

Visitor Circulation Study

Bryce Canyon National Park

Summer 1997

Brian Warren

A Contract Funded by Bryce Canyon
Natural History Association

GOALS

The Visitor Circulation Study attempts to answer two basic questions about Bryce Canyon's Visitor activities: First, where do visitors go in Bryce Canyon? Second, what do visitors do while they are in the park? This paper will discuss the goals of the project in detail, the three methodologies were employed to gather data and the results obtained in this study.

The questions of where visitors go and what visitors do can range from the seemingly broad level of where they drive to the detailed level of what concession or ranger-lead activities are undertaken while in the park. Participation in concession and other activities was left out of the data collection process for the reason that this information is collected by the concessionaires and would be redundant. The same is true for campground occupancy, number of groups requesting backcountry permits and other activities performed and monitored by the National Park Service. What remains is to determine what decisions visitors make when they are unattended by Park Service or other park personnel. In Bryce, these activities are limited to driving, biking and hiking tours of the park. Thus, this study approaches the question of visitor activities from the perspective of what decisions do they make while moving through the park in this fashion. By viewing visitors' decisions viewed holistically, an overall picture of where they go and what they do can be created.

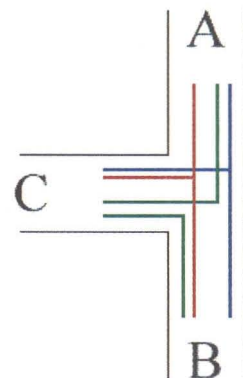
METHODOLOGY

Two methods of data collected were used to determine where visitors go and how many go there. The Intersection Analysis focuses on determining the decisions made by visitors while driving and hiking. The Flow Measurement is the simplest, strictly a flow-measuring approach to traffic. Fieldwork was conducted between May 12 and July 20 of 1997. This range covers the early and middle portions of Bryce Canyon's May to September peak tourist season.

INTERSECTION ANALYSES

Although there are greater than twenty miles of roads in Bryce Canyon, an extremely small percentage of this distance is critical to understanding the decisions made by motorists. These critical areas are the road intersections and pullouts. Once a visitor has committed to a direction, narrow roads and often-heavy traffic prevent most changes until that visitor reaches the next intersection. By concentrating on these intersections, the vast majority of decisions made by visitors may be observed. This is less true on trails, since no additional space is needed for a hiker to change direction. Visitors may hike down a trail for 50 meters or 500 meters and change their minds. This requires some additional attention when selecting survey sites, but the basic principle stands true.

So why does a visitor's decision at any one intersection matter? If the data was only valuable to evaluate behavior at a single intersection, it would matter very little. However, intersections can be looked at in series; a string of independent decisions that guide the visitor through the park



By determining the options and odds for each option at every intersection in the park, an overall model of traffic behavior (flow) is assembled. By selecting a survey location that allows a clear simultaneous view of all approaches to an intersection, the surveyor can record the number of times each of the possible decisions are made.

Figure 1 (at right) depicts an example of this. At a three-way intersection, there are two options available to a vehicle or hiker coming from any direction. A visitor coming from A (blue lines) may elect to go straight through the intersection to B or turn towards C. Combined, there are six possible movements through this intersection (A to B, A to C, B to A, B to C, C to A, C to B). By counting the number of vehicles or hikers that select each movement over a period of time, the percentage of visitors that will select a given movement can be estimated. The table above illustrates how these percentages are compiled.

Vehicles From A to B	Vehicles from A to C	Total from A	% Vehicles A to B	% Vehicles A to C
75	25	100	75.0 %	25.0 %
Vehicles From B to A	Vehicles from B to C	Total from B	% Vehicles B to A	% Vehicles B to C
350	50	400	12.5%	87.5%
Vehicles From C to A	Vehicles from C to B	Total from C	% Vehicles C to A	% Vehicles C to B
25	25	50	50%	50%

Examination of this method will show a notable flaw in the survey method; this survey assumes that a car leaving an area intends to leave it and will actually do so. In truth, a small number of vehicles do turn around and return to their sources. Rather than include this in the data model, these were logged as exceptions and will be treated as such.

Though there are many intersections and pullouts, not all were identified as necessary for use in this study. Any "Employee Only" and restricted road intersections were discounted, including the housing and maintenance area intersections, the Mixing Circle intersection and numerous service road junctions. The Mossy Cave pullout was not included in the survey both because it is situated well outside the entrance gate and main body of the park and because the majority of the Mossy cave trail was closed for the 1997 season due to trail damage. While outside the entrance stations, Fairyland Canyon intersection was included in the survey. There were two reasons behind this. The road to Fairyland Canyon is directly in the path of all visitors entering and exiting the park (unlike Mossy Cave, which is distant from the main road). Furthermore, the Fairyland overlook is a trailhead for one of the park's longest trails as well as serving as an endpoint on the rim trail. As such, it can be expected to play a substantial role in Bryce's visitation patterns. Intersections targeted for the study include: the Visitor Center parking lot; the Sunrise Road (four intersections); Sunset Point; Inspiration Point; the Bryce Point/Paria Point intersection; the Rainbow Gate intersection; Farview Overlook; and Natural Bridge. Destinations between Natural Bridge and Rainbow Point were excluded from the study since observations indicate that virtually all visitors that drive past Natural Bridge continue to Rainbow Point.¹

FLOW MEASUREMENT

¹ This was determined by examining the behavior of cars using pullouts along the south road. Cars pulling in from the north exit to the south, continuing along their route. The number of cars reversing direction was too low to be statistically significant.

Flow measurement is by far the simplest form of data collection used in this survey. It is the collection of the number of vehicles or people to pass a certain point. This form of data is very useful in certain situations however, and has three applications in this project.

Visitation to destinations by trail is accounted for by flow measurement. The primary example of this is a visitor who is staying at the park's Lodge. This visitor may park by his or her hotel room, and walk from there to any of the viewpoints in the main amphitheater. Likewise, a visitor may park at one of the viewpoints and walk to the other viewpoints in the area. This visitor is not accounted for on any road or trail intersection since they are not using roads or any of the canyon trails. By surveying points along the rim between major resources, this foot traffic may be quantified.

