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Investigating Options for Parking Reservation System at Glacier National Park

Glacier National Park Project Center

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Abstract

This project investigated different methods for implementing and assessing a parking reservation system in Glacier National Park. Due to wildfires, our team was relocated to Acadia National Park for the first four weeks of the project term to work remotely. Our team conducted visitor surveys on reservation feature preferences in Acadia National Park at Cadillac Mountain and Jordan Pond to use as reference data upon arrival in Glacier National Park. Our team designed a multi-step phase in plan for a parking reservation system for both national parks using asset mapping and cost-benefit analyses. Finally, our team developed an app for offline GPS location tracking for future use in identifying and managing traffic throughout the park in a timely and effective manner.

Executive Summary

Introduction

Following a record 305 million visitors to National Parks in 2015, the National Parks Service is struggling to manage the congestion which has increased exponentially over the past decade. This congestion has led to the diminishment of both overall visitor experience and the environment. Glacier National Park (GNP), one of the top 10 most visited National Parks, saw an increase in visitation of 400,000 people between 2015 and 2017 during the month of July alone. Our project concerns the development of a parking reservation system at the Many Glacier site (MG), one of the most congested areas in GNP.

Background

GNP covers over 1 million acres of land in Northwest Montana, and is often referred to as the “Crown of the Continent”. People from across the world visit Glacier to hike its 10,000-foot mountains, view its towering glaciers, and appreciate its diverse wildlife and unique ecosystem. (Lomax, 300). MG sits at the end of a 12-mile road which begins outside the park, and hosts a variety of activities including extensive hikes, boat tours, and horseback riding (Lomax, 132).

In July 2017, MG traffic counters recorded over 40,000 cars entering the area (“Traffic Counts”, web). According to park staff, the area has become so congested that park rangers closed the area to new visitors and implemented a one-car-in-one-car-out system at the gate on Many Glacier Road. Said gate is located 7.5 miles inside the park, resulting in many visitors being turned around after extensive travel. Analysis of the MG area through the use of Google Maps satellite imagery revealed four main parking lots: near the Many Glacier Hotel, Grinnell trailhead, Swiftcurrent Motor Inn, and Iceberg trailheads. Between the four lots, there are approximately 424 standard spaces, 132 parallel parking spaces (technically illegal), and 3 extended RV spaces. Depending on whether the park chooses to legalize said parallel spaces, the vehicle carrying capacity of the park is between 427 and 559 cars.

The issue of overcrowding has recently become the concern of many National Parks other than GNP. However, fully-developed reservation systems with concrete outcome assessments are almost non-existent due to the recency of this issue. For example, both Haleakala National Park and the Muir Woods National Monument have implemented parking reservation systems in the past two years, but neither has outcome assessments available at this time. That being said, other national parks have developed and implemented independent local policies for managing congestion. For example, Zion National Park has completely closed its doors to private vehicles and developed an extensive internal shuttle system to transport visitors within the park (Seigler 2016). Yosemite National Park is proposing an overhaul its parking system, including the restoration of 176 acres of land and development of 73 acres, in order to move day-visitor parking outside of Yosemite Valley (Mihalic, 34). Additionally, reservation systems have been streamlined and encouraged by the popularization of online systems such as Recreation.gov, a reservation management website developed by the National Recreation Reservation Service which automates the booking process (NRRS, 2018b).

MG already has most of the assets required to implement a reservation system. They already use Recreation.gov to manage online reservations for 4 of their 13 campgrounds (NRRS, 2018d). Additionally, there is a manned gate on the road to Many Glacier which is already used to check park passes. However, despite there being two hotel services, multiple reservation-based activities, and several trail heads, there is no regulation as to where cars must park once inside MG. As a result, sometimes hotel guests are prevented from parking near their hotels and are forced into overflow parking. The only current congestion management strategy at MG consists of park staff closing the gate when the park appears full and implementing a one-car-in one-car-out system.

Methods

This project is intended to provide GNP with policy recommendations for a reservation system at MG to reduce overcrowding. By managing and guaranteeing visitor entrance factors such as dates, times, and parking locations, the system will improve visitor experience and help preserve the natural resources in the area for future generations to appreciate. The project objectives are as follows:

1. Understand visitation patterns in MG and visitor needs regarding reservations
2. Understand park staff perspectives, resources, and capabilities relating to the implementation of a reservation system.
3. Assess and propose reservation system design options for MG
4. Propose methods for outcome assessments for the park staff

The final deliverable of the project will be a set of policy recommendations for reservation system parameters and an implementation strategy, as well as the raw data and analysis collected from surveys and interviews with stakeholders.

To understand visitation patterns and visitor needs, a brief survey was developed for Many Glacier visitors. Survey questions asked for information such as basic demographics and preferred reservation length, price, and booking method. For the full survey, see Appendix A. Unfortunately, due to wildfires, we were relocated to ANP for the first 4 weeks of the 7-week project term, and once we arrived in GNP, we were unable to survey MG visitors due to snow storms which closed the road. However, we redesigned the survey and distributed it to a total of 340 ANP visitors during our time in ANP. For the full ANP survey, see Appendix B.

We investigated park staff perspectives on overcrowding and reservation systems primarily through email and in-person meetings. While at ANP, we communicated with John Kelley, Management Assistant at ANP, via email and in person during two meetings which also included other ANP staff. We simultaneously communicated with Tara Carolin, Director of the

Crown of the Continent Research Center at GNP, via email, and eventually in person once on-site in GNP. The goal of said discussions was to answer two primary questions:

1. To what extent should visitor opinions influence the design of the reservation system?
2. What limitations do park staff want our team to consider when designing the system?

As the stakeholders choosing whether or not to implement our proposals, this group had the most significant influence on our proposals. Thus, the proposals catered to the staff's technology preferences and capabilities, while encouraging them to seek outside help (including future IQPs) when working with more complex technical issues.

The third objective is to assess and propose reservation system design options for MG. The proposal will consist of recommendations for parameters of a reservation system, parking logistics, enforcement, and ways to centralize the reservation system online. Reservation parameters for consideration include time, duration, booking method, fees, and maximum number per time slot.

The final objective of this project is to assess the outcomes of the reservation system implemented in MG. Given that there is no current metric to assess the outcomes of a reservation system in the National Parks, we developed a phone application to track users using GPS location based services. The final product of the GPS location based service tracking phone application was developed on the android platform in order to accomplish these main tasks:

1. Track a user using GPS location based services and timestamp
2. Store the tracking information locally on the device
3. Upload the tracking information to an online database when internet services are available
4. Remove tracking information from the device after it has been uploaded online

Once a significant amount of data has been uploaded to the resulting online database, data analytics can be performed to observe visitor use trends and predict future visitor behavior. The full source code is included in Appendix C.

Results and Analysis

Our team surveyed 340 visitors at ANP during the first four weeks of our project term. This included 230 people from Cadillac Mountain and 110 from Jordan Pond, the two locations which ANP staff were most concerned with in regards to congestion. Because ANP staff expected differing results between the two sites, the ANP survey (Appendix B) included a question regarding the location of the survey, allowing us to compare the results between said locations.

According to the survey results, 63% of ANP visitors were visiting the park for the first time. This both affirms the national trend of exponentially rising park visitation and leans in the park's favor, as new visitors are less likely to resist changes in a visitation system for which they have no frame of reference. 89% of visitors on Cadillac Mountain claimed to use cars as their primary mode of transportation in the park. At Jordan Pond, only 66% claimed to use cars, with 24% using the Acadia Shuttle System. These results show that establishing a parking reservation system will mitigate the majority of congestion in ANP, and that awareness of the shuttle system is high. The latter result is favorable for the park, as ANP planned to use the reservation fees to improve and expand the shuttle system.

Visitors were also asked about their preferred reservation durations, booking methods, and prices. Of those who answered, 82% on Cadillac Mountain supported a reservation under 3 hours, while 88% at Jordan Pond preferred a reservation under 5 hours. This is likely due to the differing activities and attractions between the two locations, and was expected by ANP. Of those who gave a preferred booking method, 82% preferred remote methods, being online, a phone app, or a call-in. However, a significant 18% preferred booking on-site at a visitor center or kiosk. Of those who gave a maximum preferred reservation price, 76% were willing to pay for a reservation while 24% believed it should be free. Within the 76% willing to pay, only 23% were willing to pay more than \$6.

Finally, when asked whether or not they would support a mandatory reservation system at popular destination sites in ANP, 42% firmly supported, while 34% firmly opposed. The

remaining 24% were unsure. A later iteration of the survey gave options for support all year long and support only during peak season. Of those who responded yes with said choice, only 23% supported it all year while 77% supported it only during peak season.

Due to late arrival and snow storms at GNP, we were unable to survey visitors or interview concessionaires at GNP. As a result, we attempted to extrapolate our results from ANP as much as possible and reached out to GNP staff for visitor use studies to supplement our findings and draw conclusions. According to a presentation given by the Montana Board of Planners in September 2018, MG parking was reported full most often between 1:00 pm and 2:00 pm. Based on average human walking speed and lengths of trails in the area, we predicted that visitors would take 5-6 hours to complete said trails. From this information, we recommended splitting day reservations into two 7-hour blocks: between 5:00 am to 12:00 pm and 12:00 pm to 7:00 pm. This would split up the main crowd between morning and afternoon as well as give visitors sufficient time to hike longer trails if desired. As preferred booking method and price can be generalized to all National Park visitors, we gave GNP the same recommendations as ANP: Online reservations with a price not to exceed \$5.

Recommendations

After thorough background research, discussions with park staff, and conducting visitor surveys, our team recommended a plan for each national park. The plans reflected the unique assets and desires of ANP and GNP, and are discussed below.

In order to help ANP achieve its goal of implementing a reservation system by 2020, a we developed a 3-step phase-in plan with increasing levels of investment. This plan incorporated the lack of gates at ANP as well as the limited cellphone reception within the park boundaries. Phase 1 is a simple honor system. Visitors would book reservations for Cadillac Mountain and Jordan Pond online via Your Pass Now, the system currently used by ANP to purchase park passes. Visitors could reserve a 3-hour block at Cadillac Mountain or a 5-hour block at Jordan Pond, and would print out their reservation to place on the dashboard of their car upon arrival to allow park rangers to check. In Phase 2, reservations would include a unique

QR code, either printed on the reservation or accessible via smartphone. Park rangers would scan the QR code with a custom smartphone app which would compare it against a database of valid reservations stored locally on the device. This app, while requiring external development, would allow rangers to rapidly accept and deny visitors from reserved parking, decreasing congestion during peak arrival times.

Finally, phase 3 provides park staff with 3 options for assessing and maintaining the system after visitor feedback and compliance rates have been determined. First, if compliance rates gradually rise with visitor awareness, there is a potential to revert back to the honor system, thus saving costs. The second option involves automating phase 2, replacing park rangers at entry sites with automated gates and kiosks to scan reservations, thus saving manpower. Finally, the third option involves increasing the efficiency of enforcement by replacing a manned or unmanned gate with an Automated License Plate Recognition (ALPR) system. An ALPR system for ANP would consist of cameras which automatically detect and read license plates of vehicles entering reserved parking and notify rangers if a vehicle without a reservation has entered reserved parking.

Due to limited time and for the sake of simplicity, we developed only one plan for MG at GNP, which would only require some additional website development and ranger stationing. This plan utilizes the manned gate on the road to MG, and thus an 'honor system' is not applicable here. Visitors would book reservations online through Recreation.gov, which it already uses for some campsites. Visitors would be allowed to reserve one space for one 7-hour block each day; either 5:00 am to 12:00 pm or 12:00 pm to 7:00 pm. This block system would both split up the peak visitation during mid-day and allow visitors to go on extended hikes on the trails surrounding MG. Additionally, these reservations would only apply to certain lots. For logistical simplicity, anyone entering the park should only require one kind of reservation. Thus, visitors with reservations for hotels, horseback riding, or backcountry camping would be allowed in without making an additional parking reservation. Once a visitor has shown their reservation at the gate, they would be directed via signs to their designated parking lot, thus allowing the many concessionaire-based reservation systems already present in MG to coexist.

Designating the four parking lots in MG is critical in allowing the reservation systems to coexist. The Many Glacier Hotel has 214 rooms available for booking, but the lot adjacent to it has only 197 parking spaces. If parallel parking is legalized, this count raises to 236 spaces. Thus, we recommend that said spaces are legalized in order to satisfy the carrying capacity of the hotel. Additionally, we recommend sectioning off around 20 of these spaces for horseback riding reservations, as this concession is nearby the Many Glacier Hotel. In contrast, Swiftcurrent Motor Inn has only 95 cabins, but the lot adjacent to it has 119 standard parking spaces. Including the 35 parallel spaces, there are 154 spaces in total, leaving 59 extra spaces after Swiftcurrent guests have parked. Thus, we recommend dedicating this lot to both Swiftcurrent Motor Inn guests and concessionaire staff, who live nearby in dedicated housing in MG during peak season.

The two remaining trailhead lots contain a total of 173 spaces, and would be the designated lots for the new day reservations. We recommend dedicating a small section of about 20 spaces within these lots for backcountry camping reservations, as their extended traveling is incompatible with day reservations. These spaces can be first-come first-serve as backcountry campers are such a small minority of the visitor population. Subtracting 20 backcountry spaces and allowing for a conservative 10% violation rate, this would allow for 137 day visitor spaces per block, or 274 spaces per day.

In order for this plan to work, GNP will need to add clear signage which designates each lot by type of reservation. Additionally, in order to enforce reservation time slots and catch those arriving outside manned gate hours, we recommend park rangers patrol lots to check reservations.

Conclusion

Despite multiple weather setbacks, our team was able to provide valuable reservation system insights for both ANP and GNP. ANP was provided with extensive survey data and analysis regarding visitor preferences on reservations as well as a phase-in plan to test reservation effectiveness with minimal upfront costs. Some of said survey analysis was also relevant to GNP, which received a thorough analysis of parking resources and recommendations for the use of each of its main parking lots. Finally, both parks were presented with examples of online reservation systems, recommendations for additional signage, and a means of developing outcome assessments through big data collected from voluntary smartphone users. our team also developed example software for quickly analyzing survey data from Brew Survey. Depending on the rate of implementation of said reservation systems, future IQPs working for both ANP and GNP may have the opportunity to aid in said outcome assessments through development, deployment, and analysis of the GPS tracking app, as well as surveying visitors on the ground as was done by this team. In order to maximize visitor contact, in-person research should be conducted during the summer or early A-term.

1. Introduction

The National Park Service (NPS) of the United States is dedicated to preserving “unimpaired the natural and cultural resources and values [...] for the enjoyment, education, and inspiration of this and future generations” (NPS, 2018a). Over 20,000 National Park employees aid in maintaining and preserving the wildlife and breathtaking scenery of these 59 National Parks across the United States (NPS, 2018a). Fulfilling this mission has become increasingly difficult as visitor use steadily increases in National Parks. A record 305 million people visited National Parks in 2015. “As the Park Service likes to point out, that's more people than went to every single Disney park, NFL, NBA [...] MLB game and NASCAR race combined” (Siegler, 2016). The NPS is now struggling to simultaneously preserve visitor experience and visitor access to the parks’ natural resources.

Overcrowding challenges the National Parks’ ability to fulfill their purpose, which is “a sense of peak naturalness” (Robbins, 2017). Overcrowding also affects the ecosystem of the entire park, diminishing the quality of wildlife and plant life the park. Trampled vegetation and failing park ecology from human foot traffic are all direct results of people choosing to park in non-designated areas rather than wait in long lines to park in a designated lot. These “visitor-made paths” damage the soil and vegetation, disrupting the ecosystem that National Parks are designed to preserve (Turkewitz, 2017). Excessive wait times and the inability to find proper parking also inconvenience many visitors, diminishing their quality of experience. Visitors who plan their vacation months in advance become gridlocked in traffic and leave the park before getting the chance to enter at all (Turkewitz, 2017).

A multitude of 21st century factors contribute to overcrowding in National Parks. A surge in baby boomer retirees with travel high on their “bucket list” and fear of terrorism in Europe resulted in many people traveling within the United States (Robbins, 2017). The promotion of National Parks to an international audience has also aided in rising congestion. For example, The Utah Office of Tourism released an advertising campaign known as the ‘The Road to Mighty’ which encourages people to explore the five National Parks located within

Utah's borders. This advertising campaign became internationally renowned, and now visitors from Japan to Germany visit these five parks (Robbins, 2017). Social media platforms have also encouraged visitation to the National Parks. When someone posts a beautiful picture from a National Park, a trickle-down effect occurs. Other people view the photo online and visit the National Parks, sometimes just to recreate these photos. This process has accelerated in the past 2-3 years as social media becomes more integrated into society, further increasing the rate of visitation in the National Parks.

Glacier National Park (GNP) has experienced increasing difficulty with balancing visitor experience and natural resource preservation in recent years. GNP spans over one million acres, and is one of the top 10 most visited National Parks (Lomax, 2017). Between 2015 and 2017, visitor use at GNP increased by over 400,000 people during the month of July alone. Though the park is vast, congestion occurs in specific areas of the park where main attraction sites are located, such as Logan Pass, Many Glacier, and Lake McDonald (Backus, 2017). The most popular drive to take in GNP is the "Going to the Sun" road, which easily becomes congested, as it is the only road which traverses the entire park. GNP Ranger Lauren Alley told the Missoulian Press, "...we have received more feedback from visitors in general who are expressing more frustrations that the park isn't meeting their expectations" (Backus, 2017). GNP is currently searching for solutions to maintain their ecosystem and the quality of visitor experience at the park in the face of this increased visitation.

Our project concerns the development of a reservation system design to aid in managing vehicle congestion in GNP, specifically at the Many Glacier (MG) site. This reservation system could prove useful in minimizing traffic congestion and improving overall visitor experience. Another positive effect could be increased visitor satisfaction because visitors would know that they have guaranteed access to the park from their reservations, creating a less stressful experience. A third potential effect of implementing a reservation system would be a greater distribution of visitors throughout the park, allowing the park to be appreciated for all of its beauty, not just a few concentrated sites.

