ALTERED VISITOR USE IN THE PARADISE AREA IN RESPONSE TO CONSTRUCTION ACTIVITY

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October 2009

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ACKNOWLEDGMENTS

The success of this project depended in large part on the survey workers, Megan Hecht and Christopher Montero. Many MORA staff members also provided essential feedback, review, and support during data collection. Barbara Samora and Darin Swinney were particularly helpful.

AUTHOR'S NOTE

At several points in this document, italicized text explains the absence of analyses that were originally planned for inclusion. All of these analyses involved relationships between counts of vehicles entering park gates and counts of vehicles or visitors in the Paradise Area. Repeated attempts were made to contact the NPS employee responsible for the archiving and distribution of the gate counts, but no response was received. Without the gate counts, the analyses could not be conducted. Unfortunately, publication of the report must go forward without these potentially useful analyses.

1. INTRODUCTION

The University of Washington Protected Area Social Research Unit administered this project. It was proposed and funded by Mount Rainier National Park (MORA). The general purpose of the project was to collect information about visitation changes occurring during a major construction project in the Paradise area of MORA. Specific efforts were made to assess changes in visitor use and subsequent changes in potential visitor impacts on park resources and visitor experiences.

1.1 Description of Paradise Construction

The Paradise area of MORA is the most heavily visited site in the park. In the peak season of July and August, almost 200,000 people drive, ride, or hike to the lodge, visitor center, and climbing facilities that are found at an elevation of 5,400 feet on the south flank of the mountain (NPS Visitor Use Statistics website).

The park has undertaken an extensive set of construction and rehabilitation projects at Paradise beginning in 2006 and continuing through 2009. The work includes rehabilitation of the historic Paradise Inn, construction of a new visitor center, and redesign of the parking lots. After the opening of the new visitor center, the current visitor center will be demolished.

During the construction period parking is significantly reduced in the immediate Paradise area and vehicular congestion is increased. Parking is permitted along the Paradise Valley Road and visitors are directed to walk back up to Paradise, along the road. Visitors are permitted to drop off passengers in the lower parking lot. A shuttle system was implemented by the 2006 July 4th weekend. Specific parking and facility status includes the following:

- Parking is available in the lower lot and along the Paradise Valley Road
- The upper parking lot is closed.
- The Jackson Visitor Center remains open.
- RVs and large vehicles must park on the Paradise Valley Road.
- Paradise Inn and the Guide House are closed.
- Climbers can obtain permits from the Jackson Visitor Center.
- Buses drop off passengers at the visitor center and park on the Paradise Valley Road.

An overview of changes to visitor access and parking during construction are noted in Fig.1.

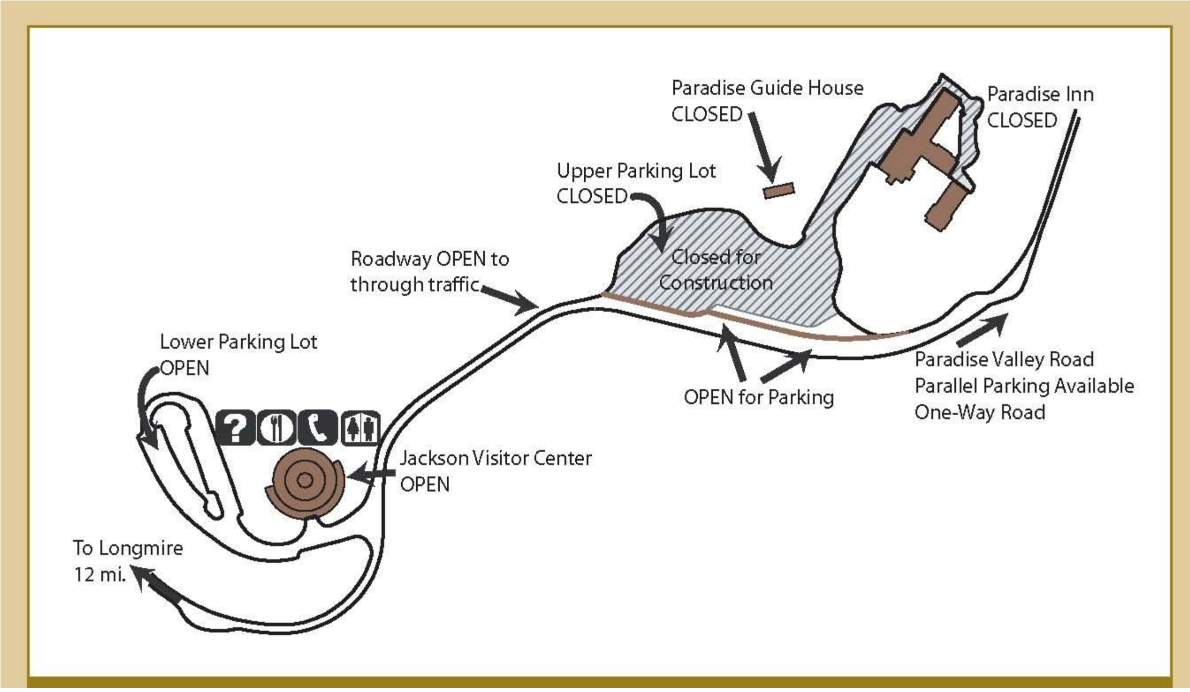

Fig 1. Paradise Construction Period Parking Access for Park Visitors.

1.2 Potential Effects of Construction on Visitors and Visitor Impacts

In the past, approximately 70 percent of visitors took walks or hikes on the system of paved and gravel trails (see Figure 1) located in the sub-alpine meadow north of the visitor center and lodge (Vande Kamp 1997 [pcthike.doc]). Those walks and hikes are an important aspect of many visitors' experiences of Mount Rainier (Vande Kamp, Swanson, and Johnson 2002). At the same time, the level of visitation in the meadow has created negative impacts on the physical resources and the quality of visitor experiences found there. Off-trail hiking has damaged vegetation in many areas of the meadow (Rochefort and Swinney 2000) and at peak times, visitor movement on popular trails is impeded by high visitor density (Vande Kamp and Zweibel 2004).

1.2.1 The Visitor Experience and Resource Protection (VERP) Framework

The Visitor Experience and Resource Protection (VERP) framework is a tool developed by the National Park Service to address user capacities and thus protect both park resources and visitor experience from impacts associated with visitor use. VERP was used in developing the Mount Rainier National Park General Management Plan. The VERP framework is an ongoing, iterative process of determining desired conditions (including desired cultural resource conditions, desired natural resource conditions, and desired visitor experiences), selecting and monitoring indicators and standards that reflect these desired conditions, and taking management action when the desired conditions are not being realized. VERP is a decision-making framework, but does not diminish management's role in decision-making. In the case of Paradise during the construction period, management must make crucial decisions to: a) determine desired conditions, b) assess the overlap between protecting park resources and providing for visitor experiences, and c) choose appropriate management action.

In its application to the Paradise area construction project, the VERP framework is being used as a form of adaptive management. Adaptive management requires a continual learning process, a reiterative evaluation of goals and approaches, and redirection based on increased knowledge and changing public expectations. Understanding of visitor use issues will improve and evolve over time, and management actions will adapt accordingly. Continual hypothesis testing, data collection, and data analysis will likely result in refinement of desired conditions and, accordingly, refinement of indicators and standards. The implementation of the VERP framework for the Paradise area during the construction period will focus on protecting the natural and cultural resources while striving to provide a high quality visitor experience during the construction phases. In addition, the VERP actions will also address management of the Visitor Facilities zone (parking lots, roads) in the Paradise area.

1.3 Assessing Changes in Visitation during Construction

The goals of this project are to assist the adaptive management process conducted under the VERP framework by assessing a variety of potential changes in visitation that might have occurred during the first (2006) season in which construction was ongoing. As described above, the knowledge gained by this project will help managers better understand visitor use and facilitate decisions of whether management action is necessary and which actions are appropriate.

1.3.1 The Four Types of Information about Visitation that were Collected

The types of information collected were intended to describe a range of general and specific aspects of visitation in the Paradise area. These four types of information include:

1. Counts of Parked Vehicles
2. Parking Durations of Vehicles
3. Counts of Hikers
4. Observation and Counts of Off-trail Hikers

The first two forms of information focus on vehicles. In the past, the vast majority of visitors have reached the Paradise area via private vehicles. During construction, a shuttle bus provided a new means of access.[1] Counting vehicles parked in the Paradise area and measuring the parking duration of a sample of vehicles will provide MORA managers with a variety of information about use, including: a) estimates of parking sufficiency, b) estimates of visit length during construction (and comparison to prior estimates), and c) estimates of total visitation via private vehicles and buses during construction (and comparison to prior estimates).

The last two forms of information focus on counts of visitors engaged in specific activities or behaviors. In combination with the vehicle information these data will provide MORA managers with information such as: a) estimates of change in hiking rates, b) estimates of change in hiking routes, c) information concerning the geographic concentration of off-trail hiking and potential for resource impacts, d) estimates of increases in off-trail hiking in specific areas that might result from changes in visitation arising due to construction activity.

[1] The number of visitors using the shuttle bus was recorded separately and is not discussed in this report.

2. COUNTING VEHICLES PARKED IN THE PARADISE AREA

Vehicle counts were collected for two primary reasons: 1) private vehicles have been (and still were in 2006) the primary means by which visitors access the Paradise area, and 2) one of the primary impacts on visitor access due to the construction activity was the decrease in the number of parking spaces available at Paradise. By counting vehicles in the Paradise area and relating those counts to the total number of vehicles entering the park, we could investigate the impact of the construction activity on visitor access.

2.1 Vehicle Counting Protocols

Two workers were available for this project. During the days when counts were conducted, each worker was assigned to count several parking areas. Three of those areas: 1) Loop A of the Picnic Area (designated for overnight parking), 2) the remainder of the Picnic Area, and 3) the JVC Parking Lot, were referred to as the "lower lot", and counted by one observer. The other observer counted four areas, 1) the spaces near the construction area (from the west end of the construction zone to the end of the rock wall), 2) the Valley Road to the 4th crossing trail, 3) the 4th crossing trail parking lot, and 4) the Valley Road beyond 4th crossing trail. These areas were referred to as the "upper lot". Counts were made on an hourly basis, and observers made separate counts recording the number of: a) motorcycles, b) standard vehicles that utilize a single parking space, and c) oversize vehicles using more than a standard parking space. Observers did not count buses parked in the dedicated bus parking area.[2]

Counts were conducted on an hourly basis by walking from one end to the other of the area to be counted. The direction of travel alternated from one hourly count to the next. The area referred to as the "upper lot" was counted by walking between the west end of the construction area to the parking area in front of the 4th crossing trail. Any vehicles parked on the road beyond the 4th crossing trail were counted during a stop at the vehicle turnout on the upper section of the valley road (the turnout lined by a rock wall that overlooks the eastern section of the Paradise Valley Road). From that vantage point, binoculars were used to count all vehicles parked from the 4th crossing trail until the last visible spot on the way to the Lake View trails.

2.2 Parking Counts: Results

Although the seven separate areas that were counted provide a reasonable description of the distribution of vehicles, the area along the Valley Road is sufficiently large that different patterns of parking might have important implications. In particular, it was possible that the presence of the Valley Road loop shuttle might encourage visitors to preferentially park in areas far from the construction area. Informal observations made during the vehicle counts suggest that the loop shuttle did not have such an effect. Visitors still preferred to park close to the Jackson Visitor Center, the Paradise Inn, and the network of trails just north of those facilities. The upper spots were generally occupied almost as soon they where free. Visitors parked further along the road as closer spaces were occupied, filling the road parking in a linear pattern, and not avoiding the construction.

Parking counts were conducted on seven days. A total of 41 hourly counts were collected. Table 1 shows when counts were collected. On the first day of data collection, counts were

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[2] The number of buses (and number of passengers per bus) entering the park is recorded by park staff at the entrance gate. These data could be compared with past years to determine if construction reduced visitation via tour buses.

recorded only for the "lower lot" and "upper lot". Thus, weekend counts for the more specific areas are based on only one day of counting. Because counts were not made for some hours on weekdays, some of the hourly averages shown in the charts were calculated based on fewer days of observation. Thus, an asterisk is included in the chart legends ("N = 5*").

Date	10:00	11:00	12:00	1:00	2:00	3:00	4:00
Sun. 7/2	X	X	X	X	X	X	X
Fri. 7/7	X	X	X	X	X	X	X
Sat. 7/15	X	X	X	X	X	X	X
Mon. 7/24	X	X	X	X	X	X	
Mon. 8/7	X	X	X	X	X		
Fri. 8/18		X	X	X	X		
Tue. 8/24	X	X	X	X	X		

Table 1. Times when vehicles were counted. "X" indicates a count was made.

2.2.1 Descriptive Data: Parking Counts

This report will focus on counts of total vehicles. Separate analyses of motorcycles, oversize vehicles, and vehicles parked illegal can also be conducted if needed by park managers.

The charts below present the average vehicle counts recorded for all the areas included in the counting protocol.