While measuring the volume of traffic along the Rim Trail is quite simple, there are complications in interpreting that data. The largest of these is the challenge of determining how many Rim Trail hikers are walking viewpoint to viewpoint above the rim and how many hikers are using the trail to complete a loop trail hike in the main amphitheater. The best way to estimate the portion of hikers using the Rim Trail to complete an amphitheater hike is to compare the raw Rim Trail volumes with the volume of hikers using the amphitheater trails at the same time. In most cases, this comparison shows that under-the-rim hikers were in the vast minority when compared to rim-walkers. The exception to this is the segment of the Rim Trail that connects Sunrise and Sunset points. Here the hiking traffic from the Navajo-Queens loop is a substantial portion of total rim-hiking traffic.

The second application of flow analysis is a determination of the traffic flow through parking lots. Collected in tandem with duration data, the number of vehicles entering and exiting a parking lot over a period of time can be extrapolated into an estimation both of the visitation rate for that resource and the maximum turnover rate for that resource (duration of stay being the other limiting factor).

The third application of flow data is the measurement of traffic flow through the entrance stations. Since Bryce has only one entrance and exit, the flow through these gates provides a clear picture of the traffic volume over time in the park. This data was collected both independently and in conjunction with Visitor Center intersection data.

TOOLS

Numerous tools were used for data collection. These range from basic data sheets to mechanical counters to electrical counters. The most common approach to data collection used in this study was basic visual counting. While labor intensive, it is highly flexible and is generally speaking the most accurate method available. Data sheets for each type of study (and in some cases each location) were developed to ease data recording and ward off errors due to recording problems. Two mechanical counters (thumb-clickers) were used in combination with these to speed data recording at busy locations.

ELECTRONIC COUNTERS

The electronic counters are photo-infrared transmitter-receiver pairs hooked up to a basic CMOS counter. The pair has a range of roughly ten meters (thirty-two feet) and is relatively unaffected by environmental conditions when compared to more traditional motion sensor devices (thermal IR, photographic and sonic sensor systems). Any break in the beam lasting greater than twenty milliseconds will trigger the counter (increasing the count value by one). A prime advantage of this style of system is that it is designed to be completely unattended, thus occupying very little of the researcher's time.

Mechanical Issues

There are, however, several challenges that must be faced when implementing this technology. The first issue to be dealt with is supplying power to mobile units where AC power is unavailable. This was worked around by using low-power sensors and running them off a series of RC batteries (7.2 volt, .5 amp-hour batteries for radio control vehicles). Each transmitter and receiver requires a minimum of 12 volts for proper operation², which translates into 4 batteries per pair. While this solution is inexpensive (\$80 per sensor pair) and readily available, the batteries are both bulky and heavy. Furthermore, they can be damaged by prolonged direct exposure to sunlight (overheating). This is resolved by placing them in light-colored plastic containers (protecting them from both sunlight and precipitation), adding further bulk.

The next significant challenge is in the setup of the devices. The photo-infrared beam (PIR beam) is very narrow (to reduce power consumption and false signaling), thus requiring some time and care when a pair is set up³. Initial trials involved attaching the sensor pairs to posts, rails, and fence wire (dog wire). Of these, only the fence wire proved to be a reliable mount. Later implementations used eighteen-inch length of rebar for mounts. This improved setup by making sure that there was a consistent object to which the sensors could be attached. However, rebar is far from a perfect solution. The largest problem with rebar is that it is round. When a sensor is attached to a curvilinear surface, there is opportunity for the sensor to rotate around the bar slightly. This rotation can break the beam, stopping data collection and invalidating the survey. Though a permanent attachment to the rebar would resolve this problem, it is not practical as a solution since the sensors would then be subject to tremendous shocks when the rebar was hammered in to the ground.

Non-Mechanical Issues

When using an automated sensor of any kind, it is important to evaluate that sensors data in comparison to other standard methods of data collection (in this case, visual). By comparing sensor readout to a known quantity, the sensor's accuracy in that implementation is determined. Thus, the first time a sensor was used in a new location, it was tested for accuracy before any surveys were performed. This is time consuming, but critical to proper data collection.

In this particular system, the need for this arrives mostly from over-sensitivity. Since the counter will activate during any twenty-millisecond disruption, it is possible to get multiple counts for a single person. For instance, if a hiker walks by the sensor swinging his or her arms, it is possible to get three or four counts (one for the torso and one for each swing of an arm past the sensor). Likewise, if the sensor is installed close to the ground, it is prone to counting once per leg rather than once per person. Since height, transmitter angle, surroundings and height of hikers all affect how many times a person will be counted, an average is taken over time of actual hikers past the counter versus counts displayed.

The possibility for which this does not account is when a visitor (or visitors) notices the sensors and stands directly in front of them for some time, blocking the signal. Another variation of this is a visitor walking up to the sensor, prodding at it and walking away. This commonly

² As documented by the manufacturer. Field experience denotes unpredictable results when voltage sags towards 12 volts, including both redundant and missing signals.

³ At five meters (5m), the beam is functionally two centimeters (2cm) wide. The receiver is one centimeter (1cm) in diameter. Thus a small change in the orientation in either the sensor or receiver can break the beam.

leaves the sensor mis-aligned, stopping data collection entirely. These are frustratingly hard to prevent and recover from without having a researcher watching the sensor.

DATA AND RESULTS

The project data will be presented in two main groups, vehicle data first and hiking data second. Of the vehicle data, the intersection analysis will be presented first, followed by duration and flow analyses. Hiking data will be discussed in terms of trail intersection analysis of the main amphitheater followed by flow analysis on the Rim Trail.

INTERSECTION RESULTS AND ANALYSES

The table key is as follows:

Location: Name of the intersection or other location

Surveys: Number of overall surveys compiled at that location. Note: Some areas may require an aggregation of multiple surveys to form one complete image. Such a location would typically be one that could not be observed in its entirety from one location.

South to In: An average of the number of vehicles per hour arriving from the south and turning in to the location.

South to Thru: An average of the number of vehicles per hour arriving from the south and continuing to the north rather than turning in to the location.

North to In: An average of the number of vehicles per hour arriving from the north and turning in to the location.

North to thru: An average of the number of vehicles per hour arriving from the north and continuing to the south rather than turning in to the location.

Out to South: An average of the number of vehicles per hour leaving the location and heading south.

Out to North: An average of the number of vehicles per hour leaving the location and heading north.

Percentage: Percentage of vehicles making one decision versus the other.

