Joshua Tree National Park Transit Feasibility Study

Institute of Transportation Engineers
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University of California, Irvine

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Executive Summary

In recent years, Joshua Tree National Park has been experiencing an increase in visitation at a level that has begun to exceed the park's infrastructure capacity. To address this issue, the National Parks Conservation Association and Joshua Tree National Park asked the University of California, Irvine Institute of Transportation Engineers Student Chapter to conduct a transit feasibility study, including the design of three shuttle system route alternatives within park grounds. The scope of this study includes a visitor survey, a parking analysis, the design of three transit routing and infrastructure alternatives, comparison between different transit technologies, and funding and finance options.

This report summarizes the park's current conditions and the results of a park visitor survey that outlines the views of park guests concerning the incorporation of a transit system. Approximately 57% of survey respondents expressed interest in a transit system and were willing to pay around $5 for the service. In addition to the survey, a parking analysis was conducted to obtain parking lot congestion level estimates and travel patterns within the park.

Based on these observed patterns and survey results, three routing and infrastructure alternatives were developed. Alternative 1 has three different lines: one connecting Joshua Tree Visitor Center (JTVS) to Barker Dam, one connecting Hidden Valley to Keys View, and one connecting Hidden Valley to Cholla Cactus Garden with a transfer stop at Hidden Valley. The visited sites in this alternative include: JTVS, Hidden Valley, Barker Dam, Keys View, Ryan Mountain, Jumbo Rocks, Arch Rock, and Cholla Cactus Garden. Alternative 2 builds upon Alternative 1 with a third route operating between the Oasis Visitor Center and Hidden Valley. Alternative 3 also builds upon Alternative 1 with the addition of a seasonal route which connects Cholla Cactus to Cottonwood Visitor Center.

Based on the findings of the parking study and visitor usage data from a 2010 visitor survey, an origin-destination (OD) matrix capturing the number of visitors traveling between sites was used to establish the characteristics of each route alternative. Total ridership, i.e. the expected number of riders per hour, was derived through comparison to other National Park transit programs. The predicted ridership of 368 riders per hour combined with the OD data was then used to find bus headways, required seating, and number of buses for each alternative.

Beyond alleviating parking and entrance station congestion, another goal of the transit system is to reduce environmental impacts resulting from vehicle emissions. Therefore six alternative transit technologies were compared. These included: diesel, bio-diesel, hybrid diesel-electric, electric, propane, and hydrogen. All six technologies operate uniquely, require specialized infrastructure for fueling and maintenance, and have various impacts on the air quality. Taking cost effectiveness and environmental impact into consideration, the propane shuttle technology was determined to best serve Joshua Tree National Park. Several other National Parks, including Yosemite and Zion, also currently operate propane buses.

The overall costs of the three routing alternatives and different transit technologies were calculated and financial options were researched to determine the most affordable options for the Park. Two options were considered for bus acquisition—a purchasing option and a leasing option. With the purchasing option, Joshua Tree National Park can purchase the buses at the beginning of the program and pay annual costs to operate and maintain the buses. The leasing option will provide the opportunity to invest a down payment the first year and have monthly payments for 72 months, as well as a buyout payment at the end of the lease. In the end, it was determined that the most effective option for the transit system is to lease propane buses. This is mostly due to the initial year costs. Although the annual costs to lease the buses are higher than the purchasing option by about $70,000 a year, the initial payment to lease a bus is only about 10% of the cost to purchase a bus. This will help Joshua Tree Park with the initial funds necessary to implement a transit system.

Funding options for the transit system are summarized in this report. Applicable funds include donation funds, Federal Lands Access Program, Federal Lands Transportation Program, entrance fee increase, and sponsorships like the National Park Foundation.

Synthesizing the findings of each aspect of the report, it was determined that route Alternative 2 operating with propane buses acquired through a leasing option is the ideal alternative. Route Alternative 2 serves visitors at two different entrance locations while maintaining access to the most popular sites in the park. Dividing traffic between entrance locations can help alleviate traffic at the Joshua Tree Visitor Center (JTVC) and its surrounding intersections and reduce the need to expand parking lot capacity at the JTVC location. Propane buses possess the best tradeoff between reduced emissions and costs. The present value cost for

Alternative 2 is approximately $28 million which includes leasing propane buses over a six year period with a buyout after the lease, operations costs such as wages and fuel over a twelve year period, and infrastructure costs for transit stop amenities such as benches and signage.

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Chapter 1: Introduction

Joshua Tree National Park is one of three Southern California desert parks as shown in Figure 1. The Park is centrally located about 140 miles east from Los Angeles, 175 miles northeast of San Diego, and 215 miles southwest of Las Vegas. The Park has three entrances in the towns of Joshua Tree, Twentynine Palms, and Cottonwood Spring/Indio. The 800,000 acre park encompasses two distinct desert ecosystems and is home to 813 desert plant species like the iconic Joshua Tree. Desert animal species such as the threatened desert tortoise also call this Park home. The land that now makes up the National Park has a storied past that can be traced back over 5,000 years to its first human inhabitants. Beginning in the 1800's the Park was grounds for cattle farming and transitioned into mining industry in the 1930's. Wanting to preserve the natural beauty of the desert plant species, the land was designated as a National Monument in 1936 and more recently a National Park in 1994. Recent visitor is reported to be around 1.4 million annual visitors with trends showing an annual increase in visitation (Figure 2) since 1979 when statistics were first gathered.

Figure 1: Joshua Tree Location in Southern California (from NPS.gov)

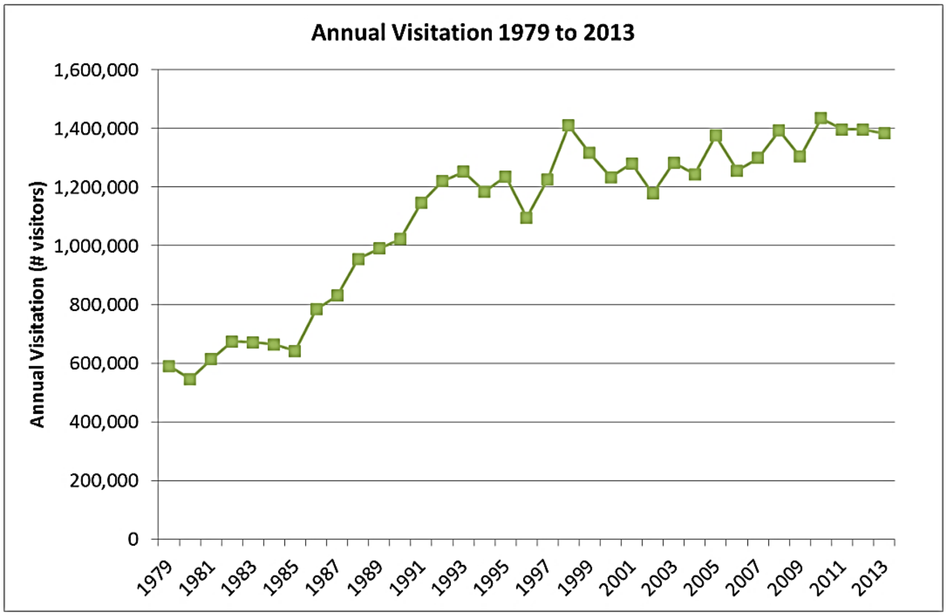


Figure 2: Annual Visitation (Source: irma.nps.gov)

In recent years, Joshua Tree National Park has been experiencing an increase in visitation at a level that has begun to exceed the parks infrastructure capacity. This has been observed in parking and entrance fee station congestion during weekends. Parking congestion has led to overflow parking issues where visitors park in undesignated spaces along park roads leading to dangerous situations for pedestrians and damage to vegetation. Parking problems and entrance fee congestion degrade the visitor experience. In addition, the Park is only accessible by personal vehicle which limits the accessibility to the Park.

Beyond visitor experience, parking overflow, entrance station congestion, and accessibility issues, the Park also faces issues with air quality. Situated in the context of the Coachella Valley and Los Angeles air basin, Joshua Tree NP experiences periods of heavy air pollution as a result of its location. In fact, the Environmental Protection Agency has decreed the air in Joshua Tree NP to exceed the ozone concentration levels. Air pollution is especially damaging to the desert plants and therefore all methods for reducing air pollution and promoting environmental sustainability in and around the Park need to be considered.

Several solutions to the multifaceted issues faced by the Park can be made through transportation improvements. For example, facing similar air pollution issues, Zion National Park reduced air pollution by disallowing personal vehicles to travel within the Park and providing reduced emission shuttles to transport visitors from entrance stations to major sites within the Park. Figure 3 depicts the confluence of current issues faced by Joshua Tree NP. The optimal solution should be able to address each issue. Parking lot expansion is a simple and potentially low cost solution to address parking overflow issues and improve the visitor experience. However, under this solution scenario entrance station congestion would persist, accessible options would remain unchanged (i.e. personal vehicle would remain the only option for park access), and environmental goals such as reducing air pollution would not be achieved. Following the lead of other Parks such as Zion NP, Grand Canyon NP, and Yosemite NP, a more robust solution is to introduce transit options.

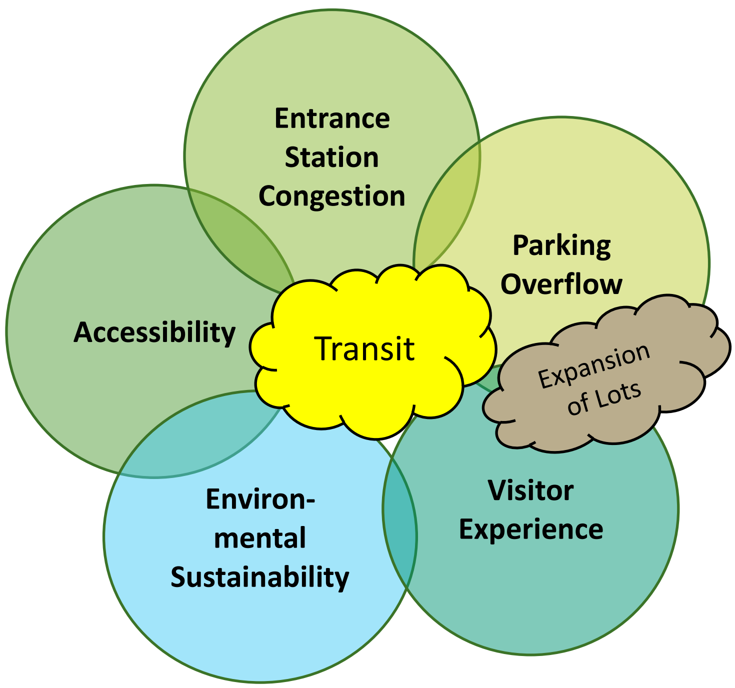


Figure 3: Issues Affecting Joshua Tree National Park and Potential Solutions

Transit has the potential to address all five of the major issues facing Joshua Tree NP. A voluntary use transit system could effectively reduce entrance station congestion and parking overflow by reducing the number of cars that enter the Park. Accessibility would improve by providing an alternative to personal vehicles. Together these three benefits would improve visitor experience by allowing visitors to access major sites in the Park without the inconvenience of searching for parking or waiting at an entrance station. Lastly, by offsetting a number of personal vehicles with fuel efficient, clean emission buses, potential environmental benefits such as reduced emissions can be achieved thus leading to a more environmentally sustainable system.

In order to determine if transit is indeed a feasible option for the Park, the National Parks Conservation Association and Joshua Tree National Park tasked the University of California, Irvine, Institute of Transportation Engineers Student Chapter to conduct a transit feasibility study. The scope of this study includes a visitor survey, a parking analysis, the design of three transit routing and infrastructure alternatives, comparison between different transit technologies, and funding and finance options.

The report is organized as follows. Chapter 2 describes the existing conditions including popular sites within and around the Park, the transportation system, and parking conditions. Chapter 3 introduces the visitor survey conducted as part of the study to determine travel patterns and transit interest. Chapter 4 discusses the results of a parking lot usage survey. Chapter 5 presents the three route alternatives and their corresponding infrastructure needs. Chapter 6 highlights the potential traffic impacts resulting from the proposed transit system. Chapter 7 discusses the sustainable transit technology alternatives along with a summary of air pollutants. Chapter 8 summarizes the costs and funding opportunities of the proposed transit system including the options to lease or purchase shuttle buses. The report concludes with a final recommendation regarding the route alternative, transit technology, and financing structure in Chapter 9.

Chapter 2: Existing Conditions

2.1 Locations within the Park

Joshua Tree National Park has several attractions. According to a visitor study conducted by the University of Idaho, the most popular locations were the Jumbo Rocks Area, Hidden Valley and the Joshua Tree Visitor Center. According to the survey results, respectively, 55%, 50%, 50%, of the 490 visitor groups visited these locations during their trip. However, the order of visitation varied; the most popular first stop was the Joshua Tree Visitor Center, followed by the Oasis Visitor Center, and lastly, the Cottonwood Visitor Center. The information collected from the rangers fall in line with the survey results. According to the park rangers of Joshua Tree, popular locations include: Jumbo Rocks/Skull Rock, Hidden Valley, Quail Springs, Black Rock, Boy Scout Trail/Indian Cove, Keys View, Barker Dam, Cholla Garden, and Cottonwood Springs.

Joshua Tree National Park has a variety of activities for the outdoor enthusiasts. One of the main attractions of the park is the campsites and hiking trails. There are a total of eight campgrounds: Belle, Black Rock, Cottonwood, Hidden Valley, Indian Cove, Jumbo Rocks, Ryan, and White Tank. The largest three campgrounds are Jumbo Rocks, Indian Cove, and Black Rock, with 124 sites, 101 sites, and 100 sites respectively. Due to the large capacity of these campsites as well as surrounding attractions, these sites are the most popular when it comes to camping.

Transportation options within the Park are limited to personal vehicles or tour buses operated by tour companies. According to the 2010 Visitor Survey, 99% of visitors enter the park in personal vehicles (only 1% reported participation with commercial tour group).

2.2 Locations Outside the Park

The main attractions of this region are within Park grounds with the exception of several sites located in the surrounding cities. More importantly, within the Park, only minimal impact camping facilities are provided, so many visitors stay overnight the over 30 hotels and motels located in the surrounding cities of Twentynine Palms, Joshua Tree, and Yucca Valley, as well as is in the Coachella Valley stretching from Desert Hot Springs in the northwest to Coachella in the southeast.

Transportation options outside the Park include public transit. The Morongo Basin Transit Authority currently implements routes between Yucca Valley and Twentynine Palms along State Route 62, with stops at both the Joshua Tree Visitor Center and the Oasis Visitor Center. Park visitors staying in the surrounding cities can choose to use the Morongo Basin Transit system to access the visitor centers, but would not be able to travel within the Park on public transit, since the public transit service does not operate within the Park.

2.3 Road Networks

Surrounding Network

Joshua Tree National Park is bordered by several freeways. State Road (SR) 62 borders the park to the north, I-10 borders the southern end, and SR 177 borders the park to the east. Several other freeways feed into those that border the national park. SR 247 feeds into SR 62 toward the western half of the park. SR 111 feeds into the I-10 toward the western half of the park and also runs relatively parallel to the I-10 from around the Palm Springs area to the Mecca area. SR 78 feeds into I-10 from the south and is located east of the national park. Lastly, SR 95 is located east of the national park and connects I-10 and SR 62. Dillon Road, although not a freeway, connects I-10 and SR 62 from around the Coachella area to the Palm Springs area.

Park Network

Within the park is a network of paved, unpaved, and 4-wheel-drive roads. Figure 4 shows the road system for the north end of the Park near the Joshua Tree and Twentynine Palms entrances. Figure 5 shows the road system at the Cottonwood entrance located in the southern area of the Park. The paved roads, in particular, allow access to many of the Park's attractions. Park Boulevard, a paved road, allows access into the park from the SR 62 through the West Entrance Station. The Utah Trail also allows access into the park from the SR 62 but through the North Entrance Station. Roughly 8 miles south of the SR 62 is Loop Road, which connects both Park Boulevard and Utah Trail. Indian Cove Road is located between the West Entrance Station and the North Entrance Station and leads to Indian Cove, a popular park attraction. Canyon Road, located between Indian Cove Road and North Entrance Station, allows access to a hiking trail leading to 49 Palms Oasis, one of the park attractions. The Pinto Basin Road along with the Cottonwood Springs Road allows access into the park from the I-10 through the southern entrance. Pinto Basin Road connects to the Loop Road near the northern entrance.

The unpaved roads in the Joshua Tree National Park tend to branch off from the paved roads and allow access to other park attractions. One of the notable unpaved roads is La Contenta Road, located between the SR 247 and the western entrance, and it allows access to Eureka Peak and the California Riding and Hiking Trail. Hidden Valley Road allows access to Keys Ranch from Park Boulevard. Queen Valley Road allows access to the Desert Queen Mine from Loop Road.

Lastly, there are several 4-wheel-drive roads that provide accessibility to more park attractions. Berdoo Canyon Road connects Dillon Road to Loop Road. Old Dale Road, also known as Mecca Dale Road, and Gold Crown Road connect the SR 62 to Pinto Basin Road toward the southern entrance. Black Eagle Mine Road branches from Pinto Basin Road and allows access to facilities past the Eagle Mountains, where the road eventually connects with the SR 177 and the I-10. Pinkham Canyon Road and Thermal Canyon Road allow access to the Cottonwood Mountains beginning from the Cottonwood Visitor Center located near the southern entrance of the park. Depending on the shuttle technologies and visitor demand, some of these roads can be used when planning routes for the transit system.

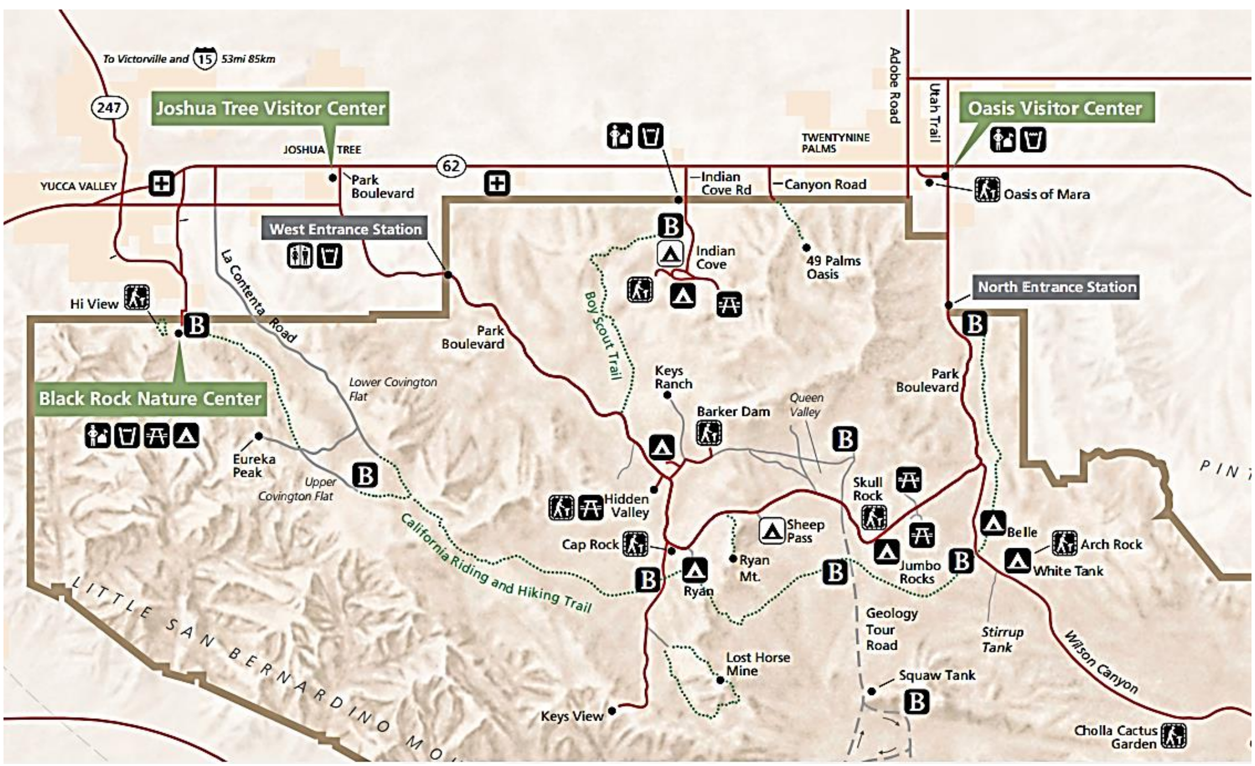


Figure 4: Northeast Park Map (Source: www.nps.gov/jotr)

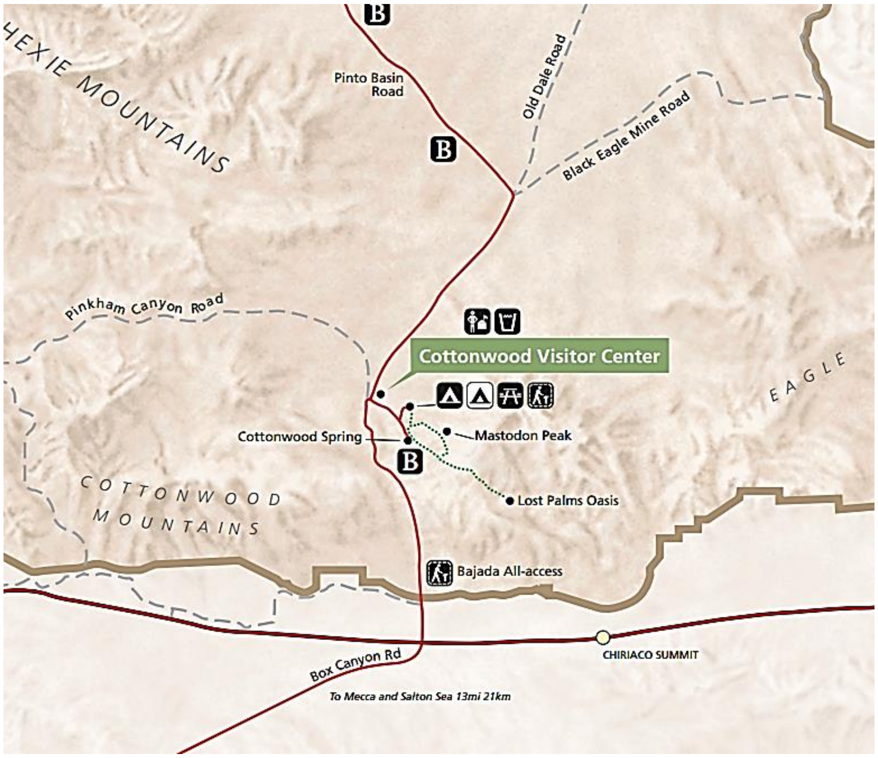


Figure 5: South entrance park map (Source: www.nps.gov/jotr)

2.4 Parking

Joshua Tree National Park currently has approximately 787 parking spots including spaces in both paved and unpaved areas and along the curb. This estimate was developed assuming an average parking space size has the dimensions of 9 x 18 ft. Most large parking lots can generally be found in popular visitor sites such as Hidden Valley and Barker Dam. Table 19 of Section C.1 in the Appendix summarizes parking lot capacities at each location identified in Figure 6. Additionally, this table identifies whether restroom facilities, RV parking, and handicap parking are available. Some parking lot conditions are also summarized.

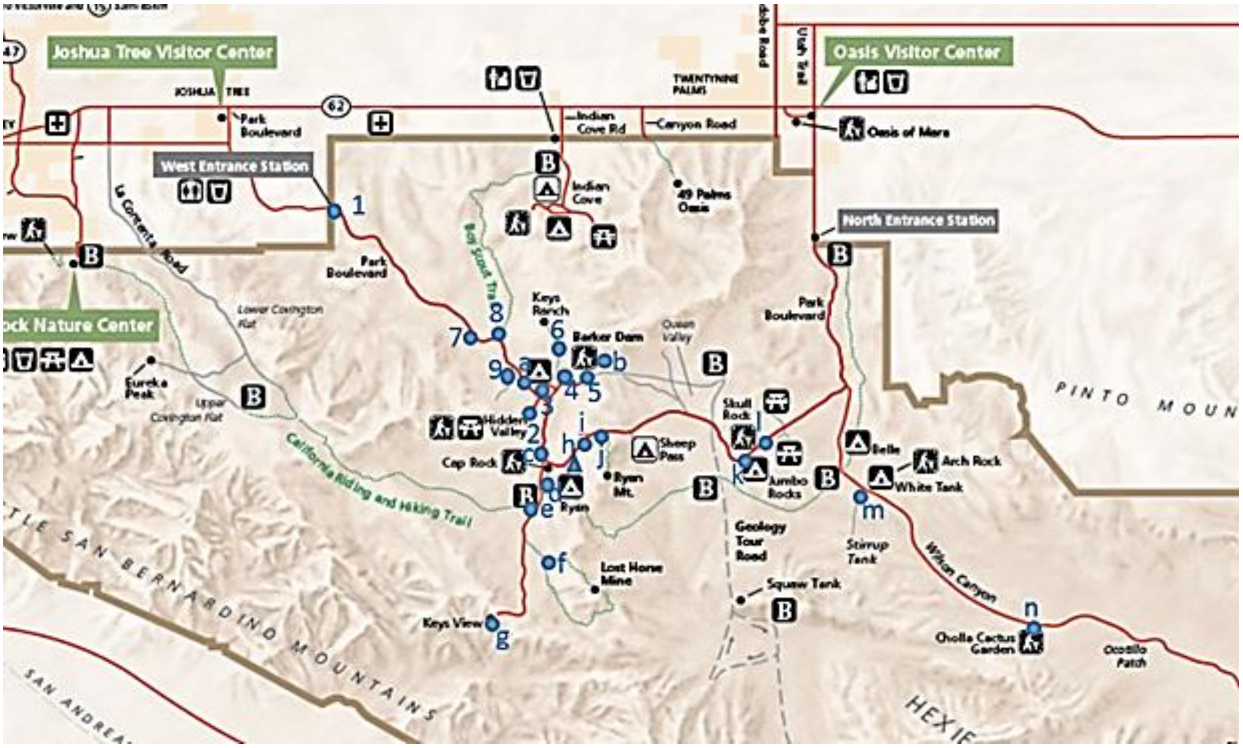


Figure 6: Location of Existing Parking Areas in Joshua Tree

A lack of parking is evident during high visitation periods. This lack of parking availability is causing dangerous scenarios as visitors begin to park in non-designated areas such as the sides of the road. To get a better understanding of the severity of this issue and the concerns of park visitors, a visitor survey and a parking survey were conducted.

Chapter 3: Visitor Survey

The goal of creating and distributing a survey was to outline the views and opinions of park guests concerning the incorporation of a transit system within the park. This provides important information and data for determining transit demand and designing route alternatives. The survey covers a variety of topics including basic demographic questions, popular park locations, popular route choices, popular mode choices, route frequencies, and possible shuttle fees to park visitors if the shuttle system were to be implemented. The survey contains 24 questions. Questions pertaining to popular locations and trip frequencies were utilized to determine routing and infrastructure locations, while questions concerning cost and technology preferences were used to determine funding and sustainable shuttle options.

Because the survey was conducted on human subjects an extensive permitting process was conducted by UC Irvine's Institutional Review Board (IRB). This process required an extensive review of the survey procedures and questionnaire. Procedures concerning public interaction and survey participation solicitation were fully detailed through IRB specifications. All students administering the survey were required to complete IRB training.

The survey was administered by two methods: a paper based survey and an online survey. The paper based survey was distributed within the Park by the ITE student chapter members and the online survey was sent to several email listserves belonging to the NPCA. The online version of the survey was generated on the UC Irvine Electronic Education Environment (EEE) system. Along with the survey questionnaire the ITE team developed an email script, survey information card, and survey information page. The survey information page detailed all the necessary information about the surveys purpose and key information required by the IRB. The information card was created to be distributed at Joshua Tree National Park and surrounding businesses. This card contained the link to the online survey. Lastly, an email script was created also containing the link to the online survey. All of these documents including the protocol narrative can be found in Appendix A.

The final draft of the survey was published and released to the public on April 11th and was granted permission to be distributed by Joshua Tree National Park. The responses from the hard copy survey were organized and manually inputted into the EEE system to systematically organize all the results.

3.1 Questionnaire Development

The questionnaire contains questions related to general visitor demographics and park usage as well as transit preferences. Demographic and usage questions follow the same format as those used in the University of Idaho 2010 Joshua Tree National Park Visitor Study. The format of questions was maintained so that comparisons could be drawn between 2010 and 2014 visitor characteristics. These questions concerned the activities, sites visited, order of sites visited, reasons for visiting the park, trip duration, visitor group characteristics such as age and group size, and accommodations used inside and outside of the park. Additional questions unique to the survey conducted for this report included parking issues such as the amount of time spent searching for a parking space and vehicle type.

The transit preference questions were loosely based on those used in the Sustainable Transit Feasibility Study for the Mojave National Preserve conducted in 2009 by the University of California, Irvine, Institute of Transportation Studies. Questions included visitors' willingness to use transit, previous experience with transit in National Parks, preferred transit system characteristics (frequency, type of bus, number of stops, etc.), and willingness to pay for transit services. Listed below is a selected sample of transit preference questions used in the survey. A brief explanation is provided to explain the purpose of the question.

Sample Survey Questions

Question (17): How often would a shuttle need to pass by a stop (pick-up point) for you to consider using the service in Joshua Tree National Park?

□ Would not use □ every 15 minutes □ every 30 minutes

□ Every hour □ every 2 hours □ Every 4 hours

Purpose: Understanding the duration a visitor is willing to spend at a park site indicates potential shuttle routes and route frequencies for consideration.

Question (18): On a future visit, how important would the following services and characteristics of a shuttle system be? Please indicate the importance of each characteristic with ‘1’ indicating ‘not important’ and ‘5’ indicating ‘very important’.

Monday-Friday shuttle service	□ 1	□ 2	□ 3	□ 4	□ 5
Frequency of shuttle service	□ 1	□ 2	□ 3	□ 4	□ 5
Ability to take bikes on shuttle	□ 1	□ 2	□ 3	□ 4	□ 5
Ability to transport gear on shuttle	□ 1	□ 2	□ 3	□ 4	□ 5
On-board orientation by Park Ranger	□ 1	□ 2	□ 3	□ 4	□ 5
On-board orientation by TV or audio recording	□ 1	□ 2	□ 3	□ 4	□ 5
Alternative fuel shuttle	□ 1	□ 2	□ 3	□ 4	□ 5
Ticket price	□ 1	□ 2	□ 3	□ 4	□ 5

Purpose: Indicates the level of preference for the above alternatives. If all visitors indicate preferences for particular alternatives, those alternatives will hold high importance in the final park shuttle system design.

3.2 Survey Procedure

The survey distribution activities took place at Joshua Tree National Park over peak visitation days during the spring. Surveys were distributed between 7am and 4pm during daylight hours, although the park operates 24 hours per day. Recruitment of survey participants followed a non-probability based approach, i.e. accidental or convenience sampling similar to that used in the 2010 University of Idaho Visitor Study. Surveys were distributed in person in a systematic process to visitor groups two high volume sites: Hidden Valley and Barker Dam.

Based on the 2010 survey of the 837 visitor groups approached for participation, 767 (91.6%) accepted questionnaires with the per site volumes of participants ranging from 20 to 165 visitors representing 3 to 22% of the total visitor volume, respectively. Thus, applying the same acceptance rate, around 185 completed surveys per day were expected to be collected total at the two sites. This number of completed surveys is within the appropriate sample size for analysis (e.g. > 30 samples for statistical significance).

The survey administration took place as follows. Visitors were briefly introduced to the survey and were asked if they would like to participate. One individual from each visitor group, 18 years of age or older, was allowed to participate. If they agreed to participate they were guided to read the survey information sheet and to ask any questions if needed. The survey took approximately 10-15 minutes to complete. Visitors who did not wish to participate after being approached by the survey team were given the survey information card containing the link to the online survey and kindly asked to participate at their own convenience.

3.3 Survey Distribution

The survey was distributed on April 12 and April 13 by the ITE student Chapter. On Day 1, Saturday, the group arrived in the park at 8am. A group of 2 students went to the Hidden Valley parking lot while another group of 3 students went to the Barker Dam parking lot. Students approached park guests, explained our project to them, and asked if they would be willing to take our survey. About half of the visitor groups who were approached participated in the survey, and those who did not participate were given a information card to have access to the online survey. On average the survey took between 5 and 10 minutes for guests to fill out. The date, time, and location were written on the front of each survey once it was completed. Survey distribution on Saturday concluded at 4pm.

On Sunday, students arrived in the park at 9am and stayed until 3pm. These shorter hours were selected due to the limited number of people in the early morning and late afternoon on the previous day. While Saturday was more crowded (the Barker Dam lot was full by 1pm), we noticed a higher visitor response rate on Sunday.

3.4 Analysis of Survey Responses

A total of 213 surveys were collected with 99 collected on the first day and 114 collected on the second day. To convert the paper responses to an electronic spreadsheet, each survey was manually entered into a modified version of the EEE online survey. Along with the question responses, each survey was labeled with an identification number so the paper copy can be matched with the electronic copy. In the following section a summary of select survey results pertaining to transit preferences are shown. The remaining questions and the corresponding results can be found in Appendix A.1.

Select Survey Results

Question (13) *If you arrived in a personal vehicle to the current site, how much time did it take for you to find a parking spot?*

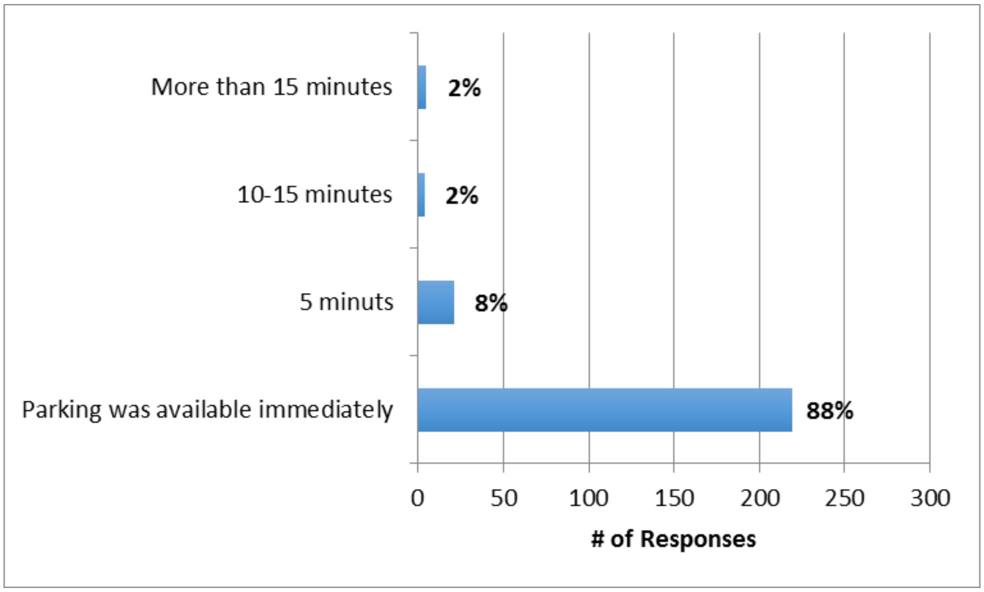
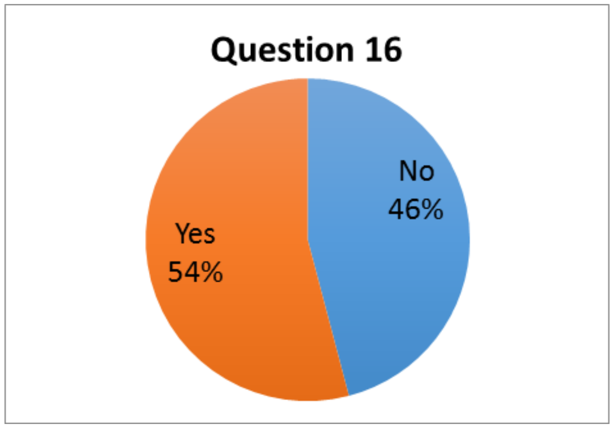


Figure 7: Average time to find parking

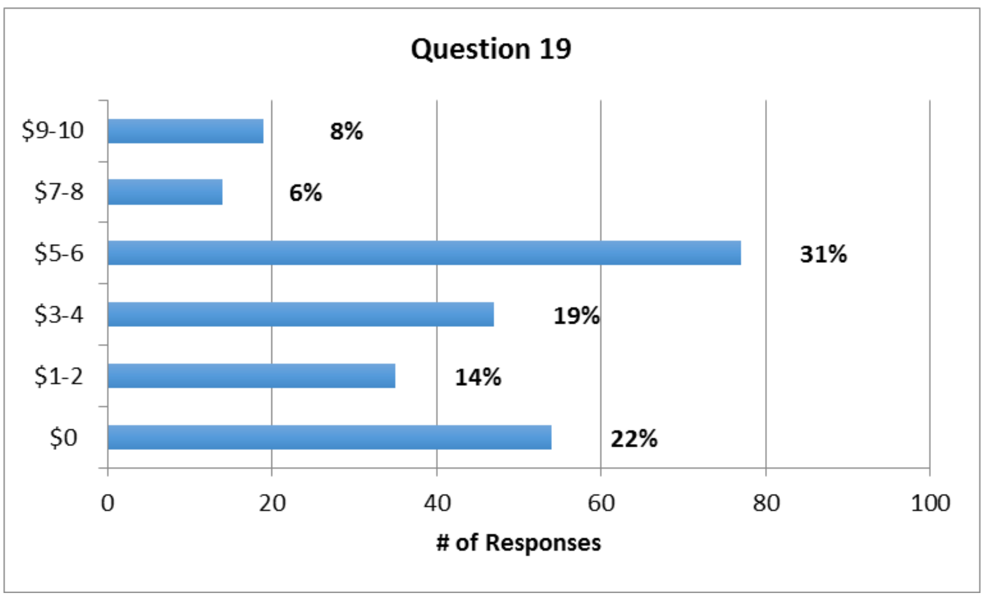
The majority of visitors (88%) reporting finding parking immediately upon arriving to the selected site. Roughly 10% of visitors struggled to find parking for more than 5 minutes. In a related question, visitors were asked to state the amount of time they would be willing to spend searching for parking before considering transit. The majority of visitors were unwilling to wait longer than 5 minutes. Park guests felt that as waiting time for parking spaces increased, they would be more willing to utilize the shuttle services. This would mean that as the number of people entering the park increases as Joshua Tree National Park has seen in recent years, guests will be increasingly likely to utilize the service.

Question (16): *The proposed Park Shuttle System for Joshua Tree National Park would allow visitors to park for free at the entrance stations and use the shuttle to visit the major sites within the Park. If such a Park Shuttle System existed within Joshua Tree National Park, would you have considered using the shuttle system for <u>this visit today</u>?*

Question (19): *Which of the amounts listed below best describes the most you would pay per person per day (unlimited rides) to use a Park Shuttle System that operated between sites within* *the Park (not including Indian Cove and Black Rock areas)? Assume that the Park entry fee still applies, parking is available for free at the entrance stations, and that the shuttle runs at least every hour.*



(a)



(b)

Figure 8: Stated willingness to use and pay for transit

Overall, the transit system is welcomed by park guests, where 54% of survey respondents showed interest in using a shuttle during their visit. Results also indicated that 31% of guests would be willing to pay an additional $5-6 for the transit service which would provide a good source of funding for the operations and maintenance of the system.