2. Background

GNP is a complex geographic and cultural landscape with a rich history. It has shared its recent explosion in popularity with National Parks all across the United States, many of which have proposed or implemented their own unique reservation systems in order to manage the overwhelming crowds. This section addresses the following topics relevant to the project:

1. A brief overview of GNP and the MG site
2. The recent extent of overcrowding in GNP
3. An overview of other National Park reservation system designs
4. Current GNP reservation policies

2.1 Overview of Glacier National Park

GNP located in Northwest Montana is often referred to as the “Crown of the Continent”. People from across the nation visit Glacier to hike its 10,000-foot mountains, view its towering glaciers, and appreciate the diverse wildlife including wolves, pikas, and grizzly bears (Lomax, 7). Its rustic landscape of towering mountains and wide valleys are the result of billions of years of geologic history, from the collision of the Pacific and Continental plates to the advancements of 1000-foot glaciers in the most recent ice age (Lomax, 300).

The region first became a public reserve when the US government purchased its eastern slopes from the Blackfeet Native American Tribe in 1895. As the Great Northern Railway expanded westward through the region, its founders saw the gorgeous landscape as an opportunity to attract wealthy passengers. As a result, they built many park facilities and high-end hotels including the MG and Glacier Park Lodge hotels to cater to the elite. Between 1919 and 1932, the 50-mile “Transmountain Highway” (now known as “Going-to-the-Sun Road”) was constructed, leading to a boom in camping fueled by the rapid growth of the automobile industry. However, the eras of the Great Depression and WWII brought on travel and fuel restrictions, causing many of the tourist attractions to suffer, and many owners to sell

their facilities to the NPS (Lomax, 316-317). In 1932, it united with Waterton Lakes National Park, Glacier's Canadian sister park, as the world's first international Peace Park (Lomax, 318).

Today, the park consists of over 1 million acres of preserved land and more than 700 miles of trails (Lomax, 7-8). Towards the eastern side of the park lies MG, the host of a hotel and campground of the same name, and one of the park's most popular locations. Sitting at the end of the 12-mile Many Glacier Road, the site is named for the five miniature glaciers which occupy its mountain peaks (Lomax, 133-135). The site hosts a boat tour and the heads of multiple extensive hiking trails, including the 52-mile Northern Circle (Lomax, 132). Sightseers visit MG to take in the soothing lakes and meadows, gorgeous sunset, and (on a rare occasion) a glimpse of the northern lights (Lomax, 131).

According to its 2016 Foundation Document, the purpose of GNP is "to preserve the scenic glacially carved landscape, wildlife, natural processes, and cultural heritage at the heart of the Crown of the Continent for the benefit, enjoyment, and understanding of the public" (4). Despite Glacier's best efforts, human factors alter the landscape. Today, less than 17% of the 150 glaciers present in the park during the early 1900s remain. The remaining 25 are expected to melt by 2030 (Lomax, 301), likely due in part to rising global temperatures brought on by climate change. Additionally, a national rise in park tourism is resulting in record visitation during the summer, resulting in long lines in some hiking trails and packed park shuttles (Lomax, 15). In this state of increasing overcrowding, the park's two goals of preserving the landscape and making it accessible to the public may begin to stand at odds with one another.

2.2 Overcrowding in Glacier National Park

Visitation to National Parks across the United States reached record highs within the past 3 years. The scope of this project includes understanding the extent and causes of overcrowding in GNP, specifically at the MG site, during peak activity months. As shown in Table 1, the total recreational visitor use at GNP during the month of July between 2015 and 2017 increased by over 300,000 visitors. Increased recreational visits also boosted visitor recreation hours from 8.7 to 11.8 million hours during this time period.

Table 1. Visitor Use at GNP in July

Year	Recreational Visitors	Non-Recreation Visitors	Recreation Visitor Hours	Non-Recreation Visitor Hours
2015	689,064	4,813	8,711,798	43,317
2016	818,481	4,679	9,968,386	42,111
2017	1,009,665	4,171	11,790,317	37,539

Obtained from National Park Service (2017). "Summary of Visitor Use By Month and Year (1979 to Last Calendar Year)".

This initial observation is further analyzed through the data provided by the National Park Service to determine specific pass sites that experience vehicular congestion. The site experiencing the worst vehicular congestion within the past 3 years is the MG site. As shown in Table 2 below, MG traffic counters recorded over 40,000 cars entered MG during the month of July in 2017. The St. Mary site also experienced heightened traffic congestion between 2015 and 2016. However, it is plausible that St. Mary would experience increased vehicle congestion, as it is the endpoint of the "Going to the Sun" Road, which is an entrance to the park. MG, however, is the only pass site located farther into the park (as shown in Figure 1) that experiences severe traffic congestion. The researchers at the Crown of the Continent Research and Learning Center, located within GNP, anecdotally supported this data, describing how MG experiences severe traffic blocks, to the extent where the MG site had to be shut down in the summer of 2017.

Table 2. GNP Traffic Counts by Location in July

Year	Many Glacier	Polebridge	Two Medicine	St. Mary Lane 2
2015	34,060	7,121	19,290	25,823
2016	37,518	8,206	19,996	37,553

2017	40,815	12,914	19,533	N/A
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Obtained from National Park Service (2017). "Traffic Counts By Location". United States Department of the Interior.

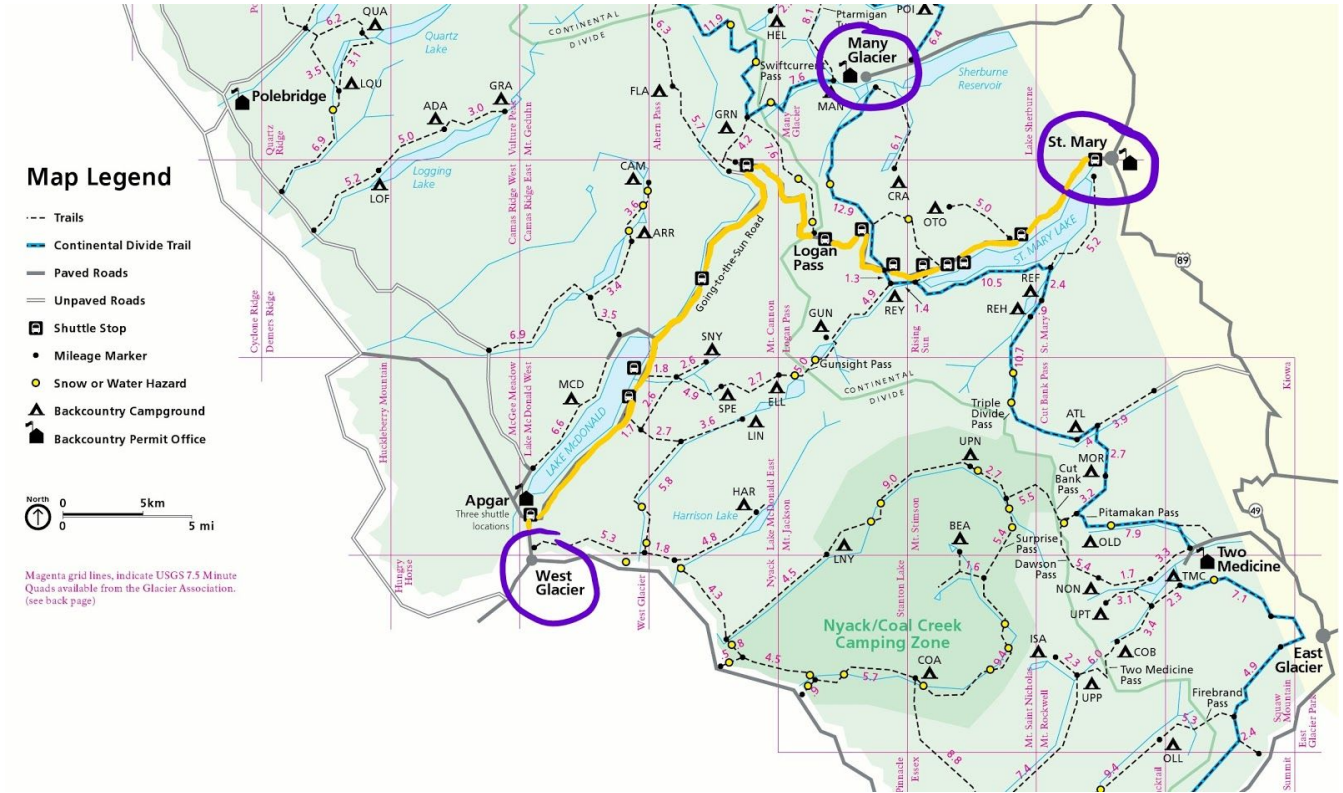


Figure 1: High Traffic Congestion Areas in GNP

2.3 Many Glacier Parking Infrastructure

MG currently has a variety of resources and strategies for managing traffic. These include a manned gate, distributed parking lots, and long-distance communication. This section discusses them in detail as they pertain to a potential reservation system at MG. The MG site is located at the end of an 11.5-mile road which begins outside the park. The manned booth is 7.5 miles in, and covers both entering and exiting vehicles, as shown in Figure 2.



Figure 2: Manned Gate at Many Glacier

Currently, this gate is used to check park passes and aid in congestion management when required. According to our sponsor, there is no hard metric for closing or restricting visitor access to MG during times of high congestion. However, park rangers communicate and close the entrance gate when they judge the parking lots to be at or near full capacity, then implement a one-car-in-one-car-out system. While sufficient to prevent a gridlock catastrophe in MG, this system still results in major inconveniences for park visitors, who must drive back at least 7.5 miles to the nearest highway intersection if they are not willing to wait potentially all day to get a parking space.

MG has four major parking lots, located at the Many Glacier Hotel, the Grinnell trailhead, the Swiftcurrent Motor Inn, and the Iceberg trailheads. Lots are shown with space counts in Figures 3 through 6. According to our sponsor, park rangers have responded to impromptu parallel parking by drawing in parallel parking space lines in an attempt to increase spatial efficiency. Thus, standard and parallel spaces were counted separately. Extended spaces refer to long parking spaces for RVs or trailers.

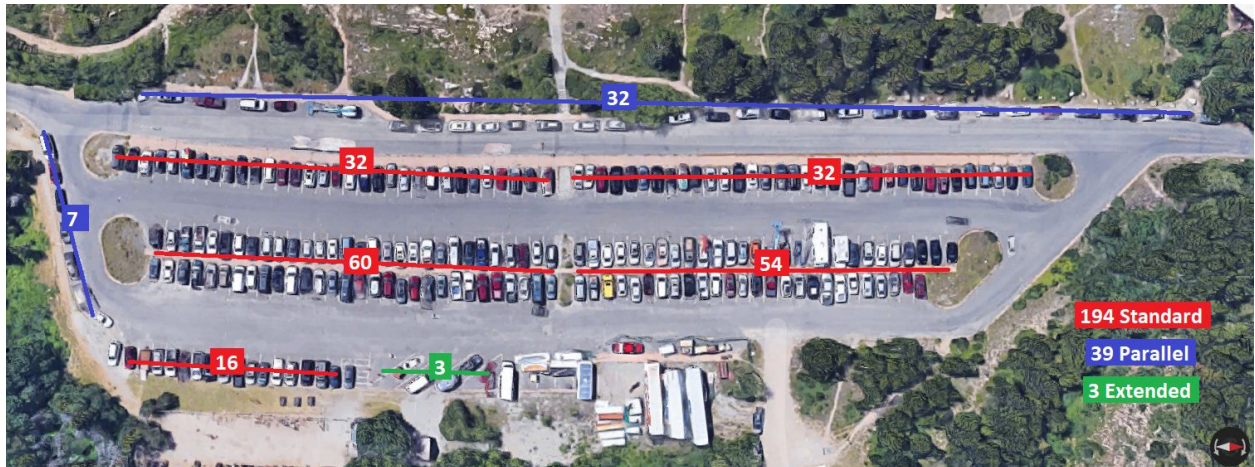


Figure 3: Many Glacier Hotel Parking Lot



Figure 4: Grinnell Trailhead Parking Lot

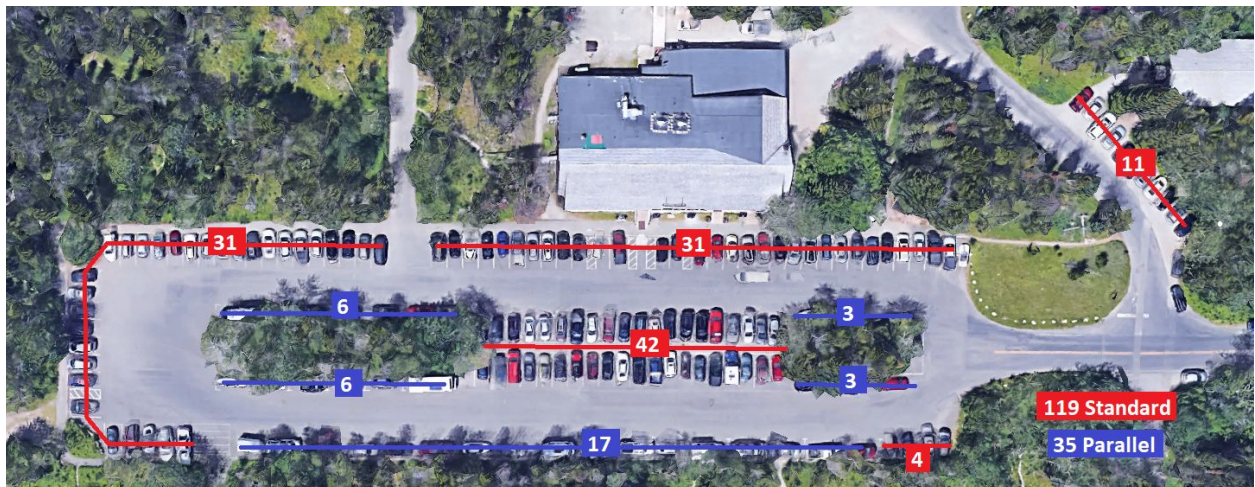


Figure 5: Swiftcurrent Motor Inn Parking Lot

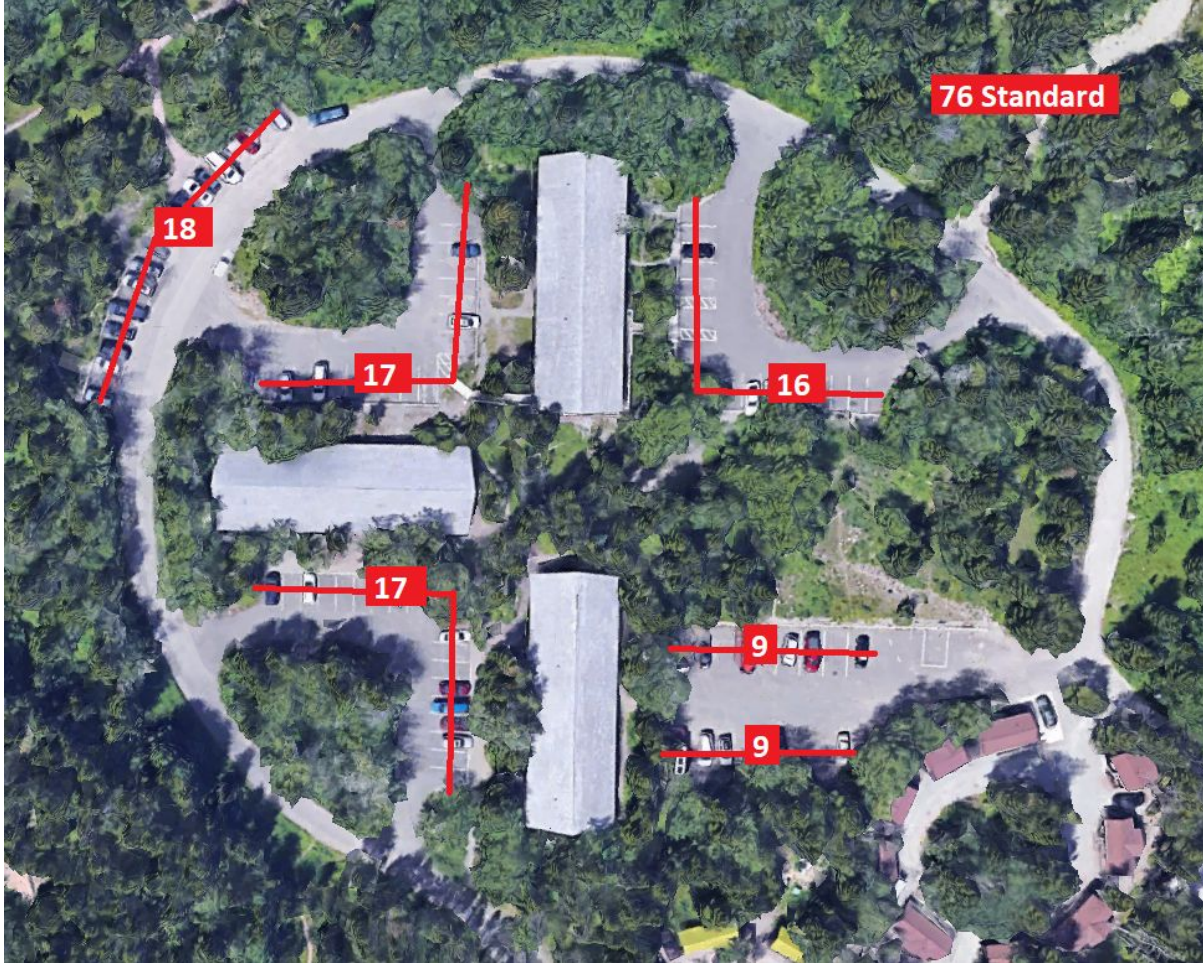


Figure 6: Iceberg Trailheads Parking Lot

The total count for all four main parking lots is 424 standard, 132 parallel, and 3 extended spaces. While there are many other smaller areas in which cars park during congestion, we assume the park does not want these spaces to be used for extended parking. Depending on whether or not the park staff wishes to continue allowing parallel parking, this puts the vehicle carrying capacity of the park between 427 and 559 cars.

2.4 Existing Reservation System Infrastructures

The issue of overcrowding has recently become the concern of many National Parks aside from GNP. However, due to the recency of this issue, finding fully-developed reservation systems to analyze and use as models presents a challenge. To best overcome this, we will examine key policies of the NPS and the individual National Parks and their effects on overcrowding. Afterwards, we will explore how to improve functionality and efficiency by centralizing independent visitor use policies and exploring how this can be utilized to perform real time system development. This information is our basis for fully understanding a wide range of policies that collectively form a reservation system.