FIGURE 2. VEHICLES PARKED IN THE PARADISE AREA ON OBSERVED WEEKDAYS AND WEEKENDS

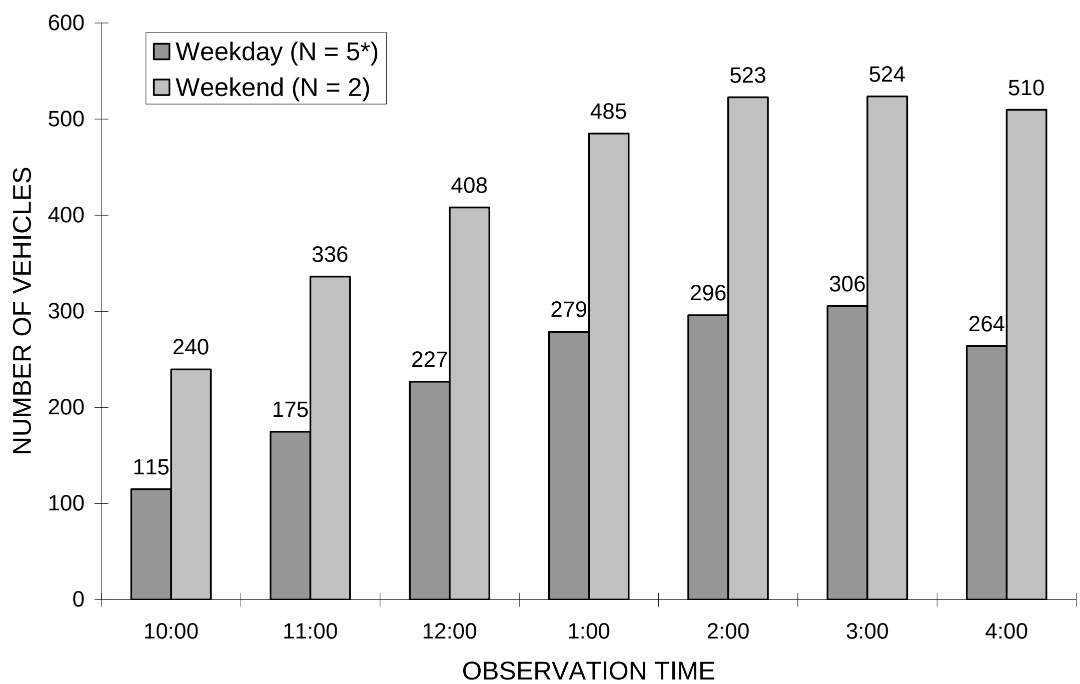


FIGURE 3. VEHICLES PARKED IN THE "LOWER" PARKING LOT ON OBSERVED WEEKDAYS AND WEEKENDS

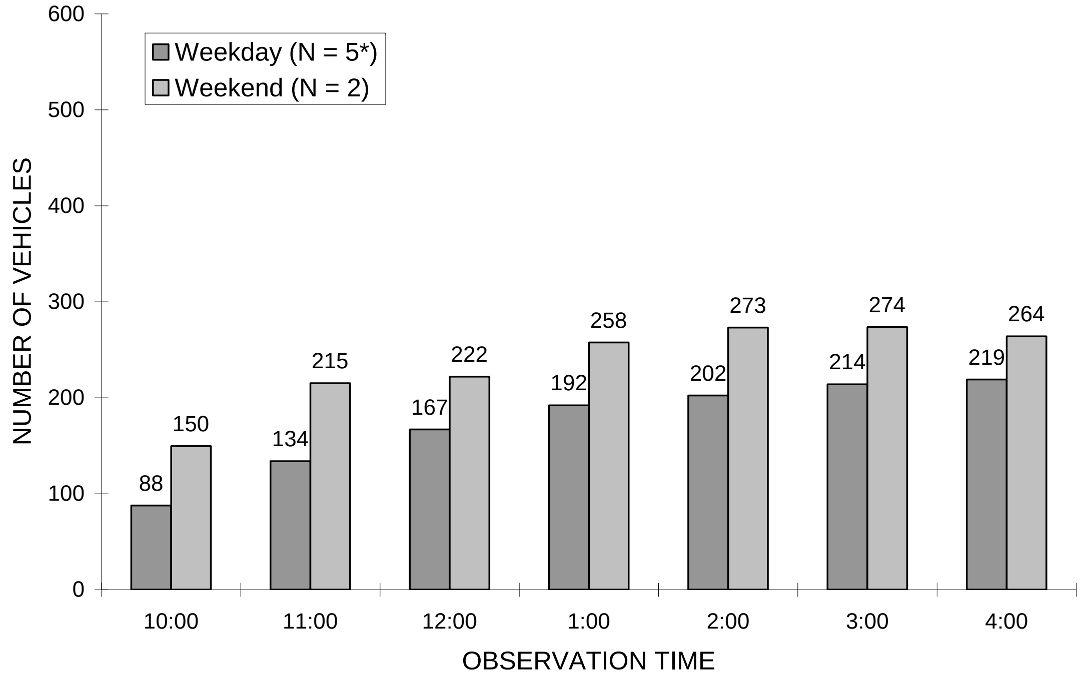


FIGURE 4. VEHICLES PARKED IN THE "UPPER" PARKING LOT ON OBSERVED WEEKDAYS AND WEEKENDS

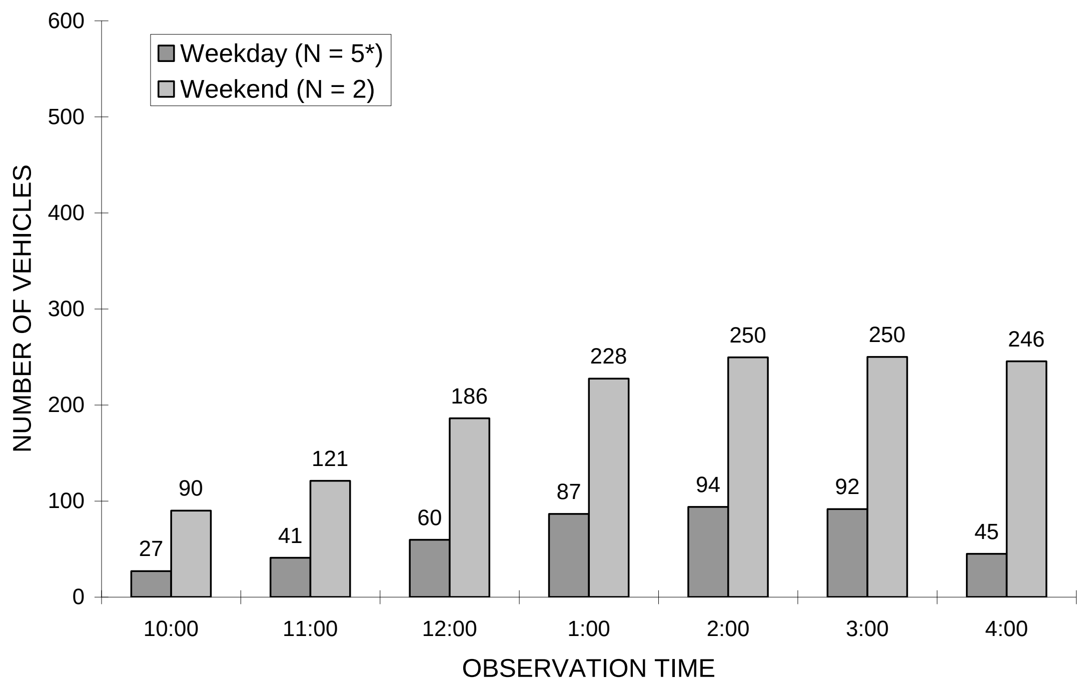


FIGURE 5. VEHICLES PARKED IN THE OVERNIGHT AREA (PICNIC LOOP A) ON OBSERVED WEEKDAYS AND WEEKENDS

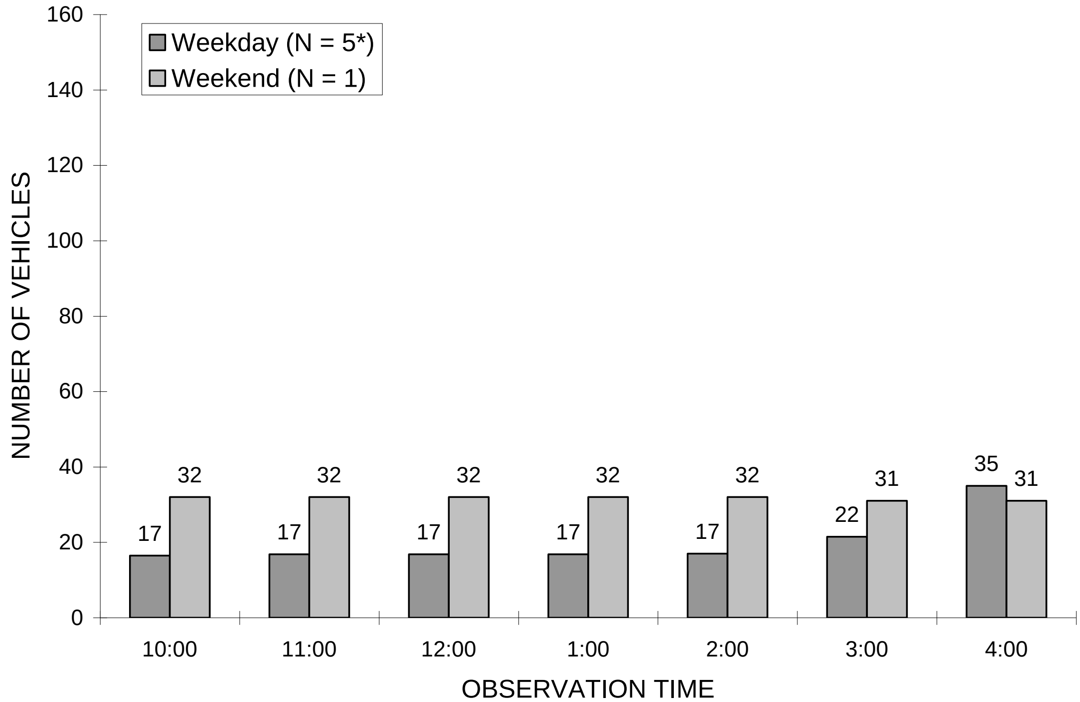


FIGURE 6. VEHICLES PARKED IN THE PARADISE PICNIC AREA (EXCLUDING OVERNIGHT PARKING) ON OBSERVED WEEKDAYS AND WEEKENDS

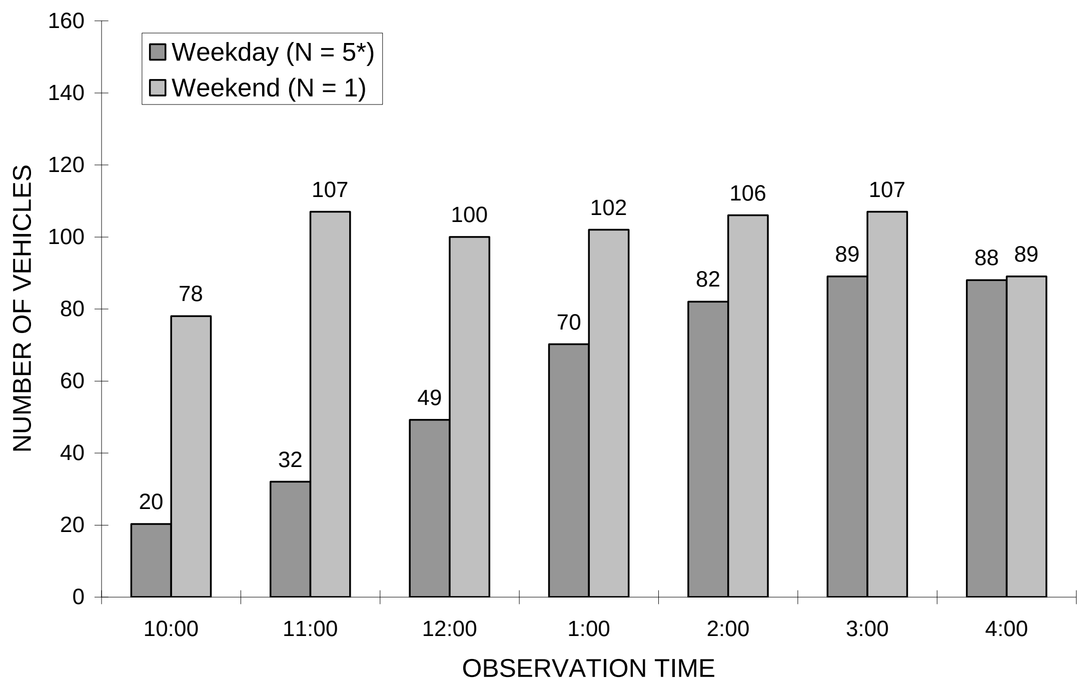


FIGURE 7. VEHICLES PARKED IN THE JACKSON VISITOR CENTER PARKING LOT ON OBSERVED WEEKDAYS AND WEEKENDS

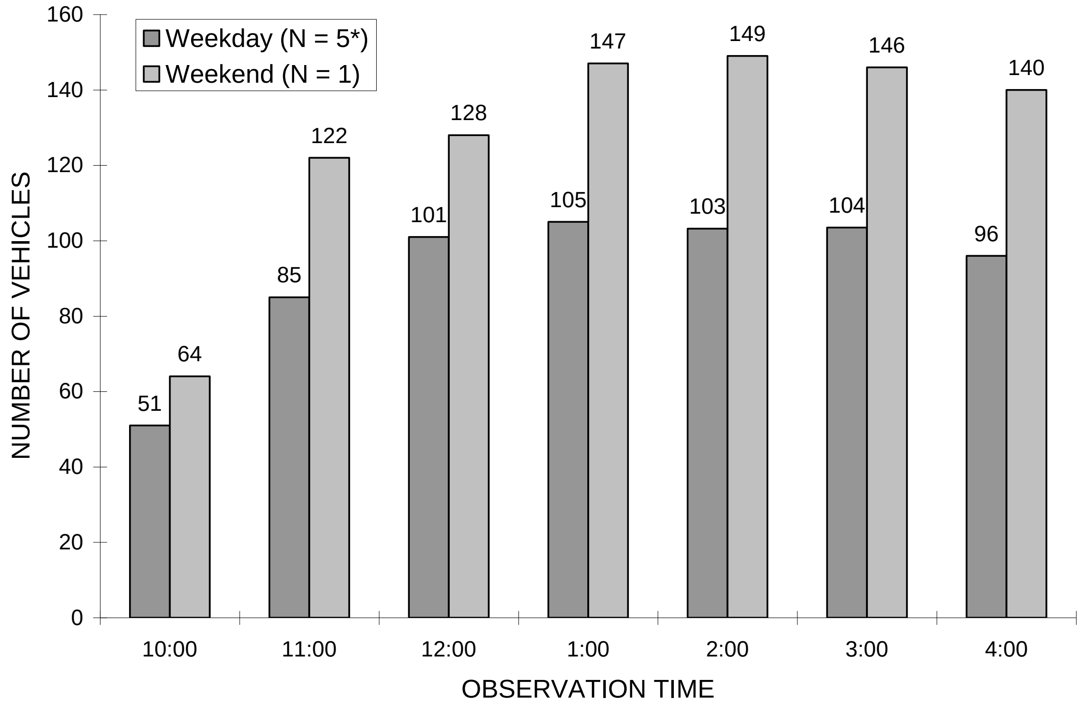


FIGURE 8. VEHICLES PARKED IN THE CONSTRUCTION AREA PARKING SPACES ON OBSERVED WEEKDAYS AND WEEKENDS

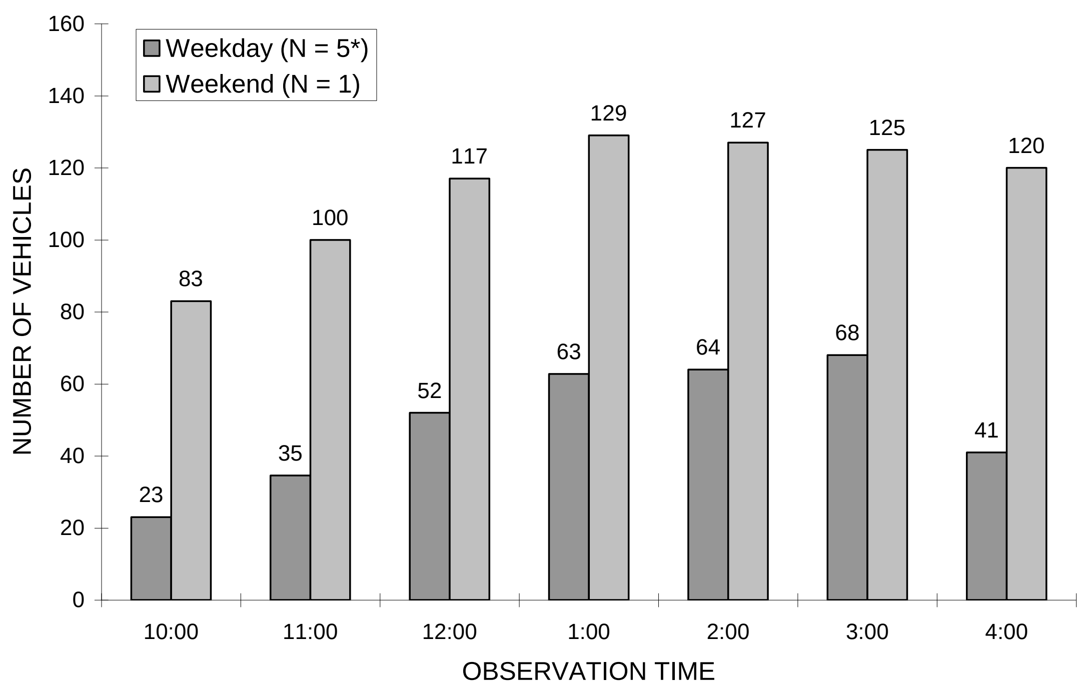


FIGURE 9. VEHICLES PARKED ON THE VALLEY ROAD BEFORE 4TH CROSSING ON OBSERVED WEEKDAYS AND WEEKENDS

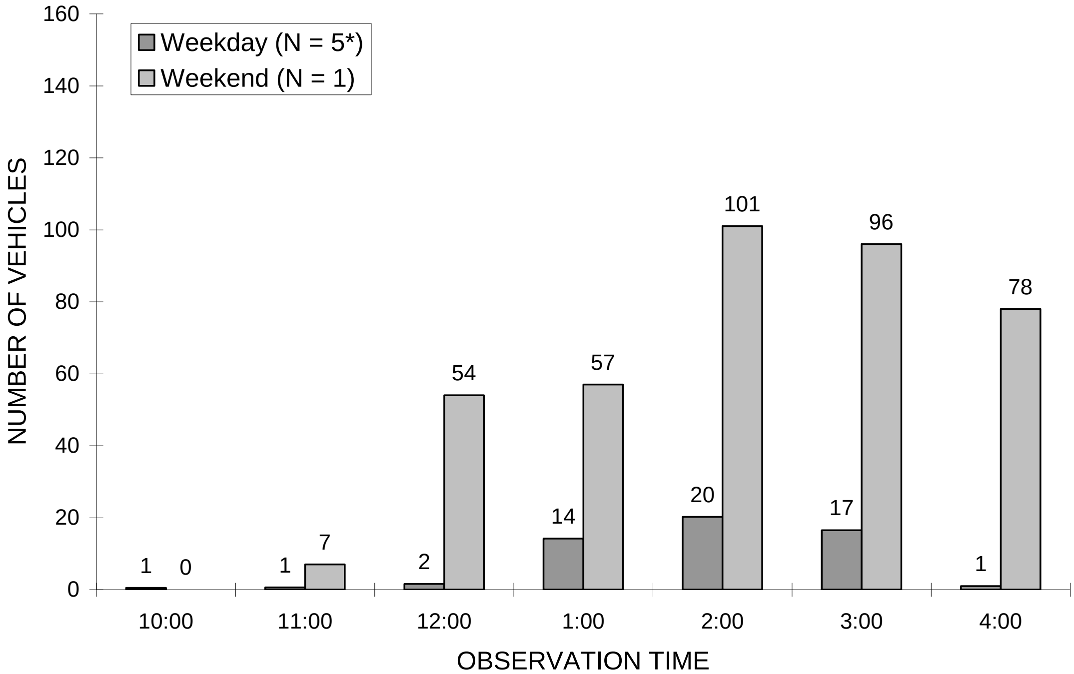


FIGURE 10. VEHICLES PARKED IN THE 4TH CROSSING TRAIL PARKING LOT ON OBSERVED WEEKDAYS AND WEEKENDS

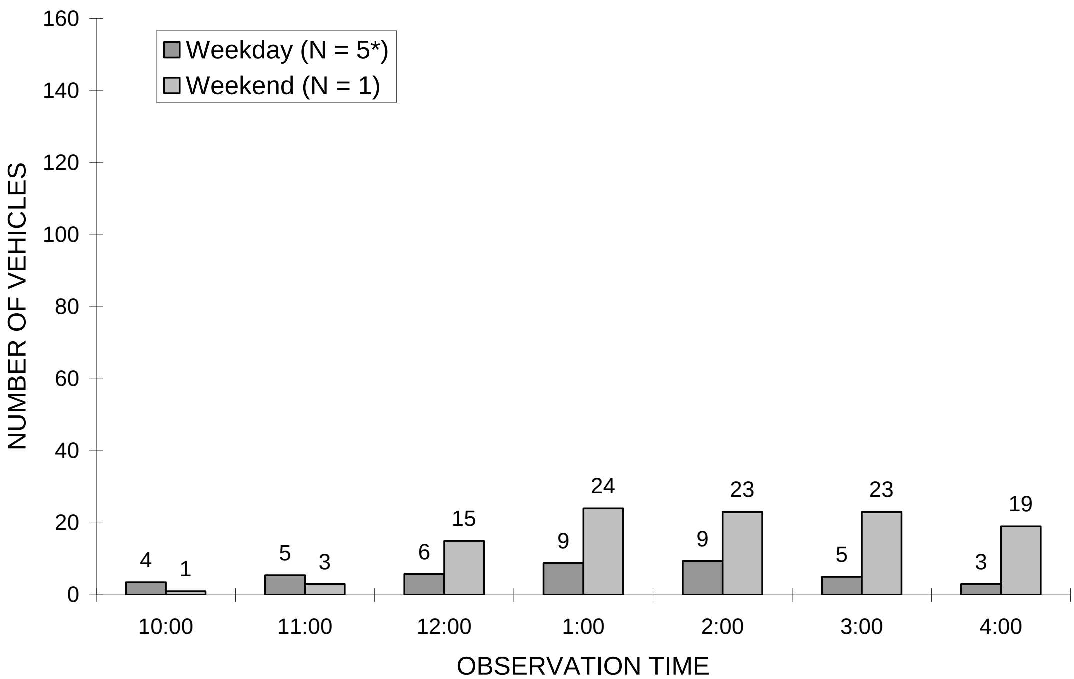
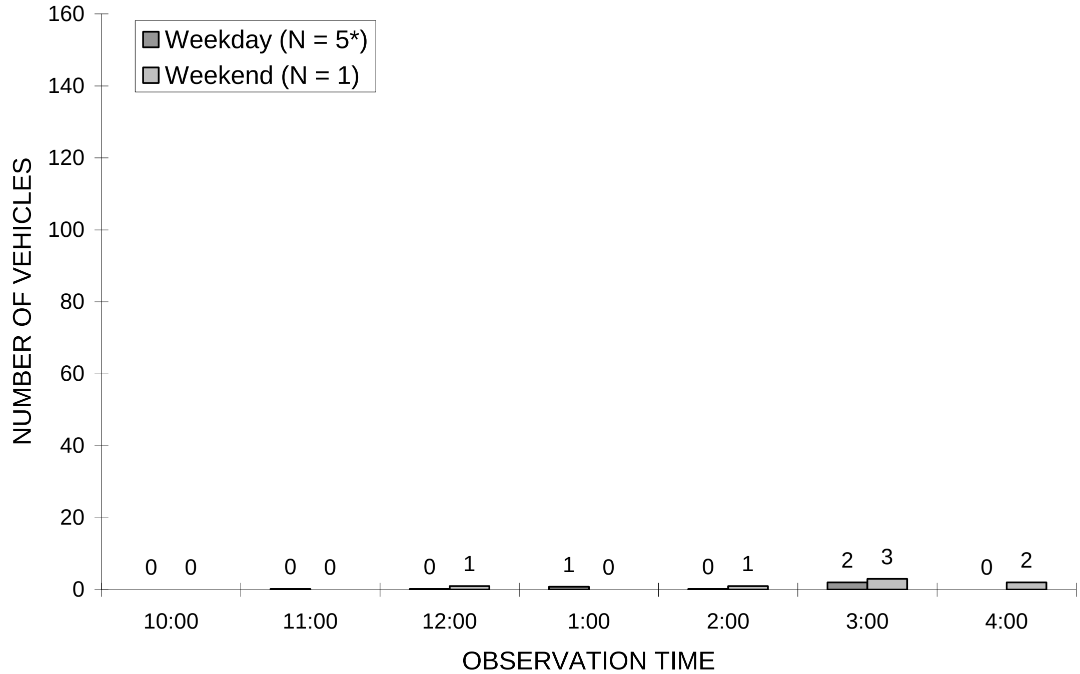


FIGURE 11. VEHICLES PARKED ON THE VALLEY ROAD AFTER 4TH CROSSING ON OBSERVED WEEKDAYS AND WEEKENDS



2.2.2 Statistical Relationships between Parking Counts and Gate Counts

One type of analyses initially planned for this report would have computed regression equations for each hour's total count based on hourly entry gate counts that lagged by X hours (with X selected based on the best fitting statistical model). Requests for entry gate counts from the NPS representative responsible for collecting and archiving that information were not answered and these potentially useful analyses are not included in this document.

2.2.4 Changes in Parking Counts during Construction

In this section we intended to compare the relationship between hourly entry gate counts and parking counts recorded in 1995 (Vande Kamp, Johnson, Kucera, and Young 1997) to the relationship observed in 2006. Such a comparison would have tested the hypothesis that a lower proportion of vehicles stopped at Paradise in 2006 than in 1995 (possibly as a results of the ongoing construction).

3. PARKING DURATIONS FOR VEHICLES PARKED IN THE PARADISE AREA

Parking durations were measured for two primary reasons: 1) in combination with the snapshot counts of private vehicles, parking durations allow the estimation of total visitation, and 2) it is possible that the construction activity changed visitor behavior in a way that altered the duration of their visits to the Paradise area. Relating 2006 parking durations to the durations measured in the 1993 BRW study provides information about the likelihood of such impacts.

3.1 Protocols for Measuring Parking Duration

Measures of parking duration were recorded at the following four locations: 1) the spaces near the construction area (from the west end of the construction zone to the end of the rock wall), 2) the JVC Parking Lot, 3) the Picnic Area (excluding Loop A that was designated for overnight parking), and 4) the Valley Road to the 4th crossing trail.

During data collection, observers sat in locations where they could monitor multiple parking spaces (at least 16 spaces; observed spaces rotated across days) and record the times when vehicles parked and departed. Partial data were recorded for vehicles that parked before the observer arrived (or during observer breaks) and those that departed after the observer left (or during observer breaks).

3.2 Parking Duration: Results

Table 2. Dates and times when parking duration data were collected at each site.

Location	Date	Time	Location	Date	Time
Construction Area	7/3	13:00 – 16:55	Picnic Area	7/14	13:00 – 16:55
Construction Area	7/6	10:00 – 4:45	Picnic Area	7/26	10:00 – 4:50
Construction Area	7/8	11:30 – 5:00	Picnic Area	7/30	10:00 – 2:35
Construction Area	7/19	12:25 – 5:00	Picnic Area	8/5	9:30 – 4:50
Construction Area	7/30	10:35 – 2:40	Picnic Area	8/14	9:48 – 2:45
Construction Area	8/22	12:30 – 5:15	Picnic Area	8/21	9:45 – 2:50
Total	6 days	1,775 Min.	Picnic Area	8/27	9:36 – 4:55
			Picnic Area	9/2	9:40 – 4:55
Jackson Visitor Center	7/3	10:00 – 3:30	**Total**	8 days	2,836 Min.
Jackson Visitor Center	7/8	10:30 – 4:50			
Jackson Visitor Center	7/14	2:10 – 4:50	Valley Road	7/26	9:45 – 4:58
Jackson Visitor Center	7/25	10:00 – 4:45	Valley Road	8/5	9:45 – 5:00
Jackson Visitor Center	7/30	10:00 – 5:00	Valley Road	8/13	9:50 – 4:50
Jackson Visitor Center	8/4	10:40 – 4:00	Valley Road	8/28	9:36 – 2:45
Jackson Visitor Center	8/10	10:00 – 5:00	Valley Road	9/3	10:20 – 5:00
Jackson Visitor Center	8/21	9:40 – 3:00	**Total**	5 days	1,997 Min.
Jackson Visitor Center	8/25	9:45 – 5:00			
Jackson Visitor Center	9/2	9:50 – 4:50			
Total	10 days	3,610 Min.			

3.2.1 Descriptive Data: Parking Duration

An important issue with the duration data is that some vehicles are present when observation starts and others have not departed when observation ends. Analysis can either exclude those vehicles from calculations, or use the beginning and ending times of observation to estimate their minimum parking duration. Either method underestimates the total duration of stays, but we know that analyses that include the estimated durations are more accurate because they increase the average parking duration (i.e., we know that if two estimates are both low, then the higher of the two must be more accurate).

A much smaller issue concerns vehicles that entered or left parking spaces during the half-hour lunch breaks taken by observers. Between 3 and 10 percent of vehicles fell into this category. In all cases, the missing time was estimated as the midpoint of the unobserved "break" period so that the maximum inaccuracy was 15 minutes. It is reasonable to assume that inaccuracies were randomly distributed and will not alter the presentation of data or the conclusions supported by the data. Thus, these estimated observations are not differentiated from those in which both entry and exit times were recorded.

Jackson Visitor Center

Based on the durations for which entry and exit were observed, as well as the minimum parking durations recorded for vehicles that entered or exited outside the observed time period, the average parking duration in the Jackson Visitor Center Parking Lot was 119.5 minutes with a standard deviation of 106.8 minutes. The median duration was 80 minutes.