Question (23): *Why would you not consider taking a Park Shuttle System within Joshua Tree National Park? Please check all that apply. Leave blank if you would consider using a shuttle service.*

Table 1: Concerns about transit

Concern	% of Responses
I don't think traffic and parking congestion are severe enough for a shuttle system to be necessary.	24%
I'm uncomfortable leaving my vehicle in a parking lot.	5%
I'm unsure if the frequency of the service would accommodate my planned activities.	26%
Planned activities in the Park require equipment, which would be inconvenient to take on a shuttle.	19%
I would not feel safe in the Park without access to my private vehicle.	3%
I need my own personal vehicle.	11%
Other	12%

There were many concerns that visitors had about such a system, however. These included concern about the frequency of the shuttle service (26% of responses) and desire to participate in activities that require equipment (19%). Approximately 24% of stated concerns were about current conditions in the park not warranting a transit system.

3.5 Conclusion

Generally guests were interested in a transit system but only when the system could provide adequate service frequency and have the ability to transport gear. Since the Park is a major rock climbing destination, visitors expressed the need to have room on the shuttle for climbing gear. In ranking shuttle characteristics, frequency was the most important with ticket prices the second most important. Other important findings are summarized below:

- 54% of visitors indicated willingness to use a shuttle system in the Park.
- Most visitors (38%) would like a shuttle to pass by a stop every 30 minutes; only 11% indicated that hourly service was acceptable.

- Frequency, ability to transport gear, and ticket price were ranked first, second, and third most important, respectively.
- Onboard orientation services including orientation by a Ranger or video/audio formats, were not ranked as important characteristics of the shuttle system. Also, the ability to transport bikes was not ranked as important.
- Visitors showed some interest in an alternative fuel shuttle, ranking it of more importance than onboard orientation and bike transport.
- Most people are willing to spend $5-6 for unlimited rides on the Park shuttle.
- The majority of visitors (63%) were not interested in additional transit services to other regional cities. Those that were interested were willing to pay $5-6 (28% of responses).
- The major concerns against transit were uncertainty about service frequency, thinking that congestion levels do not yet warrant transit system implementation, and feeling of inconvenience of carry equipment around on the shuttle.

Chapter 4: Parking Study

One of the major concerns leading to the investigation of transit feasibility is parking congestion. Park staff reported that many of the most popular sites within the Park experience parking congestion during busy weekend periods. On busy weekends, parking lots that experience the most activity have a demand that exceeds the supply. This causes the respective lots to be filled over capacity and results in visitors parking their cars along the side of the road or in undesignated spacing causing damage to vegetation and curbs thus posing a threat to the surrounding natural environment. In addition to overflow parking issues, congestion in parking lots forces visitors to possibly forego a planned visit to that site altogether. Overflow parking is also a safety concern as visitors exiting their vehicles parked along the road are exposed to vehicle traveling on that road at full speed.

In order to determine the current parking usage characteristics, a parking study analysis was performed to collected data on which lots were the most and least occupied and the average time a vehicle would spend in each lot. The parking study analyzes the parking data in three ways: by origin-destination, average time spent, and parking lot occupancy rate.

The two-day parking study was performed during President's Day weekend on Saturday (02/15/14) and Sunday (02/16/14) from 9am to 4pm. This weekend was selected because it is known to have a high visitation rate compared to other days. The focus of the study was on five of the most popular sites: Hidden Valley, Barker Dam, Cholla Cactus, Jumbo Rocks, and Keys View. Throughout the study, license plate numbers were collected every hour at each of these five sites. This information was then used to analyze parking lot occupancy rates, average time spent at each site, and visitor travel patterns among the five study areas. This information aided in determining the severity of parking congestion and the routes that could be developed for the proposed shuttle system.

4.1 Occupancy Rate Pattern

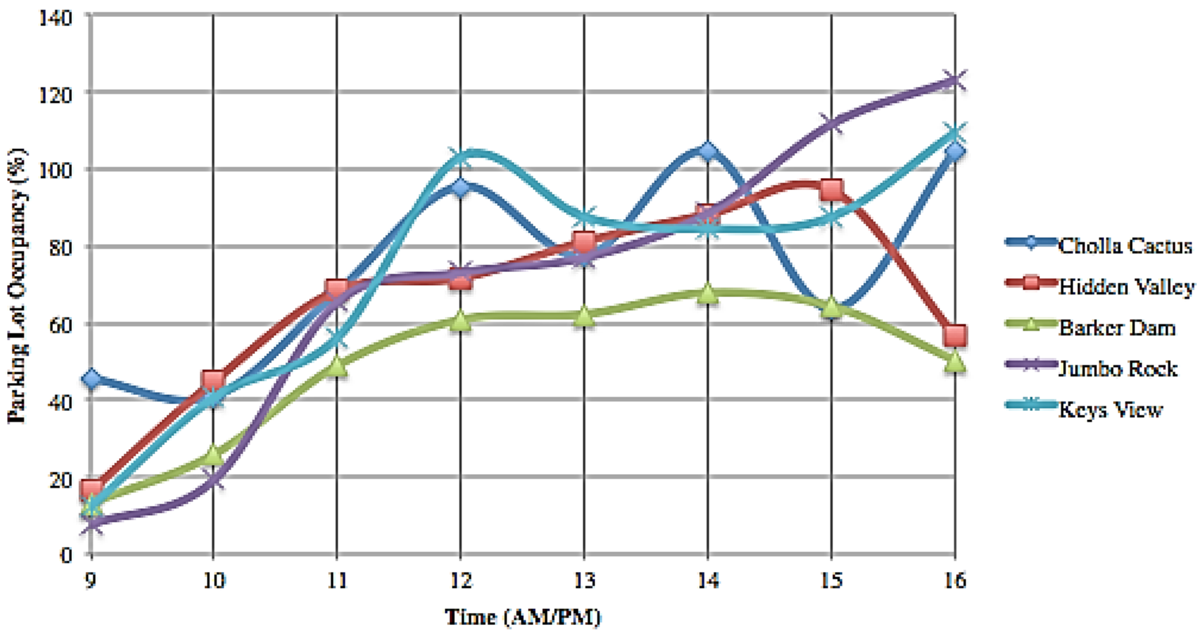
The parking occupancy rate pattern is a way of measuring parking lot utilization to determine the amount of visitor activity and interest. By comparing the number of vehicles stationed in a parking lot (demand) with the amount of parking spaces available (supply), unique usage rates are found. This identifies which site destinations within the park experience the most activity and congestion. In addition, determining an occupancy rate pattern for each individual parking lot in Joshua Tree National Park will help identify popular sites, which will aid in designing the shuttle route system.

A parking lot occupancy rate for each individual parking lot in Joshua Tree National Park was found by dividing the total hourly number of vehicles parked in the lot by the capacity of the lot. To determine the total hourly number of vehicles, hourly vehicle counts were conducted by students at the University of California, Irvine for the duration of both study days. A summary of hourly vehicle counts can be found in Tables 16 and 17 of Section B.1 of the Appendix. Table 2 shows the parking lot capacities based on estimates from the previously mentioned parking lot sizes.

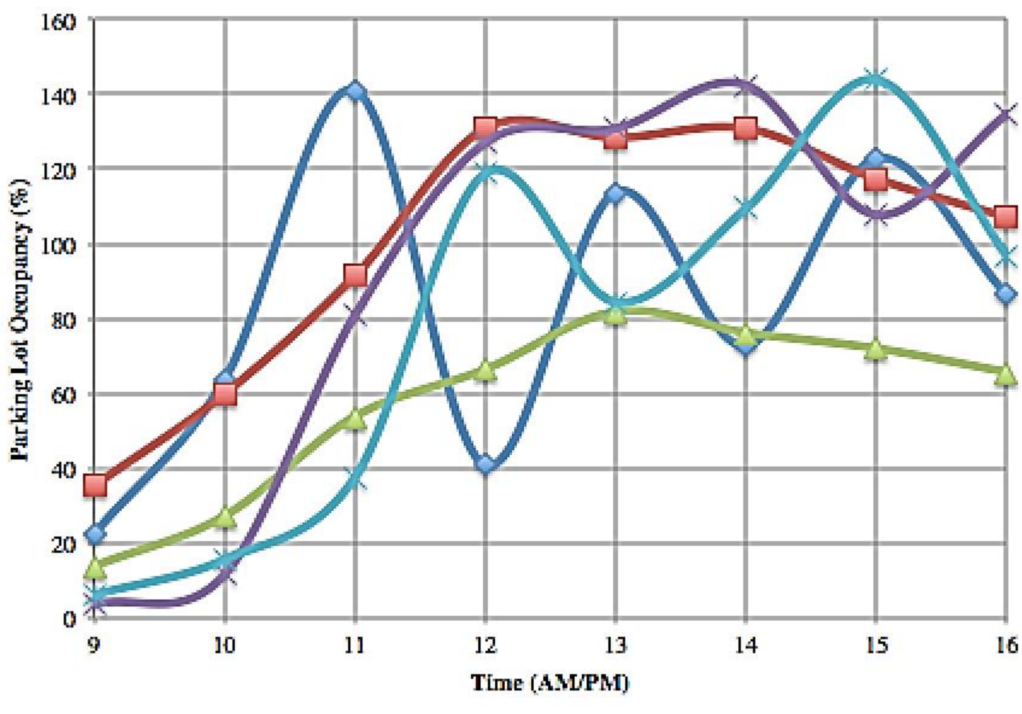
Table 2: Current Parking Lot Capacities for Joshua Tree National Park

Parking Lot	Parking Capacity (# of spots)
Cholla Cactus	22
Hidden Valley	127
Barker Dam	143
Jumbo Rock	26
Key's View	32

A final occupancy rate was found, in terms of percentages, for each hour of the study period for both days. A summary of the final occupancy rates are shown in Figure 9. These figures give insight into how full each of the lots become throughout the day, and also determines the peak hours of each individual lot. An analysis of the data shows that, with the exception of Barker Dam, all parking lots exceeded their maximum capacity by 12:00 PM. The most popular sites are Cholla Cactus, Key's View, and Jumbo Rocks. Jumbo Rocks experiences the highest capacity, exceeding 140% for both days. Ultimately, these high parking demands indicate that a shuttle system would be beneficial to alleviate congestion.



(a) Day 1



(b) Day 2

Figure 9: Parking Lot Occupancy Rates

4.2 Average Stay Pattern

The average stay pattern shows the length of stay for vehicles at each of the five study locations. This analysis shows which lots have the most and least vehicles, and which lots are occupied for the longest and shortest times. The analysis can provide useful information such as what lots should be expanded, if new lots are needed, where the placements of new lots should be, which lots are possibly not needed, or where the roads may be more congested.

The minimum, average, and maximum time a vehicle remained parked at each lot was calculated and summarized in the graphs depicted through Figure 10. The least amount of time that can be identified is one hour since license plate numbers were collected in one hour intervals. The highest number that can be observed is eight hours because the parking study was conducted for eight hours. The Day 1 (Saturday) graph indicates that the minimum average parked time was about 1.01 hours. The maximum average time spent was about 2.80 hours which was recorded from Barker's Dam lot 1 from day 1. The total average of all the lots came out to be about 1.64 hours.

The data was also plotted as histograms (Figure 11) to demonstrate how many hours vehicles were parked. The histograms indicate that most vehicles stayed at one location for one hour or less for both days. Day 1 had 961 vehicles and day 2 had 1220 vehicles parked for 1 hour in their lots. The least number of vehicles stayed for the maximum of 8 hours. Day 1 and day 2 lots had 0 vehicles and 7 vehicles parked for 8 hours respectively.

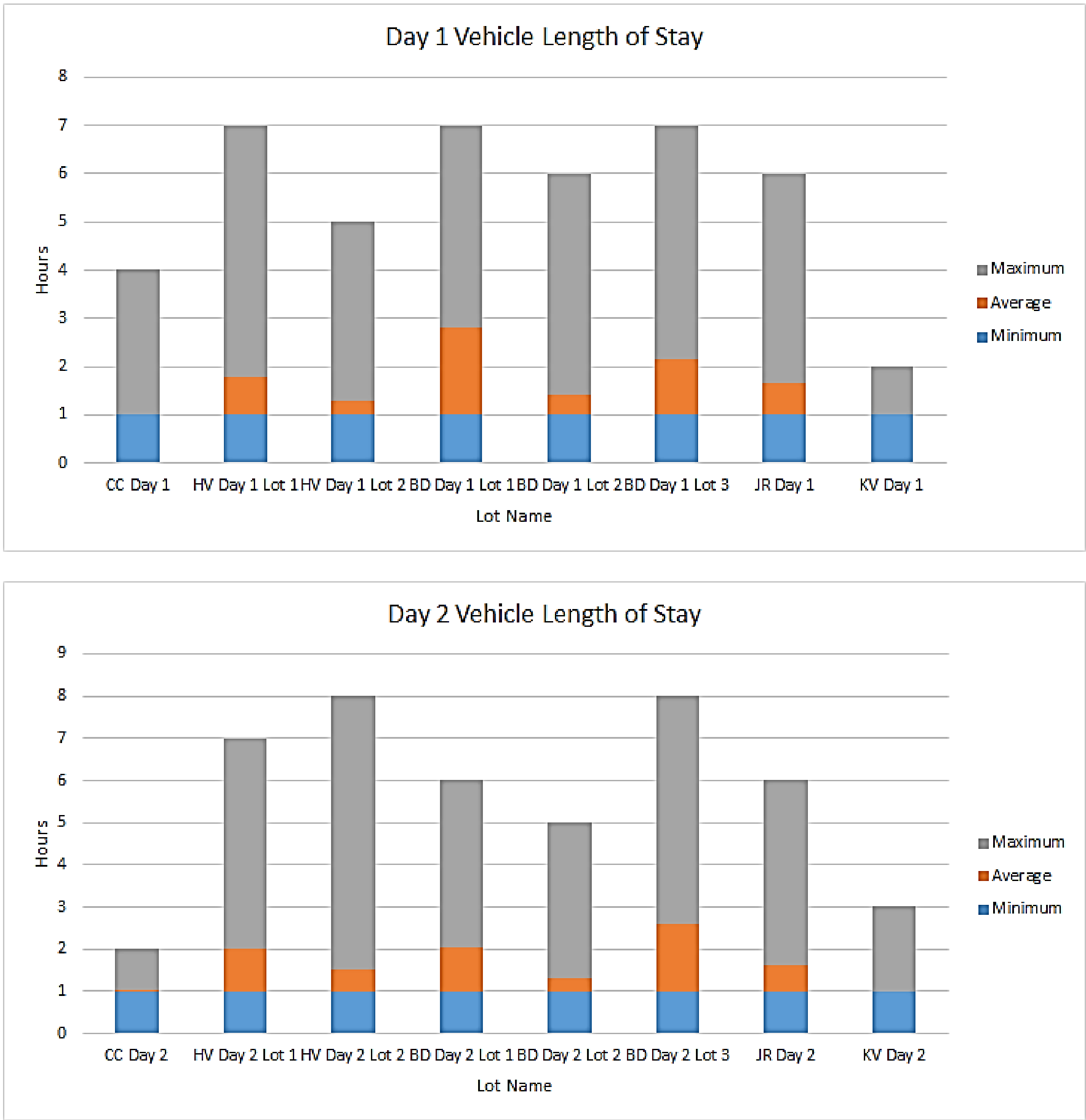
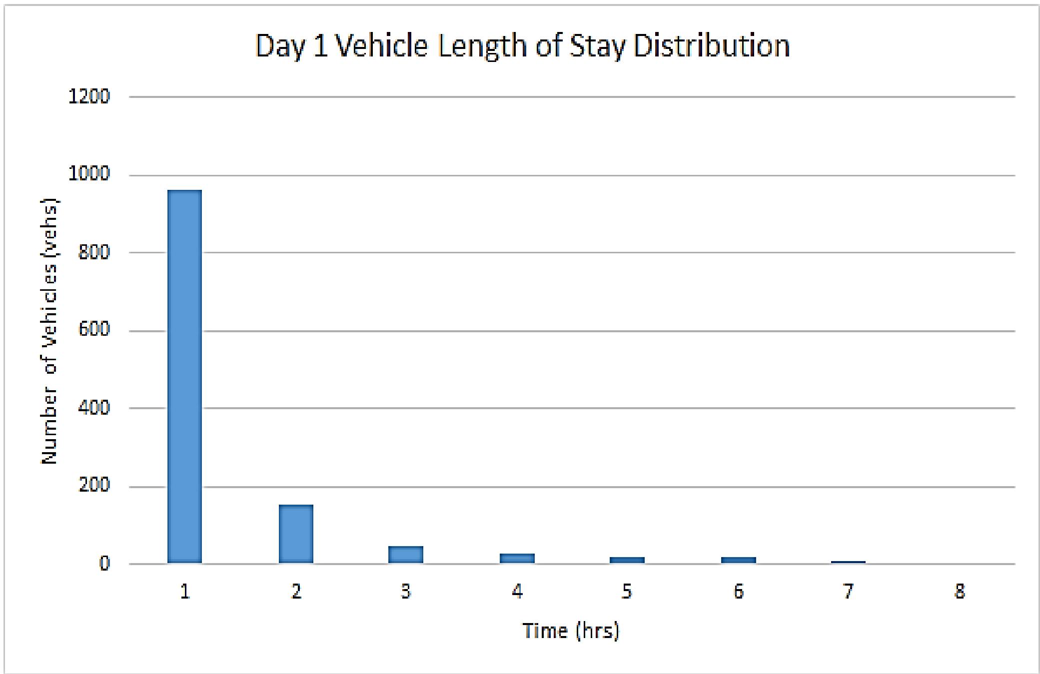


Figure 10: Graph of minimum, average, and maximum length of stay for each lot



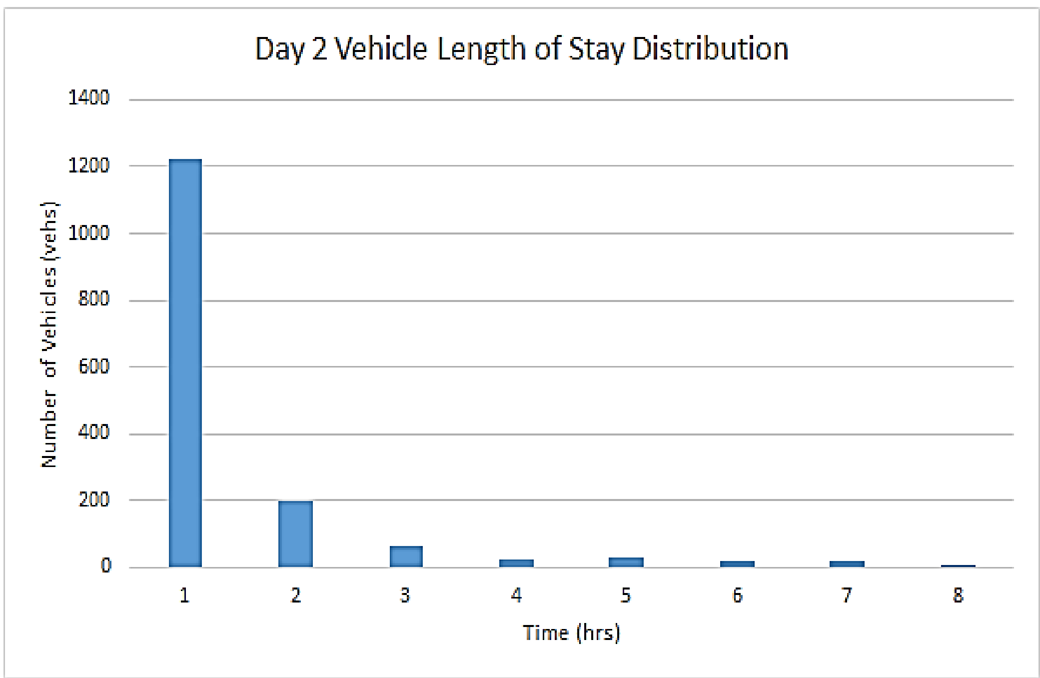


Figure 11: Distribution of number of vehicles parked for a number of hours

4.3 Origin Destination Data

An origin - destination analysis was performed to determine the travel patterns within the five study sites. The origin-destination results illustrated in Table 3 show the number of vehicle trips between these areas for Day 1 and Day 2. The left columns on these tables indicate the starting point, while top row indicate the ending point. The 'other' column shows the trips that started at one of the study sites, but ended in a location that was not included in the study.

Table 3: Origin Destination Summary

DAY 1	CC	HV	BD	JR	KV	Other	Total w/o other	TOTAL by Origin
Cholla Cactus (CC)	--	3	2	2	5	118	12	130
Hidden Valley (HV)	4	--	27	5	12	397	48	445
Barker Dam (BD)	6	16	--	4	14	276	40	316
Jumbo Rock (JR)	3	4	7	--	3	73	17	90
Keys View (KV)	8	9	5	4	--	159	26	185
TOTAL by Destination	21	32	41	15	34	1023		

DAY 2	CC	HV	BD	JR	KV	Other	Total w/o other	TOTAL by Origin
Cholla Cactus (CC)	--	5	5	1	5	109	16	125
Hidden Valley (HV)	6	--	36	7	26	407	75	482
Barker Dam (BD)	2	16	--	10	17	264	45	309
Jumbo Rock (JR)	3	4	4	--	3	80	14	94
Keys View (KV)	5	6	6	5	--	138	22	160
TOTAL by Destination	16	31	51	23	51	998		

From the number of trips summarized above, it can be determined that Hidden Valley and Barker Dam are the most popular sites. It can also be determined that most trips began in Hidden Valley followed with Barker Dam, and Keys View. After Keys View, most vehicles either returned to the Hidden Valley/ Barker Dam area or they headed east toward Jumbo Rocks or Cholla Cactus. Based on the results from day two, most vehicles traveled to Cholla Cactus before Jumbo Rock after visiting Keys View.

Chapter 5: Transit Routing & Infrastructure

5.1 Transit Ridership Estimation

Transit ridership, i.e. the percent of visitors that will use transit, is one of the most difficult parameters to predict when designing a transit system. This sentiment holds true for municipal public transit systems but becomes an even more difficult issue for National Park settings where each Park poses vastly different environmental and usage characteristics. Park characteristics can play a huge role in how many visitors are attracted to transit. For example, Joshua Tree NP is an international rock climbing destination where visitors will need to transport climbing gear and move between very spread out sites across the Park's 800,000 acres. It would be naïve to assume that this park could have the same demand for transit as a NP where visitor activities are concentrated around hiking, the natural landscape provides shade, and key visitation sites are spatially dense. Therefore, in order to obtain an accurate prediction of potential transit use for Joshua Tree National Park, transit ridership data from other National Parks with existing transit systems and as similar as possible characteristics were reviewed for comparison.

Two important considerations limited the number of Parks to be considered in the comparison: transit system operations and data availability. First, only parks with free transit systems were included in the analysis since it was predetermined that the Joshua Tree system would not be mandatory. Second, of the parks with voluntary use systems, only those with publicly available ridership data could be used. This limited the comparison scope to two parks: Rocky Mountain NP and Acadia NP. While neither of the parks can truly represent Joshua Tree NP's natural setting, a best attempt was made to select from the two parks the one that most closely matched Joshua Tree NP in terms of park size, number of sites, activities, and visitor characteristics.

The Alternative Transportation System Demand Estimation for Federal Land Management Agencies report summarized which characteristics of a park and its visitors have the greatest influence on transit ridership. The report stated that transit systems in federal public land sites needed to accommodate for certain factors such as type of visiting group, purpose of visit, length of stay, and age group of visitors. Using visitor survey data from the Park Studies

Unit at the University of Idaho, data concerning visitor characteristics were collected for Rocky Mountain and Acadia NPs.

The first characteristic to compare is group type. Group type affects percent ridership through the demand to use an actual system. For example, families may lean towards not using the transit system since it would be more comfortable to stay in one vehicle together. Visitor groups were split up into four categories: Friends and Family, Friends, Alone, and Family and plotted onto a bar graph to compare the national parks. Figure 12 compares the two parks to Joshua Tree NP. Joshua Tree NP most resembles Rocky Mountain National Park in terms of group type.

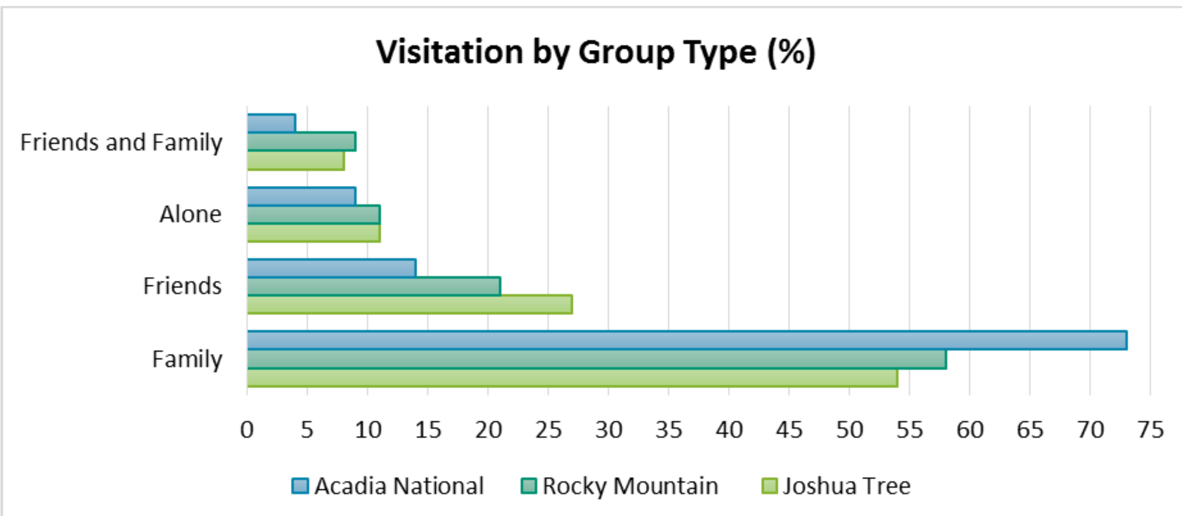


Figure 12: Visitation by Group Type

Group size will affect percent ridership and bus capacity because it determines whether or not a large group can even use the transit system. Figure 13 shows the group size comparison between the parks. Rocky Mountain and Joshua Tree NPs are the most similar in terms of group size. Acadia NP appears to have a much larger proportion of larger groups ('5 or more').

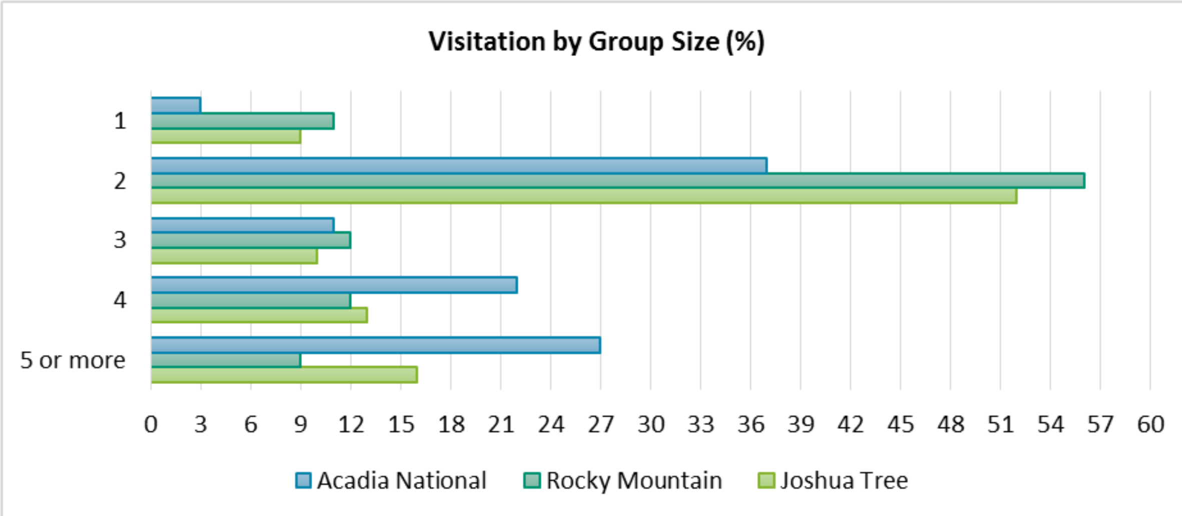


Figure 13: Visitation by Group Size

Activity participation is most closely related to the natural characteristics of the park. For instance, Joshua Tree NP is popular for rock climbing because of the attractive rock formations in the park. Activity participation is also a predictor of transit usage since activities that require lots of personal equipment many inhibit transit usage. Figure 14 shows that a significant amount of activities that visitors are involved in at Rocky Mountain NP match the types of activities done at Joshua Tree NP. Both parks saw a similar percentage of visitors that go to each respective national park to sightsee.

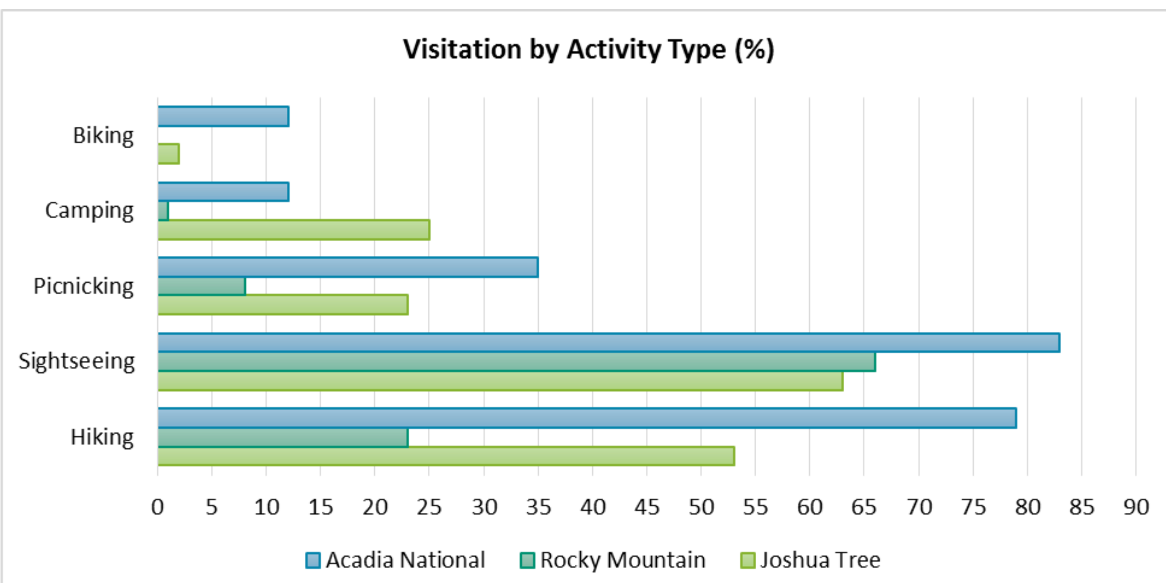


Figure 14: Visitation by Activity Type

Aside from the studies completed above, a variety of other significant categories such as age groups and visitor origin (i.e. in-state, out-of-state, vs. international) were analyzed. The left column of Table 4 summarizes the categories that were used for comparison. The two right columns summarize the average percent difference for the given category. The percent differences was computed by subtracting the category value of the park (Rocky Mtn. or Acadia) from the corresponding category value for Joshua Tree NP, and then averaging the differences across all categories. A difference closer to 100% signifies a large difference in that characteristic.

Table 4: Park Comparison

Analysis Category	Rocky Mountain NP	Acadia NP
Group Size	16%	42%
Group Type	11%	38%
Visitor Origin	52%	72%
International Visitors	18%	8%
Age Group	22%	46%
Primary Activity during Visit	74%	81%
Land Size	523,917	742,356
Number of Campsites	88	211
Number of Sites with Visitation over 25%	5	4

Weighted Score Comparison

While the percent difference values in the previous table are informative individually, a numerical combination of each category would better illustrate which park was overall more similar to Joshua Tree NP. To combine individual values, a weighted score was calculated. Weights are introduced because not all categories equally affect transit ridership. Larger weights are given to categories that would be more important indicators of transit usage according to the Alternative Transportation System Demand Estimation for Federal Land Management Agencies report. For example, group size and primary activity type have a strong impact on percent ridership, so those categories received the highest weights in this analysis. Table 5 shows the weights that were used for each category.

Table 5: Weights used for Weight Analysis

Category	Weights
Group Size	20
Group Type	15
Visitor Origin	15
International Visitors	10
Age Group	15
Primary Activity during Visit	25

A weighted sum is calculated for each of the parks according to the following equation:

$$\begin{aligned} Weighted\ Score &= 20(Group\ size\ difference) + 15(Group\ Type) + 15(Visitor\ Origin) \\ &\quad + 10(International\ Visitors) + 15(Age\ Group) + 25(Primary\ Activity) \end{aligned}$$

A weighted score of high value indicates more difference between characteristics whereas a lower score indicates more similarity. The weighted score for Rocky Mountain NP was calculated to be 36 and for Acadia NP the score was 52. Thus, the conclusion is that Rocky Mountain NP is most similar to Joshua Tree NP so the transit ridership will be estimated based on that of Rocky Mountain NP.

Estimating Ridership

The park to park comparison indicated that Rocky Mountain NP percent ridership could be a general indicator for transit usage at Joshua Tree NP. Ridership data for Rocky Mountain NP was pulled from the Grand Teton National Park Public Transit Business Plan (2009). This report provided annual visitation and transit ridership from 1999 to 2007. Figure 15 shows the percent ridership for Rocky Mountain NP from 1999 to 2007.

A ridership forecast was made to the current year (2014) based on the best fit line through the historical ridership data. Using this model, a percent ridership of 18.5% was predicted for Rocky Mountain National Park for the year 2014 and hence this is what will be used for Joshua Tree National Park.

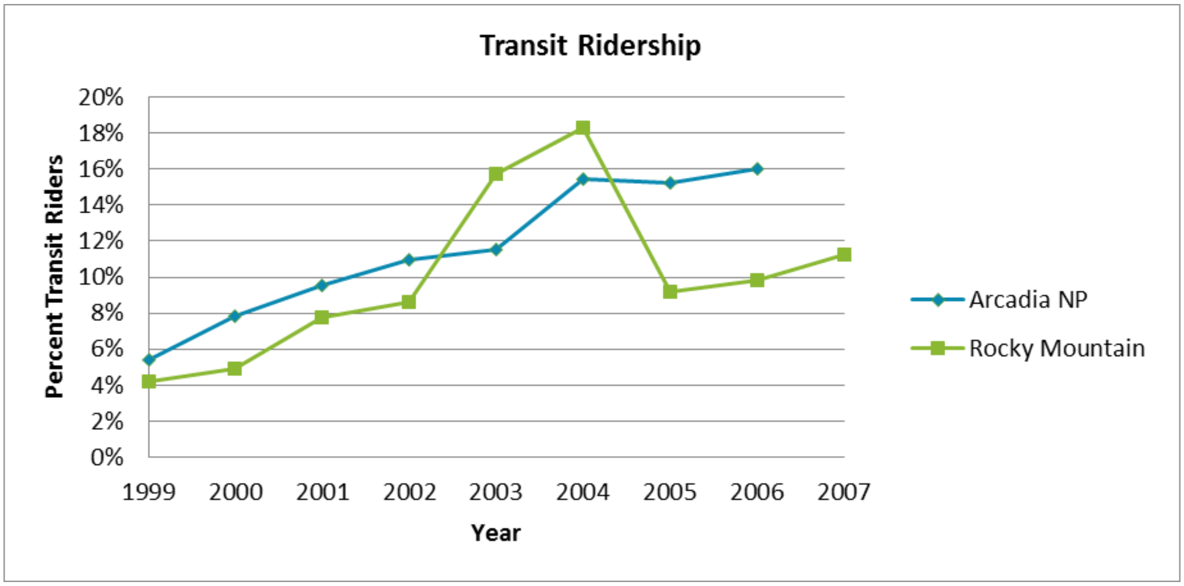


Figure 15: Transit Ridership Data from Rocky Mountain and Acadia NP

5.2 Daily Travel Demand Prediction

In order to estimate daily demand for transit, the ridership prediction of 18.5% needs to be applied to the visitation statistics for Joshua Tree NP. Visitation is provided as annual data, so the following section outlines the process for converting the annual visitation to daily demand for transit.

The annual visitation statistics for Joshua Tree National Park is provided by the NPS (National Park Service) beginning in 1979 and continuing until 2013. Over the last several years, i.e. 2011 to 2013, visitation appears to have reached a plateau around 1.4 million annual visitors.

Figure 16 shows the monthly visitation trends for 2013. Spring months, March and April, experience the highest visitation while the autumn months, September and October, experience the lowest visitation volumes.

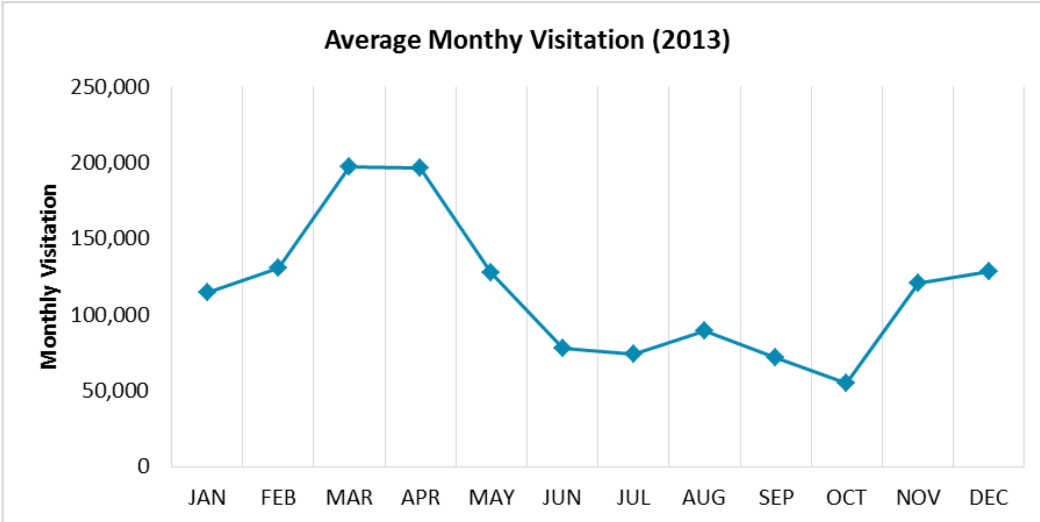


Figure 16: Monthly visitation for 2013

The *Transportation Planning Process for Transit in Federal Land Management Areas* Report recommends providing transit to meet the demands on the 90th percentile day. The report states that transportation systems are not typically designed to accommodate conditions on the busiest day of the year, but rather that planning based on the 90th percentile day may be more appropriate. The data used for this project provides visitation at the monthly level, so daily visitation numbers are not directly available. To estimate the 90th percentile day, first the 90th percentile visitation volume was determined by computing the 90th percentile visitation based on the monthly data. Figure 17 shows the 90th percentile monthly visitation observations for 1979-2013. The trend is increasing, as was previously noted in the annual visitation. For the purposes of this report, the 90th percentile of the most recent year, 2013, will be used for analysis. The 90th percentile of monthly visitation for 2013 was 189,957 visitors. This is approximately, 7,000 less than the max visitation which takes place in March.