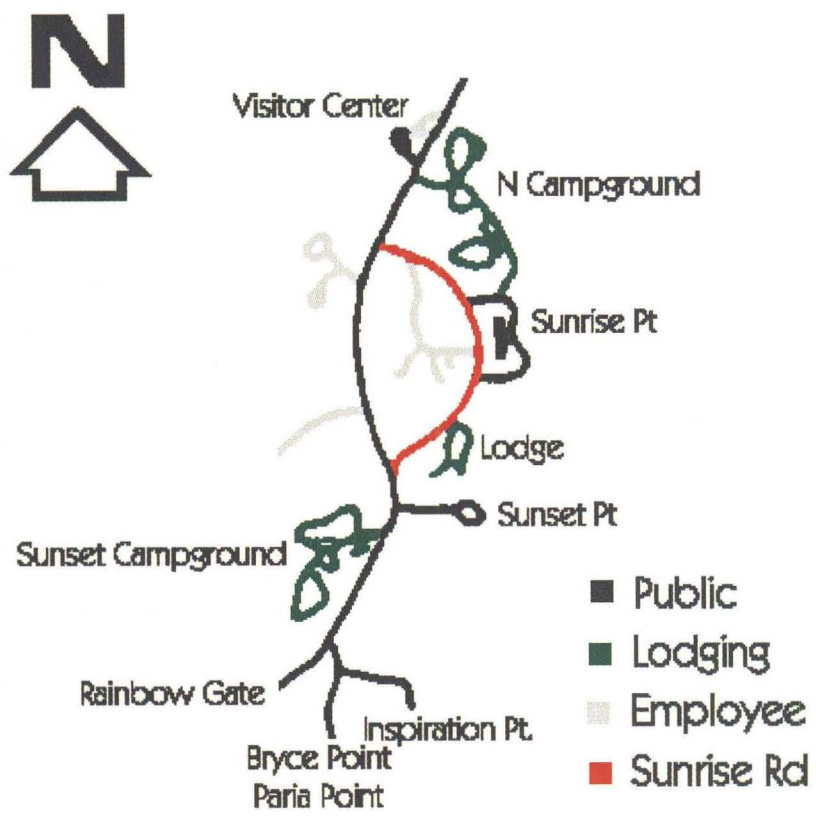
Variance: Average variation observed in three sets of ratios: ratio of the averages; ratio of the minimums; and ratio of the maximums.

Location			Surveys = 4
South to In	South to Thru	Percent In vs Total	Variance
15.0	45.0	25.0%	1.6%
North to In	North to Thru	Percent In vs Total	Variance
25.0	25.0	50.0%	2.3%
Out to South	Out to North	Percent South vs North	Variance
40.0	10.0	80.0%	6.1%

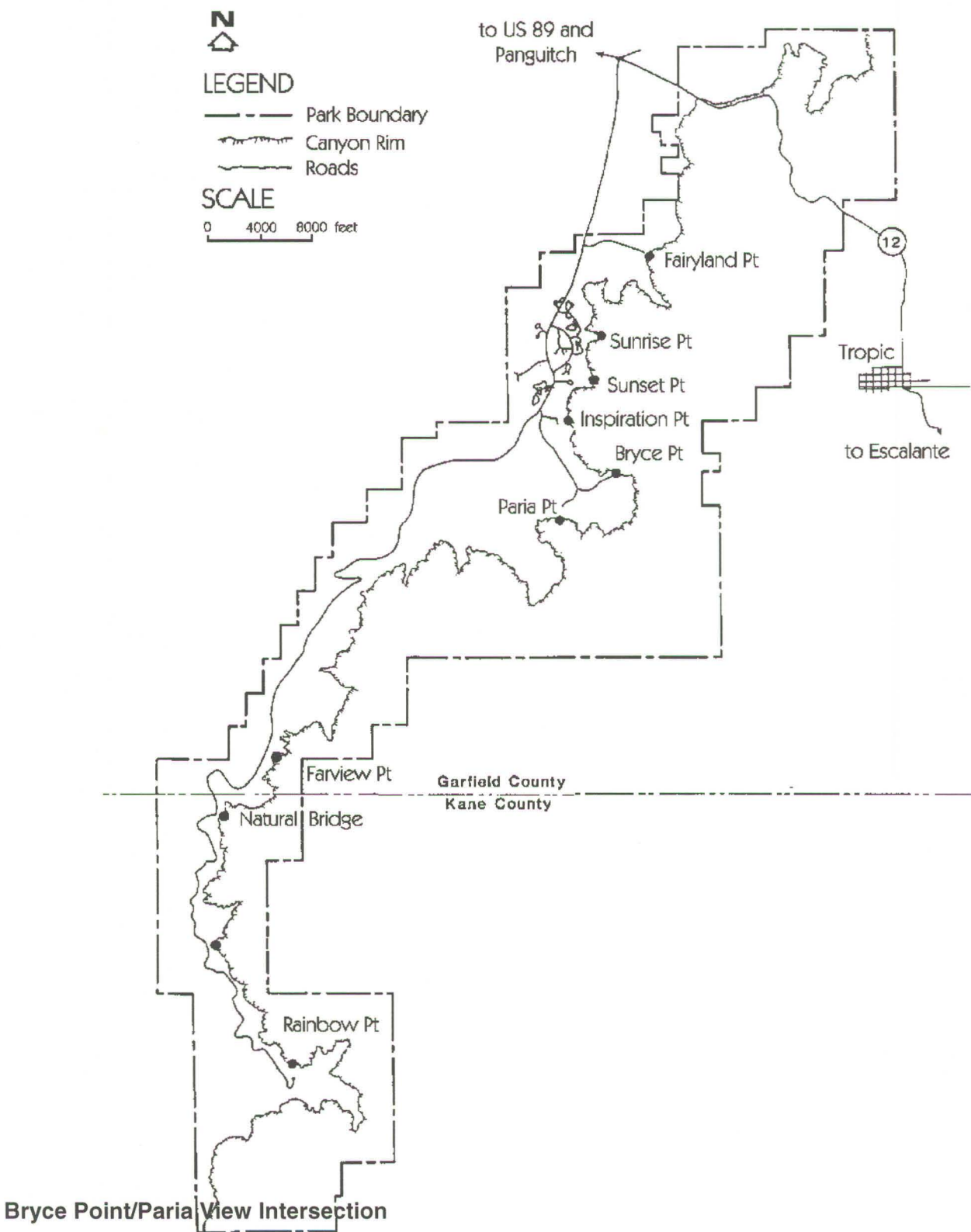
AREA MAPS

The following two maps illustrate the areas discussed in the Intersection Analysis section of this paper. The first map illustrates the road systems in the main amphitheater area of Bryce Canyon National Park. The second map covers the entire park and includes the park boundary as well as surrounding roads and towns.

