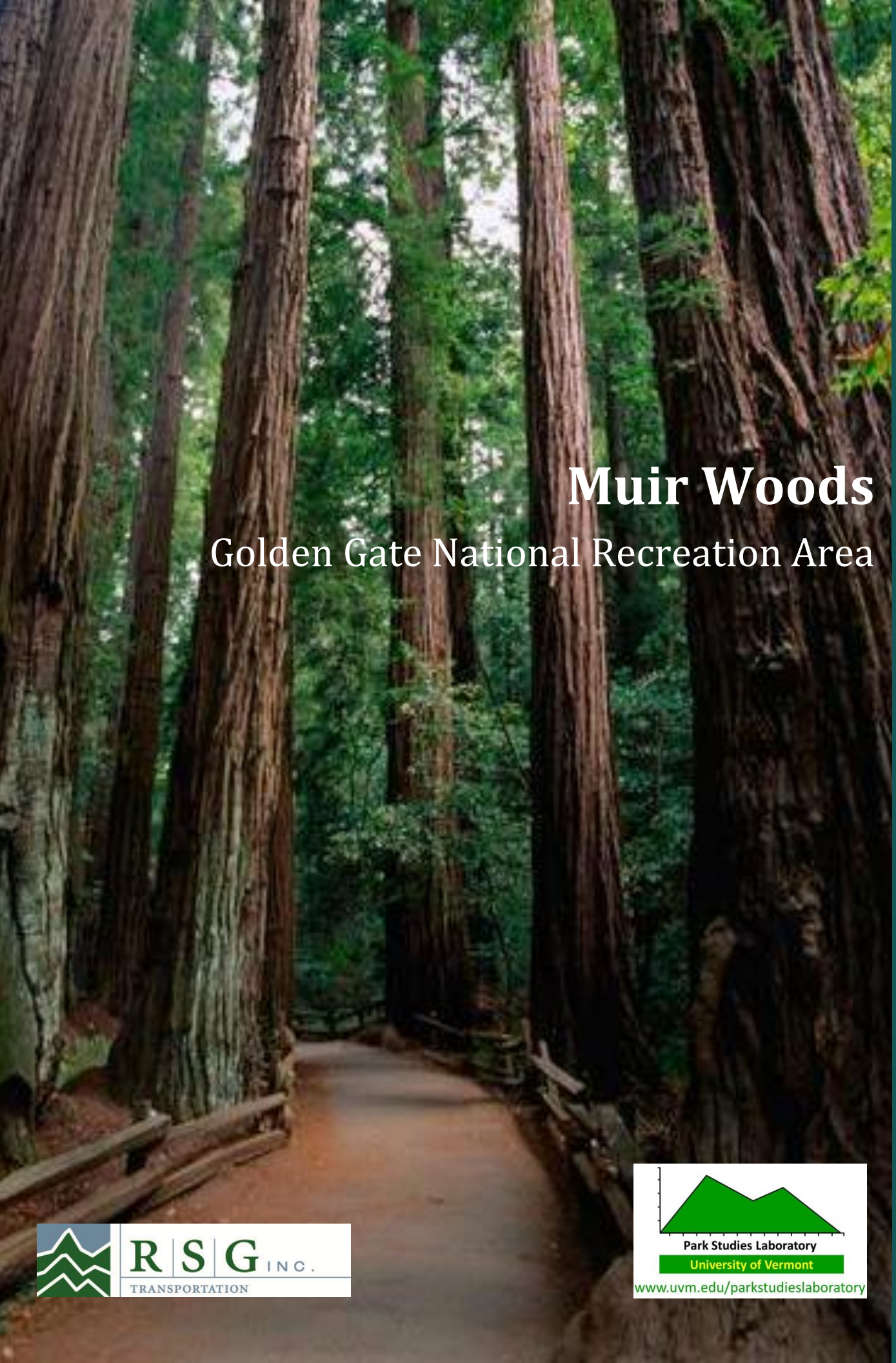

Muir Woods

Golden Gate National Recreation Area

11 NOVEMBER 2011

RSG INC.
TRANSPORTATION

Park Studies Laboratory
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TABLE OF CONTENTS

Section 1 Introduction 1

Section 2 Indicator Monitoring Descriptive Statistics 2

2.1 Redwood Cross Section 4
2.2 Pinchot Tree PAOT 8
2.3 Valley Floor Trail Interpretive Section PPV 13
2.4 Valley Floor Trail Thru-Travel Section *PPV* 18
2.5 Hillside Trail Inter-group Encounters 22

Section 3 Simulation Model Data and Methods 27

3.1 Study Site 27
3.2 Indicators and Data 29
Shuttle Arrival Times 30
Shuttle Ridership Frequency 30
Tour Bus Arrival Times 30
Tour Bus Ridership Frequency 31
Private Vehicle Interarrival Times 31
Group Size Frequency 31
Routes 32
Delay Time Distributions 37

Section 4 Simulation Modeling Existing Conditions 40

4.1 Model Overview 40
4.2 Model Algorithm and Programming 40
Arrivals H-Block 42
Node H-Blocks 42
PAOT and PPV H-Blocks 43
Encounters H-Blocks 44
4.3 Descriptive Results 45
Use Levels and Group Size 45
Bus Ridership 46
PAOT and PPV 48
Encounters 51

Section 5 Simulation Modeling Alternatives Analysis 54

5.1 Scenarios 54
5.2 Descriptive Results 55
Use Levels and Group Size 55
Parking 56
Bus Ridership 58
PAOT and PPV 60
Encounters 63

LIST OF FIGURES

Figure 1. Indicator Locations 3
Figure 2. Daily Average PAOT in the Redwood Cross section Area, by Day of the Week 4
Figure 3. Hourly Average PAOT in the Redwood Cross Section Area, by Day of Week Category 6

Figure 4. Daily Average PAOT in the Pinchot Tree Area, by Day of the Week 8
Figure 5. Hourly Average PAOT in the Pinchot Tree Area, by Day of Week Category 11
Figure 6. Daily Average PPV along the Valley Floor Trail Interpretive Section, by Day of the Week 13
Figure 7. Hourly Average PPV along the Valley Floor Trail Interpretive Section, by Day of Week Category 16
Figure 8. Daily Average PPV along the Valley Floor Trail Thru-Travel Section, by Day of the Week 18
Figure 9. Hourly Average PPV along the Valley Floor Trail Thru-Travel Section, by Day of Week Category 20
Figure 10. Daily Average Inter-group Encounters on the Hillside Trail, by Day of the Week 23
Figure 11. Hourly Average Inter-group Encounters on the Hillside Trail, by Day of Week Category 25
Figure 12. Muir Woods conceptual and route map 28
Figure 13. Route Map Nodes 34
Figure 14. Route 202 35
Figure 15. Route 405 36
Figure 16. Model Overview 41
Figure 17. Private Vehicle Group Generation H-Block 42
Figure 18. Tour and Shuttle Bus Group Generation H-Block 42
Figure 19. Private Vehicle Trip ID and Group Size Attribute Blocks 42
Figure 20. Node H-Block Structure 42
Figure 21. Example PAOT Calculation Blocks – Redwood Cross-Section 43
Figure 22. Example PPV Calculation Blocks – Through Trail Segment 44
Figure 23. Example Node with an Encounters Calculation H-Block 45
Figure 24. Example Encounters Calculation Blocks 45
Figure 25. Alternatives 54
Figure 26. Cars in MUWO Lot by GMP Alternative 56
Figure 27. Cumulative Displaced Cars from MUWO Lot by GMP Alternative 57
Figure 28. Cumulative Displaced Individuals from MUWO Lot by GMP Alternative 57
Figure 29. Boarded Shuttle Riders by GMP Alternative 59
Figure 30. Displaced Shuttle Riders by GMP Alternative 60

LIST OF TABLES

Table 1. Sampling Effort – Redwood Cross Section PAOT 4
Table 2.Percent Time in Excess of PAOT in the Redwood Cross Section Area, by Day of Week Category 5
Table 3. Hourly Average PAOT in the Redwood Cross Section Area, by Day of Week Category 5
Table 4. Weekday Hourly Average PAOT in the Redwood Cross Section Area, by Statistically Different Hours 7
Table 5. Weekend Hourly Average PAOT in the Redwood Cross Section Area, by Statistically Different Hours 7
Table 6. Sampling Effort - Pinchot Tree PAOT 8
Table 7. Percent Time in Excess of PAOT in the Pinchot Tree Area, by Day of Week Category 9
Table 8. Hourly Average PAOT in the Pinchot Tree Area, by Day of Week Category 10
Table 9. Weekday Hourly Average PAOT in the Pinchot Tree Area, by Statistically Different Hours 12
Table 10. Weekend Hourly Average PAOT in the Pinchot Tree Area, by Statistically Different Hours 12
Table 11.Sampling Effort – Valley Floor Trail Interpretive Section PPV 13

Table 12. Percent Time in Excess of PPV along the Valley Floor Trail Interpretive Section, by Day of Week Category 14
Table 13. Hourly Average PPV along the Valley Floor Trail Interpretive Section, by Day of Week Category 15
Table 14. Weekday Hourly Average PPV along the Valley Floor Trail Interpretive Section, by Statistically Different Hours 17
Table 15. Weekend Hourly Average PPV along the Valley Floor Trail Interpretive Section, by Statistically Different Hours 17
Table 16.Sampling Effort – Valley Floor Trail Thru-Travel Section PPV 18
Table 17. Percent Time in Excess of PPV along the Valley Floor Trail Thru-Travel Section, by Day of Week Category 19
Table 18. Hourly Average PPV along the Valley Floor Trail Thru-Travel Section, by Day of Week Category 19
Table 19. Weekday Hourly Average PPV along the Valley Floor Trail Thru-Travel Section, by Statistically Different Hours 21
Table 20. Weekend Hourly Average PPV along the Valley Floor Trail Thru-Travel Section, by Statistically Different Hours 21
Table 21. Sampling Effort – Hillside Trail Inter-group Encounters 22
Table 22. Percent Time in Excess of Inter-group Encounters on the Hillside Trail, by Day of Week Category 23
Table 23. Hourly Average Inter-group Encounters on the Hillside Trail 25
Table 24. Hourly Average Inter-group encounters on the Hillside Trail, by Statistically Different Hours 26
Table 25. Route Map Sampling Effort 32
Table 26. Route #202 Node Pairs 33
Table 27. Route #405 Node Pairs 33
Table 28: Delay Times in the Paved Meadow and Linger Times along the Valley Trail 37
Table 29. Delay Time Statistical Difference by Direction of Travel 38
Table 30. Delay Time Statistical Difference by Entrance Location 38
Table 31. Delay Time Statistical Difference by Exit Location 38
Table 32. Delay Time Distribution Parameters 39
Table 33. Individual Use Level, by Mode 45
Table 34. Mean Group Size, by Model 46
Table 35. Mean Tour Bus Ridership, by Hour 46
Table 36. Mean Shuttle Bus Ridership, by Hour 47
Table 37. Hourly PAOT at Redwood Cross-Section 48
Table 38. Hourly PAOT at Pinchot Tree 49
Table 39. Hourly PPV along Interp Trail Section 50
Table 40. Hourly PPV along Through Trail Section 51
Table 41. Hourly Meetings Hillside Trail 51
Table 42. Hourly Overtakings along Hillside Trail 52
Table 43. Hourly Encounters along Hillside Trail 52
Table 44.Use Levels Comparison 55
Table 45. Group Size Comparison 55
Table 46.Tour Bus Ridership Comparison 58
Table 47. Shuttle Bus Ridership Comparison 58
Table 48.Percent Buses with Overflow Demand 58

Table 49. Redwood Cross-Section PAOT Comparison 60
Table 50. Pinchot Tree PAOT Comparison 61
Table 51. Interp Trail PPV Comparison 62
Table 52. Through Trail PPV Comparison 62
Table 53. Hillside Meetings Comparison 63
Table 54. Hillside Overtakings Comparison 63
Table 55. Hillside Encounters Comparison 64

Section 1 Introduction

Muir Woods National Monument, managed as part of Golden Gate National Recreation Area (GGNRA) by the National Park Service (NPS), preserves a primeval redwood forest in Marin County just north of San Francisco. The monument receives intensive public use, with more than one million people visiting annually. NPS is revising GGNRA's General Management Plan (GMP) and developing Implementation Plans for management of visitor use in Muir Woods. This planning is guided by a management-by-objectives framework, with a key component being the development of indicators and standards of quality for visitor experiences.

The NPS has commissioned a study with the University of Vermont (UVM) and Resource Systems Group (RSG) to collect visitor use information to support the development of indicators and standards of quality for GGNRA's GMP and Implementation Plans. As part of the study, visitor use counts and observations were conducted during summer 2009 to establish the current condition of crowding-related indicators of quality. From these observations and additional data characterizing the arrival and routing of visitors, a simulation model of Muir Woods' visitor was developed. In estimating the value of crowding-related indicators under different conditions of volume and arrival the model both facilitates ongoing indicator monitoring and enables analysis of alternative management schemes. A primary purpose of the simulation model is to analyze the potential effects of GMP alternatives for transportation and visitor management in the monument.

The results presented in this report are intended to provide an empirical basis to support NPS decisions about indicators and standards of quality for visitor experiences. It is organized in four primary sections. Section 2 reviews descriptive characterizing the existing conditions of crowding-related indicators. Section 3 outlines the data and methods used to develop the simulation model. Section 4 reports results of modeling the current conditions of crowding-related indicators. Section 5 reports results of GMP alternatives analysis.

Section 2 Indicator Monitoring Descriptive Statistics

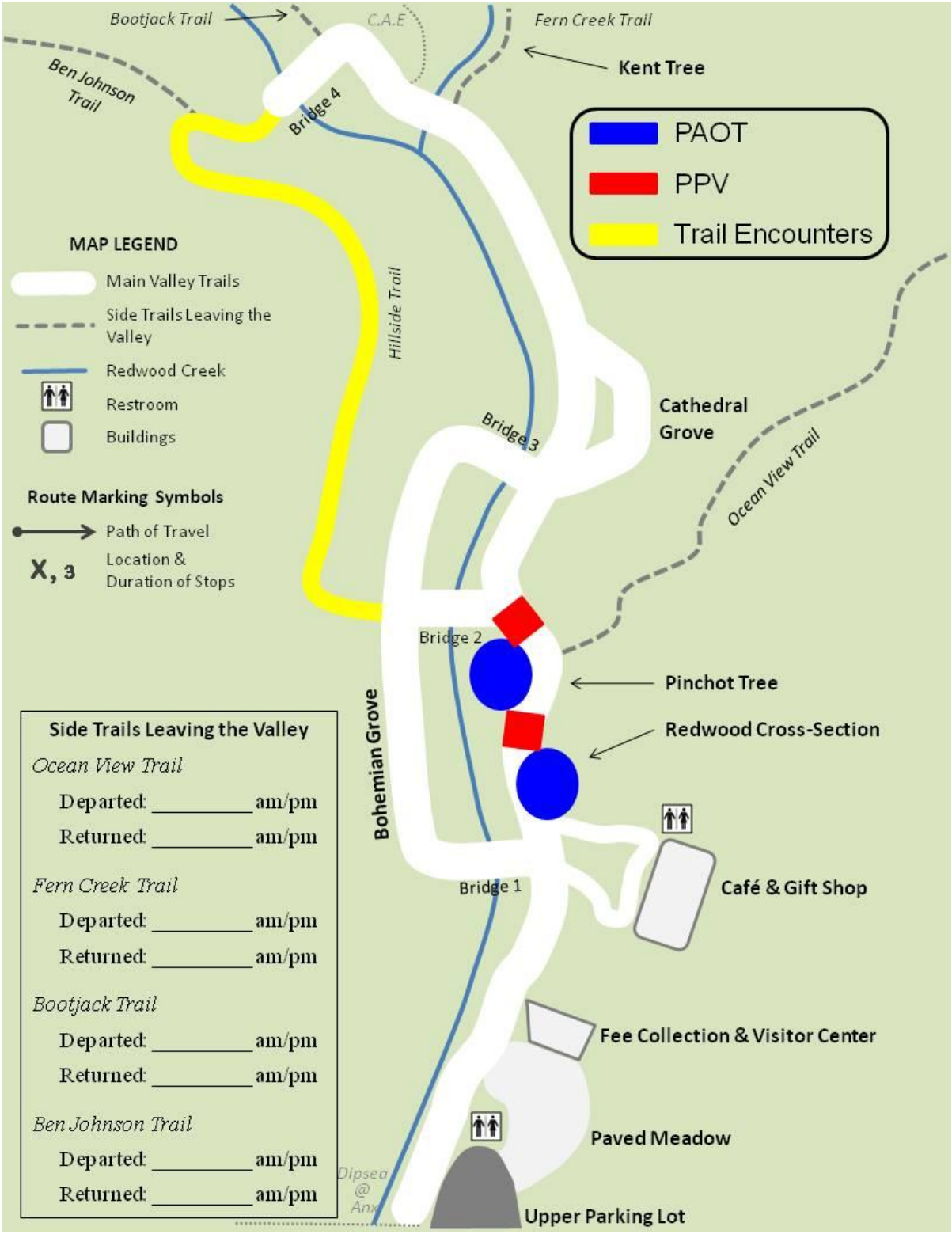
The purpose of this study is to support the implementation of indicators based management of visitor use in Muir Woods. The three indicators monitored and modeled here are: people at one time (PAOT), people per view (PPV), and trail encounter rate. PAOT is a measure of density within an area – the number of visitors in an area. PPV is a measure of visual density within a linear corridor – the number of others visible from a visitor's perspective along a trail. Unlike PAOT and PPV, trail encounter rate is an event based measure of visitor use. Trail encounter rate describes the number of others a subject visitor encounters during an analytical period – the number of other hikers passed and met while hiking a trail. PAOT, being an areal density measure, was monitored at the recreation sites within Muir Woods: the Redwood Cross Section and the Pinchot Tree. PPV, as a measure of linear density, was monitored along two sections of the valley floor trails, one section with interpretive signs and benches and one section without such features. Trail encounter rate was monitored on the Hillside Trail. In lower use setting, like the Hillside Trail, the experience of closeness with others occurs as a series discrete events rather than a continuous condition. Trail encounters, being an event based variable, is suited for this location. The locations at which these indicators were monitored are depicted in Figure 1.

This section of the report presents the results of visitor use counts and observations conducted in Muir Woods during summer 2009. The results provide detailed information about the current condition of the following crowding-related indicators of quality in Muir Woods:

- PAOT in the Redwood Cross Section area
- PAOT in the Pinchot Tree area
- PPV on valley floor trails
- Trail encounter rate on the Hillside Trail

Analyses presented in this section include statistical comparisons of weekend versus weekday conditions of the crowding-related indicators noted, where weekends include Friday through Sunday and weekdays include Monday through Thursday.

Figure 1. Indicator Locations



2.1 Redwood Cross Section

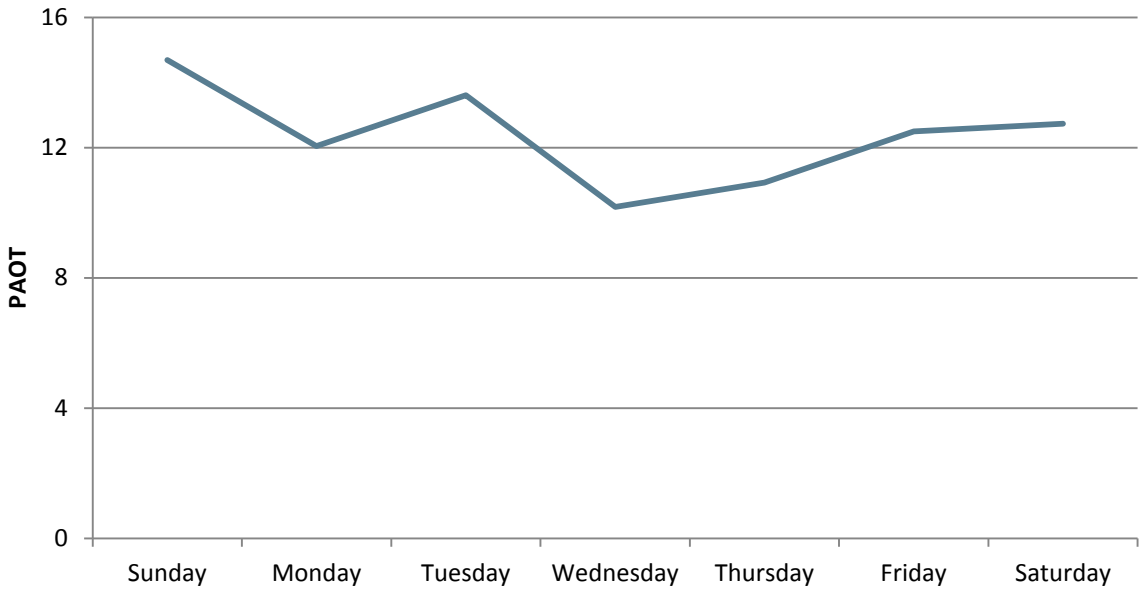
Counts of PAOT within the Redwood Cross Section interpretive area were conducted at 5-minute intervals between 9 AM and 6 PM on 20 days between June 26 and August 13, 2007. A total of 1,307 usable observations were collected (Table 1).

Table 1. Sampling Effort – Redwood Cross Section PAOT

Hour of the Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	*Total*
9:00	12	36	12	-	24	12	23	119
10:00	12	34	12	-	24	12	30	124
11:00	12	36	12	-	24	12	24	120
12:00	48	48	12	12	46	34	24	224
13:00	48	46	12	12	48	35	24	225
14:00	47	35	11	12	48	35	24	212
15:00	36	-	-	12	25	24	-	97
16:00	36	-	-	12	23	24	-	95
17:00	35	-	-	12	20	24	-	91
Total	**286**	**235**	**71**	**72**	**282**	**212**	**149**	**1,307**

Daily average PAOT within the Redwood Cross Section area ranges between 10 and 15 (Figure 2). Daily average PAOT is highest on Sundays, and statistically higher on this day than on Wednesdays and Thursdays ($F=4.597$, $p<0.001$). Mondays, Tuesdays, Fridays, and Saturdays are not statistically different than any other day of the week, with respect to daily average PAOT.

Figure 2. Daily Average PAOT in the Redwood Cross section Area, by Day of the Week



Percentages are reported in Table 2 to document the frequency with which various PAOT levels are exceeded in the Redwood Cross Section area. Overall, there are more than 12 PAOT in the cross section area 50% of the time between the hours of 9 AM and 4 PM; on weekends, there are more than 13 PAOT in the area 50% of the time. Across all days of the week, visitor use in the Redwood Cross Section area exceeds 22 PAOT only 10% of the time between the hours of 9 AM and 4 PM; on weekends, visitor use exceeds 23 PAOT only 10% of the time. The maximum level of visitor use observed in the Redwood Cross Section area was 44 PAOT.