FIGURE 12. PARKING DURATIONS INCLUDED IN THE JACKSON VISITOR CENTER ANALYSES

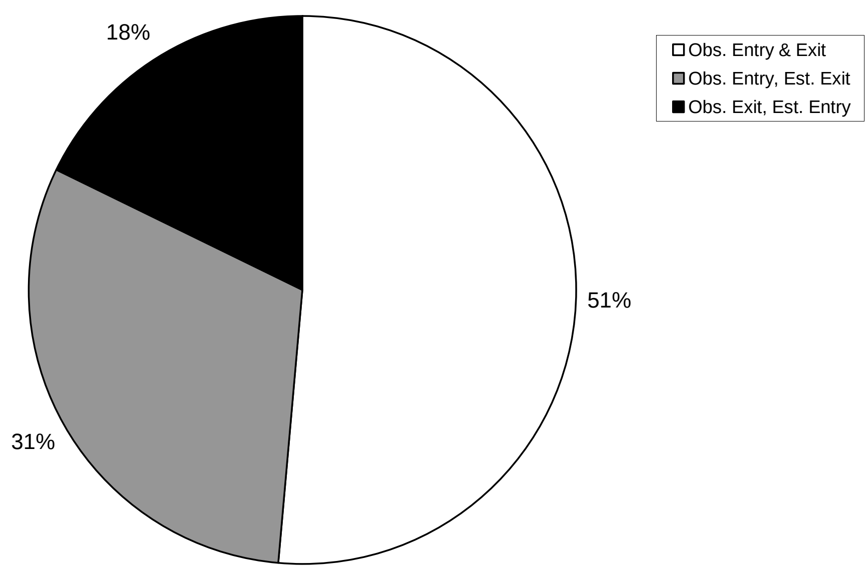
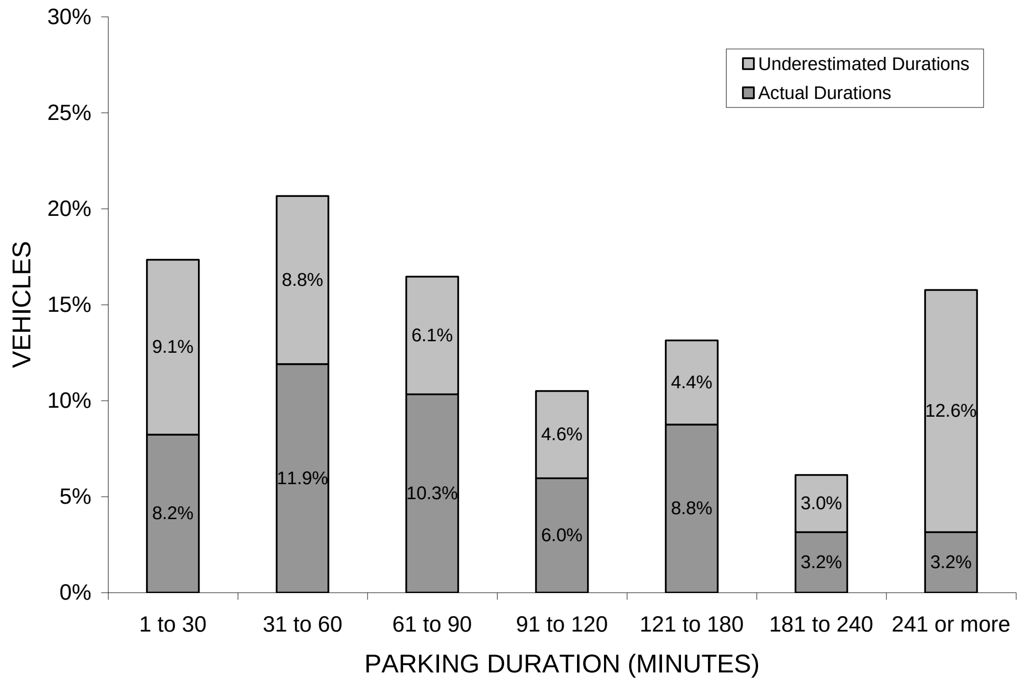


FIGURE 13. PARKING DURATIONS FOR VEHICLES PARKED IN THE JACKSON VISITOR CENTER PARKING LOT



Paradise Picnic Area

Based on the durations for which entry and exit were observed, as well as the minimum parking durations recorded for vehicles that entered or exited outside the observed time period, the average parking duration in the Paradise Picnic Area (excluding the overnight parking area) was 129.5 minutes with a standard deviation of 111.8 minutes. The median duration was 92 minutes.

FIGURE 14. PARKING DURATIONS INCLUDED IN THE PARADISE PICNIC AREA ANALYSES

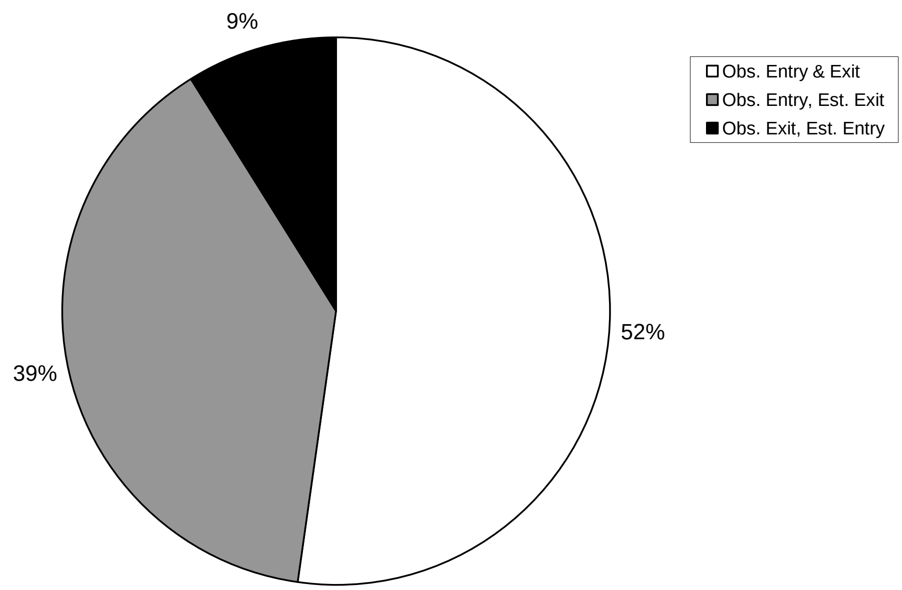
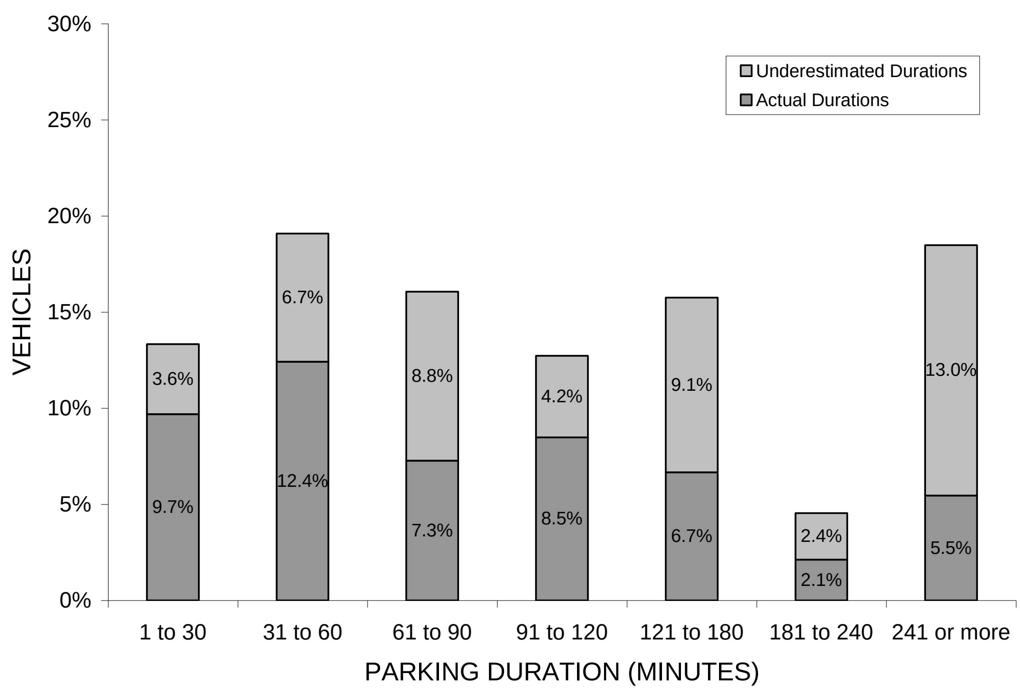


FIGURE 15. PARKING DURATIONS FOR VEHICLES PARKED IN THE PARADISE PICNIC AREA (EXCLUDING THE OVERNIGHT AREA)



Paradise Valley Road

Based on the durations for which entry and exit were observed, as well as the minimum parking durations recorded for vehicles that entered or exited outside the observed time period, the average parking duration along the Paradise Valley Road was 165.9 minutes with a standard deviation of 112.2 minutes. The median duration was 149 minutes.

FIGURE 16. PARKING DURATIONS INCLUDED IN THE VALLEY ROAD ANALYSES

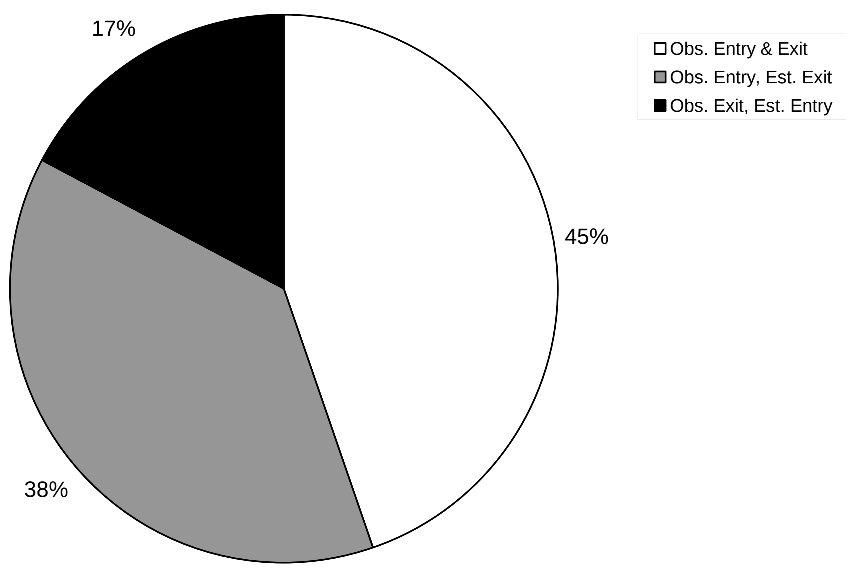
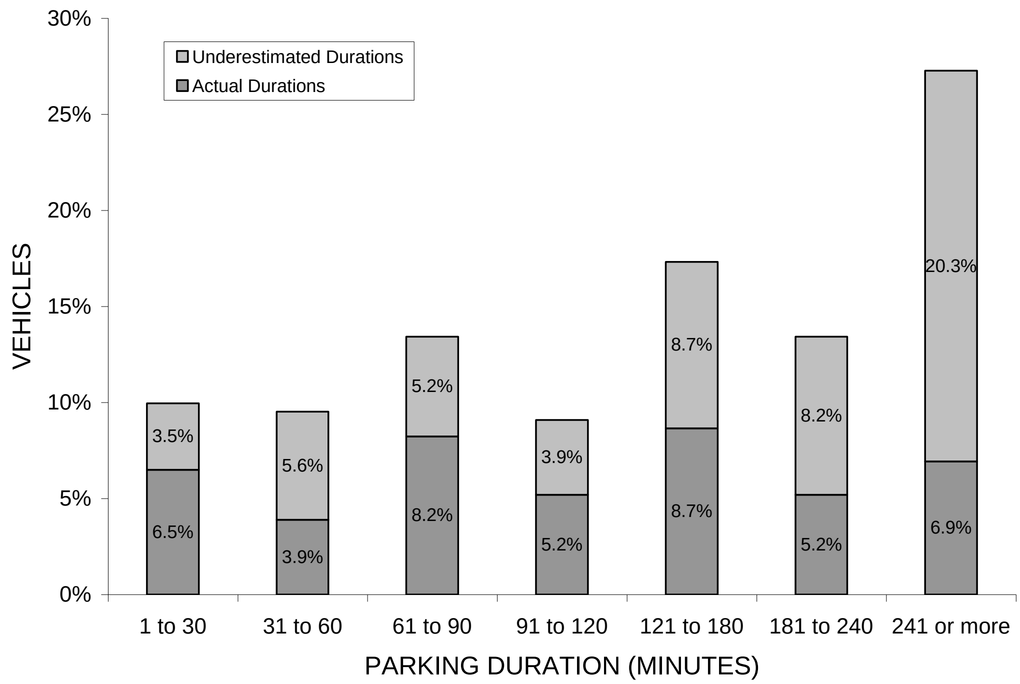


FIGURE 17. PARKING DURATIONS FOR VEHICLES PARKED ALONG THE PARADISE VALLEY ROAD



Upper Parking Lot (Spaces Near Construction Area)

Based on the durations for which entry and exit were observed, as well as the minimum parking durations recorded for vehicles that entered or exited outside the observed time period, the average parking duration for spaces in the upper parking lot (near the construction area) was 137.3 minutes with a standard deviation of 105.5 minutes. The median duration was 111 minutes.

FIGURE 18. PARKING DURATIONS INCLUDED IN THE UPPER PARKING LOT (CONSTRUCTION AREA) ANALYSES

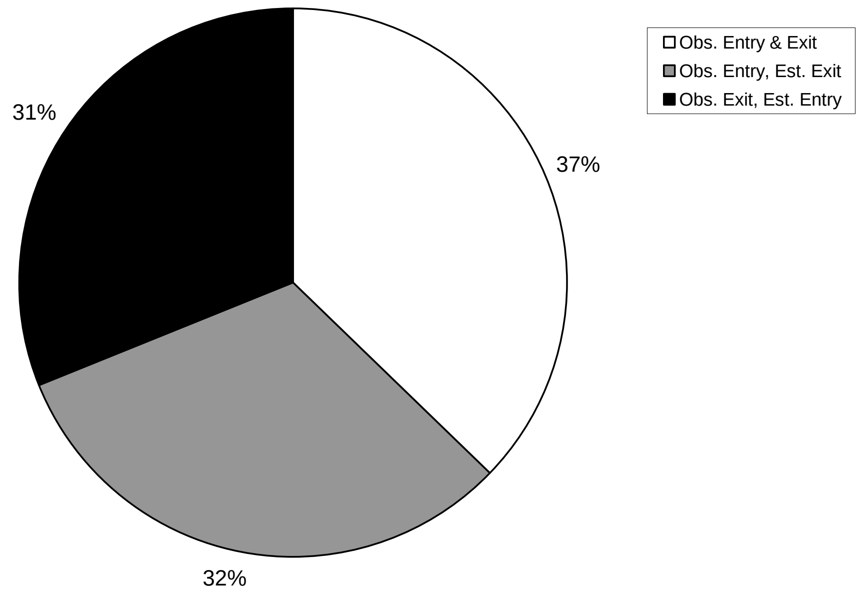
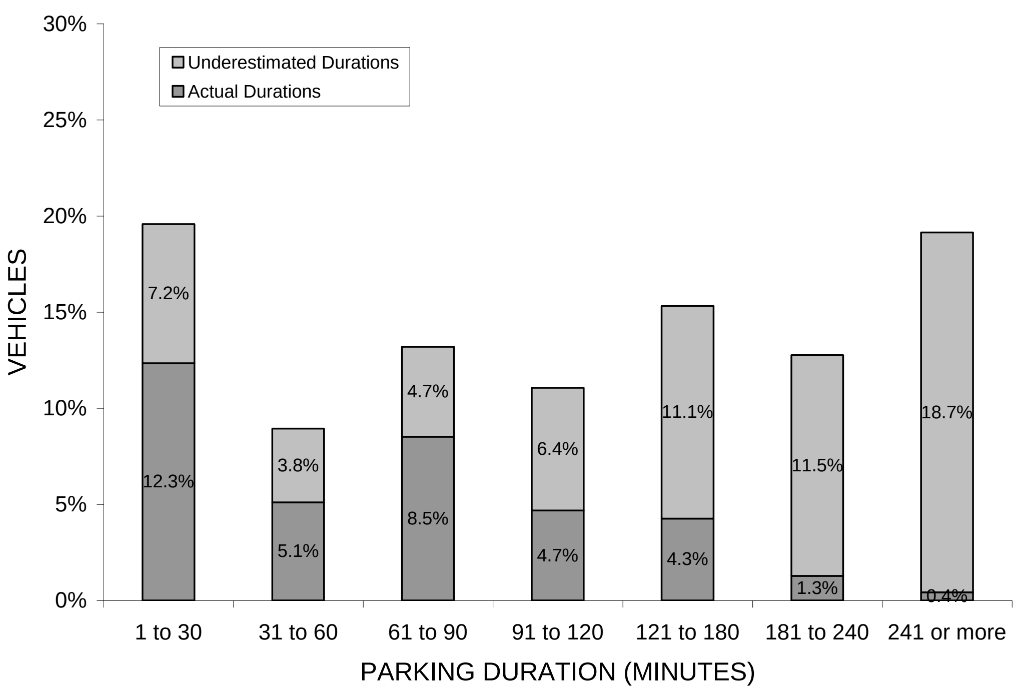


FIGURE 19. PARKING DURATIONS FOR VEHICLES PARKED IN THE UPPER PARKING LOT (CONSTRUCTION AREA)



3.2.2 Changes in Parking Duration during Construction

Information about parking duration is not routinely collected. The most recent systematically-collected information about parking duration in the Paradise area was gathered in 1993 and reported in the Transportation Feasibility Study prepared by BRW. In that study, parking durations were recorded for one day (August 29) in three different locations: 1) the Jackson Visitor Center parking lot, 2) the "close-in" area of the large upper lot (areas closed for construction in 2006), and 3) the "outlying" area of the large upper lot (portions closed in 2006 and other portions corresponding to the.

Table 3. Parking duration summaries for the two areas that were observed both in 1993 and in 2006.

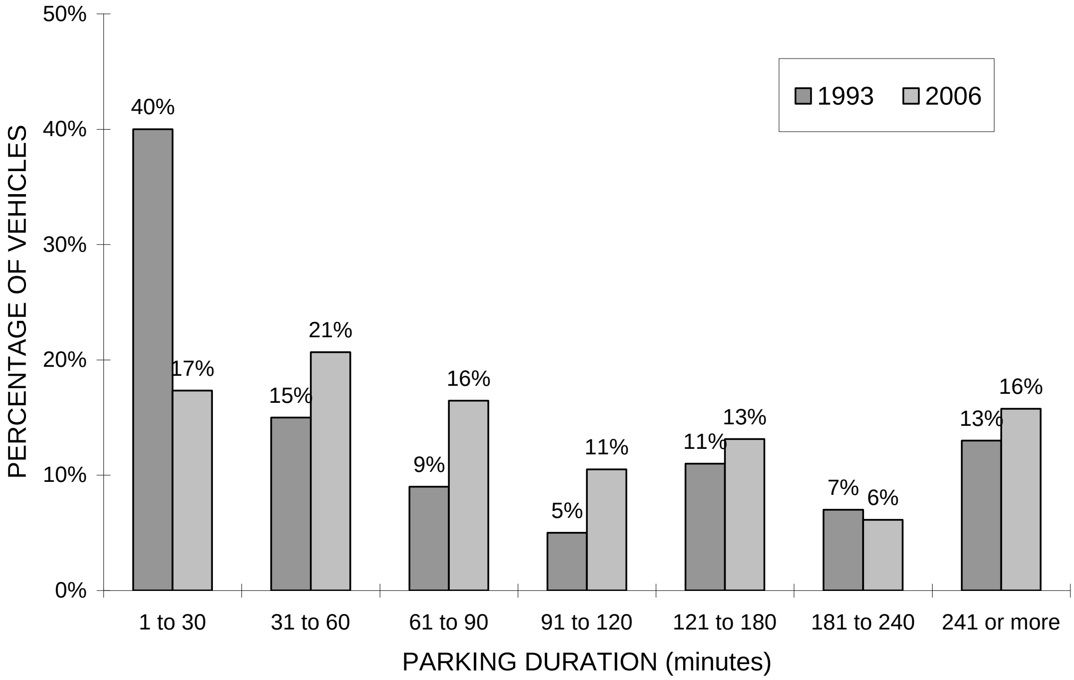
SITE	**1993**	**2006**
	Mean	**Mean**
Jackson Visitor Center P.L.	114.0 min.	119.5 min.
Upper P.L.	141.6 min.*	137.3 min.

* Table includes only the "outlying" areas of the upper parking lot because many "close-in" vehicles were driven by climbers who were required to park elsewhere in 2006.

The means reported in the table seem to indicate that parking duration changed very little due to the construction in 2006.[3] However, a closer look at the distribution of parking durations suggests that at least one important change did occur. The paired bars in the two figures below compare the distributions of parking durations from the 1993 and 2006 studies.

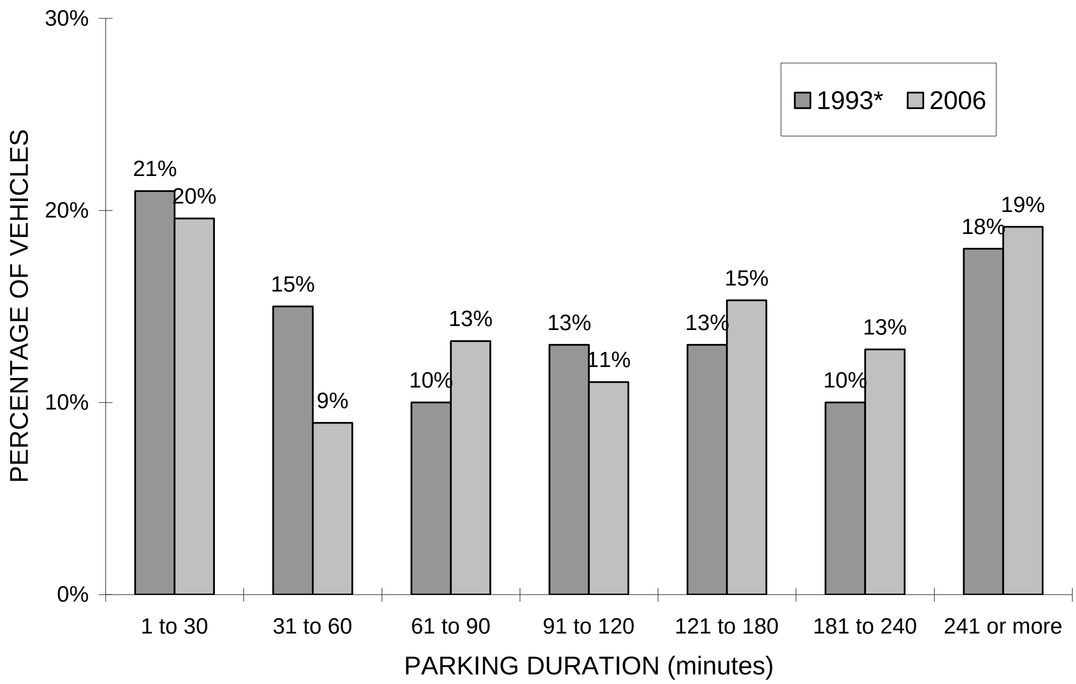
[3] We know that the 2006 data were collected and analyzed in a way that underestimates the average parking duration. The methods used to collect the 1993 are not sufficiently detailed to tell if those data were similarly biased.