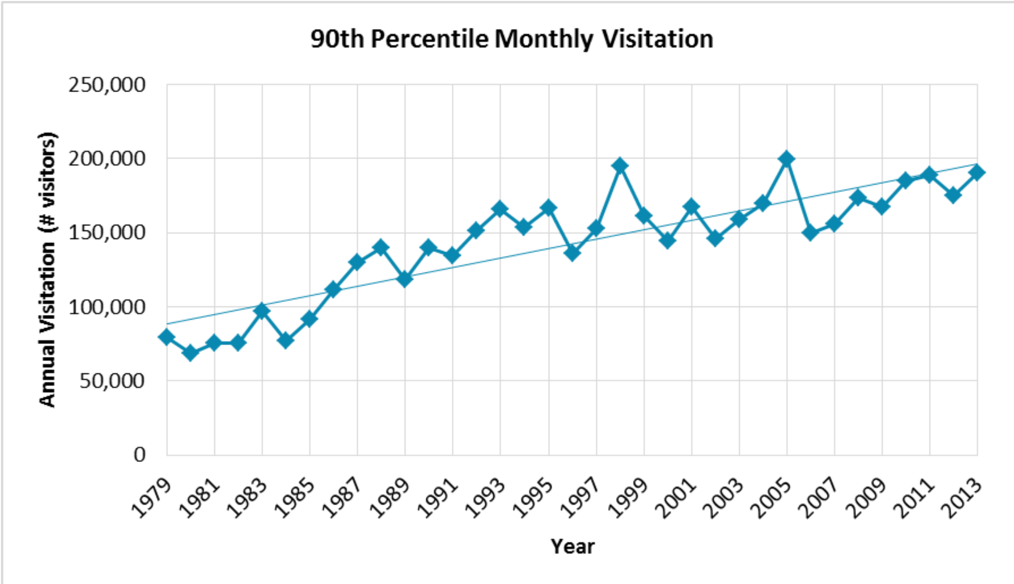


Figure 17: 90th Percentile Monthly Visitation

To determine transit system frequencies and number of buses, the 90th percentile monthly visitation was further disaggregated into daily volume and finally split into weekday and weekend volumes.

To obtain weekly transit passenger trips, the 90th percentile monthly volume (189,957 visitors per month) was divided by the average number of weeks per month, 4.348 weeks per month (365.25 days per year/ 12 months per year / 7 days per week). The weekly volume of passenger trips was further reduced by applying the fraction of visits that occur on Saturdays, approximately 0.288 Saturday visitors per week. This ratio was derived from the visitation data provided by the Joshua Tree Visitor Center staff and volunteers. The ratio is the number of Saturday visits divided by the total number of weekly visits. Their reports show that the weekend traffic is approximately 48.36% of the weekly number of visits and that Saturday is the busiest day out of the week accounting for 59.6% of weekend visits during the peak visitation months of February through May. By these calculations, the approximate number of visitors per Saturday is 11,800 visitors. This formulation is summarized as:

$$\frac{Number\ of\ \ Visits}{Saturday} = \left(\frac{90th\ percentile\ Visits}{Month}\right) x \left(\frac{4.348\ visits}{Week}\right) x \left(\frac{0.288\ visits}{Saturday}\right)$$

Lastly, the hourly visitation is an important aspect of designing the shuttle system. *Transportation Planning Process for Transit in Federal Land Management Areas* Report suggests using the maximum load point, which is the segment and time of route where ridership reaches its peak. Maximum load point is important in transit planning as it indicates the maximum level of demand for which this system will be planned. To obtain the maximum load point, the hourly distribution of visitors collected by the UCI ITE on February 15th and 16th was used. For this study, vehicles in the parking lots of the most popular park attractions were recorded hourly from 9:00 am to 4:00 pm. The hourly volumes to capacity ratios at each lot are shown in Figure 18. This figure can be interpreted as the number of parking spots occupied divided by the number of spots available. When the number exceeds 100%, this indicates an overflow parking situation. In this figure, the peak hour occurs from 1 PM (13:00) to 2 PM (14:00). A ratio of the number of vehicles for that peak period to the total number of vehicles in the entire study period, or 0.1625 in this case, was applied to the 90th percentile daily visits to obtain the maximum load point. This results in a total number of Saturday peak hour visits of 2,046 visitors. In the next section we discuss the estimation of transit riders from the total number of visitors.

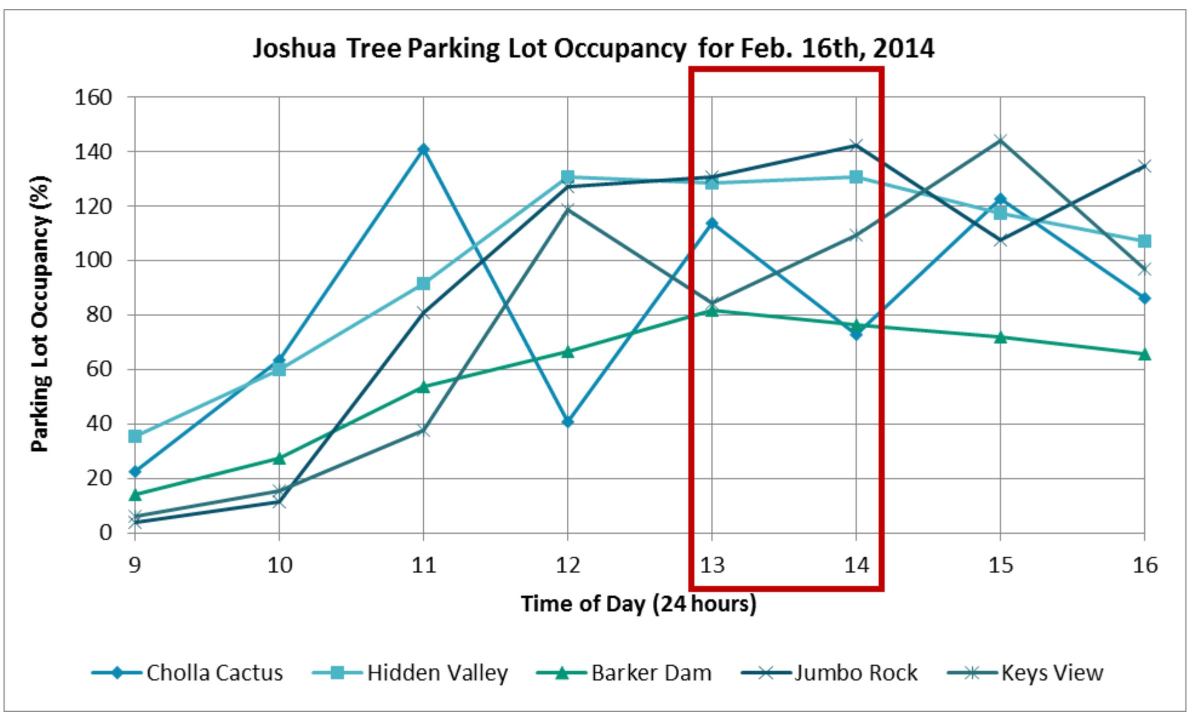


Figure 18: Hourly visitation distribution from the UCI Parking Study

A ridership of 18.5% total visitation, provided through comparing and contrasting other national parks with similar characteristics, was applied to the hourly estimated volume obtained though the methodology described in the previous section. The 'Number of Saturday Peak Hour Riders' is calculated by applying the transit ridership rate (18.5%) to the number of hourly visitors (2,046 visitors) as summarized in the following equation:

$$Num. of\ Sat. Peak\ Hour\ Riders = (2,046\ Hourly\ Visitors) x\ (18.5\%\ transit\ ridership)$$

Therefore, the total number of hourly riders is approximately 368 riders per hour.

5.3 Route Alternatives & Infrastructure Needs

Three alternatives were proposed to transport visitors throughout Joshua Tree NP. Each alternative includes stops at popular sites within the park, as indicated by the University of Idaho 2010 Visitor Demand Survey of Joshua Tree National Park and the ITE UCI Chapter Visitor Demand Survey. Each route also includes stops between the popular sites at various starting and ending points for hiking trails within the park to serve all types of visitors.

In an effort to make a visit to Joshua Tree National Park pleasant and safe, various shuttle system infrastructure was determined based on visitor needs and safety. Other national parks with successful transit systems were researched and used as a reference to determine the necessary infrastructure to support the proposed shuttle system. Proposed infrastructure includes bus stops that come with a paved landing area, shelter/canopies, sitting benches, and an information panel to display shuttle bus route maps and schedules. Additional infrastructure include parking lots near the Joshua Tree Visitor Center and the Oasis Visitor Center, parking and shuttle signage, parallel bus bays, digital two-way radio emergency call boxes, solar powered light poles, crosswalk striping, restrooms, and respective bus technologies are all also included in the proposed infrastructure. Sample infrastructure photos can be found in Section B.2 of the Appendix.

The locations of the entire proposed infrastructure are dependent on the three shuttle route alternatives. With the installation of these public facilities come concerns for protecting the natural environment. It can be very challenging to install infrastructure within a national park, mainly due to concerns of the facilities being too close in proximity to wilderness boundaries.

These concerns will need to be accounted for when installing all shuttle stop facilities. Approval may be hard to gain with new facilities being built, as it may negatively impact the environmental quality or natural beauty of the Park. However, because the transit will benefit the Park in many ways, the said facilities will be needed to facilitate the transit service.

Associated infrastructure costs came from various sources such as public contract bid summaries, transit feasibility reports and other online research. Included in all three alternatives are the required infrastructure for the possible bus technologies. Cost estimates for the use of three different transit technologies, which are propane buses, hybrid buses, and biodiesel buses, are provided.

5.2.1 Alternative 1

Alternative 1 will serve visitors entering through the West Entrance and is comprised of three routes as shown in Figure 19 with black diamonds indicating bus stops. The Blue Line will begin at the Joshua Tree Visitor Center, which is the busiest visitor center of the park. Buses will traverse Park Blvd. and stop at popular destinations in the following order: Joshua Tree Visitor Center, Barker Dam, and Hidden Valley.

Table 6 summarizes the route travel times and distances for Alternative 1. The proposed Blue Line is 15.6 miles long and has a one-way travel time of 27. A transfer stop will be placed at Hidden Valley to allow visitors the option of transferring onto the Purple Line (heading south on Keys View Rd) or Yellow Line (heading southeast on Park Blvd). The Purple line will take visitors directly to Keys View and has a length of 7.2 miles and a one-way travel time of 16 minutes. The Yellow Line will shuttle visitors to Ryan Mountain, Skull Rock, Jumbo Rock, Arch Rock, and lastly, the Cholla Cactus Garden via Pinto Basin Rd. The proposed Yellow Line has a length of 22 miles and a one-way travel time of 36 minutes. Once each bus has reached its last stop on its respective route, the bus will turn around and repeat the route in reverse.

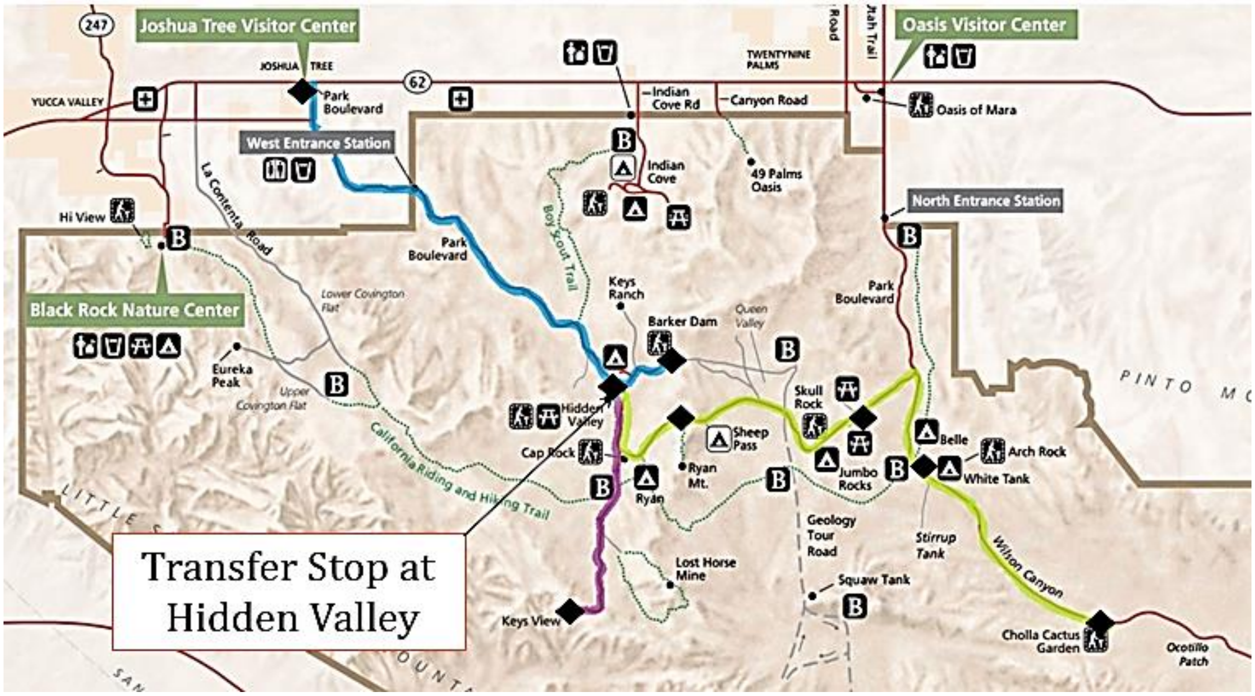


Figure 19: Route Alternative 1 Map

Table 6: Alternative 1 Route Distances and Travel Times

Shuttle Line	Distance (mi)	Time (mins)
Blue	15.6	27
Purple	7.2	16
Yellow	22	36

A total of 12 bus stops will be installed for Route 1, with one bus stop at most locations, with the exception of the Transfer Stop at Hidden Valley, Ryan Mountain, and Jumbo Rock, which will each have two bus stops (one stop for each direction). For the sites containing two bus stops, pedestrian crosswalks will be installed, forcing vehicles to yield to all pedestrians crossing the roadway. Additionally, two light poles will be installed to accommodate each bus stop along with one parallel bus bay. Each site will have an emergency call box for visitors to use in time of need. As previously discussed, additional parking at the Joshua Tree Visitor Center is proposed to be built to accommodate for visitor parking for shuttle use. Lastly, restrooms are located at every bus stop with the exception of Cholla Cactus, which will need installation of a waterless restroom. A breakdown of the individual costs and infrastructure quantities associated with Alternative 1 are shown in Table 22 of Appendix Section C.3.

5.2.2 Alternative 2

Alternative 2 is similar to Alternative 1; however the north entrance is incorporated in the shuttle system while the Cholla Cactus Garden stop has been removed. Figure 20 depicts the Alternative 2 bus stops (black diamonds) and routes. A transfer stop placed at Hidden Valley will allow visitors to move to the Purple or Yellow Line. With the exception of the Cholla Cactus Garden, the route will include the same major stops of the Blue, Purple, and Yellow routes included in Alternative 1. The Yellow Line in Alternative 2 will run from Hidden Valley along Park Blvd to the Oasis Visitor Center along Utah Trail Rd. As shown in Table 7 the proposed Yellow Line is 20.2 miles in length with a one-way travel time of 32 minutes.

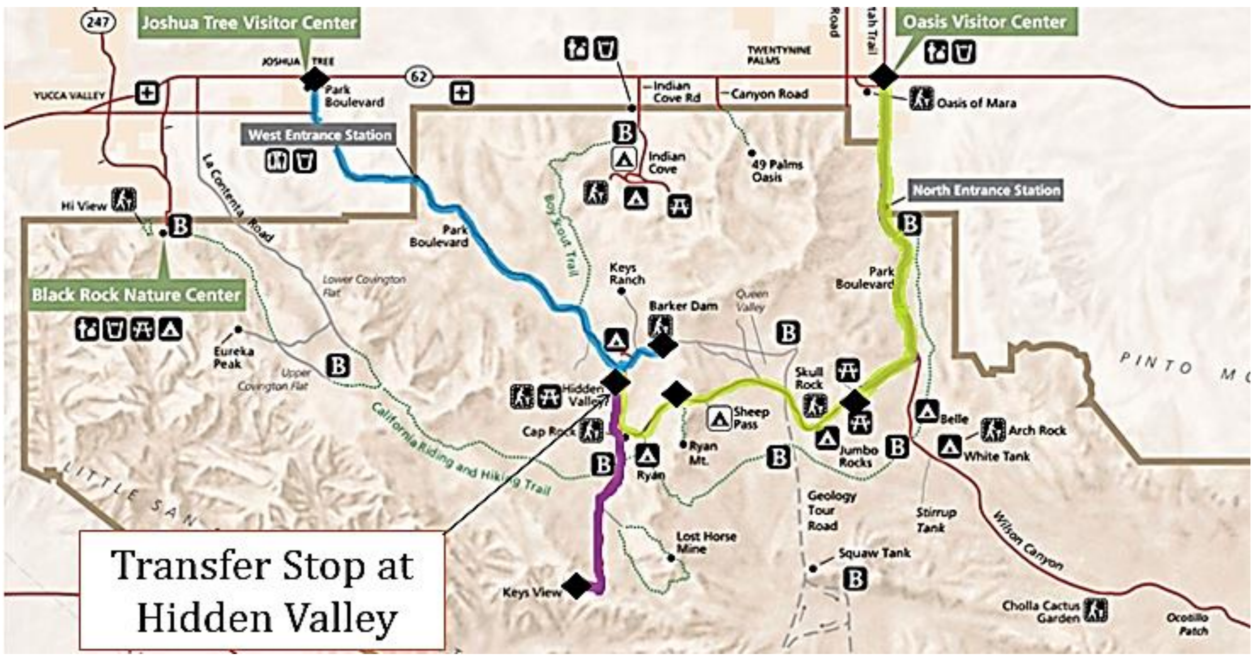


Figure 20: Route Alternative 2 Map

Table 7: Alternative 2 Route Distances and Travel Times

Shuttle Line	Distance (mi)	Time (mins)
Blue	15.6	27
Purple	7.2	16
Yellow	20.2	32

A total of 10 bus stops will be installed for Alternative 2, with one bus stop at most locations, with the exception of the Transfer Stop at Hidden Valley, Ryan Mountain, and Jumbo Rock, which will each have two bus stops (one stop for each direction). Similar infrastructure from Route Alternative 1 will be installed for all bus stops. No additional parking spaces were proposed for this alternative. However, the Joshua Tree Visitor Center parking lot needs repaving; therefore, in the associated cost it was assumed that there currently does not exist anything in that lot and complete construction is needed. A breakdown of the individual costs and infrastructure quantities associated with Alternative 2 are shown in Table 23 Section C.3 in the Appendix.

5.2.3 Alternative 3

Alternative 3 shown in Figure 21 is the most extensive of the alternatives, as the route runs across the entire park. The Blue Line includes stops at popular sites in the following order: Joshua Tree Visitor Center, Barker Dam, Keys Ranch, Hidden Valley, and Keys View. A transfer stop will be placed at Hidden Valley to allow visitors to continue on the Blue Line headed toward Keys View or transfer onto the Purple Line headed toward the Cholla Cactus Garden. Table 8 summarizes the travel times and distances of each route. The Blue Line has a length of 24.5 miles and a one-way travel time of 48 minutes. The Purple Line will include stops at Ryan Mountain, Skull Rock, Jumbo Rock, and the Cholla Cactus Garden. During the spring season, the Purple Line will extend to the Cottonwood Visitor Center, illustrated as the dotted seasonal route in Figure 13. The main Purple Line has a length of 22 miles and a one-way travel time of 32 minutes. The seasonal Purple Line running between Cholla Cactus Garden and the Cottonwood Visitor Center has a length of 41.7 miles and a travel time of 1 hour and 10 minutes.

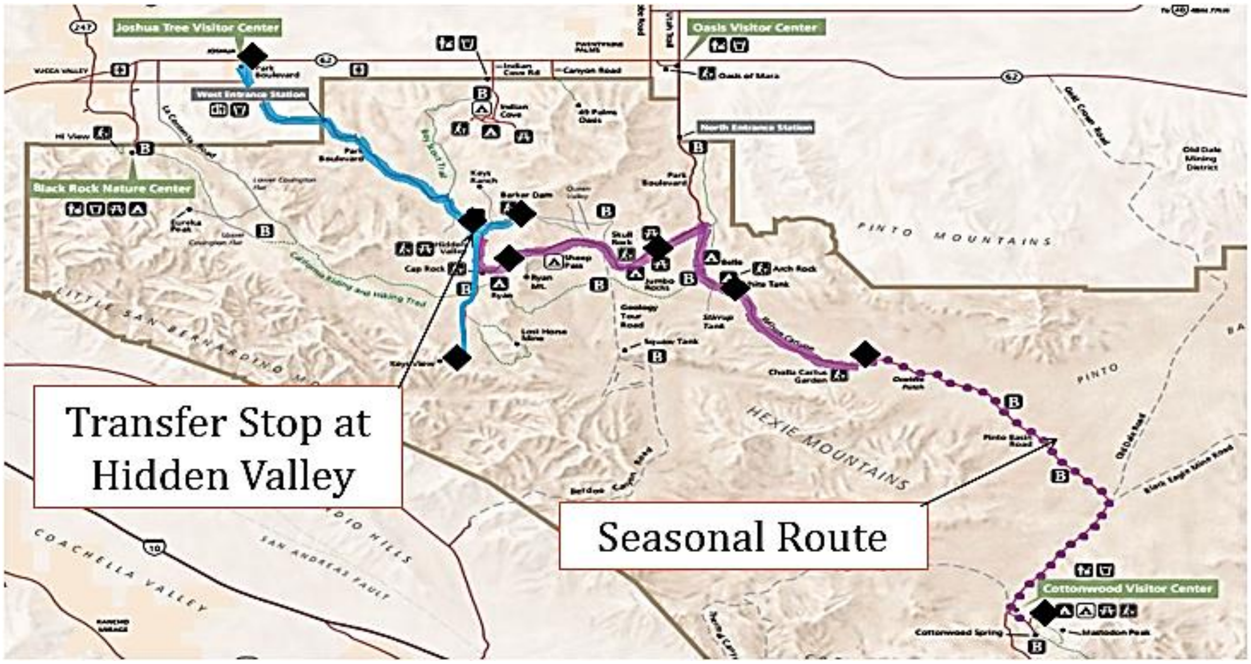


Figure 21: Route Alternative 3 Map

Table 8: Alternative 3 Route Distances and Travel Times

Shuttle Line	Distance (mi)	Time (mins)
Blue	24.5	48
Purple (Main)	22	32
Dotted Purple (Seasonal)	41.7	70

A total of 14 bus stops will be installed for Route 3, with one bus stop at most locations, with the exception of the Transfer Stop at Hidden Valley, Ryan Mountain, Jumbo Rock, Arch Rock, and Cholla Cactus which will each have two bus stops (one stop for each direction). Similar infrastructure from Route Alternatives 1 and 2 will be installed for all bus stops. Similarly to Route 1, additional parking space at the Joshua Tree Visitor Center is proposed to be built to accommodate for shuttle riders. A breakdown of the individual costs and infrastructure quantities associated with Alternative 3 are shown in Table 24 of Section C.3 in the Appendix.

5.3 Shuttle Operation

The shuttle system will operate during the hours of the Joshua Tree Visitor Center (8 AM - 5 PM), however the number of shuttles in operation will vary depending on the day of the week, holidays, weather conditions, and seasons. According to the rangers of Joshua Tree National Park, there is traffic congestion from 9 AM – 12 PM when visitors enter the park and 2-

3 PM when visitors leave the park. The shuttle system can be expected to be in full operation during peak weekends and holidays.

For the third alternative, a seasonal route, illustrated as an extension of the solid Purple Line, will run between the Cholla Cactus Garden and the Cottonwood Visitor Center. Due to the vast amount of preservation land that encompasses Joshua Tree National Park, it would be difficult to maintain the cost and operation between the 20-mile-stretch year-round. In addition, many visitors make the additional drive to the southern half of the park to primarily see the wildflowers in the lower elevations of the Pinto Basin in the southern section of the park. Wildflowers typically begin blooming in February and continue to bloom until as late as June. By placing a seasonal shuttle route according to the wildflower season, the shuttle system will reduce traffic congestion and provide visitors an accessible and sustainable alternative to get from one side of the park to the other.

5.4 Transit System Characteristics

Origin Destination Demand Estimation

The purpose of origin destination (OD) demand, in particular, private vehicle origin destination demand, is to determine the current travel patterns within Joshua Tree National Park. The OD study will also provide necessary information on the popular attraction sites. In order to obtain the OD data, the parking survey data that UCI ITE members collected during the Joshua Tree Trip on February 15th to the 16th was used. The original data only contains trip data, shown for Feb. 16th in Table 9 (a). The origin location is on the left of the table and the destination is shown on the top of the table. For example, there were five vehicles that were observed at Cholla Cactus Garden that were also observed at Hidden Valley. In order to convert these vehicle trip counts to person counts, an average of 2.7 persons per vehicle was used based on the methods reported by the NPS Visitor Statistics[1]. Table 9 (b) shows the resulting number of persons traveling between sites for Feb. 16th. Lastly, two days of data were collected during the parking study, thus, an average of the observed counts over the two days was taken. The average number of visitors traveling between sites is shown in Table 9 (c).

[1] https://irma.nps.gov/Stats/Reports/Park

Table 9: OD Trip Tables

# Vehicles	Cholla	HV	BD	JR	KV
Cholla	-	5	5	1	5
Hidden Valley	6	-	36	7	26
Barker Dam	2	16	-	10	17
Jumbo Rocks	3	4	4	-	3
Keys View	5	6	6	5	-

(a) OD Vehicle Trip Table on Feb. 16th

# People	Cholla	HV	BD	JR	KV
Cholla	-	14	14	3	14
Hidden Valley	16	-	97	19	70
Barker Dam	5	43	-	27	46
Jumbo Rocks	8	11	11	-	8
Keys View	14	16	16	14	-

(b) OD Person Trip Tables on Feb. 16th

# People	Cholla	HV	BD	JR	KV
Cholla	-	10	9	4	13
Hidden Valley	13	-	80	16	48
Barker Dam	10	41	-	18	39
Jumbo Rocks	8	11	14	-	8
Keys View	16	19	14	11	-

(c) Average OD Person Trip Tables

The OD visitor flows in Table 9 (c) which total to 402 visitors were then used as factors to predict the demand for each transit route. Table 10 shows the proportions of trips allotted to each OD pair.

Table 10: OD Trip Proportions

Trip Proportions	Cholla	HV	BD	JR	KV
Cholla	-	2.5%	2.2%	1.0%	3.2%
Hidden Valley	3.2%	-	19.9%	4.0%	11.9%
Barker Dam	2.5%	10.2%	-	4.5%	9.7%
Jumbo Rocks	2.0%	2.7%	3.5%	-	2.0%
Keys View	4.0%	4.7%	3.5%	2.7%	-

The next step is to determine the transit riders for each route. There are estimated to be 368 riders per hour during the peak hour, as explained in the previous section. The OD tables are used to proportion this demand. This is done by multiplying the hourly volume of transit riders by the OD trip proportions. Note, the values show in the table have been rounded up.

Table 11: Transit Riders in the Peak Hour

# Riders	Cholla	HV	BD	JR	KV
Cholla	-	9	8	4	12
Hidden Valley	12	-	73	15	44
Barker Dam	9	38	-	16	36
Jumbo Rocks	7	10	13	-	7
Keys View	15	17	13	10	-

Finally, the Parking Study did not measure visitor travel patterns to or from the three entrances, so an alternate estimation method was developed to link trips from each of the entrances to the five intra-park sites. First, the 2010 Visitor Demand Survey responses to Question 8a regarding entrance used to enter the park were used. The west entrance in Joshua Tree is the most popular entrance with 53% of the visitor groups passing through this entrance while Cottonwood Visitor Center attracts only 17% of visitors. Note the responses do not total to 100% because respondents were allowed to select 'other'. The number of transit riders at each entrance is found by multiplying the percent visitation by the total number of hourly riders. Table 12 shows the percent visitation by entrance location and corresponding number of riders.

Table 12: Visitation by Entrance Station

Trip Proportions	% Visitation	Riders
Joshua Tree Visitor Center	53%	195
Oasis Visitor Center	23%	85
Cottonwood Visitor Center	17%	63

The next step is to determine which sites are the first to be visited from each entrance location. Again, the 2010 Visitor Demand Survey Question 8b was used. Question 8b asks about the order in which the visitor group visited the sites within the Park. The first visit is assumed to be the visitor center. The second visit is assumed to be the closest site to the entrance station or a proportional split between the two closest sites in the case of Joshua Tree Visitor Center. Table 13 details the destinations most commonly visited after a visitor center.

Table 13: Sites visited from Visitor Centers

Trip Proportions	Site 1	Site 2
Joshua Tree Visitor Center	Barker Dam (34%)	Hidden Valley (66%)
Oasis Visitor Center	Jumbo Rocks	
Cottonwood Visitor Center	Cholla Cactus	

The final transit OD matrix is created by combining the results of Table 12 and Table 13 and appending these to the intra-park OD matrix shown in Table 11. It is assumed that there is zero visitor to visitor center travel demand for transit because visitors will need to return to their vehicles at the same visitor center where the accessed the transit system. It is also assumed that return trips from sites to the visitor centers are symmetrical to the trips from the visitor center to the site. Table 14 shows the final transit rider OD matrix. The largest flows occur between Joshua Tree Visitor Center and Hidden Valley. The second highest flows occur between the Oasis Visitor Center and Jumbo Rocks.

Table 14: Transit OD Matrix

Transit Riders	Cholla	Hidden Valley	Barker Dam	Jumbo Rocks	Keys View	Joshua Tree VC	Oasis VC	Cottonwood VC
Cholla	-	9	8	4	12	0	0	63
Hidden Valley	12	-	73	15	44	129	0	0
Barker Dam	9	38	-	16	36	66	0	0
Jumbo Rocks	7	10	13	-	7	0	85	0
Keys View	15	17	13	10	-	0	0	0
Joshua Tree VC	0	129	66	0	0	-	0	0
Oasis VC	0	0	0	85	0	0	-	0
Cottonwood VC	63	0	0	0	0	0	0	-

Assignment of Transit Trips to each Route Alternative

Using the final peak transit OD matrix, trips for each alternative were assigned based on the OD travel demands. Using the trips assigned to each route, the maximum load point was determined based on the maximum between the sum of inbound travel and the sum of outbound travel. The maximum load point is the maximum number of passengers on board the transit vehicle. In other words, this is the maximum level of demand which should be planned for. Figure 22 shows the travel demand between each site. Inbound travel is represented as the same direction of the arrowhead. Each color represents the shuttle system line of the alternative. The thickness of the lines is used to delineate travel from one location to another.

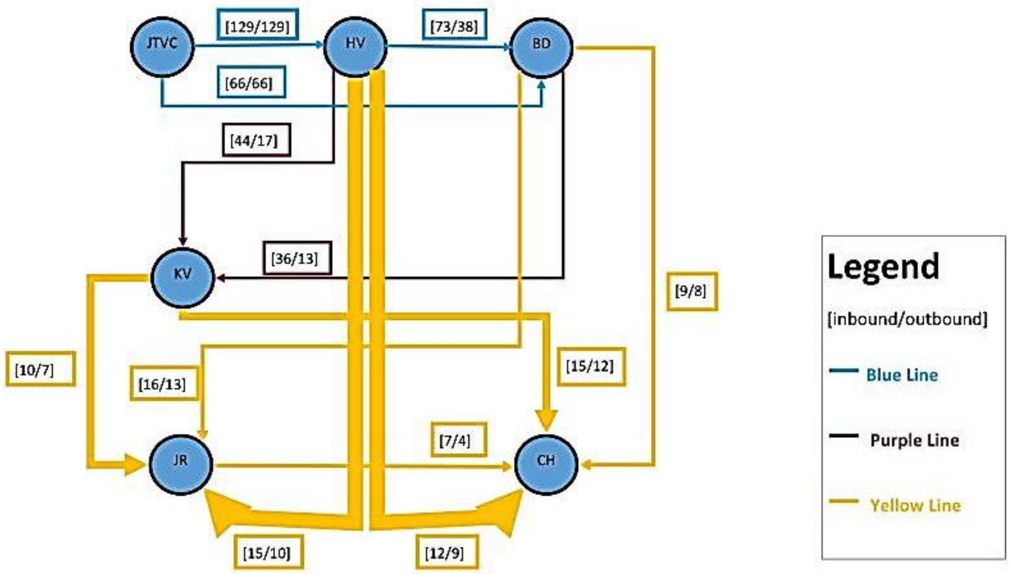


Figure 22: Route Alternative 1 Travel Patterns based on the OD Travel Matrix

The names of the locations are shown in each of the circle and are abbreviated. From the top left moving right, the full names are: Joshua Tree Visitor Center, Hidden Valley, and Barker Dam. The next row down is Keys View. And the last row is Jumbo Rocks and Cholla Cactus Garden. The travel demand for alternatives two and three are shown in the Appendix.

Headways and Number of Buses

Before headway and number of buses can be determined the maximum load point must be found. Headway is defined to be the time interval between successive arrivals of transit vehicles at a fixed location, it is also known as the frequency of the transit service. Secondly, service frequency (headway) that will adequately service the maximum load point must be determined. Once headway is determined, the number of transit vehicles and type of transit vehicle can be selected based on financial availability.

A standard bus, according to the *Transportation Planning Process for Transit in Federal Land Management Areas Volume 3*, has a seating capacity of 48 persons. Headways were iteratively determined in order to meet all transit demands while satisfying the seating capacity demand. The number of buses was determined by the total travel time multiplied by 2 for a roundtrip and adding to it the number of bus stops multiplied by a stop time of 1.5 minutes. This number was then divided by the headway to determine the number of buses needed. Overall, the number of buses for routes 1, 2, and 3 is as follows: 11, 12, and 20 buses. Note that these are the minimum number of buses that are needed in order to maintain the headways. These headways include the load times at each bus stop.

5.5 Parking Lots

Required parking lot sizes were calculated based on an estimated ridership of 18.5%. This means that 18.5% of a certain visitor population will be willing to ride the shuttle. Using this 18.5% ridership, three different estimation methods/ assumptions were made to develop an average number of parking spaces required. The first method did not rely on the ridership, but simply focused on preventing overflow based on the counts that were obtained from the parking survey during the peak hour. The second method assumed that only the visitors traveling to the five parking study sites would be willing to use the shuttle system. The third, assumed that all of the vehicles entering during a particular busy day could be potential shuttle riders. These methods are further elaborated below.

Methods for Parking Lot Size Determination

Method 1: Only the visitors traveling to the five parking study sites would be willing to use the shuttle system; therefore, the amount of visitors at the remaining locations were ignored. Parking survey data was used to obtain the maximum number of vehicles during the observed peak hour (462 vehicles). This was then subtracted from the maximum number of parking spaces available at these locations (approximately 379). From this calculation, it was determined that a minimum of 83 parking spots would be required outside of the park in order to prevent overflow.

Method 2: Only the visitors traveling to the five parking study sites would be willing to use the shuttle system; therefore, the amount of visitors at the remaining locations were ignored. The number of vehicles present at the park is the sum of the number of vehicles found during the peak hour of the parking study. A total of 462 vehicles were counted during the busiest hour; therefore, by taking 18.5% ridership of the 462, it is determined a total of 86 parking spaces are needed.

Method 3: All parking lots inside park grounds are full and visitors not traveling to the five study areas are willing to ride the shuttle regardless of the fact that it only stops at five locations. An estimated 787 parking lots were found within park grounds. If 18.5% of this population would be willing to use the shuttle system, the number of parking spaces required outside of park grounds was estimated to be 146.

Taking the average of these three parking size requirements, gives an estimate of 105 parking spaces required in order for the shuttle system to function properly. The following section briefly presents the proposed routes, which are tied with proposed parking lot locations.

Parking Lot Locations and Capacities

Based on the three proposed shuttle routes, two different potential parking lot locations have been selected. For alternative one and three, the shuttle will only be traveling to the Joshua Tree Visitor Center; therefore, additional parking will only be provided at this location. This center currently has an estimated 83 parking spaces (shown in Figure 23). However, as discussed in the previous section, the estimated demand is 105 parking spaces; therefore, additional land must be purchased to accommodate additional vehicles. Approximately 0.22 acres of land must be purchased to add 22 parking spaces. A summary of the associated costs can be found in Section B.3 of the Appendix.

Figure 23: Existing Joshua Tree Visitor Center Parking Lot

For Alternative 2, the shuttle travels to both the Joshua Tree Visitor Center and the Oasis Visitor Center. Therefore, the total parking lot demand was split between these two locations. Two-thirds of the parking demand was allocated to the Joshua Tree Visitor Center parking lot and one-third was allocated to the Oasis Visitor Center. This was based on the fact that approximately two-thirds of vehicles enter through the Joshua Tree Visitor Center compared to the Oasis entrance; therefore, more demand is expected in this area. Following these ratios, it was calculated that at least a total of 70 parking spaces are needed at the Joshua Tree Visitor Center while a total of 35 are needed at the Oasis Visitor Center. Since the Joshua Tree Visitor Center has room for approximately 83 parking spaces, no additional land must be purchased as the capacity exceeds the demand. At the Oasis visitor center, 43 parking spaces currently exist and a total of 35 parking spots are required. Again, no additional parking is needed at this visitor center as the capacity exceeds the calculated demand.

Chapter 6: Traffic Impact Analysis

With the growing number of visitors that Joshua Tree NP has been experiencing in recent years, it is expected that vehicular activity both within and outside of the bounds of the park would increase. This means more congestion, greenhouse gas emissions, and traffic related accidents. It is anticipated that all proposed route alternatives would be effective in mitigating negative impacts associated with visitor growth. For one, it would lower the number of vehicles within the park as riding the shuttle would be a safer and more convenient option. However, it is important to note that there will be two types of shuttle riders. One will be those who park their vehicles within the park to take the shuttle, and the other will be those who park outside and take the shuttle to enter the park. The following study will focus primarily on the second type, as most visitors in the future are assumed to park outside of the park to take the shuttle to travel into the park.

6.1 Analysis of Existing Intersections

The intersection near the Joshua Tree Visitor Center (West Entrance) is approximately 16 miles from the intersection leading to the Oasis Visitor Center (North Entrance). It is surrounded by homes, small businesses, and several vacant lots that are currently used for parking. Directly to the south of the Oasis visitor center is Service Road, where only employees of the park are permitted to enter. To the north, there are homes and a church. To the west is a preserved oasis known as the Oasis of Mara. To the east is a residential neighborhood. Although there are many open areas surrounding the visitor center, unlike the Joshua Tree Visitor Center, possible parking locations are limited. The visitor center currently offers parking but with a limited capacity of 83 vehicles.

6.2 Projected Traffic

It was assumed that creating alternative parking spaces outside of the park could help reduce traffic inside the park; therefore, this memo primarily focuses on the external impacts. This analysis utilized predicted average daily traffic (ADT) estimates acquired from the San Bernardino County department of transportation, which has public ADT volumes for specific intersections. These volumes were utilized to understand the direction in which most cars are traveling. Although the data provided by the San Bernardino Department of Transportation was limited and varied with season, we were able to attain the following ADTs near Joshua Tree Visitor Center and Oasis Visitor Center:

- ADT along Park Blvd. south of SR-62: 4,740 vehs/day (4/20/2011) (Fig. 13)
- ADT along Park Blvd. north of SR-62: 1,596 vehs/day (8/30/2007) (Fig. 13)
- ADT along Utah Trail south of Starlight Dr. : 553 vehs/day (6/03/2010) (Fig. 14)

These are pictured below in Figure 24 and Figure 25. The highlighted areas represent the direction in which vehicles are traveling.