Table 2.Percent Time in Excess of PAOT in the Redwood Cross Section Area, by Day of Week Category

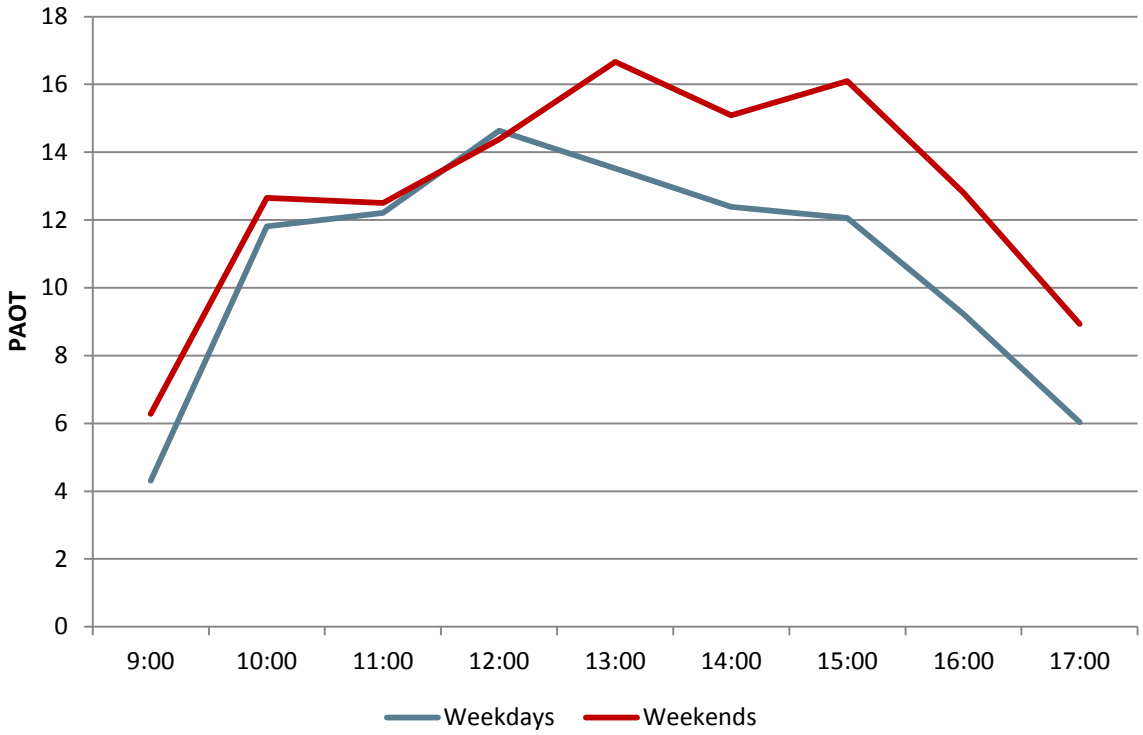
Percent	All Days	Weekdays	Weekends
75%	7	6	8
50%	12	11	13
25%	17	16	18
10%	22	21	23
Maximum	**44**	**39**	**44**

Weekdays and weekends are not statistically different between 10 AM and 1 PM, with respect to hourly average PAOT in the Redwood Cross Section area. However, during the 9 AM hour and between 1 PM and 6 PM, hourly average PAOT in the Redwood Cross Section area is significantly higher on weekends than on weekdays (Table 3 and Figure 3).

Table 3. Hourly Average PAOT in the Redwood Cross Section Area, by Day of Week Category

Hour of the Day	Weekdays	Weekends
9:00*	4.31	6.28
10:00	11.81	12.65
11:00	12.21	12.50
12:00	14.64	14.38
13:00*	13.52	16.66
14:00*	12.39	15.08
15:00*	12.05	16.10
16:00*	9.23	12.80
17:00*	6.03	8.93
*** Denotes statistically significant difference at α = 0.05**		

Figure 3. Hourly Average PAOT in the Redwood Cross Section Area, by Day of Week Category



Results of ANOVA post-hoc tests suggest that, on weekdays, the peak period of visitor use in the Redwood Cross Section area is between the hours of 10 AM and 4 PM (Table 4). On weekends, visitor use in the cross section area peaks between the hours of 12 PM and 4 PM (Table 5).

Table 4. Weekday Hourly Average PAOT in the Redwood Cross Section Area, by Statistically Different Hours

Hour of the Day	Statistically Different Grouping at α=0.05			
9:00	4.31	-	-	-
10:00	-	-	11.81	11.81
11:00	-	-	12.21	12.21
12:00	-	-	-	14.64
13:00	-	-	-	13.52
14:00	-	-	12.39	12.39
15:00	-	-	12.05	12.05
16:00	-	9.23	9.23	-
17:00	6.03	6.03		-

Table 5. Weekend Hourly Average PAOT in the Redwood Cross Section Area, by Statistically Different Hours

Hour of the Day	Statistically Different Grouping at α=0.05			
9:00	6.28	-	-	-
10:00	-	-	12.65	-
11:00	-	12.50	12.50	-
12:00	-	-	14.38	14.38
13:00	-	-	-	16.66
14:00	-	-	15.08	15.08
15:00	-	-	16.10	16.10
16:00	-	-	12.80	-
17:00	8.93	8.93	-	-

2.2 Pinchot Tree PAOT

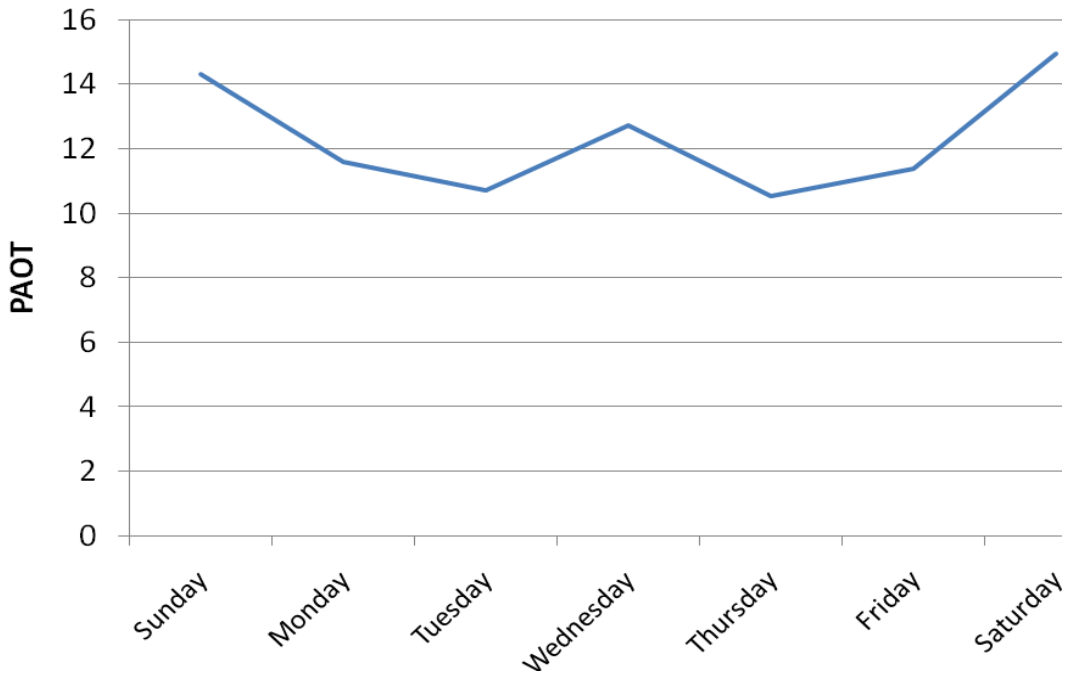
Counts of PAOT within the Pinchot Tree interpretive area were conducted at 5 minute intervals between 9 AM and 6 PM on 20 days between June 26 and August 13, 2007. A total of 1,357 usable observations were collected (Table 6).

Table 6. Sampling Effort - Pinchot Tree PAOT

Hour of the Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	*Total*
9:00	12	36	12	-	23	12	24	119
10:00	12	36	12	-	24	18	24	126
11:00	12	36	12	-	24	12	24	120
12:00	48	48	12	12	48	21	36	225
13:00	48	47	12	12	48	24	36	227
14:00	48	36	12	12	48	24	36	216
15:00	36	12	-	12	24	12	12	108
16:00	36	12	-	12	24	12	12	108
17:00	36	12	-	12	24	12	12	108
Total	**288**	**275**	**72**	**72**	**287**	**147**	**216**	**1,357**

Daily average PAOT within the Pinchot Tree area ranges between 11 and 15 (Figure 4). Daily average PAOT is highest on Saturdays and Sundays, and statistically higher on these days than on Tuesdays and Thursdays ($F=6.338$, $p<0.001$). Mondays, Wednesdays, and Fridays are not statistically different than any other day of the week, with respect to daily average PAOT.

Figure 4. Daily Average PAOT in the Pinchot Tree Area, by Day of the Week



Percentages are reported in Table 7 to document the frequency with which various PAOT levels are exceeded in the Pinchot Tree area. Overall, there are more than 10 PAOT in the Pinchot Tree area 50% of the time between the hours of 9 AM and 4 PM; on weekends, there are more than 12 PAOT in the area 50% of the time. Across all days of the week, visitor use in the Pinchot Tree area exceeds 25 PAOT only 10% of the time between the hours of 9 AM and 4 PM; on weekends, visitor use exceeds 27 PAOT only 10% of the time. The maximum level of visitor use observed in the Pinchot Tree area was 84 PAOT.

Table 7. Percent Time in Excess of PAOT in the Pinchot Tree Area, by Day of Week Category

Percent	All Days	Weekdays	Weekends
75%	6	5	7
50%	10	9	12
25%	17	15	20
10%	25	23	27
Maximum	**84**	**84**	**84**

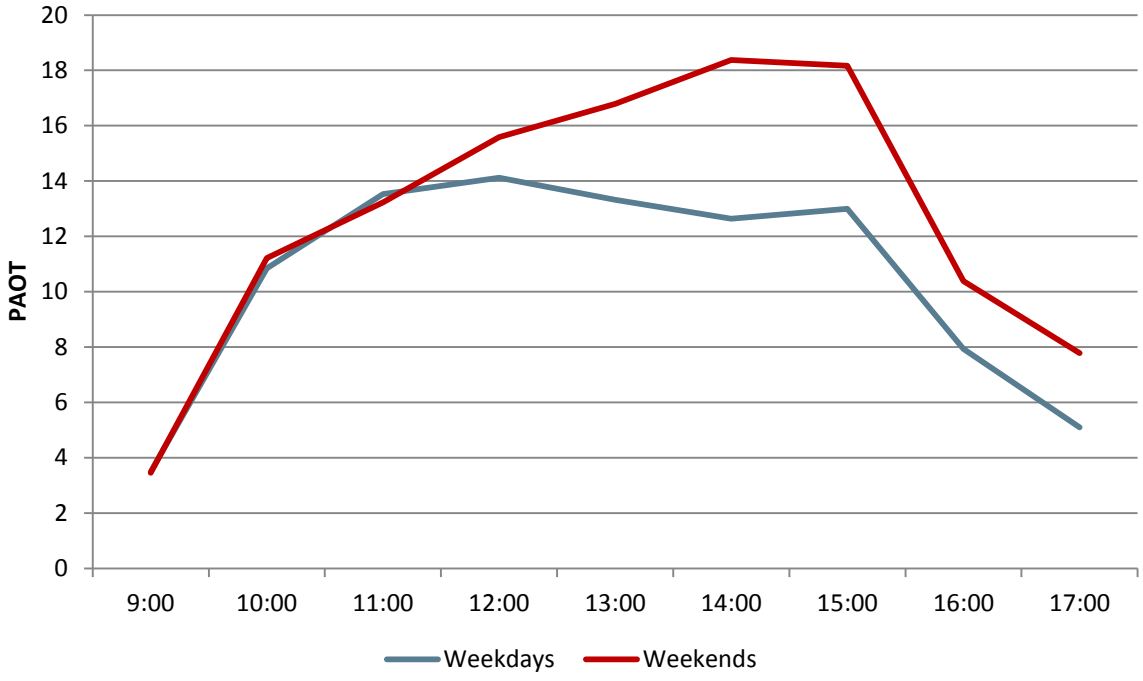
Weekdays and weekends are not statistically different during morning hours, with respect to hourly average PAOT within the Pinchot Tree area. However, between the hours of 1 PM and 5 PM, hourly average PAOT in the Pinchot Tree area is significantly higher on weekends than on weekdays (Table 8 and

Figure 5).

Table 8. Hourly Average PAOT in the Pinchot Tree Area, by Day of Week Category

Hour of the Day	Weekdays	Weekends
9:00	3.49	3.46
10:00	10.85	11.22
11:00	13.53	13.23
12:00	14.12	15.59
13:00*	13.33	16.80
14:00*	12.64	18.37
15:00*	13.00	18.17
16:00*	7.94	10.38
17:00*	5.10	7.78
*** Denotes statistically significant difference at α = 0.05**		

Figure 5. Hourly Average PAOT in the Pinchot Tree Area, by Day of Week Category



Results of ANOVA post-hoc tests suggest that, on weekdays, the peak period of visitor use in the Pinchot Tree area is between the hours of 10 AM and 4 PM (Table 9). On weekends, visitor use in the Pinchot Tree area peaks between the hours of 1 PM and 4 PM (Table 10).

Table 9. Weekday Hourly Average PAOT in the Pinchot Tree Area, by Statistically Different Hours

Hour of the Day	Statistically Different Grouping at α=0.05		
9:00	3.49	-	-
10:00	-	10.85	10.85
11:00	-	-	13.53
12:00	-	-	14.12
13:00	-	-	13.33
14:00	-	12.64	12.64
15:00	-	13.00	13.00
16:00	7.94	7.94	-
17:00	5.10	-	-

Table 10. Weekend Hourly Average PAOT in the Pinchot Tree Area, by Statistically Different Hours

Hour of the Day	**Statistically Different Grouping at α=0.05**					
9:00	3.46	-	-	-	-	-
10:00	-	11.22	11.22	11.22	-	-
11:00	-	-	13.23	13.23	13.23	-
12:00	-	-	-	15.59	15.59	15.59
13:00	-	-	-	-	16.80	16.80
14:00	-	-	-	-	-	18.37
15:00	-	-	-	-	18.17	18.17
16:00	-	10.38	10.38	-	-	-
17:00	7.78	7.78	-	-	-	-

2.3 Valley Floor Trail Interpretive Section PPV

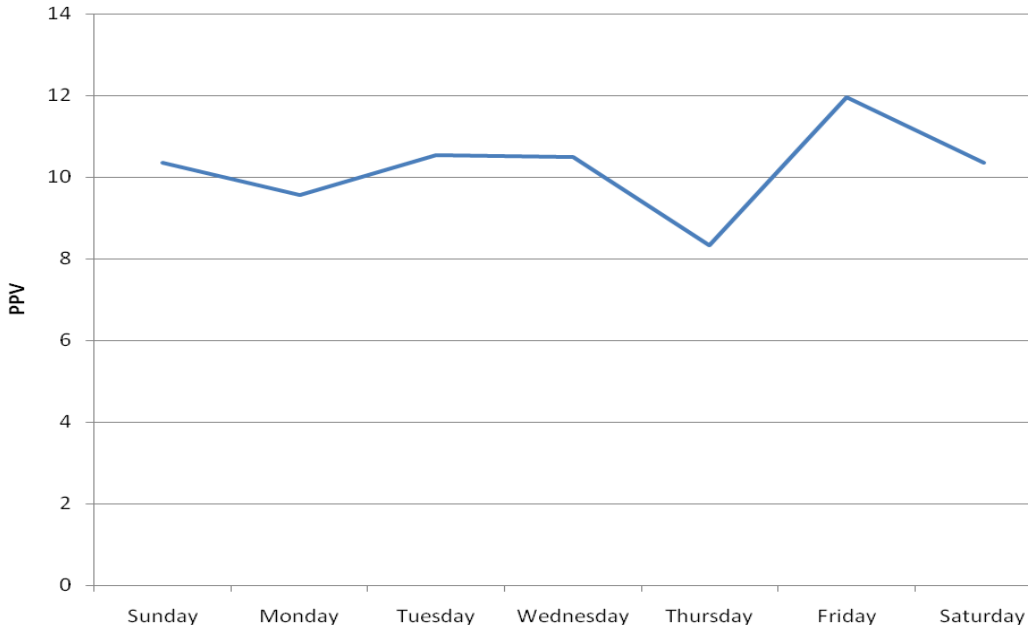
Counts of PPV along an interpretation-oriented section of the valley floor trail, including the "Family Circle" interpretive sign, were conducted at 5 minute intervals between 9 AM and 6 PM on 20 days between June 26 and August 13, 2007. A total of 679 usable observations were collected (Table 11).

Table 11.Sampling Effort – Valley Floor Trail Interpretive Section PPV

Hour of the Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	*Total*
9:00	12	12			24		12	60
10:00	12	12			24		12	60
11:00	12	12			23		11	58
12:00	12	20	9	12	12	30	12	107
13:00	12	23	12	12	12	36	12	119
14:00	10	12	12	12	12	36	12	106
15:00	21	9			8		12	50
16:00	24	12			12		12	60
17:00	23	12			12		12	59
Total	138	124	33	36	139	102	107	679

Daily average PPV along the interpretive section of the valley floor trail ranges between 8 and 12 (Figure 6). Daily average PPV is highest on Fridays, and statistically higher on this day than on Thursdays ($F=2.915$, $p=0.008$). Sundays, Mondays, Tuesdays, Wednesdays, and Saturdays are not statistically different than any other day of the week, with respect to daily average PPV.

Figure 6. Daily Average PPV along the Valley Floor Trail Interpretive Section, by Day of the Week



Percentages are reported in Table 12 to document the frequency with which various PPV levels are exceeded along the interpretive section of the valley floor trail. Overall, there are more than 9 PPV along the trail section 50% of the time between the hours of 9 AM and 4 PM; on weekends, there are more than 10 PPV along the interpretive trail section 50% of the time. Across all days of the week, visitor use exceeds 20 PPV only 10% of the time between the hours of 9 AM and 4 PM; on weekends, visitor use exceeds 21 PPV only 10% of the time. The maximum level of visitor use observed along the interpretive section of the valley floor trail was 34 PPV.

Table 12. Percent Time in Excess of PPV along the Valley Floor Trail Interpretive Section, by Day of Week Category

Percent	All Days	Weekdays	Weekends
75%	5	4	6
50%	9	8	10
25%	14	13	15
10%	20	19	21
Maximum	34	34	34

Weekdays and weekends are not statistically different during morning and midday hours, with respect to hourly average PPV along the valley floor trail interpretive section. However, between the hours of 4 PM and 6 PM, hourly average PPV along the valley floor trail interpretive section is significantly higher on weekends than on weekdays (Table 13 and

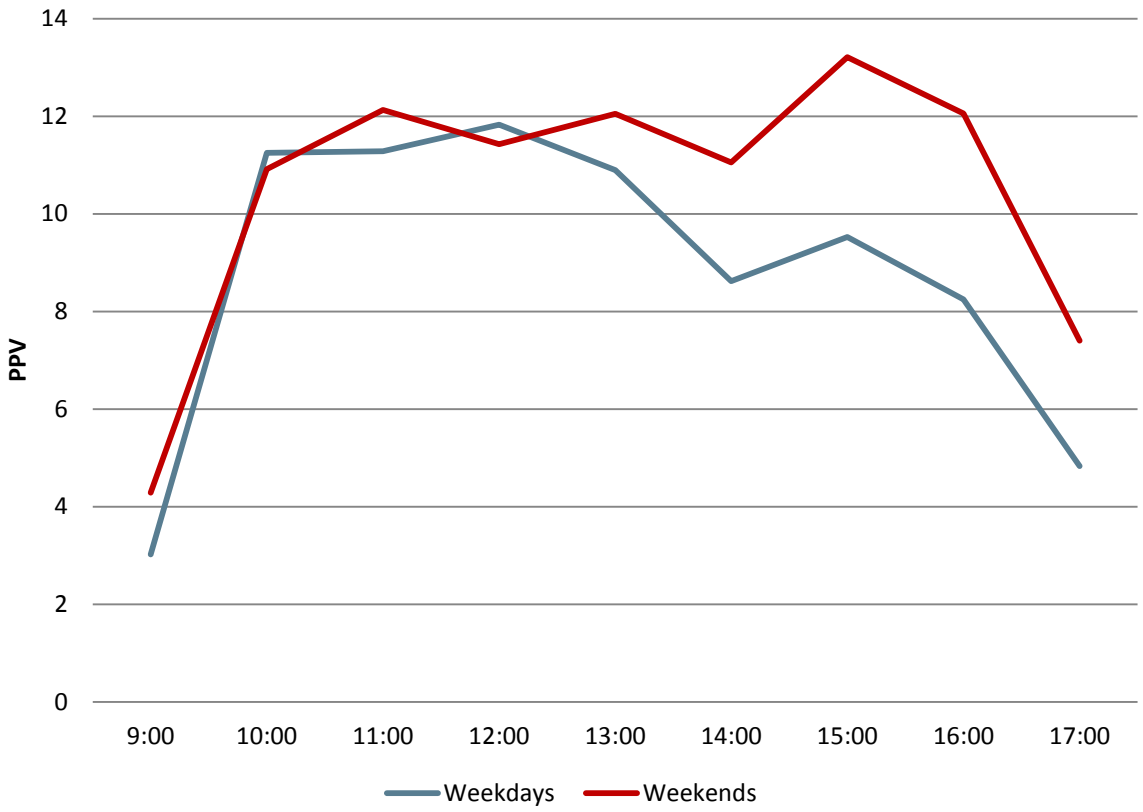
Figure 7).

Table 13. Hourly Average PPV along the Valley Floor Trail Interpretive Section, by Day of Week Category

Hour of the Day	Weekdays	Weekends
9:00	3.03	4.29
10:00	11.25	10.92
11:00	11.29	12.13
12:00	11.83	11.43
13:00	10.90	12.05
14:00	8.63	11.05
15:00	9.53	13.21
16:00*	8.25	12.06
17:00*	4.83	7.40

*** Denotes statistically significant difference at α = 0.05**

Figure 7. Hourly Average PPV along the Valley Floor Trail Interpretive Section, by Day of Week Category



Results of ANOVA post-hoc tests suggest that, on both weekdays and weekends, the peak period of visitor use along the valley floor trail interpretive section is between the hours of 10 AM and 5 PM (Table 14 and Table 15).