FIGURE 20. PARKING DURATIONS OF VEHICLES PARKED IN THE JACKSON VISITOR CENTER PARKING LOT IN 1993 AND 2006 STUDIES



Although the average parking durations were similar, it is clear that a much smaller proportion of vehicles in 2006 were making very brief stops at the Jackson Visitor Center. There are at least three possible reasons that could be fully or partly responsible for this shift: 1) because the total number of parking spaces in the area was reduced in 2006, visitors wishing to stop for brief periods may have found no empty spaces and moved along, 2) visitors who would normally stop briefly planned to drive through without stopping after learning about the construction earlier in their visit, or 3) visitors who would normally stop briefly may have been more likely to ride the Cougar Rock shuttle. The current data do not provide an opportunity to test any of these hypotheses, and this is by no means a complete representation of all plausible reasons for the discrepancy between the 1993 and 2006 parking duration data.

FIGURE 21. PARKING DURATIONS OF VEHICLES PARKED IN THE UPPER LOT IN 1993 AND 2006 STUDIES



* Data from 1993 refer only to the “outlying” areas of the upper parking lot because many “close-in” vehicles were driven by climbers who would be required to park elsewhere in 2006.

Parking durations in 1993 and 2006 were quite similar for upper lot parking. The largest discrepancy fell in the proportion of vehicles parking for 31 to 60 minutes, but the size of that discrepancy was not large. Part of the apparent consistency between the 1993 and 2006 usage of the upper lot may arise because the closure of the construction area in 2006 reduced the parking available for day visitors in a manner similar to the long-term parking by climbers and overnight guest of the Paradise Inn that occurred in 1993 (but not in 2006).

4. Estimating Total Use of Paradise Based on Parking Counts and Parking Duration

The total number of vehicles using the Paradise area can not be estimated by simply summing up the hourly counts of vehicles because we counted many vehicles multiple times. The vehicle counts need to be adjusted based on vehicle parking durations. This section describes the method for estimating total use and presents the resulting use estimates for both the various parking areas and for the Paradise area as a whole.

4.1 General Method of Estimating Total Use

The formula for estimating daily totals of visiting vehicles based on the hourly parking counts and parking durations during the observed time period is as follows:

Visiting Vehicles (10:00 to 4:00) = sum(hourly counts) / mean parking duration (in hours)

It is important to note that the average parking durations reported above and used in this section are known to underestimate the average amount of time that vehicles were actually parked. When used in the equation above, such underestimates of parking duration lead to overestimation of the number of visiting vehicles. The degree of overestimation is directly related to the degree of underestimation in the parking durations. However, both such numbers are unknown at this time. It is safe to say that no more than the estimated number of vehicles parked on weekends and weekdays.

In addition, the number of visiting vehicles outside the observed time period can be estimated based on the hourly distributions of use collected using the electronic trail counters (see Section 5 below). The distribution of use observed on the Nisqually Vista Trail was used to estimate daily vehicle totals in the Jackson Visitor Center parking lot. The distribution of use observed on the main Skyline Trail was used to estimate daily vehicle totals for all other parking areas.

4.2 Total Visitor Use at Paradise: Results

Because vehicle counts and parking duration data were collected separately at a variety of locations, estimates of total vehicle visits are presented for four specific areas (the Picnic Area, Jackson Visitor Center, Upper Lot, and Road) as well as for the Paradise area as a whole.

4.2.1 Descriptive Data: Picnic Area

The estimated use of the picnic area (excluding the overnight parking loop) is based on the following pieces of information:

TABLE 4. INFO. TO EST. TOTAL PICNIC AREA USE	Weekday	Weekend
Sum of 6 Hourly Vehicle Counts	431	689
Mean Parking Duration (in hours)	2.16	2.16
Estimated Percentage of Use Between 10:00 and 4:00 (from Skyline Trail counter)	63.1	57.1

The estimated daily total of vehicles parking in the Picnic area (excluding the overnight parking loop) is:

Weekday Daily Total = (431 / 2.16) / 0.631 = 316 vehicles
Weekend Daily Total = (689 / 2.16) / 0.571 = 559 vehicles

Because parking duration is known to be underestimated, the estimated parking duration used in the equations above leads to overestimation of the number of visiting vehicles. The degree of overestimation is directly related to the degree of underestimation in the parking durations. However, both such numbers are unknown at this time. It is safe to say that no more than the estimated number of vehicles parked on observed weekends and weekdays.

4.2.2 Descriptive Data: Jackson Visitor Center Parking Lot

The estimated use of the Jackson Visitor Center parking lot is based on the following pieces of information:

TABLE 5. INFO. TO EST. TOTAL JVC USE	Weekday	Weekend
Sum of 6 Hourly Vehicle Counts	645	896
Mean Parking Duration (in hours)	1.99	1.99
Estimated Percentage of Use Between 10:00 and 4:00 (from Nisqually Vista Trail counter)	64.6	61.0

The estimated daily total of vehicles parking in the Jackson Visitor Center parking lot is:

Weekday Daily Total = (645 / 1.99) / 0.646 = 502 vehicles
Weekend Daily Total = (896 / 1.99) / 0.610 = 738 vehicles

Because parking duration is known to be underestimated, the estimated parking duration used in the equations above leads to overestimation of the number of visiting vehicles. The degree of overestimation is directly related to the degree of underestimation in the parking durations. However, both such numbers are unknown at this time. It is safe to say that no more than the estimated number of vehicles parked on observed weekends and weekdays.

4.2.3 Descriptive Data: Upper Lot (Near Construction Area)

The estimated use of the Upper Parking Lot (near the construction area) is based on the following pieces of information:

TABLE 6. INFO. TO EST. TOTAL UPPER LOT USE	Weekday	Weekend
Sum of 6 Hourly Vehicle Counts	345	801
Mean Parking Duration (in hours)	2.29	2.29
Estimated Percentage of Use Between 10:00 and 4:00 (from Skyline Trail counter)	63.1	57.1

The estimated daily total of vehicles parking in the Upper Parking Lot (near the construction area) is:

Weekday Daily Total = (345 / 2.29) / 0.631 = 239 vehicles
Weekend Daily Total = (801 / 2.29) / 0.571 = 613 vehicles

Because parking duration is known to be underestimated, the estimated parking duration used in the equations above leads to overestimation of the number of visiting vehicles. The degree of overestimation is directly related to the degree of underestimation in the parking durations. However, both such numbers are unknown at this time. It is safe to say that no more than the estimated number of vehicles parked on observed weekends and weekdays.

4.2.4 Descriptive Data: Paradise Valley Road/Fourth Crossing Parking

The estimated use of the Paradise Valley Road and Fourth Crossing trailhead is based on the following pieces of information:

TABLE 7. INFO. TO EST. TOTAL VALLEY ROAD USE	Weekday	Weekend
Sum of 6 Hourly Vehicle Counts	99	508
Mean Parking Duration (in hours)	2.77	2.77
Estimated Percentage of Use Between 10:00 and 4:00 (from Skyline Trail counter)	63.1	57.1

The estimated daily total of vehicles parking along the Paradise Valley Road and in the Fourth Crossing parking lot is:

Weekday Daily Total = (99 / 2.77) / 0.631 = 57 vehicles
Weekend Daily Total = (508 / 2.77) / 0.571 = 321 vehicles

Because parking duration is known to be underestimated, the estimated parking duration used in the equations above leads to overestimation of the number of visiting vehicles. The degree of overestimation is directly related to the degree of underestimation in the parking durations. However, both such numbers are unknown at this time. It is safe to say that no more than the estimated number of vehicles parked on observed weekends and weekdays.

4.2.1 Descriptive Data: Total Use

The total number of vehicles parking in Paradise area can be reasonably estimated by summing the weekday and weekend totals estimated for the four different parking areas above. This total excludes vehicles parked in the overnight area (Loop A of the Picnic Area).

Weekday Daily Total = 316 + 502 + 239 + 57 = 1,114 vehicles
Weekend Daily Total = 559 + 738 + 613 + 321 = 2,231 vehicles

Because parking duration is underestimated, the number of visiting vehicles is overestimated. The degree of overestimation is directly related to the degree of underestimation in the parking durations. However, both such numbers are unknown at this time. It is safe to say that no more than the estimated number of vehicles parked on observed weekends and weekdays.

4.2.2 Changes in Total Use during Construction

In 1993, parking information about parking duration in the Paradise area was gathered (BRW 1995), and in 1995, vehicle counts were collected (Vande Kamp, Johnson, Kucera, and Young 1997). Taken together, these data provide a basis for estimating the number of vehicles visiting the Paradise area. The same formulas employed above to estimate vehicle use in 2006 were used with the 1995 and 1993 figures. Because trail counter distributions of use were not collected until recently, the same assumptions about the distribution of use outside the observed times used in estimating 2006 use were also used to estimate 1995 use.

The 1995 Visitor Distribution Survey reported actual vehicle counts, but also found that there were strong relationships between general vehicle entries into the park and the vehicle counts at Paradise. Those relationships provided the basis for estimating vehicle counts for four different combinations of weather and weekend/weekday. The daily vehicle use estimates presented below describe 1995 vehicle visits for those four different combinations.

TABLE 8. EST. TOTAL PARADISE AREA VISITS – 1995 AND 2006

Total Daily Vehicle Visits – 1995 Visitor Distribution Survey				
	Weekday		Weekend	
	Bad Weather	Good Weather	Bad Weather	Good Weather
Jackson VC	538	596	616	675
Upper Parking Lot/ Valley Road	757	1,164	1,268	1,674
Paradise Area	1,295	1,760	1,884	2,349

Total Daily Vehicle Visits – 2006 Paradise Area Visitor Use		
	Weekday	Weekend
Jackson VC	502	738
Upper Parking Lot/ Valley Road	296	934
Paradise Area (as in 1995)	798	1,672
Paradise Area (with Picnic Area)	1,114	2,231

Several differences between 1995 and 2006 complicate a direct comparison of the vehicle visit estimates. First, parking is currently different because climbers are required to park outside the park and ride a shuttle bus to Paradise. They were not required to do so in 1995, and their vehicles occupied a substantial number of spaces in the parking lot, particularly on the weekdays counted in 1995 (Thursday and Friday). Second, it is likely that many more vehicles parked in the picnic area in 2006 than in 1995 – signs and other information given to visitors were changed in 2006 to encourage parking in the picnic area. Third, and finally, the classification of the days counted in 2006 as “good weather” or “bad weather” is not clear. More sophisticated analysis relating vehicle counts at Paradise to vehicle counts at the Nisqually and Stevens Canyon entrances could address this last issue, but such analyses go beyond the scope of the current report.

The general assessment of the total vehicle visits suggests that the Paradise area was visited by a slightly fewer vehicles in 2006 than in 1995. On weekdays, the number of vehicles estimated to visit the area was lower in 2006 than in 1995, even if the Picnic Area parking is included in the 2006 counts (1,114 < the lowest 1995 estimate of 1,295). However, some of that difference is probably made up by climbers who did not park at Paradise in 2006. The difference for weekends is not as pronounced. If the Picnic Area is not included in the 2006 weekend estimates, daily vehicle visits were lower in 2006 than in 1995 (1,672 < 1,884). However, when the picnic area is included, estimated vehicle visits in 2006 were nearly as high as the highest estimated use in 1995 (2,231 and 2,349, respectively).

The similarity in the vehicle visit estimates for weekends in 1995 and 2006 does not tell the entire story about visitation to the Paradise area. The fact that shuttle buses to Paradise were available and used by both climbers and general visitors in 2006 suggests that the total number of visitors to the Paradise area was probably as high or higher in 2006 than in 1995.

5. Measuring Trail Use at Paradise using Electronic Trail Counters

One possible consequence of the construction in the Paradise area was change in the patterns of use by hikers. This possibility was assessed, directly and indirectly by installing and maintaining six trail counters at selected locations in the Paradise area.

5.1 Locations and Installation of Trail Counters

The six locations in which trail counters were installed, and the times during which they operated are represented in the table below. Installation of some counters was delayed due to snow.

TABLE 9. TRAIL COUNTER LOCATIONS AND OBSERVED TIMES	
Trail Counter	**Observed time**
Nisqually Vista Trail (near glacier overlooks)	7/3 to 9/8
Skyline Trail (past junction with Alta Vista Trail)	7/3 to 9/9
East Skyline Trail (NE of Lakes Trail junction)	7/17 to 9/9
Fourth Crossing Trail	7/10 to 9/9
High Lakes Trail South (near SE end of Valley Road)	7/14 to 9/9
Paradise Valley Trail North - to facilities (near SE end of Valley Road)	7/14 to 9/9

All counters were installed where they were not obvious to visitors. The ideal locations for installation were at sites where the trail was narrow and steep/rough enough that visitors moved slowly in single file. Such sites were not available for all six targeted trails. In several cases, the best available sites were used.

5.2 Protocols for Trail Counter Maintenance and Use

In most cases, trail counters were checked and data were downloaded twice a week. Field staff checked the count registered since the last data collection to see if it was in a reasonable range. In addition, the counter was adjusted into setup mode so that staff could confirm that the beam was being received strongly. The receiver can give an “OK” signal, even when the beam is considerably off center, but operation is more consistent when the strongest, center portion of the beam hits the receiver. Finally, whenever possible, field staff watched a few visitors walk by in order to determine that the counter was working correctly before moving on.

5.3 Validation of Trail Counters

Despite proper maintenance, the inherent limitations of the beam-based counters and the characteristics of the trail where the counter was installed lead the counters to register fewer visitors than the number that actually pass. In order to better estimate the degree of undercounting, direct observations were made of the trail counter performance at four of the six locations.

5.3.1 Validation Protocols

The basic validation procedure consisted of having an observer sit at a location where the counter readout was visible (sometimes using binoculars), watching groups of visitors walk past the counter, then recording both the number of visitors in the group and the number of “hits” recorded by the counter. Field staff also recorded the times and dates when validation data were collected.

5.4 Trail Use at Paradise: Results for Nisqually Vista Trail

The Nisqually Vista Trail is commonly used by visitors taking short hikes. It is a busy trail that is most easily accessed from the parking areas at the Jackson Visitor Center and picnic area rather than from the upper lot (construction area) or the Paradise Valley road. Changes in use of the Nisqually Vista Trail will be easiest to detect by comparing the relative proportion of hikers counted there and on other trails in the Paradise area (such as the Skyline Trail) to the proportions recorded in the waypoint studies of hiker itineraries. Counts of hiking use were conducted in the 1995 Visitor Distribution Survey, but construction of the water supply during that summer altered hiking patterns in ways that were likely to directly affect use of the Nisqually Vista Trail.

5.4.1 Validation Results: Nisqually Vista Trail

The counter installed on the Nisqually Vista Trail was observed on 3 days, for a total of 13 hours. During that time, 157 hiking parties with 504 individuals passed the counter, and the counter recorded 393 “hits”. Thus, the actual count recorded by the counter can best be multiplied by a “correction factor” of 1.282 to estimate the true number of visitors passing

5.4.2 Data Cleaning and Limitations of Data: Nisqually Vista Trail

The data collected by the Nisqually Vista Trail Counter showed some signs of counter malfunction and spurious counts. Some very high hourly counts were recorded, and some of those occurred at hours when visitor use was virtually unheard of. All hourly counts that exceeded the mean count by more than 3 times the inter-quartile range were replaced in the data set. Replacement values were the mean counts recorded on that hour (excluding the outlier values; weekend or weekday means were used as appropriate).

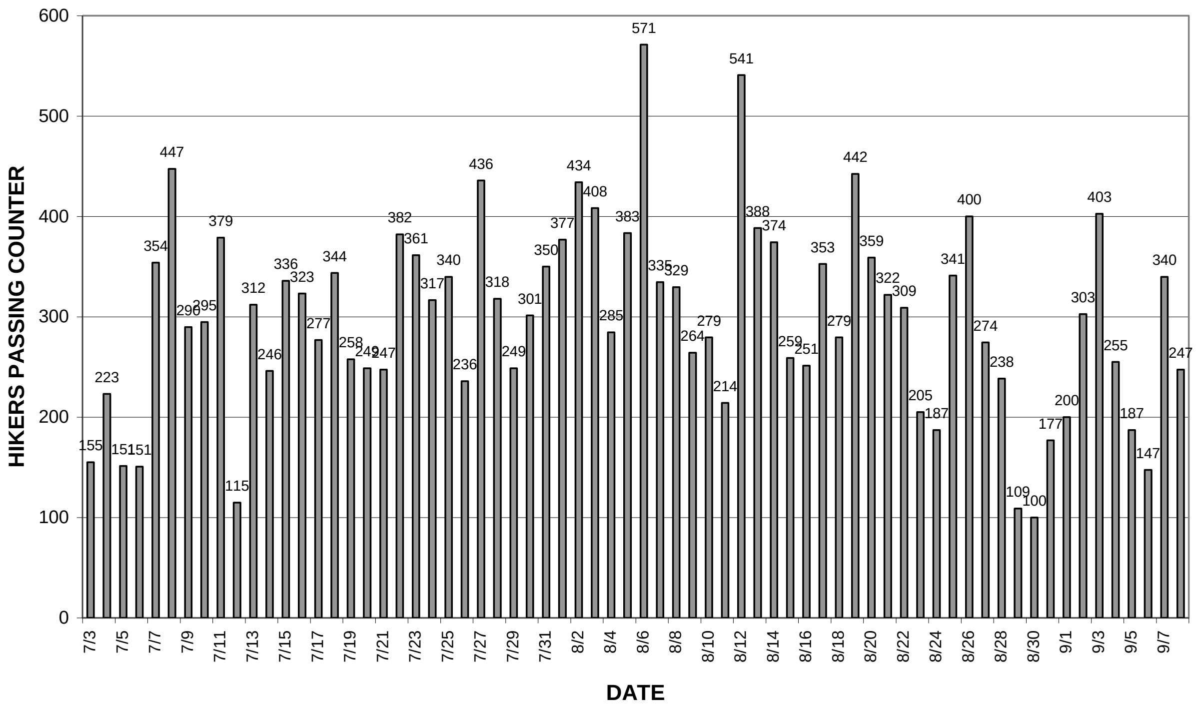
It was originally planned that a correlation between daily hiking counts registered by the counter and daily entry counts of vehicles at the Nisqually and Stevens Canyon entrances would be calculated. Ideally, gate and trail counts would show a close correspondence and there would be no days that stood out as outlying observations (i.e., none of the daily counts had high leverage values in a regression analysis predicting the trail counts based on the vehicle counts).

5.4.3 Descriptive Data: Nisqually Vista Trail

The following chart shows the estimated daily counts of hikers based on the trail counter readings (note that the correction factor of 1.282 has been applied to the counts shown in the chart). The counts show a relatively weak weekend/weekday effect. Such a result is consistent with the idea that use of the Nisqually Vista Trail is correlated with parking in the JVC lot. Because the relatively small JVC lot fills on most weekends and many weekdays, use of the trail tends to also reach peak or near peak levels on those days.

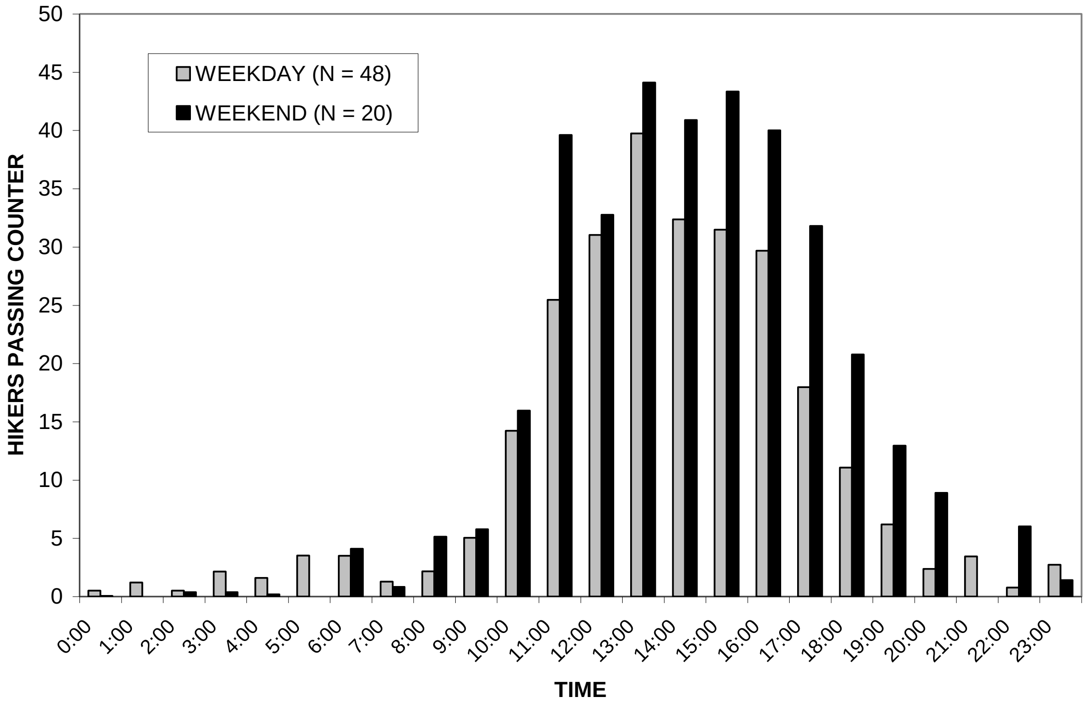
Peak use of the Nisqually Vista Trail (571 hiker passages) was recorded on August 6 with another high use day on August 12. Use was not exceptionally high on the Independence Day and Labor Day holidays. The 95th percentile day was 439 hiker passages. The average count was 272 on weekdays, with a standard deviation of 85. On weekends, the average count was 344, with a standard deviation of 119. Median counts were 278 and 358 for weekdays and weekends, respectively.

FIGURE 22. DAILY COUNTS OF VISITORS PASSING THE NISQUALLY VISTA TRAIL COUNTER BETWEEN 7/3/06 AND 9/8/06



The hourly distribution of hikers passing the Nisqually Vista Trail counter shows that use during the peak hour (13:00 to 14:00) is similar on weekends and weekdays. Both the weekend and weekday distributions are generally bell-shaped, but peak use on weekends is distributed across a longer time period (11:00 to 17:00) with some evidence of fluctuation during that time period. It is possible that the timing of ranger-led walks may be responsible for some of the observed pattern. The weekday distribution shows a single clear peak.