2.4.1 Visitor Use Policies to Combat Overcrowding

To combat overcrowding, many National Parks have developed and implemented independent policies to manage visitor use. These are classified as components of a reservation system (not to be confused with a reservation system itself) and focus on alleviating visitor traffic and congestion at targeted areas of the park.

2.4.1.2 Standard Policy

The National Parks are governed by the NPS, which standardizes the use of specific policies to ensure that basic measures are taken to manage visitor use in every park. One standard policy is the universal park pass, which allows a visitor to enter any of the National Parks. Discounts for obtaining annual and single use passes are available for senior citizens, military personnel, and NPS affiliated volunteers. This policy makes entering the parks as easy as presenting your pass at the park entrance (NPS, 2018b).

Another standard policy under the NPS is park visitor centers, which provide a one stop location for visitor information on park activities, guidelines, safety, and medical/emergency services. Activities that require special permits or reservations can be also be obtained by contacting the appropriate visitor center. These policies are most often managed on a call/walk-in basis overseen by the park staff member(s) on duty (NPS, 2018c).

When the National Parks first opened, the need for extensive regulation on visitor use was not required to support the limited traffic, but as National Parks gained popularity, these policies have become overwhelmingly unsatisfactory in managing overcrowding. Lately, “both visitors and nature are suffering. [...] some people showed up for a vacation they had planned for months, spent a day in the gridlock and turned around. Rangers, stressed by the frustrated masses, have started a monthly meeting to discuss ‘visitor use’ that some say has turned into a group-therapy session”. The natural response by many National Parks has been to implement park-specific policies that target their individual needs (Turkewitz, 2017).

2.4.1.3 Shuttle Systems at Zion National Park

In 2000, Zion National Park (ZNP) realized “traffic and air pollution got so bad... that the park banned cars at certain times” to prevent excessive lines from forming on roads (Siegler 2016). Their solution to overwhelming traffic was the implementation of a shuttle system, depicted in Figure 7, as an alternative to private vehicles for visitor transportation.



Figure 7: A Stop at the ZNP Shuttle Service

However as of 2016, they “had lines 300 deep just to get on a shuttle bus that goes from the park to the visitors center”. They were a prime “example of how parks can better manage crowds. But [...it was] getting stretched to its limit”. Ultimately the park decided an updated fleet of buses could solve their issues of overcrowding, and in 2018 ZNP expanded their existing fleet and widened roads. These improvements to the parks shuttle system allowed them to close roads to private vehicles during the shuttles’ hours of operation (Sieglar 2016).

2.4.1.4 Reservation Policies at Muir Woods National Monument

Due to the massive influx of visitors in recent years at the Muir Woods National Monument (MWNM), the NPS has launched a parking and shuttle reservation system “[to] improve visitor experience and enhance the protection of park resources” (Marin Center, 2018). Visitors to MWNM bring private vehicles that congest parking lots and the parks limited roads. The NPS hopes that a parking and shuttle reservation system “will allow us to proactively manage visitation to provide a safer and more enjoyable experience for visitors and better protection for the trees”. Information about how to make parking and shuttle reservations can be found on their website GoMuirWoods.com (NPS, 2018e).

The new parking and shuttle reservation system was implemented was implemented in January of 2018 in “hopes [that] opening the system in the quiet of winter will help them work out any problems before the next big test — spring break, when visitation begins to pick up” (Nolte, 2018).

2.4.1.5 Infrastructure and Parking at Yosemite National Park

In the Final Yosemite Valley Plan, Yosemite National Park (YNP) outlined its goals, which included reducing traffic congestion and overcrowding. The park’s preferred plan is to restore 176 acres of developed land in Yosemite to natural conditions and expand on 73 acres of currently undeveloped land for visitor and employee services like day-visitor parking. The plan also aimed to shift day-visitor parking outside of Yosemite Valley (Mihalic, 34), and mentioned a regional transportation system as “a preferred long-term approach for transporting people to the park” (Mihalic, 26).

Current development of the Mariposa Grove restoration project as part of their proposed plan is almost complete and scheduled to reopen on June 15, 2018. The restoration, depicted in Figure 8, will feature repaired park structures at Wawona Point and a new trailhead going to Grizzly Giant, both popular destination of YNP. The restoration will also entail the removal of some roads in the Mariposa Grove, a new parking area, restroom, and shuttle stop in the lower grove. In addition, there be a new service road for park staff use to bypass the lower grove (NPS, 2018f).



Figure 8: Mariposa Grove Road and Trail Closures during Restoration

In addition to the Mariposa Grove restoration project, YNP offered a limited number of day parking spots for reservation on weekends in August, the busiest month of the year. YNP has stated that anyone entering the park on weekends in August “are strongly encouraged to book a parking reservation today to guarantee a smooth parking experience”). The park hopes that “[securing] a free day parking reservation in Yosemite Valley will greatly enhance a visitor’s experience during weekends in August, the park’s busiest month”. Parking reservations to YNP can be made on Recreation.gov (NPS, 2018d).

2.4.1.6 Sunrise Reservations at Haleakala National Park

In Haleakala National Park (HNP), park staff observed heightened congestion in the Summit District between 3am - 7am as visitors arrived to watch the sunrise over the parks volcanoes. There are only 150 parking spaces available at the Summit District parking lot, and cars were circling the lot for hours at a time to find a space (Haleakala, 2017). As shown in Figure 9, HNP instituted a link through Recreation.gov, a federally run website for park reservations, that allows visitors to make a sunrise reservation online.

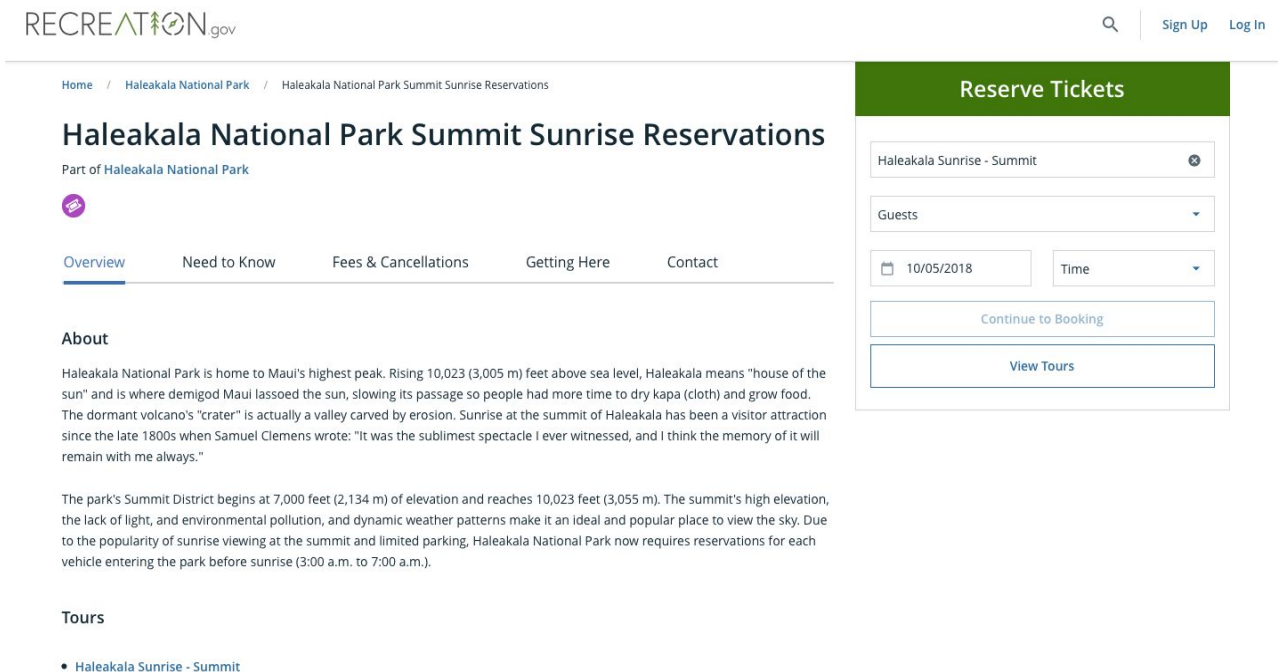


Figure 9: Haleakala National Park Reservations through Recreation.gov

Visitors obtain a 1-time parking spot through their reservation on Recreation.gov at least 1 day before arriving to the park that includes an additional \$1.50 fee for park entrance. If a visitor arrives at the gate without a printed reservation and a photo ID, they will be asked to leave the park, eliminating any issue of overcrowding on park roads and parking lots during the the implement hours (Haleakala, 2017). Table 3 displays a summary chart of each reservation system and its respective features.

Table 3: Summary of Other National Park Reservation Systems

Name of Park	Reservation Times	System on the Ground	Fees	Making a Reservation	Number of Reservations	Advance Notice
Haleakala	3 am - 7 am	Manned Gate	\$1.50 per vehicle	Recreation.gov	1 vehicle reservation per day	24 hours before visit, no refunded reservations
Muir Woods	Operating Park Hours	On Site Parking Attendants	\$8 per vehicle	GoMuirWoods.com	10 vehicle reservations per day	5 days before visit, 72 hours for refunded cancellation
Yosemite	August weekends, 7:30 am-4 pm	No Information	\$1.50 per vehicle	Recreation.gov or 1-877-444-6777	1 vehicle reservation per day	No Information

2.4.2 Centralized Systems

While a reservation system can function given an array of independent policies, most National Parks and other federal outdoor programs have begun to centralize their reservation systems to automate the process and introduce functionalities like web pages and phone applications that increase the efficiency of the reservation process.

2.4.2.1 Recreation.gov

Already mentioned because of its use in the HNP sunrise reservation policy, Recreation.gov is a federally managed website by the National Recreation Reservation Service (NRRS, 2018a). This website allows any federal outdoor program to create a custom set of links for online reservations to activities and attractions in the park. Nearly all National Parks, including those previously discussed, use Recreation.gov to manage their campsite and activity program reservations to relieve the workload of park staff during peak seasons by decreasing the frequency of call/walk-in services. As seen in Figure 10, each campground/activity webpage is complete with an overview its activities and general guidelines to followed with suggestions for nearby attractions(NRRS, 2018b).

The screenshot shows the Recreation.gov website interface for the South Campground (Ut) at Zion National Park. At the top, there is a search bar containing 'Zion National Park' and links for 'Sign Up' and 'Log In'. The main content area features a breadcrumb trail: 'Home / Zion National Park / South Campground (Ut)'. The title 'South Campground (Ut)' is prominently displayed, followed by 'Part of Zion National Park' and a small icon. Below this is a navigation menu with tabs for 'Overview', 'Need to Know', 'Fees & Cancellation', 'Getting Here', and 'Contact'. The 'Overview' tab is selected. The main text describes the campground as an ideal place to stay, noting that reservations are available 14 days ahead of arrival and that the campground is accessible via shuttle bus from February to November. It also mentions that the campground is open from March 1st to the Monday after Thanksgiving in November. A 'Facilities' section lists amenities such as flush toilets, drinking water, picnic tables, firepits, and a dump station, and notes that four group sites are available for RVs and tents. On the right side, there is a reservation interface with a 'Check in' field, a 'Check out' field, a 'Show Sites' button, and a 'Check Availability' button. Below this, it shows '92 Site(s) Total' and an 'Additional Information' section with links for 'Utah State Tourism' and 'Utah State Road Conditions'.

Figure 10: Reservations for the South Campground at ZNP

Using Recreation.gov, visitors can make reservations by searching for their desired location or activity and indicating their available arrival and departure dates, type of reservation, any requested accommodations, and vehicle information. After specifying the details of their desired reservation, visitors can see all the available reservations and choose one accordingly; if no reservations are available on the specified dates, visitors can browse all upcoming dates for an open reservation as seen in Figure 11 (NRRS, 2018c).

10/11/2018 Filters

Home / Zion National Park / South Campground (Ut) / Availability Expand Table

Check Availability

For South Campground (Ut)

< OCT 2018 > Clear Dates Next Available < Prev 5 Days Next 5 Days >

Sites	Loop	THU 11	FRI 12	SAT 13	SUN 14	MON 15	TUE 16	WED 17	THU 18	FRI 19	SAT 20
003	SOUTH CAMPGROUND (UT)										
004	SOUTH CAMPGROUND (UT)										
005	SOUTH CAMPGROUND (UT)										
006	SOUTH CAMPGROUND (UT)										
007	SOUTH CAMPGROUND (UT)										

A W

 Available Walk-up Unavailable Not Yet Released

0 Campsite Selected Book Now

We're unable to display map locations at this time. We're sorry for any inconvenience as we continue to update our data.

Catoctin Mountain Park

Catoctin Mountain, 1877 ft

mapbox

Figure 11: Upcoming Reservations for South Campground at ZNP

In addition to offering reservation services, Recreation.gov can be used to look up general information about National Parks. By using the main search feature of the site, visitors can look up web pages and articles dedicated to providing an overview of individual park attractions. It can also be used to obtain special permits that might be required for hazardous or specialized activities like backcountry camping or traditional rock climbing (NRRS, 2018d).

2.4.2.2 Your Pass Now

Another centralized reservation system is the Your Pass Now (<https://yourpassnow.com>) website that allows visitors to obtain passes to federal and state public lands online. Similar to Recreation.gov, visitors enter their destination and are directed to a list of passes available for that destination. Included on a destinations page is a “Know before you go” section that details all the information a visitor may need before booking their pass (NIC Federal, 2016). This section is shown in Figure 12.

Pass Info

Pass Type *

Visitor Info

First Name *

Last Name *

Visitor Email *

Re-Enter Visitor Email *

Know Before You Go

All park visitors are required to pay an entrance fee upon entry May – October.

When heading directly to a trailhead, in a personal vehicle, please print a hard copy pass. The pass may reside on a mobile device if first stopping at a fee station.

Riding the Island Explorer? Remember that Individual passes are \$15.00 per person not to exceed the \$30.00 Private Vehicle rate for a single family or group traveling together.

Fees are waived at National Park Service-managed sites on the [following days](#):

- January 15, 2018 – Martin Luther King, Jr Day
- April 21, 2018 – First Day of National Park Week
- September 22, 2018 – National Public Lands Day
- November 11, 2018 – Veterans Day

Need Help?

The customer service team is available Monday ? Thursday from 8 AM to 6 PM ET and on Friday from 8 AM to 5 PM ET. You may call toll-free 1-877-230-6283 or email yourpassnow@egov.com.

[Review FAQs...](#)

[Add Pass >](#)

Figure 12: Booking a pass on Your Pass Now

2.4.3 Real-Time System Development

After a system has been centralized, possibilities arise to develop the reservation system on a real-time basis, as opposed to a cause/effect analysis and response to reservation system optimizations. Using measures like custom applications, data analytics, and simulations, it is possible to monitor visitor traffic and target key areas in the park where policies need to be

altered or implemented. Because of the recent increase of overcrowding, aside from independent studies, there are no current reservation systems in NPS that provide insight into potential real time systems. However, similar concepts are seen throughout a multitude of custom developed systems.

The hotel industry has a long history of reservation systems and currently, through the use of data mining and big data analytics, many independent branches segment “guests according to booking trends, behavior and other factors in order to reveal their likelihood to respond to promotions and emerging travel trends”. By using predictive analytics such as this, hoteliers can help “figure out why things are happening, show [...] what will happen next, or even lead [...] to the best alternative action considering all [...] operating constraints”. This allows the hoteliers to stay ahead of trends in a highly competitive industry (Dragosavac, 2015).

2.4.4 Current Infrastructure of the Glacier National Park Reservation System

The current infrastructure of GNP reservation systems encompasses 4 options: standard park entrances where the National Parks pass is required to enter, visitor centers where visitors can make walk/call-in reservations (NPS, 2017a), online park pass registration through yourpassnow.com, and online reservations on Recreation.gov for 4 of their 13 campgrounds (NRRS, 2018d). Alongside the policies implemented by GNP, the concessionary services found inside the park manage their reservations through private websites; these reservations are unregulated by GNP reservation policy outside the restrictions outlined in their individual commission documentation. There is currently no concrete policy intended to manage visitor use of roads and parking lots. In MG, if visitor parking lots are “too full”, a metric which is determined by the staff members managing the MG entrance, the entrance gate is closed and vehicles are let in on a one vehicle in one vehicle out basis.

3. Methods

This project is intended to provide GNP with policy recommendations for a reservation system at MG to reduce overcrowding. By managing and guaranteeing visitor entrance factors such as dates, times, and parking locations, the system will improve visitor experience and help preserve the natural resources in the area for future generations to appreciate. Developing a system which effectively meets the goals and needs of GNP will require understanding the magnitude and impacts of overcrowding, the perspectives and influence of key stakeholders, and the resources and capabilities of the park staff.

The project objectives are as follows:

1. Understand visitation patterns in MG and visitor needs regarding reservations
2. Understand park staff perspectives, resources, and capabilities relating to the implementation of a reservation system.
3. Assess and propose reservation system design options for MG
4. Propose methods for outcome assessments for the park staff

The final deliverable of the project will be a set of policy recommendations for reservation system parameters and an implementation strategy, as well as the raw data and analysis collected from surveys and interviews with stakeholders.

3.1 Objective 1

The first objective of the project was to understand visitor perspectives on overcrowding and opinions on the implementation of a reservation system. Our team encountered initial difficulties when implementing this method, such as relocation, time constraints, and team resource consumption. Our team was relocated to ANP for the first four weeks of the project term due to severe wildfires in GNP at the end of August.

To supplement a lack of responses in GNP, our team conducted surveys in Acadia National Park at 2 sites, Cadillac Mountain and Jordan Pond, during this time period to use as reference material for sponsors upon arrival in GNP. Our team examined visitor use studies

from the Crown of the Continent Research Center and the University of Montana to supplement the lack of Glacier survey responses. This helped out team determine features of the reservation system, such as average length of stay at MG and booking methods for other activities such as horseback riding and hotel reservations. To best achieve our first objective, a survey was administered to visitors as they entered the specific park sites (See Appendix A). Figure 13 displays the parameters for a parking reservation system that we asked visitors to comment on through our survey.