Table 14. Weekday Hourly Average PPV along the Valley Floor Trail Interpretive Section, by Statistically Different Hours

Hour of the Day	**Statistically Different Grouping at α=0.05**		
9:00	3.03	-	-
10:00	-	-	11.25
11:00	-	-	11.29
12:00	-	-	11.83
13:00	-	-	10.90
14:00	-	8.63	8.63
15:00	-	9.53	9.53
16:00	-	8.25	8.25
17:00	4.83	4.83	-

Table 15. Weekend Hourly Average PPV along the Valley Floor Trail Interpretive Section, by Statistically Different Hours

Hour of the Day	Statistically Different Grouping at α=0.05		
9:00	4.29	-	-
10:00	-	10.92	10.92
11:00	-	12.13	12.13
12:00	-	11.43	11.43
13:00	-	12.05	12.05
14:00	-	11.05	11.05
15:00	-	-	13.21
16:00	-	12.06	12.06
17:00	7.40	7.40	-

2.4 Valley Floor Trail Thru-Travel Section *PPV*

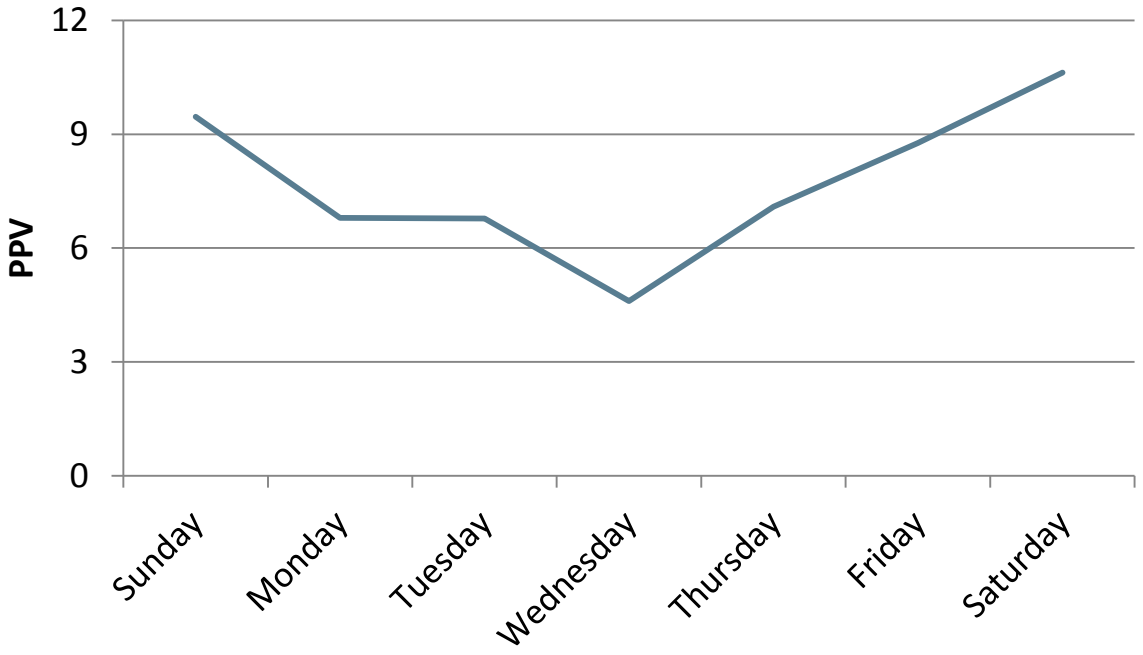
Counts of PPV along a thru-travel section of the valley floor trail (i.e., containing no benches or interpretive displays) were conducted at 5 minute intervals between 9 AM and 6 PM on 20 days between June 26 and August 13, 2007. A total of 693 usable observations were collected (Table 16).

Table 16.Sampling Effort – Valley Floor Trail Thru-Travel Section PPV

Hour of the Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	*Total*
9:00	-	24	12	-	-	12	12	60
10:00	-	24	12	-	-	12	12	60
11:00	-	23	12	-	-	12	10	57
12:00	34	22	-	-	32	-	23	111
13:00	36	24	-	-	35	-	24	119
14:00	34	24	-	-	36	-	22	116
15:00	11	-	-	9	10	20	-	50
16:00	12	-	-	12	12	24	-	60
17:00	12	-	-	12	12	24	-	60
Total	139	141	36	33	137	104	103	693

Daily average PPV along the thru-travel section of the valley floor trail ranges between 5 and 11 (Figure 8). Daily average PPV is highest on Saturdays and statistically higher on Fridays, Saturdays, and Sundays than on Wednesdays ($F=6.841$, $p<0.001$). Mondays, Tuesdays, and Thursdays are not statistically different than any other day of the week, with respect to daily average PPV.

Figure 8. Daily Average PPV along the Valley Floor Trail Thru-Travel Section, by Day of the Week



Percentages are reported in Table 17 to document the frequency with which various PPV levels are exceeded along the thru-travel section of the valley floor trail. Overall, there are more than 7 PPV along the trail section 50% of the time between the hours of 9 AM and 4 PM; on weekends, there are more than 8 PPV along the interpretive trail section 50% of the time. Across all days of the week, visitor use exceeds 17 PPV only 10% of the time between the hours of 9 AM and 4 PM; on weekends, visitor use exceeds 19 PPV only 10% of the time. The maximum level of visitor use observed along the interpretive section of the valley floor trail was 49 PPV.

Table 17. Percent Time in Excess of PPV along the Valley Floor Trail Thru-Travel Section, by Day of Week Category

Percent	All Days	Weekdays	Weekends
75%	3	3	4
50%	7	6	8
25%	11	10	13
10%	17	14	19
Maximum	**49**	**28**	**49**

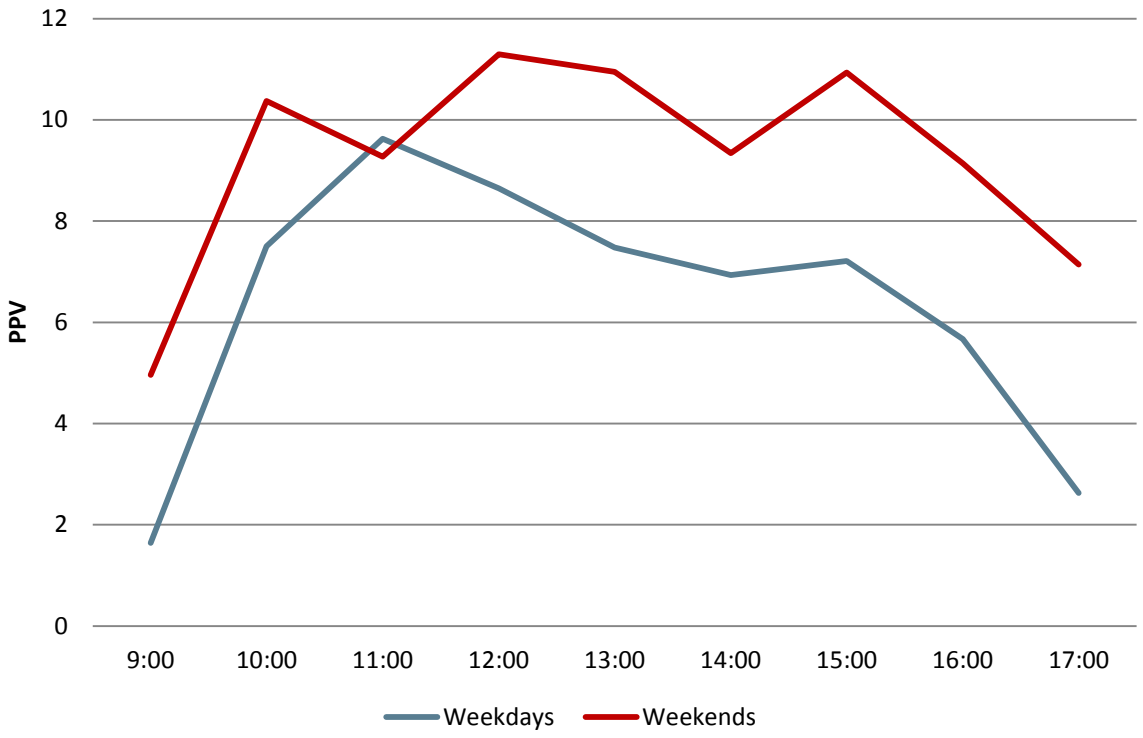
Weekdays and weekends are not statistically different during mid-morning to early afternoon, with respect to hourly average PPV along the valley floor trail thru-travel section. However, during the 9 AM hour and between the hours of 1 PM and 6 PM, hourly average PPV along the valley floor trail interpretive section is significantly higher on weekends than on weekdays (Table 18 and Figure 9).

Table 18. Hourly Average PPV along the Valley Floor Trail Thru-Travel Section, by Day of Week Category

Hour of the Day	Weekdays	Weekends
9:00*	1.64	4.96
10:00	7.50	10.38
11:00	9.63	9.27
12:00	8.65	11.30
13:00*	7.47	10.95
14:00*	6.93	9.34
15:00*	7.21	10.94
16:00*	5.67	9.14
17:00*	2.63	7.14

*** Denotes statistically significant difference at α = 0.05**

Figure 9. Hourly Average PPV along the Valley Floor Trail Thru-Travel Section, by Day of Week Category



Results of ANOVA post-hoc tests suggest that, on weekdays, the peak period of visitor use along the valley floor trail thru-travel section is between the hours of 10 AM and 4 PM (Table 19). On weekends, visitor use along the valley floor trail thru-travel section is characterized by a broad, flat peak between the hours of 10 PM and 6 PM (

Table 20).

Table 19. Weekday Hourly Average PPV along the Valley Floor Trail Thru-Travel Section, by Statistically Different Hours

Hour of the Day	Statistically Different Grouping at α=0.05			
9:00	1.64	-	-	-
10:00	-	-	7.50	7.50
11:00	-	-	-	9.63
12:00	-	-	8.65	8.65
13:00	-	-	7.47	7.47
14:00	-	-	6.93	6.93
15:00	-	-	7.21	7.21
16:00	-	5.67	5.67	-
17:00	2.63	2.63	-	-

Table 20. Weekend Hourly Average PPV along the Valley Floor Trail Thru-Travel Section, by Statistically Different Hours

Hour of the Day	Statistically Different Grouping at α=0.05	
9:00	4.96	-
10:00	10.38	10.38
11:00	9.27	9.27
12:00	-	11.30
13:00	-	10.95
14:00	9.34	9.34
15:00	-	10.94
16:00	9.14	9.14
17:00	7.14	7.14

2.5 Hillside Trail Inter-group Encounters

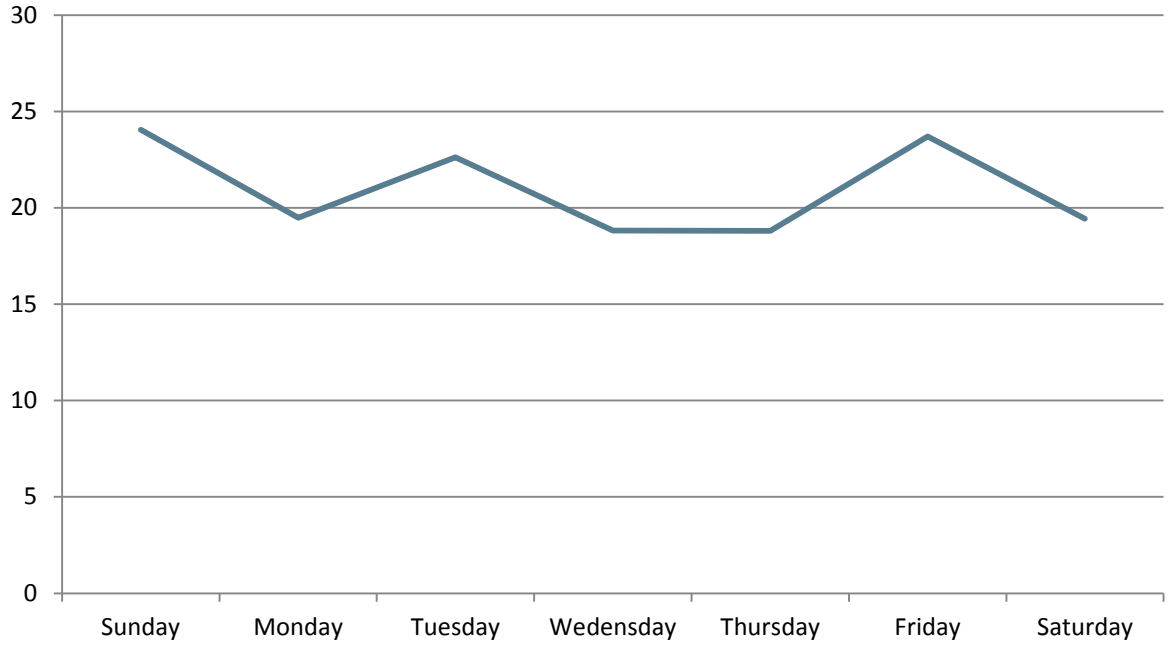
Observations of the number of inter-group encounters on the Hillside Trail were conducted between 9 AM and 6 PM on 20 days between June 26 and August 13, 2007. A total of 167 usable observations were collected (Table 21). Observations of inter-group encounters were made by randomly selecting a visitor group at one end of the Hillside Trail, following the selected group from a distance where the observer could not be noticed by the group being followed, and recording the number of groups encountered by the observed group during the course of their hike on the trail. At the end of the observation, the next arriving group was selected for observation during their hike in the opposite direction on the Hillside Trail. This process of subject selection and observation was repeated throughout the sampling day. Encounters reported in this section refer to the number of *groups* (rather than *individuals*) encountered while hiking from one end of the Hillside Trail to the other. The size of groups observed on the Hillside Trail ranged from 1 to 13, with a mean of 3.13 and a standard deviation of 1.67.

Table 21. Sampling Effort – Hillside Trail Inter-group Encounters

Hour of the Day	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	*Total*
9:00	2	3	1	1	5	3	2	17
10:00	1	3	2	3	8	3	1	21
11:00	4	3	2	2	9	2	2	24
12:00	5	6	1	2	11	5	4	34
13:00	3	5	1	1	8	7	2	27
14:00	3	3	1	2	6	5	3	23
15:00	2	2	-	-	1	3	-	8
16:00	2	1	-	-	2	4	-	9
17:00	1	1	-	-	1	1	-	4
Total	**23**	**27**	**8**	**11**	**51**	**33**	**14**	**167**

The daily average number of inter-group encounters while hiking on the Hillside Trail ranges between 18 and 24 (Figure 10). Daily average encounters is highest on Sundays, however there are no statistical differences among daily average inter-group encounters, by day of the week ($F=0.790$, $p=0.579$).

Figure 10. Daily Average Inter-group Encounters on the Hillside Trail, by Day of the Week



Percentages are reported in Table 22 to document the frequency with which various visitor encounter levels are exceeded on the Hillside Trail. Overall, 50% of groups observed had more than 19 encounters with other groups while hiking on the Hillside Trail; on weekends, 50% of groups observed had more than 22 encounters with other groups. Across all days of the week, 10% of groups observed had more than 40 inter-group encounters while hiking on the Hillside Trail; on weekends, 10% of groups observed had more than 41 encounters with other groups. The maximum number of inter-group encounters any visitor group was observed to have was 65.

Table 22. Percent Time in Excess of Inter-group Encounters on the Hillside Trail, by Day of Week Category

Percent	All Days	Weekdays	Weekends
75%	10	9	13
50%	19	16	22
25%	29	28	29
10%	40	39	41
Maximum	65	52	65

Weekends and weekdays do not differ significantly, with respect to the hourly average number of inter-group encounters visitors have while hiking on the Hillside Trail (Table 23 and

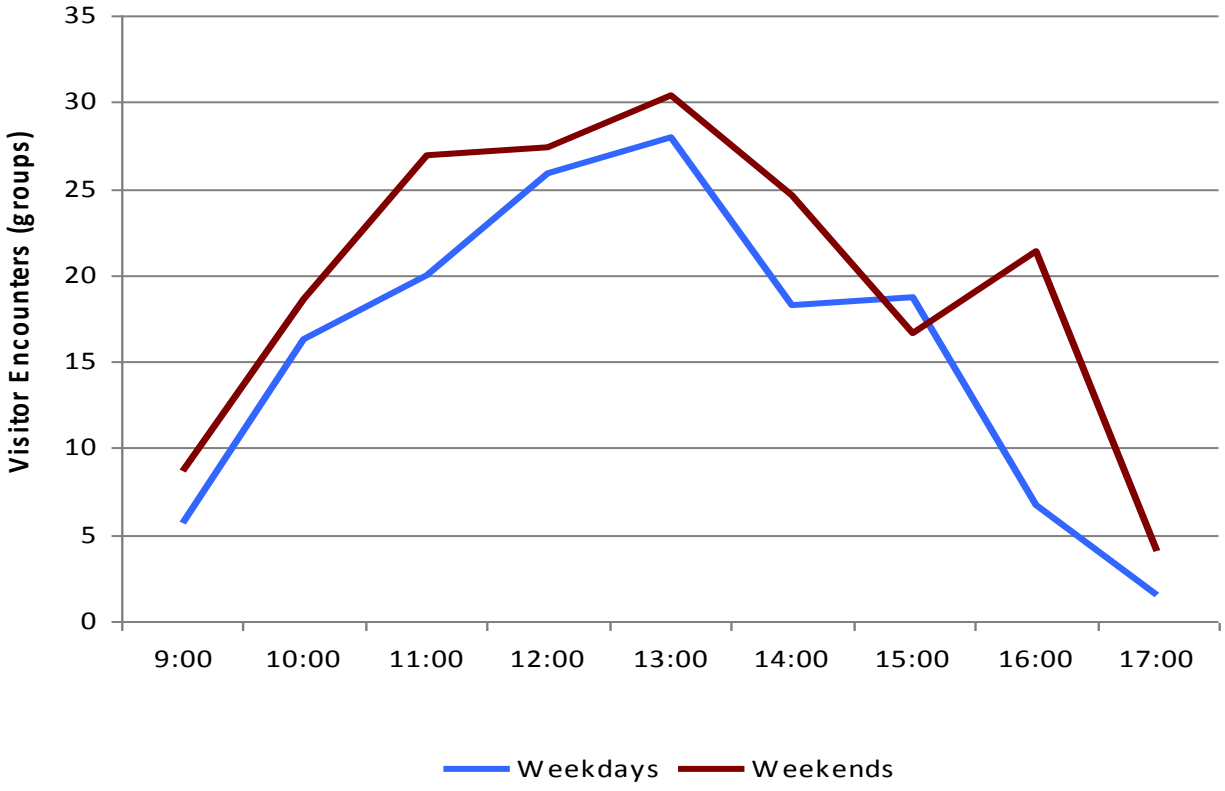
Figure 5).

Table 23. Hourly Average Inter-group Encounters on the Hillside Trail

Hour of the Day	Weekdays	Weekends
9:00	5.70	8.71
10:00	16.31	18.60
11:00	20.00	26.88
12:00	25.90	27.43
13:00	27.93	30.33
14:00	18.25	24.64
15:00	18.67	16.60
16:00	6.67	21.33
17:00	1.50	4.00

*** Denotes statistically significant difference at α = 0.05**

Figure 11. Hourly Average Inter-group Encounters on the Hillside Trail, by Day of Week Category



Results of ANOVA post-hoc tests suggest that the peak period of visitor use and associated inter-group encounters on the Hillside Trail is between the hours of 10 AM and 5 PM (Table 24).

Table 24. Hourly Average Inter-group encounters on the Hillside Trail, by Statistically Different Hours

Hour of the Day	Statistically Different Grouping at α=0.05		
9:00	6.94	6.94	-
10:00	16.86	16.86	16.86
11:00	-	-	22.29
12:00	-	-	26.53
13:00	-	-	29.00
14:00	-	21.30	21.30
15:00	17.38	17.38	17.38
16:00	16.44	16.44	16.44
17:00	2.75	-	-

Section 3 Simulation Model Data and Methods

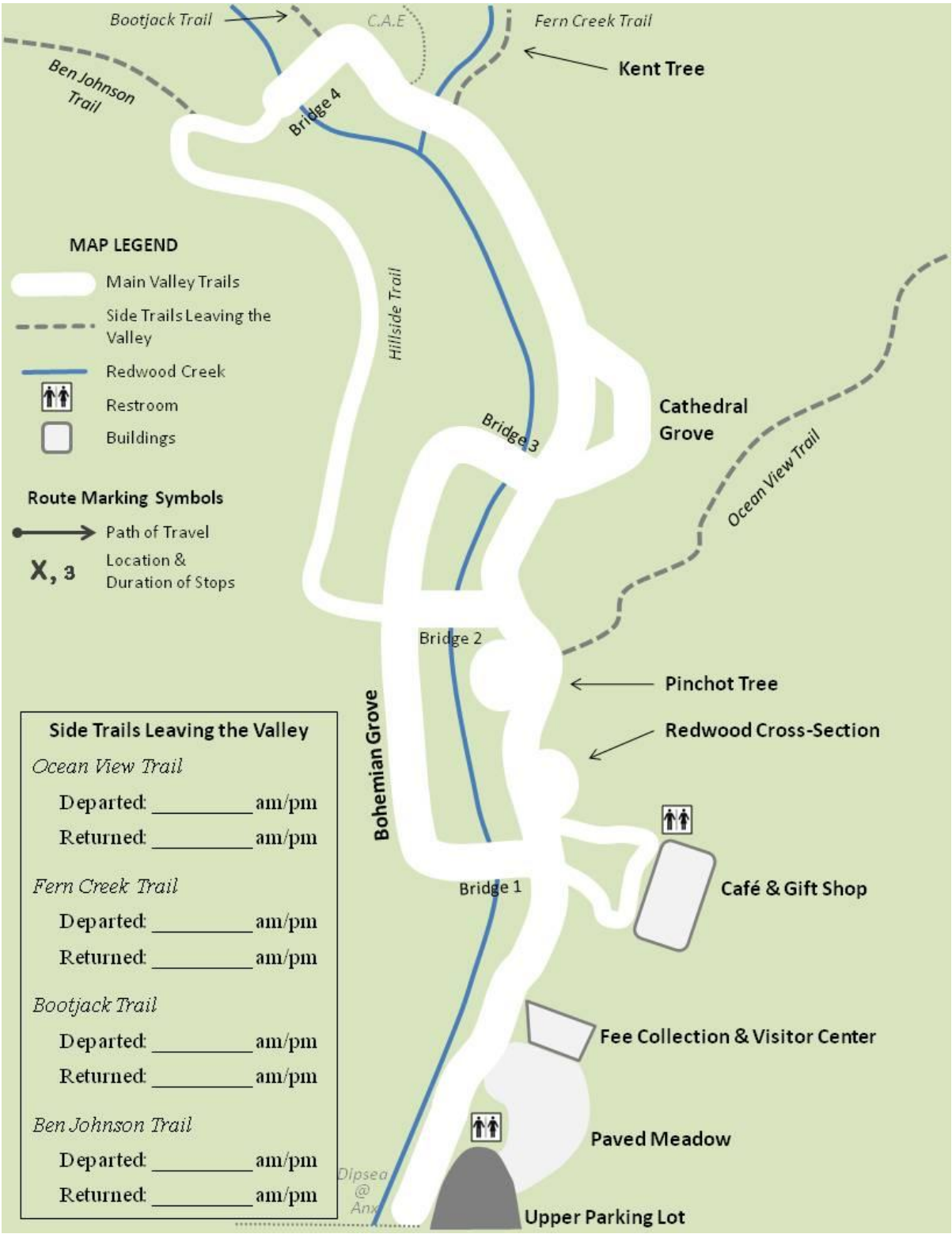
The simulation model developed for this study is a representation of Muir Woods and the movement of visitors through the monument's trail network and facilities. Several types of data inputs are required to construct and operate the model. The sources of these inputs, their organization and the methods used to prepare them for use in the simulation model are presented in this section of the report.