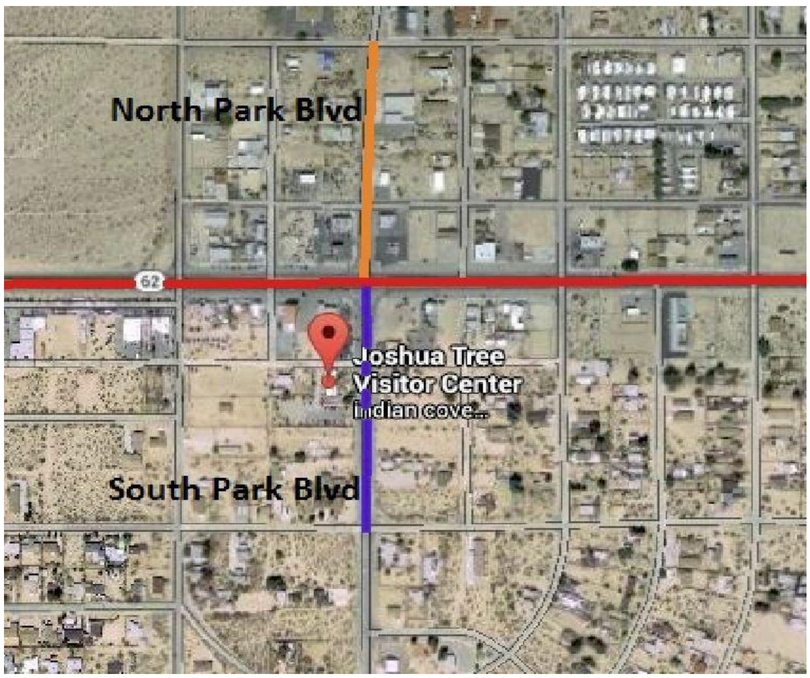


Figure 24 : ADTs data collected locations near Joshua Tree Visitor Center

These volumes vary by year for each intersection; therefore, an estimate of 2013 traffic volumes was calculated based on the percent change of vehicles entering through each of the sites. The number of vehicles entering through each of the entrances for every month was obtained from the National Park Service Visitor Use Statistics.

The monthly vehicle counts at the North and West entrances are shown below in Table 16 and Table 17. West entrances experienced a higher flow during August. Volume at North entrance is relatively low. This is also summarized in Figure 26.

Figure 25: ADTs data collected near Oasis Visitor Center

Table 15: Traffic Counts at West Entrance (Joshua Tree)

Year	April	August
2013	21,759	10,194
2012	22,518	9,493
2011	23,072	8,312
2010	22,580	9,138
2009	20,890	8,467
2008	19,619	6,821
2007	16,651	9,852

Table 16: Traffic Counts at North Entrance (Twentynine Palms Oasis)

Year	June
2013	5,750
2012	4,708
2011	5,475
2010	5,217
2009	4,713
2008	4,044
2007	7,918

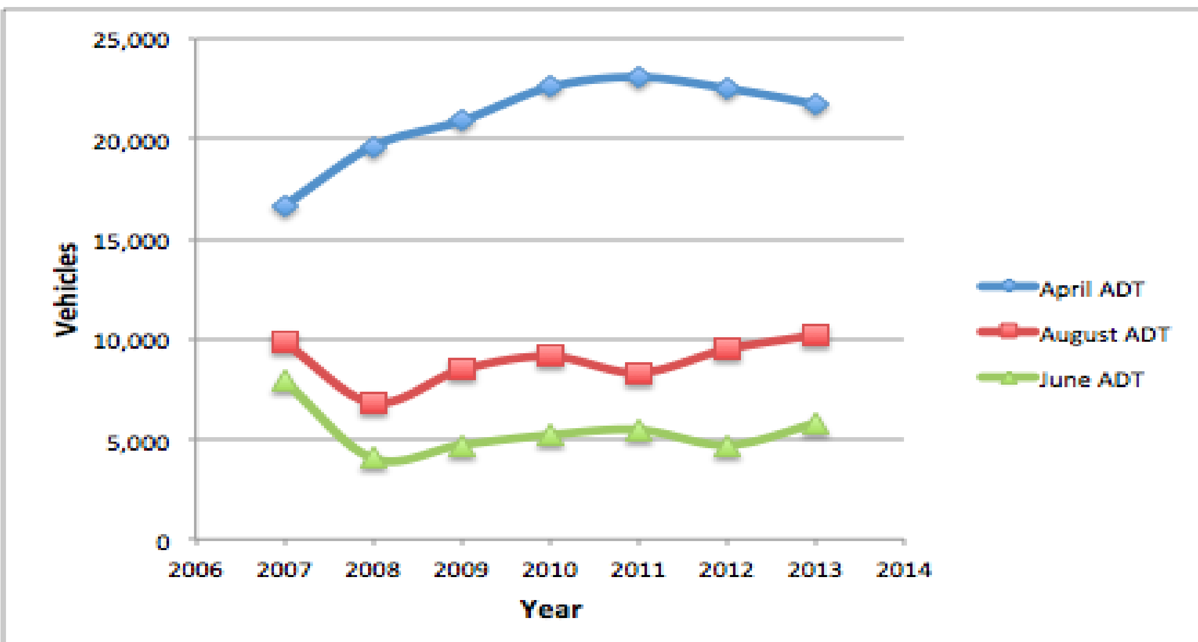


Figure 26: Monthly vehicle counts

Traffic volume processing highlighted that south of SR-62 at Park Blvd. serves an estimated 4,470 veh /day, while north of SR-62 at Park Blvd. serves 1,652 vehs/day. At the intersection of Utah Trail and Starlight Drive an estimated 6,337 vehs/day travel into the park.

6.2.2. Results

Based on the estimated ADT for Year 2013 and the traffic volume trends at each of the entrances, it was projected that the intersection of SR-62 and Park Blvd. will continue experiencing the highest volumes of the intersections studied. The North entrance is projected to remain the second most congested entrance. This is due to the fact that most of the popular sites in Joshua Tree National Park are located on the West side of the park; therefore, this will cause visitors to access the park from the entrance closest to the site they would like to visit. Traffic conditions at the intersection of SR-62 and Park Blvd. might pose a small problem if the first alternative is carried out as all visitors riding the shuttle will be forced to park in the parking lots located near the start of the shuttle route. The South entrance was disregarded because the traffic volumes are very low and do not have a significantly increasing trend. In addition, on rare occasions, this entrance may be closed during the winter season due to dangerous road conditions caused by severe weather.

Adding shuttles to the existing network may cause problems to some congested local streets, for example south Park Blvd. In order to resolve the potential traffic concerns caused by the shuttle system implementation, the main goal would be to spread parking locations along SR-62. For Alternative 1 and 3, congestion can be reduced along Park Blvd. by extending the storage length for the right turn lane in order to prevent queuing behind the existing through lane. Another option is to increase the number of parking spaces at the North entrance in order to encourage visitors to travel in that direction when parking is full at the West entrance. With the future Caltrans projects along SR-62, some safety concerns will be mitigated, but this might pose congestion issues during the years the project is under construction.

Chapter 7: Sustainability

Beyond alleviating parking and entrance station congestion, another goal of the transit system is to reduce environmental impacts resulting from vehicle emissions. As a sensitive geographical area, the air quality in Joshua Tree National Park has to meet the highest standards set by the Environmental Protection Agency (EPA), thus alternative fuel technology for transit vehicles is very important to the nature of the park. Various transit technologies, air pollutants, and emissions models are presented in this section. Six alternative transit technologies were compared. These included: diesel, bio-diesel, hybrid diesel-electric, electric, propane, and hydrogen. All six technologies operate uniquely, require specialized infrastructure for fueling and maintenance, and have various impacts on the air quality.

In this Chapter, a brief review of existing transit services is provided, followed by a description of each of the six specified transit technologies. Finally, a summary of pollutant emissions is given and a final recommendation regarding transit technology is provided.

7.1 Existing Transit Services

Pre-existing conditions of Joshua Tree National Park are very minimal in terms of transit. Joshua Tree NP does not currently have an internal transit system. Local transit authorities are the Morongo Basin Transit Authority (MBTA) and SunLine Transit Agency. MBTA has routes going through the community of Joshua Tree, as well as other local communities such as Twentynine Palms, Yucca Valley, Morongo Valley, and Landers. The MBTA operates 24 busses operating on compressed natural gas (CNG) with fueling stations in Joshua Tree and Twentynine Palms. MBTA does not have routes that go into the National Park, but has stops near by the entrances. The SunLine Transit Agency operates solely from the Desert Hot Springs area down south to the Coachella area. SunLine buses include CNG, hydrogen, and hybrid technologies.

7.2 Transit Technologies

Diesel

Diesel engines are becoming more popular in passenger cars. Modern diesel systems are clean, powerful, and fuel-efficient. Diesel engines, like gasoline engines, are both internal combustion engines. A diesel engine, however, compresses the air used in the combustion first and then injects the fuel. As the air is compressed, the temperature increases causing the fuel to ignite (Austin). They operate at a high compression ratio and the fuel has a higher energy density which allows the fuel economy to be 15% to 30% higher than gasoline engines (Tuttle). In the United States, diesel has increased in cost and currently costs more than gasoline, ranging from $1500 to $5000 more to operate. This would increase operation costs if this alternative is chosen.

Current technology of diesel engines produces 90% less emissions than the old diesel technology. Researchers have determined that new diesel engines produce emissions much lower than the EPA standards and are emitting the same as gasoline powered automobiles. Fine particulate matter has also decreased significantly with 99% lower particulate emissions coming from the 2007 diesel engines than the 2004 models. Other air pollutants have also been decreased significantly including carbon monoxide and hydrocarbons. Nitrogen oxides, however, have not been lowered enough with the new technology. Only 70% of nitrogen oxides were lowered between the 2007 and 2004 models, but larger reductions are necessary to follow the EPA set standards of nitrogen oxides emissions. Researchers are trying to reduce nitrogen oxide emissions without lowering the fuel economy, which has proven to be difficult (Cone). Diesel fuel emits about 10.21 kg of carbon dioxide per gallon. For a medium to heavy duty vehicle such as a bus, the methane emissions factor is about 0.0051 grams/mile and the nitrous oxide emissions factor is about 0.0048 grams/mile.

Diesel buses cost approximately between $250,000 and $280,000 per bus (Colorado DOT). As of April 7, 2014, the average cost of diesel in the United States was $3.959 per gallon (Gasoline and Diesel Fuel Update). There are currently a few gas stations located near Joshua Tree that already sell diesel so new diesel pumping infrastructure would not have to be built.

Diesel-Electric Hybrid

Large vehicles such as buses are capable of using diesel hybrid engines. Diesel-electric power can be used to improve fuel efficiency. While nearly all studies have shown an increase in fuel economy and decreases in brake wear, engine wear, emissions, and noise pollution; these studies have been focused on urban transport that travel with stop-and-go routes in mind. Since the Joshua Tree Project will be planned with stop sites separated by several miles, these benefits will not carry the same levels of benefits as they would in the city.

Engine systems have been innovated to make large diesel vehicles more sustainable. Studies and tests by BAE Systems have shown that new engine systems, such as the parallel system they developed, can reduce fuel consumption by up to 30% even for heavy vehicles like freight trucks. However, it was shown that the parallel system worked best for slow going vehicles with stop-and-go travels, such as garbage trucks. HybriDrive Propulsion systems use diesel to run when operating at speeds over five mph. When the bus speed drops below five mph, the engine shuts off to reduce idling time and fuel use. Heat, noise, and emissions at drop-off points are eliminated. The electric powers the bus until it reaches five mph again, which activates the diesel engine once more.

Fortunately, not all hybrid systems have been designed for only city use. Yosemite National Park has invested in hybrid shuttle buses to benefit both the visitors to the park and the park itself. Yosemite's diesel-electric hybrid shuttle buses provide a quieter, cleaner, and more fuel efficient mean of transportation throughout the park. The eighteen shuttles can serve over one thousand passengers per hour for fifteen hours a day, year round. Estimates conducted by the NPS calculate the particulate matter emissions have decreased by 90%. The car traffic in the park has also been severely reduced, thanks in part to the Yosemite shuttles offering free rides to the visitors of the parks. "The buses are operated by Delaware North Companies, which subcontracts its services to the National Park Service." Diesel-Electric buses produce the same types of emissions as traditional diesel buses, but at a reduced level, due to the switch from diesel to electric during slow moving times and idling. Emissions factors for hybrid buses are about 1.40 grams/mile for carbon dioxide, 0.02 grams/mile for particulate matter, 0.02-1.2 grams/mile for total hydrocarbons (dependent on fuel used), 0.30 grams/mile for carbon monoxide, and 1.01 grams/mile for nitrogen oxides (data based on studies performed by Connecticut Academy of Science and Engineering, Environmental and Energy Study Institute, and Federal Transit Administration).

Hybrid Buses can cost twice as much as conventional diesel buses. The average price of a 40ft hybrid bus typically ranges from $450K to $550K, while conventional diesel runs around $280K to $300K. However, studies have shown that hybrids generally save money in terms of maintenance and operational costs. While government grants may be available to help alleviate initial costs, but ultimately hybrid buses will come with a sweep initial investment.

In conclusion, Diesel Hybrid systems have been shown to be effective for city buses, large diesel trucks, and most importantly park shuttles. Unfortunately, costs for hybrids tend to be much higher for such systems as opposed to pure diesel engines. While Yosemite National Park as shown successful implementation of hybrid shuttle use, climate and visitor frequency are aspects that need to be kept in mind before making a decision.

Biodiesel

Biodiesel is a renewable fuel manufactured from biological ingredients, such as vegetable oil, animal fats, or recycled restaurant grease. Biodiesel can be used in its pure form or in a variety of blends with petroleum diesel fuel. These blends vary from 100% biodiesel (B100), 20% biodiesel and 80% petroleum diesel (B20), 5% biodiesel and 95% petroleum diesel (B5), and 2% biodiesel and 98% petroleum diesel (B2). Petroleum diesel and biodiesel are very similar chemically. Both fuels have a long chain of carbon atoms, with hydrogen atoms attached. The difference between the fuels is that biodiesel also has an ester group at the end of the chain of the carbon atoms. This is due to biodiesel being made out of vegetable oil. Vegetable oil must be converted to biodiesel in order for the fuel to reduce the molecular size. Shrinking the molecule decreases the temperature at which the fuel will start to gel. After removing any traces of water in the vegetable oil, the oil is converted into biodiesel via a transesterification reaction. Methanol is used to break down vegetable oil into biodiesel and glycerol.

Unlike petroleum diesel, biodiesel is easily replenished by farming and recycling. Biodiesel also substantially reduces tailpipe emissions of carbon monoxide (CO), nitrated polycyclic aromatic hydrocarbons, polycyclic aromatic hydrocarbons, sulfates, unburned hydrocarbons (HC), and particulate matter (PM). Biodiesel reduces the dependency of fossil fuels from foreign countries. Greenhouse gas emission is significantly reduced due to Using biodiesel reduces greenhouse gas emissions because the plant feedstock used in the production absorbs released carbon dioxide from the atmosphere when it grows, due to photosynthesis. Production particulate emissions for biodiesel are 50% less than emissions for petroleum diesel. While tailpipe emissions are reduced by 20% with biodiesel conversion. Biodiesel is also biodegradable and non-toxic. Biodiesel fuel buses emits 2% more NOx than diesel but reduces PM emissions by 10.1%,HC emissions by 21.2%, and CO emissions by 11%. CO_2 emissions are eliminated all together. Biodiesel allows for easy transition from diesel fuel to biodiesel fuel because there are no modifications required to begin fueling with biodiesel. Biodiesel is cost efficient and feasible but does not offer a great reduction of emissions compared to other fuel alternatives.

Biodiesel blends can be used in diesel vehicles without any engine modification. Therefore, the cost of a biodiesel bus is the same as a diesel bus. A transit bus averages between $250,000 and $350,000, depending on specifications. Fleets generally use B20 or B5 biodiesel blends. Blends with percentage of biodiesel higher than 20% may require engine modification, due to the biodiesel's capability of deteriorating rubber gaskets and tubing. Biodiesel has a higher flashpoint than conventional diesel so it is less flammable. Therefore, biodiesel is compatible with existing fuel storage tanks. Biodiesel also improves engine lubrication and actually cleans the engine gunk and deposits from the inside of the fuel system. The U.S. Department of Energy did a study where it compared nine identical 40-ft transit buses for two years. Five of the buses ran on B20 biodiesel fuel and the other four operated on petroleum diesel. The study titled, 100,000-Mile Evaluation of Transit Buses Operated on Biodiesel Blends (B20), concluded there is no difference between average fuel economy for diesel and biodiesel vehicles. Maintenance costs were higher for the B20 group by $0.02 per mile due to component replacements. Transitioning to biodiesel caused early problems and fuel filtering plugging.

Biodiesel fuel (B20) averaged around $4.06/gal in July 2013. Its cost fluctuates directly with the cost of diesel fuel. The closest location of a public biodiesel fuel pump is Extreme Green Technologies Incorporated in Corona, California. The station is 95 miles away from Joshua Tree NP. A plan for storing biodiesel closer to the Park should be considered.

Propane

Zion National Park, located in southern Utah, created a transit system within the park using propane powered shuttles (Green Transit - The Zion Shuttle). Propane shuttles are increasing in usage for fleet applications. A propane vehicle operates similarly to gasoline powered engines, with similar power, acceleration, cruising speeds, and driving range. Propane engines, however, have lower maintenance costs than a normal gasoline powered engine. They have a higher octane rating, and low carbon and oil contamination characteristics which result in a higher lifetime expectancy than gasoline engines.

Propane costs less than gasoline, which helps saved costs of operation. Propane engines produce lower amounts of harmful emissions compared to diesel and gasoline engines. An EPA emissions test of a propane-fueled Ford V8 resulted in a net hydrocarbon emission of 73% cleaner than the acceptable standard, NoX emissions were down 57%, and CO emissions were 93% cleaner than the federal standard. Propane engines provide 90% of gasoline's miles per gallon and propane is considered a safe motor fuel because propane tanks are 20 times as puncture-resistant as gasoline tanks and the lower flammability range (Propane Powers Zion National Park's Shuttle Bus Service). Propane buses emit about 5.72 kg carbon dioxide/gallon, 0.27 grams methane/gallon, and 0.05 grams nitrous oxides/gallon. According to the Zion National Park Study, emissions factors for propane shuttles given by the manufacturer are 3.44 grams volatile organic compound/ mile, 0.3 grams carbon monoxide/mile, and 9.85 grams nitrogen oxides/mile.

Propane vehicles are spark-ignited engines like gasoline powered engines. For a vapor injected system, liquid propane enters the engine compartment through a fuel line. A regulator or vaporizer converts the liquid propane into a vapor. The vapor is then mixed with filtered air and moved to the combustion chamber where it burns to produce the power to drive the vehicle. Because of the mixture of vapor and air, cold start problems are greatly reduced in propane engines (Propane Vehicles).

Amerigas, located in 29 Palms, currently sells propane which could fuel the shuttles for Joshua Tree. Propane engines, modeled after the propane shuttle fleet in place in Zion National Park, could be a good alternative for the Joshua Tree transit system due to the low maintenance and operational costs, lower harmful emissions, and safety.

Electric

An electric bus is a bus powered by electricity. Electric buses are on the rise in the United States. However, the biggest problem is that batteries don't allow these buses to travel a satisfactory range. They are mainly concentrated in the airport and other short shuttle route. For example, Foothill Transit has several electric buses on Route 291 and it has shown that these buses have short recharging periods.

Since the battery technology is still not very developed, it is very unlikely for the transit industry to use this technology. This technology needs to be developed to a point where a vehicle can easily travel around 200-300 miles on a single charge. The delays caused for the need for en-route charging will make it too costly for a transit agency. Furthermore, the capital cost for an electric bus is estimated to be around $700,000 in fuel and maintenance over a 12 year period. On top of that, the cost of necessary charging stations can be up to $50,000 each. The estimated cost to charge the buses each time would be about 20 to 30 cents per mile traveled.

Electric Buses emit no gases since it has no tailpipe emissions and use less energy per miles than diesel buses. This technology is still not mature, but electric buses are a clear example involving technology in air control and alternative fuel vehicles. Since electricity is produced from renewable energy sources, such as wind or hydro-electric power, greenhouse gas emissions for electric buses should be minimal or close to zero.

With the recent discovery of massive amounts of natural gas in the United States, agencies have decided not to adopt electric buses. As a result, the price of natural gas has gone down. Natural gas will prove to be a cheaper source for buses than electricity. However, electric buses have the greatest appeal in California since pollution is preventing the purchase of diesel buses.

Yosemite National Park has invested in two electric-powered shuttle buses. These buses provide millions of Yosemite visitors an eco-friendly type of transportation. These electric buses have "no odors, no noise, [and] no pollution." Electric buses are a clear example involving new technology in air control and alternative fuel vehicles. With this idea in mind, electric buses can be incorporated in Joshua Tree National Park as well.

Hydrogen

The hydrogen fuel cell vehicle is a zero emission vehicle which has a high positive impact to the environment. Although it is relatively expensive to produce, the invention of the hydrogen fuel cell technology is another leap to the improvement to the technology for the environment because it produces only water vapor through combustion. Major car manufacturers such as Toyota and Hyundai have begun producing the hydrogen fuel cell vehicle and they are ready to run in California. There are not many hydrogen fuel stations in the US and they are mainly available in major cities in the US. California has committed to invest $200 million USD to produce around 100 hydrogen fuel station by 2024.

Hydrogen buses operate more efficiently than gasoline buses. Fuel Cell technology utilizes up to 60% of the total power where as gasoline technology utilize up to 40% of the total power. Fuel Cell technology generates electricity and heat using hydrogen. The advantage about fuel cell technology is that the combustion releases zero pollutants which are good development in technology.

Hydrogen fuel buses have been around in Burbank, California, and operated 250 miles before recharging time which can rotate between the city’s 4 routes. The advantages of the hydrogen fuel busses would be improved fuel economy, Greenhouse gas reduction, improved air quality and enhanced rider experience. The disadvantage of the fuel cell bus would be the availability of the fuel stations and the price of hydrogen fuel bus is 4 times of the price of diesel bus. There are no recent hydrogen fuel stations that are being developed in the region. The popularity for hydrogen fuel cell are low at the moment which makes it hard for hydrogen fuel bus to be the right choice at the moment but it is a good alternative for the future because fuel cell technology hold great potential for the better future.

Table 14: Transit Technology Summary Table

Transit Technology	Pros	Cons	Currently Used In
Diesel	• Lower fuel consumption rate • Affordable startup cost • Convenient stations	• Very high emissions	• Denali National Park, CA • Los Angeles, CA • Mount Rainier National Park
Diesel-Electric Hybrid	• Great city fuel rate • Prevents emissions during idling • Reduced noise • Reduced exhaust odor • Higher fuel-economy	• High purchase cost • Electric only operates when traveling <5 mph • Studies on city travel • Long term battery life never proven	• Yosemite National Park, CA • Sequoia National Park, CA • Minneapolis & St. Paul, MN • London, England • New York City, NY
Biodiesel	• Renewable energy produced domestically • Reduced tail pipe emissions • Can be used in diesel vehicle without modifications	• Can freeze at higher temperatures • Fluctuating fuel costs • Must be administered under special protocol to avoid problems • Limited fuel stations	• St. Louis Metro, MO • Oahu, HI • Olympia, WA • MATBUS North Dakota
Propane	• Reduced emissions • Convenient station • Narrow flammability range • Reduction in fuel cost • Similar operating range to diesel	• Newer technology • Special training for mechanics • Additional fueling infrastructure	• Zion National Park, UT • Mesa Verde National Park, CO • Acadia National Park, ME
Electric	• Reduce pollution • Quiet and quick • Reduce exhaust odor • Cheap to operate	• Limited range • Long refueling time • High cost • Lack of consumer choice	• Yosemite National Park, CA • Sequoia Nation Park, CA • Kings Canyon National Park, CA • South Korea • San Francisco, CA
Hydrogen	• Zero emissions • Clean air • More efficient	• Expensive • High maintenance cost • Limited fuel station area • Less popular	• Burbank, CA • San Francisco, CA • Tokyo, Japan • Seoul, S. Korea • London, England

7.3 Air Pollutants

Carbon Monoxide

Carbon Monoxide, CO, is a colorless odorless and very poisonous gas that is formed from the incomplete burning of carbon. This is primarily found when carbon fuels, or fossil fuels, are not fully processed in the engines of vehicles, construction equipment, and military equipment. Carbon Monoxide poisoning can occur at very low concentrations. Carbon monoxide poisoning is the most common fatal type of air poisoning in several countries. Common symptoms include headaches, nausea, dizziness, and even death. Death can occur in 30 minutes at a CO air concentration of 0.32% (Goldstein, 2008). For the sake of brevity, we will focus on CO from vehicle emissions.

In the city, automobile exhaust accounts for 95% of CO emissions (U.S. EPA, 2003). Thanks in part to increased standards and regulations, man-made CO emissions decreased by 46% between 1990 and 2005. However, 60% of carbon monoxide in America is caused by automobile exhaust. Diesel engines are said to produce very little carbon monoxide in their emissions due to the way diesel burns fuel with an excess of air. Regardless, carbon monoxide is a very dangerous emission that is fatal to humans and animals alike.

Carbon Dioxide

Carbon Dioxide (CO2) occurs naturally as a part of the carbon cycle. The carbon cycle is the act by which carbon is exchanged among the atmosphere, oceans, soil, plants, and animals. CO2 is produced by plants during respiration. Nevertheless, human-related CO2 emissions are responsible for the exponential increase in the atmosphere. The primary source of human-related CO2 emissions is from fossil fuel (coal, natural gas, gasoline, and oil) combustion for energy and transportation. Transportation contributes to 31% of total U.S CO2 emissions and 26% of total U.S. greenhouse gas emissions in 2011.

The emission levels of CO2 present at Joshua Tree National Park were recorded in the Visitor Vehicle Emissions Study in 2005. The emission levels, which were measured by MOBILE6, were exponentially larger than all of the remaining studied pollutants combined.

From the study results, it is clear that CO_2 is the most prominent pollutant emitted at Joshua Tree.

Nitrous Oxides

Nitrogen Oxides are a group of highly reactive gases that most commonly include Nitric Oxide (NO), Nitrogen Dioxide (NO_2), and Nitrous Oxide (N_2O) when referring to air pollution. Nitrogen Oxides are produced from the emissions of cars, trucks, buses, power-plants, and off-road equipment (Nitrogen Dioxide). Approximately 40% of all nitrogen oxide emissions come from human interaction with the environment including agriculture, transportation, and industry (Overview of Greenhouse Gases). Nitrogen Oxides cause problems with the respiratory system, including irritation of the nose, throat, and respiratory tract (An Introduction to Indoor Air Quality). Long exposure to the toxic gases can cause many respiratory infections and can lead to chronic and acute bronchitis.

The EPA (Environmental Protection Agency) first set standards to reduce nitrogen oxide emissions in 1971 with 0.053 ppm, averaged annually. By 2010, the EPA had dropped their standards significantly to 100 ppb, averaged over a one hour period (Nitrogen Dioxide). However, nitrogen oxide emissions have not decreased enough to follow the standards.

Sulfur Oxide

Sulfur oxide, SO_x, refers to all sulfur oxides with the two major ones being sulfur dioxide (SO_2) and sulfur trioxide (SO_3). Sulfur dioxide is a colorless gas with a pungent, irritating odor and taste. It is very soluble in water and can form weak acidic sulfuric acid. Sulfur trioxide is slowly formed when sulfur dioxide combines with oxygen (O_2) in the air. Sulfur trioxide quickly combines with water to produce sulfuric acid. Sulfur oxides normally last in the atmosphere between four to ten days.

Sulfur dioxide can damage a person's respiratory system with symptoms such as broncho constriction and increased asthma symptoms. EPA's National Ambient Air Quality Standard for SO_2 is made to protect against exposure to the entire sulfur oxides. Sox can easily react with other compounds in the atmosphere to form small particles that can penetrate deeply into sensitive parts of the lungs and can cause or worsen respiratory disease. It can also worsen existing heart disease, leading to increased deaths.

Volatile Organic Compounds

Volatile Organic Compounds (VOCs) exist 2-5 times higher exposure indoor rather than outdoors in average. The sources of VOCs indoors are paints, lacquers, paint supplies, building materials and many more. Low exposure of VOCs can cause eye, nose or throat irritation, headaches, loss of coordination and nausea. In high exposure, they can cause damage to liver, kidney and central nervous system and maybe the cause of cancer. The steps to reduce VOC exposure at home is by increasing ventilation when using products that contain VOCs and meet or exceed any label precautions. One of the main compounds is formaldehyde which serves as carcinogen. OHSA has restricted the Permissible Exposure Level (PEL) of 0.75 ppm with action level of 0.5 ppm. HUD has restricted the concentration of mobiles homes by a level of 0.4 ppm. Furthermore, it is recommended to mitigate formaldehyde that is over 0.1 ppm.

Particulate Matter

Particulate matters, PM, are pollution particles made up of tiny particles of liquids and solids, both organic and inorganic in nature. PM is divided into two classes: Course particles and fine particles, depending on the size of the particulates.

Particulate matters ranging from 2.5 to 10 micrometers in diameter, PM 2.5-PM 10, are classified as “course particles” (U.S. EPA, 2013). Course particles are generally caused by dust being kicked up by vehicles or weather, or they can be caused by construction. These larger particles are able to be inhaled through the air which can lead to health problems in the lungs and/or heart.

Any particulate matter that is smaller than PM 2.5 is called a “fine particle” (U.S. EPA, 2013). Fine particles are so small that they only be seen with an electron microscope, however, their small size make them far easier to reach deep sections of the lungs. In December of 2004, the EPA added standards to regulate PM 2.5 emission, which are believed to be responsible for acute health problems (FHWA, 2006).

Ozone

Ozone is present at ground level and in the upper regions of the atmosphere. Atmospheric ozone protects the earth from harmful ultraviolet rays, while ground level ozone is the main component of smog. Ground level ozone is a pale blue gas with a distinctively pungent smell. Ozone is not emitted but rather is formed when nitrogen oxides (NOx) and volatile organic compounds (VOCs) react in sunlight. Ground level ozone is harmful to the public's health due to ozone being a main component in the air the public breaths.

Ozone is not included in the Visitor Vehicle Emissions Study in 2005 due to none of the proposed emission models measuring the presence of ozone. Nevertheless, ozone is designated as one of the six common air pollutants. In future emission studies, ozone emissions must also be included.

Smog

Smog is fog or haze combined with smoke and other atmospheric pollutants. In other words, it is a type of air pollutant. Cars that combust fuel emit smog forming emissions such as nitrogen oxide, non-methane organic gases, carbon monoxide, particulate matter, and formaldehyde. These emissions usually trap on the ground and form a brownish haze that pollutes the air. Smog can be cause health problems such as breathing difficulties and lung diseases such as asthma, emphysema, and chronic bronchitis.

In general, vehicles are getting more efficient. Cars and trucks are 98-99% cleaner than they were in the late 1960s for smog-related pollutants. These vehicles are getting cleaner every year as there are more efficient, and clean options.

7.4 Comparison of Transit Technology Emission Rates

In a Meta-Analysis of Transit Bus Exhaust Emissions[2] researchers compiled emissions rates from a variety of transit technologies. Figure 27 summarizes and compares the pollutant emission rates across the six transit technologies by pollutant. Electric and hydrogen produce zero tailpipe emissions. Diesel and bio-diesel the highest carbon monoxide emission rates, while

[2] Cooper, E., Arioli, M., Carrigan, A., and Jain, U.,"Meta-Analysis of Transit Bus Exhaust Emissions", Transportation Research Record, No. 2340, 2013.

propane and hybrid have the lowest. Propane also has the lowest CO_2 emissions. NOx emissions are highest for diesel and lowest for hybrid, with propane ranking in between. Diesel has the highest PM emissions while hybrid has the lowest, with propane ranking in the middle.

Figure 28 compares the emissions rates per person between passenger cars and each of the transit bus technologies under the assumption of 2.7 passengers per car and 50 passengers per bus. Average passenger car emission rates were pulled from the EPA's Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Truck report. These charts compare compressed natural gas (CNG), diesel, hybrid, bio diesel, and propane against a standard passenger car. On a per person basis, passenger cars produce higher CO and CO_2 emissions than all technologies. Propane technology achieves lower emissions across all pollutants than passenger cars on a per person basis.

7.5 Summary

Following the lead of Zion and Acadia NPs, propane transit technology is the recommended technology given the conditions of Joshua Tree National Park considering the possibility for reduced emissions and lower cost for the bus, fuel, and infrastructure requirements.

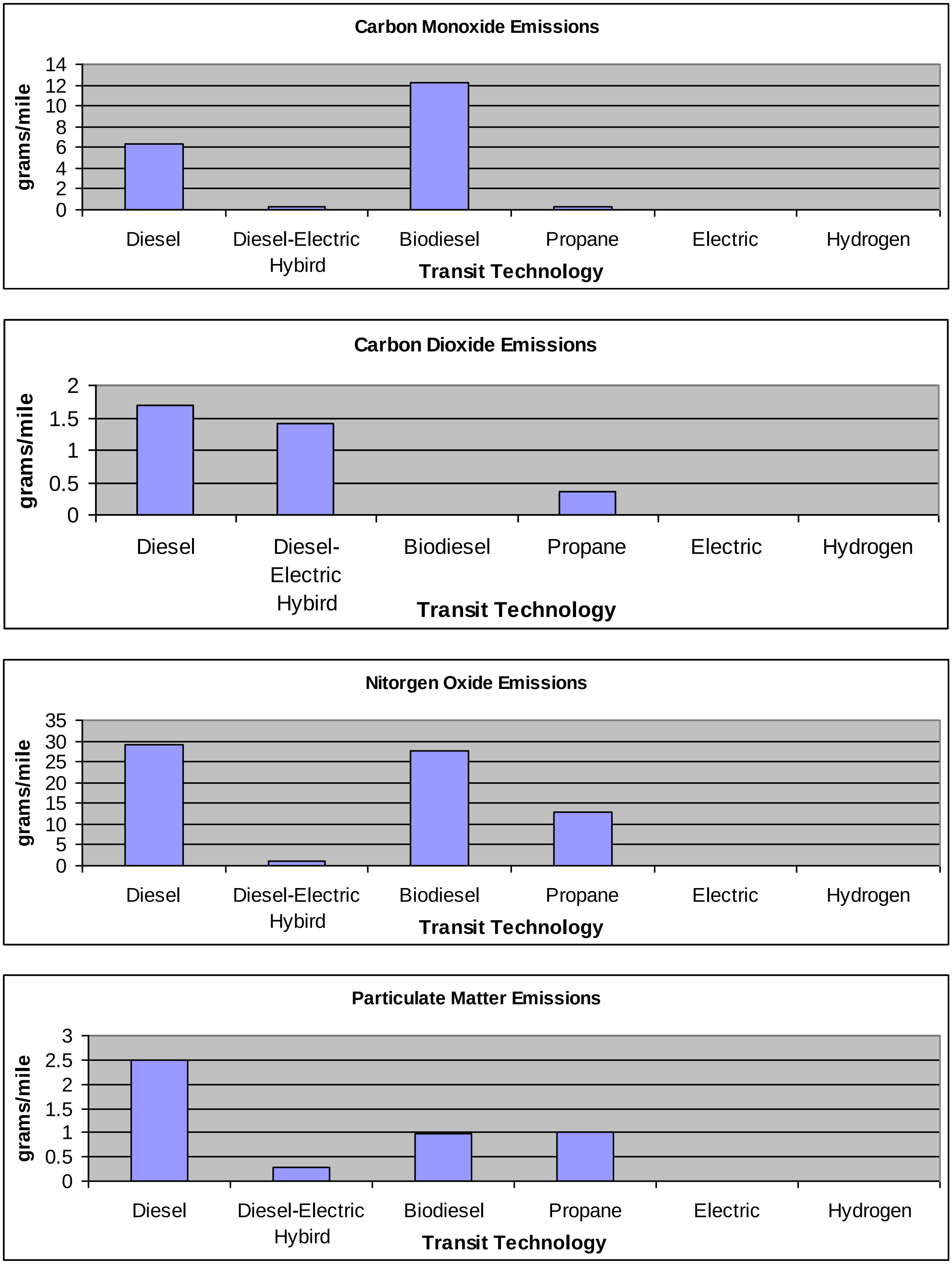


Figure 27: Emissions Rates by transit technology and pollutant

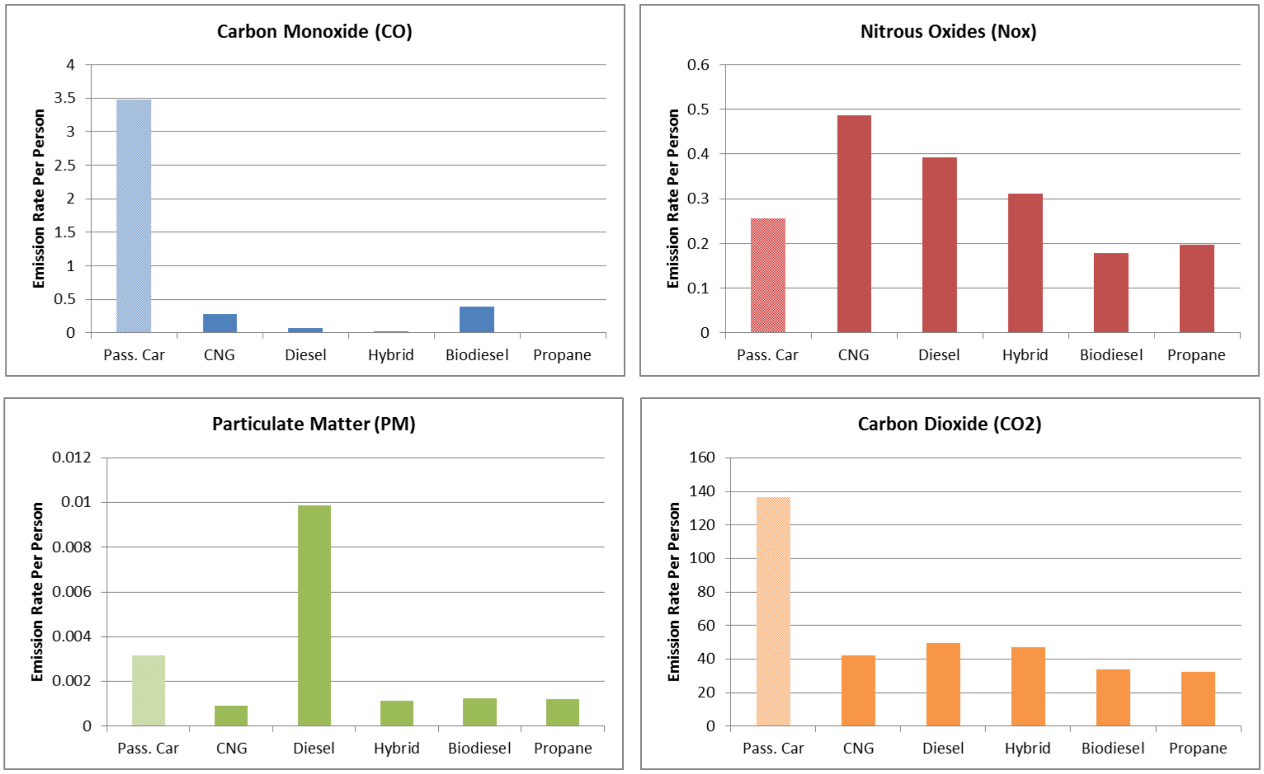


Figure 28: Per person emissions by transit technology and pollutant

Chapter 8: Funding & Finance

The purpose of this Chapter is to evaluate benefits associated with each routing alternative and present the most cost effective choice in conjunction with a sustainable shuttle bus technology. In addition to the financial perspective of this transit feasibility study, different modes of funding to help offset the cost of this project are considered.

