals occurring from 10:00 AM – 11:00 AM. Figure 3.6 provides a comparison between arrival data collected in 2008, 2010 and 2011. The dates of data collection are the same as those described for daily arrivals presented in Figure 3.4. Average peak arrival for 2011 weekends and weekdays was below peak arrivals



for weekends (permit days) in 2010 and significantly below peak arrivals for 2008 (Figure 3.6). Numeric hourly arrival estimates for Saturdays/holidays in 2011, permit days in 2010, and Saturdays/holidays in 2008 are presented in Table 3.10.

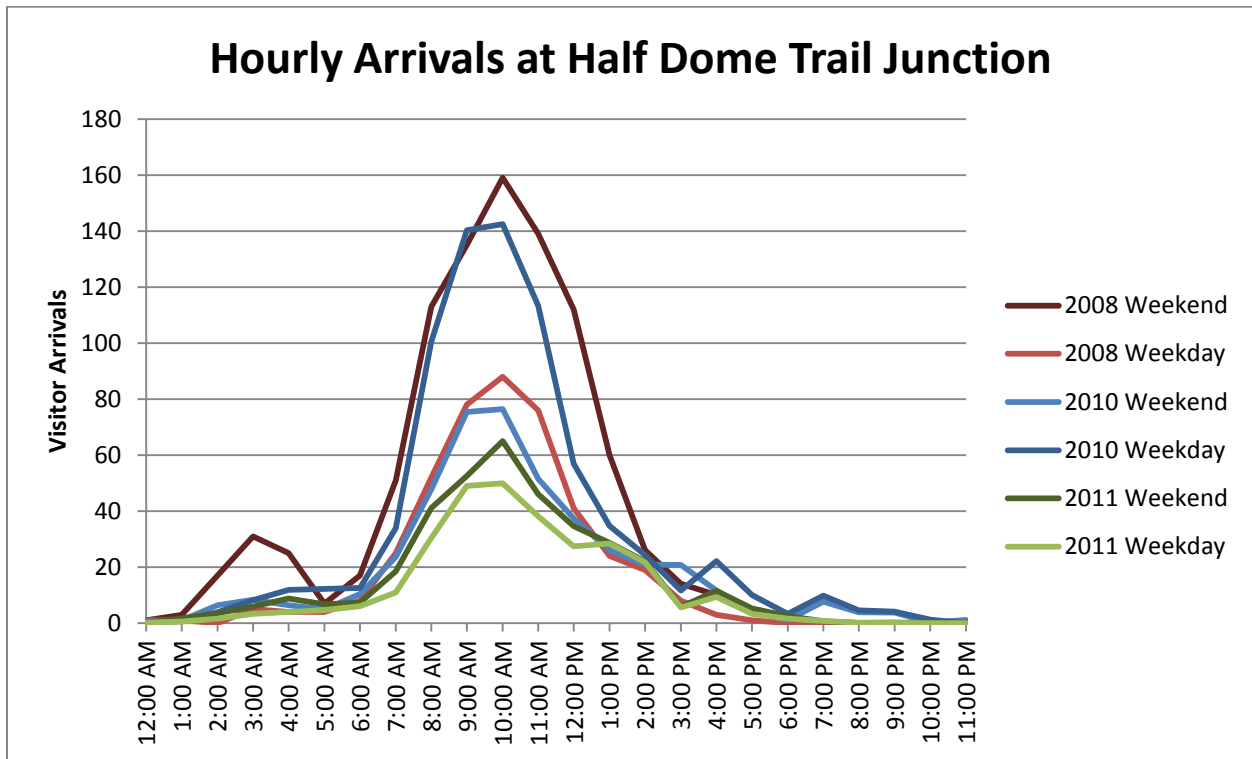


Figure 3.6. Hourly Arrivals at Half Dome for 2011, 2010 and 2008 by weekend/weekday.



Table 3.10. Average hourly arrivals at the Half Dome trail junction, 2011, 2010 and 2008.

Hour	2011 Sat/Holiday	2010 Permit	2008 Sat/Holiday
12:00 AM	0	1	1
1:00 AM	1	1	3
2:00 AM	3	4	17
3:00 AM	6	9	31
4:00 AM	8	8	25
5:00 AM	7	6	7
6:00 AM	8	8	17
7:00 AM	19	18	51
8:00 AM	37	30	113
9:00 AM	55	49	135
10:00 AM	67	52	159
11:00 AM	49	41	139
12:00 PM	35	26	112
1:00 PM	33	20	60
2:00 PM	25	17	26
3:00 PM	7	11	14
4:00 PM	13	10	10
5:00 PM	6	4	5
6:00 PM	2	2	1
7:00 PM	1	1	0
8:00 PM	0	0	0
9:00 PM	0	0	0
10:00 PM	0	0	0
11:00 PM	0	0	0

3.6. WILDERNESS ENCOUNTERS

About 36 hours of data were collected to estimate wilderness encounters. Results indicate that wilderness encounters tended to be higher on the trail segment from the Half Dome trail junction to the subdome than from Nevada Fall to the Half Dome trail junction (Table 3.11).