3.1 Study Site

Muir Woods and its facilities are arranged along the Redwood Creek, which flows along the valley's floor. Figure 12 presents the map of Muir Woods used to describe and conceptualize the woods for the purposes of this study. While the map is not drawn to scale, it reflects the essential organization and key components of Muir Woods. For reference, Redwood Creek flows from the top of the map to the bottom, where the narrow valley contained within the national monument opens to adjoin California state park land. Muir Woods Road passes by the opening of the valley and is the only public road access to the monument. Visitors arriving by car park in one of two parking lots or along the road to the southwest. The upper parking lot, the closest lot to Muir Woods, appears at the bottom of the map. Tour and shuttle buses deliver visitors to the upper parking lot and visitors arriving by bicycle must ride through the lot to enter. All visitors, beside the few who hike backcountry trails into Muir Woods, arrive in some way via the upper parking lot. Upon arriving, visitors pass through a former parking lot turned interpretive and gathering area here referred to as the paved meadow. To enter Muir Woods proper, visitors must pass by the entrance station where a fee is collected from 8:00 AM – 6:00 PM. The entrance station also houses a small visitor center and book shop. Immediately after the entrance station visitors pass under the monument's arch and enter Muir Woods.

Muir Woods, as conceptualized by this study, has three primary types of visitor use areas. These are the main network of trails, side trails, and interpretive sites and visitor facilities. The main network of trails provides access to the central resources of Muir Woods and accommodates the majority of visitor use. A number of side trails depart the main network trails, climb out of the valley, and lead visitors out of Muir Woods into a variety of adjoining public lands. Side trails receive substantially less use than the main trail network. Interpretive sites and visitors facilities are areas, rather than lineal features like trails, areas in which visitors gather for a variety of reasons. Some of these areas overlay sections of the main trail network, others are distinct spaces separate from trail features.

Figure 12. Muir Woods conceptual and route map



Visitors experience Muir Woods from its trail network. The main network of trails extends about one mile into the valley following Redwood Creek. These trails are represented as white lines in Figure 12. The main network of trails has two elements, the valley floor trails and the Hillside Trail. The valley floor trails, depicted by the broad white lines, are paved or boardwalk, approximately 10 feet wide, laterally confined and often lined with interpretive signage and benches. These trails follow the entire length of the valley floor on the east side of the creek and the lower reaches of the valley on the west side. The upper reaches of the valley on west side are accessed via the Hillside Trail. The Hillside Trail is a natural surface trail, constructed along a contour some distance above the valley floor. It is depicted as a narrower white line in Figure 12. While the valley floor trails are built to accommodate large numbers of visitors and emphasize presentation of interpretive information, the Hillside trail is narrow and intended to provide a contrast and change of perspective from the more developed and populated valley floor trails. Four footbridges cross Redwood creak and provide connectivity among the main network of trails on the valley floor. Most visitor use occurs on the main valley floor and Hillside trails.

A number of side trails connect to the main trail network. These side trails, which include the Ocean View, Fern Creek, Camp Alice Eastwood, Bootjack, and Ben Johnson Trails, are depicted as gray dashed lines in Figure 12. Side trails are natural surface hiking trails that ascend from the Redwood Creek valley to the slopes of Mt. Tamaulipas above, where they connect with each other and/or other roads and trails that do not enter Muir Woods. The side trails enable visitors to take linger hikes departing from and returning to Muir Woods. Visitor use on the side trails is relatively light when compared to use levels on the main valley floor trails.

Interpretive sites and visitor facilities are concentrated mainly in the lower stretches of the valley. Interpretive sites are locations where managers seek to highlight monument resources and encourage visitors to pause or congregate so that interpretive information can be better communicated. This study designates five interpretive sites: the paved meadow, the redwood cross-section, the Pinchot Tree area, Cathedral Grove, and Bohemian Grove (Figure 12). With the exception of the paved meadow, each of these interpretive sites coincides with the valley floor trails and is characterized by widened areas of hardened trail surface with prominent informational signs and exhibits. In contrast with interpretive sites, visitor facilities are structures that house services within the monument. Visitor facilitates within the study area include the entrance station (fee collection & visitor center) and the café & gift shop. Unlike interpretive sites, visitor facilities do not coincide with the valley floor trails, but lie outside of the trail network. Most visitors pass through the interpretive sites and visitor facilities at some point during their visits to Muir Woods.

3.2 Indicators and Data

The purpose of this study is to support the implementation of indicators based management of visitor use in Muir Woods. The three indicators monitored and modeled here are: people at one time (PAOT), people per view (PPV), and trail encounter rate. PAOT is a measure of density within an area – the number of visitors in an area. PPV is a measure of visual density within a linear corridor – the number of others visible from a visitor's perspective along a trail. Unlike PAOT and PPV, trail encounter rate is an event based measure of visitor use. Trail encounter rate describes the number of others a subject visitor encounters during an analytical period – the number of other hikers passed and met while hiking a trail. PAOT, being an areal density measure, was monitored at the recreation sites within Muir Woods: the Redwood Cross Section and the Pinchot Tree. PPV, as a measure of linear density, was monitored along two sections of the valley floor trails, one section with interpretive signs and benches and one section without such features. Trail encounter rate was monitored on the Hillside Trail. In lower use setting, like the Hillside Trail, the experience of closeness with others occurs as a series discrete events rather than a continuous condition. Trail encounters, being an event based variable, is suited for this location. Conditions of these five variables were monitored and are reported by hour of day and day of week in Section 2 of this report. These estimates of the values for these variables under specific conditions of visitor use are the outputs of the simulation model.

Data collection was conducted during the months of June, July and August in 2009. The primary collection period took place over twenty days during which 5 data collectors worked simultaneously. The five staff persons were stationed, one each, at: the entrance to the paved meadow, the Redwood Cross Section, the Pinchot Tree, the valley floor trails, and the Hillside Trail. The collector stationed at the entrance to the paved meadow collected group sizes, tour bus arrivals, tour bus ridership, and trip routes. The data collectors stationed at the Redwood Cross Section, Pinchot Tree, and along the valley floor trails observed linger or travel times of visitors within the analyzed areas. The data collector working on the Hillside Trail unobtrusively followed hikers on the trail, recording the number of trail encounters experienced by the observed subject. In this manner, data collectors simultaneously collected data inputs required for development of the simulation model and monitored indicators for validation of the model. The specific dates and times of this data collection are listed in Section 2 of this document. In addition to these primary indicator locations, model inputs were collected at the paved meadow, the entrance station, on bridges crossing Redwood Creek, in Bohemian Grove, and at the Café & Gift Shop. The next two sections of this report outline the variables for which data was collected. This begins with a brief discussion of the indicator of quality modeled and monitored followed by an outline of the simulation model's input data and its sources.

This simulation model is designed to estimate conditions of the above indicator variables under current and alternative patterns of and visitor use. To create these estimates, the model generates visitor groups arriving by car, shuttle and tour bus, delays these groups as they move throughout the Muir Woods trail network, interpretive sites and facilities, and reports estimated conditions of the indicator variables during simulated use days. To do this, the model requires data inputs including arrival rates private vehicle, shuttle and tour bus visitors, sizes for visitor groups, routes by which visitors move through the woods, and distributions of the amount of time spent by visitors traveling trail sections and lingering at interpretive sites and facilities. What follows is an explanation of the discrete data inputs required to develop and drive the simulation model.

Shuttle Arrival Times

Shuttle arrival times describe the rate of shuttle busses arriving at Muir Woods. Shuttle arrival times, as defined and constant values, dictate to the simulation model the number of shuttle busses that arrive during a visitor day and the times during the day that these busses arrive. The arrival times, expressed as the minute of the day during which a shuttle arrives, are drawn from the Golden Gate Transit Route 66/Muir Woods shuttle bus schedule. Twenty-eight shuttle busses arrive between 10:00AM and 6:00PM on Saturdays, Sundays and summer holidays.

Shuttle Ridership Frequency

Shuttle ridership frequency describes the relative likelihood with which a shuttle bus will arrive carrying a specific number of individuals. Shuttle ridership frequency provides the distribution from which the simulation model stochastically selects a number of riders on each arriving shuttle bus. These frequencies originate in observed 2009 ridership data for the Route 66 buses supplied by Golden Gate Transit. To reflect changes in shuttle ridership throughout the day, ridership frequencies are grouped by hour. That is, each hour of the day has its own frequency table for shuttle ridership. The shuttle ridership frequencies represent the probability that a shuttle bus arriving during a given hour will be carrying any number of visitors.

Tour Bus Arrival Times

Tour bus arrival times describe the rate at which tour busses arrive at Muir Woods throughout the day. Tour bus arrival times, as defined and constant values, dictate to the simulation model the number of tour busses that arrive during a visitor day and the times during the day that these busses arrive. The arrival times, expressed as the minute of the day during which a tour bus arrives, were observed directly in the upper parking lot. A data collector logged the arrival time of each tour bus during the hours that route maps were administered (Table 25). Tour busses are commercial busses carrying independent groups or

individuals to Muir Woods whose only connection to each other is riding the bus: commercial busses chartered by exogenously organized groups are not considered tour busses. Tour bus arrival schedules were created by averaging the number of tour busses arriving per hour across sampling days. Three arrival schedules were created: weekday off-peak, weekday peak, and weekend. Weekdays include Monday, Tuesday, Wednesday and Thursday. Peak weekday hours include 9:00 AM to 12:00 PM and the 3:00 PM hour. Off-peak weekday hours are the 12:00 PM, 2:00 PM and 4:00 PM hours. Weekends include Friday, Saturday and Sunday. No tour busses were observed to arrive on weekdays during the 1:00PM hour, therefore there are no busses scheduled to arrive during this hour. The off-peak and peak hour designations are the result of statistical differences in tour bus ridership frequency, or the number of riders per tour bus, reported below.

Tour Bus Ridership Frequency

Tour bus ridership frequency describes the relative likelihood with which a tour bus will arrive carrying a specific number of individual. Tour bus ridership frequency provides the distribution from which the simulation model stochastically selects a number of riders to assign to each tour bus arriving at Muir Woods. These frequency distributions originate from on-site observation. As part of the same exercise, the data collector observing tour bus arrival times collected ridership numbers from the tour busses' drivers. These ridership counts were averaged by hour across weekdays and weekend days. No statistical differences were found between hours of the day on weekends. On weekdays, tour busses arriving during the hours of 9:00AM, 10:00AM, 11:00AM & 3:00OPM had significantly higher average ridership than tour busses arriving during the hours of 12:00PM, 2:00PM and 4:00PM ($F = 4.330$, $\alpha<0.001$). The tour bus ridership frequencies represent the probability that a tour bus arriving during a given day and hour will be carrying any number of visitors.

Private Vehicle Interarrival Times

Private vehicle interarrival times describe the interval of time between the arrival of private vehicles to Muir Woods. For example: if an average of two private vehicles arrive every minute, the interarrival time would be 30 seconds; if 16 vehicle arrive in an hour, the interarrival time would be 3 minutes and 45 seconds. Private vehicle interarrival times for Muir Woods are calculated using fee collection data from the Golden Gate National Parks Conservancy, Golden Gate Transit's Route 66 ridership data discussed above, and this study's observations of tour bus arrivals. The calculation begins with the assumption that all visitors to Muir Woods arrive by car, shuttle or tour bus. While some visitors do walk or bike to the Monument, this number is both practically insignificant and inconsequential for the purposes of the model. Using their entrance fee collection system and its sales database, Golden Gate National Parks Conservancy counted the number of individuals entering the gateway of Muir Woods during the summer of 2009. These counts represent the total number of all individuals arriving at Muir Woods by hour and day. They are understood to include private vehicle, shuttle and tour bus arrivals. When the number of visitors arriving by shuttle is subtracted from this total arrival counts, the number of visitors arriving by private vehicle and tour bus remain. From this value, the number of visitors arriving by private vehicle is generated by subtracting tour bus arrivals. The average number of tour bus riders by hour of day and weekday vs. weekend, from the above described observations, was applied throughout the period for which entrance station fee data and shuttle ridership data was available (6-24-09 through 8-14-09). The arrivals remaining after subtraction of shuttle and tour bus riders is the number of visitors arriving to Muir Woods by private vehicle. This number of individuals arriving by private vehicle, grouped by hour and weekday vs. weekend, is divided by the average group size, discussed below, to yield private vehicle groups arriving per hour. The 60 minutes of an hour are then divided by the number of private vehicle groups arriving per hour to create private vehicle interarrival times expressed in minutes.

Group Size Frequency

Group size frequency describes the relative likelihood that a group arriving by any mode (private vehicle, shuttle, tour bus) will be of a specific size. That is, the likelihood that an arriving group will consist of any

single number of individuals. Group size frequencies provide the distribution from which the simulation model stochastically selects the number of individuals of which a group visiting Muir Woods will consist. These frequencies originate from observations of group size collected during the administration of route maps (described below). Three group size frequency distributions were developed, one each for the three modes of arrival. The private vehicle group size frequency reflects only those visitor groups arriving via private vehicle. Because of a relative paucity of visitors arriving by shuttle and tour bus within the route map data set, group size frequency distributions for those modes were created by combining the mode specific group sizes with those groups arriving by private vehicle. That is, the shuttle group size distribution combines groups arriving by shuttle and private vehicle and the tour bus group size distribution combines groups arriving by both tour bus and private vehicle when developing the respective group size frequencies.

Routes

Visitor groups are routed within the simulations model based the frequency of routes taken by visitors documented by route maps. At ten minute intervals between the hours of 9:00 AM and 4:00 PM, visitor groups arriving at the entrance to the Paved Meadow were solicited to carry the study's map of Muir Woods and track their route as they went. While on the main trail network, visitors traced a line along the trails they traveled, using arrow heads to indicate direction. If the respondent group hiked side trails leaving the main trail network, they were instructed to record the times of departure from and return to the main trail network. During the recruitment process, route map administrator also collected information on the group's size and mode of arrival. The map administrator remained on-site to collect maps from departing visitors until two hours after the end of distribution. When those visitors who declined to complete a route map because they were members of a tour group are removed from the response rate calculation, 53.7% of solicited visitors agreed to participate and complete a route map. Table 25 summarizes the route map sampling effort.

Table 25. Route Map Sampling Effort

	Day of Week							
Hour	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Total**
9:00	6	18	6	0	6	6	12	54
10:00	6	18	6	0	10	6	12	58
11:00	12	12	6	0	12	6	12	60
12:00	24	14	6	6	18	17	18	103
1:00	18	6	0	6	12	12	6	60
2:00	18	5	0	6	12	12	6	59
3:00	18	1	0	6	12	12	6	55
4:00	1	0	0	0	1	0	0	2
Total	103	74	24	24	83	71	72	451

Complete route maps are raw data. To be usable for modeling, the information they contain must be coded and transformed. The simulation model routes visitor groups through Muir Woods' trail network via a node pair system. Expressed in node pairs, a route transforms from a continuous sequence to a series of form-to combinations. A visitor's route that goes from Place 1 to Place 2 to Place 3 become, when expressed as node pairs, the series of pairs: from 1 to 2; from 2 to 3. To transform route map data to node pairs, nodes must be designated corresponding with trail segments, intersections, interpretive sites, and facilities. Figure 13 presents the nodes designated in Muir Woods and used to encode visitor routes. It should be noted that the code 99 is an exit code, designating a route's end. The range of routes visitors take can be described with unique combinations of these numbers into node pairs. Two examples will help to illustrate the process. Figure 14 presents route #202. This route, like all routes, begins after the visitors pass through the fee collection station. The visitors pass through the Redwood Cross Section and Pinchot Tree areas, proceed to Bridge 3 and the Cathedral Grove, before crossing Bridge 4, hiking the Hillside Trail, returning to the interpretive sites via Bridge 5, and finally visiting Café & Gift Shop before departing. Coded as a sequence of node numbers, this route would be: 16, 18, 2, 6, 8, 9, 12, 21, 7, 5, 6, 2, 3, 99. This sequence of node codes is transformed in to a series of node pairs that define route #202. Route #405, depicted in Figure 15, is similar to route #202 but includes an excursion from the main trail network onto a side trail. This excursion is noted both with the node code 13, but also with times of departure from and return to the main trail network. As a sequence of nodes, route #405 is: 16, 18, 3, 2, 6, 9, 13, 13, 12, 21, 7, 4, 1, 3, 99.

Table 26. Route #202 Node Pairs

From	To
16	18
18	2
2	6
6	8
8	9
9	12
12	21
21	7
7	5
5	6
6	2
2	3
3	99

Table 27. Route #405 Node Pairs

From	To
16	18
18	3
3	2
2	6
6	9
9	13
13	13
13	12
12	21
21	7
7	4
4	1
1	3
3	99

Figure 13. Route Map Nodes

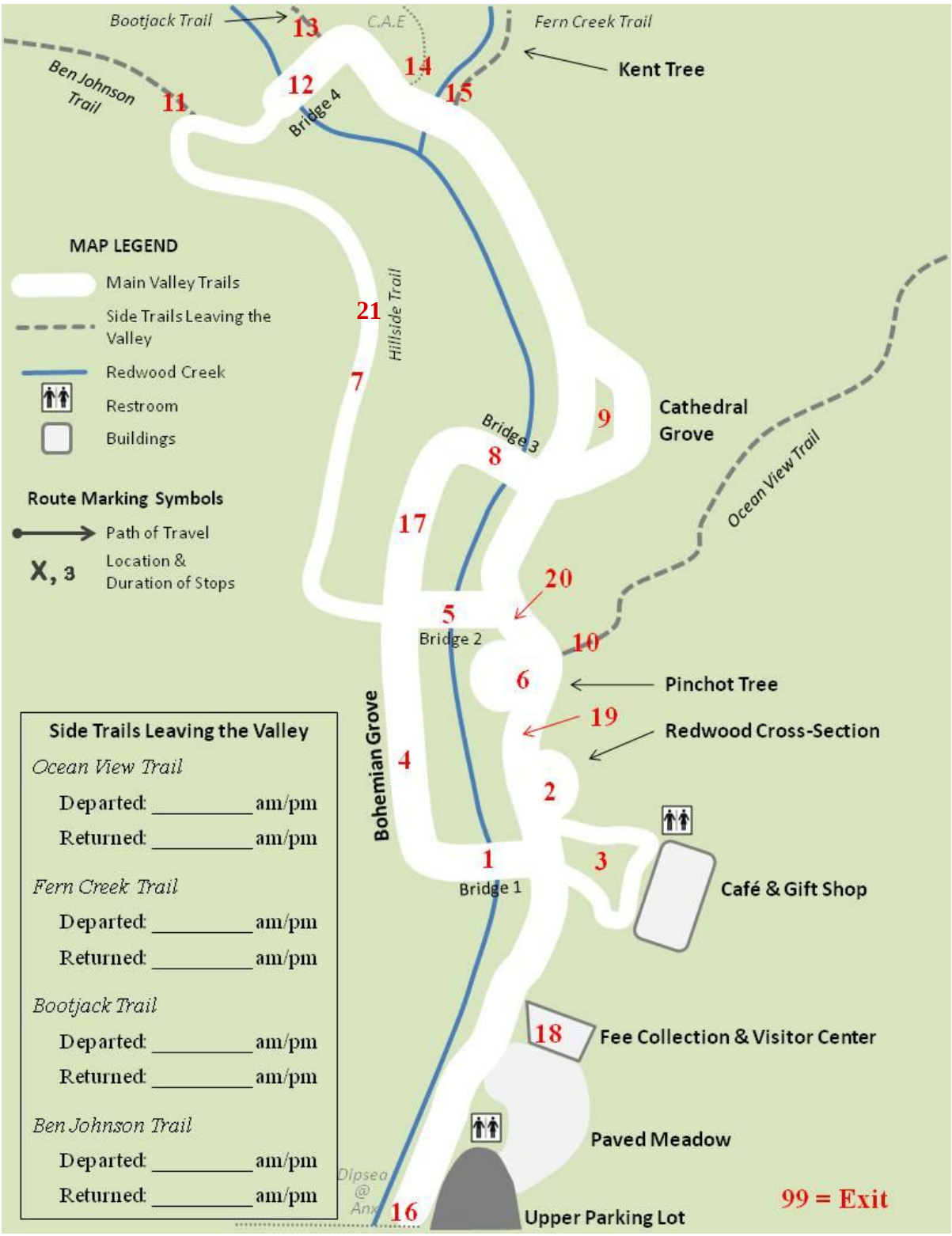
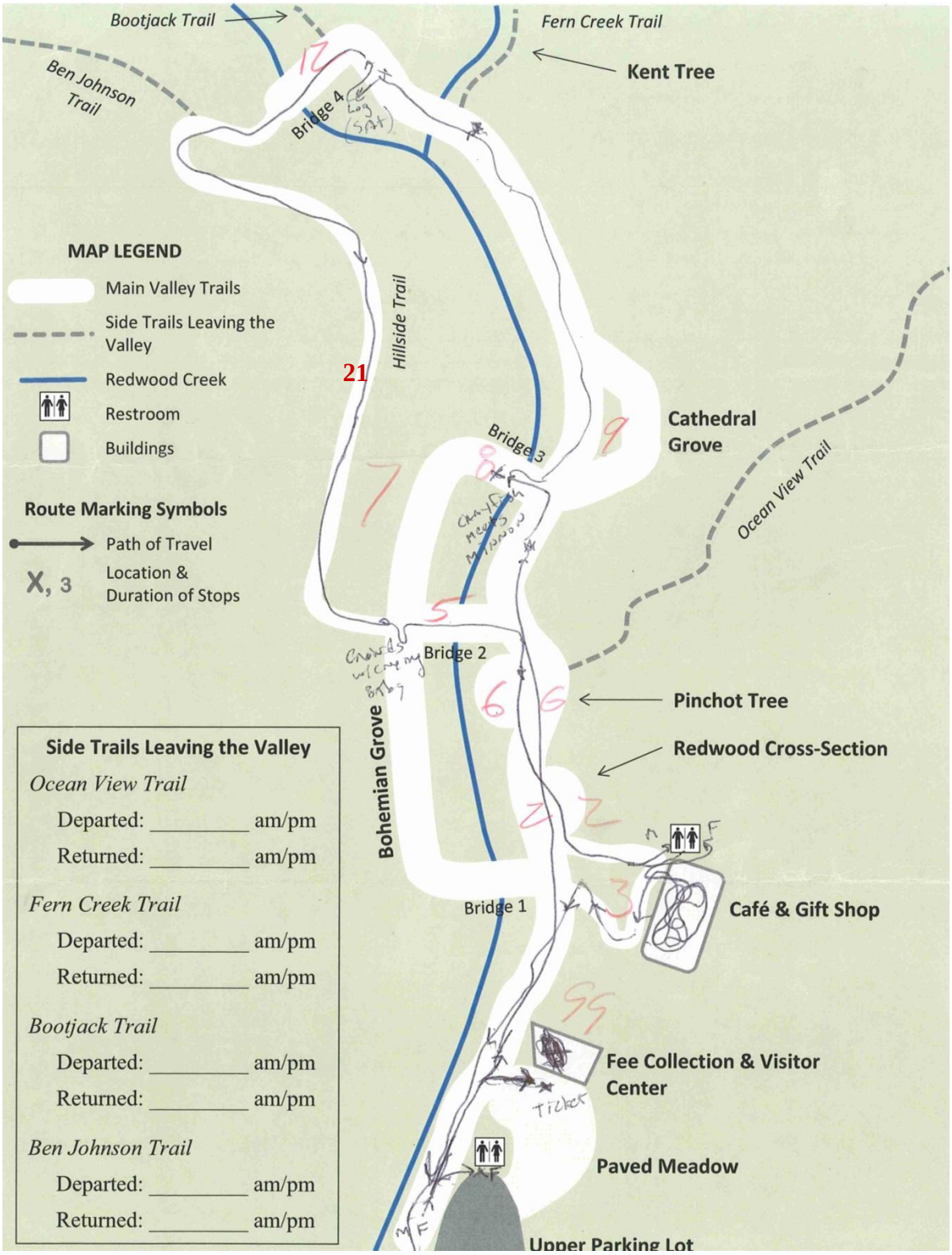
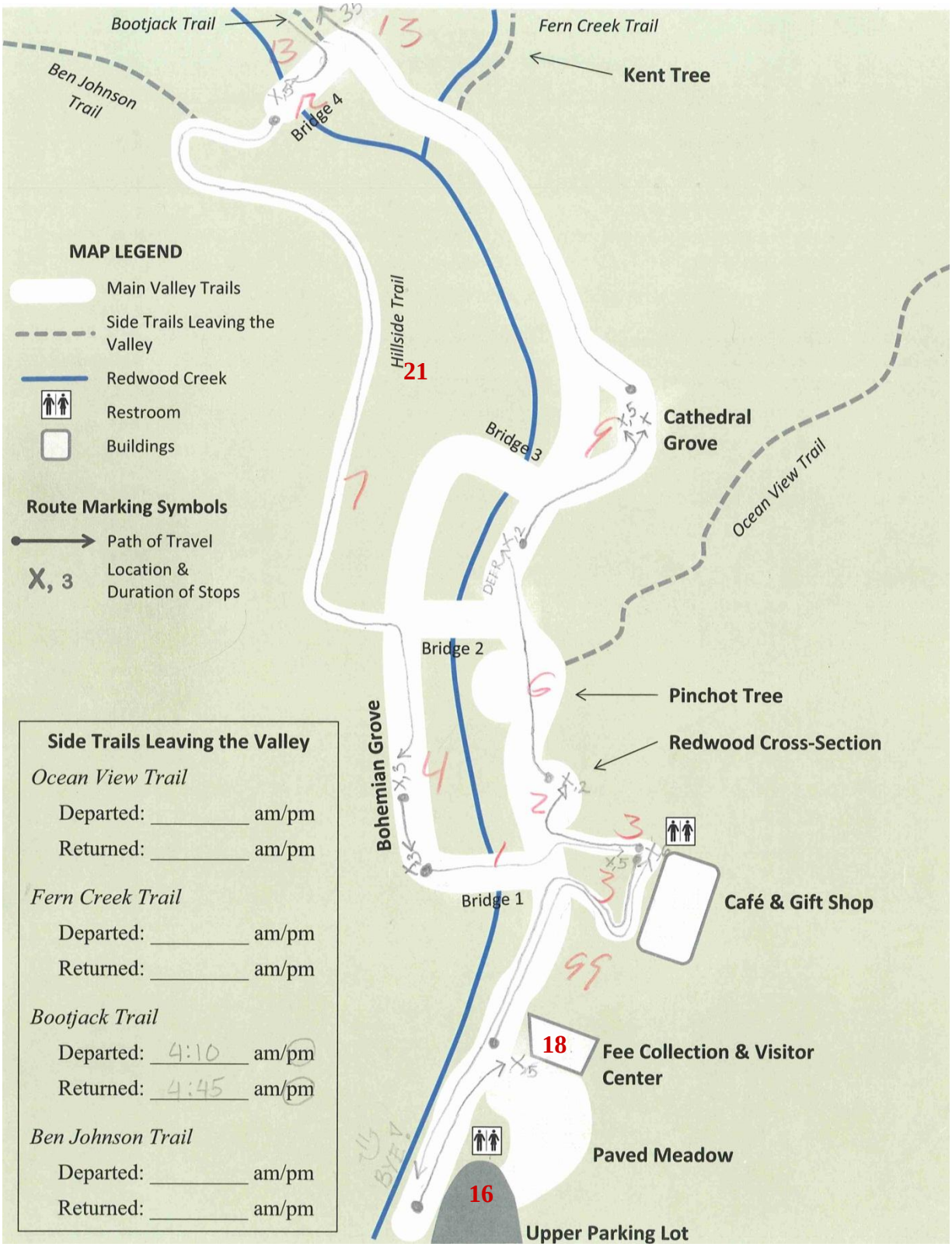