FIGURE 23. HOURLY AVERAGE OF VISITORS PASSING THE NISQUALLY VISTA TRAIL COUNTER BETWEEN 7/3/06 AND 9/8/06



5.5 Trail Use at Paradise: Results for Skyline Trail (past Alta Vista Junction)

The Skyline Trail location may be the most informative location for at least two reasons. First, it is the busiest trail measured, so changes in the overall level of hiking at Paradise during construction are more likely to be detected. Second, a trail counter was installed at the identical location (using even the same trees) in 2004 when visitation at Paradise presumably followed a normal pattern. Comparison of the 2006 and 2004 results can also help us detect possible changes in the daily distribution of hiking activity.

5.5.1 Validation Results: Skyline Trail

The counter installed on the Skyline Trail (past the junction with the Alta Vista Trail) was the focus of more validation observation than any other location. This imbalance was intentional, reflecting the importance of the information gained at this location. Thus, it was desirable that counts in that location be consistent and the level of undercounting be estimated accurately.

The Skyline Trail counter was observed on 4 days, for a total of 17 hours, 15 minutes. During that time, 360 hiking parties with 932 individuals passed the counter, and the counter recorded 707 “hits”. Thus, the actual count recorded by the counter can best be multiplied by a “correction factor” of 1.318 to estimate the true number of visitors passing the counter.

It is worth noting that the performance of the trail counter in this location was very similar in 2004 and 2006. In 2004, validation determined that the appropriate “correction factor” was 1.368.

5.5.2 Data Cleaning and Limitations of Data: Skyline Trail

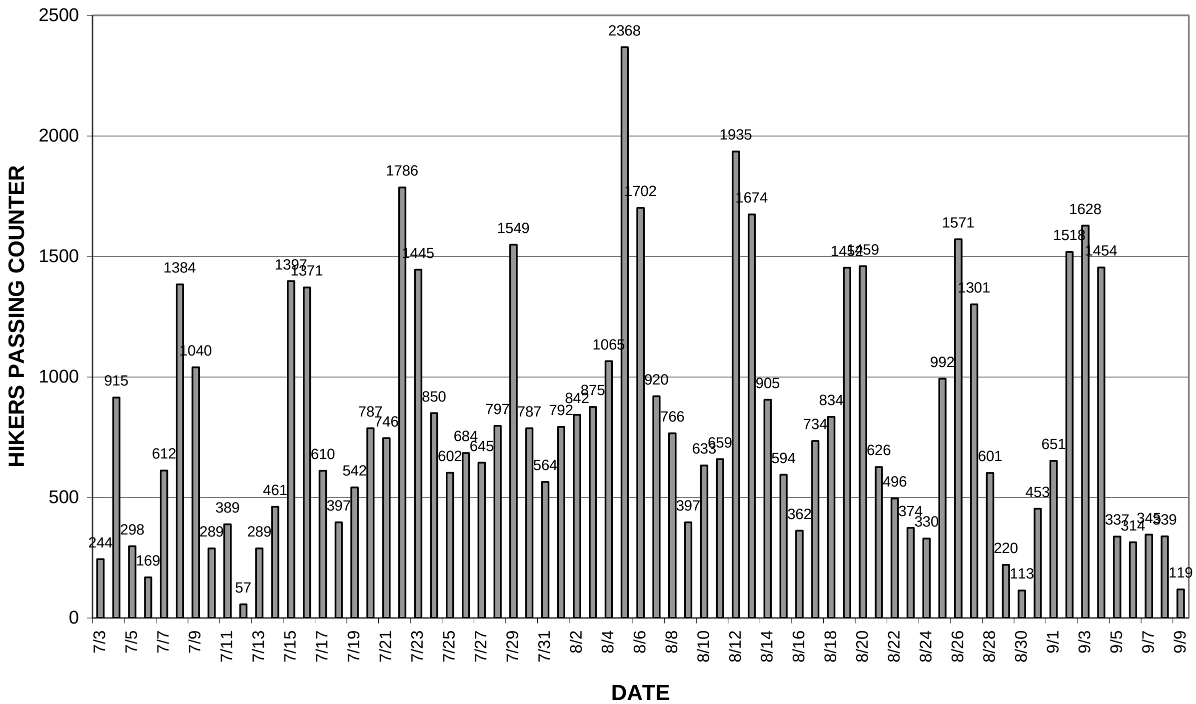
The data collected by the Skyline Trail Counter show no outward signs of malfunction or spurious counts.

It was originally planned that a correlation between daily hiking counts registered by the counter and daily entry counts of vehicles at the Nisqually and Stevens Canyon entrances would be calculated. Ideally, gate and trail counts would show a close correspondence and there would be no days that stood out as outlying observations (i.e., none of the daily counts had high leverage values in a regression analysis predicting the trail counts based on the vehicle counts).

5.5.3 Descriptive Data: Skyline Trail

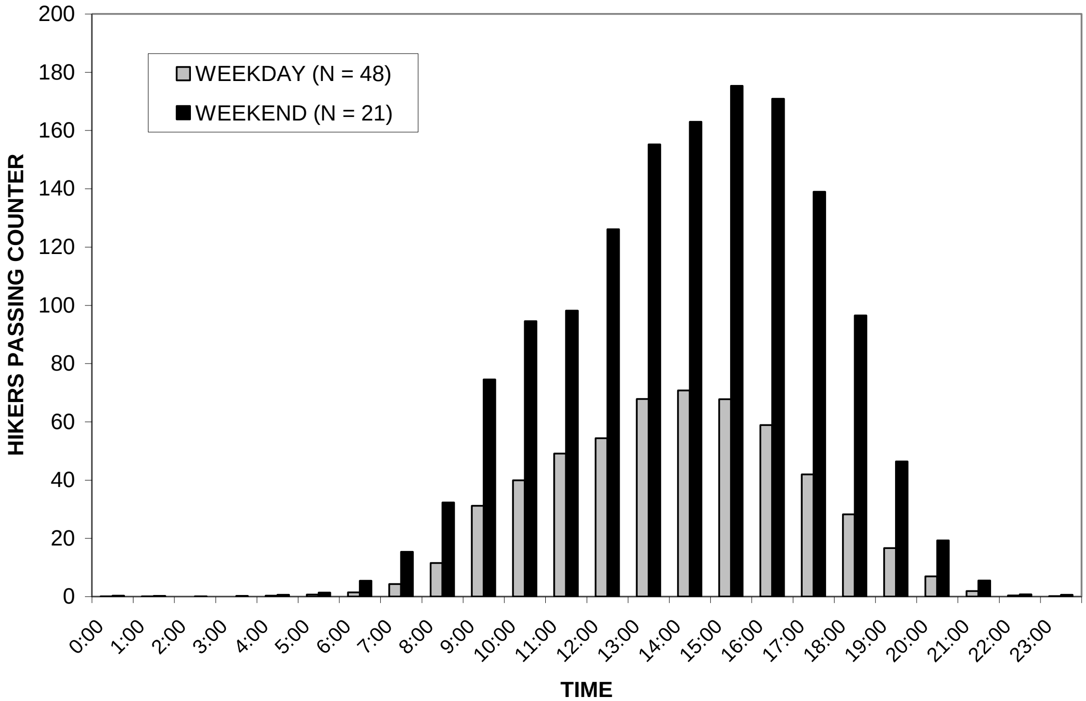
The following chart shows the estimated daily counts of hikers based on the trail counter readings (note that the correction factor of 1.318 has been applied to the counts shown in the chart). The counts show a strong weekend/weekday effect, with peak use on August 5 (2368 hiker passages) and moderate to high use on the Independence Day and Labor Day holidays. The 95th percentile day was 1689 hiker passages. The average count was 554 on weekdays, with a standard deviation of 246. On weekends, the average count was 1422, with a standard deviation of 450. Median counts were 594 and 1453 for weekdays and weekends, respectively.

FIGURE 24. DAILY COUNTS OF VISITORS PASSING THE SKYLINE TRAIL COUNTER BETWEEN 7/3/06 AND 9/9/06



The hourly distribution of hikers passing the Skyline Trail counter shows a bell-shaped distribution with the peak use between 15:00 and 16:00 on weekends and 14:00 and 15:00 on weekdays. Use is concentrated somewhat more tightly between 9:00 and 19:00 on weekends than on weekdays when the distribution of use decreases slightly more smoothly.

FIGURE 25. HOURLY AVERAGE OF VISITORS PASSING THE SKYLINE TRAIL COUNTER BETWEEN 7/3/06 AND 9/9/06



5.6 Trail Use at Paradise: Results for East Skyline Trail

The East Skyline Trail between the Lakes Trail junction and Sluiskin Falls is commonly used by visitors taking longer loop day hikes. It is a moderately busy trail. The hiking routes of visitors who do loop day hikes is probably not highly influenced by where they park, however some use of the East Skyline may consist of visitors who park along the Paradise Valley Road and use the Fourth Crossing Trail to access the trail system. Changes in use of the East Skyline Trail may be detected by comparing the relative proportion of hikers counted there and on other trails in the Paradise area (such as the Skyline Trail) to the proportions recorded in the waypoint studies of hiker itineraries. Also, counts of hiking use conducted in the 1995 Visitor Distribution Survey might be compared. However, construction of the water supply during that summer probably altered hiking patterns in ways that were likely to directly affect use of the East Skyline Trail.

5.6.1 Validation Results: East Skyline Trail

The counter installed on the East Skyline Trail was observed on 2 days, for a total of 12 hours. During that time, 153 hiking parties with 317 individuals passed the counter, and the counter recorded 295 "hits". Thus, the actual count recorded by the counter can best be multiplied by a "correction factor" of 1.075 to estimate the true number of visitors passing. The better accuracy of this trail counter compared to the Skyline and Nisqually Vista counters can be largely attributed to the narrower width of the trail forcing visitors to hike in a single file configuration that leads to fewer uncounted hikers.

5.6.2 Data Cleaning and Limitations of Data: East Skyline Trail

The data collected by the East Skyline Trail Counter showed a few signs of counter malfunction and spurious counts. Some very high hourly counts were recorded, and some of those occurred at hours when visitor use was virtually unheard of. Five hourly counts that exceeded the mean count by more than 3 times the inter-quartile range were replaced in the data set. Replacement values were the mean counts recorded on that hour (means excluded outlier values; weekend or weekday means were used as appropriate).

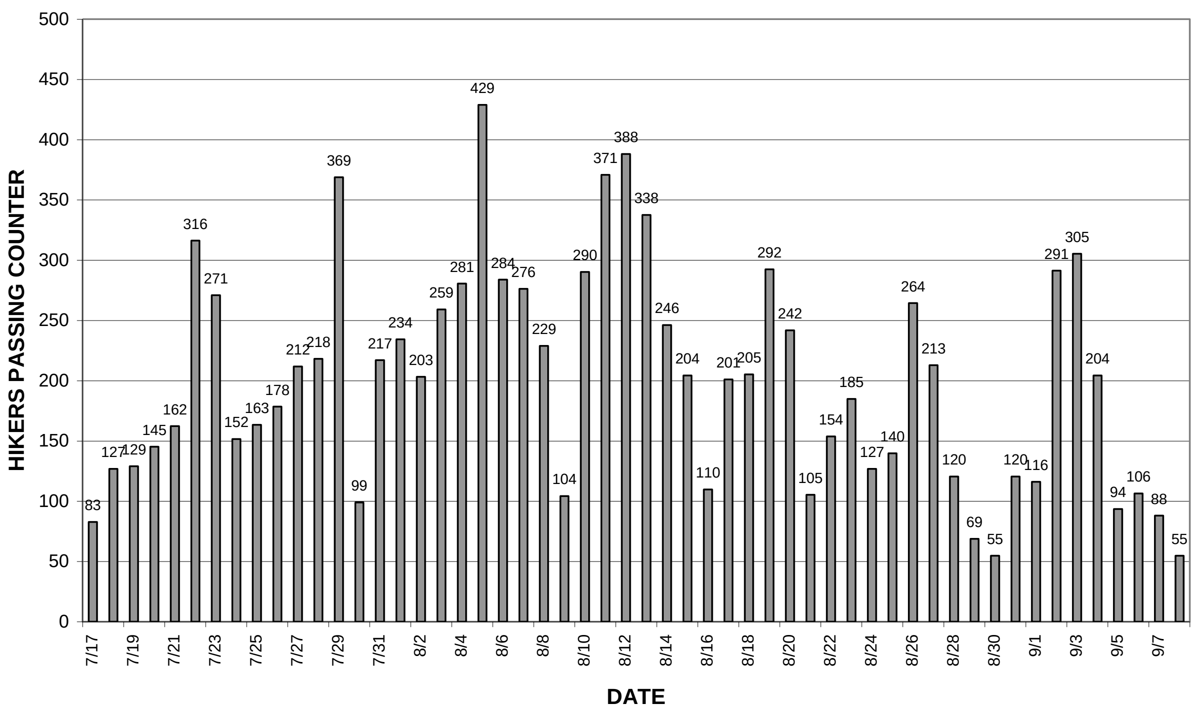
It was originally planned that a correlation between daily hiking counts registered by the counter and daily entry counts of vehicles at the Nisqually and Stevens Canyon entrances would be calculated. Ideally, gate and trail counts would show a close correspondence and there would be no days that stood out as outlying observations (i.e., none of the daily counts had high leverage values in a regression analysis predicting the trail counts based on the vehicle counts).

5.6.3 Descriptive Data: East Skyline Trail

The following chart shows the estimated daily counts of hikers based on the trail counter readings (note that the correction factor of 1.075 has been applied to the counts shown in the chart). The counts show a strong weekend/weekday effect, but it is not as extreme as the differences in use shown by the other Skyline Trail counter.

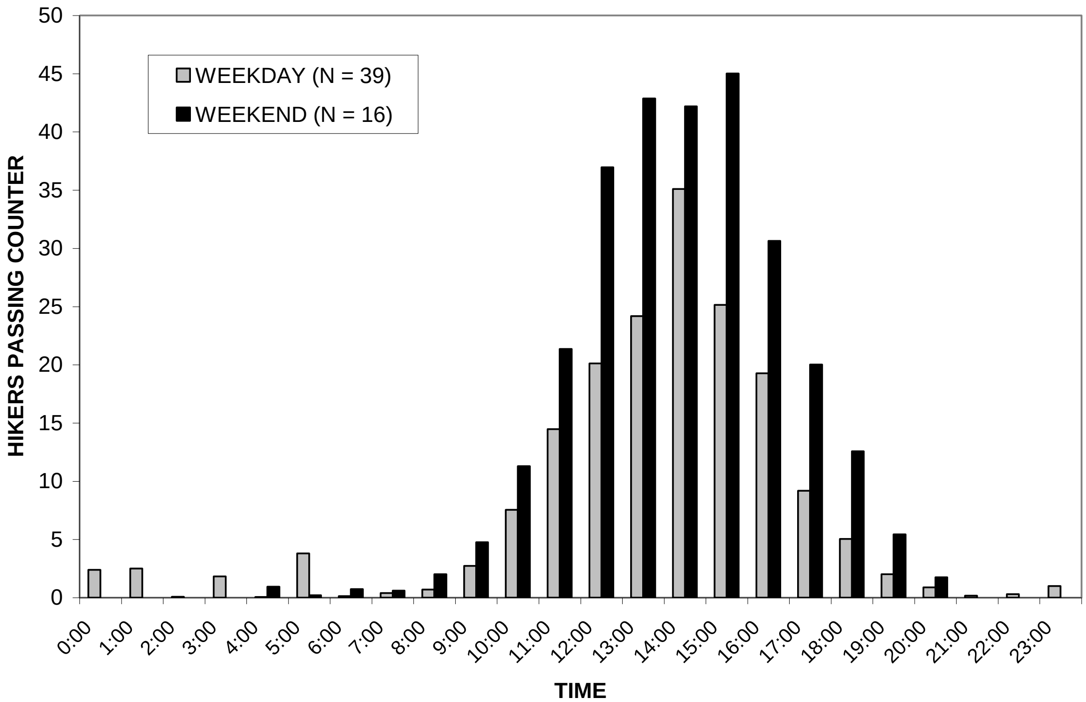
Peak use of the East Skyline Trail (429 hiker passages) was recorded on August 5. The 95th percentile day was 369 hiker passages. The average count was 168 on weekdays, with a standard deviation of 72. On weekends, the average count was 274, with a standard deviation of 94. Median counts were 154 and 288 for weekdays and weekends, respectively.

FIGURE 26. DAILY COUNTS OF VISITORS PASSING THE EAST SKYLINE TRAIL COUNTER BETWEEN 7/17/06 AND 9/9/06



The hourly distribution of hikers passing the East Skyline Trail counter shows a bell-shaped distribution with the peak use between 13:00 and 16:00 on weekends and 14:00 and 15:00 on weekdays. Peak use is concentrated somewhat more tightly on weekdays than on weekends, when the distribution of use shows a peak across the early afternoon. Although weekend use is heavier than weekdays, the differences are much smaller than those shown by the other Skyline Trail counter.

FIGURE 27. HOURLY AVERAGE OF VISITORS PASSING THE EAST SKYLINE TRAIL COUNTER BETWEEN 7/17/06 AND 9/9/06



5.7 Trail Use at Paradise: Results for 4th Crossing Trail

The 4th Crossing Trail is commonly used by visitors who park along the Paradise Valley Road or in the lot near the trailhead. It is a moderately busy trail. Use of the 4th crossing trail was potentially affected greatly by the construction activity, shuttle service, and increased parking along the road. There have been no prior counts of visitors using this trailhead, so no direct comparisons can be used to estimate changes in use. However, by collecting data in 2006, the absolute level of use can be estimated and used to assess whether impacts to physical resources or visitor experiences are likely.

5.7.1 Validation Results: 4th Crossing Trail

The counter installed on the 4th Crossing Trail was observed on 2 days, for a total of 12 hours. During that time, 161 hiking parties with 467 individuals passed the counter, and the counter recorded 443 “hits”. Thus, the actual count recorded by the counter can best be multiplied by a “correction factor” of 1.054 to estimate the true number of visitors passing. The better accuracy of this trail counter compared to the Skyline and Nisqually Vista counters can be largely attributed to the narrower width of the trail forcing visitors to hike in a single file configuration that leads to fewer uncounted hikers.

5.7.2 Data Cleaning and Limitations of Data: 4th Crossing Trail

The data collected by the Skyline Trail Counter showed a few signs of counter malfunction and spurious counts. Some very high hourly counts were recorded, and some of those occurred at hours when visitor use was virtually unheard of. Thirty-five hourly counts that exceeded the mean count by more than 3 times the inter-quartile range were replaced in the data set. Replacement values were the mean counts recorded on that hour (means excluded outlier values; weekend or weekday means were used as appropriate).

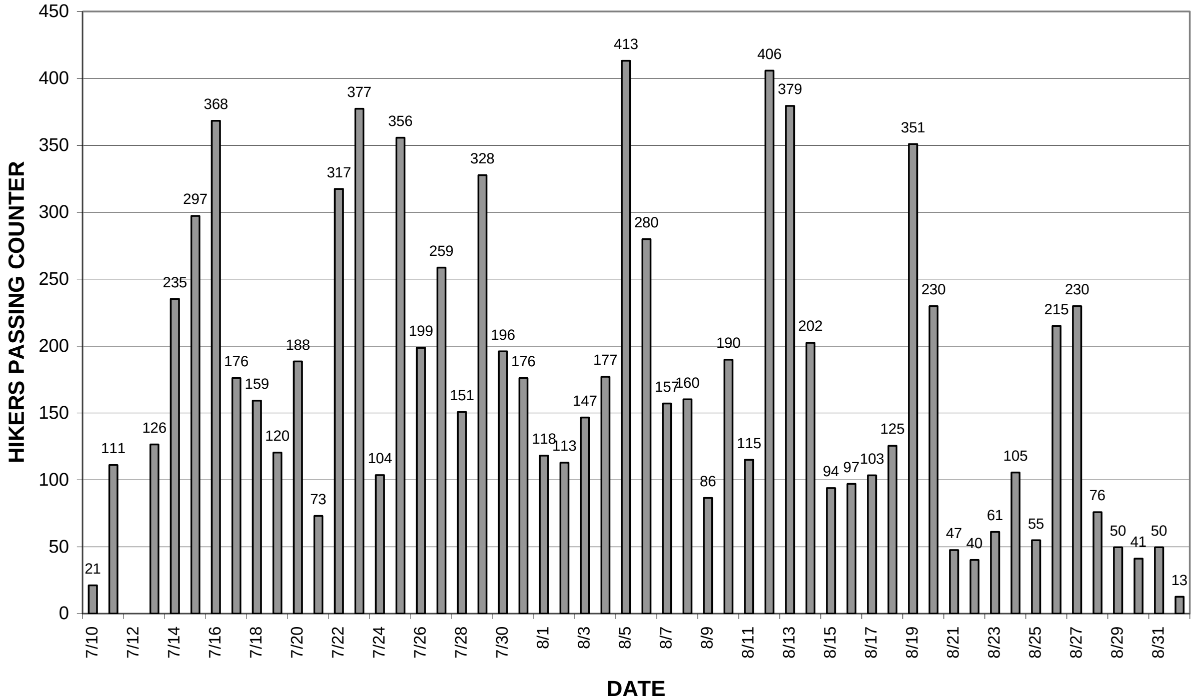
It was originally planned that a correlation between daily hiking counts registered by the counter and daily entry counts of vehicles at the Nisqually and Stevens Canyon entrances would be calculated. Ideally, gate and trail counts would show a close correspondence and there would be no days that stood out as outlying observations (i.e., none of the daily counts had high leverage values in a regression analysis predicting the trail counts based on the vehicle counts).

5.7.3 Descriptive Data: 4th Crossing Trail

The following chart shows the estimated daily counts of hikers based on the trail counter readings (note that the correction factor of 1.054 has been applied to the counts shown in the chart). The counts show a strong weekend/weekday effect, similar to that shown by the main Skyline Trail counter.