Figure 13: Surveying ANP Visitors to Address Key Research Questions

The goal of these surveys was to determine the parameters of a reservation system that satisfied the average visitor’s requirements for using such a system. These surveys were conducted as a sample of convenience, asking visitors to fill out a two-minute survey as they passed our team at Cadillac Mountain and Jordan Pond. Our sampling occurred on weekdays in during peak visitation hours (10 am - 3pm) in the park to maximize the amount of responses that we received. Visitors physically took the surveys through using a team member’s phone to

view an online app called Brew Survey (<https://brewsurvey.com>). This app allowed visitors to take surveys in an offline environment, as there is limited cellular connectivity in national parks. Figure 14 displays screenshots of the survey that visitors completed in Acadia National Park.

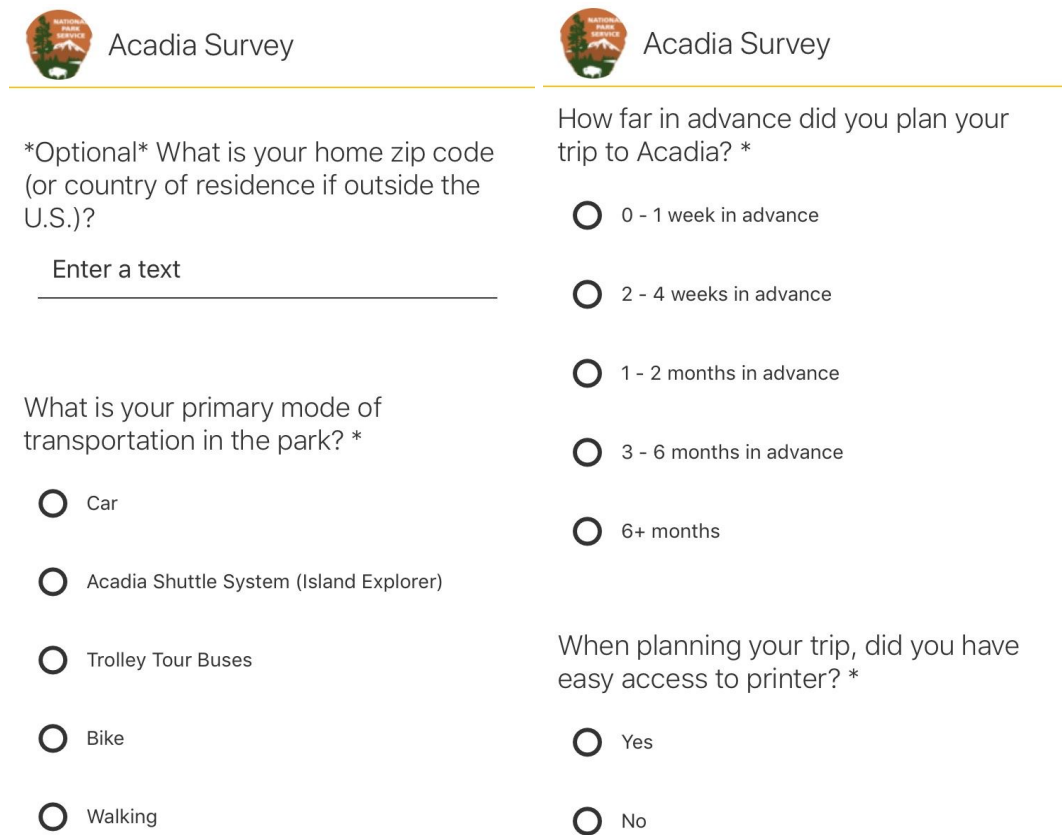


Figure 14: Acadia Parking Reservation Survey Displayed on Brew Survey

Additionally, Brew Survey allows survey data to be exported as an Excel file, so a set of Matlab functions and scripts was developed to automatically process the survey data, count the number of completed responses, and generate overall and conditional pie charts of the responses to each question (see Appendix C).

3.2 Objective 2

The second objective addressed another primary stakeholder group: park staff. Our team investigated staff perspectives on overcrowding in MG and their opinions on different styles of reservation systems, as they will be the stakeholder group that implements the reservation system. Due to relocation to ANP, communication with park staff was primarily

through email, and then casual interviews upon arrival in GNP. While in Acadia National Park, Our team communicated with John Kelly, Management Assistant at Acadia National Park, via email and in person during 2 group meetings. Our team simultaneously communicated with Tara Carolin, Director of the Crown of the Continent Research Center in GNP, via email and in person when arriving to GNP. Our team answered two primary questions through our discussions with John and Tara, which are listed below:

1. To what extent should visitor opinions influence the parking reservation system?
2. What limitations (electronic, staff, infrastructure) do park staff want our team to consider when designing this reservation system?

This stakeholder group held significant influence over our team's final proposal for a reservation system, as park staff had to be willing to implement this system if it is to be effective. Our designs catered to the staff's technology preferences and capabilities as well as the need for sufficient system training.

3.3 Objective 3

The third objective of this project was to assess and propose reservation system design options for MG. Given the information about the social complexities and current measures used by other National Parks, we fully analyzed the potential impacts of implementing new independent policies MG to develop the current GNP reservation system. Our proposal consisted of two main types of recommendations:

1. Independent visitor-use policies
2. Policies for a centralized reservation system

With the inclusion of these two components, we were able to propose a reservation system design that outlined a plan to resolve all current and foreseeable issues of overcrowding in MG.

3.3.1 Recommendations for Independent Visitor-Use Policies

The main focus of our proposal was to recommend independent visitor-use policies to combat overcrowding in MG. Using policies from other National Parks, our team assessed each to determine the complexity and feasibility according to a given set of metrics. Metrics we considered included:

1. Reservation Time Length
2. Reservation Booking Method
3. Reservation Fees
4. Maximum Number of Reservations
5. Advance Booking and Cancellations
6. Enforcing Reservations through Physical Systems

Current policies we considered because of their direct impacts on overcrowding included:

1. Implementing a bus/shuttle system
2. Encouraging visitors to park outside the park
3. Reservations changed to include a parking spot
4. Increase functionality of gateway monitoring at park entrances

The goal of recommending independent visitor-use policies was to allow the park to take immediate action against overcrowding without the requirement of extensive modification to the existing reservation system.

3.3.2 Recommendations for a Centralized Reservation System

The second priority of our proposal was to recommend a plan to centralize the portion of the GNP reservation system that managed MG. Recreation.gov was our team's best solution to conveniently implementing this plan because it provided the basic functionality required and was already used by GNP.

Updates to Recreation.gov to consider included:

1. Adding an included parking spot with online reservations to all current reservations
2. Expand Recreation.gov to include concessionary services' reservation information

Another option to consider was a custom web application that would replace Recreation.gov as the reservation system database manager; it would keep the same basic functionalities and the above recommendations would be considered in its implementation. The focus here was to switch the platform of the current GNP reservation system to make development more feasible due to it being hosted locally in the park instead of through a 3rd party provider. The goal of centralizing the portion of the current GNP reservation system in MG was to provide GNP with one user interface that can view and manage all the information pertaining to reservation systems and reservation system policies.

3.4 Objective 4

The final objective of this project was to assess the outcomes of the reservation system implemented in MG. Given that there is no current metric to assess the outcomes of a reservation system in the National Parks, we developed a phone application to track users using GPS location based services. The final product of the GPS location based service tracking phone application was developed on the android platform in order to accomplish these main tasks:

1. Track a user using GPS location based services and timestamp
2. Store the tracking information locally on the device
3. Upload the information to an online database when internet services are available
4. Remove tracking information from the device after it has been uploaded online

Once a significant amount of data had been uploaded to the resulting online database, data analytics can be performed to observe visitor use trends and predict future visitor behavior. The full source code is included in Appendix D.

4. Results and Analysis

Due to wildfires at GNP which extended into the project term, the project work was transferred to Acadia National Park (ANP) for the first four weeks and finished at GNP during the final three weeks. The new goal was to conduct similar reservation research for ANP and use the information to inform a more narrowly-scoped effort in GNP. Unlike GNP staff, ANP staff already firmly intended to implement a parking reservation system by 2020, and wanted to know visitor opinions regarding parameters of the system as well as inexpensive methods for quickly implementing a system and gathering outcome assessments. Thus, the GNP visitor survey was adapted to and administered at ANP as well as GNP for similar purposes (see Appendix B).

4.1 Surveys for Acadia National Park

Our team surveyed 340 visitors at ANP at the two most congested sites: 230 from Cadillac Mountain and 110 from Jordan Pond. A question was added to the survey to indicate survey location, as ANP staff suspected differing results from the two sites. This section will present and analyze relevant survey results and findings.

4.1.1 Park Visitation History

The majority of park respondents were visiting for the first time, as shown in Figure 15.

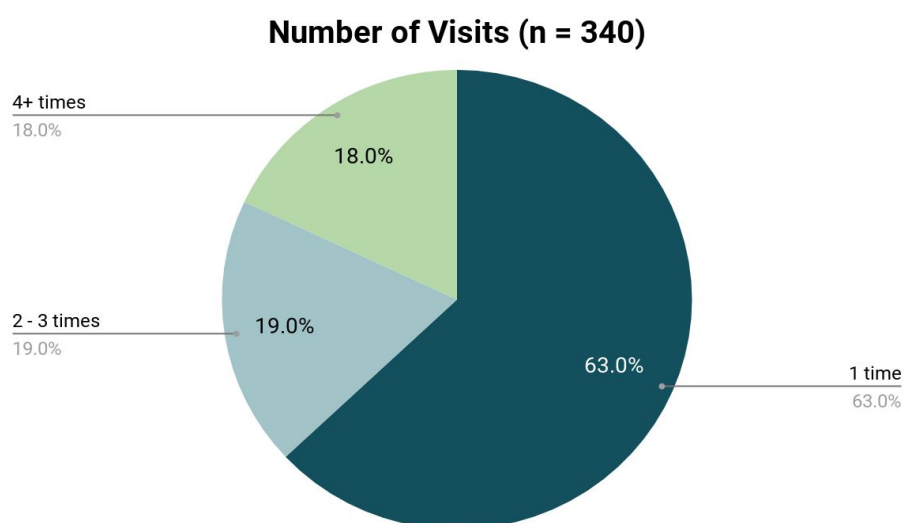


Figure 15. Distribution of Number of ANP Visits

This logically follows the trend of rapidly increasing national park visitation in the past decade. This is also beneficial to ANP, as first-time visitors are less likely to oppose changes in a park visitation system given a lack of previous park experience.

4.1.2 In-Park Transportation

Park visitors were also asked of their primary mode of transportation in the park. The responses differed significantly between Cadillac Mountain and Jordan Pond, as shown below:

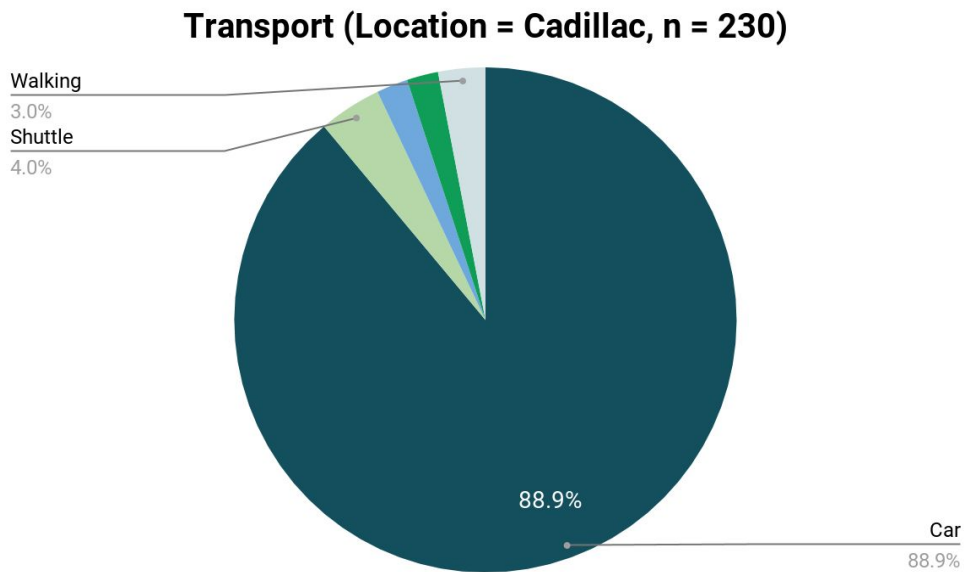


Figure 16: Visitor Transportation at Cadillac Mountain

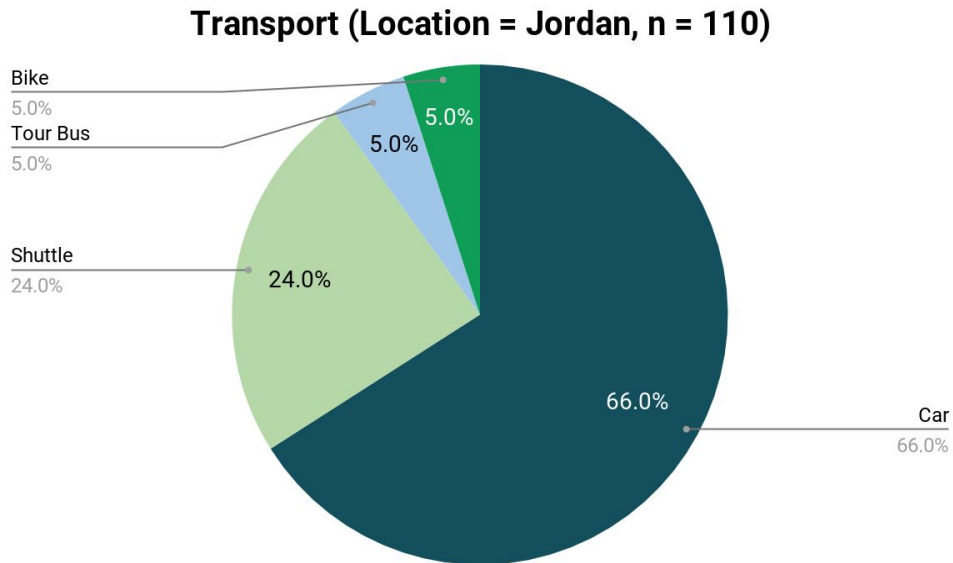


Figure 17: Visitor Transportation at Jordan Pond

At Cadillac Mountain, approximately 90% of respondents reported using cars. At Jordan Pond, while the majority still reported using cars, nearly one in four people used the Acadia shuttle system, a network of buses used for transporting visitors within the park boundaries. This difference is expected, as the shuttle system does not visit the top of Cadillac Mountain. These results indicate both the popularity of the shuttle system when available and the potential to significantly reduce visitor congestion through a private vehicle parking reservation system, as the park desired.

4.1.3 Length of Parking Reservation

At each site, visitors were asked how long they would want to reserve a parking space for. Again, the result differed significantly between Cadillac Mountain and Jordan Pond, as shown in Figure 18 and Figure 19.

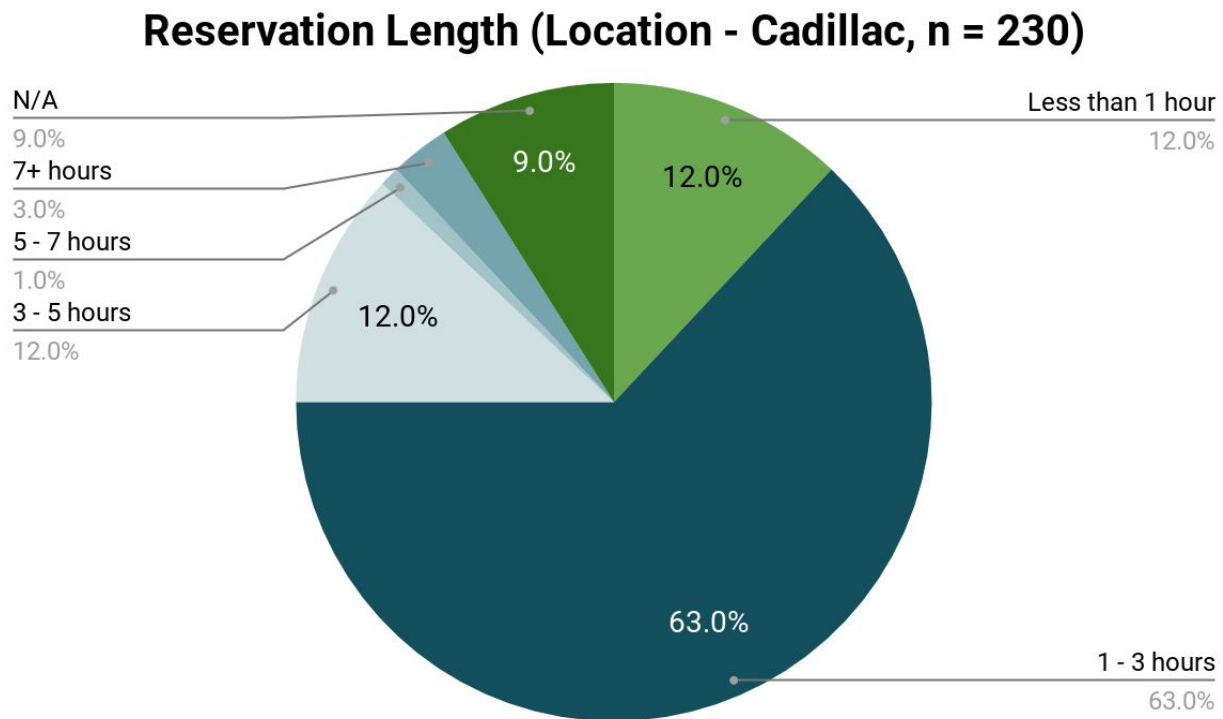


Figure 18: Desired Reservation Durations at Cadillac Mountain

Reservation length (Location - Jordan, n = 110)