Table 3.11. Descriptive statistics of people encountered per hour along trails in wilderness near Half Dome.

Location	<i>n</i>	Average	Median	Min	Max
<i>Nevada Fall-Half Dome trail junction</i>	18	64.66	65	11	118
<i>Half Dome trail junction-subdome</i>	26	103.72	94	39	246



Group size was recorded during the wilderness encounters. Group sizes were very similar between weekdays and weekend days (Table 3.12). Table 3.13 shows descriptive statistics of group encounters on the two trail segments. Similar to individual encounters, group encounters tended to be higher on the trail segment from the Half Dome trail junction to the subdome than from Nevada Fall to the Half Dome trail junction.

Table 3.12. Half Dome hiking group size.

Sample Day	Average	Median	Standard Deviation
Sat-Sun	2.50 (N=741)	2.00	2.02
Mon-Fri	2.44 (N=464)	2.00	1.55

Table 3.13. Descriptive statistics of groups encountered per hour in wilderness near Half Dome.

Location	<i>n</i>	Average	Median	Min	Max
<i>Nevada Fall-Half Dome trail junction</i>	18	26.69	27	6	44
<i>Half Dome trail junction-subdome</i>	26	41.10	37	18	93

3.7. REGRESSION ANALYSES

Attempts were made to explore regression analysis between the total number of arrivals at the Half Dome trail junction and observation-based components. However, as a result of the first trail counter being stolen there were too few data points from which to generate viable regression models. The lack of regression models for this monitoring year is more impactful on predictive abilities from 2011 than on evaluation of current conditions. The descriptive components in preceding sections present a representative basis from which to evaluate the effects of a seven day a week permit system. It should also be noted that predictive models from 2010 are only representative of the use conditions in 2010 (i.e., only weekend permits) and should not be applied to 2011 use conditions.

3.7.1 PAOT on the Half Dome Summit ~ PAOT on the Half Dome Cable Route

Regression analysis between PAOT on the summit and PAOT on the cables did not rely on data from the stolen trail counter and was therefore able to be explored. A moderately strong statistical relationship was found between PAOT on the Half Dome cable route and PAOT on the Half Dome summit. A model was estimated for this relationship from *average* hourly PAOT counts, where PAOT on the cable route was input into the model as an explanatory (independent) variable for PAOT on the summit. The term *average* hourly PAOT is used because hourly estimates are based on the *average* of three PAOT observations over the course of one hour documented systematically in 20 minute intervals. *Average* hourly counts were correlated with no time lag. In other words, PAOT counts from 12:00 PM – 1:00 PM



on the cable route were correlated with PAOT counts from 12:00 PM – 1:00 PM on the summit. As with the models described in the previous sections, linear regression models produced the best fit to estimate this relationship ($F(1,70)=87.69$, $R^2=0.556$) (Table 3.14). The minimum *average* hourly PAOT on the cable route in this analysis was 5.00 and the maximum *average* hourly count on the cable route was 53.33.

Table 3.14. Model parameters to estimate average hourly PAOT on the Half Dome summit from average hourly PAOT on the cable route.

Variable	β	SE	p
Intercept	5.424	2.757	0.053
PAOT on cable route	0.967	0.103	<0.001

The coefficient of these models (β) can be interpreted as follows: between the hours of 9:00 AM and 4:00 PM an increase in PAOT of 10 on the cable route results in an increase in PAOT on the summit of just under 10 (.967) people.

These results indicate that PAOT on the summit is related to PAOT on the cable route. Figure 3.7 graphically depicts the relationships between PAOT on the cable route and PAOT on the summit. Predicted values above the maximum observed cable PAOT count of 63 should be interpreted with some caution; however, this information is presented in order to provide some understanding of the maximum levels of PAOT observed on the cable route in this study (i.e., 63 PAOT).