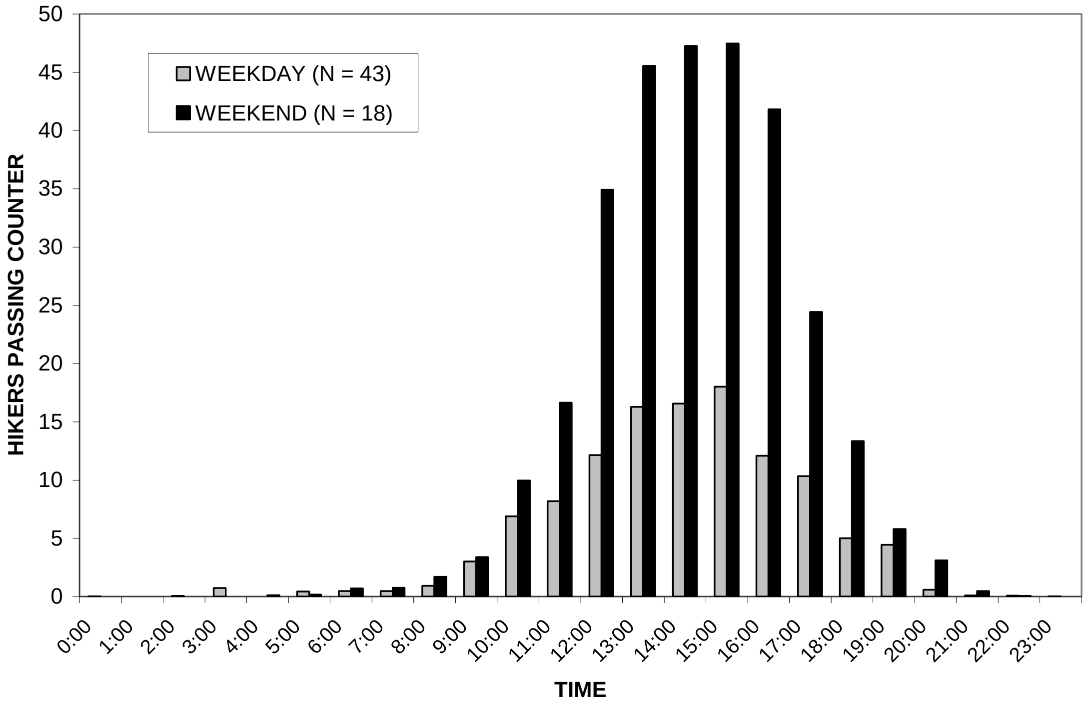
Peak use of the 4th Crossing Trail (413 hiker passages) was recorded on August 5. The 95th percentile day was 358 hiker passages. The average count was 111 on weekdays, with a standard deviation of 68. On weekends, the average count was 282, with a standard deviation of 91. Median counts were 105 and 306 for weekdays and weekends, respectively.

FIGURE 28. DAILY COUNTS OF VISITORS PASSING THE 4th CROSSING TRAIL COUNTER BETWEEN 7/10/06 AND 9/9/06



The hourly distribution of hikers passing the 4th Crossing Trail counter shows a bell-shaped distribution with a relatively long period of peak use between 13:00 and 16:00 on weekends and weekdays. Weekend use is clearly much heavier than weekdays, similar to the pattern shown at the main Skyline Trail counter.

FIGURE 29. HOURLY AVERAGE OF VISITORS PASSING THE 4th CROSSING TRAIL COUNTER BETWEEN 7/10/06 AND 9/9/06



5.8 Trail Use at Paradise: Results for High Lakes Trail

There is a little-used trailhead for the High Lakes Trail at the lower end of the Valley Road near the junction with the Stevens Canyon Road. Although this trail is used by Wonderland Trail hikers who choose not to hike to the Paradise facilities, day-hiking from this trailhead is relatively uncommon and such use was potentially affected greatly by the construction activity, shuttle service, and increased parking along the road. There have been no prior counts of visitors using this trailhead, so no direct comparisons can be used to estimate changes in use. However, by collecting data in 2006, the absolute level of use can be estimated and used to assess whether impacts to physical resources or visitor experiences are likely.

Due to the limited time available for all data collection, and the priorities placed on the various tasks, no validation data were collected for the High Lakes Trail counter.

5.8.1 Data Cleaning and Limitations of Data: High Lakes Trail

The data collected by the Skyline Trail Counter showed a few signs of counter malfunction and spurious counts. Some very high hourly counts were recorded, and some of those occurred at hours when visitor use was virtually unheard of. Eighteen hourly counts that exceeded the mean count by more than 3 times the inter-quartile range were replaced in the data set. Replacement values were the mean counts recorded on that hour (means excluded outlier values; weekend or weekday means were used as appropriate).

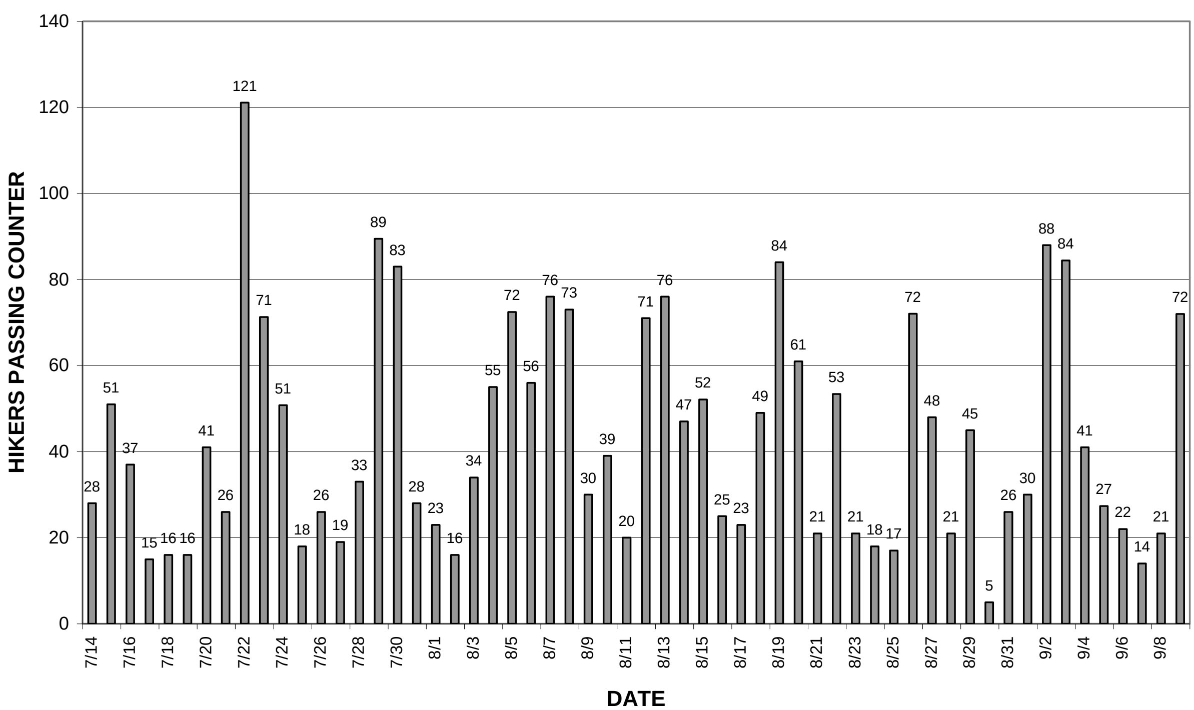
It was originally planned that a correlation between daily hiking counts registered by the counter and daily entry counts of vehicles at the Nisqually and Stevens Canyon entrances would *be calculated. Ideally, gate and trail counts would show a close correspondence and there would be no days that stood out as outlying observations (i.e., none of the daily counts had high leverage values in a regression analysis predicting the trail counts based on the vehicle counts).*

5.8.2 Descriptive Data: High Lakes Trail

The following chart shows the daily counts of hikers recorded by the trail counter. Note that the counts are likely to be slightly lower than actual use levels, but that the degree of undercounting can not be estimated precisely in the absence of validation data. Based on the high accuracy of the 4th Crossing and East Skyline counters, counts are likely to be good estimates of actual use. The counts show a strong weekend/weekday effect, similar to that shown by the main Skyline Trail counter.

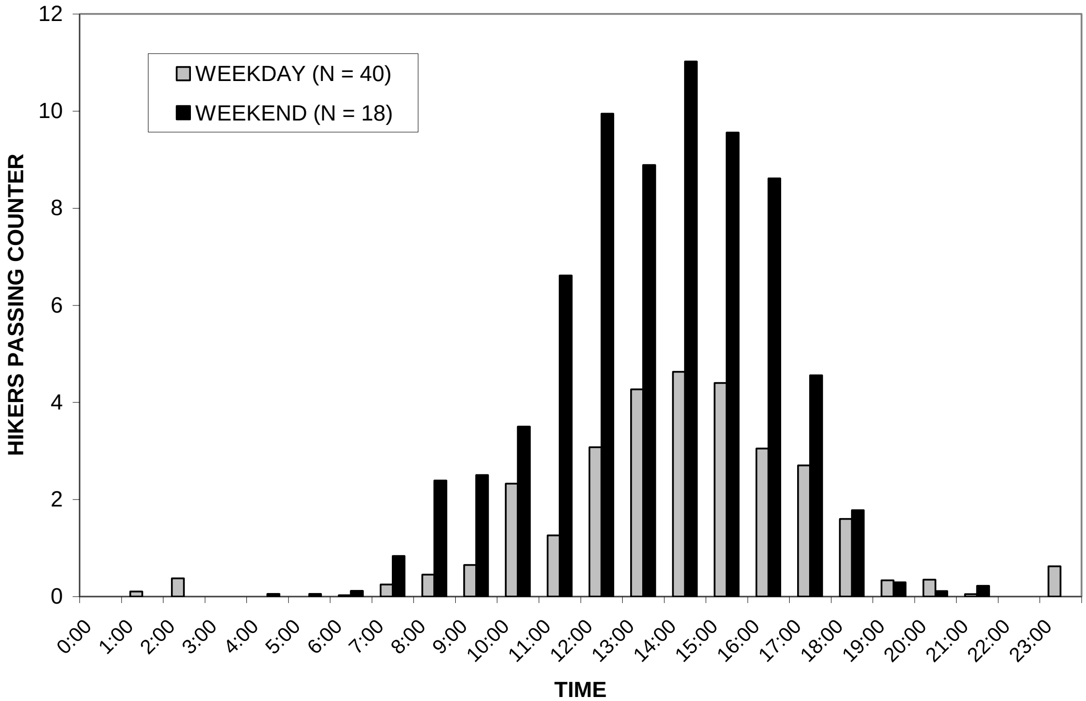
Peak use of the High Lakes Trail (121 hiker passages) was recorded on July 22. This was also the peak use day on the Paradise Valley Trail (see section 5.9 below). The 95th percentile day was 85 hiker passages. The average count was 31 on weekdays, with a standard deviation of 16. On weekends, the average count was 71, with a standard deviation of 20. Median counts were 26 and 72 for weekdays and weekends, respectively.

FIGURE 30. DAILY COUNTS OF VISITORS PASSING THE HIGH LAKES TRAIL COUNTER BETWEEN 7/14/06 AND 9/9/06



The hourly distribution of hikers passing the High Lakes Trail counter shows a bell-shaped distribution with a peak use between 14:00 and 15:00 on weekends and weekdays. Weekend use is clearly much heavier than weekdays, similar to the pattern shown at the main Skyline Trail counter.

FIGURE 31. HOURLY AVERAGE OF VISITORS PASSING THE HIGH LAKES TRAIL COUNTER BETWEEN 7/14/06 AND 9/9/06



5.9 Trail Use at Paradise: Results for Paradise Valley Trail

A second little-used trailhead provides access to the Paradise Valley section of the Lakes Trail (hereafter called the Paradise Valley Trail). The trailhead is located at the lower end of the Valley Road near the junction with the Stevens Canyon Road. Use of this trailhead was potentially affected greatly by the construction activity, shuttle service, and increased parking along the road. There have been no prior counts of visitors using this trailhead. However, the 1995 Visitor Distribution Survey counted visitors entering and leaving the north end of the same trail segment. Construction of the water supply during the summer of 1995 may have altered hiking patterns on the Paradise Valley Trail, but there is no clear reason to suspect that such alteration was dramatic.

Due to the limited time available for all data collection, and the priorities placed on the various tasks, no validation data were collected for the Paradise Valley Trail counter.

5.9.1 Data Cleaning and Limitations of Data: Paradise Valley Trail

The data collected by the Skyline Trail Counter showed no signs of counter malfunction or spurious counts. None of the hourly counts were so high as to be implausible, and all the high counts were recorded during peak use hours.

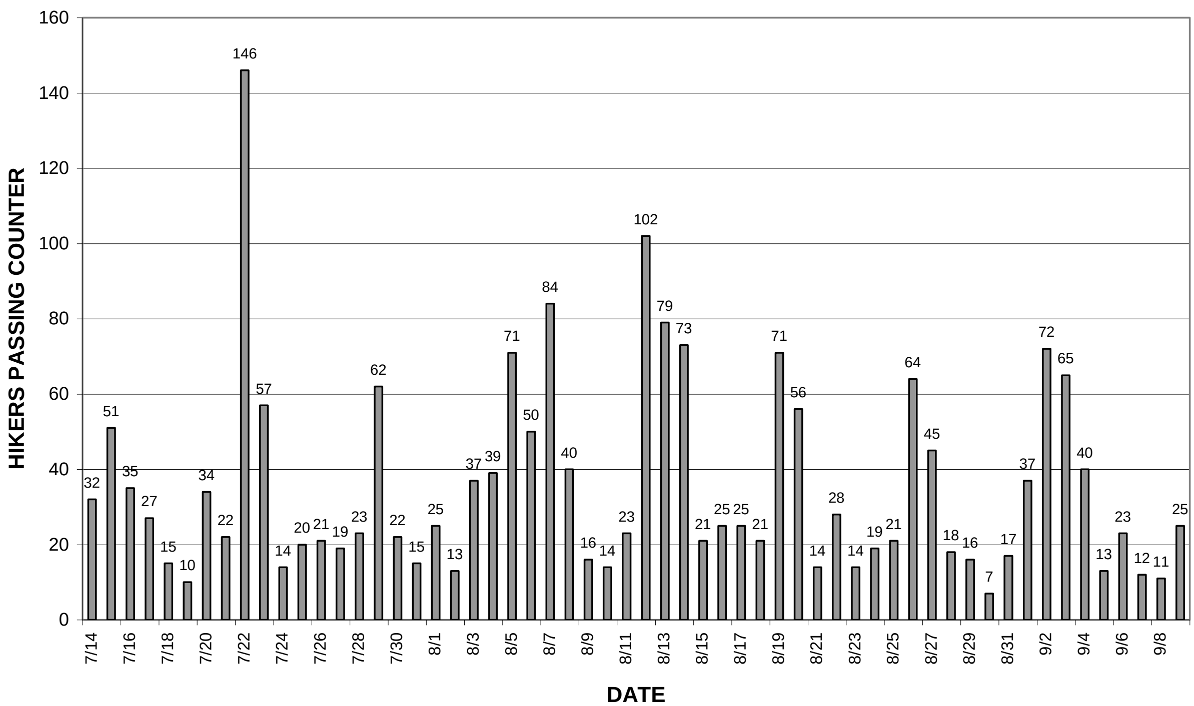
It was originally planned that a correlation between daily hiking counts registered by the counter and daily entry counts of vehicles at the Nisqually and Stevens Canyon entrances would be calculated. Ideally, gate and trail counts would show a close correspondence and there would be no days that stood out as outlying observations (i.e., none of the daily counts had high *leverage values in a regression analysis predicting the trail counts based on the vehicle counts).*

5.9.2 Descriptive Data: Paradise Valley Trail

The following chart shows the daily counts of hikers recorded by the trail counter. Note that the counts are likely to be slightly lower than actual use levels, but that the degree of undercounting can not be estimated precisely in the absence of validation data. Based on the high accuracy of the 4th Crossing and East Skyline counters, counts are likely to be good estimates of actual use. The counts show a strong weekend/weekday effect, similar to that shown by the main Skyline Trail counter.

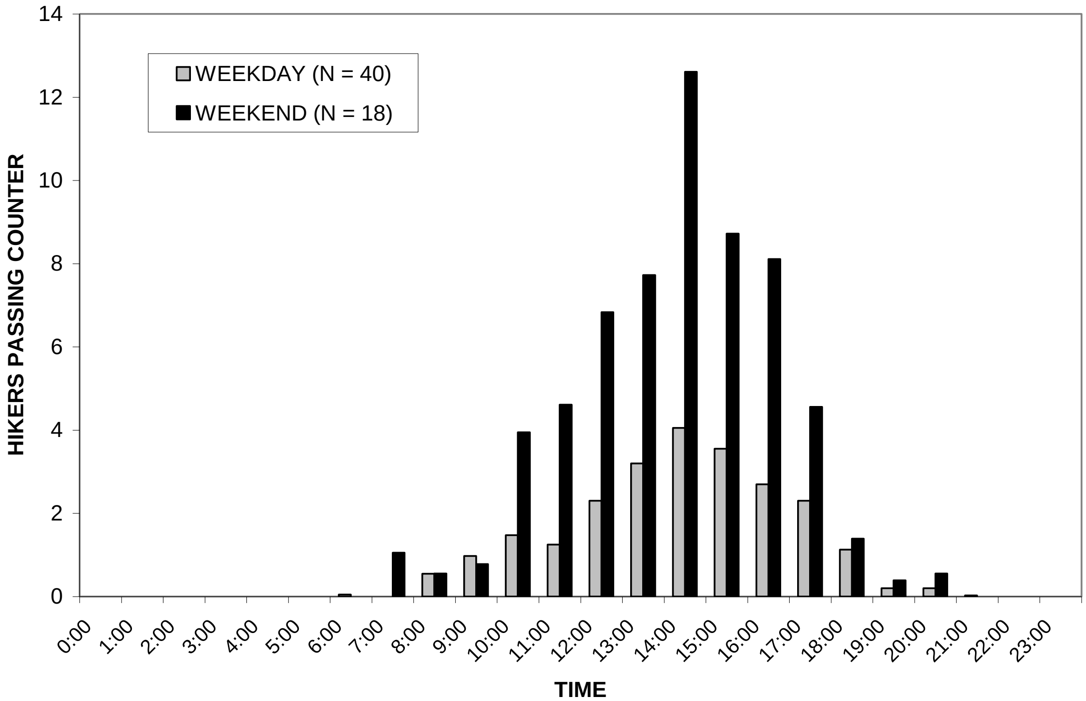
Peak use of the Paradise Valley Trail (146 hiker passages) was recorded on July 22. This was also the peak use day on the Paradise Valley Trail (see section 5.8 above). The 95th percentile day was 80 hiker passages. The average count was 24 on weekdays, with a standard deviation of 15. On weekends, the average count was 62, with a standard deviation of 29. Median counts were 21 and 60 for weekdays and weekends, respectively.

FIGURE 32. DAILY COUNTS OF VISITORS PASSING THE PARADISE VALLEY TRAIL COUNTER BETWEEN 7/14/06 AND 9/9/06



The hourly distribution of hikers passing the Paradise Valley Trail counter shows a bell-shaped distribution with a strong peak in use between 14:00 and 15:00 on weekends, and a similar pattern with a weaker peak on weekdays. Weekend use is clearly much heavier than weekdays, similar to the pattern shown at the main Skyline Trail counter.

FIGURE 33. HOURLY AVERAGE OF VISITORS PASSING THE PARADISE VALLEY TRAIL COUNTER BETWEEN 7/14/06 AND 9/9/06



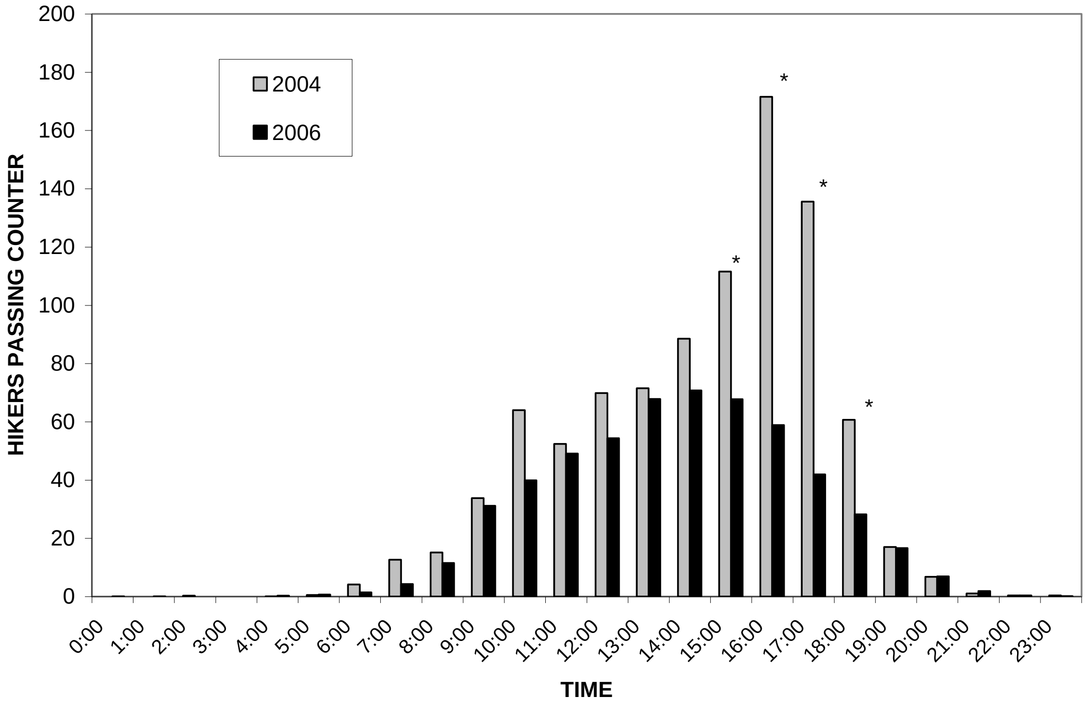
5.10 Changes in Trail Use during Construction

There are three sources of information about past patterns of hiking use in the Paradise area, 1) electronic trail counts of the main Skyline Trail collected in 2004, 2) hiking counts collected in 1995 and reported in the Visitor Distribution Survey, and 3) hiking itineraries collected in 2003 and 2004 using the waypoint survey method. Each source of information is used in analyses examining possible changes in hiking use during construction.