8.1 Cost Analysis

The three alternative bus routes were used to determine several details of projected costs. The route alternatives vary by total mileage, number of buses, and service frequency resulting in varying operating and capital costs. This was all taken into consideration when considering the different costs of each route alternative. The major things that were considered for each alternative were the total miles per route, the miles per gallon of fuel (if applicable), the number of buses needed, and infrastructure costs. In this section a summary of the costs for the leasing and purchasing options are provided. Details of all costs are provided in Appendix D for further review.

The park is limited financially so this makes cost of implementing any transit system a major consideration. The differing bus types all provide the park with several different benefits including costs savings and environmental benefits. Electric buses are an example of this. The electric buses were the only ones that provide the park with a zero local emissions transit option. However, when looking solely at cost, both the hydrogen and electric options suffer because of their higher costs compared to the cheapest option of bio-diesel bus. The reason that other technology alternatives other than the cheapest were considered is because the park service has a serious commitment to "conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.” The difficult choice to make is whether or not spending the additional funds on a more sustainable method of transit is something the park service can afford and is willing to consider. Overall, the costs are all fairly similar and allow for some justification of the use of a more costly alternative if the price increase is not incredibly high and the park benefits are noticeable.

Capital Costs Considerations

Joshua Tree National Park has the choice to either lease or purchase the shuttle buses. These two different methods of paying for the buses were compared at a total cost over twelve years. The purchasing option requires a large initial investment from the park, while the leasing option allows for a smaller initial investment although it results in a general increase in cost for all bus types. The lease term was considered to last for six years and resulted in a six year study where maintenance and operational costs were the only costs accounted for during that period. A six year leasing period was chosen because researched lease terms for similar facilities and plans lasted for up to six years. The present value calculations were calculated by taking all of the costs of the buses for the twelve years by year and adding them up with the use of a discount rate that adjusts for future inflation. The three route alternatives were considered with this present value calculation and each route was considered individually with differing bus technologies in order to compare the results and determine which bus technology is best for the park and which route choice is best simultaneously. For both the purchasing option and the leasing option, the cost of building the infrastructure needed for the different bus types was the same so that variable would not skew the results in favor of one option or another.

Purchasing Option

The purchasing option entails buying the buses required for the differing routes up front and paying only maintenance and operation costs every year. Figure 29 shows the initial purchase prices of the buses for each technology. The purchasing option, as expected, required that the park put forth a larger sum of money to acquire the buses as an initial investment in the project. This would mean that the park would be the sole owner of these buses and would be responsible for all operations, maintenance, and other costs associated with running the proposed services. This alternative, while seeming to be most off putting initially, ended up providing the most beneficial results over a twelve-year period. The purchasing total costs are lower for all bus types than those of the leasing options. The major drawback of the purchasing option is the initial investment that the park would be required to make in order to finance the purchasing of the buses needed for the route selected. The park is lacking in funds currently and funds that would come in for this project would not be solely used for the purchasing of buses. The purchasing costs of each bus for each routing and infrastructure alternative is shown in Figure 29.

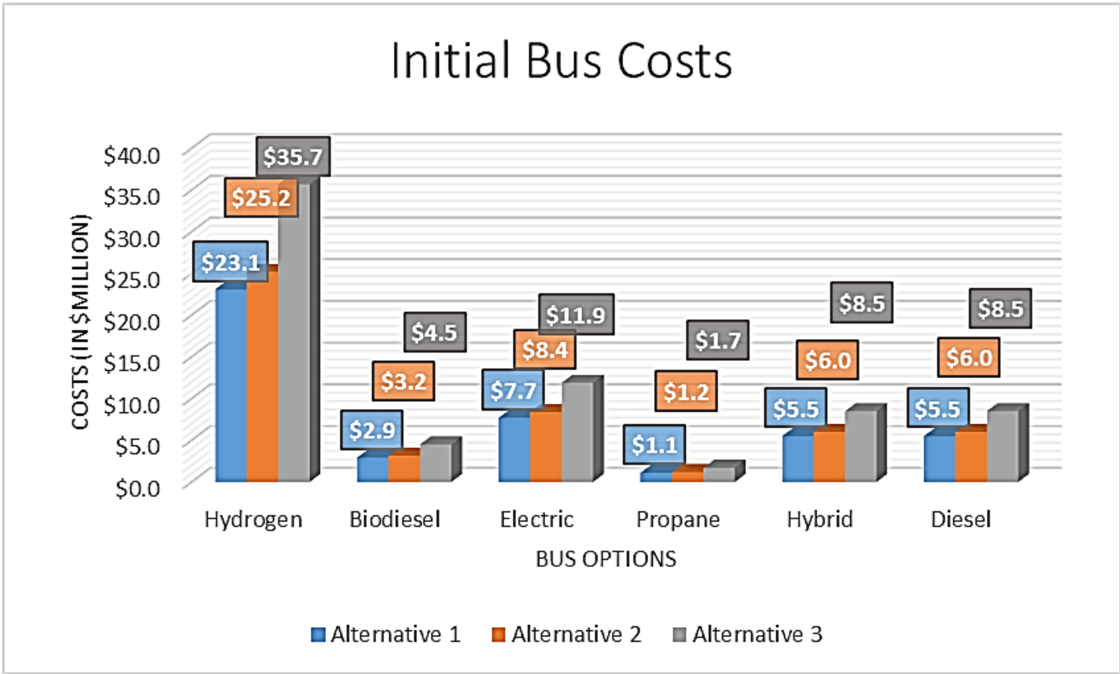


Figure 29: Initial Bus Costs for Purchase Option

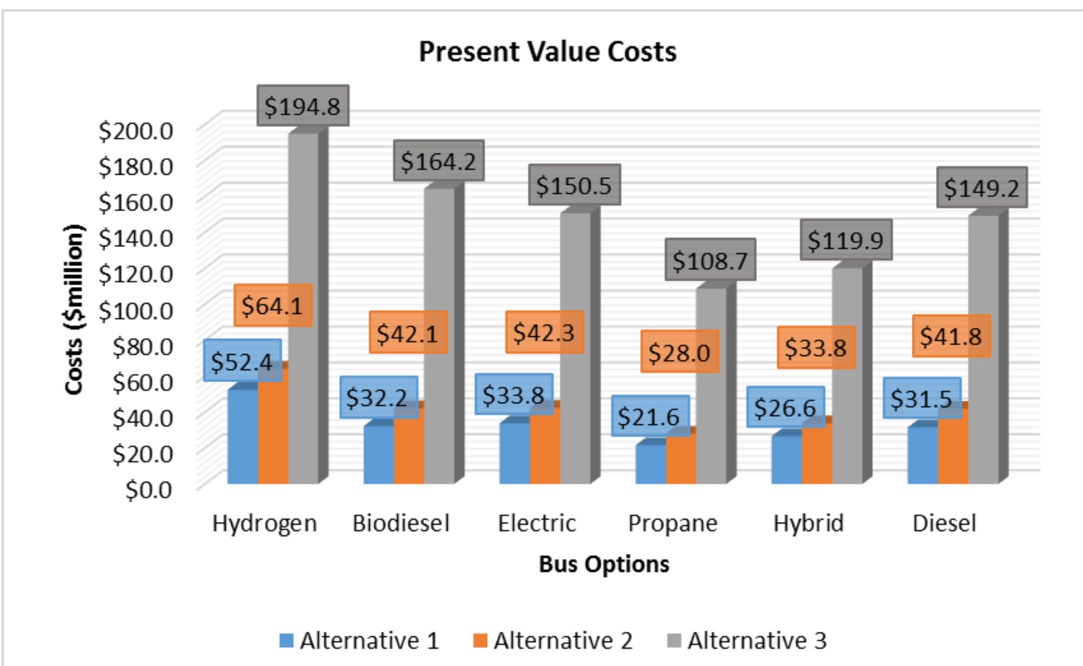


Figure 30: Present Value Costs of the Purchasing Option (in million dollars)

Leasing Option

The leasing option gives one major benefit over the purchasing option because it allows the park to invest less money at the beginning of the considered twelve year time frame. The major drawback to leasing the buses, no matter what technology was used for the buses, is that the overall cost is higher than purchasing the buses. The three routes all have higher total present worth values when leasing the buses for all bus technologies than their purchasing counterparts. The leasing present value takes into consideration the six year lease period as well as all infrastructure costs, maintenance costs and the buyout price of the buses at the six year mark. The buyout price is the price of purchasing the buses after paying the lease for six years. The buyout price is extremely low compared to the original price of the buses for all technologies due to depreciation. The depreciation rate used was 12 percent for all buses in all route choices. This was the standard found through research and makes the buses 72 percent cheaper to purchase after leasing them for six years. The same buses would then remain in service at the park for the following six years of the study. The buyout happens at year six but does not affect the costs after that. The cost of leasing the buses after year six is therefore zero. This indicates that the leasing option is, in fact, the more costly of the two funding alternatives and that the majority of its costs are within the first six years. The leasing costs of each bus for each routing and infrastructure alternative is shown in Figure 30.

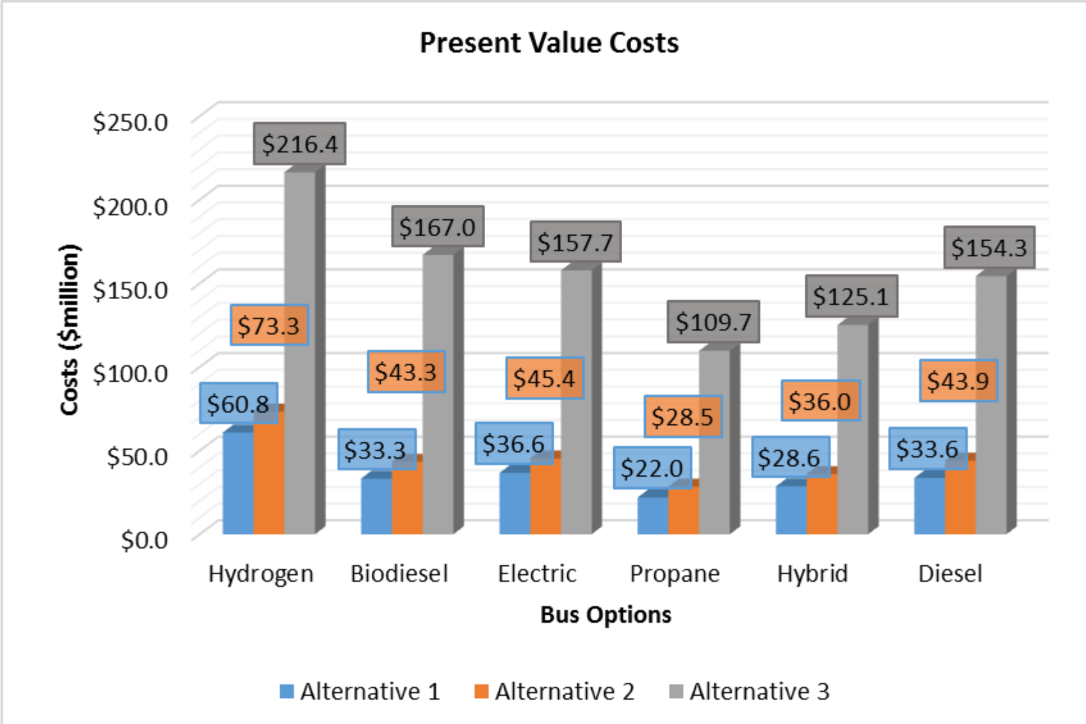


Figure 31: Present Value Costs of the Leasing Option (in million dollars)

Recommendations

Ultimately, the choice to initially purchase or lease the shuttle buses will be made by the park based off of several factors including costs. The cost of the different bus technologies will play a major role in the ultimate decision though. This means that the cheapest alternative will be looked at to ensure that it also meets other park goals. Joshua Tree, being a national park, is dedicated to environmental preservation. The bus technology chosen should provide the park with an affordable choice while also reducing the carbon footprint of the route system selected. The park will have to determine how much more spending can be justified for the purpose of meeting other goals other than reducing costs. The propane bus technology was the lowest in cost for both the purchasing option and the leasing option. The purchasing option total was just over $16 million for alternative one while the leasing option was just over $17 million for the same alternative route system. This is the cheapest route and bus technology combination of all. The route choice and bus technology might not completely meet all of the park's stated goals and objectives for this project however, and that is why several alternatives were considered. The three cheapest bus technologies for the route alternatives were propane, hybrid, and electric buses. This is true for both the purchasing and leasing options. The propane is significantly lower in price than the hybrid and electric bus options but the environmental effects are much less pronounced.

If cost is the only factor considered, it is recommended to choose route alternative one with the use of purchased propane buses. The park may choose to invest a higher amount of money and lease the buses over a six year period then buy them out and continue to use them. This would result in a higher total expenditure by about $1 million, but would reduce the initial investment required significantly. Two other technology alternatives are recommended if the park is willing to spend more money for cleaner technology. The hybrid and electric bus technologies offer better environmental benefits than propane but cost at least $5 million more over the course of twelve years. The data presented in the tables provided in Appendix D will act as a guide for the park when choosing the bus alternative that best suits Joshua Tree National Park.

8.2 Funding Analysis

The proposed transit system must be properly funded in order to be successful. To find the most feasible sources of possible funding, research was conducted on several national parks with existing transportation programs. Most of these options involve the creation of innovative partnerships among federal land management agencies, gateway communities, state departments of transportation, federal transportation agencies, foundations, businesses, regional organizations, and other groups. Some national parks with transit systems already in place include Zion National Park in Springdale, Utah, Acadia National Park in Bar Harbor, Maine, Glacier National Park in West Glacier, Montana, and Lewis and Clark National Historical Park in Astoria, Oregon. These and other parks were studied for their funding tactics and techniques. After comparing what each park has previously used, it was determined that there are four possible funding sources:

1) Federal Grants

2) Park-Sustained Income (ex. entrance fees)

3) Local Opportunities & Donation Funds

4) Sponsorships

Park Comparisons

A summary of funding strategies was gathered from several National Parks that currently have transit systems. These parks include Acadia NP, Zion NP, Lewis and Clark NP, and Glacier NP. While this is certainly not a comprehensive review of all park funding programs, this selection of parks provides a good summary of funding strategies.

Acadia National Park

A variety of federal, state, park, local, and private funding has been used to support national park transportation systems. In regards to Acadia National Park, Maine's Department of Transportation purchased the propane-powered shuttle buses. The national park, Friends of Acadia, and local towns provided the Congestion Mitigation and Air Quality (CMAQ) funds. The funding for the Intelligent Transportation Systems Field Operational Test (FOT) came from the U.S. Department of Transportation ITS Joint Program Office. Acadia National Park purchased additional buses with funding from the National Park Service Alternative Transportation Program (ATP). The park uses fee demonstration funds to help support development and operation of its buses. The park added the transit fee to the daily, weekly, and annual park passes in 2004. This is the main source of operation funding for the transit system in Acadia National Park.

In 2013, Acadia welcomed double the amount of Joshua Tree's visitors while being smaller than Joshua Tree by a large margin (Acadia being 47,452 acres large and Joshua Tree being 790,630 acres large). Acadia National Park had 2,254,992 visitors in 2013, which is noticeably larger than the 1,383,340 visitors that Joshua Tree National Park welcomed in 2013. Acadia National Park successfully manages the high visitation rates through its public transit system. Acadia National Park manages to serve the large amount of visitors despite the fact that it is smaller than Joshua Tree National Park. By looking at this, it is evident that a transit system will also benefit Joshua Tree as well.

Zion National Park

The funding methodology for Zion National Park's transit system is similar to Acadia's. Funding came from a mix of federal, state, local, private, non-profit, and private funding. Zion National Park purchased the 30 propane-powered buses and the 21 trailers. The park was also responsible for funding the transit stops, the parking areas, and the transfer points. The park uses a portion of the entrance fees to support the ongoing operation of the system. The Town of Springdale helped fund the bus shuttle stops and related streetscape improvements with the help of Utah's Department of Transportation. The town provides ongoing funds for the maintenance of the transit system. Additional funding comes from hotel/motel taxes, resort taxes, and sales taxes.

Just like Acadia National Park, Zion greets over 2 million visitors annually. In 2013, Zion National Park had 2,807,387 visitors. This is well over double the amount that Joshua Tree had in 2013. In addition, Joshua Tree is over five times the size of Zion (with Joshua Tree being 790,636 acres and Zion being 146,597 acres).

Lewis and Clark National History Park

At the Lewis and Clark National Historical Park, a variety of sources were used to fund the various projects and program elements. A $2.5 million Federal Transit Adminstration grant was used to fund the purchase of additional buses and the construction of a transit center and additional shuttle parking in Astoria. Planning, designing, and constructing the park-and-ride and education center at Netul Landing was funded through a $2 million grant from the National Park Service ATP fund. The Oregon Department of Transportation provided $500,000 in funding for new signing and traveler information. In addition, the National Park Service and the Western Federal Lands Highway Division have funded the ongoing seasonal shuttle service. Since the national park is only 3,300 acres and has an annual visitation of 191,860, it can be used to study the proposed funding of the Joshua Tree transit system on a smaller scale.

Glacier National Park

A mix of funding sources was used to purchase the Glacier shuttle buses at Glacier National Park in West Glacier, Montana. These sources helped construct the transit centers and service operations. A combination of state-run mitigation funds, such as the Sun Road fund, the Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users fund, the Transit in the Parks program, and Flathead County funds were used to purchase the buses.

Additional funding from Federal Lands Highway Program, Glacier National Park and the National Park Service supported the transit centers, stops, information signs, and supports ongoing operations and marketing. In addition, Glacier National Park implemented a transportation fee as part of the park entrance fee in 2007 to help fund the shuttle service. This fee was $5.00 initially and was increased to $7.00 in 2009. This transportation fee is a viable option that can be implemented into the Joshua Tree National Park transit system.

Federal Grants

The first possible source of funding is a federal grant from one or both primary transportation agencies, the Federal Transit Administration and the Federal Highway Administration. Other national parks in California have received federal aid for similar projects. Yosemite National Park received $1.3 million from the Federal Transit Administration in 2010 to improve the transportation system within the park. Under the Federal Transit Administration, a program called the Paul S. Sarbanes Transit in Parks was established to address the pollution and congestion created by increased personal vehicle use. The program provides funding for alternative transportation methods within and around national parks, forests, and wildlife refuges; supported transportation methods include shuttle services and railways. Unfortunately, this program was repealed by Congress recently and the last award winners were announced in February of 2014, so Joshua Tree National Park would not be eligible to apply for this grant. However, the Federal Transit Administration is directing all remaining eligible alternative transportation projects to apply for the Federal Highway Administration's Federal Lands Transportation Program and Federal Lands Access Program.

The Federal Lands Access Program (FLAP) provides funds for operational and maintenance costs of transportation facilities and all components of a transit system, including vehicles. The Federal Lands Transportation Program (FLTP) complements the FLAP in that it focuses on the transportation infrastructure owned and maintained by Federal lands management agencies, whereas the FLAP provides funds for State and local roads that access the Federal estate.

Both of these programs are part of the Federal Highway Administration. Although the overseeing governmental agency changes from that which supported Yosemite National Park, these grants would be a viable funding alternative. If accepted, one of these grants could help fund much of the costs associated with the proposed shuttle service.

Park-Sustained Income

A large portion of national parks with transit systems fund their shuttle systems by setting money aside from the entrance fee. This can be seen in two cohesive charts included in the Grand Teton National Park Business Plan created by Montana State University. The first compares different national parks and their transit systems, and the other compares their respective entrance fees and how much is put aside for the transit system. The purpose of charging an embedded transit fee is to help cover operating and maintenance costs, and sometimes even capital costs as well. Zion National Park, for example, implements a mandatory shuttle system that requires shuttle use to see their most popular attraction. This is effective in increasing revenue from the entrance fees. Zion charges an entrance fee of $25/vehicle; however, parking lots are almost always full by 10 am and all overflow vehicles are directed to the neighboring town to park there and take the shuttle into the park. When arriving without a vehicle, such as on the shuttle service, each person is charged $12. For a typical family of 4 this charge quickly adds up. Whereas the typical park entrance fee would have covered the entire family for $25, using the shuttle system would charge them a total of $48 – practically a 100% increase. While an increased entrance fee could be implemented to partially pay for a transit system in the park, officials should also be wary to increase them so high as to deter visitors. In the feasibility survey collected for this study, it was found that the amount most people were willing to pay for the use of a transit system was around $5-$6. Multiplied by an approximate annual traffic count of 366,000 (using 2013 data from the National Park Service), increasing the Joshua Tree National Park entrance fee from $15 to $20 to include the transit fee could yield $1,830,000 in one year. Increasing the fee to $25 is also an option that could yield $3,660,000 in one year, but considering that an overwhelming amount of survey respondents replied that they would only consider paying if the fee was at or under $5-$6, this could result in a major deterrent for visitors and a subsequent backlash.

Local Opportunities and Donations Funds

The third possible funding source is finding and utilizing local opportunities and creating private donation funds. There are many local opportunities that exist to a national park. One option that other national parks have found useful is to implement a sales-tax-based transit financing formula which primarily consists of targeted taxes on tourism-related expenditures. For example, Acadia National Park's surrounding local communities dedicate a portion of their sales tax revenue to the park's transit system. This was done because there is a strong relationship between the local businesses and a national park. The more accessible it is, the more visitors the park receives and the more visitors pass through the local communities to generate business and revenue. Furthermore, a donation fund can be created in order for the local communities to help out with private donations. Possible donors include individuals who support local businesses, the national park, transit programs. Donation funds can be useful for receiving monetary support for a transit system that makes Joshua Tree National Park a more enjoyable, accessible, and environmentally conscious park.

Sponsorships

The fourth possible funding source is to have companies sponsor the transit program. One alternative in this facet could be for corporate sponsors to donate the necessary shuttles in order to offset total costs. In return, the corporation may be able advertise via logos and slogans on the buses. This kind of idea is not new. Since the National Park Foundation is a non-profit organization, it has been reliant on a number of different partners. This partnership between sponsors dates back 40 years. A portion of the sponsorship money goes towards the support of America's national parks. This support can be a vital asset towards the possible funding of the shuttle system. Some corporate sponsors that have donated at least $1,000,000 towards the National Park Foundation include ARAMARK, The Coca-Cola Company, L.L. Bean, and Underwriters Laboratories (UL). In addition, Disney and AIR WICK have both donated at least $500,000 to fund the National Parks. Since these companies have a history of showing support towards America's national parks, they can also be contacted to fund the Joshua Tree National Park shuttle service.

In addition to household-name corporations, Joshua Tree National Park has also been supported by its local businesses and organizations. Some of the park's projects and attractions, such as its Art Show and Faire and the Joshua Tree Astronomy Arts Theatre, have been funded by sponsors such as the City of Twentynine Palms, 29 Palms Inn, Twentynine Palms Band of Mission Indians, The Community Foundation of Riverside & San Bernardino Counties, and Burrtec Waste & Recycling systems. Local sponsors such as these should also be contacted regarding the funding of the shuttle system. This will attract people to support both Joshua Tree National Park and the supporters who sponsor the shuttle service.

By targeting sponsors that have helped Joshua Tree in the past, our group will become more likely to receive sponsorship money that will go towards the shuttle system. The National Park Foundation sponsors have a record of supporting national park projects, and Joshua Tree local businesses and organizations will gain more tourist support by helping the funding of the project.

Funding Recommendations

By looking at previous transit programs conducted by other national parks, it was determined that there are four primary sources of funding available: federal grants, park-sustained income, local opportunities/donation funds, and sponsorships. An initial look at Joshua Tree National Park's transit system shows that utilizing a combination of funding techniques that are already in place in other national parks seems to be the most beneficial option. Just like Acadia National Park and Zion National Park, funding should be coming from a variety of federal, state, park, local, and private sources to obtain the maximum amount of funds available. Overall, a strong relationship between Joshua Tree National Park and other influential entities will help fund not only the transit program, but other programs in the future.

Chapter 9: Recommendation and Conclusion

While transit is not the only alternative which can mitigate parking and entrance station congestion, it is the solution alternative that can best address those concerns while also improving accessibility by providing an alternate mode of transportation and promote environmental sustainability. Several other National Parks have already employed transit systems to better handle increased visitation and preserve natural resources.

The findings of this report are drawn from visitor survey data, parking lot usage statistics, comparisons of costs and environmental benefits of transit technologies, ridership and transit system characteristics seen at other National Parks, and route alternative capital and infrastructure costs. The visitor survey conducted in April 2014 revealed high interest in a transit system. Visitors considered hourly service frequency, the ability to take gear needed for various activities on the bus, and ticket prices as some of the more important transit system characteristics. The majority of visitors interested in transit stated willingness to pay around $5 for the service which indicates the possibility that the transit system could function off its own revenue. The visitors that were not willing to take transit cited reasons such as disbelief that congestion conditions were not bad enough to warrant an investment in transit and aversion to having to transport gear on the shuttle. Joshua Tree NP is a premier rock climbing destination, for which large and heavy gear is required, thus this is a valid concern that will need to be addressed.

The parking study conducted in February 2014 on a busy holiday weekend validated the observed congestion effects reported by Park Staff. Several sites included in the study experienced parking overflow conditions for several hours during the study time period. Parking overflow leads to unsafe conditions for visitors and can cause damage to vegetation and curbing. A license plate survey revealed the origin-destination (OD) travel patterns of park visitors. OD travel patterns combined with the transit ridership prediction, which was based on Rocky Mountain NP annual transit ridership statistics, was used to determine the stop location, service frequency, and number of buses needed to service each route.

Based on all these considerations the final recommendation is for route Alternative 2, with propane buses acquired through a leasing option. Route Alternative 2 serves visitors at two different entrance locations while maintaining access to the most popular sites in the park. Dividing traffic between entrance locations can help alleviate traffic at the Joshua Tree Visitor Center (JTVC) and its surrounding intersections and reduce the need to expand parking lot capacity at the JTVC location. Propane buses possess the best tradeoff between reduced emissions and costs. The cost for Alternative 2 is approximately $28 million including leasing, operations, and infrastructure costs, making it one of the less expensive options for the Park.

To better support this decision, several additional extensions can be integrated to this study for future work. Among these extensions is a cost- benefit analysis that takes into account emissions reductions benefits. Second, a more in depth, quantitative, traffic impact analysis needs to be conducted to ensure that any possible congestion issues are addressed. Third, challenges from adding infrastructure within park grounds needs to be identified in order to avoid severe environmental damages. Lastly, the possibility of extending the transit route system to local businesses must be further researched as this option could possibly serve as a future shuttle funding opportunity.

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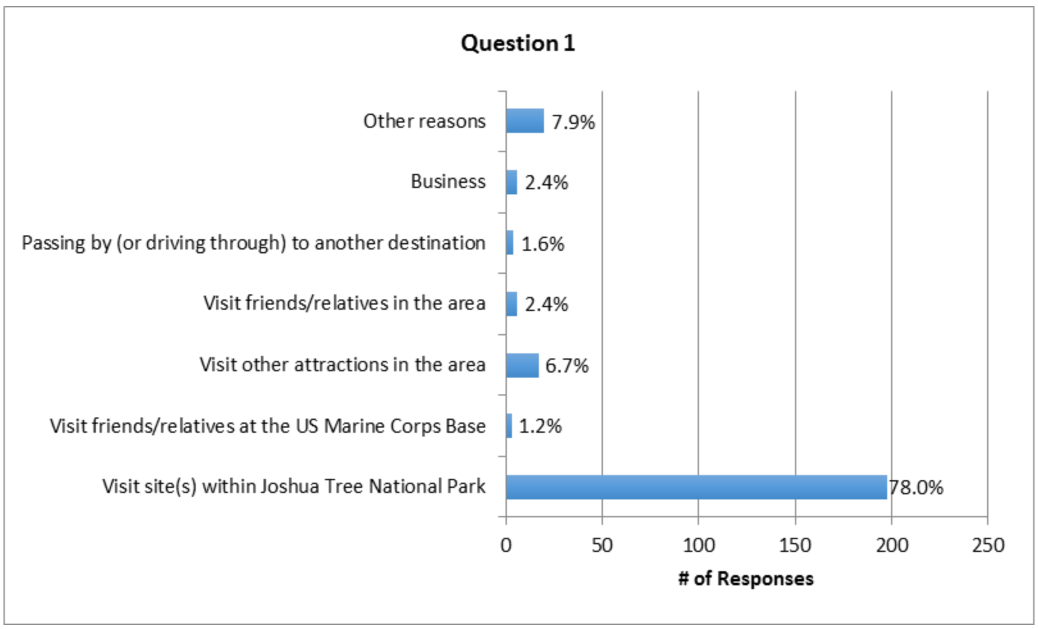
Appendix A

Section A.1: Survey Results

Question (1): On this visit to Southern California, what was the primary reason that you and your group visited the Joshua Tree National Park area (Yucca Valley, Joshua Tree, Twentynine Palms)? Please check only one.

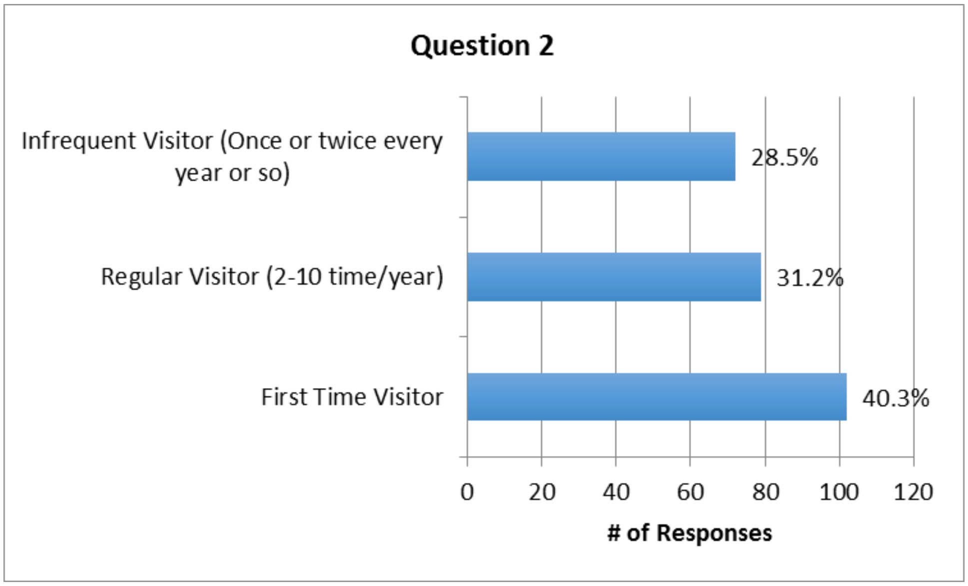
- □ Visit site(s) within Joshua Tree National Park
- □ Visit friends/relatives in the area
- □ Visit friends/relatives at the US Marine Corps Base
- □ Business
- □ Passing by (or driving through) to another destination
- □ Other reasons
- □ Visit other attractions in the area (Other attractions visited: ____________________)



Question (2): How often do you visit Joshua Tree National Park?

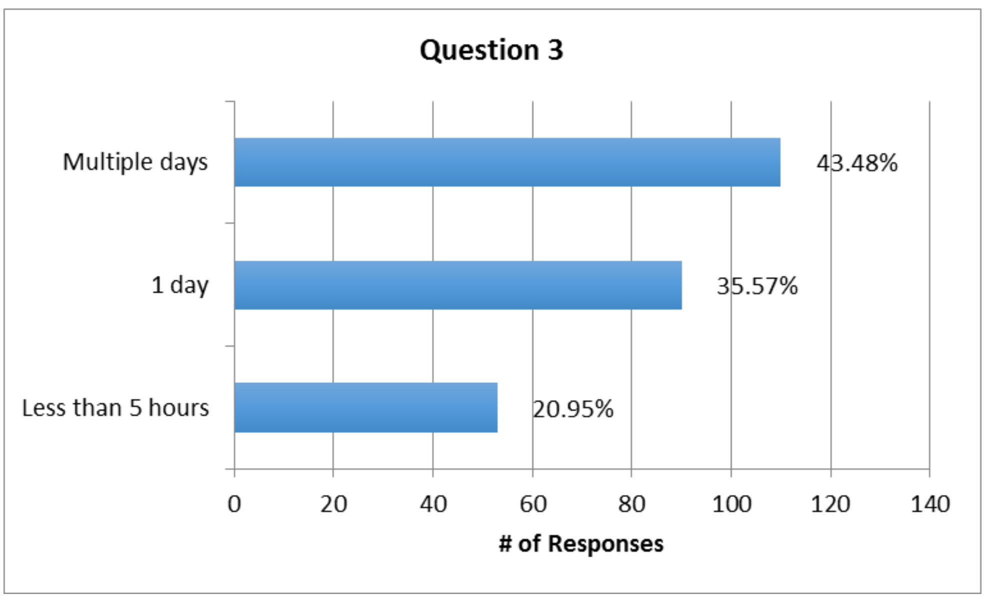
□ First time visitor □ Regular visitor (2-10 times/year)

□ Infrequent visitor (Once or twice every year or so)



Question (3): On this visit, how long do you and your group plan to visit the park? Please check only one.

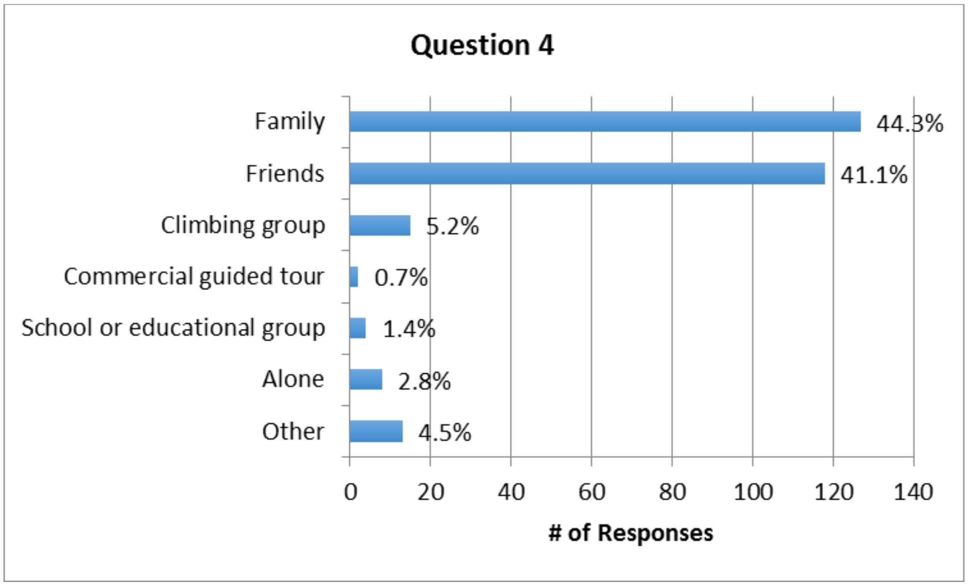
□ Less than 5 hours □ 1 day □ Multiple days



Question (4): On your visit to the park today, what type of group were you with? (Check all that apply)

□ Alone □ Family □ Friends □ Climbing group

□ Commercial guided tour □ School or educational group □ Other

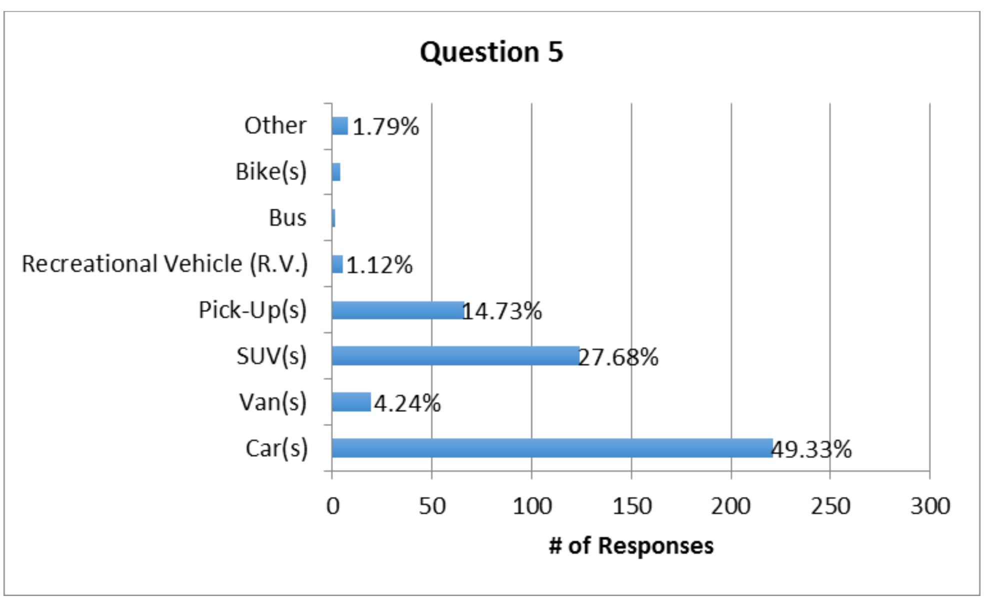


Question (5): On this visit to the park today, please list the number of each type of vehicle(s) in which you and your group <u>arrived</u>:

Passenger vehicles: ___cars(s) ___van(s) ___SUV(s) ___Pick-up(s)

Recreational Vehicle (R.V.): ___ Bus: ___ Bike(s): ___

Other (specify type of vehicle): ______________________

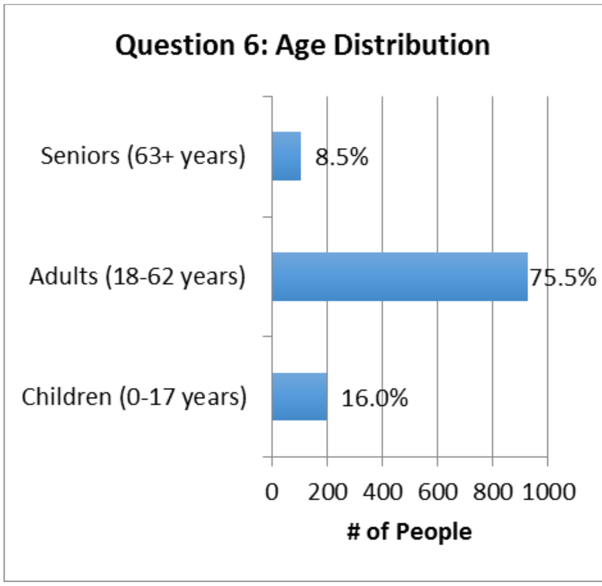


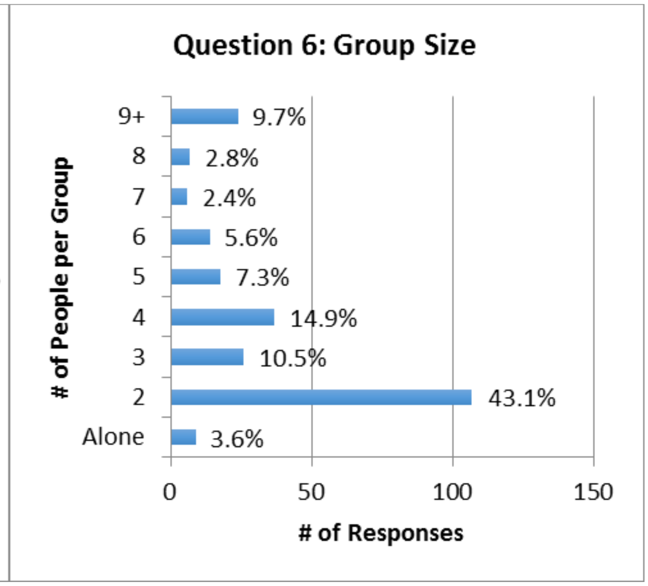
Question (6): How many people, including yourself, are in your personal group today? Please provide the number of people in each age group.