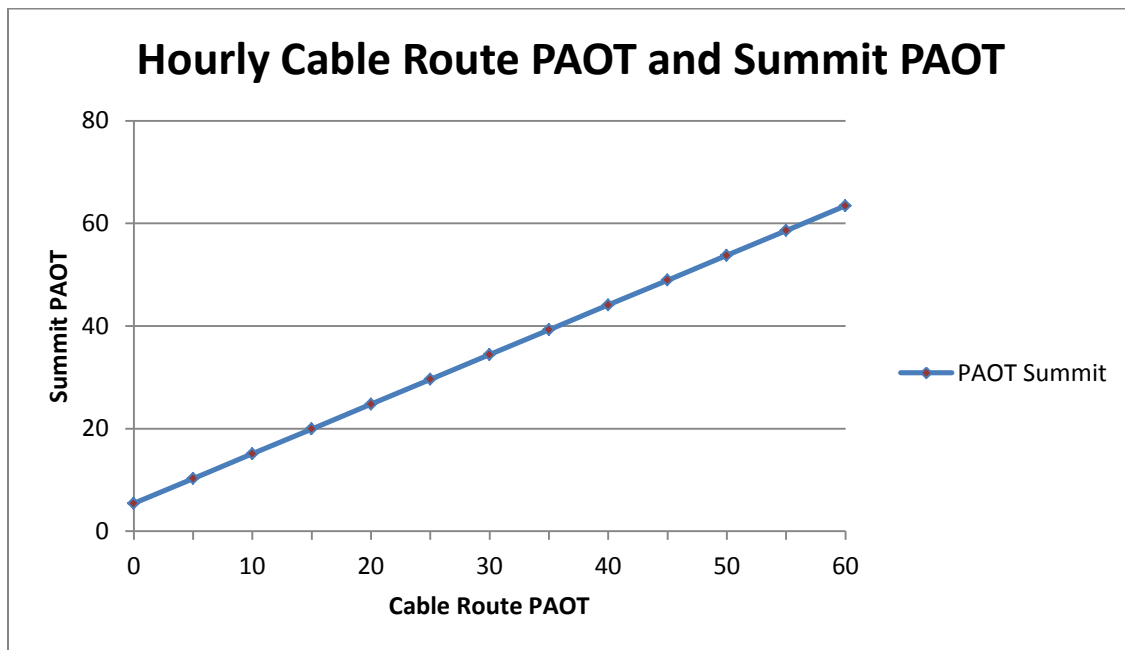


Figure 3.7 Predicted values for PAOT on the Half Dome summit.



Table 3.15. Predicted values for average PAOT on the Half Dome summit.

Average Hourly PAOT on Cable Route	Average Hourly PAOT on Summit
0	5
5	10
10	15
15	20
20	25
25	30
30	34
35	39
40	44
45	49
50	54
55	59
60	63



4. DISCUSSION

The results from this study show that visitor use on Half Dome varies only slightly throughout the week and that implementing a seven day a week permit system removed the temporal displacement in visitor use that occurred in 2010. Regression and thus predictive models were unable to be generated due to the theft of the trail counter for a significant portion of the collection. Low use across monitoring components is likely a reflection of the “closed” system of visitor access to Half Dome. In other words, the vast majority of visitors access Half Dome via the Half Dome trail to the subdome and subsequently to the summit. Thus, the “simplicity” of the travel system lends itself well to predictability and potentially the application of limits on visitor use levels to achieve management objectives. Similar results have been found in other closed travel systems including Glacier Point, Bridalveil Fall, and Yosemite Falls in YNP (Pettebone, 2009; Lawson, et al., 2009b) and Devils Postpile NM (Pettebone, et al., 2010).

4.1. LEVELS OF VISITOR USE ON HALF DOME

The 2008, 2010, and 2011 studies describe the variability of visitor use on Half Dome throughout the course of a day and show that the temporal characteristics of visitor use are similar between the three study seasons. Perhaps the most important finding from the 2011 study was that visitor use was relatively even throughout the week and that requiring a permit every day of the week was successful in reducing the maximum number of PAOT on the cables.

PAOT estimates on the cable route are particularly important because evaluative data related to safety and visitor experience on the Half Dome cable route were collected in 2008. These evaluative data provide a clear and concise measure from which to consider the implications of various levels of visitor use. Specifically, the 2008 study identifies thresholds of: 1) 30 PAOT to provide for unimpeded visitor travel on the cable route, and 2) 70 PAOT when visitors perceive safety issues and unacceptable experiential conditions on the cable route. During the 2011 season, the 30 PAOT threshold was exceeded only 31% of the time and the 70 PAOT threshold was not exceeded on any sample days. Thus, during the sample period, visitor travel was unimpeded 69% of the time, preserving conditions where visitors did not perceive safety issues and negative impacts to their experience. Thus, if management of the permit system remains similar to 2011, YNP managers should expect visitor travel on the cables to be impeded to some degree during the day even with a permit system.

