COVID-19 and Outdoor Recreation in Maine and New Hampshire: Analysis of Trends Using Passive Visitation Data

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ABSTRACT

The COVID-19 pandemic has motivated alterations to the way people approach and practice outdoor recreation. Access to outdoor areas has changed rapidly in response to measures like travel bans, closures, and health and safety guidelines. Recreation managers have had to act quickly to keep up with these visitor use fluctuations in order to protect resources from use degradation. I explored how pandemic effects have changed visitation behaviors and trends in outdoor recreation in Acadia National Park and the White Mountain National Forest. Acadia National Park is a well-known and highly trafficked outdoor recreation area with over 3 million visits annually and many entries and exits; the White Mountain National Forest, has similar diffuse entries, has diverse recreation opportunities, and sees less overall visitation than Acadia. This study includes a review of relevant literature on COVID-19 effects on outdoor recreation, an exploration of the use of passive use cellular data derived from the data company StreetLight for visitation estimates, and an analysis of survey data from 2020-2021 about COVID-19 impacts on Acadia visitors and visitor demographics. This paper is unique in that it includes passive use cellular data for examining visitation shifts during the pandemic in diffuse entry outdoor recreation areas. Results indicate that in addition to changes in the overall visitation to these outdoor recreation areas, pandemic visitation also saw shifts in visitor demographics. Additionally, passive cellular data were useful in estimating visitation volume within recreation areas. It is likely there are several areas where recreation managers could incorporate StreetLight InSight analysis results and data gathering techniques into their operations to improve existing outdoor recreation practices.
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LIST OF ABBREVIATIONS

NPS: National Park Service
NP: National Park
USDA: United States Department of Agriculture
USFS: United States Forest Service
ANP: Acadia National Park
WMNF: White Mountain National Forest
MWS: Mount Washington Summit
PNVC: Pinkham Notch Visitor Center
DCC: Dolly Copp Campground
HBO: Home-based other travel
HBW: Home-based work travel
NHB: Non-home based travel
LNT: Leave No Trace
CM: Cadillac Mountain
SB: Sand Beach
JP: Jordan Pond
TH: Thunder Hole
BHL: Bass Harbor Lighthouse
SP: Schoodic Peninsula
PLR: Park Loop Roa
INTRODUCTION

It has been over a year since the World Health Organization (WHO) announced the status of the COVID 19 outbreak as a global pandemic\(^1\). Since then, the pandemic has motivated numerous changes to health practices, behaviors, and perceptions of people around the world. One specific way that the pandemic has affected people is by altering behaviors and access centered around outdoor recreation. The onset of the pandemic brought travel bans and restrictions which altered the accessibility of outdoor recreation to many\(^2\). Although there was an initial decline in visitation following the WHO announcement, many areas like public lands have seen an overall influx in visitation, especially in 2021. Units in the National Park Service (NPS) and other outdoor recreation areas are facing some of the highest visitation numbers they have ever seen\(^3-5\). Visitation over the carrying capacity that an area is able to handle presents a serious issue for the integrity of natural resources and environments. The rapid increase in visitation to parks also stands to adversely affect visitor experiences\(^6\).

Land managers need accurate and efficient methods for quantifying visitation use in order to keep up with these rapid visitation changes, overcrowding, and environmental effects. Traditional methods for monitoring visitation to outdoor recreation areas are often complex, costly, and time consuming. The use of passive mobile data can fill in gaps left by the use of more traditional methods such as surveys and cameras. StreetLight is one company offering passive mobile data to consumers. StreetLight gathers large data samples from smart phones and other navigation devices. More specifically, the data is derived from navigational GPS data and Location Based Services (LBS) and has been
shown to be an effective tool for visitation estimates in outdoor recreational spaces\textsuperscript{7}. The software is especially effective in areas where there is a diffuse method of entry to an area\textsuperscript{8}, a quality similar to entry areas in Acadia and the White Mountain National Forest (WMNF).