Children (0-17 years): __________

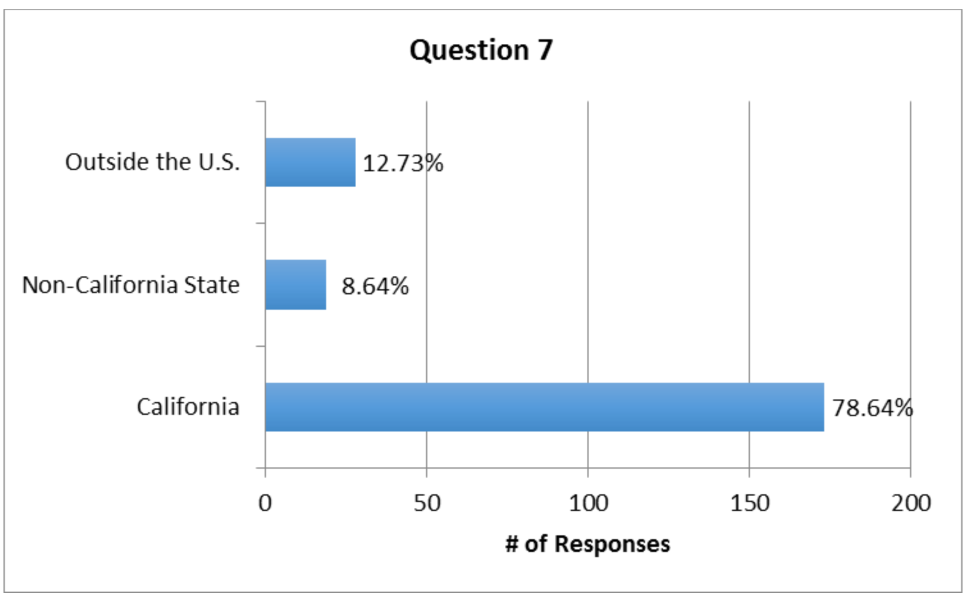
Adults (18-62 years): ___________

Seniors (63+ years): ___________





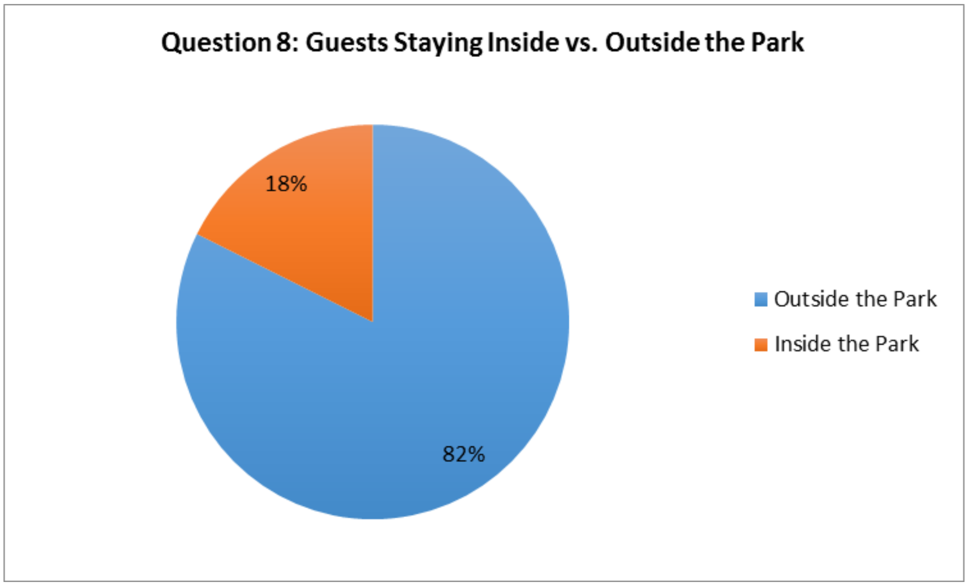
Question (7): What is the U.S. ZIP code (or name of country) of your group's primary residence?

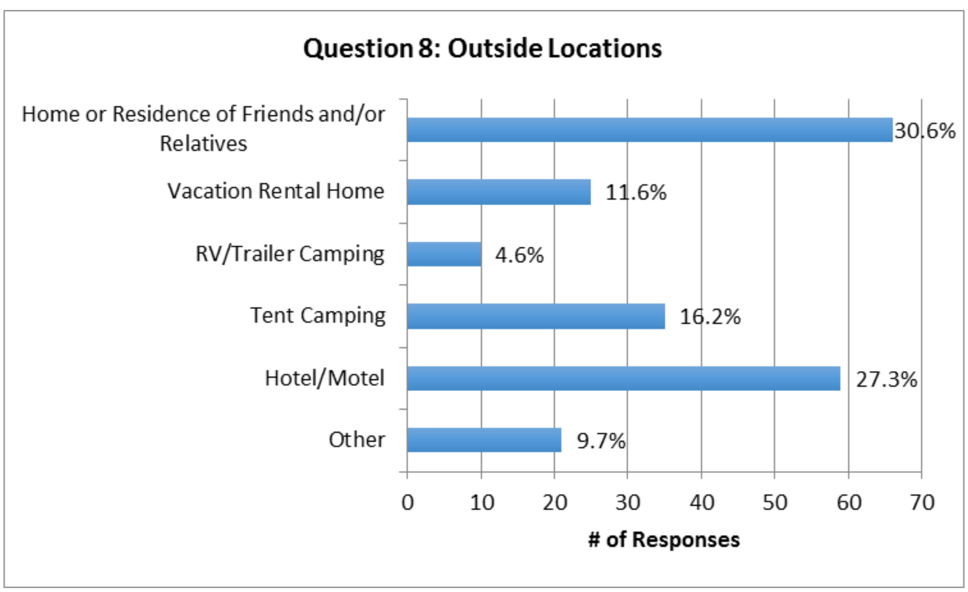


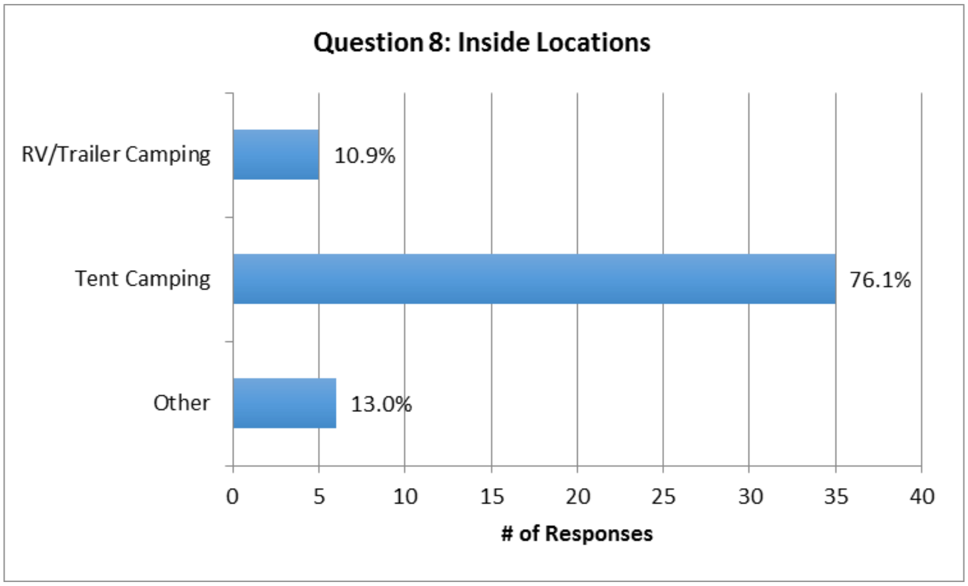
Question (8): Last night, where did you and your personal group stay? Please check only one.

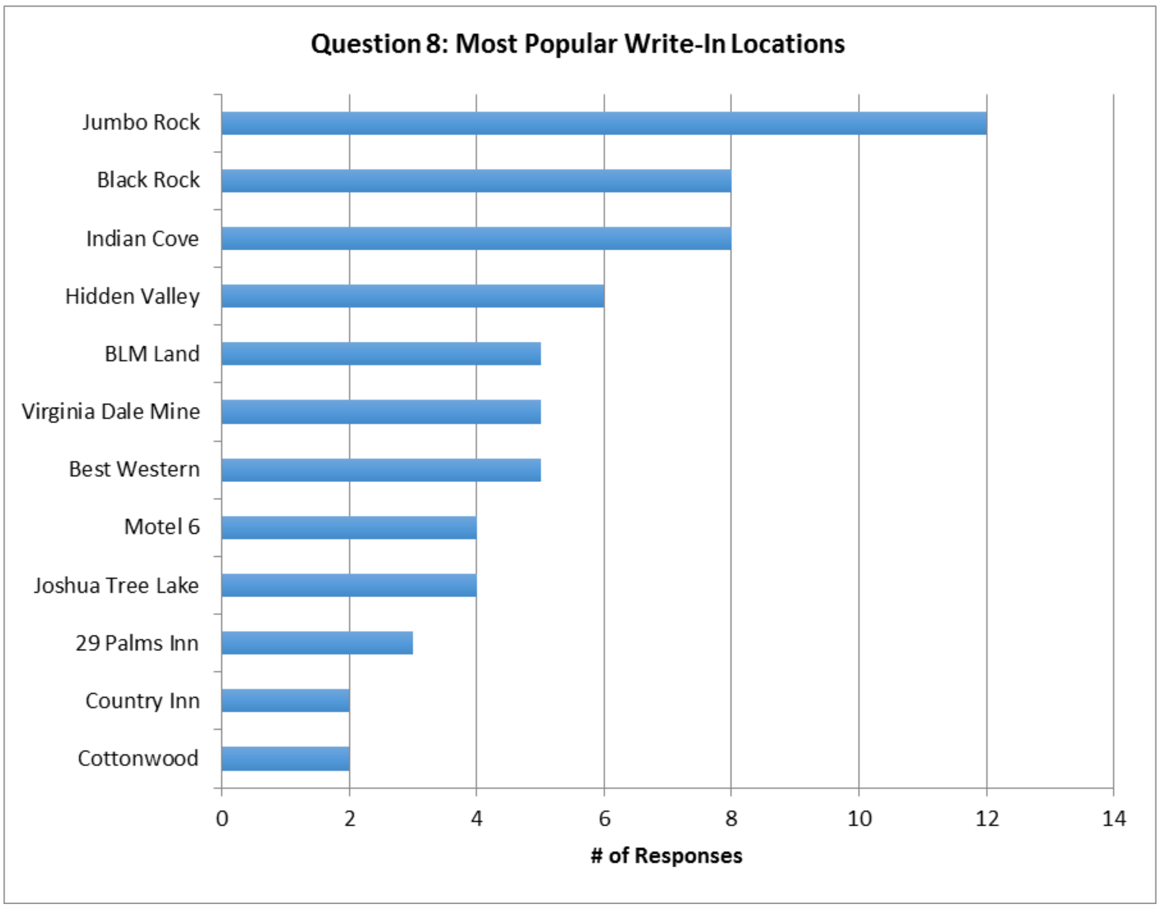
Outside the Park
□ Home or residence of friends and/or relatives
□ Vacation rental home
□ RV/trailer camping (campground: ____________________)
□ Tent camping (campground: ________________________)
□ Hotel/Motel (name of hotel: _______________________)
□ Other (please specify: ____________________________)

Inside the Park
□ RV/trailer camping (campground: ____________________)
□ Tent camping (campground: ________________________)
□ Other (please specify: ____________________________)






Question 8: Inside Locations
RV/Trailer Camping
10.9%
Tent Camping
76.1%
Other
13.0%
0
5
10
15
20
25
30
35
40
# of Responses


Question 8: Most Popular Write-In Locations
Jumbo Rock
Black Rock
Indian Cove
Hidden Valley
BLM Land
Virginia Dale Mine
Best Western
Motel 6
Joshua Tree Lake
29 Palms Inn
Country Inn
Cottonwood
0
2
4
6
8
10
12
14
# of Responses

Question (9): On this visit today, at which location did you first ENTER the park?

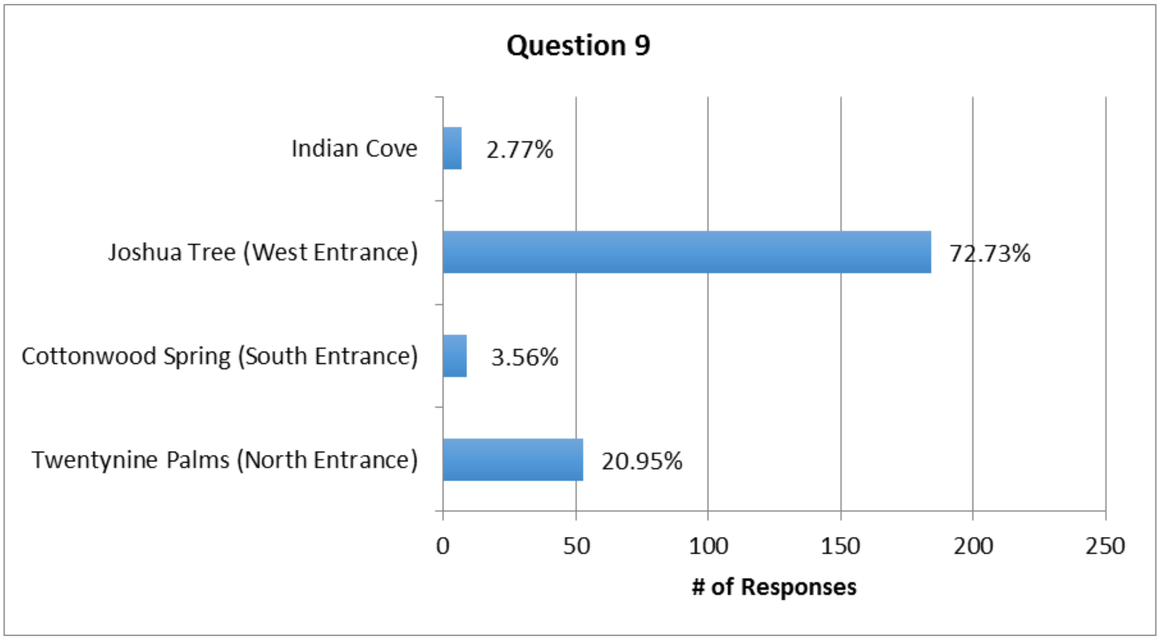
□ Twentynine Palms (North Entrance) □ Joshua Tree (West Entrance)

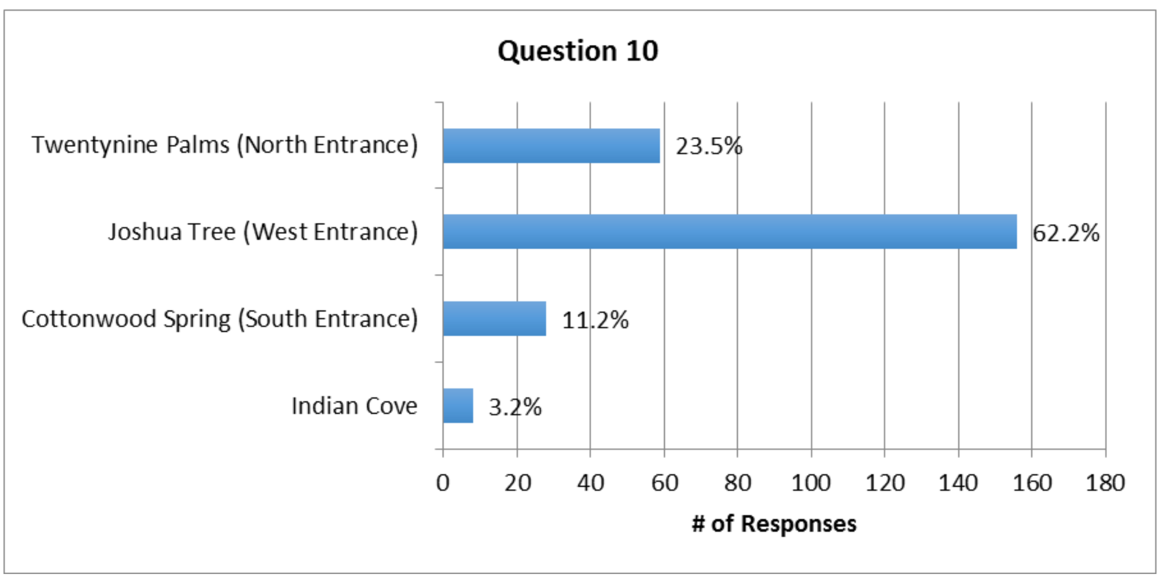
□ Cottonwood Spring (South Entrance) □ Indian Cove

Question (10): On this visit today, at which location do you plan to EXIT the park?

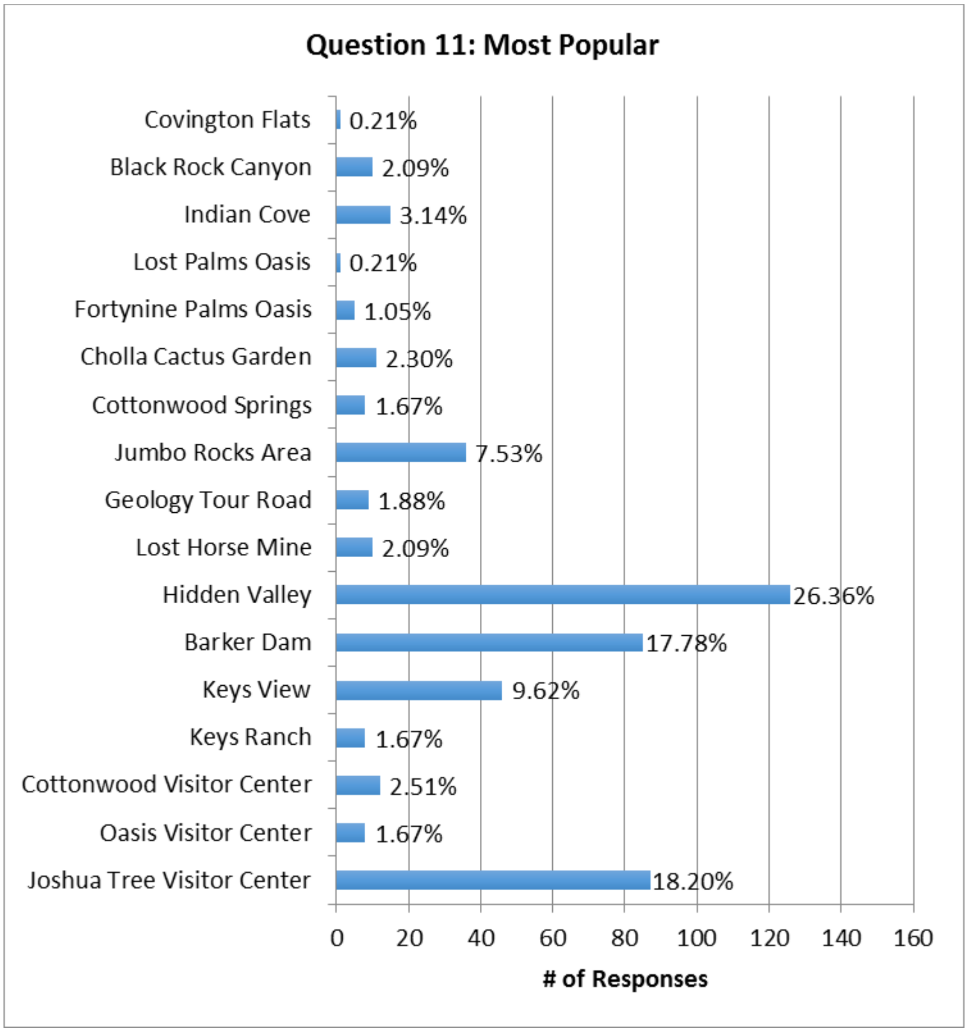
□ Twentynine Palms (North Entrance) □ Joshua Tree (West Entrance)

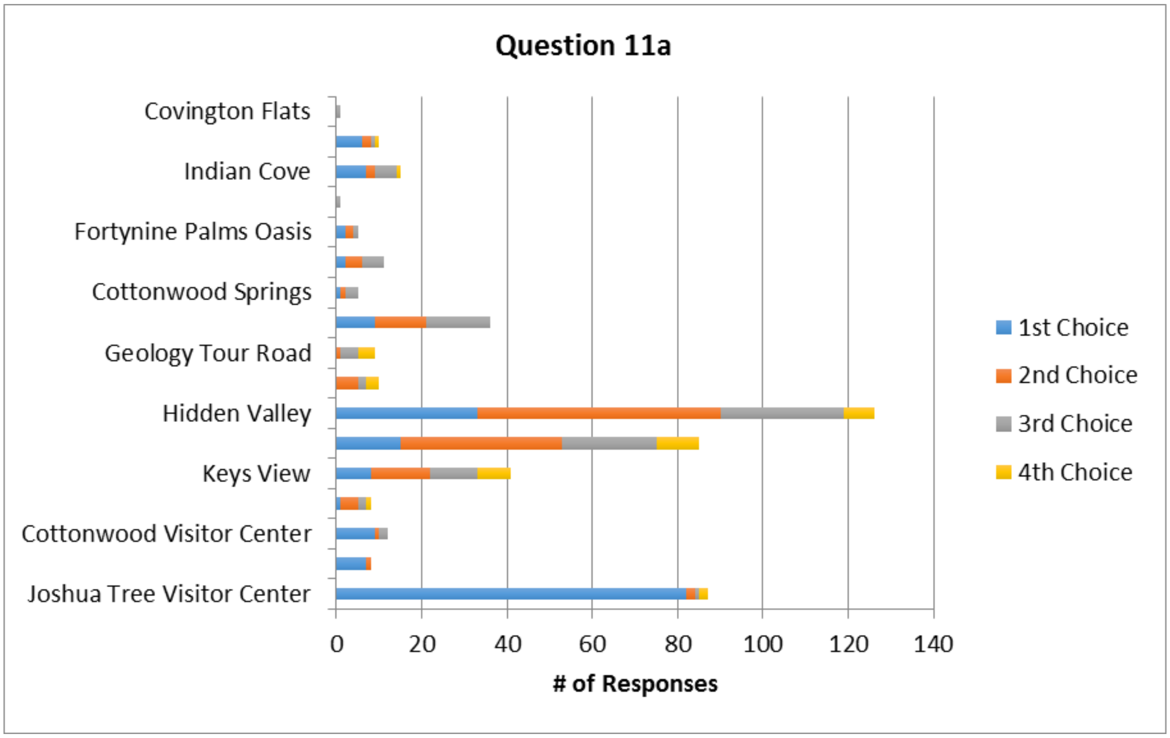
□ Cottonwood Spring (South Entrance) □ Indian Cove

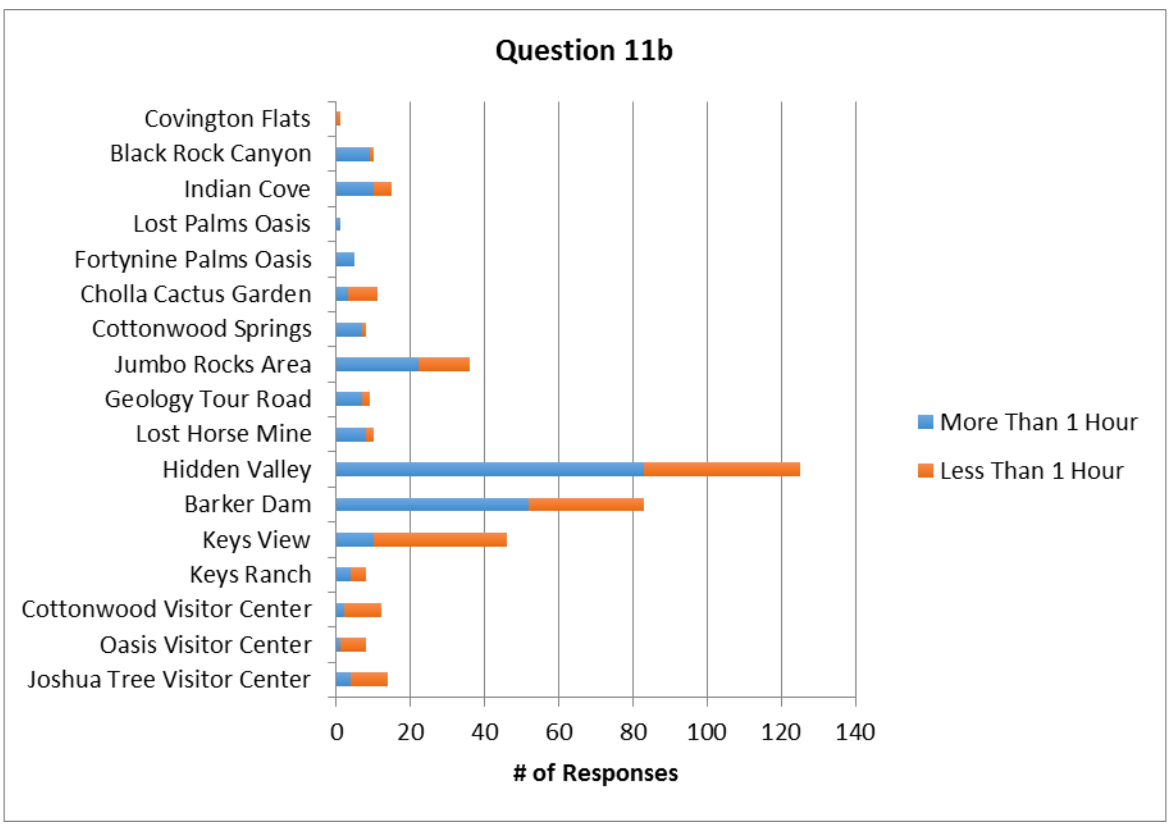




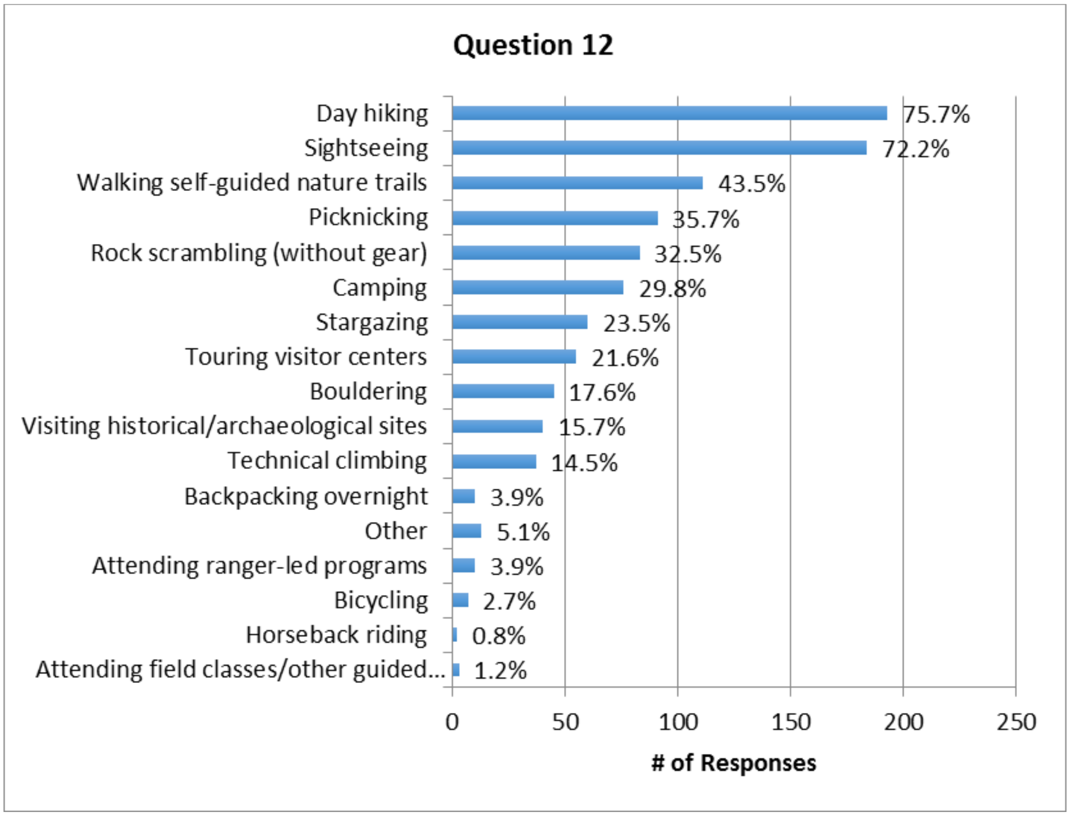
Question (11): On the list below, please indicate the order in which you and your group visited these sites at Joshua Tree National Park during this trip. Simply write 1, 2, 3, and so forth, on the line beside each place you visited. Do not mark any sites that you did not visit. In the last column, indicate the length of time you spent at the site. See map above for assistance locating sites within the park.



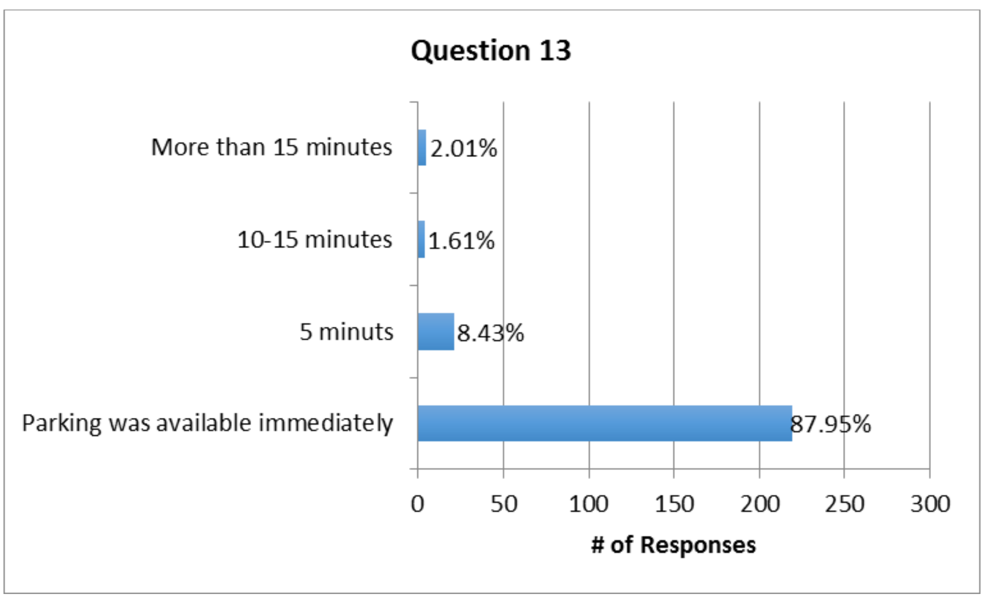

Question 11a
Covington Flats
Indian Cove
Fortynine Palms Oasis
Cottonwood Springs
Geology Tour Road
Hidden Valley
Keys View
Cottonwood Visitor Center
Joshua Tree Visitor Center
0
20
40
60
80
100
120
140
# of Responses
1st Choice
2nd Choice
3rd Choice
4th Choice


Question 11b
Covington Flats
Black Rock Canyon
Indian Cove
Lost Palms Oasis
Fortynine Palms Oasis
Cholla Cactus Garden
Cottonwood Springs
Jumbo Rocks Area
Geology Tour Road
Lost Horse Mine
Hidden Valley
Barker Dam
Keys View
Keys Ranch
Cottonwood Visitor Center
Oasis Visitor Center
Joshua Tree Visitor Center
0
20
40
60
80
100
120
140
# of Responses
More Than 1 Hour
Less Than 1 Hour

Question (12): On the list below, please check all activities that you and your group participated in at Joshua Tree National Park.



Question (13): If you arrived in a personal vehicle to the current site, how much time did it take for you to find a parking spot?

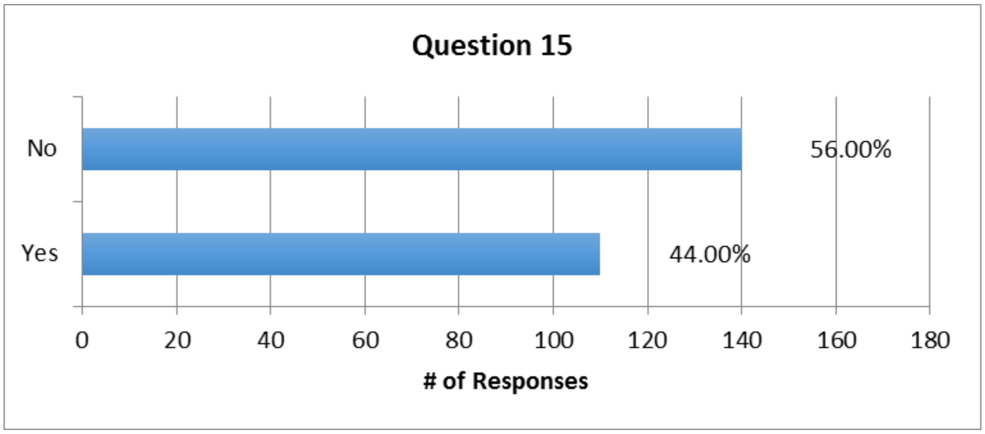


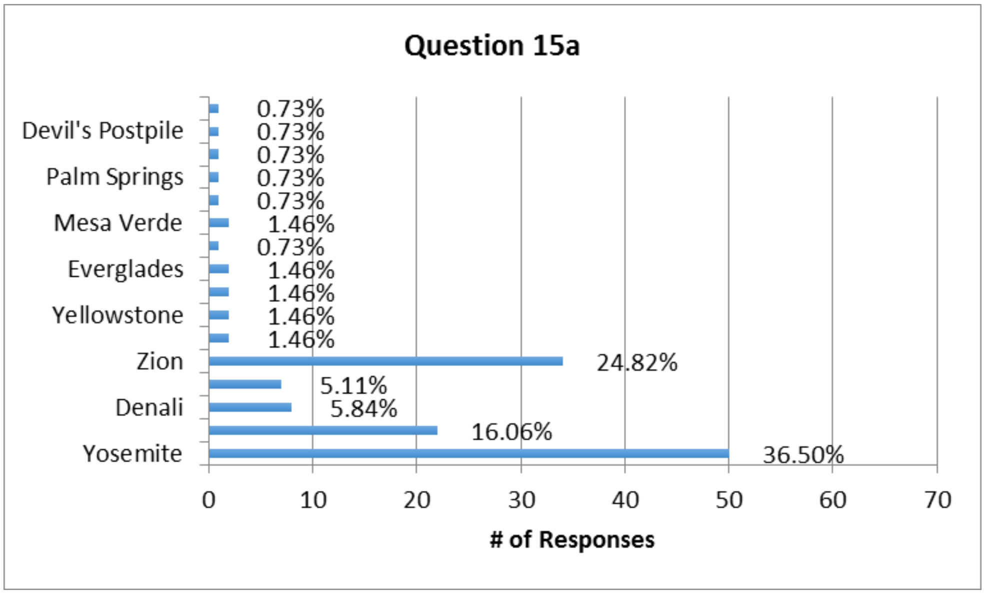
Question (14): Please comment below if you have had any negative parking experiences within the park on your current visit.

Results: There are several themes that free response answers fall into.

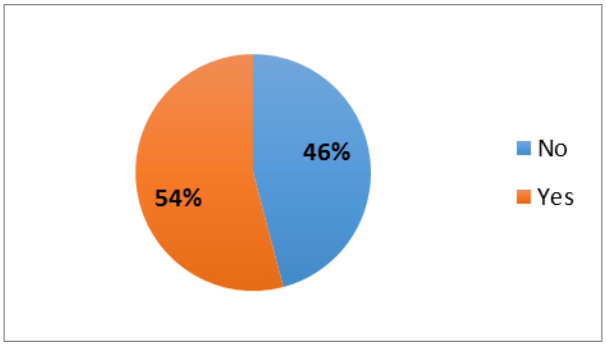
- Campsites: Visitors complained about lack of parking at their campsites. Some also had trouble finding how to get there.
- General parking: Some visitors commented on the limited parking options in the afternoon. Some were forced to park in RV stalls.

Question (15): Have you ever used public transit (such as a bus or shuttle) provided by a national park to access sites within that park?

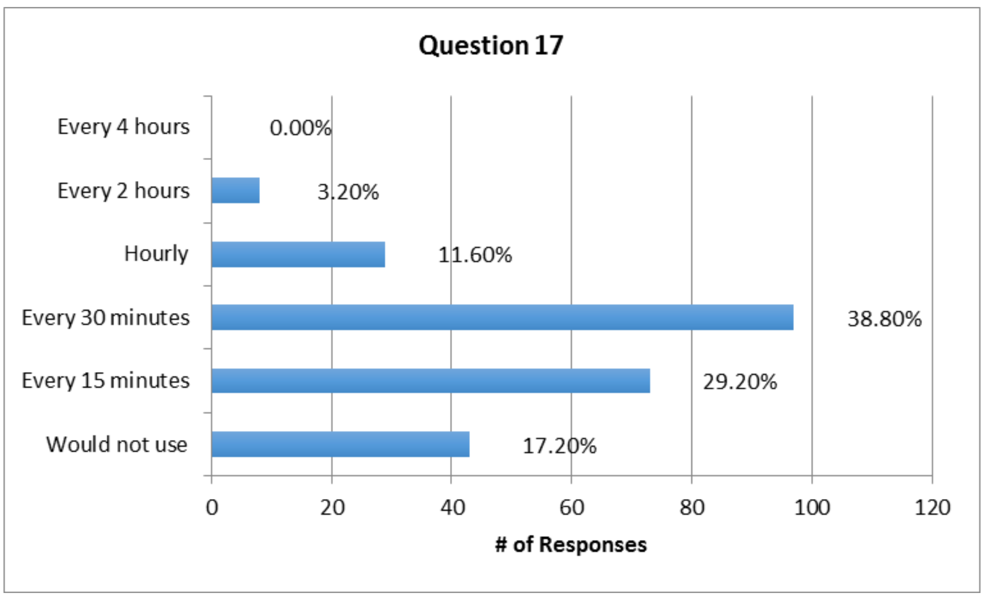




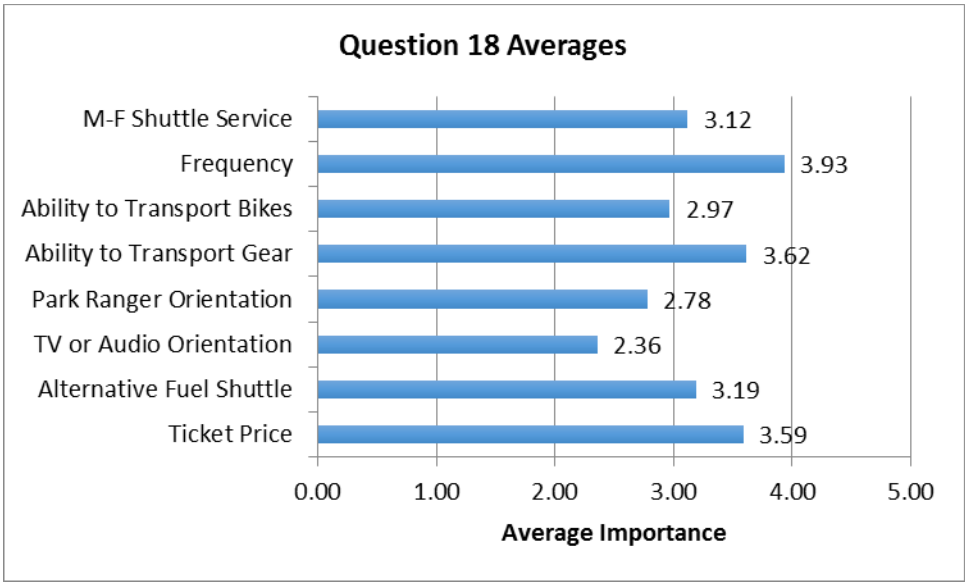
Question (16): The proposed Park Shuttle System for Joshua Tree National Park would allow visitors to park for free at the entrance stations and use the shuttle to visit the major sites within the Park. If such a Park Shuttle System existed within Joshua Tree National Park, would you have considered using the shuttle system for this visit today?