Figure 14. Route 202



Note: Node 16, 18 & 21 were added after initial coding of route maps.

Figure 15. Route 405



Note: Node 16, 18 & 21 were added after initial coding of route maps.

Two frequency distributions of are used to assign routes to visitor groups upon their arrival to Muir Woods in the simulation model. One of these distributions assigns routes to visitor groups arriving by private vehicle and shuttle. The other distribution is used to assign routes to groups arriving by tour bus. The private vehicle and shuttle distribution contains all routes collected from visitors who arrived by private vehicle and shuttle. The tour bus distribution contains all routes collected from visitors who arrived by tour bus and private vehicle routes that are less than two hours in total duration. Routes assigned to visitors arriving by tour bus are limited at two hours to reflect the time constraints associated with typical tour bus stays at the woods. Every visitor group within the model has an equal chance of being assigned any given route from the appropriate distribution. In the simulation model, each unique route is referred to as a Trip ID.

Delay Time Distributions

While the routing procedure described above define the spatial sequence simulated visitors groups follow through Muir Woods, the time spent by each group traveling a trail segment or lingering at an interpretive site or facility is assigned from the delay time distributions. These times were collected from unobtrusive observations of visitor groups at the paved meadow, the fee collection station, valley floor trail, Hillside Trail, Bridge 2, Bohemian Grove, Redwood Cross-Section, Pinchot Tree area, and Café & Gift Shop. An additional set of delay times for the amount of time spend by visitors hiking side trails was collected from route maps. Similarly to group size and routes, travel times are assigned to simulated groups probabilistically from distributions, however, unlike the other distributions, delay times are continuous variables. Rather than having a discrete probability for each possible delay time, the probabilistic distributions for delay times are defined by the sample's mean and standard deviation. For each time delayed activity modeled (i.e. lingering in the Paved Meadow or traveling the Hillside Trail) extreme outliers were removed from the dataset before analysis. The remaining data was aggregated by group size, direction of travel, entrance location and exit location, as appropriate, and tested for statistical differences in mean delay time. Statistical difference between mean delay times incorporated into the simulation model are listed in Table 28, Table 29,

Table 30, and

Table 31, respectively. Along with the delay times obtained from observation of visitor behaviors, delay times defining the amount of time spent by visitors lingering on side trails were extracted from the route map data. These delays were grouped geographically according to the side trail excursion's location of departure from and return to the main trail network. Table 32 presents the time distributions employed to delay simulated visitor groups along their routes through Muir Woods.

Table 28: Delay Times in the Paved Meadow and Linger Times along the Valley Trail

Activity	**Small Group (1-3 people)**		**Large Group (4-10 people)**		***T***	***p*-value**
	Mean	N	Mean	N		
Paved Meadow Linger	00:03:14	81	00:05:00	44	-3.037	= 0.003
Valley Trail Travel[1]	00:00:01.59	289	00:00:01.98	162	-4.726	< 0.001

[1] Mean & Standard Deviation travel times are expressed as time/meter of trail traveled.

Table 29. Delay Time Statistical Difference by Direction of Travel

Activity	Inbound (Entrance → Bridge 4)		Outbound (Bridge 4 → Entrance)		*T*	*p*-value
	Mean	N	Mean	N		
Hillside Trail Travel[1]	00:00:01.33	70	00:00:01.17	98	3.267	= 0.001
Bohemian Grove Linger	00:02:09	46	00:01:23	79	3.307	= 0.01
Redwood X-Sec. Linger	00:01:26	856	00:00:38	396	12.802	< 0.001
Pinchot Tree Linger	00:01:16	811	00:00:35	413	10.625	< 0.001

[1] Mean & Standard Deviation travel times are expressed as time/meter of trail traveled.

Table 30. Delay Time Statistical Difference by Entrance Location

Activity	Enter at Visitor Center		Enter at Ticket Window		*T*	*p*-value
	Mean	N	Mean	N		
Fee Collection Linger	00:03:06	9	00:01:28	237	2.142	= 0.05

Table 31. Delay Time Statistical Difference by Exit Location

Activity	Exit toward Bridge 1		Exit toward Redwood X-Sec.		*T*	*p*-value
	Mean	N	Mean	N		
Café & Gift Shop Linger	00:12:31	136	00:16:26	237	-2.639	= 0.009

Table 32. Delay Time Distribution Parameters

Activity	Group Type/Direction of Travel	n	Mean[1]		Std Dev
Paved Meadow Linger	Small group (1-3 People)	81	00:03:14	a	00:02:17
	Large group (4-10 People)	44	00:05:00	b	00:04:16
Fee Collection Linger	Enter @ Visitor Center	9	00:03:06	a	00:01:48
	Enter @ Ticket Counter	237	00:01:28	b	00:01:29
Valley Trail Travel[2]	Small group (1-3 People)	289	00:00:01.59	a	00:00:00.90
	Large group (4-10 People)	162	00:00:01.98	b	00:00:00.92
Hillside Trail Travel[2]	Inbound	70	00:00:01.33	a	00:00:00.36
	Outbound	98	00:00:01.17	b	00:00:00.27
Bridge Linger	All groups	440	00:00:33		00:00:39
Bohemian Grove Linger	Inbound	46	00:02:09	a	00:01:25
	Outbound	79	00:01:23	b	00:01:09
Redwood Cross-Section Linger	Inbound	856	00:01:26	a	00:01:00
	Outbound	396	00:00:38	b	00:00:44
Pinchot Tree Linger	Inbound	811	00:01:16	a	00:01:03
	Outbound	413	00:00:35	b	00:00:47
Café & Gift Shop Linger	Stairs / to Bridge 1	136	00:12:31	a	00:10:21
	Ramp / to Redwood XC	87	00:16:26	b	00:11:07
Side Trail Linger[3]	10-10	39	00:53:00		00:48:00
	15-15	51	00:22:00		00:27:00
	10-14, 10-15, 15-10	34	01:32:00		00:37:00
	11-11, 11-13, 11-16, 13-13, 13-16, 14-13, 14-14, 15-11, 15-13, 15-14	36	00:54:00		00:44:00

[1] Superscripts denote statistical differences between mean delay times.
[2] Mean & standard deviation travel times are expressed as time/meter of trail traveled.
[3] Side trial linger times grouped by routing node pair.

Section 4 Simulation Modeling Existing Conditions

4.1 Model Overview

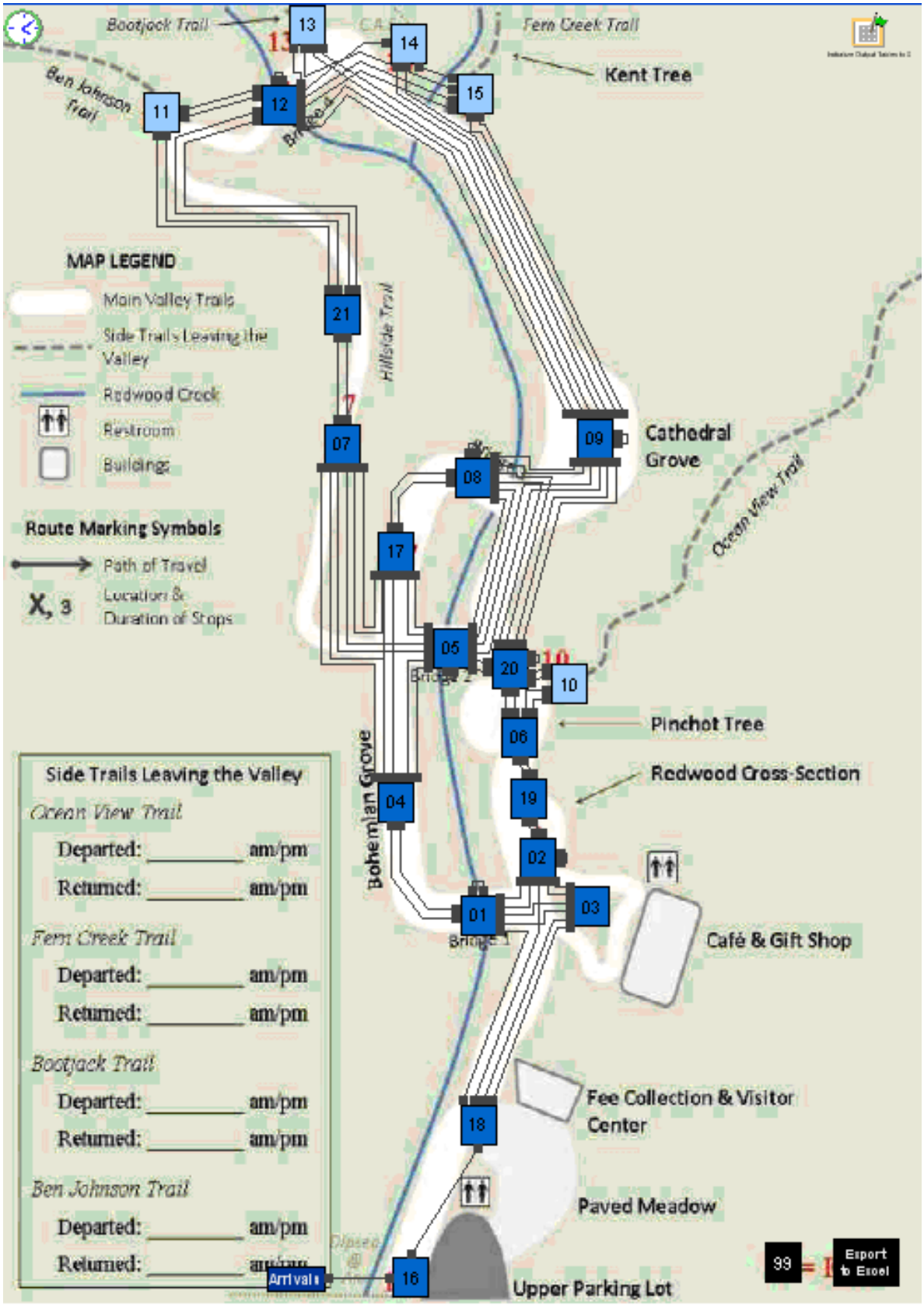
This chapter of the report presents the methods used to develop a computer simulation model of visitor use on the Muir Woods Trail and associated descriptive results. The chapter begins by describing the model algorithm and programming. Model results are then compared with data from observations conducted in summer 2009.

4.2 Model Algorithm and Programming

The computer simulation model of visitor use on the Half Dome Trail and cables route was developed using Extend v.7 (2007) discrete-event systems simulation software. The structure of the model consists of hierarchical blocks (H-blocks) that: 1) simulate visitor use and behavior on the Muir Woods trail; 2) monitor people at one time (PAOT) at points of interest (i.e., Redwood Cross-Section and Pinchot Tree; 3) monitor people per view (PPV) on a 50-meter section of trail designated as an interpretive route and a 50-meter section of trail designated as a through route; and 4) monitor intergroup encounters on the Hillside Trail. Each type of hierarchical block contained within the study model is described in the following paragraphs.

An overview of the model is shown in Figure 16.

Figure 16. Model Overview



Arrivals H-Block

The Arrivals H-block used within the study model to generate simulated visitor groups who arrived via private vehicle is shown in Figure 17. Visitor group arrival rates (interarrivals) within the model vary by time of day and are based on the visitor counts at Muir Woods during summer 2009. The arrival rates specified within the model can be "ramped up" or "ramped down" to model changes in visitation from that measured during summer 2009.

Separate H-blocks are used to simulate visitor groups arriving via tour bus and shuttle bus, as shown in Figure 18. Existing ridership data for tour and shuttle buses were available for individuals, not groups. In order to convert individuals alighting from buses into groups, the model batched individuals into groups based on survey data. The blocks shown in Figure 18 generate individuals per bus according to the tour and shuttle bus schedules.

After visitor groups are generated, they are assigned Trip IDs and group sizes. As the Figure 16indicates, there are a variety of node combinations that could comprise a trip. Data collected in summer 2009 defined 408 different trips that occurred with varying frequencies. Trips IDs and group sizes are assigned randomly using empirical distributions.

Figure 19 illustrates the blocks used to assign Trip IDs and group sizes for private vehicle groups.

Node H-Blocks

After visitor groups are generated, they are routed within the model along a series of node blocks according to their Trip ID. At each node in their trip, they are assigned an attribute that tells them the next node they will be routed to and how long it will take them to travel to that node. Groups are then delayed for that amount of travel time before they arrive at the next node in their trip. Figure 20 illustrates the overall structure within each node block.

Figure 17. Private Vehicle Group Generation H-Block

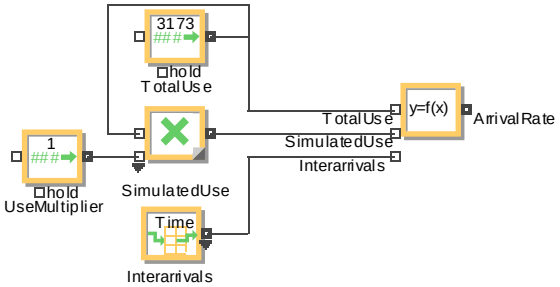


Figure 18. Tour and Shuttle Bus Group Generation H-Block

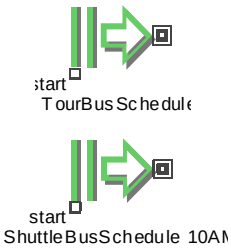


Figure 19. Private Vehicle Trip ID and Group Size Attribute Blocks

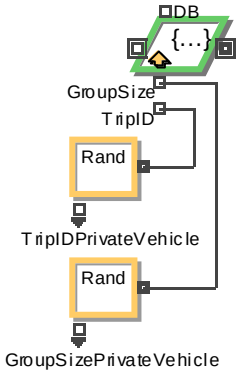


Figure 20. Node H-Block Structure

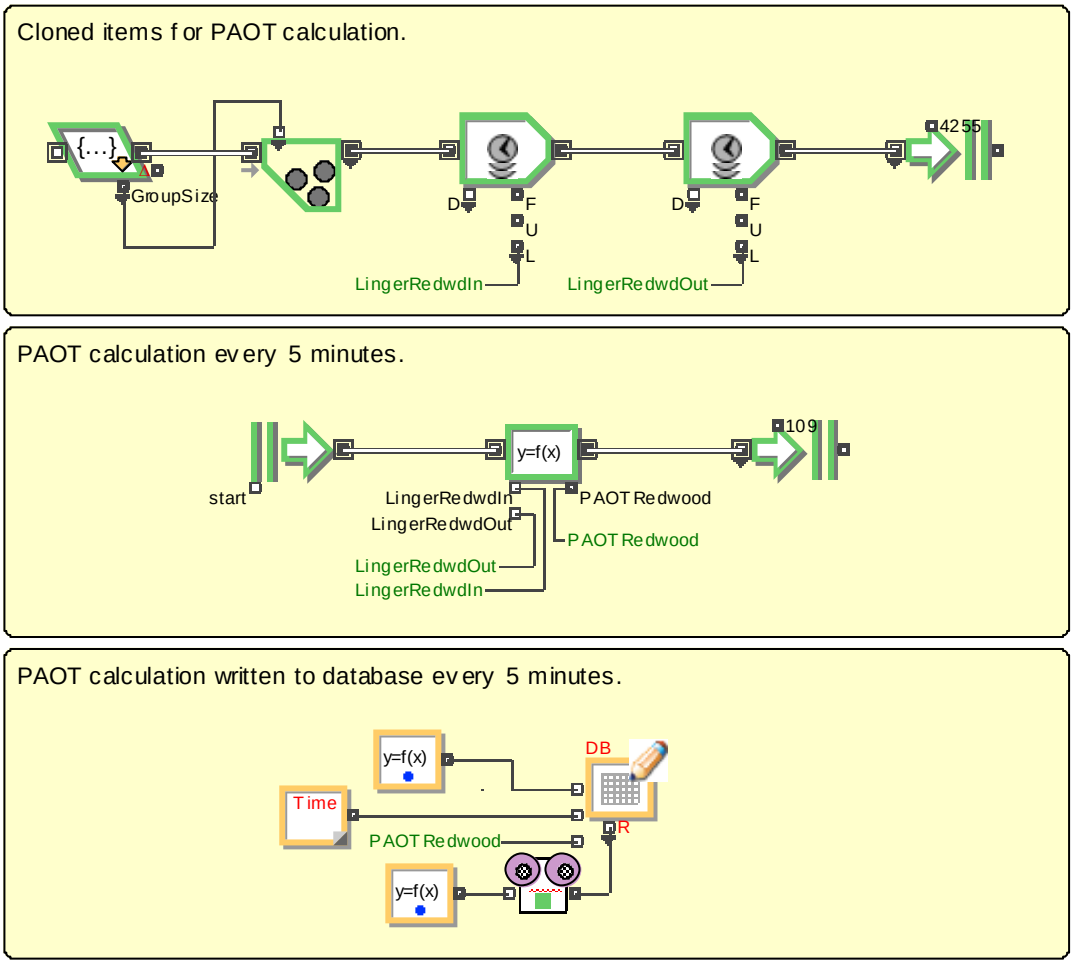
PAOT and PPV H-Blocks

For nodes that contain an indicator (PAOT or PPV) location, an additional block calculates the indicator data. PAOT H-blocks monitor the number of people in Redwood Cross-Section and Pinchot Tree area at one time at 5-minute intervals throughout the course of each simulated visitor use day. Similarly, PPV H-blocks monitor the number of people on a 50-meter section of trail designated as an interpretive route and a 50-meter section of trail designated as a through route at 5-minute intervals through the course of each simulated visitor use day.

PAOT is calculated by creating a copy of each visitor group that passes through the node. An example of the blocks within the PAOT H-block for Redwood Cross-Section is shown in Figure 21. Each visitor group is then unbatched into individuals, as the PAOT is a calculation of individual people, not groups. The individuals are delayed in the block according to their previously set delay time. The PAOT blocks calculate the number of people delayed in the area every five minutes and then write that number to a database that records the PAOT data for the entire day and over multiple model runs. The individuals used for the PAOT calculation are then exited out of the system since they are clones of groups that already exist within the system.