5.10.1 Assessing Hiking Changes Based on Electronic Trail Counts of the Skyline Trail in 2004

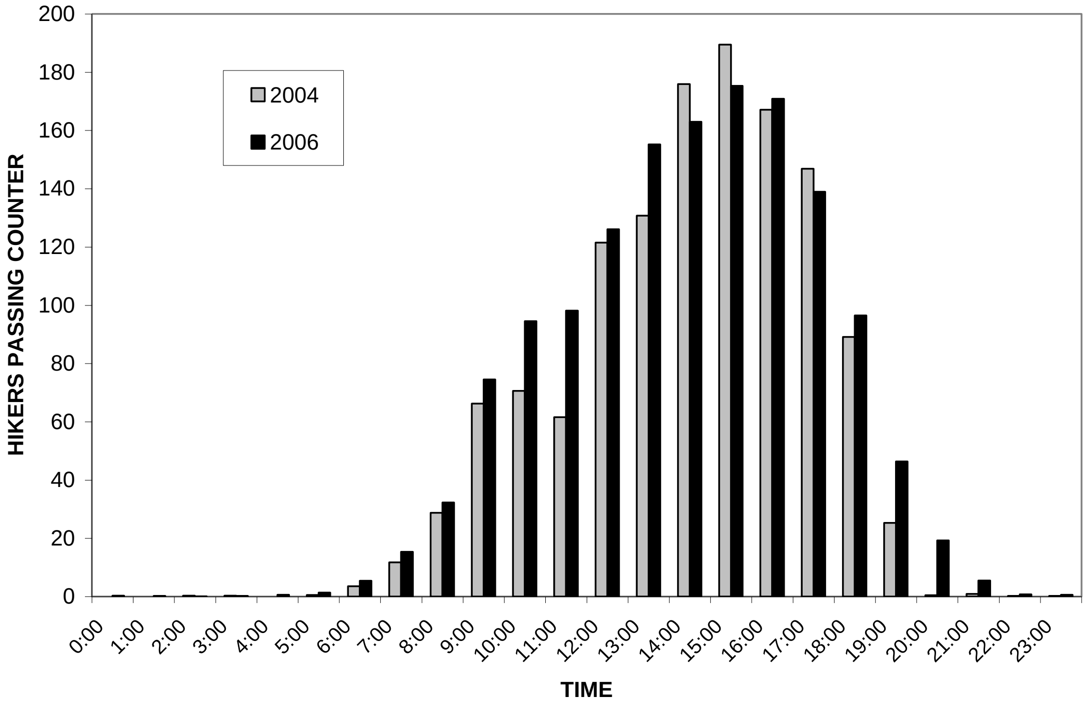
The most direct comparison capable of detecting changes in trail use uses data from a trail counter that was installed in the identical location in 2004 and 2006 on the main Skyline Trail. There is no obvious reason other than construction activity that hiking activity in 2004 and 2006 should differ. In the months of July and August when trail counters were installed, the reported visitation to Paradise was 191,964 in 2004 and 190,735 in 2006. The chart below shows the hourly distribution of hiker passages counted by the trail counter on weekdays in 2004 and 2006. Note that, with the exception of the hours from 15:00 to 19:00, the distribution is very similar. There is some reason to suspect that there were spurious counts in the 2004 data for those hours. If the counts from the suspect time periods are included, then the average weekday visitation in 2004 was substantially higher (918 hiker passages) than in 2006 (554 hiker passages). If we exclude the suspect hours from the comparison, the average weekday use in 2004 was still higher (438 hiker passages) than in 2006 (357 hiker passages) but not as dramatically.

FIGURE 34. HOURLY AVERAGE OF VISITORS PASSING THE SKYLINE TRAIL COUNTER ON WEEKDAYS IN 2004 AND 2006



The comparison of hiker passages counted by the trail counter on weekends in 2004 and 2006 shows more similarity than that found on weekdays. The chart below shows that, in contrast to the weekday counts, the average weekend visitation in 2004 (1291 hiker passages) was slightly lower than in 2006 (1422 hiker passages). In addition, the hourly distribution of use was quite similar in both years, with a slightly more regular, bell-shaped distribution in 2006.

FIGURE 35. HOURLY AVERAGE OF VISITORS PASSING THE SKYLINE TRAIL COUNTER ON WEEKENDS IN 2004 AND 2006



One possible explanation for some of the differences between the 2004 and 2006 data is that the shuttle program that operated on the weekends was sufficient to offset the decreased hiking use due to construction activity that was observed on weekdays. The suspect counts included in the weekday counts from 2004 dictate caution in making strong conclusions based solely on these comparisons, but our best interpretation of the data is: a) on weekdays, levels of hiking use may have been decreased by the construction activity; and b) on weekends, there is no evidence that hiking use levels were reduced due to construction.

5.10.2 Assessing Hiking Changes Based on the 1995 Visitor Distribution Survey

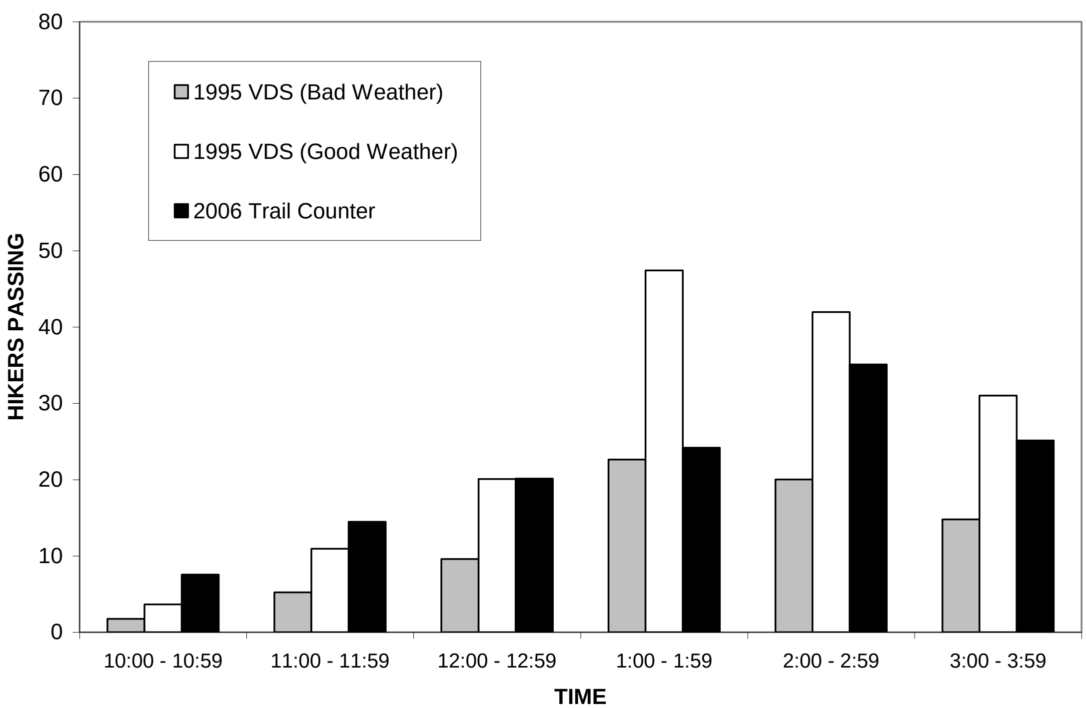
The patterns of hiking use collected during the 1995 Visitor Distribution Survey are of limited use because hiking that year was altered by a construction project that upgraded the Paradise water supply – the Myrtle Falls trail and the southeastern section of the Skyline trail were closed. Thus, hikers wishing to make a loop hike to Panorama Point were required to use the Fourth Crossing trail. This likely altered hiking patterns throughout the system. Nonetheless, two comparisons with 2006 trail counter data are of potential interest. The first, compares the counts recorded by the trail counter on the East Skyline trail to VDS counts made of visitors using the same trail segment. The second compares the counts recorded by the lower end of the Paradise Valley Trail (i.e., Lakes Trail) to VDS counts made of visitors entering and leaving the upper end of the same trail segment.

The 1995 Visitor Distribution Survey reported actual hiker counts, but also found that there were strong relationships between general vehicle entries into the park and the hiker counts on many trails at Paradise. Those relationships provided the basis for estimating hiker counts for four different combinations of weather and weekend/weekday. The daily hiker use estimates presented in the charts below describe 1995 hiker counts for those combinations.

East Skyline Trail

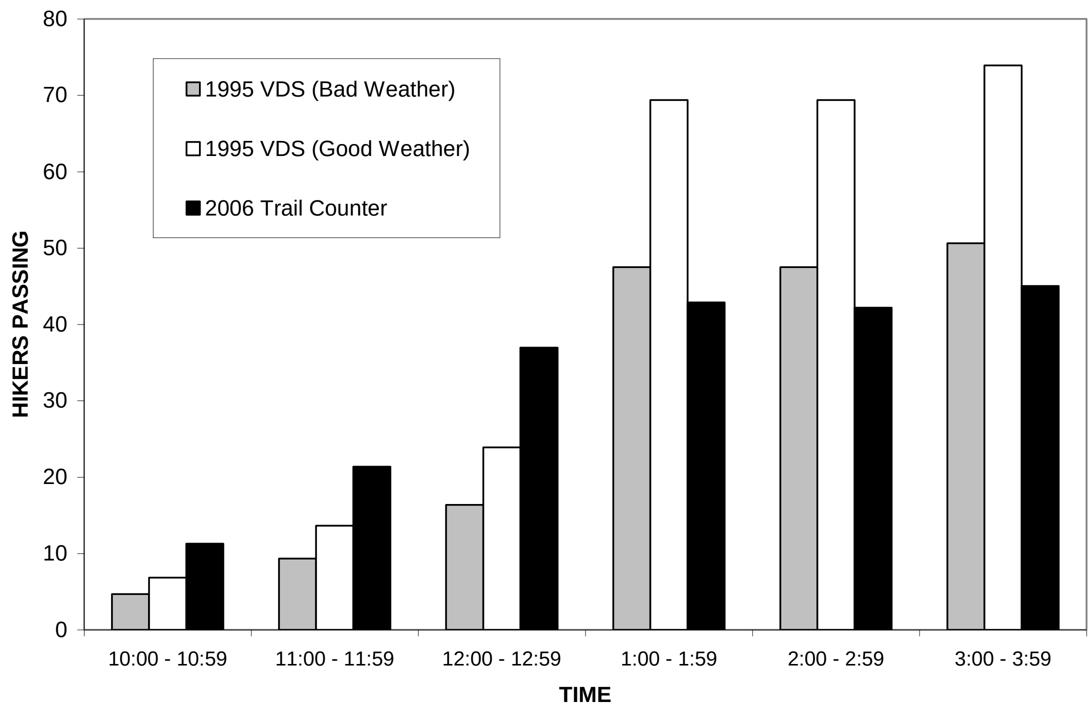
On weekdays, the daily counts of hikers using the East Skyline Trail between 10:00 and 4:00, based on the electronic trail counter used in 2006 (127 hiker passages), fell between the “good weather” (155 hiker passages) and “bad weather” (74 hiker passages) estimates based on direct counts of visitors in 1995. The chart below, however, shows that the distribution in time was different in 2006, with more visitors using the trail earlier in the day, and relatively few passing between 1:00 and 1:59.

FIGURE 36. WEEKDAY HOURLY AVERAGES OF VISITORS HIKING THE EAST SKYLINE TRAIL ESTIMATED BASED ON 1995 AND 2006 OBSERVATIONS



On weekends, the daily counts of hikers using the East Skyline Trail between 10:00 and 4:00, based on the electronic trail counter used in 2006 (200 hiker passages), also fell between the “good weather” (257 hiker passages) and “bad weather” (176 hiker passages) estimates based on direct counts of visitors in 1995. However, comparing the distribution of visitor use in time between 2006 and 1995 showed differences that were more dramatic than the weekday data. On weekends in 2006, many more visitors used the trail earlier in the day, and relatively few passed after 1:00.

FIGURE 37. WEEKEND HOURLY AVERAGES OF VISITORS HIKING THE EAST SKYLINE TRAIL ESTIMATED BASED ON 1995 AND 2006 OBSERVATIONS

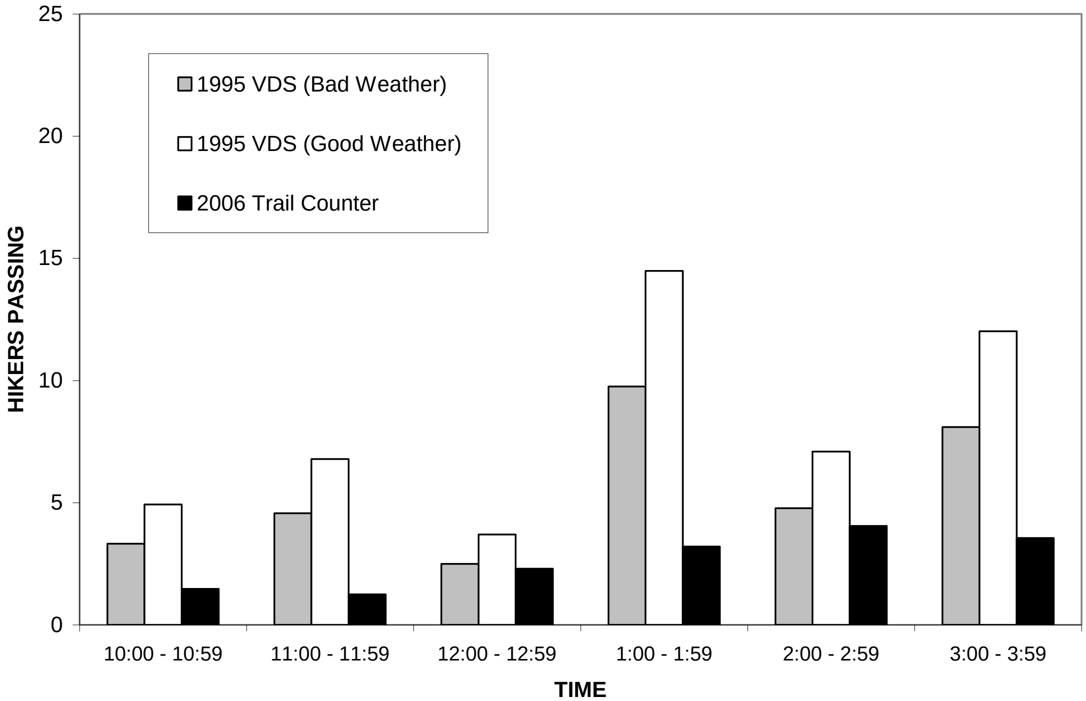


Care must be taken in making conclusions based on these comparisons between 1995 and 2006. Construction of the water supply during the summer of 1995 may have altered hiking patterns of the East Skyline Trail, and it is not clear whether it increased or decreased use. Thus, we have little basis for concluding how use in 2006 compared to "normal" conditions. What this comparison can support is a conclusion that 2006 use levels of the trail are roughly comparable to the use that occurred in 1995. If the level of resource impact or other types of visitor impacts observed in 1995 did not stand out as particularly high or low, then it is likely that impacts in 2006 were similar.

Paradise Valley (i.e., Lakes) Trail

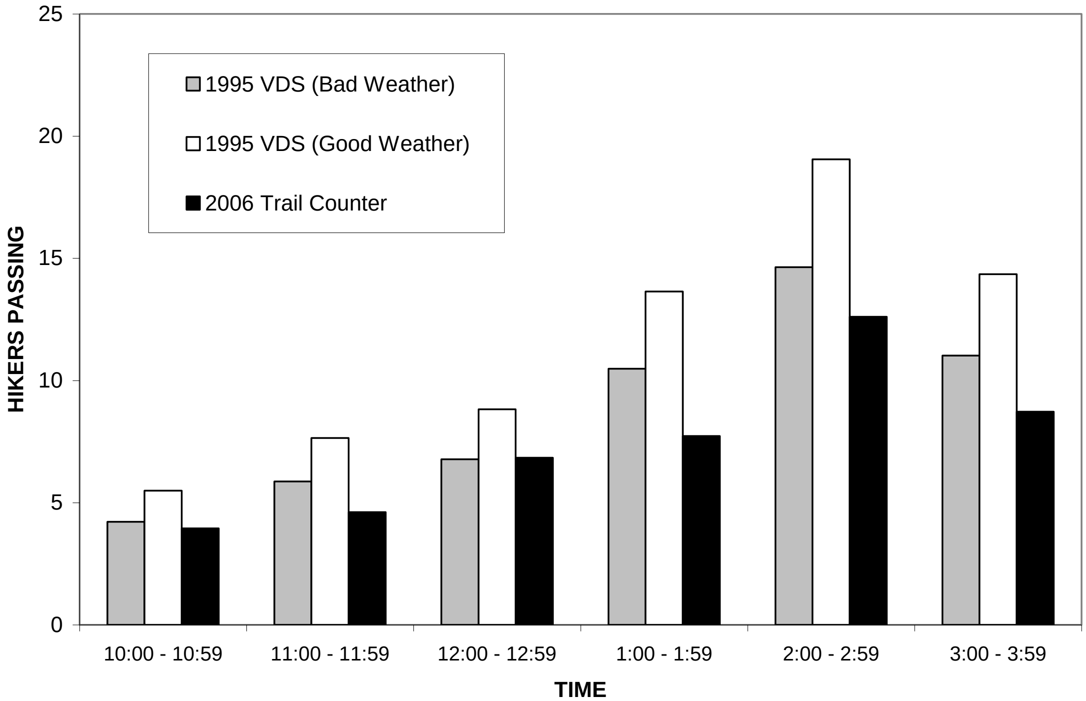
On weekdays, the daily counts of hikers using the Paradise Valley Trail between 10:00 and 4:00, based on the electronic trail counter used in 2006 (16 hiker passages), was much lower than either the "good weather" (49 hiker passages) and "bad weather" (33 hiker passages) estimates based on direct counts of visitors in 1995. The chart below, however, shows that the distribution in time was more even in 2006, but was much lower than the 1995 estimates.

FIGURE 38. WEEKDAY HOURLY AVERAGES OF VISITORS HIKING THE EAST SKYLINE TRAIL ESTIMATED BASED ON 1995 AND 2006 OBSERVATIONS



On weekends, the daily counts of hikers using the Paradise Valley Trail between 10:00 and 4:00, based on the electronic trail counter used in 2006 (44 hiker passages), were also much lower than the "good weather" (69 hiker passages) and "bad weather" (53 hiker passages) estimates based on direct counts of visitors in 1995. However, the distribution of visitor use in time was quite similar in 2006 and 1995, with peak use falling between 2:00 and 2:59.

FIGURE 39. WEEKEND HOURLY AVERAGES OF VISITORS HIKING THE EAST SKYLINE TRAIL ESTIMATED BASED ON 1995 AND 2006 OBSERVATIONS



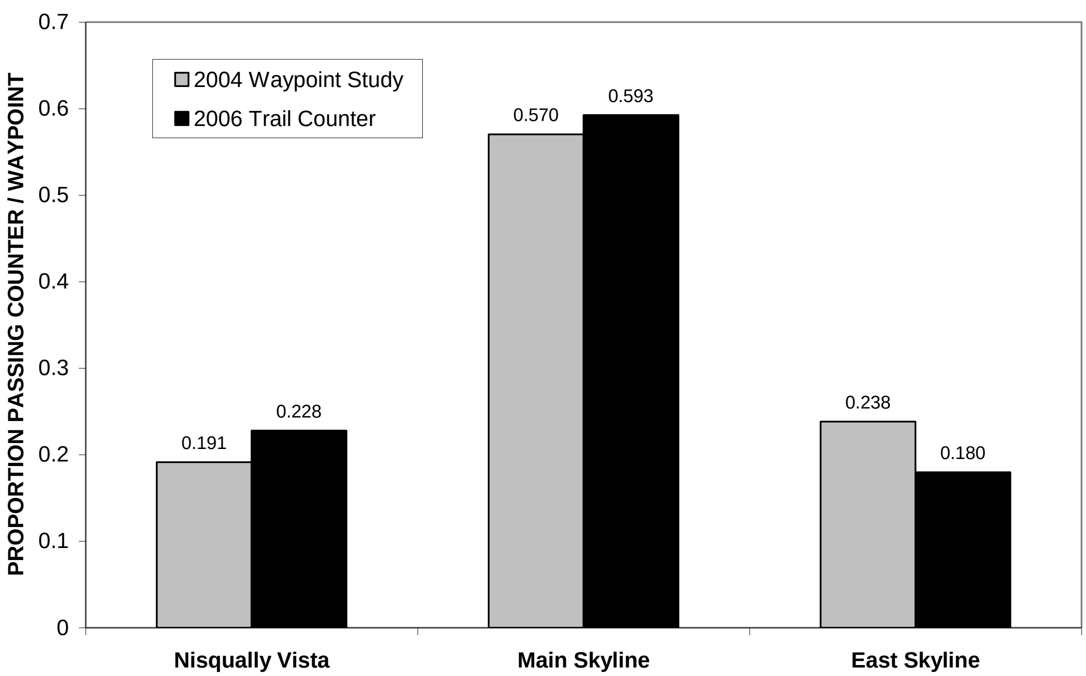
The primary caveat to be considered when comparing the 1995 and 2006 estimates of use on the Paradise Valley Trail is that the counts were made at opposite ends of the trail segment. In 1995, the observer was stationed near the facilities at the north end of the trail. In 2006, the electronic trail counter was installed at the south end of the trail segment, near the point where the trail crosses the Paradise Valley Road. It is possible that many hikers use the trail to enter the valley from the developed zone and never reach its southern end. Thus, again, the comparison provides little basis for concluding how use of this trail in 2006 compared to "normal" conditions. However, the data do suggest that 2006 use almost certainly did not increase to some level substantially greater than past use. Thus, concerns about increased impacts of visitation on this trail due to the 2006 construction might be somewhat allayed.

5.10.3 Assessing Hiking Changes Based on the Waypoint Study of Hiking Itineraries

A final method of assessing changes in the patterns of hiking use is to compare data collected using trail counters in 2006 to data collected during the 2003 and 2004 waypoint study of hiking itineraries. In the waypoint studies, hikers entering Paradise Meadow were given a small card and asked to record the time and the letter written on signs that were posted along trails. The sequence of signs they passed could be used to describe their hiking itinerary. If the construction activity in 2006 had a large effect on hiking use, it would most likely alter hikers' itineraries and thus alter the proportion of hikers who pass the points where signs were posted.