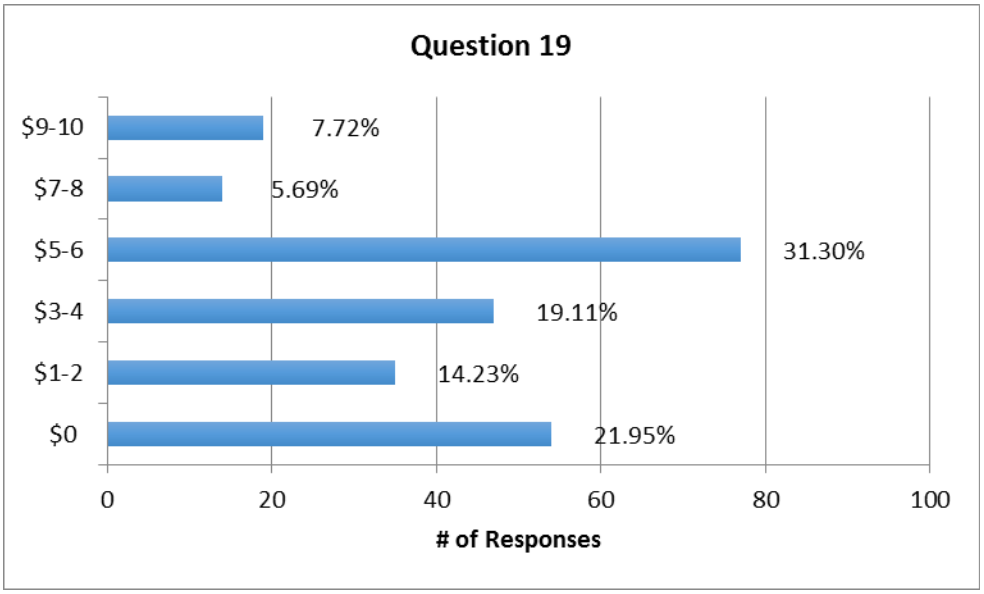
Question (17): How often would a shuttle need to pass by a stop (pick-up point) for you to consider using the service in Joshua Tree National Park?



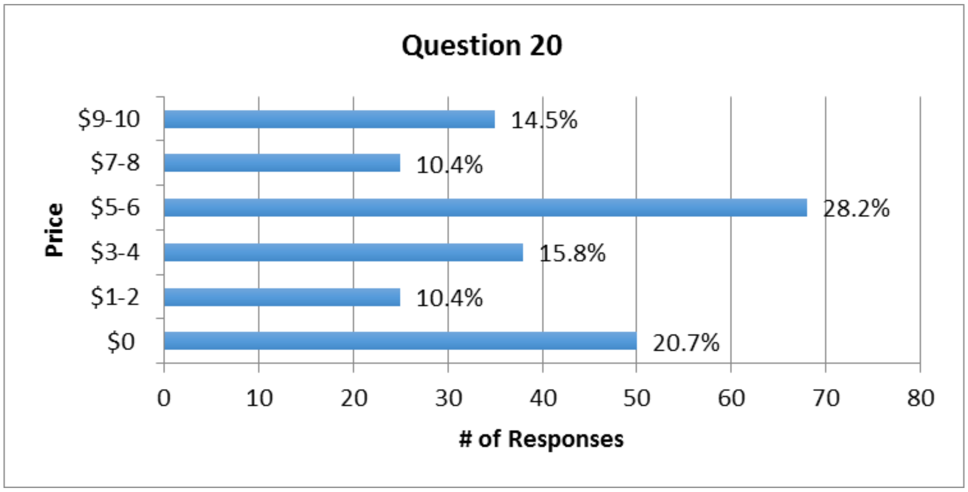
Question (18): On a future visit, how important would the following services and characteristics of a shuttle system be? Please indicate the importance of each characteristic with ‘1’ indicating ‘not important’ and ‘5’ indicating ‘very important’.



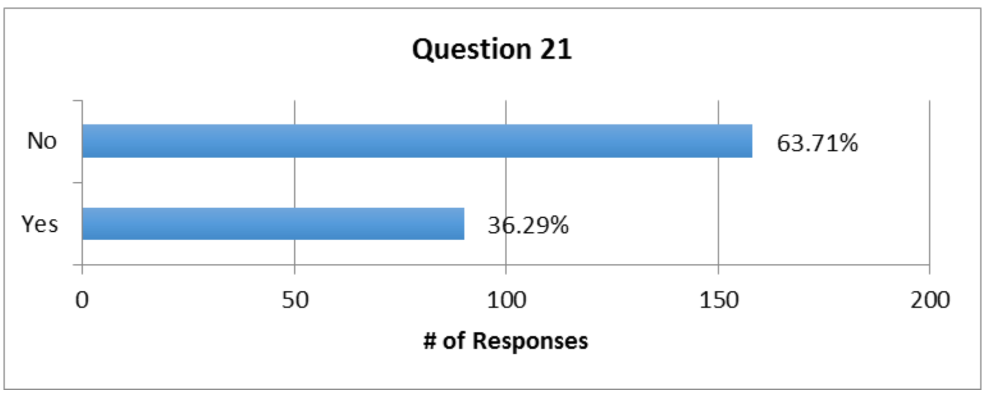
Question (19): Which of the amounts listed below best describes the most you would pay per person per day (unlimited rides) to use a Park Shuttle System that operated between sites within the Park (not including Indian Cove and Black Rock areas)? Assume that the Park entry fee still applies, parking is available for free at the entrance stations, and that the shuttle runs at least every hour.



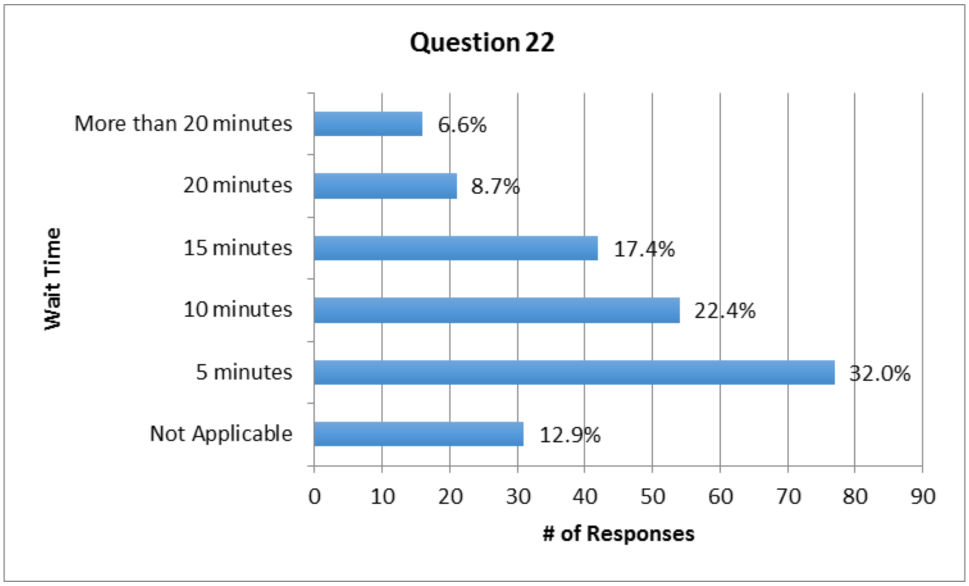
Question (20): In addition to the Park Shuttle System that operated between sites within the park, a transit service could operate between local hotels, campgrounds (including Indian Cove and Black Rock areas), and the Park entrances. Which of the amounts listed below best describes the most you would pay per person per day (unlimited rides) for use of a shuttle system that picked up at local sites and worked in coordination with the Park Shuttle System within the park? Assume that the Park entry fee still applies, parking is available for free at the entrance stations, and that the shuttle runs at least every hour.



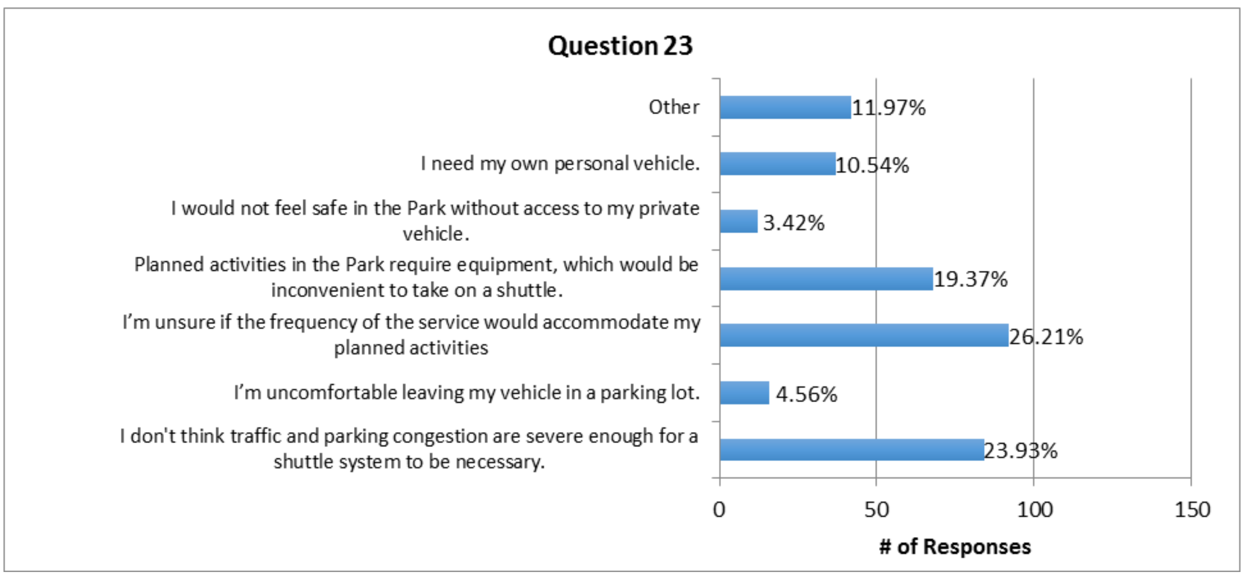
Question (21): Would you be interested in an additional transit service that connected to regional cities including Desert Hot Springs, Palm Springs, Palm Desert, and Indio?



Question (22): How much longer would you tolerate waiting on average for a parking spot at any site within the Park before you would consider using the Park Shuttle Service?



Question (23): Why would you not consider taking a Park Shuttle System within Joshua Tree National Park? Please check all that apply. Leave blank if you would consider using a shuttle service.



Question (24): Please provide any other comments you may have about a future Park Shuttle System or transportation issues in Joshua Tree National Park.

Results: There are several themes that free response answers fall into.

- Visitors would like shuttle connections with existing transit options outside the park.
- Visitors are unsure if a shuttle system is necessary.
- Shuttle stops should have good facilities with bathrooms and information boards.
- Visitors are concerned with taking gear on the bus.
- Visitors commented that the shuttle system is a good idea.

Section A.2: Survey Questionnaire

University of California, Irvine

Study Information Sheet

Transit Feasibility Study for Joshua Tree National Park

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Joshua Tree National Park has seen an increase in the number of vehicles that enter the park over the past years. Like several other National Parks including Yosemite National Park, Zion National Park, Rocky Mountain National Park, and Grand Canyon National Park, Joshua Tree National Park is proposing a shuttle system to transport park visitors to major points of interest throughout the park. The purpose of this survey is to gauge visitor interest in a voluntary Park Shuttle System. The data collected will be analyzed and used to design a Park Shuttle System, which meets the needs of Park visitors. The study is being conducted at the University of California, Irvine, as part of the Institute of Transportation Engineers Student Chapter Annual Project, under the supervision of the Department of Civil and Environmental Engineering.

- You are being asked to participate in a research study about visitor interest in public transit at Joshua Tree National Park.
- You are eligible to participate in this study if you are at least 18 years of age or older.
- The research procedures involve completion of a short survey. The survey should take only 10-15 minutes of your time.
- The research intends to cause no physical or psychological harm or offense and to abide by all commonly acknowledged ethical codes.
- There are no direct benefits from participation in the study. However, this study may explain Park visitor transit preferences needed to design a transit system.
- You will not be compensated for your participation in this research study.
- All research data collected will be stored securely and confidentially. You will not be asked for your name, address, phone number, or any other identifiable information.
- If you have any comments, concerns, or questions regarding the conduct of this research please contact the researchers listed at the top of this form.
- Please contact UCI's Office of Research by phone, (949) 824-6662, by e-mail at IRB@research.uci.edu or at 5171 California Avenue, Suite 150, Irvine, CA 92617 if you are unable to reach the researchers listed at the top of the form and have general questions; have concerns or complaints about the research; have questions about your rights as a research subject; or have general comments or suggestions.
- Participation in this study is voluntary. There is no cost to you for participating. You may choose to skip a question. You may refuse to participate or discontinue your involvement at any time without penalty. You are free to withdraw from this study at any time. If you decide to withdraw from this study you should notify the research team immediately.
- This research study currently holds UCI IRB approval.

Questions (1) - (14) relate to visitor demographics and park usage:

(1) On this visit to Southern California, what was the primary reason that you and your group visited the Joshua Tree National Park area (Yucca Valley, Joshua Tree, Twentynine Palms)? Please check only one.

☐ Visit site(s) within Joshua Tree National Park ☐ Visit friends/relatives in the area

☐ Visit friends/relatives at the US Marine Corps Base ☐ Passing by (or driving through) to another destination

☐ Business ☐ Other reasons

☐ Visit other attractions in the area (Other attractions visited: ________________________________)

(2) How often do you visit Joshua Tree National Park?

☐ First time visitor ☐ Regular visitor (2-10 times/year) ☐ Infrequent visitor (Once or twice every year or so)

(3) On this visit, how long do you and your group plan to visit the park? Please check only one.

☐ Less than 5 hours ☐ 1 day ☐ Multiple days

(4) On your visit to the park today, what type of group were you with? (Check all that apply)

☐ Alone ☐ Family ☐ Friends ☐ Climbing group

☐ Commercial guided tour ☐ School or educational group ☐ Other

(5) On this visit to the park today, please list the number of each type of vehicle(s) in which you and your group arrived:

Passenger vehicles: ______cars(s) ______van(s) ______SUV(s) ______Pick-up(s)

Recreational Vehicle (R.V.): ______ Bus: ______ Bike(s): ______

Other (specify type of vehicle): _______________________

For questions (6) and (7) your personal group is defined as anyone who you are visiting the park with, such as family, spouse, friends, etc. It does not include the larger group you may be traveling with, such as an organized tour.

(6) How many people, including yourself, are in your personal group today? Please provide the number of people in each age group.

Children (0-17 years): _________ Adults (18-62 years): __________ Seniors (63+ years): __________

(7) What is the U.S. ZIP code (or name of country) of your group's primary residence? ____________________

(8) Last night, where did you and your personal group stay? Please check only one.

Outside the Park

☐ Home or residence of friends and/or relatives

☐ Vacation rental home

☐ RV/trailer camping (campground: ___________________)

☐ Tent camping (campground: _______________________)

☐ Hotel/Motel (name of hotel: ______________________)

☐ Other (please specify: ____________________________)

Inside the Park

☐ RV/trailer camping (campground: ___________________)

☐ Tent camping (campground: _______________________)

☐ Other (please specify: ____________________________)

(9) On this visit today, at which location did you first ENTER the park? See map on next page.

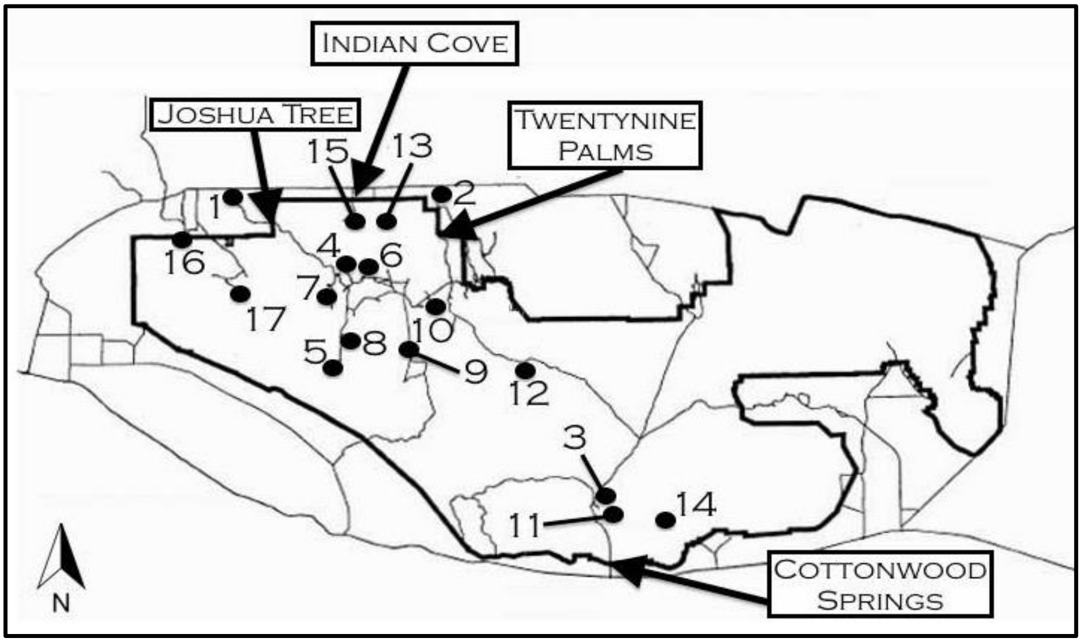
☐ Twentynine Palms (North Entrance) ☐ Joshua Tree (West Entrance)

☐ Cottonwood Spring (South Entrance) ☐ Indian Cove

(10) On this visit today, at which location do you plan to EXIT the park? See map on next page.

☐ Twentynine Palms (North Entrance) ☐ Joshua Tree (West Entrance)

☐ Cottonwood Spring (South Entrance) ☐ Indian Cove



(11) On the list below, please indicate the order in which you and your group visited these sites at Joshua Tree National Park during this trip. Simply write 1, 2, 3, and so forth, on the line beside each place you visited. Do not mark any sites that you did not visit. In the last column, indicate the length of time you spent at the site. See map above for assistance locating sites within the park.

Site Name	Order Visited	Length of time spent at site	
1. Joshua Tree Visitor Center		□ less than 1 hour	□ more than 1 hour
2. Oasis Visitor Center		□ less than 1 hour	□ more than 1 hour
3. Cottonwood Visitor Center		□ less than 1 hour	□ more than 1 hour
4. Keys Ranch		□ less than 1 hour	□ more than 1 hour
5. Keys View		□ less than 1 hour	□ more than 1 hour
6. Barker Dam		□ less than 1 hour	□ more than 1 hour
7. Hidden Valley		□ less than 1 hour	□ more than 1 hour
8. Lost Horse Mine		□ less than 1 hour	□ more than 1 hour
9. Geology Tour Road		□ less than 1 hour	□ more than 1 hour
10. Jumbo Rocks Area		□ less than 1 hour	□ more than 1 hour
11. Cottonwood Springs		□ less than 1 hour	□ more than 1 hour
12. Cholla Cactus Garden		□ less than 1 hour	□ more than 1 hour
13. Fortynine Palms Oasis		□ less than 1 hour	□ more than 1 hour
14. Lost Palms Oasis		□ less than 1 hour	□ more than 1 hour
15. Indian Cove		□ less than 1 hour	□ more than 1 hour
16. Black Rock Canyon		□ less than 1 hour	□ more than 1 hour
17. Covington Flats		□ less than 1 hour	□ more than 1 hour
Other (please specify):		□ less than 1 hour	□ more than 1 hour

(12) On the list below, please check all activities that you and your group participated in at Joshua Tree National Park.

☐ Sightseeing ☐ Bicycling ☐ Touring visitor centers

☐ Day hiking ☐ Horseback riding ☐ Walking self-guided nature trails

☐ Picnicking ☐ Technical climbing ☐ Visiting historical/archaeological sites
☐ Stargazing ☐ Rock scrambling (without gear) ☐ Attending ranger-led programs
☐ Camping ☐ Bouldering ☐ Attending field classes/other guided activities
☐ Backpacking overnight ☐ Other (please specify): ______________________________

(13) If you arrived in a personal vehicle to the current site, how much time did it take for you to find a parking spot?

☐ No time spent, a parking spot was available immediately

☐ 5 minutes ☐ 10-15 minutes ☐ More than 15 minutes

☐ I was not able to find a marked stall (What did you do? ______________________________)

(14) Please comment below if you have had any negative parking experiences within the park on your current visit.

Questions (15) - (24) visitor preferences for a future shuttle system in Joshua Tree National Park:

(15) Have you ever used public transit (such as a bus or shuttle) provided by a national park to access sites within that park?

☐ **Yes,** please specify the park(s): ______________________________ ☐ **No**

(16) The proposed Park Shuttle System for Joshua Tree National Park would allow visitors to park for free at the entrance stations and use the shuttle to visit the major sites within the Park. If such a Park Shuttle System existed within Joshua Tree National Park, would you have considered using the shuttle system for this visit today? ☐ **Yes** ☐ **No**

(17) How often would a shuttle need to pass by a stop (pick-up point) for you to consider using the service in Joshua Tree National Park? ☐ Would not use ☐ every 15 minutes ☐ every 30 minutes ☐ Hourly

(18) On a future visit, how important would the following services and characteristics of a shuttle system be? Please indicate the importance of each characteristic with ‘1’ indicating ‘not important’ and ‘5’ indicating ‘very important’.

Monday-Friday shuttle service	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Frequency of shuttle service	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Ability to take bikes on shuttle	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Ability to transport gear on shuttle	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
On-board orientation by Park Ranger	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
On-board orientation by TV or audio recording	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Alternative fuel shuttle	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
Ticket price	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

(19) Which of the amounts listed below best describes the most you would pay per person per day (unlimited rides) to use a Park Shuttle System that operated between sites within the Park (not including Indian Cove and Black Rock areas)? Assume that the Park entry fee still applies, parking is available for free at the entrance stations, and that the shuttle runs at least every hour.

☐ $0 ☐ $1-2 ☐ $3-4 ☐ $5-6 ☐ $7-8 ☐ $9-10

(20) In addition to the Park Shuttle System that operated between sites within the park, a transit service could operate between local hotels, campgrounds (including Indian Cove and Black Rock areas), and the Park entrances. Which of the amounts listed below best describes the most you would pay per person per day (unlimited rides) for use of a shuttle system that picked up at local sites and worked in coordination with the Park Shuttle System within the park? Assume that the Park entry fee still applies, parking is available for free at the entrance stations, and that the shuttle runs at least every hour.

☐ $0 ☐ $1-2 ☐ $3-4 ☐ $5-6 ☐ $7-8 ☐ $9-10

(21) Would you be interested in an additional transit service that connected to regional cities including Desert Hot Springs, Palm Springs, Palm Desert, and Indio? ☐ **Yes** ☐ **No**

(22) How much longer would you tolerate waiting on average for a parking spot at any site within the Park before you would consider using the Park Shuttle Service?

☐ 5 minutes ☐ 10 min. ☐ 15 min. ☐ 20 min. ☐ More than 20 minutes

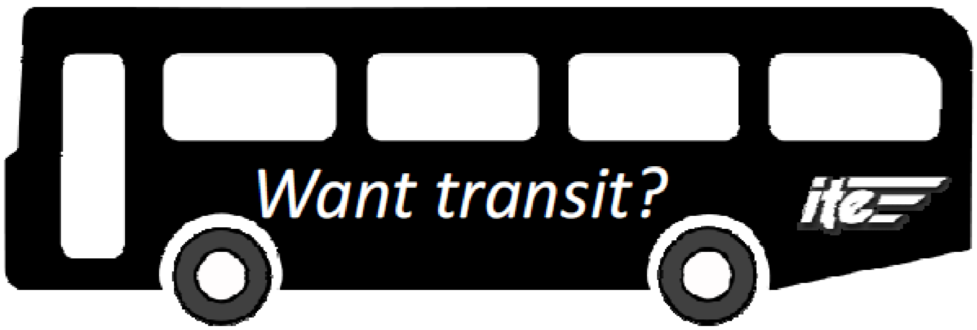
(23) Why would you not consider taking a Park Shuttle System within Joshua Tree National Park? Please check all that apply. Leave blank if you would consider using a shuttle service.

- ☐ I don't think traffic and parking congestion are severe enough for a shuttle system to be necessary.
- ☐ I'm uncomfortable leaving my vehicle in a parking lot.
- ☐ I'm unsure if the frequency of the service would accommodate my planned activities.
- ☐ Planned activities in the Park require equipment, which would be inconvenient to take on a shuttle.
- ☐ I would not feel safe in the Park without access to my private vehicle.
- ☐ I need my own personal vehicle.
- ☐ Other (Please specify): ____

(24) Please provide any other comments you may have about a future Park Shuttle System or transportation issues in Joshua Tree National Park.

END OF SURVEY
Thank you for your participation!

Section A.3: Survey Information Card



Give us your opinion on the usefulness of shuttle buses in **Joshua Tree National Park!**

Conducted by the University of California, Irvine,
Institute of Transportation Engineers Student Chapter

http://eee.uci.edu/survey/JoshuaTree

University of California, Irvine:
Transit Feasibility Study for
Joshua Tree National Park

The University of California, Irvine is conducting a transit study for JTNP to assess the interest of park guests in a shuttle system. The survey primarily includes questions about popular locations around the park, frequency of shuttle routes, and costs to visitors.

The study involves a short survey, 10-15 minutes, which can be taken online at the link provided. Only adults over the age of 18 are allowed to participate in the survey. Participation in the survey is voluntary and can be stopped at any time. The link contains more information about survey participation and procedures.

http://eee.uci.edu/survey/JoshuaTree

Appendix B

Section B.1: Park Visitor Comparison

Table 16: Visitor Survey Data Matrix

Visitor Survey Data	Joshua Tree	Rocky Mountain	Acadia
Home State	California	Colorado	Maine
Survey Year	2010	2011	2009
2013 Visitation (people)	1,383,340	2,991,141	2,254,922
2012 Visitation (people)	1,396,117	3,229,617	2,431,052
2011 Visitation (people)	1,396,237	3,176,941	2,374,645
2010 Visitation (people)	1,434,976	2,955,821	2,504,208
Group Size	2 [52%]	2 [56%]	2 [37%]
Group Type	Family [54%]	Family [58%]	Family [73%]
Visitors Origin	In State [50%]	In State [76%]	In State [14%]
	Out of State [50%]	Out of State [24%]	Out of State [86%]
International Visitor (Assumption <1% = 0.5%)	19%	~1%	~11%
Lifetime Visits	1 [56%]	21 or more [37%]	1 [50%]
	5 or more [22%]	5 or fewer [34%]	6 or more [23%]
Age Groups	76 or older [2%]	76 or older [2%]	76 or older [2%]
	71-75 [4%]	71-75 [3%]	71-75 [2%]
	66-70 [7%]	66-70 [5%]	66-70 [4%]
	61-65 [12%]	61-65 [11%]	61-65 [7%]
	56-60 [9%]	56-60 [11%]	56-60 [8%]
	51-55 [7%]	51-55 [13%]	51-55 [11%]
	46-50 [7%]	46-50 [9%]	46-50 [11%]
	41-45 [8%]	41-45 [6%]	41-45 [9%]
	36-40 [8%]	36-40 [7%]	36-40 [7%]
	31-35 [9%]	31-35 [7%]	31-35 [4%]
	26-30 [8%]	26-30 [8%]	26-30 [4%]
	21-25 [6%]	21-25 [5%]	21-25 [4%]
	16-20 [2%]	16-20 [2%]	16-20 [5%]
	11-15 [3%]	11-15 [4%]	11-15 [9%]
	10 or younger [8%]	10 or younger [7%]	10 or younger [13%]
Primary Reasons for Visit	Visit the Park [75%]	Visit the Park [73%]	
	Visit other attractions [8%]	Visit other attractions [8%]	
	Unplanned Visit [7%]	Visit Friends and relatives [7%]	
Primary Activities during Visit	Day hiking [27%]	Viewing scenery [36%]	Sightseeing for Pleasure [83%]
	Sightseeing [23%]	Wildlife Viewing [45%]	Hiking on Trails [79%]
	Technical Climbing [14%]	Snowshoeing [42%]	Walking on Carriage Roads [44%]
Length of Visit (hrs)	6 or more [40%]	7 or more [20%]	6 or more [64%]
	4-5 [31%]	5-6 [29%]	4-5 [20%]
	Up to 1 [9%]	3-4 [10%]	2-3 [12%]
Length of Visit (days)	1 day [11%]	1 day [19%]	1 day [8%]
	2 days [32%]	2 days [39%]	2 - 3 days [42%]
	3 days [24%]	3 days [29%]	4-5 days [23%]
	4 or more [32%]	4 or more [23%]	6-7 days [17%]

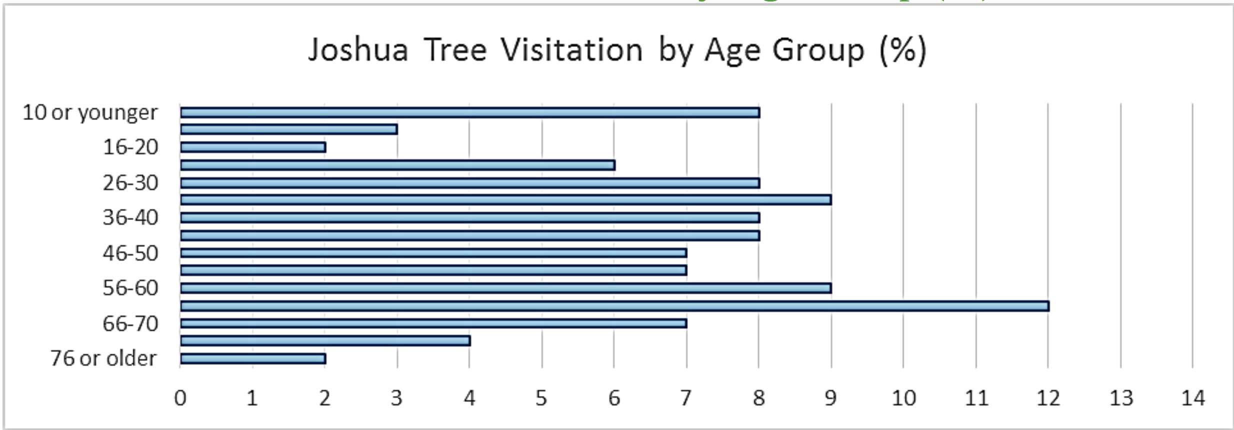
Table 17: Geographical Data Matrix

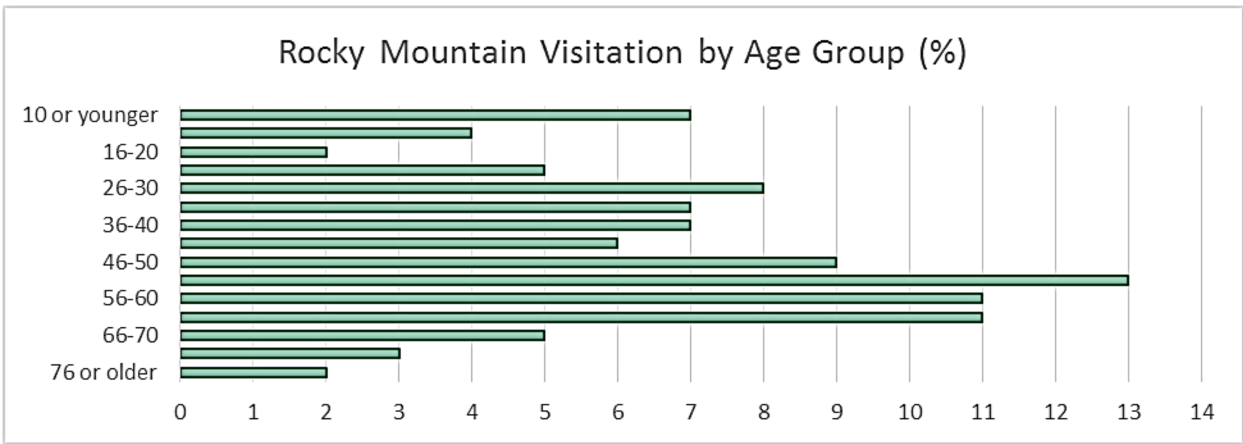
Geographical Information	Joshua Tree	Rocky Mountain	Acadia
Home State	California	Colorado	Maine
Size of Land Mass (Acres)	789,745	265,828	47,389
Trails (miles)	33.65	355	125
Main Attractions	Jumbo Rocks Area (Viewpoint) [55%]	Bear Lake [44%]	Cadillac Mountain Summit [75%]
	Hidden Valley [50%]	Beaver Meadows Visitor Center [28%]	Jordan Pond House and area [67%]
	Joshua Tree Visitor Center [50%]	Fall River Visitor Center [23%]	Sand Beach [63%]
	Keys View (Viewpoint) [41%]	Sprague Lake [21%]	Thunder Hole [62%]
	Cholla Cactus Garden (Nature Walk) [37%]	Hidden Valley [17%]	Seawall Area [36%]
	Barker Dam [37%]	Old Fall River Road (Scenic Road) [15%]	Bass Harbor Head Lighthouse [35%]
	Oasis Visitor Center [26%]	Trail Ridge Road (Scenic Road) [13%]	Bubble Rock [35%]
	Cottonwood Visitor Center [24%]	Kawuneeche Visitor Center [11%]	Bubble Pond [34%]
	Cottonwood Spring (Natural Springs) [19%]	Colorado River Trail [9%]	Eagle Lake Parking Area [33%]
Things to do	Art and Photography	Art and Photography	
		Auto Touring	Auto Touring
	Backpacking		Backpacking
	Biking	Biking	Biking
			Bird watching
	Camping	Camping	Camping
		Fishing	Fishing
	Hiking	Hiking	Hiking
		Horseback Riding & Stock Use	Horseback Riding & Stock Use
	Picnicking	Picnicking	Picnicking
	Ranger and Interpretive Programs		Ranger and Interpretive Programs
	Rock Climbing		Rock Climbing
	Tours	Tours	Tours
	Viewpoints	Viewpoints	
			Water Activities
			Winter Sports
Campsites	517	429	
Number of Access Points	2	3	
Entrance Fee/Private Vehicle	$15.00	$20.00	$20.00
Entrance Fee/Person	$5.00	$10.00	$5.00

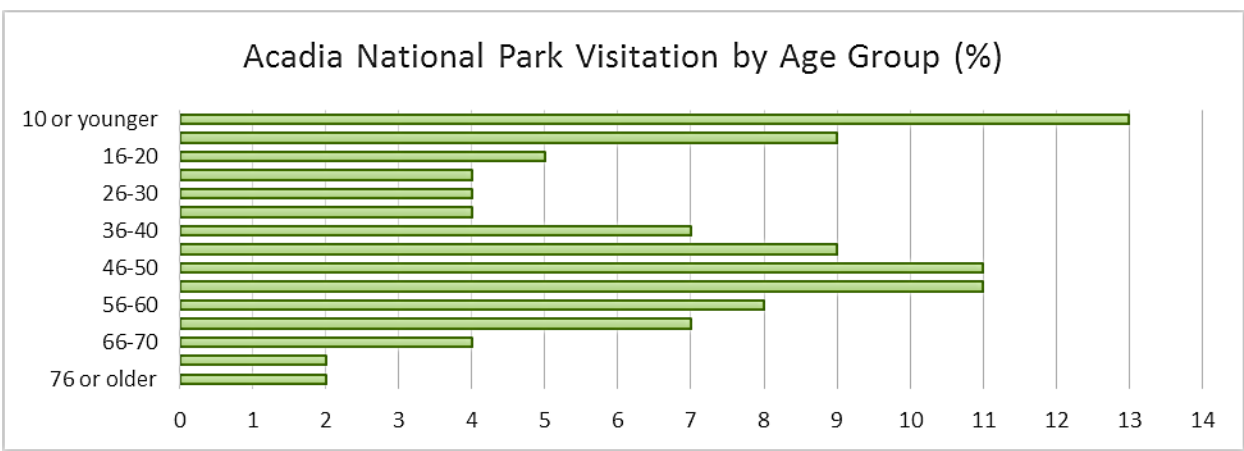
Table 18: Transit System Data Matrix

Transit System Information	Joshua Tree	Rocky Mountain	Acadia
Home State	California	Colorado	Maine
Type of Transit System	Bus	Bus	Bus
Frequency		30 minutes	15-30 minutes
Type of Service	Free	Free	Free
Type of Fuel		Diesel	Propane
Number of Buses		N/A	29
Number of Routes	3	3	8
Hourly Operating Cost		$144	$48
Operating Hours		7 am - 7 pm	6:45 am - 10:45 pm
Seasonal Schedule	Winter - Daily	Winter - No service	Winter - Daily
	Spring - Daily	Spring - Weekends	Spring - Daily
	Summer - Daily	Summer - Daily	Summer - Daily
	Fall - Daily	Fall - Weekends	Fall - Daily

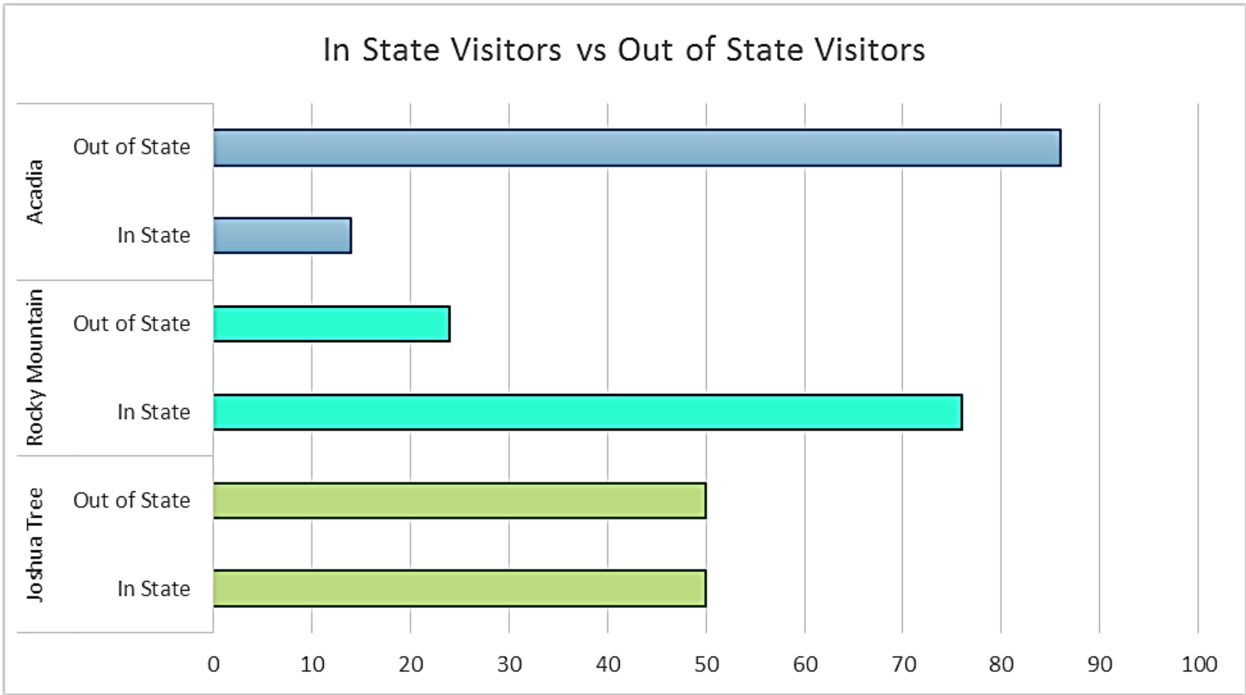
Section B.2 : National Parks Visitation by Age Group (%)