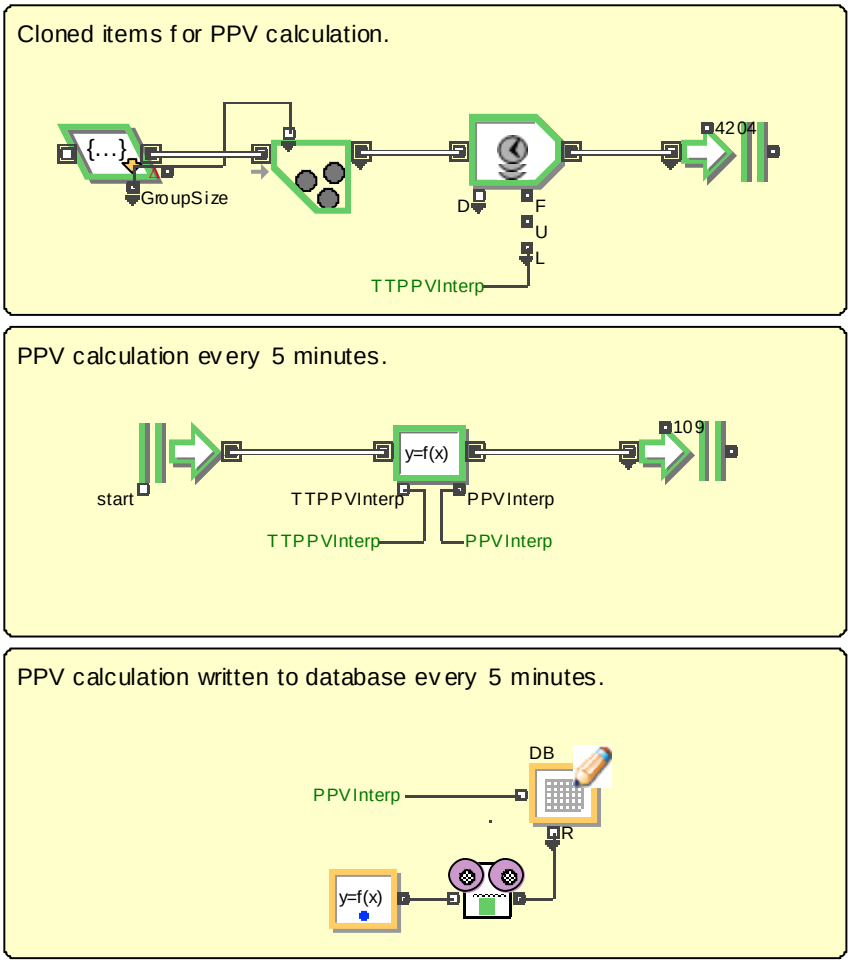
The PAOT data can be used to calculate the percentage of time within a simulated visitor use day user-specified standards of quality for PAOT in each area are exceeded. Thus, the PAOT H-block could be used as a key component of simulation analyses designed to estimate user capacities for both Redwood Cross-Section and Pinchot Tree.

Figure 21. Example PAOT Calculation Blocks – Redwood Cross-Section



The PPV H-block operates very similarly to the PAOT H-block. Figure 22 gives an example of the set of blocks that calculate the PPV value for a through trail segment. Groups are again cloned and unbatched into individuals. The individuals are delayed according to their previously set delay time and the PPV blocks calculate how many people are in that viewscape every five minutes over the course of the entire model day. The PPV data are written to a database that records the PPV over the day and over multiple runs.

Figure 22. Example PPV Calculation Blocks – Through Trail Segment

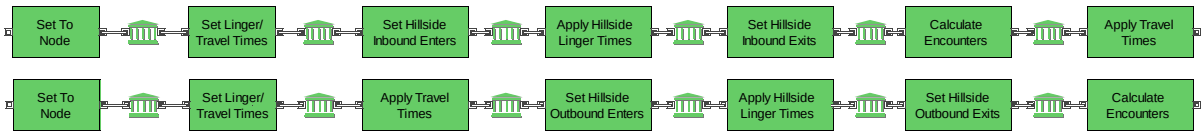


Encounters H-Blocks

A section of the Hillside Trail was analyzed for the mean number of encounters each visitor group encountered per visit to the Hillside Trail. Encounters consist of both meetings, where two groups headed in opposite directions pass one another, and overtakings, where two groups are headed in the same direction and one overtakes the other.

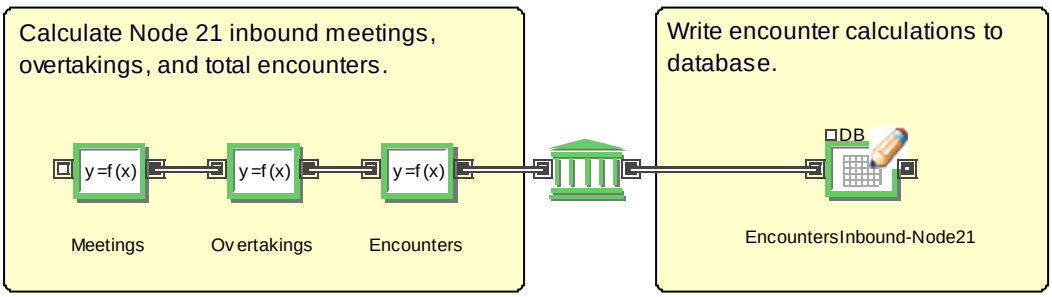
Figure 23 displays an example of the layout of a node that contains a calculation of encounters. In a standard node within the model, there are H-blocks for setting the *To Node*, setting the *Travel/Linger Times*, and applying the *Travel/Linger Times*. In a node that contains a calculation of encounters, the additional H-blocks set the time groups enter the Hillside Trail, the time groups exit the Hillside Trail, and calculate the number of encounters they experience while on the Hillside Trail.

Figure 23. Example Node with an Encounters Calculation H-Block



The time groups enter and exit the Hillside Trail segments are written to databases. A series of equations blocks (Figure 24) utilize those data to calculate the number of meetings and overtakings experienced by each group. The number of meetings and overtakings are summed to yield the number of encounters, and the number of meetings, overtakings, and encounters are then appended to the databases.

Figure 24. Example Encounters Calculation Blocks



4.3 Descriptive Results

Descriptive results from the simulation of summer 2009 visitor use at Muir Woods are reported in **Error! eference source not found.** and **Error! Reference source not found.**. In particular, **Error! Reference source not found.** reports the average number of people at one time: 1) in the subdome area; 2) on the Half Dome cables route; and 3) on the Half Dome summit. It should be noted that separate results were generated for Saturdays/holidays and Sundays/weekdays, as presented in **Error! Reference source not ound.**. **Error! Reference source not found.** reports model estimates of mean travel times to ascend and descend the cables route, by day of week category.

Use Levels and Group Size

Table 33. Individual Use Level, by Mode

	Entrance Station Data	Entrance Data on Indicator Observation Days	Model Estimates
Private Vehicle			
Mean (Std Dev)	3173 (285)	3148 (305)	3175(97)
N	20	10	100
Tour Bus			
Mean (Std Dev)	403 (48)	403 (51)	405 (49)
N	20	10	100
Shuttle Bus			
Mean (Std Dev)	446 (125)	390 (124)	476 (66)
N	15	8	100
Total			
Mean (Std Dev)	4022 (458)	3941 (480)	4057 (123)
N	55	28	100

* Statistically different from Entrance Station Data
** Statistically different from Entrance Data on Indicator Observation Days

Table 34. Mean Group Size, by Model

	Route Survey Data	Model Estimates
Private Vehicle		
Mean (Std Dev)	3.25 (1.61)	3.26 (1.62)
N	413	50,670
Tour Bus+PV		
Mean (Std Dev)	3.21 (1.60)	3.19 (1.57)
N	427	6,582
Shuttle Bus+PV		
Mean (Std Dev)	3.27 (1.62)	3.23 (1.62)
N	431	7,748

* Statistically different

Bus Ridership

Table 35. Mean Tour Bus Ridership, by Hour

	Indicator Observation Data	Model Estimates
9:00 AM		
Mean (Std Dev)	21.35 (8.73)	17.98 (3.60)
N	26	100
10:00 AM		
Mean (Std Dev)	21.28 (11.63)	18.60 (4.81)
N	18	100
11:00 AM		
Mean (Std Dev)	15.00 (10.82)	18.93 (10.15)
N	3	100
12:00 PM		
Mean (Std Dev)	13.11 (7.36)	19.67 (10.75)
N	9	100
1:00 PM*		
Mean (Std Dev)	13.75 (9.18)	. (.)
N	4	.
2:00 PM		
Mean (Std Dev)	16.34 (10.28)	18.43 (5.46)
N	38	100
3:00 PM		
Mean (Std Dev)	19.75 (10.64)	18.17 (6.67)
N	20	100
4:00 PM*		
Mean (Std Dev)	8.20 (6.76)	19.79 (10.45)
N	5	100
5:00 PM		
Mean (Std Dev)	. (.)	. (.)
N	.	.
Total		
Mean (Std Dev)	18.33 (10.41)	18.79 (7.91)
N	236	700

* Statistically different

Table 36. Mean Shuttle Bus Ridership, by Hour

	Transit Service Data	Model Estimates
9:00 AM		
Mean (Std Dev)	. (.)	. (.)
N	.	.
10:00 AM		
Mean (Std Dev)	13.93 (15.99)	13.55 (8.13)
N	43	100
11:00 AM		
Mean (Std Dev)	22.76 (12.74)	22.89 (7.16)
N	42	100
12:00 PM		
Mean (Std Dev)	23.73 (13.58)	24.10 (7.55)
N	56	100
1:00 PM		
Mean (Std Dev)	20.47 (12.56)	20.13 (4.82)
N	70	100
2:00 PM		
Mean (Std Dev)	20.13 (13.49)	21.17 (6.90)
N	54	100
3:00 PM		
Mean (Std Dev)	13.49 (11.14)	12.42 (6.63)
N	45	100
4:00 PM		
Mean (Std Dev)	8.79 (11.52)	9.00 (5.98)
N	58	100
5:00 PM		
Mean (Std Dev)	4.07 (6.31)	3.88 (3.30)
N	42	100
Total		
Mean (Std Dev)	16.43 (4.98)	15.89 (9.39)
N	15	800

* Statistically different

PAOT and PPV

Table 37. Hourly PAOT at Redwood Cross-Section

	Indicator Observation Data	Model Estimates
9:00 AM		
Mean (Std Dev)	6.28 (4.79)	7.21 (5.91)
N	10	100
10:00 AM		
Mean (Std Dev)	12.65 (7.08)	14.78 (8.45)
N	11	100
11:00 AM*		
Mean (Std Dev)	12.50 (6.67)	18.93 (9.02)
N	10	100
12:00 PM*		
Mean (Std Dev)	14.38 (6.99)	21.30 (9.82)
N	19	100
1:00 PM		
Mean (Std Dev)	16.66 (6.91)	20.79 (9.16)
N	19	100
2:00 PM*		
Mean (Std Dev)	15.08 (6.73)	20.56 (9.30)
N	18	100
3:00 PM		
Mean (Std Dev)	16.10 (7.40)	18.92 (8.86)
N	9	100
4:00 PM		
Mean (Std Dev)	12.80 (7.45)	17.11 (8.27)
N	8	100
5:00 PM		
Mean (Std Dev)	8.93 (5.55)	11.96 (7.28)
N	8	100
Total*		
Mean (Std Dev)	13.52 (7.33)	16.87 (9.59)
N	-	100

* Statistically different

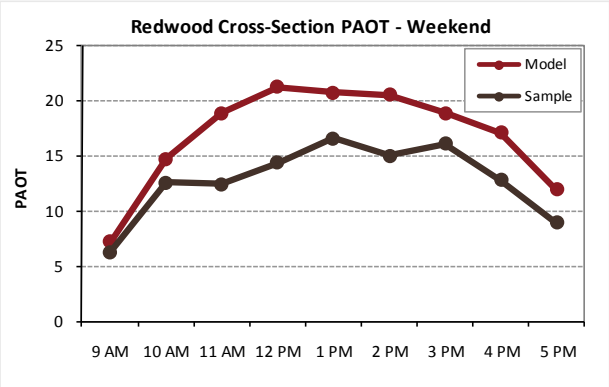


Table 38. Hourly PAOT at Pinchot Tree

	Indicator Observation Data	Model Estimates
9:00 AM		
Mean (Std Dev)	3.46 (4.31)	5.81 (5.86)
N	10	100
10:00 AM		
Mean (Std Dev)	11.22 (8.02)	12.62 (7.75)
N	11	100
11:00 AM		
Mean (Std Dev)	13.23 (9.66)	16.89 (8.13)
N	10	100
12:00 PM		
Mean (Std Dev)	15.59 (10.19)	18.49 (8.93)
N	19	100
1:00 PM		
Mean (Std Dev)	16.80 (11.30)	18.92 (8.90)
N	19	100
2:00 PM		
Mean (Std Dev)	18.37 (10.89)	17.46 (8.57)
N	18	100
3:00 PM		
Mean (Std Dev)	18.17 (13.48)	17.18 (8.47)
N	9	100
4:00 PM		
Mean (Std Dev)	10.38 (5.35)	15.16 (8.18)
N	9	100
5:00 PM		
Mean (Std Dev)	7.78 (5.71)	10.73 (7.00)
N	9	100
Total		
Mean (Std Dev)	13.86 (10.37)	14.83 (8.99)
N	-	100

* Statistically different

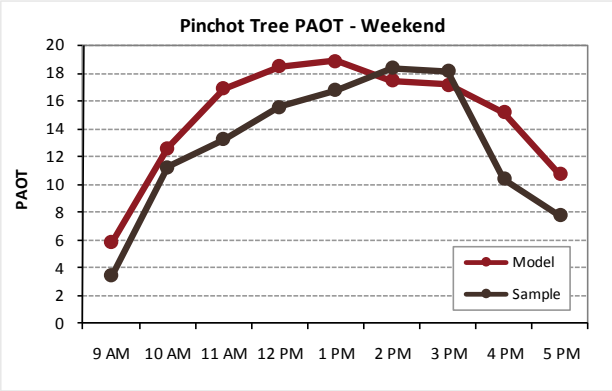


Table 39. Hourly PPV along Interp Trail Section

	Indicator Observation Data	Model Estimates
9:00 AM		
Mean (Std Dev)	4.29 (4.10)	4.93 (5.26)
N	5	100
10:00 AM		
Mean (Std Dev)	10.92 (6.91)	11.19 (7.23)
N	5	100
11:00 AM		
Mean (Std Dev)	12.13 (7.63)	15.05 (8.04)
N	5	100
12:00 PM		
Mean (Std Dev)	11.43 (7.21)	16.85 (8.60)
N	10	100
1:00 PM		
Mean (Std Dev)	12.05 (6.94)	16.50 (8.30)
N	10	100
2:00 PM		
Mean (Std Dev)	11.05 (6.46)	15.93 (8.18)
N	9	100
3:00 PM		
Mean (Std Dev)	13.21 (8.23)	15.27 (8.00)
N	5	100
4:00 PM		
Mean (Std Dev)	12.06 (6.07)	13.75 (7.57)
N	5	100
5:00 PM		
Mean (Std Dev)	7.40 (4.25)	9.60 (6.50)
N	5	100
Total*		
Mean (Std Dev)	10.82 (7.03)	13.27 (8.43)
N	-	100

* Statistically different

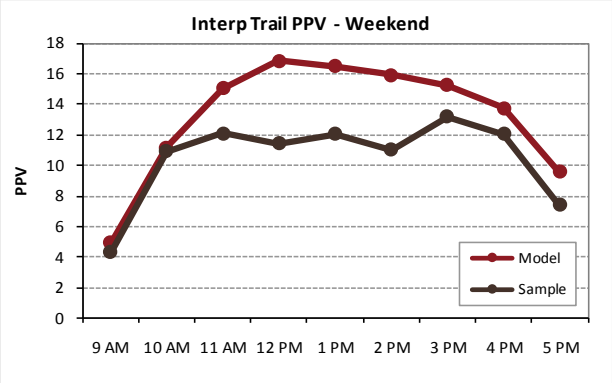
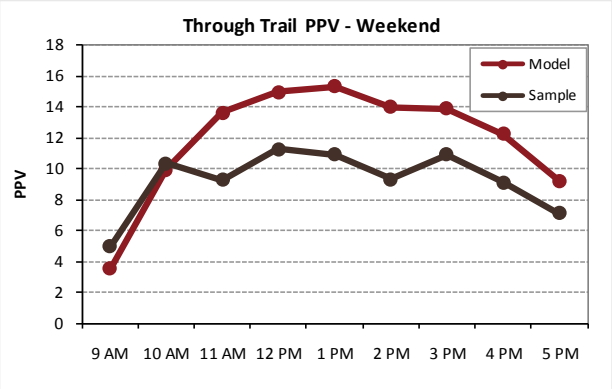


Table 40. Hourly PPV along Through Trail Section

	Indicator Observation Data	Model Estimates
9:00 AM		
Mean (Std Dev)	4.96 (4.49)	3.54 (4.63)
N	5	100
10:00 AM		
Mean (Std Dev)	10.38 (6.24)	9.94 (6.89)
N	5	100
11:00 AM		
Mean (Std Dev)	9.27 (5.86)	13.64 (7.55)
N	5	100
12:00 PM		
Mean (Std Dev)	11.30 (8.58)	14.97 (7.90)
N	10	100
1:00 PM		
Mean (Std Dev)	10.95 (7.22)	15.32 (7.85)
N	10	100
2:00 PM		
Mean (Std Dev)	9.34 (6.42)	13.99 (7.65)
N	10	100
3:00 PM		
Mean (Std Dev)	10.94 (5.58)	13.93 (7.70)
N	6	100
4:00 PM		
Mean (Std Dev)	9.14 (5.37)	12.27 (7.37)
N	5	100
5:00 PM		
Mean (Std Dev)	7.14 (4.97)	9.22 (6.41)
N	5	100
Total*		
Mean (Std Dev)	9.60 (6.79)	11.92 (7.99)
N	-	100

* Statistically different



Encounters

Table 41. Hourly Meetings Hillside Trail

	Sample				Model			
Hour	Mean	Std Dev	N	95th CI	Mean	Std Dev	N	95th CI
9 AM	5.25	5.77	8	4.00	4.14	3.67	911	0.24
10 AM	19.17	8.56	12	4.84	12.36	7.67	4730	0.22
11 AM	14.82	11.76	11	6.95	16.29	12.26	8169	0.27
12 PM	27.38	13.62	15	6.89	17.48	13.78	9241	0.28
1 PM	26.20	13.83	16	6.78	17.04	14.37	9493	0.29
2 PM	19.60	10.85	10	6.72	15.36	13.31	8890	0.28
3 PM	18.00	7.40	5	6.49	14.97	13.08	8675	0.28
4 PM	12.88	12.88	6	10.31	13.38	12.24	7974	0.27
5 PM	1.67	1.83	4	1.79	9.80	10.60	4610	0.31
Daily	18.73	12.86	-	-	14.94	12.88	62693	0.10

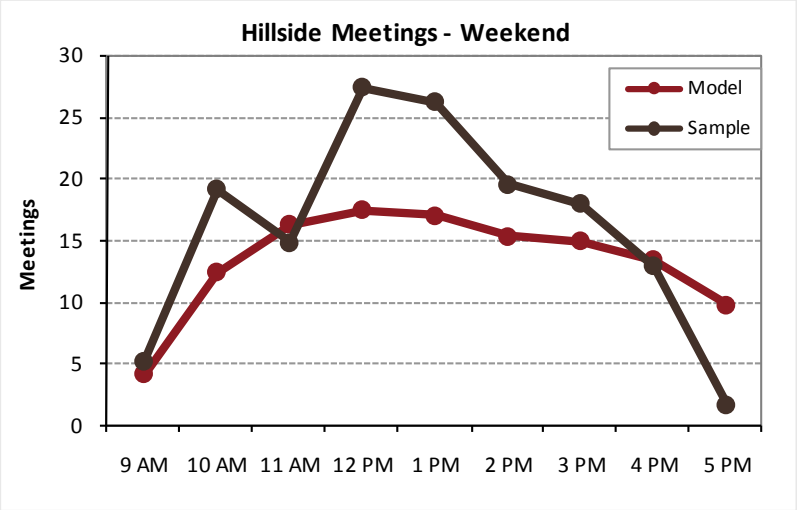


Table 42. Hourly Overtakings along Hillside Trail

	Sample				Model			
Hour	Mean	Std Dev	N	95th CI	Mean	Std Dev	N	95th CI
9 AM	2.00	1.46	8	1.01	0.70	1.12	911	0.07
10 AM	0.83	1.89	12	1.07	1.88	2.40	4730	0.07
11 AM	1.64	1.41	11	0.84	3.33	3.76	8169	0.08
12 PM	2.31	1.97	14	1.03	3.86	4.25	9241	0.09
1 PM	3.50	2.28	16	1.12	3.97	4.45	9493	0.09
2 PM	1.80	1.62	10	1.00	3.81	4.23	8890	0.09
3 PM	0.80	1.06	5	0.93	3.70	4.17	8675	0.09
4 PM	1.13	0.93	6	0.74	3.50	3.96	7974	0.09
5 PM	0.67	0.96	4	0.94	2.74	3.13	4610	0.09
Daily	1.84	1.84	-	-	3.45	4.00	62693	0.03

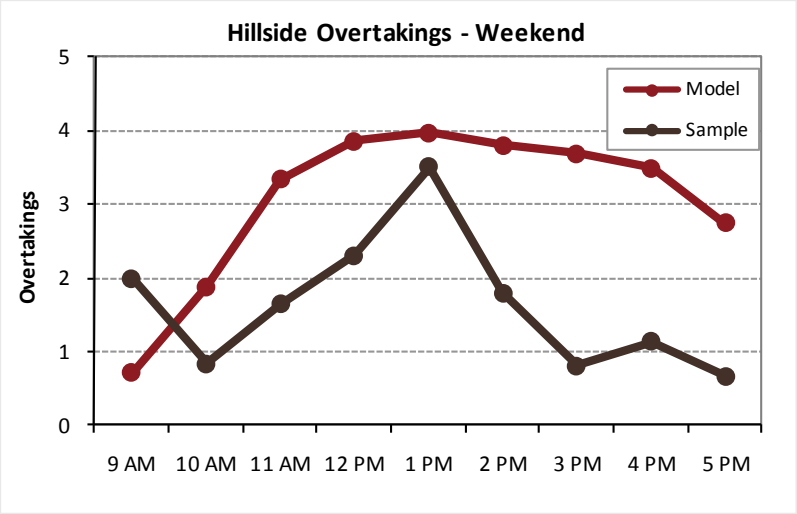
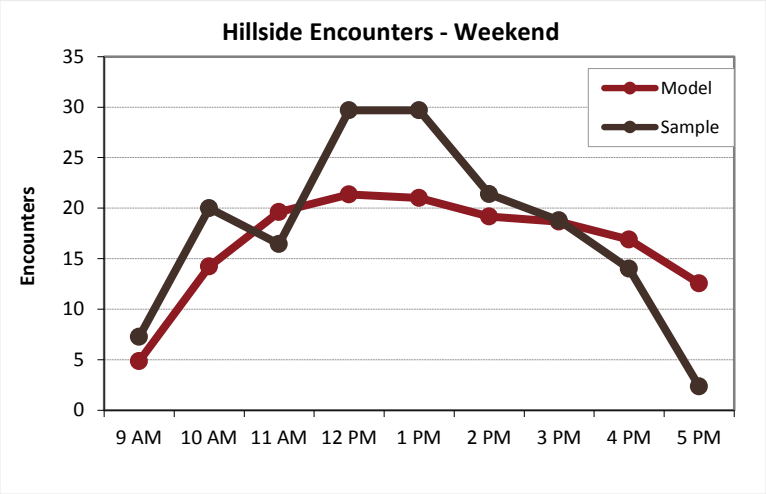


Table 43. Hourly Encounters along Hillside Trail

	Sample				Model			
Hour	Mean	Std Dev	N	95th CI	Mean	Std Dev	N	95th CI

9 AM	7.25	6.50	8	4.51	4.84	4.17	911	0.27
10 AM	20.00	9.39	12	5.31	14.24	8.33	4730	0.24
11 AM	16.45	11.52	11	6.81	19.62	12.47	8169	0.27
12 PM	29.69	13.19	15	6.68	21.34	13.86	9241	0.28
1 PM	29.70	14.58	16	7.14	21.01	14.30	9493	0.29
2 PM	21.40	10.61	10	6.58	19.17	13.29	8890	0.28
3 PM	18.80	7.13	5	6.25	18.66	13.02	8675	0.27
4 PM	14.00	12.81	6	10.25	16.88	12.20	7974	0.27
5 PM	2.33	1.50	4	1.47	12.53	10.51	4610	0.30
Daily	20.57	13.23	-	-	18.40	13.04	62693	0.10



Section 5 Simulation Modeling Alternatives Analysis

5.1 Scenarios

Figure 25. Alternatives

	No Action	Alt 1	Alt 2	Alt 3
Parking capacity at MUWO	379	219	20	179
Parking capacity at intercept area	500	500	500	500
Bus capacity	35	35	35	35
Bus Headway		Min headway 10 min.	Min headway 10 min.	
		First-come, first-serve, limit to number of buses they'll wait for	First-come, first-serve, limit to number of buses they'll wait for	Reservations and Paid Parking; Spread it evenly through the day
Meadow Linger (discussed with Mia)	Mean= 5 mins	Visitors' average linger times in the restored meadow will be similar to the average linger times observed in the café/gift shop during summer 2009.	Visitors' average linger times in the restored meadow will be similar to the average of linger times observed in Redwood Crosscut, Pinchot Tree, and Bohemian Grove during summer 2009.	Visitors' average linger times in the restored meadow will be similar to the average linger times observed in the potential restored meadow during summer 2009.