Main Amphitheater



Bryce Canyon National Park



Seventy vehicles per hour enter the Bryce Point and Paria View intersection from the Inspiration intersection. Of these, 49.7 enter Bryce Point (70%) and 21.3 enter Paria (30%). Of vehicles that go to Bryce Point first, one third continue on to Paria, accounting for about 21 vehicles per hour (half of Paria's visitation). In contrast, three quarters of the vehicles that go to Paria first then go to Bryce Point. Overall, just over half of the vehicles reaching the intersection visit both points (36 out of 70 vehicles per hour).

Bryce Point/Paria View Intersection			Surveys = 3
South to In	South to Thru	Percent In vs Total	Variance
14.0	27.7	33.6%	3.4%
North to In	North to Thru	Percent In vs Total	Variance
49.7	21.3	70.0%	2.1%
Out to South	Out to North	Percent South vs North	Variance
21.7	44.0	33.0%	0.8%

Fairyland Canyon Road Intersection

The Fairyland Canyon data shows clearly that exceptionally few visitors enter Fairyland in the process of entering the park, and roughly fourteen percent of visitors attend the viewpoint on their way out. Very few if any of the viewpoint's visitors return to the park when they leave Fairyland.

Fairyland Canyon Intersection			Surveys = 3
South to In	South to Thru	Percent In vs Total	Variance
16.7	101.7	14.1%	1.2%
North to In	North to Thru	Percent In vs Total	Variance
1.7	116.0	1.4%	0.3%
Out to South	Out to North	Percent South vs North	Variance
2.0	16.0	11.1%	1.6%

Farview Point Intersection

The percentages of visitors entering the Farview parking lot from the north and the south are almost identical at 35% and 33% respectively. Unsurprisingly, the percentage of visitors leaving Farview to the north and the south are also quite similar (47% and 53% respectively). This implies that visitors entering from the north exit to the south and vice versa, continuing travel in their original direction with very few exceptions (roughly one in one hundred).

Farview Point Intersection			Surveys = 4
South to In	South to Thru	Percent In vs Total	Variance
16.0	32.0	33.3%	8.1%
North to In	North to Thru	Percent In vs Total	Variance
28.5	52.0	35.4%	1.8%
Out to South	Out to North	Percent South vs North	Variance
22.8	20.5	52.6%	5.1%

Inspiration Point and Bryce/Paria Intersection

Of the 99 vehicles per hour that enter the Inspiration/Bryce/Paria complex, 60% visit Inspiration Point and 81% continue south towards the Bryce Point and Paria viewpoints. Two thirds of the visitors go directly to the Bryce/Paria intersection upon entering the complex. One third of those visit Inspiration Point on the way back to the main road.

Inspiration Point Intersection			Surveys = 3
South to In	South to Thru	Percent In vs Total	Variance
22.7	46.3	32.9%	6.6%
North to In	North to Thru	Percent In vs Total	Variance
37.3	61.3	37.8%	9.0%
Out to South	Out to North	Percent South vs North	Variance
19.7	41.3	32.3%	7.8%

Natural Bridge Intersection

Like Farview Point, Natural Bridge does not appear to affect the direction of traffic flow.

Visitors entering from the south tend to exit to the north and vice versa. Of the visitors that stop at the viewpoint, most stop on the return drive from the southern extremes of the park rather than stopping on their way south. The parking lot is on the right hand side of the road for northbound traffic and is designed to easy access for northbound vehicles. Since this

Natural Bridge Intersection			Surveys = 3
South to In	South to Thru	Percent In vs Total	Variance
31.3	11.0	74.0%	0.4%
North to In	North to Thru	Percent In vs Total	Variance
15.7	55.3	22.1%	1.3%
Out to South	Out to North	Percent South vs North	Variance
15.7	30.0	34.3%	5.9%

viewpoint and all viewpoints to the south of it are designed in this manner, visitors are encouraged at the Visitor Center to drive to the southern end (Rainbow Point) and stop at the intermediary destinations on the way back to the north.

Rainbow Gate: South Park and Inspiration/Bryce/Paria Complex

One of the most complicated park intersections, Rainbow Gate has a high occurrence of visitors changing their minds and altering their decisions in the middle of the intersection. Such vehicles were observed until they exited the intersection and were counted only for the final result. Thus a car entering the intersection from the north, making four turns in the intersection and then finally exiting to the south would only be counted as moving north to south.

Rainbow Gate and Insp/Bryce/Paria			Surveys = 3
South to In	South to Thru	Percent In vs Total	Variance
33.0	40.3	45.0%	4.1%
North to In	North to Thru	Percent In vs Total	Variance
42.3	54.7	43.6%	4.8%
Out to South	Out to North	Percent South vs North	Variance
25.0	50.3	33.2%	5.0%

An average of 97 vehicles per hour approach the Rainbow Gate intersection from the north. Of these, 55 go directly through towards the southern extremes of the park, and the remaining 42 entering the Inspiration/Bryce/Paria complex (Inspiration complex). In that same hour's period, the Inspiration complex receives an additional 33 vehicles that enter the complex while returning from the southern end of the park, yielding a total of 75 vehicles per hour entering Inspiration complex. The number of vehicles exiting south through Rainbow Gate (25) is lower than the number of vehicles entering the complex from the north (42), indicating that a significant number of visitors choose not to drive further south than the Inspiration complex. In comparison, a much higher percentage (58 of the 73 vehicles per hour, or 79%) of vehicles that exit Rainbow Gate have already or will visit the Inspiration complex.

Sunrise Road and 63 (North intersection)
Sunrise Road and 63 (South Intersection)

The Sunrise Road loop is the most complex set of intersections to model in the park. The Sunrise loop has multiple direct connections the main park road as well as one indirect connection via North Campground. Furthermore, it has several side loops with complex entrance and exit patterns. The result is that there are many ways for a vehicle to reach any one side of the intersection from any other. Contrast this to Sunset Point's simple traffic flow: cars can come to the Sunset Point intersection from the viewpoint's parking lot, the southern portion of the park, or the northern portion of the park. There is only one way to get from any one side of the intersection to any other.