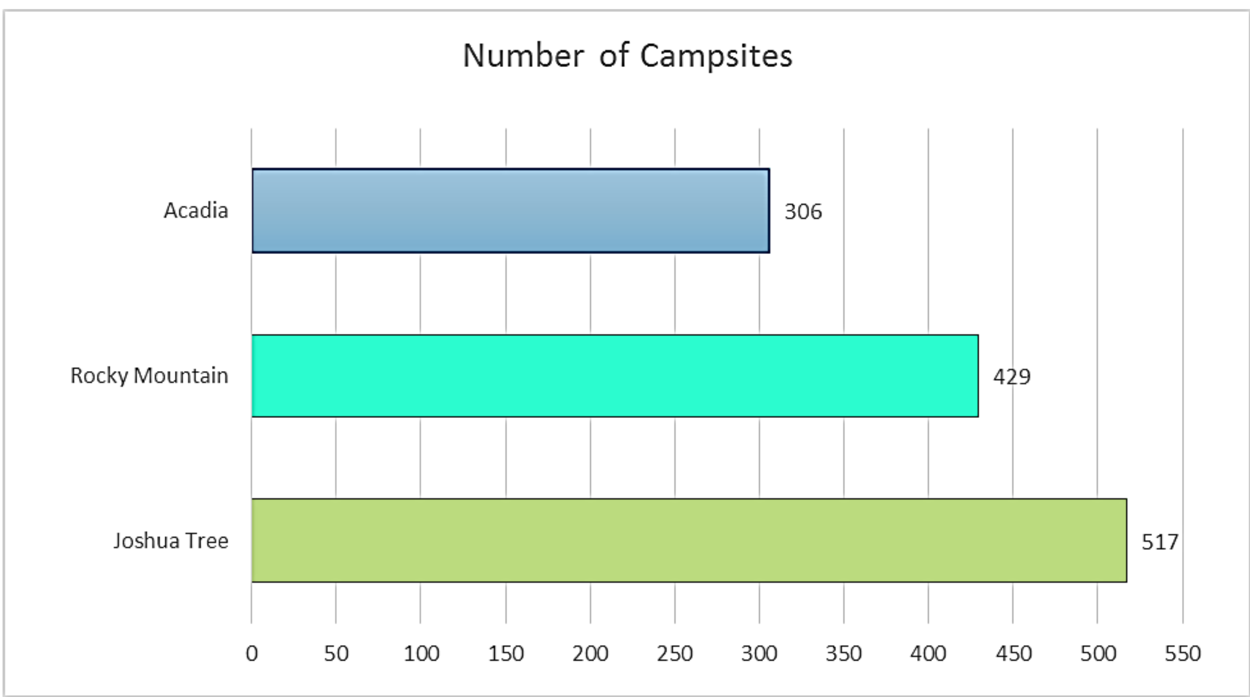




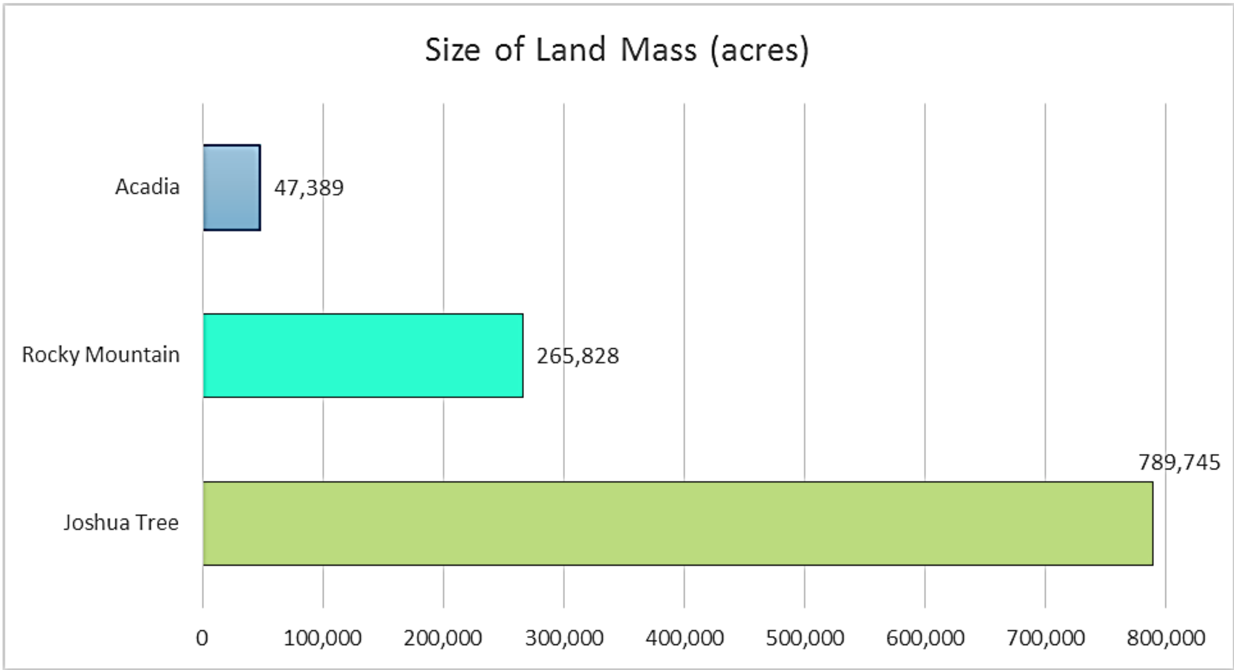
Section B.3: National Parks Visitation by In State and Out of State Visitors (%)



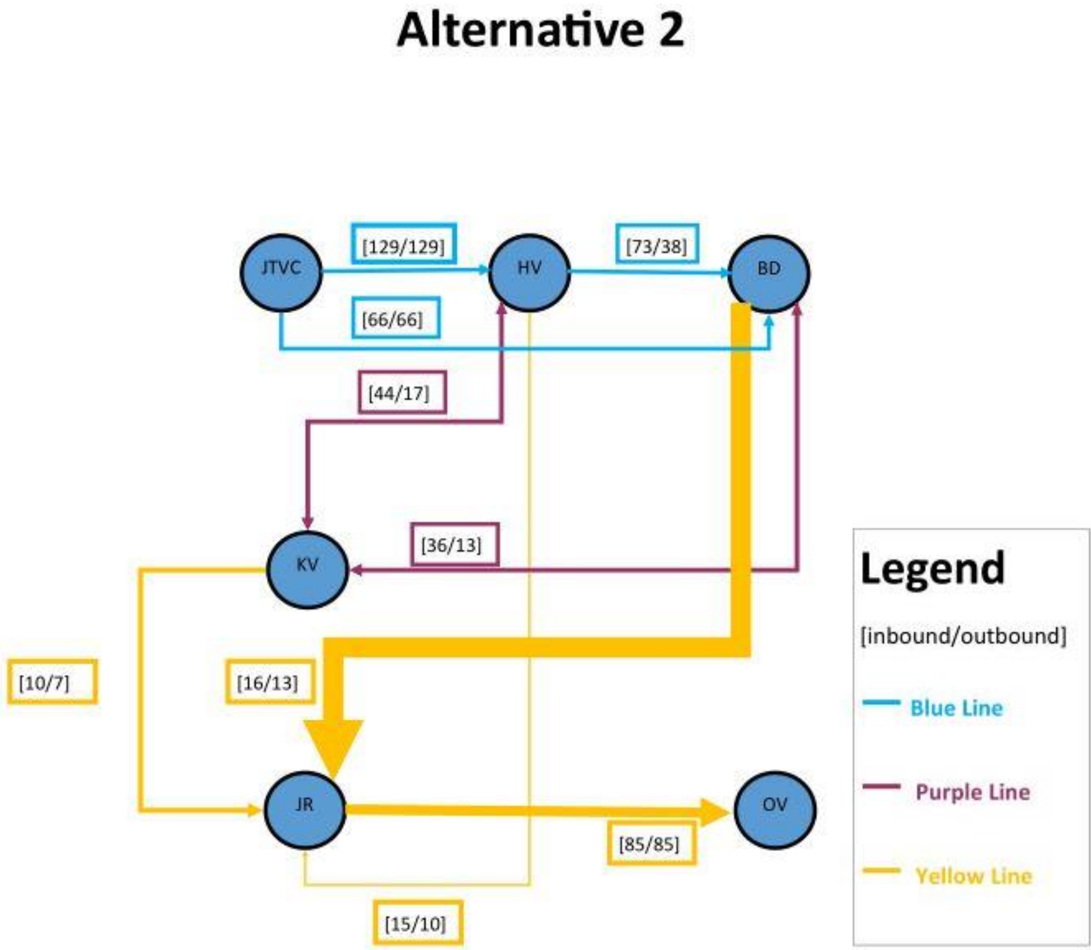
Section B.4: Number of Campsites in National Parks



Section B.5: Size of Land Mass of National Parks

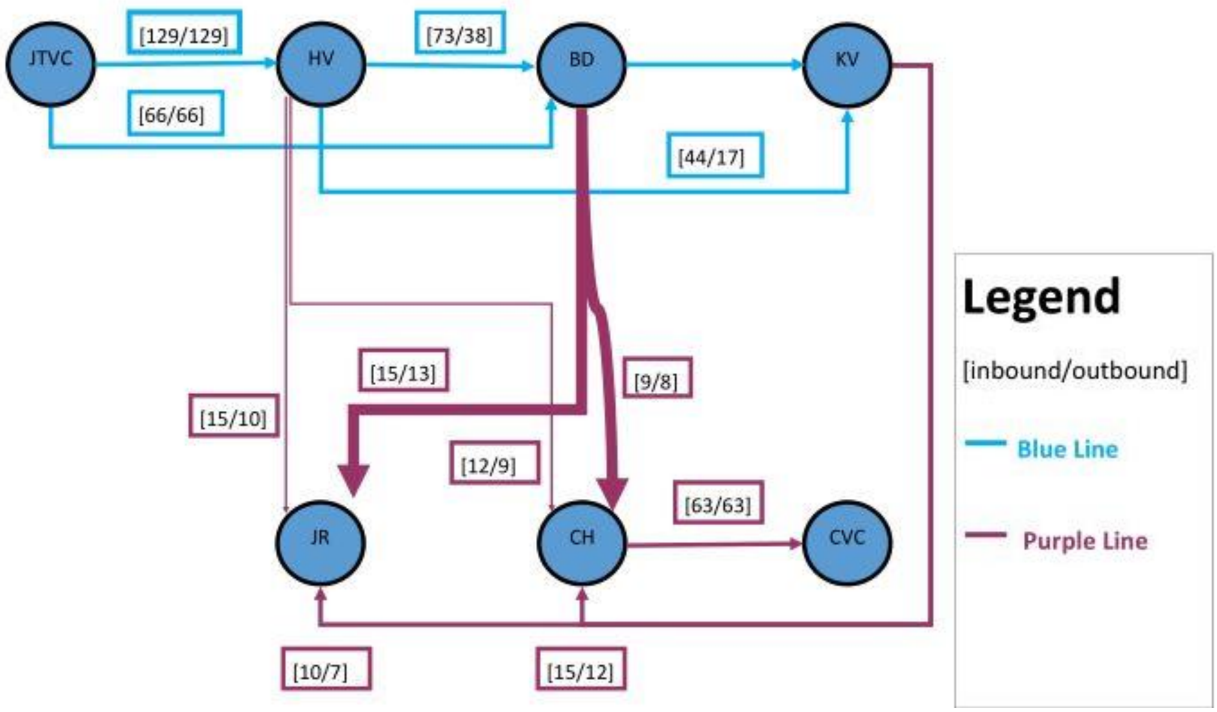


Section B.6: Intra-park Travel Demands



Top row: Joshua Tree Visitor Center, Hidden Valley, and Barker Dam. Second row: Keys View. Third Row: Jumbo Rock and Oasis Visitor Center

Alternative 3



Top row: Joshua Tree Visitor Center, Hidden Valley, Barker Dam, and Keys View. Second Row: Jumbo Rock, Cholla Cactus Garden, and Cottonwood Visitor Center.

Appendix C

Section C.1: Infrastructure Tables

Table 19: Parking Lot Capacities Referencing Figure 1

Parking Lot ID	Paved/ Unpaved	Striped	Approximate # of Reg. Parking Spaces	Handicap Parking Spaces	RV Spaces	Restrooms
1	yes	yes	16	0	0	no
2	yes	yes	72	4	8	yes
3			55	1	5	yes
4	yes	yes	90	0	0	yes
5			55	4	4	yes
6			12	0	0	yes
7	yes	yes	31	2	3	yes
8			33	0	1	yes
9			43	0	0	yes
a	yes	yes	20	2	3	yes
b			10	0	0	yes
c	yes	yes	8	1	2	no
d	yes	yes	26	2	5	yes
e			19	0	0	no
f			10	0	0	yes
g	yes	yes	32	0	4	yes
h			0	0	7	no
i	yes	yes	22	2	3	yes
j	yes	yes	43	2	5	yes
k	no	no	26	0	0	no
l	part	no	41	0	0	no
m			6	0	0	no
n	yes	yes	22	-	0	no
o	yes	yes	19	2	5	yes
p			12	0	3	yes

Table 20: Parking Lot Hourly Volume Counts for Day 1 (Saturday)

Time	Cholla Cactus	Hidden Valley	Barker Dam	Jumbo Rock	Key's View
9:00 AM	10	21	19	2	4
10:00 AM	9	57	37	5	13
11:00 AM	15	87	70	17	18
12:00 PM	21	91	87	19	33
1:00 PM	17	103	89	20	28
2:00 PM	23	112	97	23	27
3:00 PM	14	120	92	29	28
4:00 PM	23	72	72	32	35

Table 21: Parking Lot Hourly Volume Counts for Day 2 (Sunday)

Time	Cholla Cactus	Hidden Valley	Barker Dam	Jumbo Rock	Key's View
9:00 AM	5	45	20	1	2
10:00 AM	14	76	39	3	5
11:00 AM	31	116	77	21	12
12:00 PM	9	166	95	33	38
1:00 PM	25	163	117	34	27
2:00 PM	16	166	109	37	35
3:00 PM	27	149	103	28	46
4:00 PM	19	136	94	35	31

Section C.2: Infrastructure Images

Sample Infrastructure Photos:

Figure 32: Restrooms at Joshua Tree National Park

Figure 33: Shuttle stop from Zion National Park

Section C.3: Cost Estimates

Table 22: Alternative 1 Infrastructure Costs

<table>
<tr><th>Infrastructure</th><th>Description</th><th>Quantity</th><th>Unit Cost ($/unit)</th><th>Total Cost ($)</th></tr>
<tr><td rowspan="4">Bus Stops</td><td>Paved Landing Area (including ADA accessible bus ramps)</td><td rowspan="4">12</td><td rowspan="4">11,000</td><td rowspan="4">132,000</td></tr>
<tr><td>Shelter/Canopy</td></tr>
<tr><td>Benches</td></tr>
<tr><td>Information Panel</td></tr>
<tr><td rowspan="3">Parking Lots *</td><td>Grading</td><td rowspan="3">26,218 SF</td><td rowspan="3">40 (per SF)</td><td rowspan="3">1,048,720</td></tr>
<tr><td>Paving</td></tr>
<tr><td>Striping</td></tr>
<tr><td>Land Purchase</td><td>--</td><td>0.22 acres</td><td>27,778 (per acre)</td><td>6,111</td></tr>
<tr><td rowspan="4">Parking Lot and Shuttle Signage</td><td>Parking</td><td>1</td><td rowspan="4">180</td><td rowspan="4">6,660</td></tr>
<tr><td>Yield</td><td>12</td></tr>
<tr><td>Crosswalk</td><td>12</td></tr>
<tr><td>Bus Stop</td><td>12</td></tr>
<tr><td rowspan="3">Parallel Bus Bays</td><td>Preliminary Eng./Environmental</td><td>1</td><td>1,500</td><td>1,500</td></tr>
<tr><td>Construction Contract (including contingency)</td><td>1</td><td>110,000</td><td>110,000</td></tr>
<tr><td>Construction Engineering</td><td>12</td><td>15,000</td><td>180,000</td></tr>
<tr><td>Emergency Call Box</td><td>Wireless - Digital Two-Way Radio</td><td>8</td><td>6,000</td><td>48,000</td></tr>
<tr><td rowspan="4">Light Poles</td><td>Pole</td><td rowspan="4">22</td><td rowspan="4">500</td><td rowspan="4">11,000</td></tr>
<tr><td>Light Bulb</td></tr>
<tr><td>Arm</td></tr>
<tr><td>Solar Panel</td></tr>
<tr><td>Crosswalk Striping</td><td>High-Visibility</td><td>4</td><td>2,600</td><td>10,400</td></tr>
<tr><td>Restroom</td><td>Waterless</td><td>1</td><td>--</td><td>--</td></tr>
<tr><td>Bus Technologies</td><td>--</td><td>--</td><td>--</td><td>--</td></tr>
<tr><td rowspan="3">Technologies</td><td>Propane Technology</td><td>1</td><td>37,000 - 175,000 varies based on situation and need.</td><td>37,000 - 175,000</td></tr>
<tr><td>Hybrid Technology</td><td>1</td><td>2,500/unit</td><td>2,500</td></tr>
<tr><td>Biodiesel</td><td>1</td><td>1,461/ bus</td><td>-</td></tr>
<tr><td colspan="2">Total w/o bus technology</td><td colspan="3">$1,554,391</td></tr>
</table>

*Note: It was assumed that the parking lot at the Joshua Tree visitor center is not currently paved because based on the current conditions, the lot would need serious of work

Table 23: Alternative 2 Infrastructure Costs

Infrastructure	Description	Quantity	Unit Cost ($/unit)	Total Cost ($)
Bus Stops	Paved Landing Area (including ADA accessible bus ramps)	10	11,000	110,000
	Shelter/Canopy			
	Benches			
	Information Panel			
Parking Lots*	Grading	26,218 SF	40 (per SF)	1,048,720
	Paving			
	Striping			
Parking Lot and Shuttle Signage	Parking	2	180	5,760
	Yield	10		
	Crosswalk	10		
	Bus Stop	10		
Parallel Bus Bays	Preliminary Eng./Environmental	1	1,500	1,500
	Construction Contract (including contingency)	1	110,000	110,000
	Construction Engineering	10	15,000	150,000
Emergency Call Box	Wireless - Digital Two-Way Radio	7	6,000	42,000
Light Poles	Pole	20	500	10,000
	Light Bulb			
	Arm			
	Solar Panel			
Crosswalk Striping	High-Visibility	3	2,600	7,800
Bus Technologies	--	--	--	--
Technologies	Propane Technology	1	37,000 - 175,000 varies based on situation and need	37,000 - 175,000
	Hybrid Technology	1	2,500/unit	2,500
	Biodiesel	1	1,461/ bus	-
Total w/o bus technology		$1,485,780		

*Note: It was assumed that the parking lot at the Joshua Tree visitor center is not currently paved because based on the current conditions, the lot would need serious of work

Table 24: Alternative 3 Infrastructure Costs

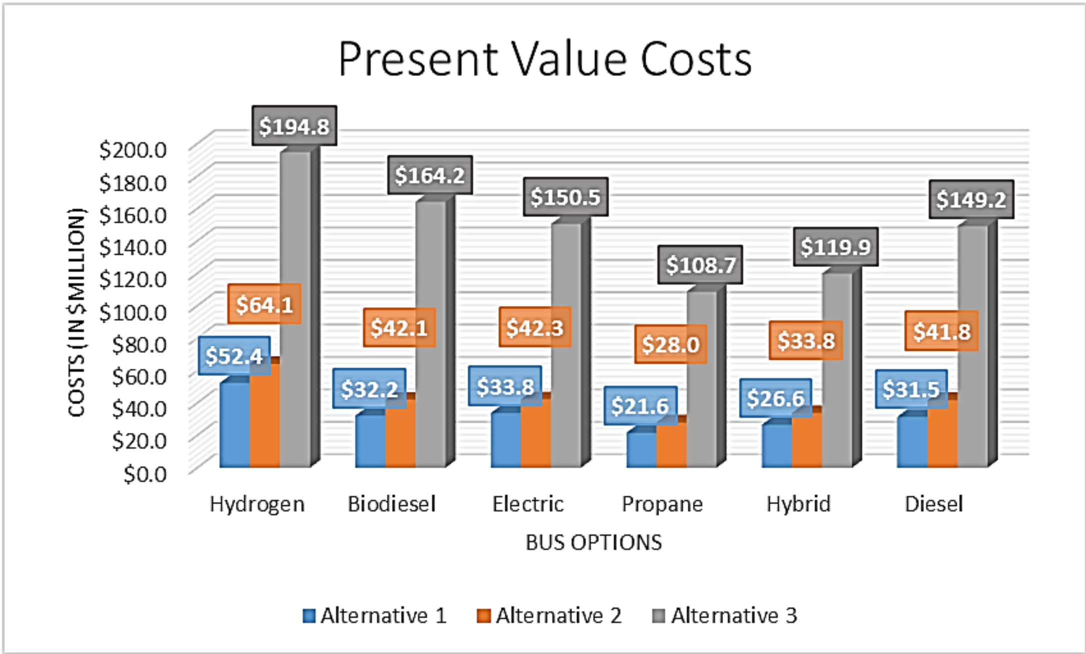
Infrastructure	Description	Quantity	Unit Cost ($/unit)	Total Cost ($)
Bus Stops	Paved Landing Area (including ADA accessible bus ramps)	14	11,000	154,000
	Shelter/Canopy			
	Benches			
	Information Panel			
Parking Lots*	Grading	54,000 SF	40 (per SF)	2,160,000
	Paving			
	Striping			
Land Purchase	--	0.22 acres	27,778 (per acre)	6,111
Parking Lot and Shuttle Signage	Parking	2	180	7,920
	Yield	14		
	Crosswalk	14		
	Bus Stop	14		
Parallel Bus Bays	Preliminary Eng./Environmental	1	1,500	1,500
	Construction Contract (including contingency)	1	110,000	110,000
	Construction Engineering	14	15,000	210,000
Emergency Call Box	Wireless - Digital Two-Way Radio	9	6,000	54,000
Light Poles	Pole	28	500	14,000
	Light Bulb			
	Arm			
	Solar Panel			
Crosswalk Striping	High-Visibility	5	2,600	13,000
Restroom	Waterless	1	--	--
Bus Technologies	--	--	--	--
Technologies	Propane Technology	1	37,000 - 175,000 varies based on situation and need.	37,000 - 175,000
	Hybrid Technology	1	2,500/unit	2,500
	Biodiesel	1	1,461/ bus	-
Total w/o bus technology		$2,730,531		

*Note: It was assumed that the parking lot at the Joshua Tree visitor center is not currently paved because based on the current conditions, the lot would need serious of work

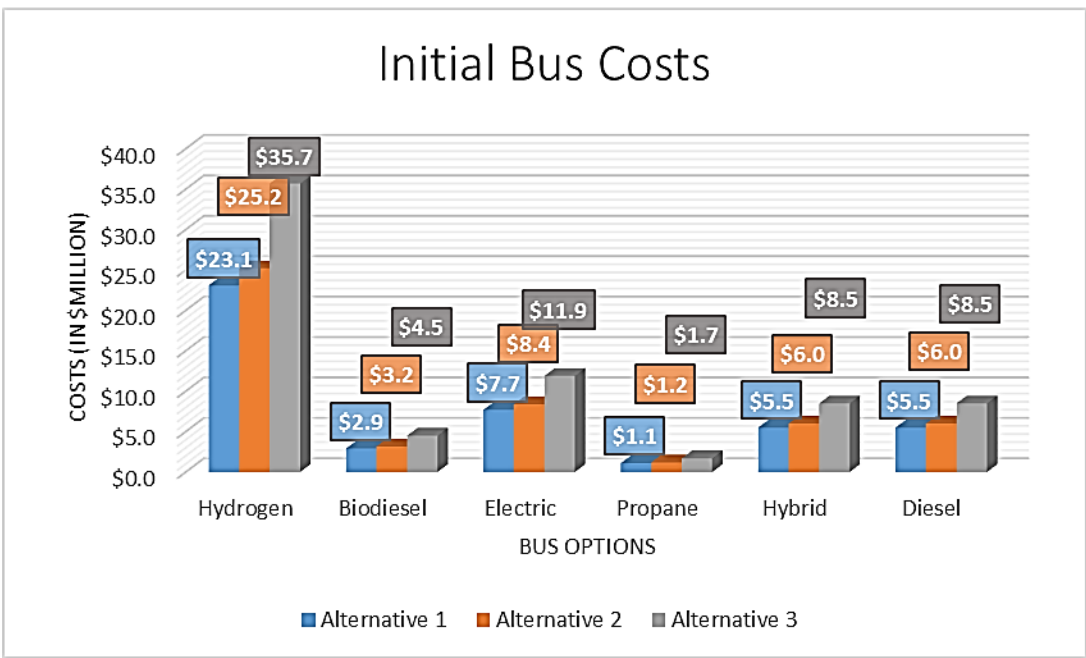
Appendix D

Section D.1: Purchasing Option

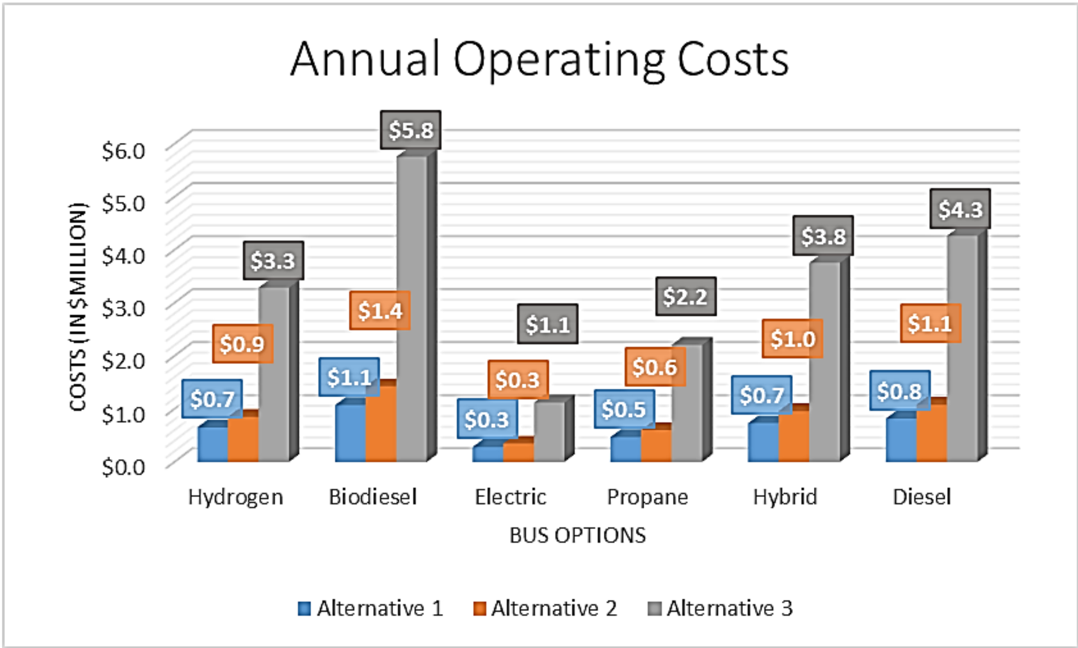
Present Value Costs over a 12-year Span



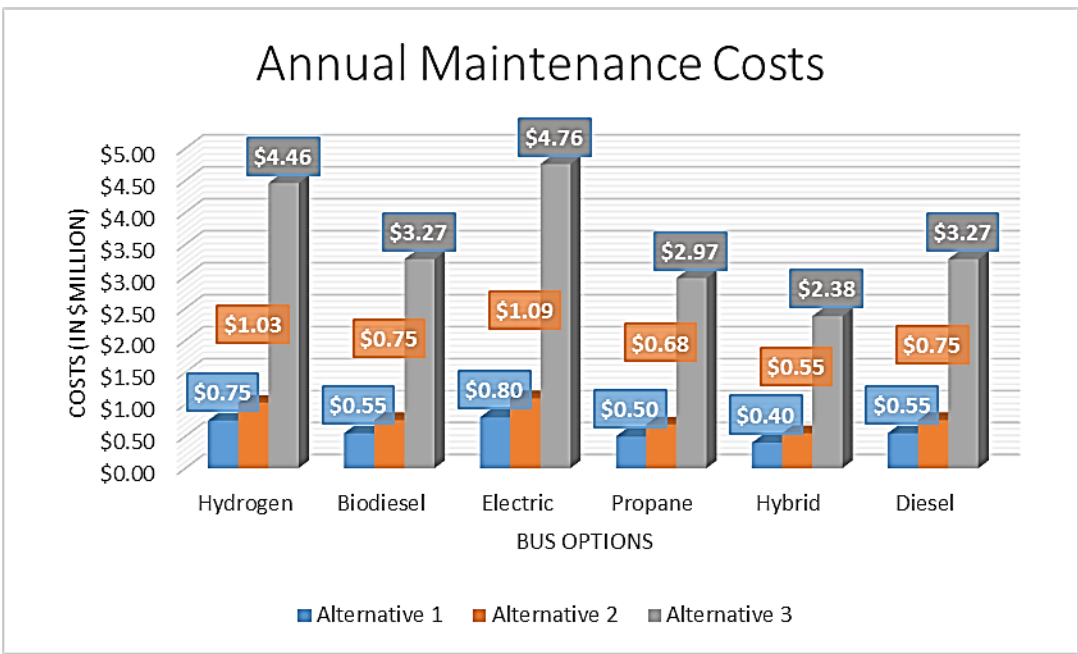
First Year Initial Bus Costs



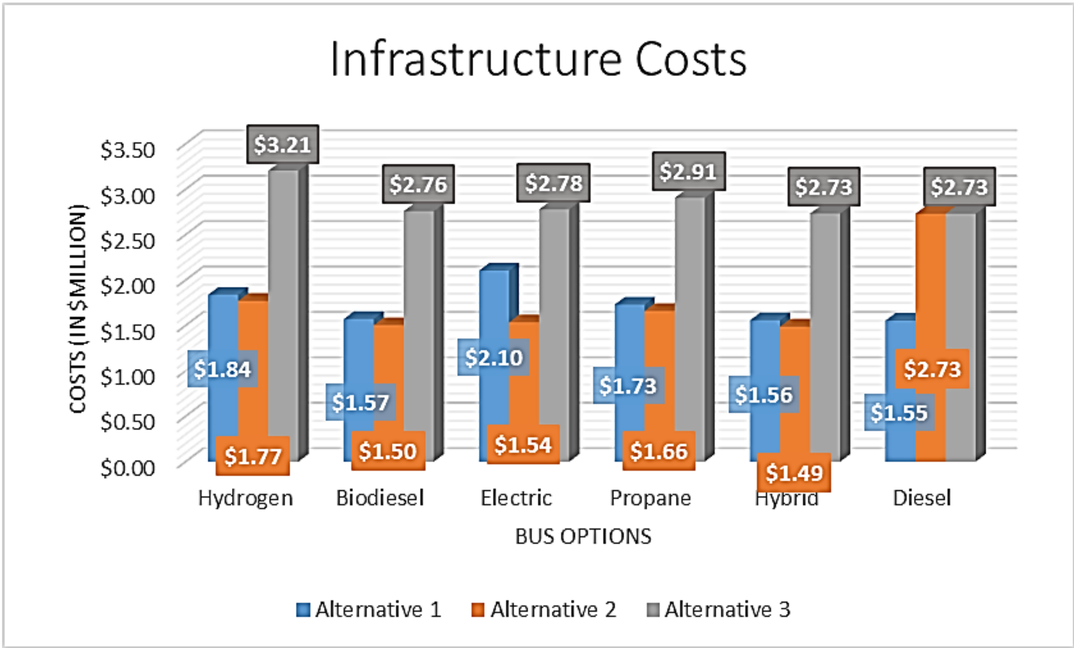
Annual Operating Costs



Annual Maintenance Costs



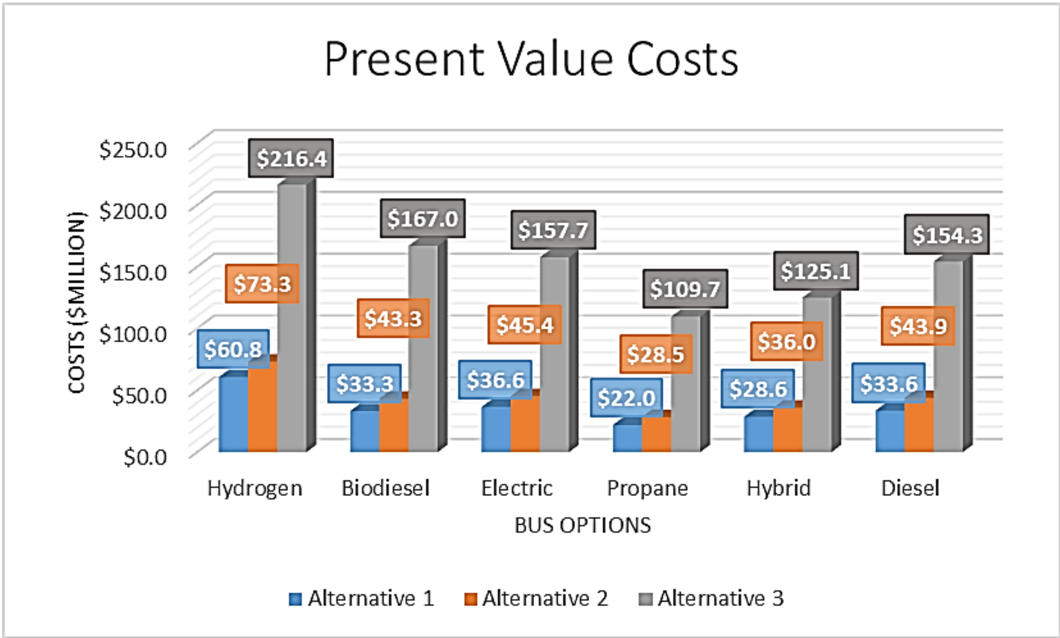
Infrastructure Costs



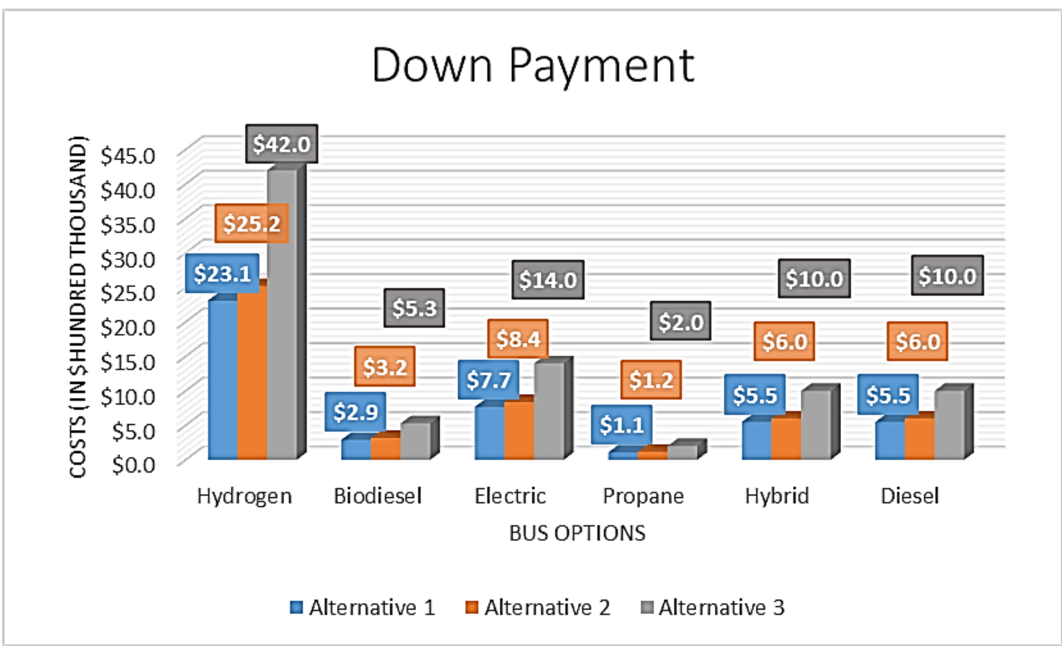
Section D.2: Leasing Option

(note: same annual operating costs, maintenance costs, and infrastructure costs as purchasing option)

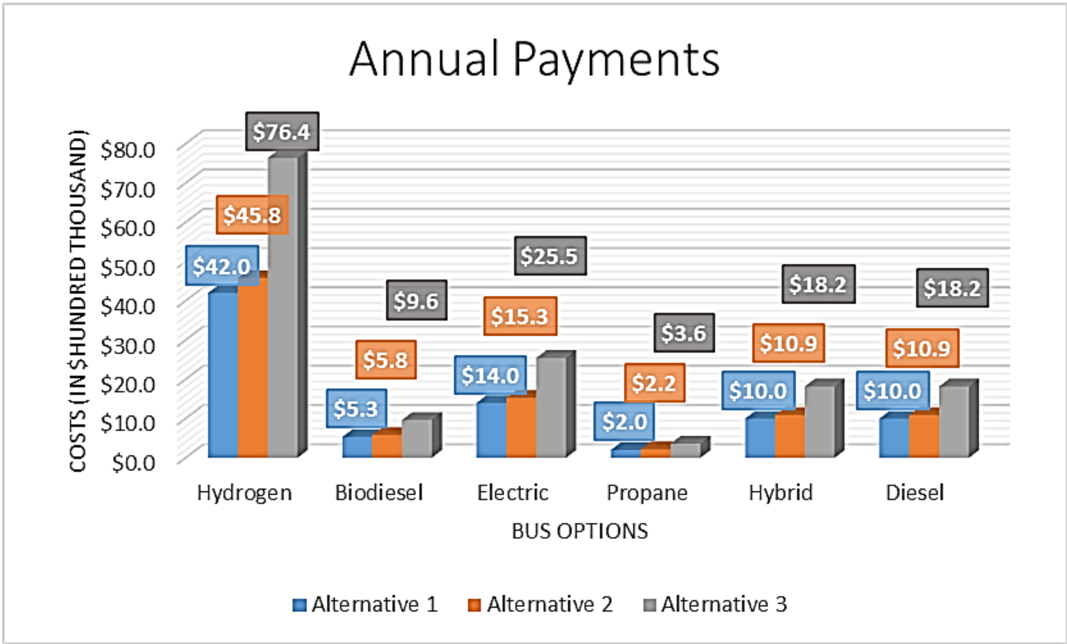
Present Value Costs over a 12-year Span



Bus Down Payment



Annual Payment



Buyout Rate