The purpose of this paper is to address the research question, “how has the onset of the global COVID-19 pandemic affected visitation trends in outdoor recreation areas, specifically in Maine and New Hampshire?” To do this, I conducted a three part study which includes a review of current literature on pandemic effects to outdoor recreation and the use of StreetLight data for visitation analysis in outdoor recreation areas, an exploration of visitation trends using StreetLight \textit{InSight} in the WMNF, and an analysis of visitation and reported behaviors from a 2020-2021 visitor survey in ANP. I find that COVID-19 impacted outdoor recreation areas through changes to mobility and access, risk perceptions, and visitation levels and that big data companies like StreetLight can provide useful information for visitation monitoring, especially in areas where data does not exist. The information gathered through the literature review, StreetLight analysis, and survey analysis show that changes from the COVID-19 pandemic presented outdoor recreation concerns that heightened the need for accurate use monitoring and that a multifaceted approach to use monitoring is the most informative method for gathering measurements related to visitation numbers.
PART I: LITERATURE REVIEW

Over the past few years, a large body of COVID-19 related studies on impacts to outdoor recreation have been published. These studies reveal information on changes to visitation patterns, visitor demographics, managerial responses, and risk perception for outdoor recreation during the pandemic. Dramatic changes like those created during the pandemic highlight the need for accurate and timely methods of analyzing visitation trends to outdoor recreation areas. Visitation trend data provides essential information for recreation managers to be able to implement things like health and safety measures for COVID-19 social distancing or site capacity systems which limit visitation to overcrowded use areas.

This literature review will look at how the onset of the COVID-19 pandemic has impacted outdoor recreation in a variety of manners. First, it will outline information on outdoor recreation both within and out of the study sites used in the following data analyses. Then it will address literature on outdoor recreation in the context of the pandemic including changes to visitation trends, the economy in outdoor recreation-dependent areas, health, the environment, risk awareness and behaviors, and management. The literature review then covers use monitoring in outdoor recreation areas through both traditional methods and mobile device big data. The overall purpose of the review is to give insight into pandemic-related changes in outdoor recreation and how these changes relate to the need for accurate and attainable use estimation methods.
Outdoor Recreation

Outdoor recreation includes such activities like hiking, sightseeing, biking, kayaking, and climbing. It also ranges from urban areas like city parks to more remote areas like federally designated Wilderness Area zones\(^2\). Outdoor recreation areas are managed by different agencies under differing guidelines. These different guidelines mean different management concerns and tactics, including in their responses to COVID-19. For example, the National Park Service (NPS) manages a large portion of federal public lands under the administration of the US Department of the Interior\(^1\). The NPS aims to preserve natural land resources while also allowing for recreation and education to occur in these areas\(^2\). This opens the door for issues involving overuse and crowding, an issue that has been exacerbated in many NPS units during the pandemic\(^3\). Unlike the NPS, the USDA Forest Service (USFS) is run under the US Department of Agriculture and is focused on the conservation of land areas and their resources for sustained use in meeting resource needs\(^4\). Visitation impacts are still felt here, but there might be less emphasis on preservation than in the NPS. In comparison to federal lands, state parks are run at the state level and include preservation and conservation management for a variety of recreation purposes\(^5\). Other recreation lands might be run by conservation organizations or municipal governments\(^6\).

About the Study Sites

The other two sections of this study focus on two primary outdoor recreation areas to explore visitation trends that were impacted or created by the onset of COVID-19. The first study site is ANP, and the other is the WMNF.
**Acadia National Park**

ANP is a unit in the NPS on the coast of Maine. It is a very popular site, receiving millions of visits per year\(^4\). Recreation opportunities include hiking, biking, horseback riding, camping, and kayaking along the roads, trails, and lakes\(^{17}\). ANP is a patchwork of land spread across several different Maine islands with the majority of land resting on Mount Desert Island. This segmented layout means that there are numerous entry and exit points within the system, making obtaining visitation estimates a complex process\(^4\). The COVID-19 pandemic has impacted visitation in ANP as evidenced by recreational visitation estimation. The Park saw declines of roughly 770 thousand recreation visits from 2019-2020\(^5\). In 2021, visitation reached a record-breaking over 4 million recreational visits, an increase of roughly 500 thousand from 2019 and 1.2 million from 2020\(^4\).