Though roughly the same percentage of traffic from the north and south enter the Sunrise Road at the northern intersection, 71% of traffic outbound from Sunrise Road turn to the north. This would suggest that visitors do tend to use the northern exit of the loop to turn north and the southern exit of the road to turn south. This is corroborated by a 65% chance of visitors at the southern intersection (see second table) turning south. The southern intersection receives northbound traffic at a much higher rate than the northern intersection does, with 28% of northbound traffic entering and 18% of the southbound traffic as opposed to 14% and 18% respectively at the northern intersection. This is not surprising, since visitors entering the park are intuitively less likely to head for the lodge or camp store than a viewpoint or trailhead. Visitors returning from the viewpoints are much more likely to be looking for food, drink or rest.

Sunrise Rd and 63 (North Intersection)			Surveys =10
South to In	South to Thru	Percent In vs Total	Variance
16.9	104.1	14.0%	4.1%
North to In	North to Thru	Percent In vs Total	Variance
28.9	133.8	17.8%	1.2%
Out to South	Out to North	Percent South vs North	Variance
14.3	35.4	28.8%	2.6%
Sunrise Rd and 63 (South Intersection)			Surveys = 4
South to In	South to Thru	Percent In vs Total	Variance
28.0	72.5	27.9%	3.4%
North to In	North to Thru	Percent In vs Total	Variance
22.5	103.3	17.9%	1.1%
Out to South	Out to North	Percent South vs North	Variance
35.5	19.5	64.5%	3.4%

Sunrise Road and Sunrise Point Entrance
Sunrise Road and Sunrise Point Exit

Sunrise Point is served by two intersections. The eastern intersection (Sunrise Point Entrance) is a one-way entrance that leads directly to the District Ranger Office (DRO), Sunrise Store, and Sunrise Point trail. The western intersection (Sunrise Point Exit) is two-way at its junction with the Sunrise Road, but branches quickly. One branch serves as a one-way exit for the DRO, Sunrise store and viewpoint parking. The other branch remains two-way, and serves as entrance and exit for the North Campground's amphitheater and picnic areas. To further complicate matters, the North Campground acts as an alternate entrance and exit for the loop since it connects back to the main park road just south of the Visitor Center.

Traffic studies at Sunrise Point are not only complicated by road layout but by the types of resources available at the viewpoint and the ease of reaching it on foot from two of the parks residential areas (North Campground and the lodge).

In addition to the overlooks and trail heads, the Sunrise Road contains the parks two options for buying food (the Lodge's dining hall and the Camper Store), the shower and bathroom facilities located in the Camper store, picnic areas, a dump station for recreational vehicles (RV's), and an Amphitheater where nightly programs if presented. These factors combine in a terrible muddle: visitors may stop at this viewpoint several times during their stay; they may travel to it by foot or by vehicle; and they may arrive (by vehicle) to resources on the loop from three or four unique paths.

Thirty-nine vehicles per hour enter the Sunrise Point loop through the eastern intersection. 25 of these enter from the east side of the loop, indicating that they are coming from the lodge or the southern portions of the park rather than the Visitor Center. This implies that visitors tend to bypass Sunrise Point on their way into the park and either drive or walk to it later on in their visit. Vehicles exiting the Sunrise Point loop are split evenly with 51% of traffic turning to the east.

14.3 vehicles per hour enter the western intersection. Of these, more than 11 come from the eastern (Lodge and rim) end of the Sunrise Road. Thus, vehicles entering Sunrise Road from the northern intersection (the first major intersection encountered by visitors as they enter the park) tend to continue on to the viewpoint or lodge.

Sunrise Pt Entrance			Surveys = 3
West to In	West to Thru	Percent In vs Total	Variance
14.0	9.3	60.0%	13.8%
East to In	East to Thru	Percent In vs Total	Variance
25.0	24.0	51.0%	0.9%
Out to West	Out to East	Percent West vs East	Variance
n/a	n/a	n/a	n/a
Sunrise Pt Exit, Campground Entrance			Surveys = 3
West to In	West to Thru	Percent In vs Total	Variance
3.0	15.7	16.1%	1.7%
East to In	East to Thru	Percent In vs Total	Variance
11.3	41.3	21.5%	4.7%
Out to West	Out to East	Percent West vs East	Variance
30.7	29.0	51.4%	7.4%

Sunset Point Intersection

The sunset point intersection show that nearly twice as many visitors enter Sunset Point on their way into that park (39% of southbound traffic) rather than their way out (22% of northbound traffic). However, a little less than 47% exit the viewpoint to the south. This translates into one third of the cars entering Sunset on their way into the park never go any further.

Sunset Pt Intersection			Surveys = 4
South to In	South to Thru	Percent In vs Total	Variance
26.0	91.3	22.2%	2.3%
North to In	North to Thru	Percent In vs Total	Variance
45.8	74.3	38.1%	5.8%
Out to South	Out to North	Percent South vs North	Variance
34.3	37.8	47.6%	8.0%

Visitor Center Parking Lot Intersection

Though the Visitor Center (VC) lot has little effect on traffic in terms of redirecting flow, it is significant in other ways. By stopping at the Visitor Center, visitor has a chance to talk to a park ranger or view printed materials that can influence their decisions about where to go in the park. Although a visit to the VC at any time is valuable from the

Visitor Center Intersection			Surveys = 4
South to In	South to Thru	Percent In vs Total	Variance
23.0	103.8	18.1%	1.1%
North to In	North to Thru	Percent In vs Total	Variance
79.5	116.5	40.6%	3.8%
Out to South	Out to North	Percent South vs North	Variance
83.0	23.3	78.1%	11.3%

standpoint of visitor education, only visits upon entering the park pay off in terms of guiding visitor activities. This survey found just short of 41% of the vehicles entering the park stopped at the VC.

Since this data cannot differentiate between new entries and reentries, it is possible that the numbers are substantially higher. In addition, an average of 80 vehicles per hour entered the VC from the gates, while 83 per hour exited the VC parking lot into the park. This means that several vehicles already in the park return to the Visitor Center before they have completed their stay.

While this is not as ideal as visiting upon entry, it does give some chance for visitor guidance. Of all vehicles exiting the park, only 18% stop at the Visitor Center. Note that the number of cars per hour exiting the visitor center regardless of their origin (from the park or outside of it) is slightly higher than the number of cars entering the Visitor Center on their way out. This indicates that some additional 4% of visitors may be entering the park, stopping at the Visitor Center, and then leaving the park. While it is possible that these visitors never reach the main body of the park, it is more likely that they are visitors staying in hotels or campgrounds outside of the park and merely dropping into the park briefly for information. Such visitors do travel further into the park either before or after these quick stops and may be largely ignored in terms of overall visitation patterns inside the park boundaries.