5.2 Descriptive Results

Use Levels and Group Size

Table 44.Use Levels Comparison

	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
Private Vehicle	3173	3175	2505	330	2379
Tour Bus	403	405	388	406	393
Shuttle Bus	446	476	972	1746	1266
Total	**4022**	**4057**	**3865**	**2482**	**4038**

Table 45. Group Size Comparison

	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
Private Vehicle	3.25	3.26	3.24	3.22	3.26
Tour Bus+PV	3.21	3.19	3.17	3.23	3.15
Shuttle Bus+PV	3.27	3.23	3.25	3.29	3.28

Parking

Figure 26. Cars in MUWO Lot by GMP Alternative

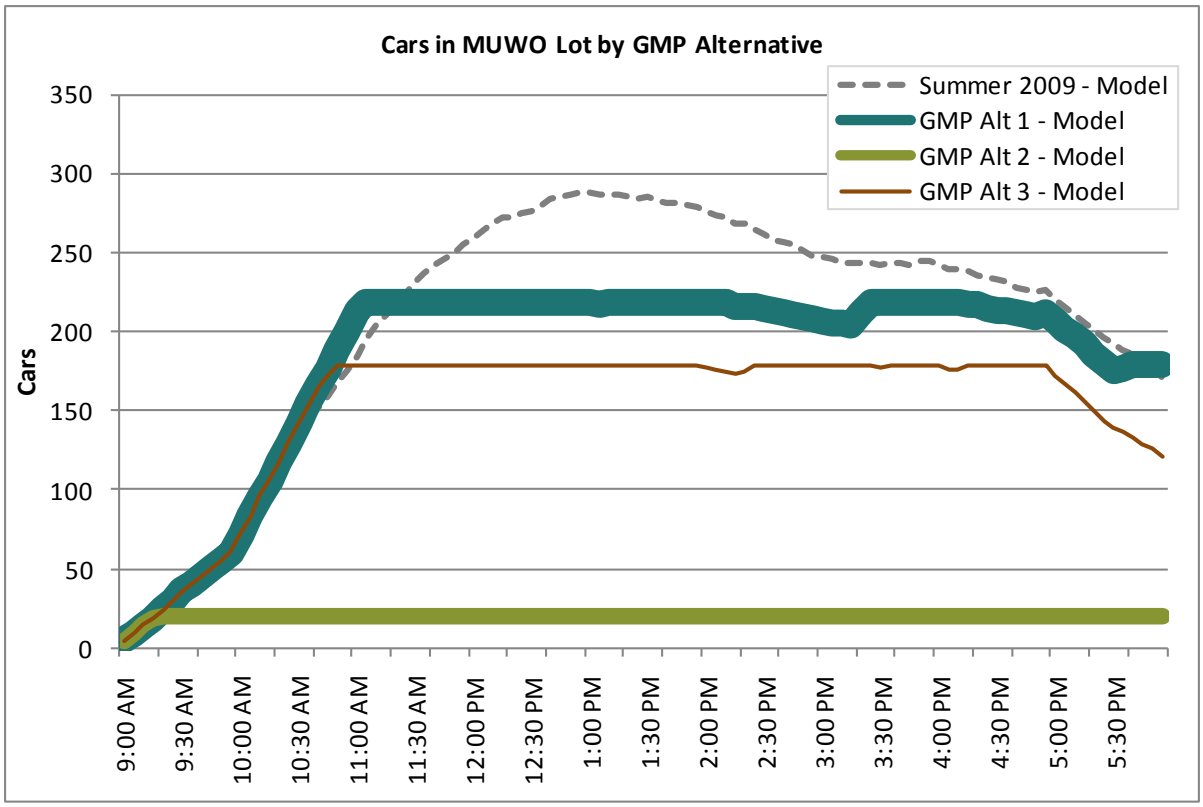


Figure 27. Cumulative Displaced Cars from MUWO Lot by GMP Alternative

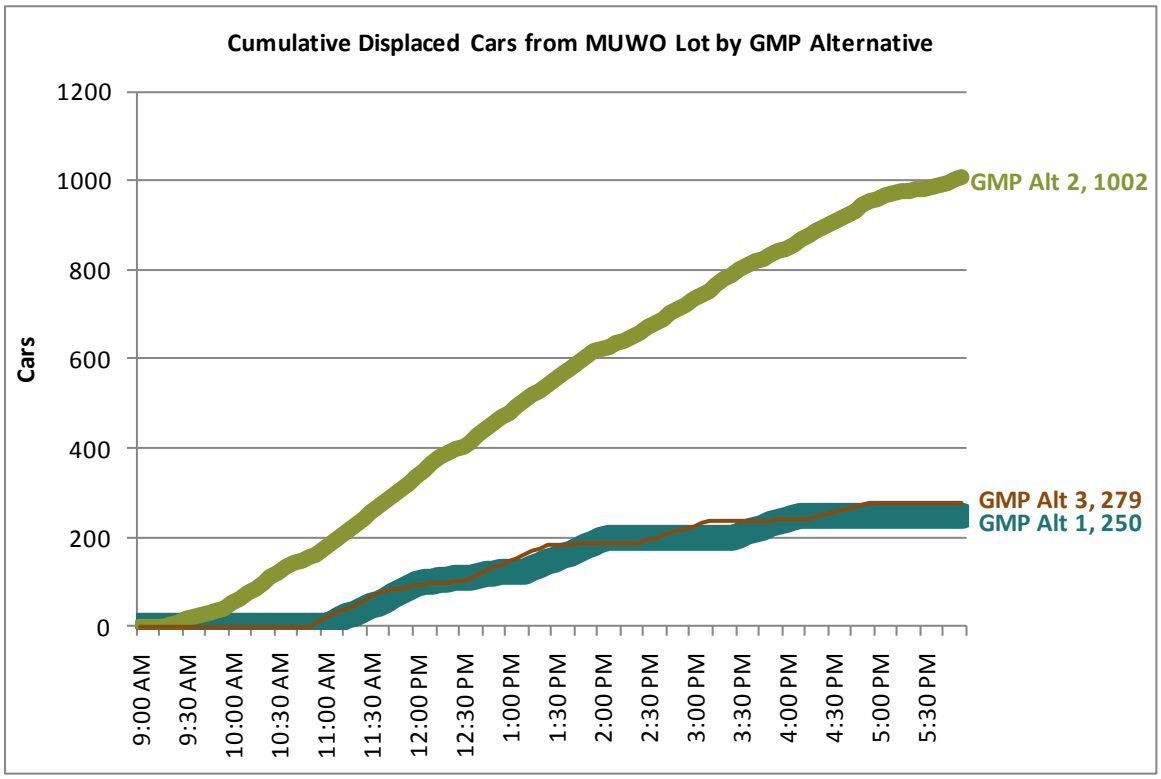
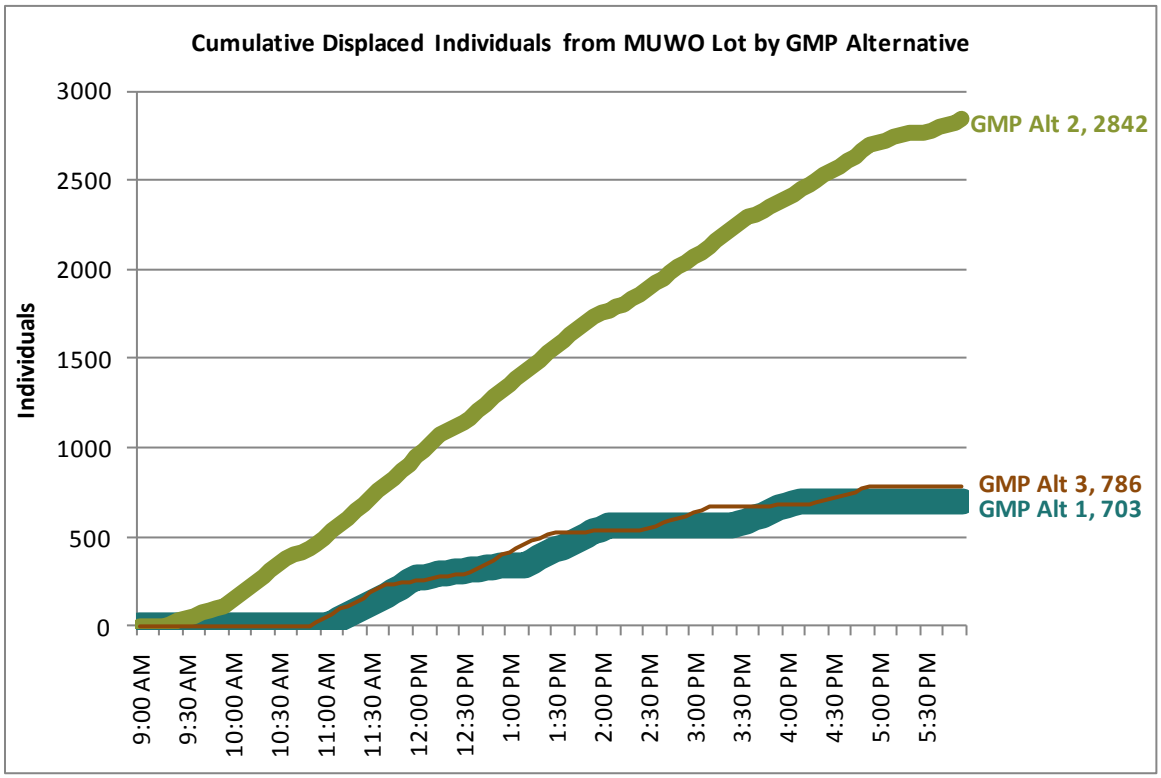


Figure 28. Cumulative Displaced Individuals from MUWO Lot by GMP Alternative



The number of displaced individuals were then redirected to using shuttle service.

Bus Ridership

Table 46.Tour Bus Ridership Comparison

Hour	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
9:00 AM	21.35	17.98	17.92	17.11	18.84
10:00 AM	21.28	18.60	16.55	19.70	17.67
11:00 AM	15.00	18.93	16.08	19.72	14.44
12:00 PM	13.11	19.67	17.24	19.28	17.80
1:00 PM	13.75	.	.	.	.
2:00 PM	16.34	18.43	19.53	17.40	17.69
3:00 PM	19.75	18.17	16.47	19.32	18.19
4:00 PM	8.20	19.79	18.96	21.40	14.88
5:00 PM	.	.	.	.	.
Daily	**18.33**	**18.79**	**17.54**	**19.13**	**17.07**

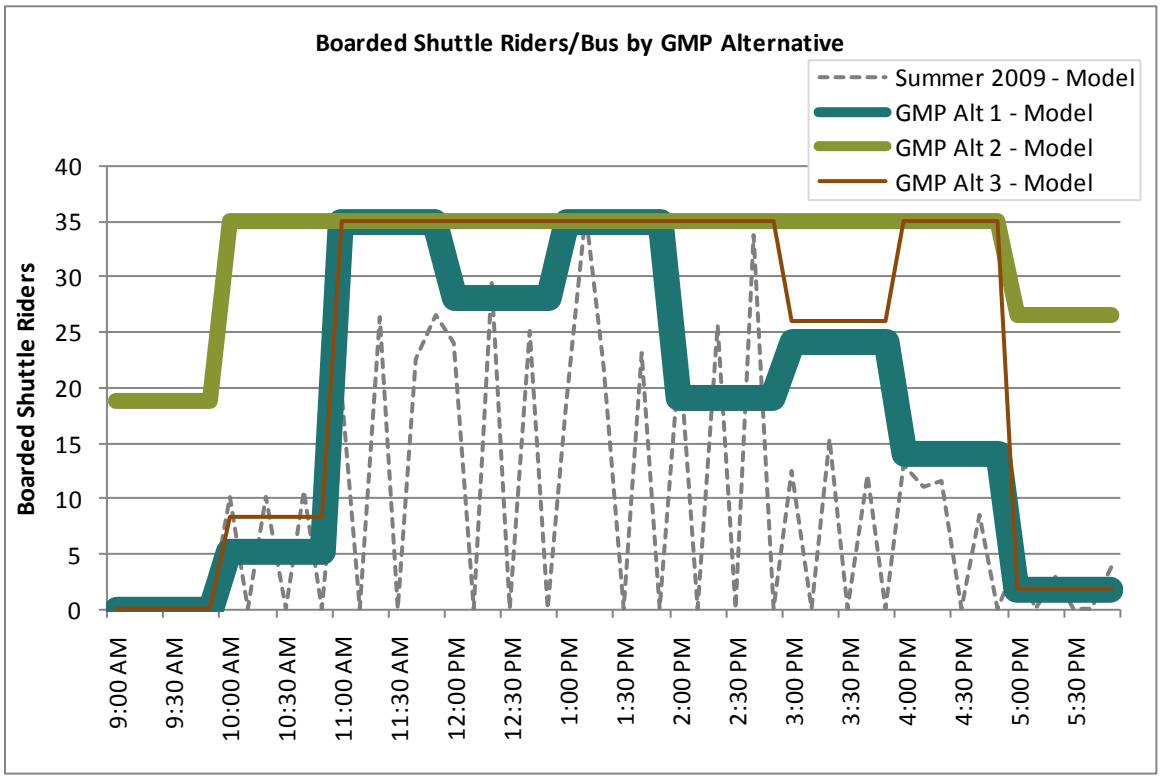
Table 47. Shuttle Bus Ridership Comparison

Hour	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
9:00 AM	.	.	0.00	19.00	0.00
10:00 AM	13.93	13.55	5.00	35.00	8.00
11:00 AM	22.76	22.89	35.00	35.00	35.00
12:00 PM	23.73	24.10	28.00	35.00	35.00
1:00 PM	20.47	20.13	35.00	35.00	35.00
2:00 PM	20.13	21.17	19.00	35.00	35.00
3:00 PM	13.49	12.42	24.00	35.00	26.00
4:00 PM	8.79	9.00	14.00	35.00	35.00
5:00 PM	4.07	3.88	2.00	27.00	2.00
Daily	**16.43**	**15.89**	**18.00**	**32.33**	**23.44**

Table 48.Percent Buses with Overflow Demand

	GMP Alt 1	GMP Alt 2	GMP Alt 3
Total Buses	54	54	54
Total Overflow Demand Buses	12	42	0
% Overflow Demand Buses	22%	78%	0%
Overflow Passengers	210	1580	0
Note: Based on 10-minute headways. Summer 2009 had 29 buses.			

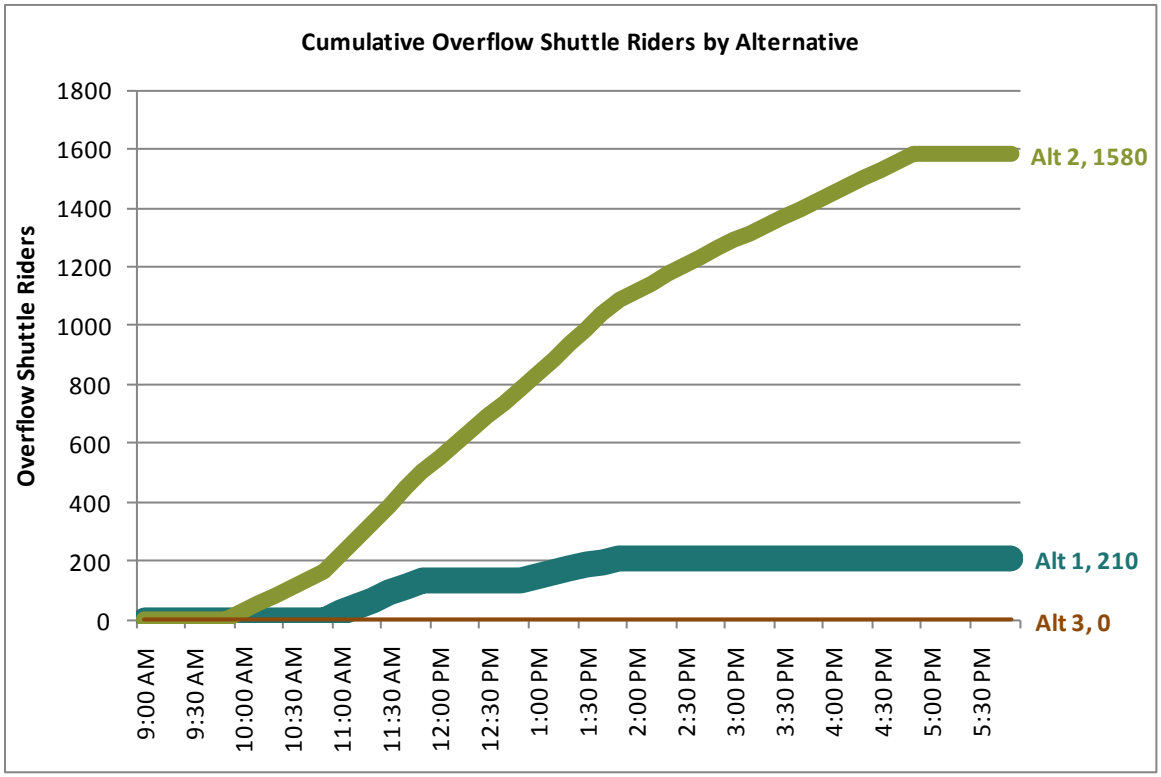
Figure 29. Boarded Shuttle Riders by GMP Alternative



In GMP Alternative 3, the shuttle demand is lower from 3:00PM-4:00PM due to fewer displaced cars from the MUWO parking lot being converted to shuttle riders during that time.

Figure 30 shows the cumulative number of individuals that wanted to ride the shuttle but could not fit onto a shuttle bus. These are the number of individuals that do not make it to the park at all.

Figure 30. Displaced Shuttle Riders by GMP Alternative



Note explaining this chart.

PAOT and PPV

Table 49. Redwood Cross-Section PAOT Comparison

Hour	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
9:00 AM	6.28	7.21	6.88	7.38	7.05
10:00 AM	12.65	14.78	14.30	11.93	14.38
11:00 AM	12.50	18.93	17.67	11.01	17.05
12:00 PM	14.38	21.30	20.39	11.46	20.17
1:00 PM	16.66	20.79	18.91	9.11	19.25
2:00 PM	15.08	20.56	19.44	11.20	20.87
3:00 PM	16.10	18.92	18.87	12.83	21.53
4:00 PM	12.80	17.11	16.61	10.81	19.52
5:00 PM	8.93	11.96	11.76	9.26	12.09
Daily	**13.52**	**16.87**	**16.12**	**10.55**	**16.90**

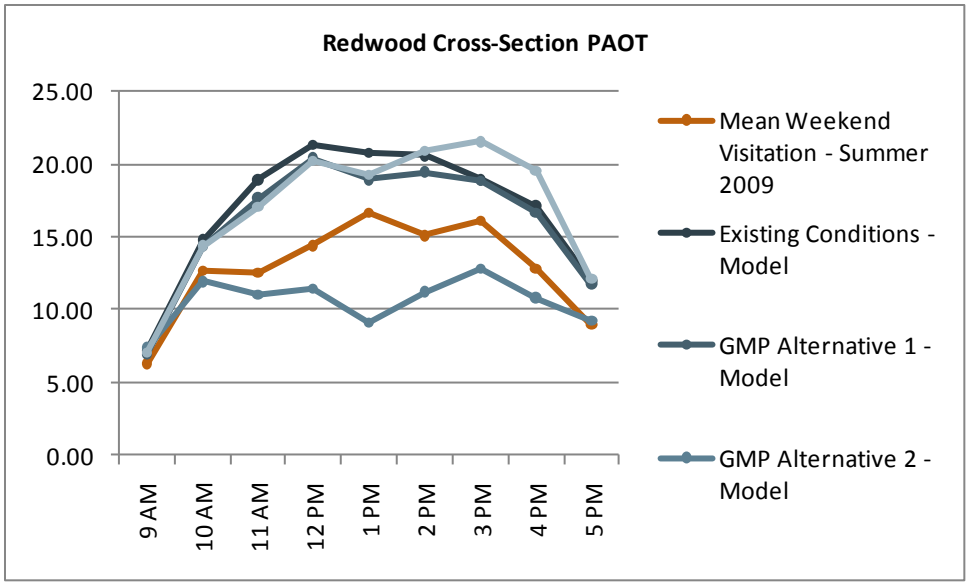


Table 50. Pinchot Tree PAOT Comparison

Hour	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
9:00 AM	3.46	5.81	5.34	5.09	5.44
10:00 AM	11.22	12.62	11.48	9.80	12.34
11:00 AM	13.23	16.89	15.45	9.55	15.48
12:00 PM	15.59	18.49	17.16	9.29	16.50
1:00 PM	16.80	18.92	16.30	7.62	17.57
2:00 PM	18.37	17.46	16.61	9.23	18.15
3:00 PM	18.17	17.18	17.55	11.05	19.64
4:00 PM	10.38	15.16	15.05	9.83	16.93
5:00 PM	7.78	10.73	10.70	8.28	11.27
Daily	**13.86**	**14.83**	**14.00**	**8.89**	**14.84**