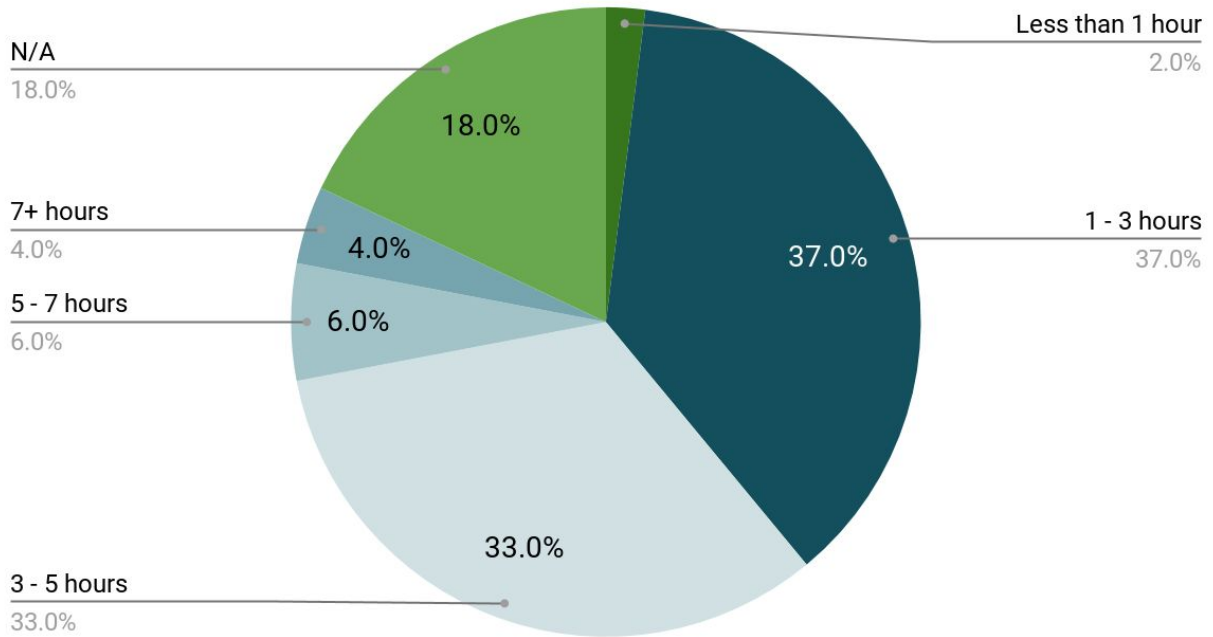


Figure 19: Desired Reservation Durations at Jordan Pond

Note that the 'NA' response was offered for people who expressed that they would not participate in the reservation system if it were implemented. Of those who did not respond 'NA', 82% of Cadillac Mountain visitors supported reservations under 3 hours. At Jordan Pond, however, only 48% of respondents fell into said category, with a much larger 88% preferring a reservation under 5 hours. This is likely due to the differing activities between the two locations. Most Cadillac Mountain visitors drive to the top to briefly appreciate the scenery before moving on. In contrast, Jordan Pond has a restaurant and is a focal point for many casual hiking trails and carriage roads, encouraging visitors to stay for longer durations. As a result, we recommended that ANP staff set up 3 hour block reservations for Cadillac Mountain and 5 hour block reservations for Jordan Pond. When considering GNP, this finding shows that the activities associated with a location should play a significant role in the duration of a reservation.

4.1.4 Reservation Booking Method

Visitors were also asked for their preferred method of booking a reservation. The results are shown in Figure 20.

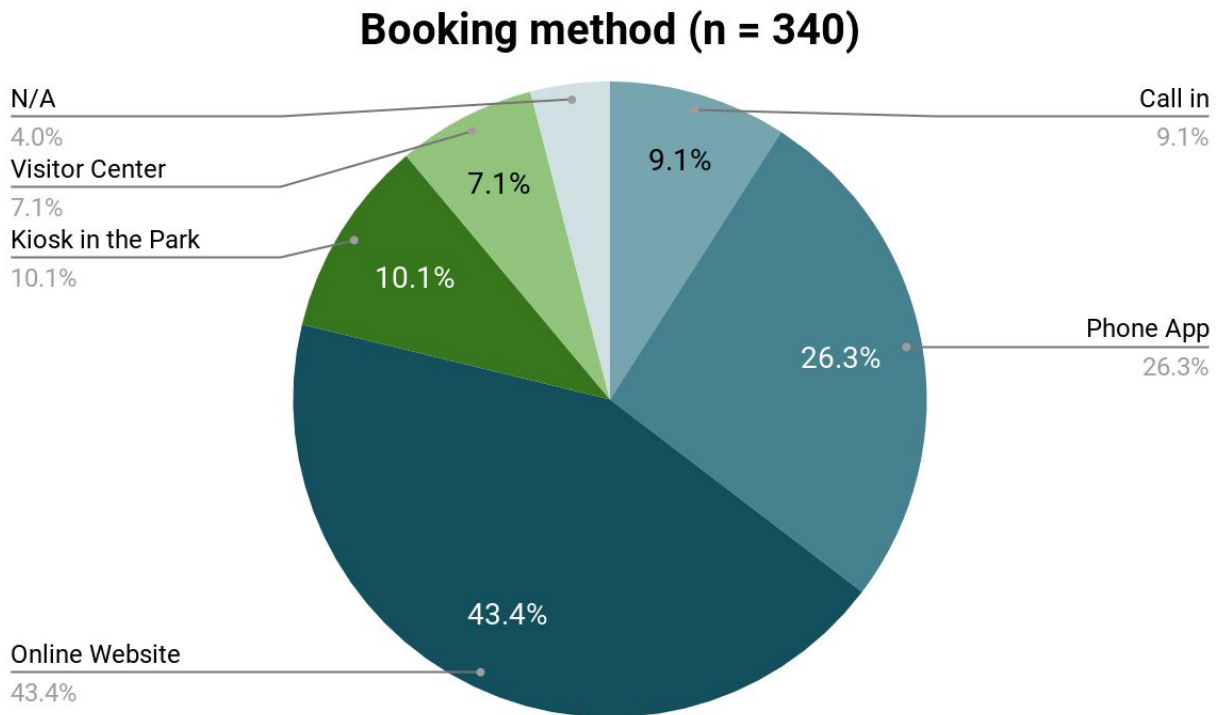


Figure 20: Preferred Reservation Booking Methods at ANP

Of those who picked an option, an 82% majority preferred remote methods (online, app, and call-in). However, a significant 18% minority still preferred on-site methods (visitor center and kiosks). As a result, we recommended that ANP staff set up the reservation system online, with available call-in and visitor center assistance for those unfamiliar or incapable with online methods. When considering GNP, this finding shows that a general visitor would prefer remote booking methods over in person methods, as it allows for advance planning of their itinerary.

4.1.5 Reservation Fee

Visitors were asked the maximum amount they would be willing to pay for a reservation at the given site. The results are shown in Figure 21. Those who responded 'NA' would not be willing to reserve a space, even if it was free.

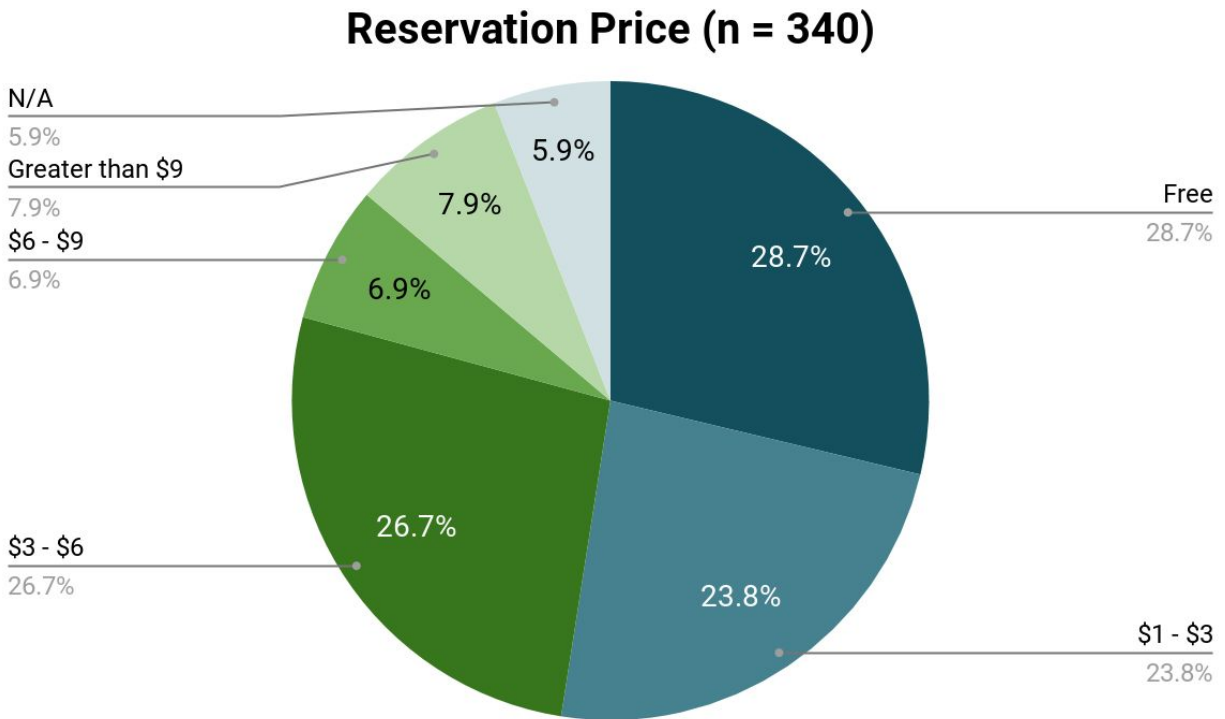


Figure 21: Maximum Preferred Reservation Fees for ANP

Of those who did not respond 'NA', 76% were willing to pay while 24% believed the reservation should be free. Of those willing to pay, only 23% were willing to pay more than \$6. Because the ANP staff intended to use the reservation fees to maintain and expand the Acadia Shuttle System, we recommended they charge no more than \$5 per reservation and advertise their funding intentions in order to best finance their goal.

4.1.6 Support for a Mandatory Reservation System

Finally, ANP visitors were asked whether or not they would support a mandatory reservation system at popular destination sites in the park to minimize traffic congestion. The results are shown in Figure 22. Note the three 'Yes' options. The early versions of the survey only had options 'Yes', 'No', and 'Not sure'. Many park visitors who answered 'No' told our team that they would support a reservation system, but only during peak visitation season (June - August). As a result, the final version of the survey replaced the 'Yes' option with 'Yes (all year long)' and 'Yes (peak season only)'. Note that Figure 22 shows the combined results of all versions of the survey.

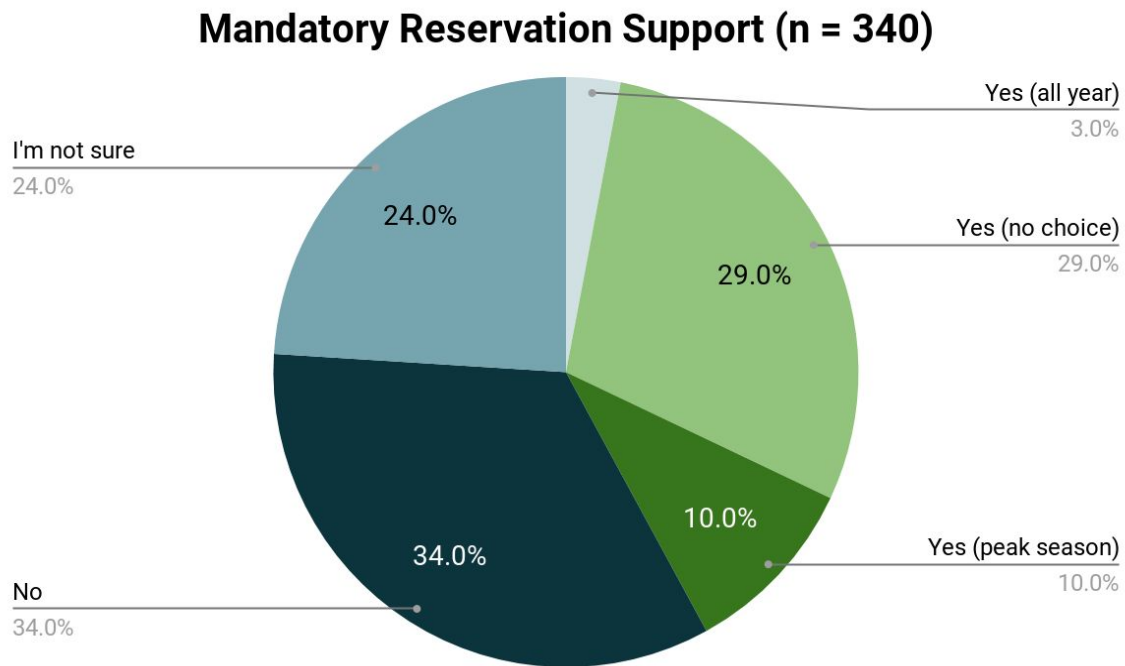


Figure 22: Support for Mandatory Reservation System at ANP

Overall, 42% of respondents firmly supported a reservation system and 34% firmly opposed it. Within those who supported the reservation system and were given the choice between peak season and all year, 77% supported a system only during peak season, with only 23% supporting it all year long. As ANP staff were intent on implementing some kind of reservation system, we recommended they begin implementing it in the peak season, and warned them of the potential opposition.

4.2 Results for Glacier National Park

Due to our team’s post-peak season arrival in GNP, concessionaires such as the Many Glacier Hotel, Swiftcurrent Motel, and horseback riding had closed for the season. The combination of concessionaires closing and snow significantly decreased the volume of individuals in MG. Our team’s access to many Glacier was also limited due to road closures from snow and bear sightings. Limited access and fewer individuals in MG prevented our team from conducting surveys as a data collection method. To draw significant conclusions about a reservation system policy in MG, our team used visitor data from ANP and looked at previous traffic research done in MG to develop reservation system policies, which are discussed below. Please see Appendix A if you would like to view the survey that our team would have used when conducting surveys at the MG site (See Appendix A).

The Montana Board of Planners released a transportation and visitation presentation in September 2018 that included traffic data about the MG site. Figure 23 shows the frequency at which the MG site was closed based on the time of day. According to this histogram, the MG site was reported full five times between 12:30 pm and 1:30 pm. This leads our team to believe that the largest volume of visitors are present at Many Glacier between 12 pm and 2 pm.



Figure 23: Frequency of MG Closure Based on Time of Day

The MG site also contains 2 popular trailheads, Grinnell Glacier Trailhead and Iceberg Trailhead. The Grinnell Trail is approximately 12 miles round trip with a maximum elevation of 6515 ft. The Iceberg Trail is approximately 9.7 miles with a maximum elevation of 6160 ft (Hiking Glacier Web). Based on an estimated average walking speed of 2 miles per hour, this would take an average visitor between 5-6 hours to complete one trail. With this trail information, our team recommended that two, 7 hour blocks of parking reservations should allow for visitors to complete trails without overstaying their visit. The first reservation block should run from 5am - 12pm, and the second block would run from 12pm - 7pm to distribute the spike in visitors shown in Figure 23 over a greater period of time.

There are two other primary features of a reservation system that our team determined through surveys at ANP: The booking method and price of a parking reservation. ANP and GNP both use Your Pass Now and Recreation.gov for booking passes, tours, and backcountry camping. Because both parks offer similar services for booking activities throughout the park, our team made the decision to use our ANP survey data as reference material for determining reservation prices and booking methods in GNP. Therefore, our team recommended visitors book their reservations online with call-in options available, and the price of reservations should not exceed \$5 per reservation.

4.3 GPS Tracking Application

The final product of the GPS location based service tracking phone application can result in four main uses:

1. Observe frequently traveled routes within the park
2. Observe frequently traveled times during the day and season
3. Observe deviations in traffic patterns given a set of conditions
4. Predict future traffic patterns based upon the above observations

This set of observations and predictions based on a large data set can allow the NPS on visitor use patterns so they may react and prepare for congestion in a informed manner.

5. Recommendations

After thorough background research, interactions with staff, and conducting visitor surveys, our team recommended a plan to phase in parking reservations for each national park. Both plans reflected the unique assets and needs of GNP and ANP, which are discussed here.

5.1 Phase-In Plan for Acadia National Park

After analysis of visitor survey data and background research, our team's most favorable recommendation to ANP staff was to phase in a parking reservation system in three steps: an honor system, a physical checking system on the ground, and system assessment and maintenance. These 3 phases were selected due to Acadia's specific needs for a parking reservation system: increased compliance rates, a gateless system to allow for turnaround, and limited cell phone reception in the park. Each phase is discussed below in greater detail.

5.1.1 Phase 1: Honor System

Phase one of the parking reservation plan requires visitors to book a parking reservation online through the website Your Pass Now. Our team recommended using Your Pass Now because ANP "Fees and Passes" page of their website displays several links to Your Pass Now for advance pass booking, as shown in Figure 24.

Entrance Fees

All park visitors are required to pay an entrance fee upon entry **May–October**. Passes are non-transferable. Credit cards are accepted at all fee collection areas.

Private Vehicle: \$30

Valid for seven days

Admits private, non-commercial vehicle (15 passenger capacity or less) and all occupants. If the vehicle pass is purchased, no other pass is necessary. [Buy and print your pass online](#)

Motorcycle: \$25

Valid for seven days

Admits one or two passengers on a private, non-commercial motorcycle. [Buy and print your pass online](#)

Per Person: \$15

Valid for seven days

Admits one individual with no car (bicyclist, hiker, pedestrian). Youth 15 and under are admitted free of charge. [Buy and print your pass online](#)



Buy and Print Your Pass Online

Save time and skip lines. You can buy your Acadia annual or weekly pass online at [Your Pass Now](#).
Please be sure to print a copy to display on your windshield throughout your visit.

Figure 24: ANP Fees and Passes Page

Including parking reservations on Your Pass Now aggregates information from the park pass database with the parking reservation database, which prevents park staff from having to use multiple platforms for various functions and separating visitor data. Using one website for multiple functions also minimizes visitor confusion, as they only need to visit one website to book all reservations and passes related to the park.