INTERSECTION ANALYSIS SUMMARY

To view the overall picture, each intersection must be examined in turn as a vehicle travels through the park. For reference, the table at right shows the overall percentages of vehicles that enter individual Destinations as well as what percentage of vehicles go no farther than a single destination. The most critical limitation in the use of this data is that this model assumes that each route will only be taken once. For example, a vehicle will enter the park, visit several viewpoints in sequence and leave. Many vehicles will arrive, visit several viewpoints, drive back to the lodge for a meal or rest, go to the Visitor Center, and then go to the south end of the park. In this case, a single vehicle will pass the same destination several times and probably still only turn in once. This creates artificially low percentages of the vehicles stopping at those destinations that are passed repeatedly. This only appears to affect destinations north of Sunset Campground (the first five listed in the table).

Destination	% of Visitation that reach this point () indicates % entering the point
Fairyland Point	100% (16%)
Visitor Center	100% (59%)
Sunrise Road	100% (29%)
Sunset Point	100% (59%)
Inspiration Point	42% (42%)
Bryce Point	43% (43%)
Paria Point	34% (34%)
Farview Point	68% (34%)
Natural Bridge	68% (41.4%)
Rainbow Point	68% (68%)

* See accompanying text for limitations in using this data.

Main Trunk of the Park Road System

Sunrise Rd:

Extremely complex, making results unreliable. However, general observations suggest that few to no visitors enter the park without at least reaching the Sunset Point intersection. Assuming 100% of visitors pass Sunrise Rd before exiting.

Sunset Point:

From north: 121.1

To south: 74.3 (through traffic) and 34.3 (traffic from overlook), total = 108.6

To the point: 45.8 (from north) and 26.0 (from south), total = 71.8

121.1 cars reached this point and 107.6 continued. This means 89.7% of the total traffic continued to Rainbow Gate. 10.3% traveled no further than Sunset Point

Notes: Of the cars that enter Sunset point, 1/3 do not go any further.

Cumulative Percentage of visitation traveling beyond this point: 89.7%

Rainbow Gate:

From north: 97.0

To south: 54.7 (through traffic) and 25.0 (traffic from Insp/Bryc/Pari), total = 79.7

To the point: 42.3 (from north) and 33.0 (from south), total = 75.3

97 cars reached this point and 79.7 continued. This means 82.1% of the total traffic continued to the south of Rainbow Gate. 17.9% traveled no further than Sunset Point. 77.6% of traffic reaching the Rainbow Gate intersection opted (at one time or another) to travel towards Inspiration, Bryce and Paria overlooks.

Cumulative Percentage of visitation traveling beyond (south) this point: 73.6%

Cumulative Percentage of visitation traveling beyond (to INSP/BRYC/PARI) this point: 69.6%

Southern Branch of the Park Road System

Farview Point:

From north: 80.5

To south: 52.0 (through traffic) and 22.8 (traffic from overlook), total = 74.8

To the point: 28.5 (from north) and 16.0 (from south), total = 44.5

80.5 cars reached this point and 74.8 continued. This means 92.9% of total traffic continued to Natural Bridge. 7.1% traveled no further than Farview.

Cumulative Percentage of visitation traveling beyond this point: 68.4%

Natural Bridge:

From north: 71.0

To south: 55.3 (through traffic) and 15.7 (traffic from overlook), total = 71.0

To the point: 15.7 (from north) and 31.3 (from south), total = 47.0

71 cars reached this point and 71 continued, meaning that 100% of total traffic continued to other overlooks. Of the 47 cars per hour entering the overlook, very few (22.1%) entered while heading south while the majority of vehicles returning from the south end of the park (74.0%) stopped at the viewpoint.

Note: A higher percentage of vehicles heading north stopped at the viewpoint despite the lack of a sign marking the overlook for north-bound vehicles and the presence a such a sign for southbound traffic.

Cumulative Percentage of visitation traveling beyond this point: 68.4%

Beyond Natural Bridge:

No statistically significant turnarounds (fewer than 1%) were recorded at any pullout up to Rainbow Point (where turnarounds are guaranteed to be 100%).

Eastern Branch of the Park Road System

Inspiration and Bryce/Paria Intersection:

From north: 99.0

To south: 61.3 (through traffic) and 19.7 (traffic from overlook), total = 80.0

To the point: 37.3 (from north) and 22.7 (from south), total = 60.0

99 cars per hour reached this point and 80 continued. This means 80.8% of total traffic continued to Bryce Point and/or Paria Point. 19.2% traveled no further than Inspiration Point. 60.6% of the total traffic through the intersection attended Inspiration Point.

Cumulative Percentage of visitation traveling beyond (to BRYC/PARI) this point: 56.2%

Cumulative Percentage of visitation reaching Inspiration Point: 42.2%

Bryce and Paria Intersection:

From north: 71.0

To south: 21.3 (through traffic) and 21.7 (traffic from Bryce Point), total = 43.0

To Bryce Point: 49.7 (from north) and 14.0 (from south), total = 53.7

75.6% of the cars reaching this intersection visited Bryce Point, while 60.6% percent of the cars visited Paria Point.

Note: Two-thirds of the vehicles that visited Paria Point first also visited Bryce Point, while less than half of the vehicles that visited Bryce Point first continued to Paria Point.

Cumulative Percentage of visitation reaching Bryce Point: 42.5%

Cumulative Percentage of visitation reaching Paria Point: 34.1%

PARKING LOT FLOW ANALYSES

Data on the rate of traffic inbound to parking lots was collected during duration analyses. This data serves as additional information on utilization of the viewpoints that can be used in combination with portions of the intersection analysis data. Since flow data is collected in both duration and intersection analyses, a large base of data is available for points covered by both surveys. The first table displays the average (arithmetic mean) flow into each destination.

Flow data collected during the duration surveys have the added advantage of containing an additional level of detail: whether or not vehicles are registered in Utah. Some Utah-registered vehicles may be rentals and contain out-of-state visitors. However, the number of Utah-tagged vehicles may be used as a maximum for the number of locals visiting the park versus travelers from outside the state. There is one notable limitation to the data: collection was completed early in the summer season, around the same time or before the school year ended for many Utah school districts. This probably means that the data is not representative of peak volumes for in-state visitation.