The results from this study suggest that PAOT on the summit is similar to PAOT on the cables. In other words, if there are 50 PAOT on the cable route there will be about 53 PAOT on the summit for a total of about 100 PAOT on Half Dome from the base of the cable route and up. However, PAOT on the cables increases at a slightly higher rate than PAOT on the summit. The relationship between PAOT on the cable route and PAOT on the summit has two important implications related to visitor evacuation in the occurrence of a weather event: 1) during high levels of use on the cable route (>100 PAOT) a total of about 200 visitors may need to be evacuated from Half Dome, and 2) visitor travel times on the cable



may be slow for long periods of time during an evacuation based on the high volumes of people descending from the summit. No evaluative data have been collected or developed regarding safety or visitor acceptability on the summit of Half Dome. However, as noted, the Half Dome Visitor Use Model has been used to simulate the implications of various PAOT levels on the summit, with respect to visitors' travel times to descend the cables. Thus, simulation results and data from the 2010 and 2011 monitoring provide an understanding about visitor use on the summit that was previously unavailable and can be used to develop common sense approaches to provide for visitor safety and quality visitor experiences.

4.2. WILDERNESS ENCOUNTERS

Group encounters along trail segments in wilderness were found to be somewhat related to the daily number of people hiking to Half Dome. Both groups and individual people were the metrics used by observers when collecting data. The differences in the number of people per hour on the trail segment from the Half Dome trail junction to the base of the subdome was statistically significant, but the segment between Nevada Fall and the Half Dome trail junction was not statistically significant at the 95% confident interval. The small sample size of this dataset, a result of the trail counter being stolen, does not provide a particularly robust estimation of encounter rates along trails in the Half Dome area and should be interpreted with caution.

To put these levels of group encounters into a wilderness context, we offer a comparison of encounter rates reported in previous research in other high-use wilderness areas (Table 4.1). Estimates of hourly group encounters on the two trail segments in the Half Dome study show that encounter rates are substantially higher than encounter rates in other high-use wilderness areas. While groups per hour were higher than other high-use wilderness areas, the number of people per hour on the Nevada Fall to Half Dome trail junction section was 64.66, which is comparable to the Snow Lake weekend rate of 68.96 people per hour. Due to the small sample size per trail in this study, results should be interpreted with caution.



Table 4.1. Comparison of group encounter rates on trails in wilderness areas.

Location	Groups/hour	People/hour
USFS-Washington and Oregon (Cole, et al., 1997)		
Snow Lake-weekend	18.27	68.96
Snow Lake-weekday	6.67	N/A
Rachel/Rampart Lakes	7.50	N/A
Green Lakes	4.00	N/A
NPS-Yosemite-Tuolumne Meadows (Broom and Hall, 2010)		
Cathedral Lakes	11.17	27.89
Lyell Canyon	7.89	18.89
Rafferty Creek	6.15	15.50
Dog Lake	12.79	43.74
Young Lakes-West	2.96	9.00
Young Lakes-East	2.56	5.97
Mono Pass	3.58	8.16
NPS-Yosemite-Half Dome		
Nevada Fall to Half Dome trail junction	26.69	64.66
Half Dome trail junction to subdome	41.10	103.72



5. CONCLUSION

The purpose of the Half Dome Trail Visitor Use Study was to document visitor use conditions on the Half Dome Trail and to examine the effects of the seven day a week permit system. Specifically, this research sought to answer four questions: 1) What are the changes in visitor use conditions on the Half Dome Trail in 2011 compared to conditions in 2008 and 2010? 2) How are visitor arrivals at the Half Dome trail junction related to average and maximum people at one time (PAOT) on the subdome, cables, and summit? 3) Does the 400 people per day permit system maintain 'free flow' travel conditions on the cable route? 4) Is the seven-day permit system effective in maintaining the 'free flow' standard for the number of PAOT on the cables?

In contrast to the visitor use levels studied in 2008 and 2010, results from this study show that the seven day a week permit system was effective in maintaining consistent visitor use conditions across weekdays, weekends, and holidays.

Visitor arrivals at the Half Dome trail junction showed a strong statistical relationship with use on the Half Dome cables. However, due to the theft of the automated counter, results of this relationship must be interpreted with caution. Additionally, use on the cables demonstrated a strong statistical relationship with use levels on the Half Dome summit.

Requiring visitors to obtain a permit seven days a week resulted in a fairly uniform visitation level on the Half Dome cables throughout the season, and limiting use to a maximum of 400 visitors per day resulted in the 30 PAOT threshold being exceeded only 31% of the time. Additionally, the 70 PAOT threshold was not exceeded at all during the sampling period. Maintaining the 'free flow' safety threshold of 30 PAOT on the cables can result in a safer, more enjoyable experience for park visitors.

The Half Dome cables permit system has undergone several changes during its implementation; thus, Half Dome cables monitoring will continue due to several reasons. During the two seasons that permits have been required for Half Dome, the reservation system has changed, and will change again for the 2012 season. With the implementation of a lottery system for reserving permits in the 2012 season, additional monitoring will be necessary to ensure desirable conditions are being met. Additionally, as more visitors experience the permit system, visitor awareness of ranger enforcement times will increase, which may lead to changes in travel patterns throughout the day. If travel patterns change, monitoring will be required to understand how use is distributed throughout the day and along the trail to Half Dome.



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