To implement this online system, our team recommended adding an extended drop-down menu to the current Acadia National park page on Your Pass Now. The extended drop-down menu includes a calendar for visitors to select dates for their visit, time slots for each day, and whether or not handicap parking is required. The length of time slots for the Cadillac Mountain Summit Lot would be 3 hours, whereas the length of reservation at Jordan pond would be 5 hours. A comparison between the current Acadia Your Pass Now page and our team's suggested extended drop down is shown in Figure 25 and Figure 26.

Pass Info

Pass Type *

Private Vehicle (\$30 valid for 7 days) ▾

Start Date *

09/17/2018

Valid Through

09/23/2018

Vehicle Type *

-- select an option -- ▾

License Plate Number *

Visitor Info

First Name *

Last Name *

Visitor Email *

Re-Enter Visitor Email *

Figure 25: Current Your Pass Now Webpage for ANP

Are you visiting Cadillac Mountain Summit or Jordan pond during your visit?

▾
Yes
No

Due to the popularity of these 2 sites, parking is available by reservation only. Please indicate which dates you plan on visiting these two sites below.

Cadillac Mountain

AUGUST 2017 @myadventures.com						
SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Jordan Pond

AUGUST 2017 @myadventures.com						
SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Please select the time slot for your parking reservation.

Cadillac Mountain ▾
Sunrise (3 am - 7am)
Morning Session (7 am - 11 am)
Afternoon Session (11 am - 3 pm)
Sunset (3 pm - 7pm)
N/A

Jordan Pond ▾
Sunrise (3 am - 7am)
Morning Session (7 am - 11 am)
Afternoon Session (11 am - 3 pm)
Sunset (3 pm - 7pm)
N/A

Do you require handicap parking? ▾
Yes
No

Figure 26: Proposed Drop Down Menu for New ANP Your Pass Now Webpage

Once visitors have booked their reservation, they would print out their reservation and display the reservation on the dash of their car upon arriving at Cadillac Mountain Summit or Jordan Pond. Rangers may check for reservation compliance as they walk through the parking lot, and fine violators of the reservation system. A cost-benefit analysis was conducted for this for implementing this system, shown in Table 4.

Table 4: Cost-Benefit Analysis for Implementing the Honor System at ANP

	COST	BENEFIT
PARK STAFF	Reconfiguring Your Pass Now	Gateless System
	Proper signage to designate reserved parking	Low maintenance
	<u>Opportunity Cost</u> : time ticketing violators	Influx of funding for bus system
VISITORS	Printing their Reservation	Guaranteed parking
	<u>Opportunity Cost</u> : Planning your trip further in advance	

5.1.2 Phase 2: Checking Parking Reservations on the Ground

The second phase of a parking reservation system builds upon phase one, requiring park staff to physically check the reservations at these particular sites. This phase would be introduced if compliance rates to the reservation system was very low, and park staff needed a stronger enforcement policy. This phase would be achieved through 2 steps: adding a unique identifier to a parking reservation and stationing rangers at entrance points to the parking lots to check the reservations.

Our team recommends that park staff connect with Your Pass Now for adding a QR or barcode to provide a visitor with a unique identifier with their parking reservation. The unique identifier would be on top of the previous additions made to Your Pass Now in phase one. In this phase, visitors would have the option of either printing out their reservation or storing it on their phone. Upon arrival to either Cadillac Mountain or Jordan Pond, visitors would be

required to show the unique identifier to a park staff member before entering the lot. Park staff members would scan the unique identifier, allow reservation members to enter the parking lot, and redirect visitors without a reservation to a turnaround point.

A third cost that would be introduced in this phase is the optimal placement for rangers, which varies between Jordan Pond and Cadillac Mountain. At Jordan Pond, there is one optimal placement for a ranger to check reservations, which is demonstrated in Figure 27. The placement of a ranger in this location allows for traffic to be redirected out of the loop if a visitor does not have a reservation without slowing the flow of traffic.



Figure 27: Optimal Ranger Placement at Jordan Pond House Lot

At Cadillac Mountain, however, there are two viable placements for rangers: one ranger at the base of Cadillac Mountain, or two rangers at the Cadillac Mountain Summit and Blue Hills Overlook Lot. These two placements are shown in Figure 28 and Figure 29.



Figure 28: Option 1 for Ranger Placement on Cadillac Mountain



Figure 29: Option 2 for Ranger Placement at Cadillac Mountain

Placing two rangers at the summit of the mountain allows for coverage of both parking lots and an easy turnaround for visitors without a reservation. However, there is an opportunity cost for using 2 rangers to check parking tickets rather than perform other duties. This ranger placement also allows visitors without a parking reservation to drive up and park along the

Cadillac Summit road, which still can contribute to traffic congestion. Another configuration would be to place one ranger at the base of Cadillac Summit Road to check parking reservations.

This configuration decreases the opportunity cost of manpower and prevents any visitors without a parking reservation from entering Cadillac Summit Road. However, two primary issues exist: a lack of infrastructure and oncoming traffic. If a visitor does not have a parking reservation, there is no safe turnaround at the base of Cadillac Mountain for those visitors to use. Visitors also take a left hand turn into oncoming traffic, which could potentially increase traffic congestion if cars must stop to have their reservations checked directly after making that turn. Park staff would need to consider building infrastructure to allow for a visitor turnaround and a safe flow of traffic, such as a traffic light or an addition to the road for a turnaround. A cost-benefit analysis of Phase 2 is detailed in Table 5.

Table 5: Cost-Benefit Analysis of Implementing a QR Code Scanner at ANP

	Physical Costs	Opportunity Costs	Benefits
Park Staff	-QR code scanner and configuration -Potential Housing for Rangers checking reservations -Potential Traffic Light -Turnaround	-stationing rangers at sites to check reservations	-rangers do not have to circle the parking lot -greater enforcement for reservation compliance -long term congestion decrease
Visitors	-Printing out their reservation	-Time spent making a reservation -Time spent waiting to get reservations verified	-guaranteed parking -decreased wait times for a parking spot

5.1.3 Phase 3: System Assessment and Maintenance

Phase Three of the parking reservation system provides park staff with three options for assessing and maintaining the system: “rolling back” to the honor system, fully automating the check in system, or increasing enforcement efficiency through Auto License Plate Recognition (ALPR) systems.

Park staff would initiate option one, the “rollback” system, if compliance rates for the parking reservation steadily increase and people become more aware of the parking policy at these specific sites. If park staff believe that the trend of increased compliance rates will continue, there is an option to move back to the honor system. This would remove the opportunity cost of stationing rangers atop or at the base of the mountain and bring the reservation back to a paper system. Our team recommends reverting to this system if compliance rates are high because it will remove software maintenance costs and opportunity costs of stationing rangers at Cadillac Mountain or Jordan Pond.

The second option entails automating the systems already in place. Instead of reverting to the honor system, park staff may choose to fully automate the checking in system with a gate and kiosk. In the case of Jordan Pond, the gate would be placed at the entrance to Jordan Pond House Lot, as shown in Figure 27. For Cadillac Mountain, WPI’s 2017 Tourist Congestion team in Acadia National Park determined the optimal placement of a gate to be at the base of Cadillac Mountain. The minimum cost for installment of an independent check-in website and single gate, which was also determined by WPI’s 2017 Tourist Congestion team, is \$130,000. This team also determined that a single gate creates long queue times for visitors, especially if a visitor does not have a parking reservation, and must turn around (Cosmopoulos, Gaulin, Jauris et. al., pg 69). Our team recommends that the park does not pursue this option unless compliance rates for the reservation system in phase one and two are below 60%, or park staff is looking for a long term investment that ensures 100% compliance.

The third option involves increasing the efficiency of the enforcement system through ALPR systems. ALPR Camera Systems read, detect, and corroborate license plates with a specific set of information, such as a database of parking reservations. These cameras can be mounted

in a fixed state or on a patrol car that would drive through a parking lot. If this system were implemented, visitors would still book reservations through Your Pass Now and display the reservations in the dash of their car. This system would not be gated. The key distinction is the park ranger's ability to drive through either the Cadillac Mountain Summit or Jordan Pond House parking lot and determine violators in under 5 minutes. If compliance rates to the parking reservation system were continually low (under 60%), an ALPR system will increase the speed at which park rangers identify and ticket violators. It would also remove the need for rangers to physically check reservations when visitors first enter the parking lot.

There are several costs to using this system. According to a quote from Liberty Technology for the City of Hapeville in 2016, 2 mountable vehicle cameras from Genetec, an established smart surveillance company, with a warranty and software package included would cost an initial \$21,665 (Liberty Tech Web). This does not include future maintenance or replacement costs. Fining 440 individuals an average of \$50 per parking ticket would cover the cost of initially implementing this system. This software would also need to use and analyze information from the Your Pass Now database in an offline setting, as there is limited cellular connectivity in the park, which would require pre-downloading the database every day into the car application before the car visited each site. Though this option is less expensive than implementing a gated kiosk system, our team recommends that the park does not pursue this option unless they foresee using this system long term.

5.2 Parking Reservation Plan for Many Glacier

Through researching MG assets and parking, using select visitor data from ANP, and interacting with GNP staff, our team developed a multi-step plan for GNP staff to implement a parking reservation system at the MG site. This plan does not follow the model of a phase-in plan, as certain models, such as the honor system, do not fit the structure of MG. The plan in this section details the necessary steps to implement a parking reservation system at MG.

5.2.1 Visitor Timeline

As stated in section 4.2, our team recommended that visitors book their reservations online. We further recommended that GNP use the website Recreation.gov in a similar manner to Haleakala National Park's Sunrise Reservation page. For exact information on the structure of the Haleakala Sunrise Summit Reservations page with images included, please visit Background section 2.4 letter e. Visitors would select the date for their parking reservation at MG as well as the time block for their reservation. Our team determined in Results section 4.2 that 2 reservation blocks should exist: one from 5am - 12pm, and one from 12 pm - 7 pm. Visitors would receive and print this reservation prior to arrival at the park. The fee for booking this parking reservation would be on top of the park pass fee.

Upon arrival at the MG gate, visitors would show their park pass and parking reservation to the ranger at the gate. It is important to note that our team recommends visitors with a hotel reservation, horseback riding reservation, or visitors who plan on backcountry camping do not need a parking reservation. This is because booking multiple reservations on a variety of platforms increases barriers to enter the park and detracts from visitor experience. These visitors, however, will still need to show proof of their other reservations to a ranger at the MG gate in order to enter the site. Once a reservation has been verified, visitors will park in a designated lot based on their activities for that day, and then leave their reservation on the dash of their car for rangers walking around the parking lot to verify.

5.2.2 Lot Designations

To provide the maximum number of spaces to day and multiple-day visitors, each of the four MG lots should be designated for visitors participating in specific activities. The parking lot located directly above the Many Glacier lot should be reserved for MG Hotel Guests and visitors with horseback riding reservations only, as horseback riding begins near the MG Hotel. Figure 30 displays the lot as well as a possible location for horseback riding reservations. These figures denoted spaces as legitimate parking spaces, blue spaces as drawn-in spaces for overflow parking, and green spaces as extended RV spaces. Because the MG Hotel capacity is 214 rooms, and the parking lot only contains 194 legitimate parking spaces, our team recommends that a significant portion of the blue “drawn-in” spaces become legitimate parking spaces to respect the carrying capacity of the hotel.

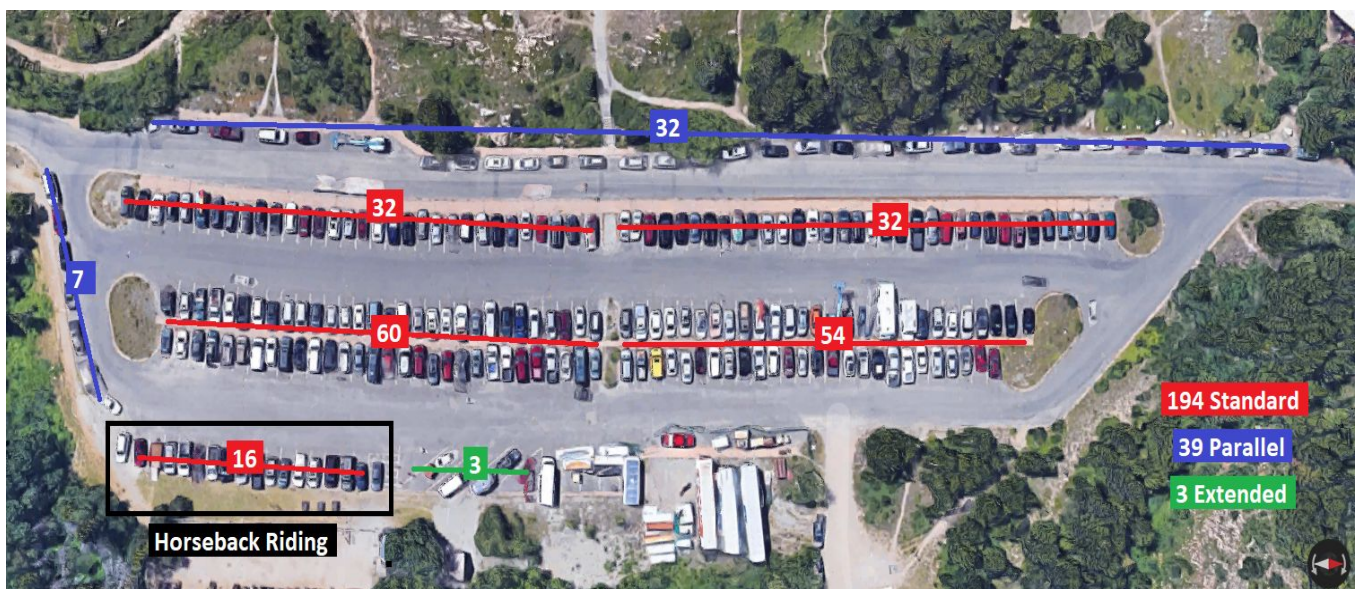


Figure 30: Many Glacier Hotel Lot Designation

The second hotel in MG, the Swiftcurrent Motor Inn, also has a parking lot directly in front of the hotel. The capacity of the hotel is 95 rooms, and there are 119 legitimate parking spaces, as shown in Figure 31 below. Due to the extra space in this parking lot, our team recommends that this lot be used for all Swiftcurrent Motor Inn Guests and Xanterra staff, who are housed near the Iceberg trailhead, a 15 minute walk from the Swiftcurrent Motor Inn.

Legalizing some of the parallel spaces in Figure 31 may be necessary depending on the number of Xanterra park staff members.



Figure 31: Swiftcurrent Motor Inn Lot Designation

The final two lots in MG are located near two major trailheads: Grinnell Trail and Iceberg Trail. Our team recommends that these two lots be designated for the day visitors who would make a parking reservation on Recreation.gov. Our team also recommends that these two parking lots be lumped together on Recreation.gov, allowing a visitor with a day reservation to park in either lot but not guarantee them a spot in a specific lot. This is because these parking lots are within a 15 minute walk of one another, and each lot is located relatively close to the most popular day activities in MG: trails.

Including blue “drawn-in” spaces, there are 173 spaces to offer between these 2 lots, which is shown in Figure 32 below. When considering a 10% violation rate during initial implementation of the system, our team recommends offering 150 spaces per time block to allow visitors who make a parking reservation to park even if violators take up certain spaces. Our team also recommends leaving a certain number of first-come, first serve spaces available for backcountry campers, which is shown in Figure 32. Backcountry campers do not fit the model of a day visitor or hotel guest, and therefore do not fit the boundaries of this reservation system. Because these campers are such a small percentage of the population visiting MG, it is

feasible to allot a small number of non-reserved spaces for them as long as they display their backcountry reservation on the dash of their car.

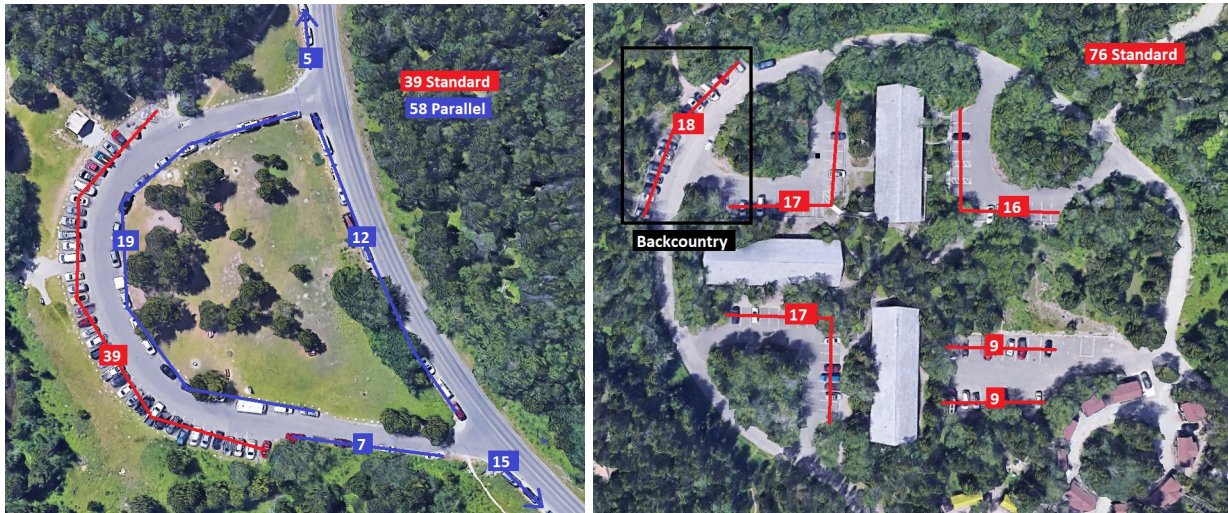


Figure 32: Grinnell and Iceberg Trailhead Parking Lot Designations

5.2.3 Communication and Costs

To communicate lot designation clearly to visitors, our team recommends developing clear signage at the MG gate and at each parking lot to clearly indicate the types of visitors that can park in specific lots. An example set of signs that our team designed for GNP staff are shown in Figure 33.



Figure 33: Example of Signs to Designate Parking at GNP

A cost-benefit analysis of developing this system is shown in Table 6.