Location	Cars/hour	% In State
Agua Canyon	36.7	0.0%
Bryce Point	60.3	5.4%
Fairyland Point	18.3	10.6%
Farview Point	46.5	3.8%
Inspiration Point	54.5	4.5%
Natural Bridge	51.8	7.6%
Paria Point	41.7	5.8%
Ponderosa Point	51.5	0.0%
Rainbow Point	40.9	4.3%
Sunrise Point	47.5	10.7%
Sunset Point	63.8	11.0%

In terms of traffic in-flow, Sunset Point maintains the highest traffic by a slim margin over Bryce Point. These are the only two destinations that surpass one car per minute (60/hour). Fairyland Canyon is dramatically the least visited, with only 18 cars per hour visitation. Of particular note is the comparison between destinations south of Rainbow Gate and those in the northern section of the park. Though nothing in the southern portion of the park matches the visitation of Sunset Point or Bryce Point, their visitation is ranges around 40 to 50 vehicles per hour, the same level of visitation seen at Sunrise Point and Inspiration Point, and much higher than that found at the Fairyland Canyon overlook. These numbers are consistent with the intersection analysis data, which indicated that a similar percentage of vehicles entering the park would reach Rainbow Point as the destinations in the northern end of the park.

The main surprise in this data is that Rainbow Point receives fewer vehicles per hour than the other destinations along the southern reaches of the park road. The intersection analysis of the southern range of the park showed that vehicles did not tend to turn around before reaching Rainbow Point. Furthermore, Rainbow Point is unlike the other southern destinations in that vehicles are forced to enter even if they wish to simply turn around. It is not clear why the data differentiates so notably from the other destinations, but random sampling variations are the most likely cause.

A comparison between in-state and out-of-state visitation levels readily shows that the vast majority of Bryce's visitors are from out of state. The highest percentage of local visitors is only eleven percent (11%) and the average was below six percent (6%). Though the number of locally registered vehicles was insignificant in many cases, the destinations with the highest local attendance were the three northernmost viewpoints: Fairyland, Sunrise and Sunset overlooks, each with roughly ten percent (10%) local vehicles.

AMPHITHEATER INTERSECTION DATA

Of the main trails in the main amphitheater, two were surveyed in detail. Navajo Loop and Queens Garden were each observed at their respective trailheads and canyon floor intersections. Peekaboo loop was included in the intersection study of Navajo Loop since this was the only access point for the trail during the survey period⁴. Fairyland Loop was not included in this analysis due to a lack of statistically significant usage. The number of hikers per day that use Fairyland is so small as to make hourly analysis meaningless.

Navajo Loop

An intersection analysis of Navajo Loop shows that the majority of hikers (more than three quarters) descend by Wall Street. Few to no hikers leave by the same trail on which they entered. Hikers leaving the canyon by Navajo Loop are evenly split between Wall Street and Twin Bridges (48% and 52% respectively). These numbers appear unusual at first glance since most hikers on loop trails descend by one route and return by the other. The discrepancy here arises from Navajo Loop's connection to the Queens Garden trail. Using the canyon floor junction data, the surveys show that the prevalent uses of the loop are to hike down Wall Street and return by Queens Garden. The explanation for why Wall Street and Twin Bridges' usages are balanced lies in the relatively even use of both options by hikers coming from Queens Garden.

Navajo Loop- Sunset Point Trail head			
Trail	Wall St	Twin Bridges	% hiking to landing and back only
% Entering by trail	74.5%	21.5%	
% Leaving by trail	47.3%	52.7%	4.1%

Note that while three quarters (496/666) of hikers descending Navajo Loop walk down Wall Street, only two-thirds (194/293) of hikers that actually reach the canyon floor travel by Wall Street. This indicates that a greater number of hikers change their minds about hiking to the bottom of the canyon while hiking Wall Street than the number of hikers who change their minds while hiking Twin Bridges.

Navajo Loop-Queens Garden: Canyon junction				
TRAIL	Wall St	Twin Bridges	Queens Garden	% of hikers taking Peekaboo Loop
In-Traffic	194	99	121	
Out-Traffic	171	111	178	
% Entering	46.9%	23.9%	29.2%	
% Exiting	37.2%	24.1%	38.7%	10.2%

Queens Garden

Since Queens Garden trail has very few intersections as options for hikers, modeling its usage is much easier than that of Navajo Loop. Hikers descending from Sunrise exit the canyon by Navajo Loop almost without fail and hikers entering from Navajo Loop always exit by Queens Garden trail to Sunrise Point. The predominate flow pattern (69% of visitors passing the intersection) is to enter Queens Garden from Navajo Loop and hike out to Sunrise Point. This is tightly corroborated by a measurement of 67% at the trail head, indicating that very few hikers descend partially into the canyon via Queens (unlike Navajo Loop, where there is a substantial difference in traffic between the upper and low junctions due to visitor turn-around).

The only option presented to the hiker is whether or not to hike the short (200 meter) spur to

⁴ Bryce Point's connecting trail was closed until early July due to trail damage.

Queens Garden itself. Survey data indicates that roughly forty percent (40%) of the trail's hikers visit the Queens Garden spur.

Queens Garden- Canyon Floor Junction			
Trail	Sunrise Point	Navajo Loop	% of hikers taking Queens Garden
% Arriving by	31.5%	68.5%	
% Leaving by	68.5%	31.5%	40.6%

Queens Garden- Sunrise Point Trail head	
% Departing	33%
% Returning	67%

RIM FLOW TRAIL DATA

Information collected along the Rim Trail is limited to flow along segments between major viewpoints and the lodge. These surveys are designed to capture information about how many visitors attend the major viewpoints without being counted in vehicle analyses. Surveys were distributed between 9:00am and 6:00pm and typically lasted for one hour or more per survey. Data was compiled first as an overall average for the day and then limited to the expected peak hiking hours (11:00am through 4:00pm) for comparison.

Traffic between Sunrise and Sunset points accounts for a majority of Rim Trail usage with both segments (separated by the lodge) hovering around 130 hikers per hour. The trail between Sunset and Inspiration points also showed significant usage,

Rim Trail Flow Data					
From	Fairyland	Sunrise	Lodge	Sunset	Inspiration
To	Sunrise	Lodge	Sunset	Inspiration	Bryce
Measurements over a full day:					
Flow per hour	17.2	135.6	126.2	63.1	27.5
Measurement of midday hours only:					
Flow per hour	15.0	155.0	141.5	74.3	26.3

with nearly seventy-five hikers per hour. The peripheral portions of the amphitheater received very little usage, with twenty-six hikers per hour reaching Bryce Point and only seventeen hikers reaching Fairyland Canyon each hour. Examining peak hours only, Bryce and Fairyland actually received marginally fewer hikers, indicating that many visitor may hike these trails in the cooler morning or evening hours. Trail segments in the main portion of the amphitheater (Sunrise to Inspiration) rose between ten and twenty visitors per hour, corresponding to heavy visitation of those viewpoints and high usage of the Navajo-Queens trail complex (which requires returning to the point of origin via the Rim Trail).