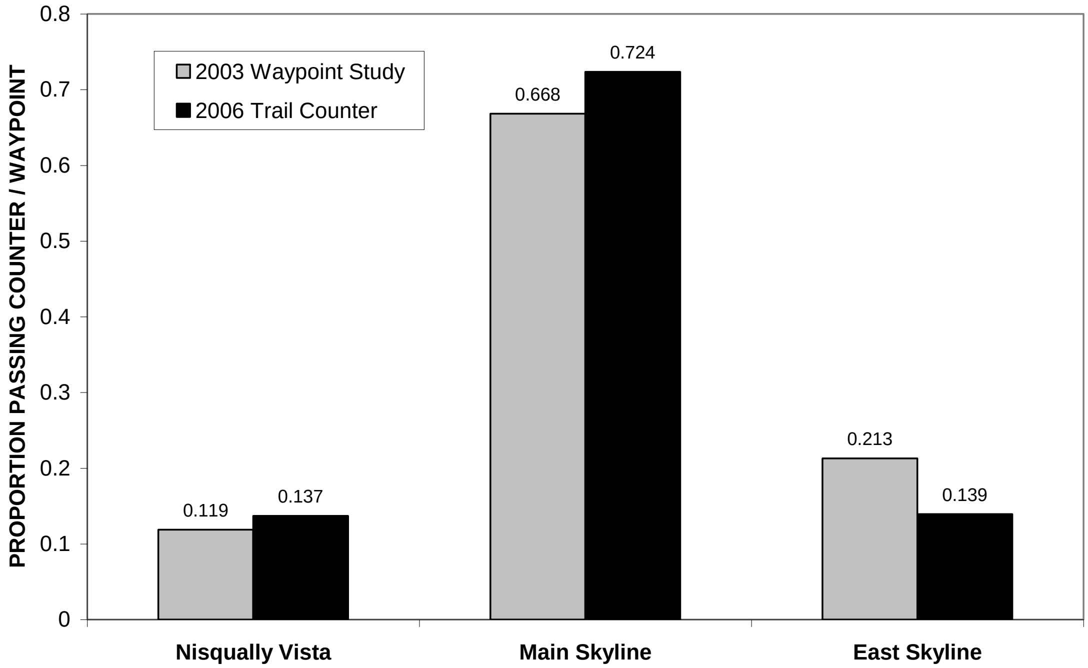
In 2006, three of the electronic trail counters were placed in locations close to where waypoint signs were posted in 2004. The relative proportion of use recorded in these areas can thus be compared to the relative proportion of use recorded by the waypoint studies. The charts below show the data from weekdays observed in 2004 and 2006 and weekends observed in 2003 and 2006 (during the 2004 waypoint studies, weekend data were only collected in early June when snow cover had a large impact on hiking itineraries). On weekdays, the relative proportion of hikers passing the three different sites was quite similar, and did not differ statistically in a chi-square test ($X^2(2) = 4.97$, $p = .083$). However, at least one difference between the data collected by the two methods should be kept in mind when evaluating this comparison – climbers were included in the 2006 counts but were not surveyed in the waypoint study. Thus, the waypoint proportion on the Main Skyline should be slightly higher. Such an adjustment would increase the 2004/2006 discrepancy for the Nisqually Vista and decrease the 2004/2006 discrepancy for the East Skyline Trail. However, it would be unlikely to alter the general conclusion that the pattern of weekday hiking was not altered dramatically by the construction activity.

FIGURE 40. RELATIVE PROPORTION OF WEEKDAY VISITOR PASSAGES ON THREE TRAILS IN 2004 AND 2006



On weekends, the relative proportion of hikers passing the three different sites was still quite similar, but the proportions differed statistically in a chi-square test ($X^2(2) = 7.98$, $p = .019$). Here again, the fact that climbers were included in the 2006 counts but were not surveyed in the 2003 waypoint study should be kept in mind. If climbers were included, the waypoint proportion on the Main Skyline would be slightly higher. Such an adjustment would increase the 2003/2006 discrepancy for the Nisqually Vista and decrease the 2003/2006 discrepancy for the East Skyline Trail. However, as on weekdays, it would be unlikely to alter the general conclusion that the pattern of weekend hiking was not altered dramatically by the construction activity.

FIGURE 41. RELATIVE PROPORTION OF WEEKEND VISITOR PASSAGES ON THREE TRAILS IN 2003 AND 2006



6. Observation of Off-trail Hiking

One of the principle forms of visitor impact in the Paradise area is trampling of vegetation (Rochefort and Swinney 2000). Because the construction activity was expected to increase parking in the Picnic Area and along the Paradise Valley Road, there were concerns that natural areas adjacent to those sites would be subject to increased trampling. In order to assess the prevalence of off-trail activity, systematic observation was conducted to count the number and record the locations of visitors using areas off official trails or roads.

This section describes the numerical results of the systematic observation. Because the observers also recorded the spatial location of off-trail hikers, GIS analysis could also be conducted to relate the observed locations of off-trail hikers to inventoried damage to vegetation, or to relate the locations of off-trail hikers to physical features of the environment such as picnic tables, shallow vs. steep slopes, or social trails. Such GIS-based analyses are not included in this document.

6.1 Locations and Protocols for Observing Off-trail Hiking

Systematic observations of visitors seen in areas off official trails or roads were made at the following three locations:

1. Paradise Picnic Area
2. Paradise Valley inside the loop of the Valley Road
3. Lower half of the Fourth Crossing Trail

Observation data were recorded on maps showing each area. Every 30 minutes the observer used a new map to record the locations of any visitors seen in areas off official trails or roads. For the Picnic Area and Fourth Crossing Trail, the observer moved through the mapped location. For the Paradise Valley, the observer was stationary at a viewpoint behind the rock wall lining the Valley Road not far from the construction area.

In conjunction with each mapped record of visitor locations, observers also recorded the number of vehicles present in specified parking areas: 1) all vehicles in the picnic area (excluding the overnight loop) were counted, 2) vehicles parked in the lot at the 4th Crossing Trailhead were counted, and 3) the vehicles parked along the Valley Road below the 4th Crossing Trailhead were counted.

6.2 Off-trail Activity at Paradise: Results for the Picnic Area

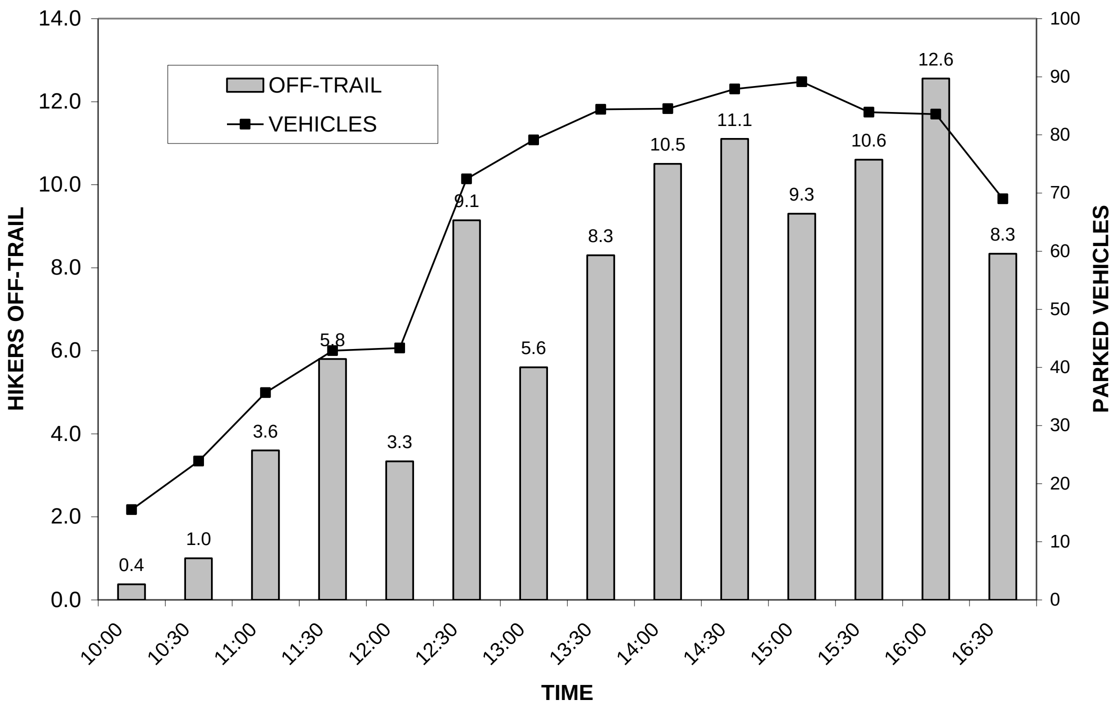
Observations of off-trail activity in the picnic area were recorded on ten days between July 9 and September 3, 2006. The location and number of off-trail visitors was recorded a total of 127 times on ½-hour intervals between 9:30 and 5:00.

6.2.1 Descriptive Data: Off-trail Hiking

An average of 7.26 (SD = 10.74) visitors were recorded in off-trail locations. The figure below shows the half-hourly averages recorded for off-trail visitors and shows the average number of vehicles parked between 10:00 and 4:30[4].

[4] Note that some observations were made outside the time period shown, but there were not enough observations at those times to support reliable summary statistics.

FIGURE 42. VISITORS COUNTED IN OFF-TRAIL LOCATIONS AND VEHICLES PARKED IN THE PARADISE PICNIC AREA



The number of off-trail visitors was strongly related to the number of vehicles parked in the picnic area. A regression analysis of the data shown in the figure above (with data aggregated into 14 half-hour categories) found a correlation of .917 ($p < .0001$), and also found that the regression equation was:

# of Off-Trail Visitors = (0.136 * Parked Vehicles) – 1.609

If we assume a party size of 3.06 visitors per vehicle (Vande Kamp, Swanson, and Johnson 2002), then this relationship suggests that when the average number of vehicles are parked (64.85 vehicles), 3.65 percent of visitors (7.24 out of 198.45) will be in off-trail areas of the picnic area. Similarly, during the peak observed hour for parked vehicles (89.13 vehicles @ 15:00), 3.87 percent of visitors (10.55 out of 272.72 visitors) will be in off-trail areas of the picnic area.

These estimated rates of off-trail activity are lower than the rates observed in the other two locations. However, the way visitors used the picnic area may have biased those estimates. If a substantial proportion of parties parked their vehicles in the picnic area and then walked out of the area to visit other attractions, then they were not in the observed area and their location on or off-trail is unknown. Although this effect was also likely to bias the off-trail rates calculated at the other locations, it probably had the greatest effect in the picnic area because visitors were specifically encouraged to view the area as an alternative parking lot for visiting Paradise in general, and its proximity to the visitor center and other facilities made it attractive for that purpose.

6.2.2 Statistical Relationships between Off-trail hiking and Gate Counts

It was originally intended that additional analyses would establish a relationship between hourly vehicle counts at the gate and counts of parked vehicles. Above, parked vehicles were shown to be related to off-trail hiking. If both relationships were strong, it was assumed that hourly gate counts could be used to predict off-trail hiking.

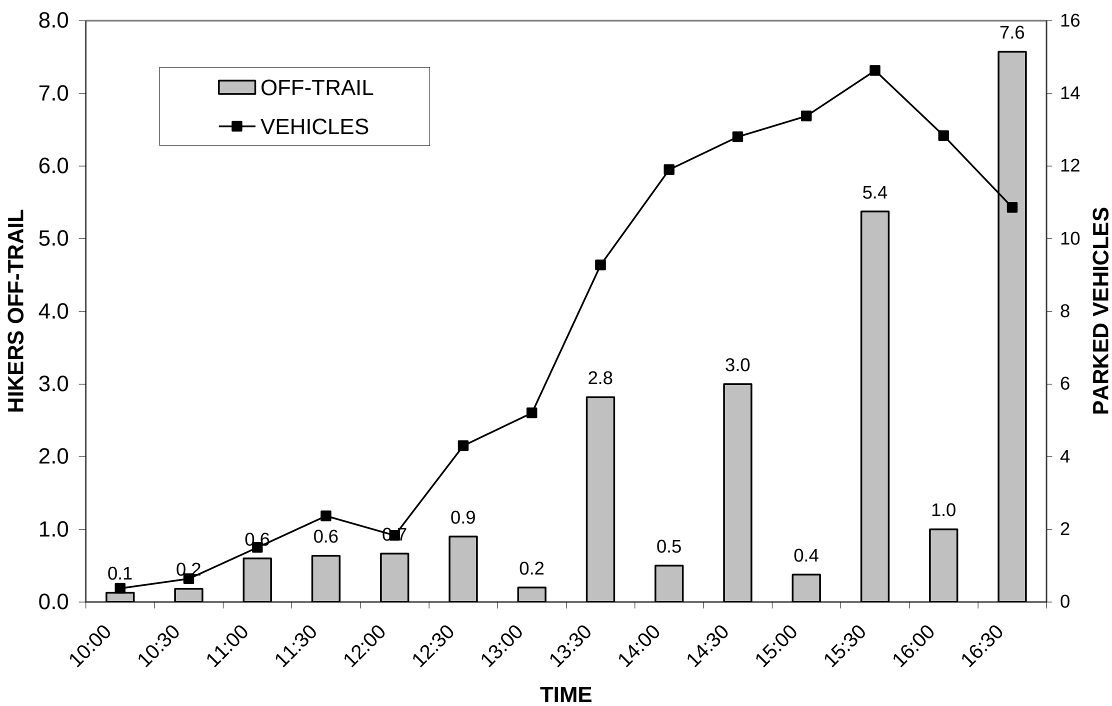
6.3 Off-trail Activity at Paradise: Results for the Paradise Valley

Observations of off-trail activity in the Paradise Valley were recorded on twelve days between July 9 and September 4, 2006. The location and number of off-trail visitors was recorded a total of 129 times on ½-hour intervals between 9:30 and 5:00.

6.3.1 Descriptive Data: Off-trail Hiking

An average of 1.58 (SD = 5.70) visitors were recorded in off-trail locations in the Paradise Valley. The figure below shows the half-hourly averages recorded for off-trail visitors and shows the average number of vehicles parked on the road below the 4th Crossing trailhead between 10:00 and 4:30[5].

FIGURE 43. VISITORS COUNTED IN OFF-TRAIL LOCATIONS IN THE PARADISE VALLEY AND VEHICLES PARKED ON THE ROAD BELOW 4TH CROSSING



The number of off-trail visitors was weakly related to the number of vehicles parked along the road. A regression analysis of the data shown in the figure above (with data aggregated into 14 half-hour categories) found a correlation of .527 (p =.053), and found that the regression equation was:

[5] Note that some observations were made outside the time period shown, but there were not enough observations at those times to support reliable summary statistics.

# of Off-Trail Visitors = (0.218 * Parked Vehicles) + 0.122

If we assume a party size of 3.06 visitors per vehicle (Vande Kamp, Swanson, and Johnson 2002), then this relationship suggests that when the average number of vehicles are parked (6.88 vehicles), 7.71 percent of visitors (1.62 out of 21.04 visitors) will be in off-trail areas of Paradise Valley. Similarly, during the peak observed hour for parked vehicles (14.63 vehicles @ 15:30), 7.41 percent of visitors (3.32 out of 44.75 visitors) will be in off-trail areas of Paradise Valley.

If a substantial proportion of parties parked their vehicles along the road below 4th Crossing and then walked or took the shuttle bus out of the area to visit other attractions, then the estimated rates of off-trail activity are biased, and underestimate the true rate. Even if the estimates are not biased, they are large enough to suggest that efforts to deter off-trail activity could substantially alter the number of visitors trampling the vegetation in the Paradise Valley.

6.3.2 Statistical Relationships between Off-trail hiking and Gate Counts

It was originally intended that additional analyses would establish a relationship between hourly vehicle counts at the gate and counts of parked vehicles. Above, parked vehicles were shown to be weakly related to off-trail hiking. Due to that weak relationship, it is unlikely that hourly gate counts could be used to predict off-trail hiking in this area.

6.4 Off-trail Activity at Paradise: Results for the Fourth Crossing Trail

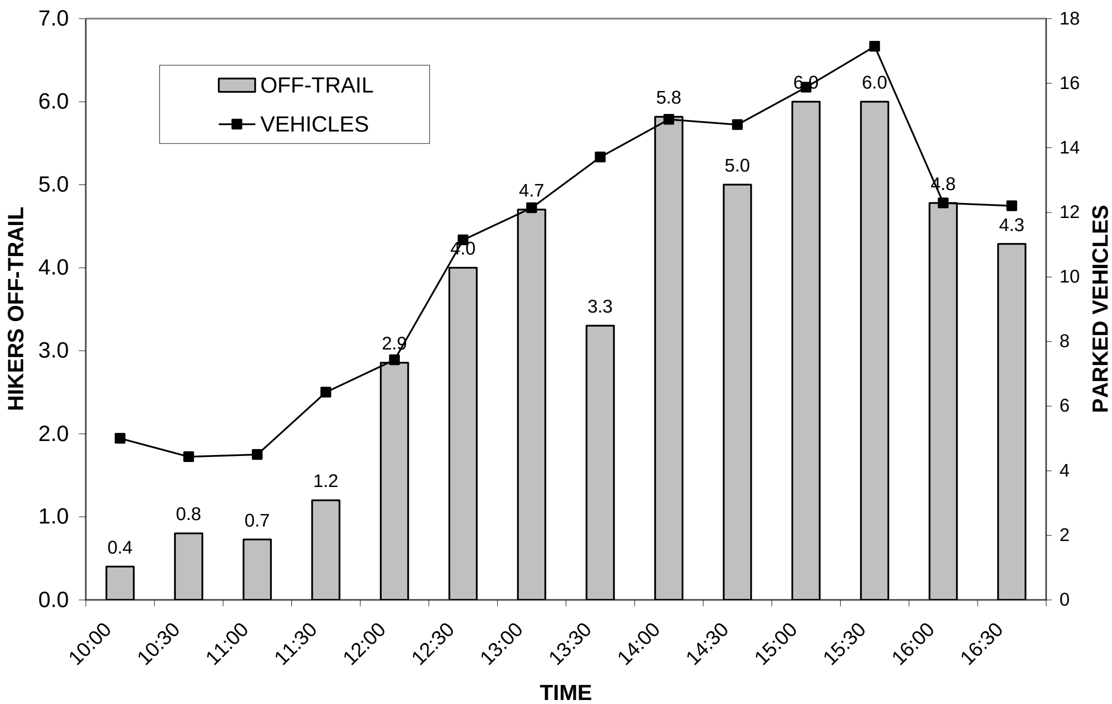
Observations of off-trail activity along the lower half of the Fourth Crossing Trail were recorded on eleven days between July 9 and September 4, 2006. The location and number of off-trail visitors was recorded a total of 132 times on ½-hour intervals between 9:30 and 4:30.

6.4.1 Descriptive Data: Off-trail Hiking

An average of 3.68 (SD = 4.79) visitors were recorded in off-trail locations along the lower half of the Fourth Crossing Trail. The figure below shows the half-hourly averages recorded for off-trail visitors and shows the average number of vehicles parked at the trailhead parking lot between 10:00 and 4:30[6].

[6] Note that some observations were made outside the time period shown, but there were not enough observations at those times to support reliable summary statistics.

FIGURE 44. VISITORS COUNTED IN OFF-TRAIL LOCATIONS ALONG THE 4TH CROSSING TRAIL AND VEHICLES PARKED AT THE 4TH CROSSING TRAILHEAD



The number of off-trail visitors was strongly related to the number of vehicles parked along the road. A regression analysis of the data shown in the figure above (with data aggregated into 14 half-hour categories) found a correlation of .956 ($p < .001$), and found that the regression equation was:

# of Off-Trail Visitors = (0.440 * Parked Vehicles) - 1.206

If we assume a party size of 3.06 visitors per vehicle (Vande Kamp, Swanson, and Johnson 2002), then this relationship suggests that when the average number of vehicles are parked (11.09 vehicles), 10.81 percent of visitors (3.67 out of 33.95 visitors) will be in off-trail areas along the lower half of the 4th Crossing Trail. Similarly, during the peak observed hour for parked vehicles (17.14 vehicles @ 15:30), 12.06 percent of visitors (6.33 out of 52.46 visitors) will be in off-trail areas along the trail.

These estimated rates of off-trail hiking are higher than the rates observed in the other two locations. Some of that difference might arise because the proportion of the parties parked at the trailhead lot that could be observed along the trail may be higher than the proportion of parked parties that could be observed in the picnic area and the Paradise Valley. However, there is little reason to suspect that the off-trail hiking rates are overestimates. Apparently, the combination of off-trail attractions, social trails, and narrow trail width of the 4th Crossing Trail lead a relatively high percentage of visitors to walk or hike in off-trail locations. Note also that these rates estimate the proportion of visitors who are off-trail at any given moment. The proportion of visitors who spend some time off-trail at some point during their hike is likely to be considerably higher. These findings suggest that efforts should be made to improve the trail in ways that limit off-trail activity, and managers should communicate with visitors in order to deter them from off-trail activity.

6.4.2 Statistical Relationships between Off-trail hiking and Gate Counts

It was originally intended that additional analyses would establish a relationship between hourly vehicle counts at the gate and counts of parked vehicles. Above, parked vehicles were shown to be related to off-trail hiking. If both relationships were strong, it was assumed that hourly gate counts could be used to predict off-trail hiking.

7. Summary of Changes during Construction and Potential Impacts on Resources and Visitor Experience

The general picture of visitation that emerges from the data collected in 2006 is that the level and pattern of general visitation in the Paradise area was not altered dramatically by the construction activity. The estimates of total vehicle use suggest that the total number of visitors to the paradise area on weekdays may have been decreased somewhat. However, there is no evidence that weekend visitation was decreased. If anything, the addition of the Cougar Rock shuttle may have increased the total number of weekend visitors slightly (see Section 4.2.2 and 5.10.1).

Although there were no baseline data to assess changes in use of the Picnic Area and Fourth Crossing Trail, those were the areas where use was most likely to have been altered by the construction activity. The parking counts (Section 2.2.1), total vehicle use estimates (Section 4.2.1 and 4.2.4), trail counter data (Section 5.7.3), and descriptions of off-trail hiking (Sections 6.2.1 and 6.4.1) provide a broad description of the use that occurred in 2006. In combination with other efforts to measure visitor impacts to resources, these data can help guide management actions in those areas. For example, it may be useful to assess whether the physical design of the Fourth Crossing Trail is sufficient to serve use levels of nearly 50 hikers per hour. The relatively high rates of off-trail hiking observed in that area (see Section 6.4.1) suggest that the trail may not be sufficient.

One aspect of the construction that was not measured in this project, but may have had impacts on resources and visitor experiences was the alteration to the natural soundscape from construction equipment and other activity. Although there is no evidence that the sounds of construction displaced visitors. The visitor experience for an unknown proportion of the Paradise area was altered by those sounds. Such alteration may or may not have detracted significantly from visitor experiences.

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