Table 6: Cost-Benefit Analysis of a Parking Reservation System at MG

	Opportunity Cost	Physical Cost	Benefit
Park Staff	- Stationing Rangers to walk around parking lots and check reservations	- Using Recreation.gov as a platform for booking parking reservations - Adding to the GNP NPS website and including links to this reservation system	- Long term decrease in traffic congestion at MG
Visitors	- Taking a greater amount of time to plan their trip itinerary	- Printing a physical reservation	- Ease of parking - Decreased visitor congestion at the MG site

6. Conclusion

Despite multiple weather setbacks, our team was able to provide valuable reservation system insights for both ANP and GNP. ANP was provided with extensive survey data and analysis regarding visitor preferences on reservations as well as a phase-in plan to test reservation effectiveness with minimal upfront costs. Some of said survey analysis was also relevant to GNP, which received a thorough analysis of parking resources and recommendations for the use of each of its main parking lots. Finally, both parks were presented with examples of online reservation systems, recommendations for additional signage, and a means of developing outcome assessments through big data collected from voluntary smartphone users. Our team also developed example software for quickly analyzing survey data from Brew Survey. Depending on the rate of implementation of said reservation systems, future IQPs working for both ANP and GNP may have the opportunity to aid in said outcome assessments through development, deployment, and analysis of the GPS tracking app, as well as surveying visitors on the ground as was done by this team. In order to maximize visitor contact, in-person research should be conducted during the summer or early A-term.

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Appendix A: Visitor Survey for Glacier National Park

Paperwork Reduction and Privacy Act Statements: The Paperwork Reduction Act requires us to tell you why we are collecting this information, how we will use it, and whether or not you have to respond. We are authorized by the National Park Service Protection Interpretation and research in System (54 USC §100702) to collect this information. The routine uses of this information will be for the benefit of NPS Managers and Planning staff at Glacier National Park in future initiatives related to existing visitor use patterns, experiences, and perspectives about vehicle reservation systems within the park. Your participation is completely voluntary and can end the process at any time without being penalized in any way for choosing to do so. All paper versions of the information collected will be destroyed at the end of the collection period and no personal identifiable records will be maintained or stored for any purposes. Data collected will only be reported in aggregates and no individually identifiable responses will be reported. A Federal agency may not conduct or sponsor, and you are not required to respond to, a collection of information unless it displays a currently valid OMB Control Number (1024-0224). We estimate that it will take about 5 minutes to complete this questionnaire. You may send comments concerning any aspect of this information collection to Chris Monz, Department of Environment and Society, Utah State University; chris.monz@usu.edu (email); or Phadrea Ponds, NPS Information Collection Coordinator, Fort Collins, CO 80525, pponds@nps.gov (email).

1. How many times have you visited Glacier National Park?
 - a. 1 time
 - b. 2 - 3 times
 - c. 4 or more times
2. What is your home zip code (or country of residence if outside of the U.S.)?
 - a. _____
3. What is your primary mode of transportation in this park?
 - a. Car
 - b. Glacier Shuttle System
 - c. Tour bus
 - d. Bike
 - e. Walking
4. What has been your experience in Glacier National Park regarding overcrowding?
 - a. There were a lot less people than I expected
 - b. There were a few less people than I expected
 - c. There were a about as many people as I expected
 - d. There were a few more people than I expected
 - e. There were a lot more people than I expected
 - f. I do not know
5. How many days have you been in Glacier on this trip?
 - a. 1st day
 - b. 2nd day
 - c. 3rd day
 - d. 4th day
 - e. More than 4 days
6. What option would you prefer when visiting Glacier National Park?
 - a. I would prefer to drive into the park at any time with the possibility of being unable to obtain a parking spot
 - b. I would prefer to have a reserved parking spot, but have limits to how long I can remain in the park
7. If it was necessary to make a daily reservation to enter the park, how long would you prefer the reservation to be?

- a. 1 - 3 hours
 - b. 3 - 5 hours
 - c. 5 - 7 hours
 - d. 7+ hours
8. How much would you be willing to pay for a daily reservation?
- a. \$1 - \$3
 - b. \$3 - \$6
 - c. \$6 - \$9
 - d. Greater than \$9
 - e. The reservation should be free
9. What would be your preferred method of making such a parking reservation?
- a. Call-in
 - b. Phone App
 - c. Online Website
 - d. In person at the Visitor Center
 - e. Other: _____
10. Do you feel that vehicle reservations in Glacier National Park would improve the traffic congestion problem?
- a. Yes
 - b. No
 - c. Unsure
11. Would you support a mandatory vehicle reservation system in Glacier National Park?
- a. Yes
 - b. No
 - c. Undecided

Appendix B: Visitor Survey for Acadia National Park

Hello, we are students from Worcester Polytechnic Institute assisting Acadia National Park with collecting data to improve visitor experience at popular destinations throughout the park! By taking this voluntary survey, you consent to providing general and anonymous information for research in Acadia National Park.

1. What location are you currently at?
 - a. Cadillac Mountain
 - b. Jordan Pond
2. How many times have you visited Acadia National Park?
 - a. 1 or less
 - b. 2-3 times
 - c. 4 or more
3. How many days have you spent in and/or visited Acadia on your trip?
 - a. 1 day
 - b. 2 days
 - c. 3 days
 - d. 4 days
 - e. Longer than 4 days
4. *Optional* What is your home zip code (or country of residence if outside the U.S.)?

-
5. What is your primary mode of transportation in the park?
 - a. Car
 - b. Acadia Shuttle System (Island Explorer)
 - c. Trolley Tour Buses
 - d. Bike
 - e. Walking
 6. When preparing for your trip to Acadia, how far in advance did you plan your trip?
 - a. 0 - 1 week in advance
 - b. 2 - 4 weeks in advance
 - c. 1 - 3 months in advance
 - d. 3 - 6 months in advance
 - e. Longer than 6 months in advance
 7. When planning your trip to Acadia, did you have easy access to a printer?
 - a. Yes
 - b. No
 8. What has been your experience here in regards to the number of people there?
 - a. There were a lot less people than I expected
 - b. There were a few less people than I expected
 - c. There were about as many people as I expected

- d. There were a few more people than I expected
 - e. There were a lot more people than I expected
 - f. I do not know
9. If it was necessary to make a reservation to drive to either Cadillac Mountain or Jordan Pond, how long would you prefer the reservation to be?
- a. 1-3 hours
 - b. 3-5 hours
 - c. 5-7 hours
 - d. 7+ hours
10. How much would you be willing to pay for such a reservation at either Cadillac Mountain or Jordan Pond?
- a. \$1 - \$3
 - b. \$3 - \$6
 - c. \$6 - \$9
 - d. Greater than \$9
 - e. The reservation should be free
11. What would be your preferred method of making a reservation?
- a. Call-in
 - b. Kiosks throughout the park
 - c. Phone App
 - d. Online website
 - e. In person via the Visitor Center
 - f. Other: _____
12. Would you support a mandatory reservation system at popular destination sites, such as Cadillac Mountain, to limit traffic congestion in Acadia National Park?
- a. Yes
 - b. No
 - c. Undecided

Appendix C: Matlab Survey Analyzer Scripts

The Matlab code for processing the survey results and generating pie charts is all included below, divided by file. All Matlab files, both functions and scripts, use the (.m) extension.

process.m

```
%% Processes Data from Acadia Surveys

% Clear Workspace
close all
clear
clc

% Load Survey Data
file = 'Responses_All.xls'; % Excel file containing survey data
[resp, n] = loadSurvey(file); % Loads responses into 'resp' struct

% Overall Responses
singlePie(resp, 'Survey Locations', 'Location');
singlePie(resp, 'Number of Visits', 'Visits');
singlePie(resp, 'Advanced Planning', 'Planning');
singlePie(resp, 'Printer Access', 'Printer');
singlePie(resp, 'Zip Codes', 'Zip');
singlePie(resp, 'Crowding Perception', 'Crowding');
singlePie(resp, 'Max Price', 'Price');
singlePie(resp, 'Booking Method', 'Method');
singlePie(resp, 'Reservation Stance', 'Stance');

% Conditional Responses
condPie(resp, 'Transport', 'Location');
condPie(resp, 'Duration', 'Location');
condPie(resp, 'Stance', 'Days');
condPie(resp, 'Planning', 'Visits');
```

loadSurvey.m

```
function [resp, n] = loadSurvey(filename)
    % LOADSURVEY Parses survey excel file with given file name.
    % [resp, n] = LOADSURVEY(filename) returns responses in struct
    % array 'resp' and the number of valid responses 'n'.

    %% Load excel to cell array
    [~, excel, ~] = xlsread(filename);

    % Remove Useless Rows and Columns
    excel(1, :) = [];
```

```

excel(:, 17) = [];
excel(:, 16) = [];
excel(:, 14) = [];
excel(:, 1) = [];

%% Parse Responses

% Responses Data Structure
resp = struct([]);

% For Each Response
i = 1;
while i < size(excel, 1)
    %% Check for Abandonment
    for j = 1 : 13
        if isempty(excel{i, j}) && j ~= 6
            excel(i, :) = [];
            continue
        end
    end
    end
    clear j

    %% Survey Location ('Location')
    row = 1;
    switch excel{i, row}
        case 'Cadillac Mountain'
            loc = 'Cadillac';
        case 'Jordan Pond'
            loc = 'Jordan';
    end
    resp(i).Location = loc;
    clear loc;

    %% Number of Park Visits ('Visits')
    row = 2;
    visits = excel{i, row};
    switch visits(1)
        case {'T', '1'}
            visits = '1';
        case '2'
            visits = '2 - 3';
        case '4'
            visits = '4 +';
    end
    resp(i).Visits = visits;
    clear visits

    %% Days Visited ('Days')

```



```

row = 3;
days = excel{i, row};
switch days(1)
    case 'm'
        days = '5 +';
    otherwise
        days = days(1);
end
resp(i).Days = days;
clear days

%% Time Planned in Advance ('Planning')
row = 4;
plan = excel{i, row};
switch plan(1)
    case '0'
        plan = '0 - 1 wk';
    case '2'
        plan = '2 - 4 wk';
    case '1'
        plan = '1 - 2 mo';
    case '3'
        plan = '3 - 6 mo';
    case '6'
        plan = '6 + mo';
end
resp(i).Planning = plan;
clear plan

%% Printer Access ('Printer')
row = 5;
resp(i).Printer = excel{i, row};

%% Zip Code or Country ('Zip')
row = 6;
zip = excel{i, row};
if isempty(zip)
    % No Response
    zip = 'No Response';
elseif sum(isstrprop(zip, 'alpha'))
    % International
    zip = 'International';
else
    % US Zip Code
    zip = [zip(1) 'xxxx'];
end
resp(i).Zip = zip;
clear zip

```

```

%% Transportation Mode ('Transport')
row = 7;
transport = excel{i, row};
switch transport(1)
    case 'A'
        transport = 'Shuttle';
    case 'T'
        transport = 'Trolley';
end
resp(i).Transport = transport;
clear transport

%% Crowding Expectation ('Crowding')
row = 8;
crowd = excel{i, row};
switch crowd(16 : 18)
    case 't l'
        crowd = 'Lot Less';
    case 'w l'
        crowd = 'Few Less';
    case 't a'
        crowd = 'Same';
    case 'w m'
        crowd = 'Few More';
    case 't m'
        crowd = 'Lot More';
end
resp(i).Crowding = crowd;
clear crowd

%% Desired Reservation Duration ('Duration')
row = 9;
dur = excel{i, row};
switch dur(1)
    case 'L'
        dur = '< 1 hr';
    case '1'
        dur = '1 - 3 hr';
    case '3'
        dur = '3 - 5 hr';
    case '5'
        dur = '5 - 7 hr';
    case '7'
        dur = '> 7 hr';
    otherwise
        dur = 'NA';
end

```

```

resp(i).Duration = dur;
clear dur

%% Max Reservation Price ('Price')
row = 10;
price = excel{i, row};
switch price(2)
    case '1'
        price = '1 - 3 $';
    case '3'
        price = '3 - 6 $';
    case '6'
        price = '6 - 9 $';
    case 'r'
        price = '> 9 $';
    case 'h'
        price = 'Free';
    case '/'
        price = 'NA';
end
resp(i).Price = price;
clear price

%% Preferred Booking Method ('Method')
row = 11;
method = excel{i, row};
switch method(1)
    case 'C'
        method = 'Call';
    case 'K'
        method = 'Kiosks';
    case 'P'
        method = 'App';
    case 'O'
        method = 'Website';
    case 'I'
        method = 'Visitor Center';
    case 'N'
        method = 'NA';
end
resp(i).Method = method;
clear method

%% Stance on Reservations ('Stance')
row = 12;
stance = excel{i, row};
switch stance(1)
    case 'Y'

```

```

        len = length(stance);
        if len > 20
            stance = 'Yes (Peak Season)';
        elseif len > 3
            stance = 'Yes (All Year)';
        else
            stance = 'Yes (No Choice)';
        end
        case 'N'
            stance = 'Oppose';
        case 'I'
            stance = 'Unsure';
        end
        resp(i).Stance = stance;
        clear stance

%% Survey Timestamp ('Timestamp')
row = 13;
time = excel{i, row};
time = str2double(time(1 : 2));
if time <= 7
    time = 'Sunrise (3-7am)';
elseif time <= 11
    time = 'Morning (7-11am)';
elseif time <= 15
    time = 'Afternoon (11-3pm)';
elseif time <= 19
    time = 'Sunset (3-7pm)';
else
    time = 'Evening (7-3am)';
end
resp(i).Timestamp = time;
clear time

%% Go to next row
i = i + 1;
end

%% Count valid responses
n = length(resp);
end

```

singlePie.m

```

function singlePie(data, figTitle, question)
% SINGLEPIE Generates response pie chart for single survey question.
% SINGLEPIE(data, figTitle, question) generates a pie chart of

```

```

% responses to question 'question' as a field of struct array 'data'
% and makes the title 'figTitle'.
catArr = getCat(data, question);
figure
n = length(catArr);
pie(catArr)
title([figTitle ' (n = ' int2str(n) ')'])
end

```

condPie.m

```

function condPie(data, outQ, condQ)
% CONDPIE Conditional distribution pie charts.
% CONDPIE(data, outResp, question) Plots a pie chart of responses to
% the question 'outQ' for every response group to 'condQ' given
% survey struct array 'data'.
%
% Example: CONDPIE('Transport', 'Location') will generate a transport
% method pie chart for those who went to Cadillac and those who went
% to Jordan Pond.
cat = getCat(data, condQ);
cats = categories(cat);
numcats = length(cats);
figure
for i = 1 : numcats
    subplot(1, numcats, i)
    catArr = getCat(data, outQ, condQ, cats{i});
    n = length(catArr);
    pie(catArr)
    title([outQ ' ( condQ ' = '' cats{i} '' , n = ' int2str(n) ')'])
end
end

```

getCat.m

```

function cat = getCat(data, outResp, question, inResp)
% GETCAT Returns categorical array from response data struct.
% GETCAT(data, outResp) Returns categorical array of data.outResp.
% GETCAT(data, outResp, question, inResp) Returns categorical array
% of data.outResp filtered by data.question == inResp.
if nargin > 2
    filt = data(arrayfun(@(r) strcmp(eval(['r.' question]), inResp), data));
else
    filt = data;
end
cat = categorical(arrayfun(@(r) eval(['r.' outResp]), filt, 'UniformOutput', false));
end

```

Appendix D: GPS Tracking App Code

The Java code for tracking a user, storing tracking information locally, and uploading tracking information online is all included below, divided by file. All Java files use the (.java) extension and the php back end request handling uses the (.php) extension.

MainActivity.java

```
package com.example.reserveteam.parktrackerbeta;

import android.Manifest;
import android.content.pm.PackageManager;
import android.location.Address;
import android.location.Geocoder;
import android.location.Location;
import android.location.LocationListener;
import android.location.LocationManager;
import android.net.ConnectivityManager;
import android.net.NetworkInfo;
import android.os.Bundle;
import android.support.v4.app.ActivityCompat;
import android.support.v4.app.FragmentActivity;
import android.widget.Toast;

import com.example.reserveteam.parktrackerbeta.GPSDatabaseHelper;
import com.google.android.gms.maps.CameraUpdateFactory;
import com.google.android.gms.maps.GoogleMap;
import com.google.android.gms.maps.OnMapReadyCallback;
import com.google.android.gms.maps.SupportMapFragment;
import com.google.android.gms.maps.model.LatLng;
import com.google.android.gms.maps.model.MarkerOptions;
import com.google.gson.Gson;

import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStreamReader;
import java.io.OutputStreamWriter;
import java.util.List;
import java.util.ArrayList;
import java.net.HttpURLConnection;
import java.net.URL;

import org.json.JSONException;
import org.json.JSONObject;

import javax.net.ssl.HttpURLConnection;
```

```

/**
 * Created by Andrew Hand on 09/11/2018
 */

public class MapsActivity extends FragmentActivity implements OnMapReadyCallback {

    private GoogleMap mMap;

    LocationManager locationManager;
    GPSTDatabaseHelper mGPSTDatabaseHelper = new GPSTDatabaseHelper(this);

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);

        // Setting Main Activity Layout to Maps
        setContentView(R.layout.activity_maps);
        // Obtain the SupportMapFragment and get notified when the map is ready to be used.
        SupportMapFragment mapFragment = (SupportMapFragment)
        getSupportFragmentManager()
            .findFragmentById(R.id.map);
        mapFragment.getMapAsync(this);

        /** Track a Location
         * Uses a devices system services to obtain a GPS Coordinate
         * Checks for device permissions
         * Checks is Network Provider is enabled
         * Uses GPS Provider if Network Provider is not available
         */
        locationManager = (LocationManager) getSystemService(LOCATION_SERVICE);

        /**
         * Checking for all permissions
         * App will not function without these permissions
         */
        if (ActivityCompat.checkSelfPermission(this,
        Manifest.permission.ACCESS_FINE_LOCATION) !=
        PackageManager.PERMISSION_GRANTED && ActivityCompat.checkSelfPermission(this,
        Manifest.permission.ACCESS_COARSE_LOCATION) !=
        PackageManager.PERMISSION_GRANTED && ActivityCompat.checkSelfPermission(this,
        Manifest.permission.GET_ACCOUNTS) != PackageManager.PERMISSION_GRANTED &&
        ActivityCompat.checkSelfPermission(this,
        Manifest.permission.ACCESS_NETWORK_STATE) !=
        PackageManager.PERMISSION_GRANTED) {