NON-QUANTITATIVE DATA

The process of data collection uncovered much useful information that could not practically be quantified. This section will briefly cover several of the varied observations collected while gathering other data.

Driving-related Information

When lines at the entrance gates are long, a lower percentage of vehicles enter the Visitor Center. This also applies to construction delays outside the entrance gates.

The majority of visitors driving to the southern end of the park drove all the way to the end and stopped at the pullout viewpoints on their way back north. Many visitors were overhead saying that they were told to do so at the Visitor Center.

RV's and large vans do not necessarily carry more people than sedans. Very few RV's or

privately owned vans carried more than four people and many carried only two.

Most bus tours tend to use Inspiration Point and Sunrise Point as the endpoints for the hiking/rimwalk section of their tours. Visitors will be let out at Inspiration Point to walk the downhill trail towards Sunrise Point rather than walking from Sunrise to Inspiration. Variations on this include starting from Bryce Point rather than Inspiration or using Sunset Point as an endpoint when no bus parking is available at Sunrise Point. Due to the limited bus parking available at Sunrise Point, many drivers park their buses at Sunset while waiting for their tours to catch up and only move the buses to Sunrise around the planned pick-up time.

Several intersections repeatedly baffle visitors. The Rainbow Gate/Inspiration/Bryce/Paria Point intersection is by far the most complex and a substantial number of vehicles (10 or more per hour) will have to circle through it multiple times to go the desired direction. The northern-most intersection of 63 and the Sunrise Road is another problem intersection. Northbound vehicles often fail to see the sign in time and miss the intersection or have to break hard to make the turn. While this situation is less confusing than the Rainbow Gate intersection, it is much more likely to result in a traffic accident. Several near-accidents occurred as large vehicles locked their brakes trying to make the turn and nearly slid into vehicles looking to pull out onto 63.

Other than Visitor Center parking lot congestion, parking overflow conditions were minimal during the data collection period. Sunrise Point did experience several situations where bus parking was problematic, indicating a need to push more bus traffic towards Sunset or to create more bus parking at Sunrise Point.

While too sparse to measure accurately, vehicle traffic (almost entirely cars) continues until midnight on most dry and clear nights. This traffic is focused on Inspiration, Sunset, and Sunrise Points but does include some traffic to the lower end of the park.

The feeding of deer from vehicles appeared to be very low during the survey period. However, visitors are still quite prone to feeding small animals and deer while on foot at the viewpoints.

Hiking-Related Information

Very few hikers carry ample water when hiking below the rim. Many groups leave with a one-quart to share among three or more people. A large number of these visitors are unaware that there are no chances to refill canteens in the main amphitheater outside of Peekaboo Loop.

While a very large number of hikers wear improper footwear, most appear to at least recognize that they should be wearing boots.

Many hikers complain heavily about the signs along Navajo Loop and Queens Garden. It is more common than not for visitors to stop and talk with other hikers to find out which way to go after failing to understand the signs. A map of the amphitheater trail system located at the canyon floor intersection of Navajo Loop, Queens Garden, and Peekaboo Loop would be particularly useful.

SUMMARY

Vehicle traffic portion of the study yielded three main conclusions. First, vehicle traffic in the park is spread much more evenly across the viewpoints than was readily apparent. Both the intersection analyses and the flow analyses indicate that the destinations below Rainbow Gate received almost as much vehicle traffic as the viewpoints in the main amphitheater. Second, the proportion of visitors that are from Utah is very low, averaging around 6%. The vast majority of

vehicles that enter Bryce have California, Nevada, or Arizona plates and are rental vehicles. Third, intersection analysis showed that 59% of visitors stopped at the Visitor Center. This percentage is probably low, placing overall usage of the Visitor Center potentially much higher. This means that information distributed there has the potential to heavily impact the usage patterns of the park.

Analysis of the park's trail system usage patterns turned out much as would be expected. The vast majority of foot traffic occurs between Sunrise Point and Sunset Point, with roughly half as many hikers heading out towards Inspiration Point. The trails between Inspiration and Bryce Points and between Sunrise and Fairyland Points received very sparse usage. Of hikers using Navajo Loop, the dominant pattern is to descend by Wall Street and return to the rim by either the Queens Garden trail or Twin Bridges. Peekaboo Loop is used by few hikers relative to Navajo loop, with only 10% of hikers reaching the canyon floor actually taking the trail.

APPENDIX - DATA SHEETS

The following pages include the templates used for data recording throughout the project. Note that some data sheets are location-specific, while others were applied at many locations. Each data sheet includes several basic features: location, date and time, duration of survey, and environmental information.

Environmental information included opening and closing temperatures, estimated wind speed at opening, maximum wind speed during the survey, degree of overcast, and precipitation type if any. The "Location Description" and "Location Comments" fields were used to capture the specific location from which the survey was performed and any anomalies in the data that would not be readily visible in the numerical data. For example, a single car passing back and forth through an intersection repeatedly can skew the data and would be noted in the comment block to aid in interpreting the survey's information. A diagram of the intersection type is provided on each data sheet and can be labeled to visually correspond the data fields with the intersection's options.

While data was collected to include several categories, only visitor's personal vehicles were included in this survey. The other vehicles had inadequate traffic for this analysis. Categories collected during survey: Cars (visitor's personal vehicles), Bikes (bicycles and motorcycles), Buses (commercial vehicles), Shuttles (local shuttle service vehicles), and Federal/Official vehicles (government vehicles, local school buses, and service vehicles).

I. Three-Way Intersection (Generic): used for Sunrise Rd, Sunset Pt, Fairyland, and viewpoints south of Rainbow Gate.

II. Rainbow Gate Intersection

III. Inspiration and Bryce/Paria Intersection

IV. Bryce and Paria Intersection

V. Gate Data: used for the main entrance gate

VI. Parking Lot Data: used for all parking lots

VII. Visitor Center Parking Lot: modified parking lot sheet to include the direction of exits (out through gates and in from gates)

VIII. Navajo Loop Intersection

IX. Counter Verification: used to ground truth results from the electronic counters

Locations without set templates: Trail heads, Rim foot-traffic data