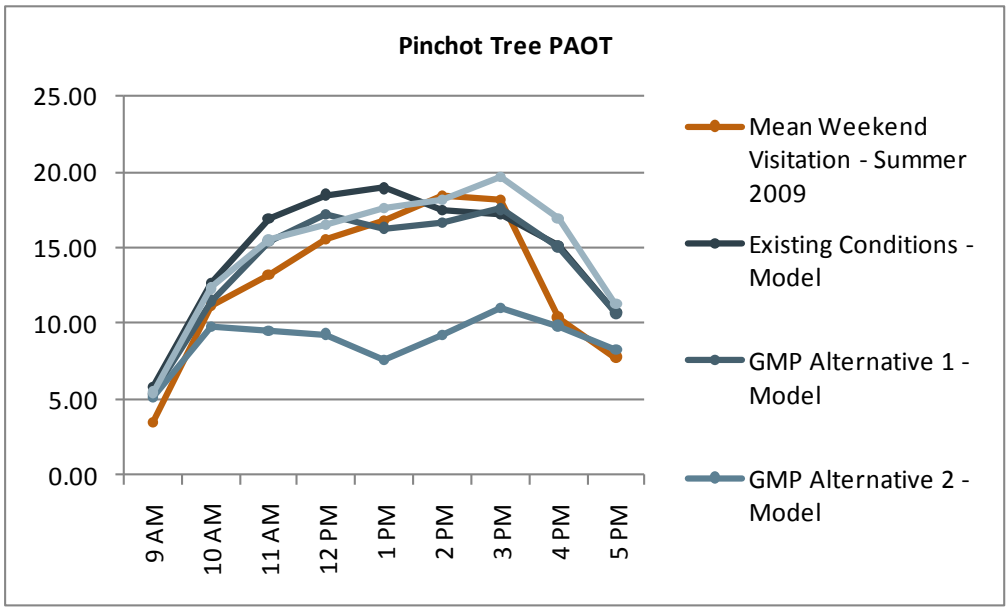


Table 51. Interp Trail PPV Comparison

Hour	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
9:00 AM	4.29	4.93	4.74	4.89	5.08
10:00 AM	10.92	11.19	10.92	8.84	10.61
11:00 AM	12.13	15.05	13.36	8.33	13.66
12:00 PM	11.43	16.85	14.88	8.68	15.16
1:00 PM	12.05	16.50	15.54	7.37	14.87
2:00 PM	11.05	15.93	15.77	8.64	15.95
3:00 PM	13.21	15.27	15.36	9.70	16.83
4:00 PM	12.06	13.75	12.50	8.23	15.30
5:00 PM	7.40	9.60	9.10	6.92	10.30
Daily	**10.82**	**13.27**	**12.48**	**8.01**	**13.11**

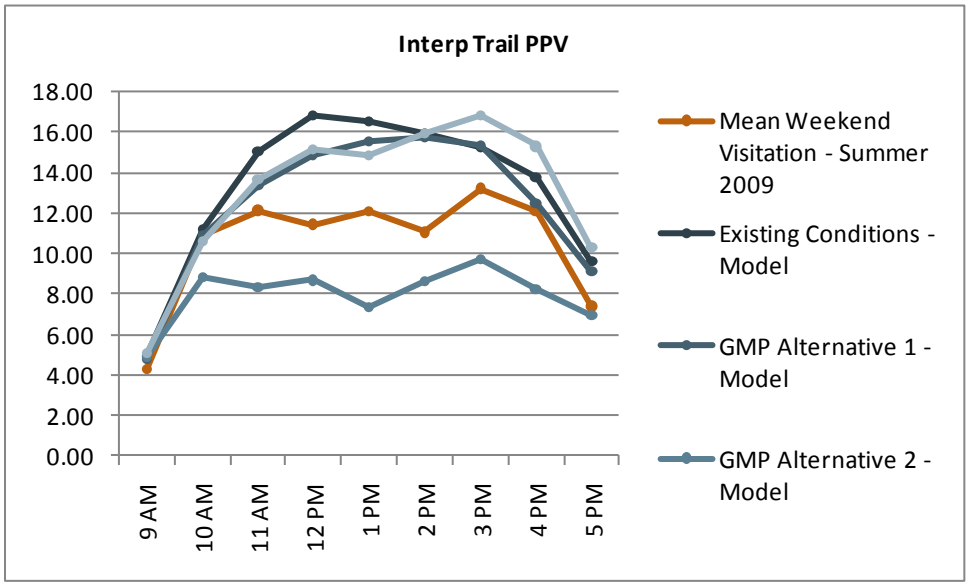
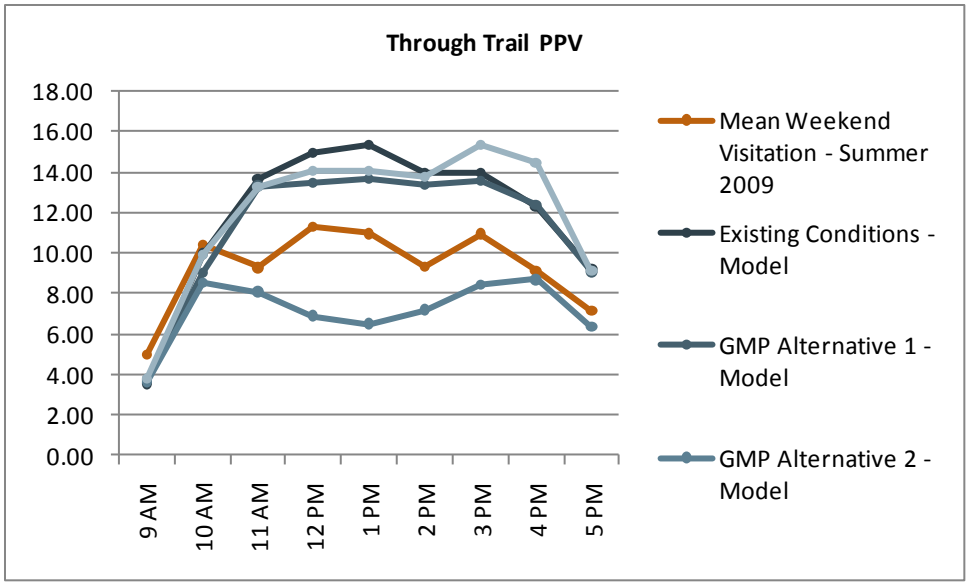


Table 52. Through Trail PPV Comparison

Hour	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
9:00 AM	4.96	3.54	3.73	3.64	3.81
10:00 AM	10.38	9.94	8.99	8.53	9.91
11:00 AM	9.27	13.64	13.30	8.08	13.29
12:00 PM	11.30	14.97	13.48	6.89	14.07
1:00 PM	10.95	15.32	13.68	6.49	14.02
2:00 PM	9.34	13.99	13.37	7.18	13.75
3:00 PM	10.94	13.93	13.56	8.45	15.31
4:00 PM	9.14	12.27	12.38	8.68	14.48
5:00 PM	7.14	9.22	9.07	6.38	9.13
Daily	**9.60**	**11.92**	**11.33**	**7.17**	**12.02**



Encounters

Table 53. Hillside Meetings Comparison

Hour	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
9:00 AM	5.25	4.14	4.31	4.38	4.34
10:00 AM	19.17	12.36	11.92	9.82	12.09
11:00 AM	14.82	16.29	14.20	8.96	14.60
12:00 PM	27.38	17.48	15.99	8.37	15.35
1:00 PM	26.20	17.04	15.74	7.22	15.84
2:00 PM	19.60	15.36	14.93	9.06	17.78
3:00 PM	18.00	14.97	15.00	9.63	18.13
4:00 PM	12.88	13.38	12.69	8.62	14.19
5:00 PM	1.67	9.80	9.66	7.15	9.42
Daily	**18.73**	**14.94**	**13.99**	**8.58**	**15.02**

Table 54. Hillside Overtakings Comparison

Hour	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
9:00 AM	2.00	0.70	0.65	0.60	0.63
10:00 AM	0.83	1.88	1.89	1.64	1.89
11:00 AM	1.64	3.33	3.37	2.20	3.07
12:00 PM	2.31	3.86	3.24	1.90	3.25
1:00 PM	3.50	3.97	3.73	1.85	3.70
2:00 PM	1.80	3.81	3.39	1.69	3.44
3:00 PM	0.80	3.70	3.72	2.06	3.68
4:00 PM	1.13	3.50	3.53	2.32	4.06
5:00 PM	0.67	2.74	2.80	1.67	3.08
Daily	**1.84**	**3.45**	**3.28**	**1.91**	**3.34**

Table 55. Hillside Encounters Comparison

Hour	Mean Weekend Visitation - Summer 2009	Existing Conditions - Model	GMP Alternative 1 - Model	GMP Alternative 2 - Model	GMP Alternative 3 - Model
9:00 AM	7.25	4.84	4.97	4.98	4.96
10:00 AM	20.00	14.24	13.81	11.46	13.98
11:00 AM	16.45	19.62	17.57	11.16	17.67
12:00 PM	29.69	21.34	19.23	10.27	18.59
1:00 PM	29.70	21.01	19.47	9.07	19.53
2:00 PM	21.40	19.17	18.32	10.75	21.21
3:00 PM	18.80	18.66	18.72	11.69	21.81
4:00 PM	14.00	16.88	16.22	10.94	18.25
5:00 PM	2.33	12.53	12.47	8.82	12.51
Daily	**20.57**	**18.40**	**17.26**	**10.49**	**18.36**

Appendix A. Route 66/Muir Woods Shuttle Schedule

MUIR WOODS INFORMATION

MUIR WOODS PARK HOURS SUMMER 2009

8:00 am to 8:00 pm every day

Note: The last Route 66 bus leaves Muir Woods at 7:00 pm

ENTRANCE FEES

Individuals 16 years of age and older:
$5.00 per day or $20 for a season pass
Individuals under 16 years of age: **FREE**

Muir Woods Information

Visitor Information (Recorded Message)
(415) 388-2595

Muir Woods Headquarters
(415) 388-2596

Information For Hearing Impaired (TTY)
(415) 556-2766

www.nps.gov/muwo

marin transit

MUIR WOODS

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ROUTE INFORMATION

ROUND TRIP SHUTTLE FARES

Adults	$3
Youth (6-18)/ Seniors (65+)/ Persons with Disabilities	$1

FOR PASSENGERS TRAVELING ON *DIRECT* ROUTE 66 SERVICE FROM MARIN CITY, POHONO STREET OR SAUSALITO FERRY TO MUIR WOODS

Round trip fares are collected in the westbound direction traveling toward Muir Woods. A "Round Trip Muir Woods Shuttle Pass" is issued when you pay your fare. **Please retain your Shuttle Pass and present it to the driver on your return trip.** *No one-way fares are available.* Round Trip Shuttle Passes are valid only for the day of purchase.

Fares may be paid by cash (exact change required), Value Cards or Marin Transit passes. No other fare media including TransLink® tickets or transfers accepted on Route 66.

FOR PASSENGERS ORIGINATING FROM OTHER MARIN COUNTY LOCATIONS

Sausalito Passengers: When direct Route 66 service from Sausalito to Muir Woods is not available, passengers may board GGT Routes 10 or 22 in Sausalito and advise the driver that you wish to travel to Muir Woods. Pay $3.00 to purchase a Round Trip Muir Woods Shuttle Pass. Travel from Sausalito to Marin City on Routes 10 or 22 will be included in this fare. In the eastbound direction, passengers transferring from Route 66 to travel to Sausalito will present their Muir Woods Shuttle Pass on Routes 10 or 22 for free travel from Marin City to Sausalito.

Central and Northern County Marin Passengers: For connecting travel from Central and Northern Marin County, advise the driver that you wish to travel to Muir Woods and pay $3.00 to purchase a Round Trip Muir Woods Shuttle Pass. Travel from points in Central and Northern Marin County to Marin City will be included in this fare. Passengers needing to make a second transfer for travel to/from Muir Woods should present their Muir Woods Shuttle Pass on the next bus for free travel.

PASSENGER CAPACITY OF EACH BUS

Due to safety considerations, standees will not be carried on Route 66. Arrive at bus stop early to ensure a seat on the bus. The last bus leaves Muir Woods at 7:00 p.m.

BIKE RACKS

Bike racks are available on a limited number of Route 66 buses on a first-come, first-served basis. There is no guarantee that a bus returning from Muir Woods will be bike rack-equipped. For loading and unloading instructions please visit goldengatetransit.org/services. Bikes are not allowed inside buses.

PARKING AND BOARDING INFORMATION

Use the Highway 1 exit. Parking is available at Pohono St. and Manzanita Park & Ride lots. See map for bus stop boarding and deboarding locations.

STROLLERS/LUGGAGE/BICYCLES

Luggage and other personal articles must be placed in your lap or under a seat. Personal articles cannot be stored in the aisles, wheelchair securement areas or on seats. Fold up strollers and hold babies in your lap. Bicycles are not allowed inside bus.

FOOD AND DRINK

Smoking, eating and drinking are NOT permitted aboard buses. California State Law prohibits alcoholic beverages aboard public transit buses. Refreshments are available at Muir Woods.

TRANSIT CONNECTIONS

BUS TO/FROM SAUSALITO

GGT Routes 10 and 22 provide combined service every 30 minutes between downtown Sausalito and Marin City. Board a Route 10 bus (every 60 minutes) at Bridgeway & Bay in Sausalito or board a Route 22 bus (every 60 minutes) on Bay St. at Bridgeway near the ferry terminal. Purchase your Muir Woods Shuttle Pass on the bus, which is also good for return trip.

BUS TO/FROM SAN FRANCISCO

GGT Routes 70 and 80 provide combined service every 30 minutes between Mission & 1st Streets in San Francisco and Marin City. Passengers also may board buses in San Francisco at Mission & 3rd Streets, Mission & 5th Streets, 7th & Market Streets, McAllister & Hyde, McAllister & Polk Streets, and Van Ness Avenue & Geary Blvd. Additional stops are available along Van Ness Avenue and Lombard Street. The adult cash fare is $3.75 ($3.95 after July 1, 2009). No free transfers are available to and from the Muir Woods Shuttle.

FERRY TO/FROM SAN FRANCISCO

Golden Gate Ferry provides service between San Francisco Ferry Building and Sausalito. Adult cash fare is $7.45 each way ($7.85 after July 1, 2009) and youth (6-18), seniors (65+), persons with disabilities/Medicare receive a 50% discount. Children 5 and under ride free (2 per full fare adult). In Sausalito, board Route 66 at Humboldt Street for direct service to Muir Woods. Purchase Round Trip Muir Woods Shuttle Pass ($3.00 for adults, $1.00 for youth, seniors, and persons with disabilities) at the San Francisco Ferry ticket booth. No free transfers are available to or from the Muir Woods Shuttle.

SUMMER 2009 MUIR WOODS SHUTTLE

WEEKEND AND HOLIDAY SERVICE

INFORMATION CONTACTS

toll-free **511** (say "Golden Gate Transit" then "Operator")

TDD 711

Monday – Friday 7:00 am – 7:00 pm
Saturdays and Holidays 8:00 am – 6:00 pm
(Closed Sundays)

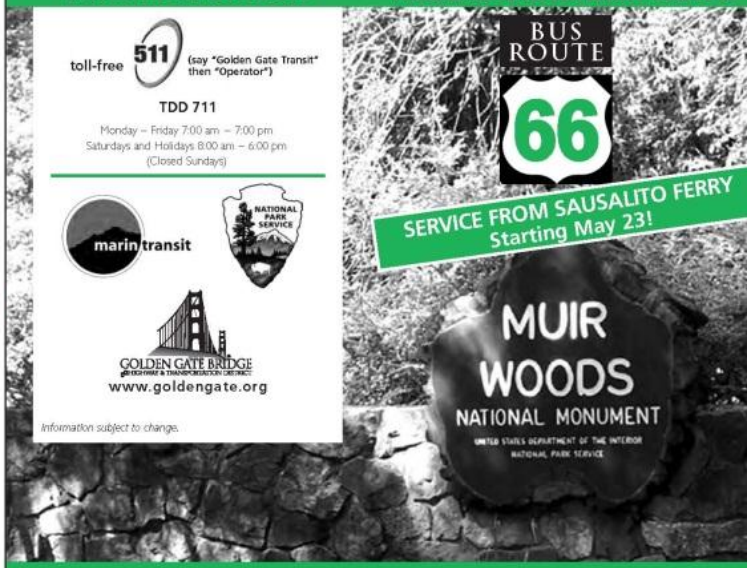
marin transit

NATIONAL PARK SERVICE

GOLDEN GATE BRIDGE HIGHWAY & TRANSPORTATION DISTRICT

www.goldengate.org

Information subject to change.



MARIN CITY/POHONO ROUTE
May 2 to September 27, 2009

SAUSALITO FERRY ROUTE
May 23 to September 7, 2009

May 2 – 17 AND September 12 – 27, 2009

WEEKENDS AND HOLIDAYS

Muir Woods

Westbound

Marin City — Pohono St. — Muir Woods

Leaves Marin City (Donahue & Terners)	Pohono St.	Muir Woods
9 30	9 36	9 56
10 00	10 06	10 26
10 30	10 36	10 56
11 00	11 06	11 26
11 30	11 36	11 56
12 00	**12 06**	**12 26**
12 30	**12 36**	**12 56**
1 00	**1 06**	**1 26**
1 30	**1 36**	**1 56**
2 00	**2 06**	**2 26**
2 30	**2 36**	**2 56**
3 00	**3 06**	**3 26**
3 30	**3 36**	**3 56**
4 00	**4 06**	**4 26**
4 30	**4 36**	**4 56**
5 00	**5 06**	**5 26**
5 30	**5 36**	**5 56**

WEEKENDS AND HOLIDAYS

Manzanita Park & Ride/Marin City

Eastbound

Muir Woods — Manzanita Park & Ride — Marin City

Muir Woods	Manzanita Park & Ride	Arrive Marin City (Donahue & Terners)
11 05	11 25	11 29
11 35	11 55	11 59
12 05	**12 25**	**12 29**
12 35	**12 55**	**12 59**
1 05	**1 25**	**1 29**
1 35	**1 55**	**2 00**
2 05	**2 25**	**2 30**
2 35	**2 55**	**3 00**
3 05	**3 25**	**3 30**
3 35	**3 55**	**4 00**
4 05	**4 25**	**4 29**
4 35	**4 55**	**4 59**
5 05	**5 25**	**5 29**
5 35	**5 55**	**5 59**
6 05	**6 25**	**6 29**
6 35	**6 50**	**6 54**
7 05	**7 20**	**7 24**

Remember to keep your shuttle pass for your return trip.

Westbound trips will pick up passengers at Pohono St. stop. Westbound bus will NOT stop at Manzanita.
Eastbound trips will drop off passengers at Manzanita and will NOT serve Pohono.
Times shown are approximate and are dependent on varying traffic conditions.

All buses serving this route are wheelchair accessible.

May 23 – September 7, 2009

WEEKENDS AND HOLIDAYS

Muir Woods

Westbound

Sausalito Ferry Terminal or Marin City — Pohono St. — Muir Woods

Ferry Arrives in Sausalito	Sausalito Ferry Terminal (Bay & Bridgeway)	Leaves Marin City (Donahue & Terners)	Pohono St.	Muir Woods
—	—	9 30	9 36	10 01
—	—	9 50	9 56	10 21
—	—	10 10	10 16	10 41
—	—	10 30	10 36	11 01
—	—	10 50	10 56	11 21
—	—	11 10	11 16	11 41
11 10	11 20	—	11 35	12 00
—	—	11 30	11 36	12 09
—	—	11 50	11 56	12 29
—	—	12 10	12 16	12 49
—	—	12 30	12 36	1 09
—	—	12 35	12 41	1 14
12 30	12 40	—	12 55	1 20
—	—	12 50	12 56	1 29
—	—	1 10	1 16	1 49
—	—	1 30	1 36	2 09
—	—	1 50	1 56	2 29
—	—	2 10	2 16	2 49
1 55	2 05	—	2 20	2 45
—	—	2 30	2 36	3 09
—	—	2 50	2 56	3 29
—	—	3 10	3 16	3 49
—	—	3 30	3 36	4 09
3 20	3 40	—	3 55	4 20
—	—	3 50	3 56	4 21
—	—	4 10	4 16	4 41
—	—	4 30	4 36	5 01
—	—	4 50	4 56	5 21
—	—	5 20	5 26	5 51

WEEKENDS AND HOLIDAYS

Manzanita P&R, Marin City, Sausalito

Eastbound

Muir Woods — Manzanita Park & Ride — Marin City or Sausalito Ferry Terminal

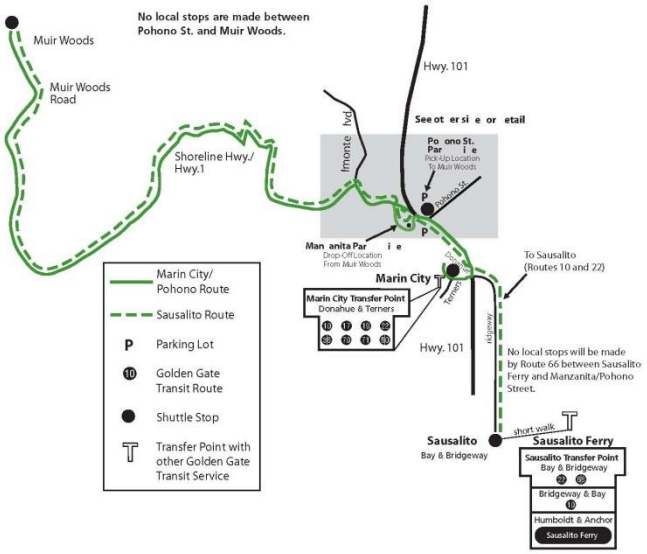
Muir Woods	Manzanita Park & Ride	Arrive Marin City (Donahue & Terners)	Sausalito Ferry Terminal (Bay & Bridgeway)	Ferry Departs Sausalito
10 50	11 15	11 26	—	—
11 10	11 35	11 46	—	—
11 30	11 55	12 06	—	—
11 50	12 15	12 26	—	—
12 15	12 45	12 49	—	—
12 40	1 05	1 09	—	—
1 00	1 25	1 29	—	—
1 20	1 45	—	1 55	2 10
1 20	1 45	1 49	—	—
1 35	2 00	—	—	—
1 40	2 05	2 09	—	—
2 00	2 25	2 29	—	—
2 20	2 45	2 49	—	—
2 40	3 05	3 09	—	—
2 55	3 20	—	3 30	3 50
3 00	3 25	3 29	—	—
3 20	3 45	3 49	—	—
3 40	4 05	4 09	—	—
4 00	4 25	4 29	—	—
4 20	4 45	4 49	—	—
4 30	4 55	5 01	—	—
4 30	4 55	—	5 05	5 35
4 50	5 15	5 21	—	—
5 10	5 35	5 41	—	—
5 30	5 55	6 01	—	—
5 30	5 55	—	6 05	6 30
6 00	6 25	6 31	—	—
6 30	6 50	6 54	—	—
7 00	7 20	7 24	—	—

Light type = am times
Bold type = pm times

Direct service to/from Sausalito is available ONLY between May 23 and September 7, 2009.

No local stops will be made by Route 66 between Sausalito Ferry and Manzanita/Pohono Street.

MUIR WOODS SHUTTLE MAP



Map not to scale.

SPONSORSHIP OF ROUTE 66 SERVICE

Route 66 (Muir Woods Shuttle) is funded by Marin Transit and the National Park Service, and operated under a service agreement between Marin Transit and the Golden Gate Bridge, Highway and Transportation District (the operator of Golden Gate Transit).