```

```

// TODO: Consider calling
// ActivityCompat#requestPermissions
// here to request the missing permissions, and then overriding
// public void onRequestPermissionsResult(int requestCode, String[] permissions,
// int[] grantResults)
// to handle the case where the user grants the permission. See the documentation
// for ActivityCompat#requestPermissions for more details.
return;
}

// Tracking when Network Provider is available
if (locationManager.isProviderEnabled(LocationManager.NETWORK_PROVIDER)){
    locationManager.requestLocationUpdates(LocationManager.NETWORK_PROVIDER, 0,
0, new LocationListener() {
        @Override
        public void onLocationChanged(Location location) {
            // get the latitude
            double latitude = location.getLatitude();
            // get the longitude
            double longitude = location.getLongitude();

            /**
             * Storing Latitude and Longitude offline on device via SQLite
             * To be uploaded to online MySQL Database when NETWORK_PROVIDER is
available
             */

            // instantiate the Class LatLng
            LatLng latLng = new LatLng(latitude, longitude);
            // instantiate the Class Geocoder
            Geocoder geocoder = new Geocoder(getApplicationContext());
            try {
                List<Address> addressList = geocoder.getFromLocation(latitude, longitude, 1);

                /** here we can get the name of the location we are at using
                 * String str = addressList.get(0).get...chooseTypeOfLocation...() + "," <- only use
if adding to string;
                 * Can add on to that string with
                 * str += addressList.get(0).get...chooseTypeOfLocation...();
                 */

                String str = addressList.get(0).getLocality();
                str += ", " + addressList.get(0).getCountryName();
                mMap.addMarker(new MarkerOptions().position(latLng).title(str));
                mMap.moveCamera(CameraUpdateFactory.newLatLngZoom(latLng, 15.0f));

```



```

        // Only record data points in the park
        if (inAcadiaNationalPark(latitude, longitude) ||
inGlacierNationalPark(latitude,longitude)) {

            /**
             * Store new data point in on board SQLite database
             * With NETWORK_PROVIDER available upload SQLite database to MySQL
             * Check for error while uploading and clear SQLite if successful
             * Wait to clear if not successful to upload on next data point
             */

            mGPSDatabaseHelper.addData(latitude, longitude);
        }

    } catch (IOException e){
        e.printStackTrace();
    }
}

@Override
public void onStatusChanged(String provider, int status, Bundle extras) {

}

@Override
public void onProviderEnabled(String provider) {

}

@Override
public void onProviderDisabled(String provider) {

}
});
}

// Tracking with GPS when Network Provider is unavailable
else if (locationManager.isProviderEnabled(LocationManager.GPS_PROVIDER)) {
    locationManager.requestLocationUpdates(LocationManager.GPS_PROVIDER, 0, 0, new
LocationListener() {
        @Override
        public void onLocationChanged(Location location) {
            // get the latitude
            double latitude = location.getLatitude();

```

```

// get the longitude
double longitude = location.getLongitude();
// instantiate the Class LatLng
LatLng latLng = new LatLng(latitude, longitude);
// instantiate the Class Geocoder
Geocoder geocoder = new Geocoder(getApplicationContext());
try {
    List<Address> addressList = geocoder.getFromLocation(latitude, longitude, 1);

    /** here we can get the name of the location we are at using
    * String str = addressList.get(0).get...chooseTypeOfLocation...() + "," <- only use
if adding to string;
    * Can add on to that string with
    * str += addressList.get(0).get...chooseTypeOfLocation...();
    */

    String str = addressList.get(0).getLocality();
    str += ", " + addressList.get(0).getCountryName();
    mMap.addMarker(new MarkerOptions().position(latLng).title(str));
    mMap.moveCamera(CameraUpdateFactory.newLatLngZoom(latLng, 15.0f));

    // Only record data points in the park
    if (inAcadiaNationalPark(latitude, longitude) ||
inGlacierNationalPark(latitude,longitude)) {

        /**
        * Store new data point in on board SQLite database
        * With NETWORK_PROVIDER available upload SQLite database to MySQL
        * Check for error while uploading and clear SQLite if successful
        * Wait to clear if not successful to upload on next data point
        */

        mGPSDatabaseHelper.addData(latitude, longitude);
    }

} catch (IOException e){
    e.printStackTrace();
}
}

@Override
public void onStatusChanged(String provider, int status, Bundle extras) {

}

```

```

    @Override
    public void onProviderEnabled(String provider) {

    }

    @Override
    public void onProviderDisabled(String provider) {

    }
});
}

/**
 * Syncing the database and removing the synced data entries
 */
if (isConnectedToInternet()) {
    syncSQLiteMySQLDB();
    mGPSDatabaseHelper.removeSyncedLocations();
}
}

/**
 * Manipulates the map once available.
 * This callback is triggered when the map is ready to be used.
 * This is where we can add markers or lines, add listeners or move the camera. In this case,
 * we just add a marker near Sydney, Australia.
 * If Google Play services is not installed on the device, the user will be prompted to install
 * it inside the SupportMapFragment. This method will only be triggered once the user has
 * installed Google Play services and returned to the app.
 */
@Override
public void onMapReady(GoogleMap googleMap) {
    mMap = googleMap;
}

/**
 * Checks the GPS coordinates to determine if user is within the bounds of Acadia National
Park
 * Checks for Mount Desert Island and Schoodic Peninsula
 * GPS bounds obtained from Google Maps
 */
public boolean inAcadiaNationalPark(double latitude, double longitude) {

```

```

        if (((latitude > 44.221669 && latitude < 44.4453492) && (longitude > -68.4314468 &&
longitude < -68.17351)) || ((latitude > 44.328687 && latitude < 44.378786) && (longitude >
-68.084131 && longitude < -68.037105))) {
            return true;
        } else {
            return false;
        }
    }
}

/**
 * Checks the GPS coordinates to determine if user is within the bounds of Glacier National
Park
 * GPS bounds obtained from Google Maps
 */
public boolean inGlacierNationalPark(double latitude, double longitude) {
    if (((latitude > 48.179530 && latitude < 49.215783) && (longitude > -115.224387 &&
longitude < -112.861409))) {
        return true;
    } else {
        return false;
    }
}

/**
 * Updates the SQLite database when an entry has been synced
 */
public void updateLocationStatus(ArrayList<JSONObject> updateLocations) {
    for (int i = 0; i < updateLocations.size(); i++) {
        try {
            JSONObject obj = updateLocations.get(i);
            mGPSDatabaseHelper.updateSyncStatus(obj.get("ID").toString(),
obj.get("updateStatus").toString());
        }

        catch (JSONException e) {

        }
    }
}

/**
 * Checks if the device is connected to the internet to upload SQLite data
 */
public boolean isConnectedToInternet() {
    boolean connected = false;

```

```

    ConnectivityManager connectivityManager =
    (ConnectivityManager) getSystemService(MapsActivity.this.getApplicationContext().CONNEC
    TIVITY_SERVICE);
    if(connectivityManager.getNetworkInfo(ConnectivityManager.TYPE_MOBILE).getState()
    == NetworkInfo.State.CONNECTED ||
    connectivityManager.getNetworkInfo(ConnectivityManager.TYPE_WIFI).getState()
    == NetworkInfo.State.CONNECTED) {
        //we are connected to a network
        connected = true;
    }
    else {
        connected = false;
    }
    return connected;
}

```

```

/**
 * Upload unsynced data
 * Do we need a network connection check if we've already done this? What about wifi?
Permissions check?

```

```

 * Call update sync status helper form database manager
 * Call remove synced data helper from database manager
 */
public void syncSQLiteMySQLDB(){

```

```

    ArrayList<JSONObject> locationList =
    mGPSDatabaseHelper.composeJSONfromSQLite();

```

```

    if(locationList.size() != 0){
        if(mGPSDatabaseHelper.dbSyncCount() != 0){

```

```

            /**
             * Establish connection to MySQL database and post with error handling
             */
            // Enter new IP address for yourIPAddressHere
            String query = "http://yourIPAddressHere/sqlitemysqlsync/insertlocation.php";

```

```

            try {
                URL url = new URL(query);
                HttpURLConnection conn = (HttpURLConnection) url.openConnection();
                conn.setDoOutput(true);
                conn.setDoInput(true);
                conn.setRequestProperty("Content-Type", "application/json; charset=UTF-8");
                conn.setRequestProperty("Accept", "application/json");
                conn.setRequestMethod("POST");

```

```

OutputStreamWriter out = new OutputStreamWriter(conn.getOutputStream());
for (int i = 0; i < locationList.size(); i++) {
    out.write(locationList.get(i).toString());
}
out.flush();

/**
 * Read response response code
 * Complete update status if response is OK
 * Send error message if response is an error
 */
int responseCode = conn.getResponseCode();

if (conn.getResponseCode() == HttpURLConnection.HTTP_OK) {

    /**
     * Get feedback from your request and convert to JSON Array
     * Update sync status for each object in JSON Array
     */
    BufferedReader in = new BufferedReader(new
InputStreamReader(conn.getInputStream()));
    String inputLine;
    ArrayList<JSONObject> updateLocations = new ArrayList<JSONObject>();
    while ((inputLine = in.readLine()) != null) {
        JSONObject updateLocation = new JSONObject();
        Gson g = new Gson();
        updateLocation = g.fromJson(inputLine, JSONObject.class);
        updateLocations.add(updateLocation);
    }
    in.close();
    updateLocationStatus(updateLocations);
}

/**
 * Error handling for the server request
 */
else {
    if(responseCode == 404){
        Toast.makeText(getApplicationContext(), "Requested resource not found",
Toast.LENGTH_LONG).show();
    }else if(responseCode == 500){
        Toast.makeText(getApplicationContext(), "Something went wrong at server
end", Toast.LENGTH_LONG).show();
    }else{

```



```

import org.json.JSONObject;

/**
 * Created By Andrew Hand on 09/11/2018
 */

public class GPSDatabaseHelper extends SQLiteOpenHelper {

    private static final String TAG = "GPSDatabaseHelper";

    private static final String TABLE_NAME = "LatLng_Table";
    private static final String COL_0 = "ID";
    private static final String COL_1 = "UserEmail";
    private static final String COL_2 = "Time";
    private static final String COL_3 = "Latitude";
    private static final String COL_4 = "Longitude";
    private static final String COL_5 = "UpdateStatus";
    private String userEmail = null;

    public GPSDatabaseHelper(Context context) {
        super(context, TABLE_NAME, null, 1);
        Pattern emailPattern = Patterns.EMAIL_ADDRESS;
        Account[] accounts = AccountManager.get(context).getAccounts();
        for (Account account : accounts) {
            if (emailPattern.matcher(account.name).matches()) {
                this.userEmail = account.name;
            }
        }
    }

    @Override
    public void onCreate(SQLiteDatabase db) {
        String createTable = "CREATE TABLE " + TABLE_NAME + " (" + COL_0 + " INTEGER
PRIMARY KEY AUTOINCREMENT, " + COL_1 + " TEXT, " + COL_2 + " INTEGER, " +
COL_3 + " REAL, " + COL_4 + " REAL, " + COL_5 + " TEXT)";
        db.execSQL(createTable);
    }

    @Override
    public void onUpgrade(SQLiteDatabase db, int oldVersion, int newVersion) {
        db.execSQL("DROP TABLE IF EXISTS " + TABLE_NAME);
        onCreate(db);
    }
}

```



```

/**
 * Put User Locations into on device SQLite database
 */
public void addData(double latitude, double longitude) {
    SQLiteDatabase db = this.getWritableDatabase();
    ContentValues values = new ContentValues();
    values.put(COL_1, this.userEmail);
    values.put(COL_2, System.currentTimeMillis());
    values.put(COL_3, latitude);
    values.put(COL_4, longitude);
    values.put(COL_5, "No");

    Log.d(TAG, "addData: Adding " + values + " to " + TABLE_NAME);

    db.insert(TABLE_NAME, null, values);
    db.close();
}

/**
 * Get User Locations from on device SQLite database as an Array List
 */
public ArrayList<HashMap<String, String>> getAllLocations() {
    ArrayList<HashMap<String, String>> locationList;
    locationList = new ArrayList<HashMap<String, String>>();
    String selectQuery = "SELECT * FROM " + TABLE_NAME;
    SQLiteDatabase database = this.getWritableDatabase();
    Cursor cursor = database.rawQuery(selectQuery, null);
    if (cursor.moveToFirst()) {
        do {
            HashMap<String, String> map = new HashMap<String, String>();
            map.put(COL_0, cursor.getString(0));
            map.put(COL_1, cursor.getString(1));
            map.put(COL_2, cursor.getString(2));
            map.put(COL_3, cursor.getString(3));
            map.put(COL_4, cursor.getString(4));
            locationList.add(map);
        } while (cursor.moveToNext());
    }
    database.close();
    return locationList;
}

/**
 * Compose JSONArray out of SQLite records
 */

```

```

public ArrayList<JSONObject> composeJSONfromSQLite() {
    ArrayList<JSONObject> locationList = new ArrayList<JSONObject>();
    String selectQuery = "SELECT * FROM " + TABLE_NAME;
    SQLiteDatabase database = this.getWritableDatabase();
    Cursor cursor = database.rawQuery(selectQuery, null);
    if (cursor.moveToFirst()) {
        do {
            try {
                JSONObject location = new JSONObject();
                location.put(COL_0, cursor.getString(0));
                location.put(COL_1, cursor.getString(1));
                location.put(COL_2, cursor.getString(2));
                location.put(COL_3, cursor.getString(3));
                location.put(COL_4, cursor.getString(4));
                locationList.add(location);
            }

            catch (JSONException e) {

            }
        } while (cursor.moveToNext());
    }
    database.close();
    return locationList;
}

/**
 * Update Sync status against each User ID
 */
public void updateSyncStatus(String id, String status) {
    SQLiteDatabase database = this.getWritableDatabase();
    String updateQuery = "UPDATE " + TABLE_NAME + " SET " + COL_5 + " = " + status +
    " WHERE ID=" + id + """;
    Log.d(TAG, "updateSyncStatus: Updated " + id + " to " + status + " in " + TABLE_NAME);
    database.execSQL(updateQuery);
    database.close();
}

/**
 * Remove Location from on device SQLite database if it has been upload to online MySql
database
 */
public void removeSyncedLocations() {
    SQLiteDatabase database = this.getWritableDatabase();

```

```

        String updateQuery = "DELETE FROM " + TABLE_NAME + " WHERE " + COL_5 +
        "='Yes'";
        Log.d(TAG, "removeSyncedLocations: Removed all locations in " + TABLE_NAME + "
that have synced to online MySQL");
        database.execSQL(updateQuery);
        database.close();
    }

    /**
     * Checks if SQLite database has any entries
     */
    public int dbSyncCount(){
        int count = 0;
        String selectQuery = "SELECT * FROM " + TABLE_NAME;
        SQLiteDatabase database = this.getWritableDatabase();
        Cursor cursor = database.rawQuery(selectQuery, null);
        count = cursor.getCount();
        database.close();
        return count;
    }
}

```

Config.php

```

/**
 * Created By Andrew Hand on 09/12/2018
 */

<?php
/**
 * DB configuration variables
 */
define("DB_HOST", "localhost");
define("DB_USER", "root");
define("DB_PASSWORD", "YourPassword");
define("DB_DATABASE", "GPSDatabase");
?>

```

db_connect.php

```

/**
 * Created By Andrew Hand on 09/12/2018
 */

<?php

```

```

class DB_Connect {

    // constructor
    function __construct() {
    }

    // destructor
    function __destruct() {
        // $this->close();
    }

    // Connecting to database
    public function connect() {
        require_once 'config.php';

        // connecting to mysql
        $con = mysql_connect(DB_HOST, DB_USER, DB_PASSWORD);

        // selecting database
        mysql_select_db(DB_DATABASE);

        // return database handler
        return $con;
    }

    // Closing database connection
    public function close() {
        mysql_close();
    }
}
?>

```

db_functions.php

```

/**
 * Created By Andrew Hand on 09/12/2018
 */

```

```

<?php

```

```

class DB_Functions {

    private $db;

```

```

//put your code here

// constructor
function __construct() {
    include_once './db_connect.php';

    // connecting to database
    $this->db = new DB_Connect();
    $this->db->connect();
}

// destructor
function __destruct() {

}

/**
 * Storing new user
 * returns user details
 */
public function storeLocation($Id,$User) {

    // Insert user into database
    $result = mysql_query("INSERT INTO GPSDatabase VALUES($LocationId,'$UserEmail',
$Time, $Latitude, $Longitude)");

    if ($result) {
        return true;
    } else {
        if( mysql_errno() == 1062) {

            // Duplicate key - Primary Key Violation
            return true;
        } else {

            // For other errors
            return false;
        }
    }
}

/**
 * Getting all users
 */
public function getAllLocations() {

```

```

        $result = mysql_query("SELECT * FROM GPSDatabase");
        return $result;
    }
}
?>

```

insertLocation.php

```

/**
 * Created By Andrew Hand on 09/12/2018
 */
<?php

include_once './db_functions.php';

//Create Object for DB_Functions class
$db = new DB_Functions();

//Get JSON posted by Android Application
$json = $_POST["LocationsJSON"];

//Remove Slashes
if (get_magic_quotes_gpc()){
    $json = stripslashes($json);
}

//Decode JSON into an Array
$data = json_decode($json);

//Util arrays to create response JSON
$a = array();
$b = array();

//Loop through an Array and insert data read from JSON into MySQL DB
for ($i=0; $i<count($data) ; $i++) {

//Store User into MySQL DB
$res = $db->storeLocation($data[$i]->ID, $data[$i]->UserEmail, $data[$i]->Time,
    $data[$i]->Latitude, $data[$i]->Longitude);

//Based on insertion, create JSON response
if ($res) {
    $b["ID"] = $data[$i]->ID;
    $b["Status"] = 'yes';
    array_push($a,$b);
}
}

```

```
} else {  
    $b["ID"] = $data[$i]->ID;  
    $b["Status"] = 'no';  
    array_push($a,$b);  
}  
}
```

```
//Post JSON response back to Android Application  
echo json_encode($a);  
>
```