**White Mountain National Forest**

The WMNF is a unit in the USDA Forest Service on the Maine/New Hampshire border. It is also a popular recreation area which is host to many recreational activities including hiking, backpacking, camping, climbing, and kayaking along the many roads, trails, and lakes\(^{18}\). The Appalachian Trail also runs along the mountain range bringing visitation from long-distance and thru-hikers\(^{19}\). Like ANP, WMNF is similarly composed of patchwork land with many access points. However, the area is roughly 15 times the size of ANP and includes wilderness areas\(^{19,20}\). The USDA Forest Service approaches visitation estimates differently than the NPS. In Acadia, there is annual use information and information at the site-specific level. For the USFS, recreational visit estimates are developed on five-year cycles. Current visitation estimates as of March 2022 indicate a
general increase in visitation to the site without more specific information on the pandemic-related changes\textsuperscript{21}.

**Outdoor Recreation in the Context of the Pandemic**

**Visitation and Travel Trends**

COVID-19 regulations and safety concerns led to dramatic changes in travel and visitation trends. For example, the United Nations World Tourism Organization reported that world tourism declined by 73\% from 2019-2020. While tourism increased in 2021 following the wide availability of COVID-19 vaccines, tourist arrivals were still 72\% of the volume seen in 2019\textsuperscript{22}. The vaccine opened up travel for many towards the end of 2021 leading to an increase in visitation and tourism in many areas. A study focused on travel within the United States reported that over half of the vaccinated adults in the U.S booked travel within 2021. Nearly 2/3rds of the total adults booking travel in 2021, did so towards the end of the year, indicating a rapid uptick in recreation travel plans\textsuperscript{23}.

Visitation and travel for the purposes of outdoor recreation exhibited similar patterns. For many areas, initial concerns over public health and safety from local communities meant implementing strict regulations and closures\textsuperscript{13,24}. For example, in a preliminary report on outdoor recreationists, Rice et al (2021) found that respondents did not support tourist visitation with no health restrictions in place and only slightly supported tourist visitations with restrictions in place. Within those communities, those at higher risk of contracting COVID-19 were more unsupportive on average\textsuperscript{24}. Since the pandemic was declared, evolving perceptions and protocols have led visitation in outdoor
recreation areas to vary greatly both spatially and temporally. Where some outdoor recreation areas saw an overall decline in visitation in 2020 compared to pre-pandemic years, other areas saw record visitation as more people looked to the outdoors for travel and recreation\textsuperscript{13,25-28}. For example, from 2019 to 2020 Grand Canyon National Park (NP) saw declines of roughly 3.1 million recreation. In contrast, visitation to Cuyahoga NP and Delaware Water Gap National Recreation Area (NRA), both located near urban populations, saw an increase in visitation of roughly 520 thousand and 790 thousand visits respectively\textsuperscript{5}.

Several studies also reported an initial drop in visitation to outdoor recreation areas followed by a sharp increase during the first few years of the pandemic\textsuperscript{10,26,29}. For example, in a study on avid outdoor recreationists, 56\% of respondents reported canceling a trip during the period between March to December 2020 because of the pandemic. Only 25\% reported having taken a trip within the first 5 months of the pandemic. The same survey found that there was an overall 26\% trip reduction post-COVID compared to pre-COVID within the first 5 months of the pandemic\textsuperscript{10}. Similarly, research involving a 3-phase study on outdoor recreationists found that over the first few months of the pandemic (April-May 2020), the frequency of outdoor recreation, the distance traveled to recreate, and the average group size increased after an initial decline, but these factors did not reach pre-pandemic levels over the study period\textsuperscript{29}. In 2021, recreation visits continued to rise with the introduction and widespread availability of COVID-19 vaccines and the lessening of government restrictions\textsuperscript{3}. For example, the NPS reported 60 million more recreational visits in 2021 than in 2020, a 25.3\% increase \textsuperscript{3}. 
Economic Impacts

To date, COVID-19 has had broad economic implications\textsuperscript{30}. These economic implications are especially prominent in the travel and recreation industry which relies on visitor mobility for success. Economic changes to outdoor recreation dependent areas are of note as visitation to these areas brings in essential income to bordering or gateway towns and businesses\textsuperscript{13,25,30-31}. For example, visitation to US NPs is a large source of economic revenue for gateway towns. In 2019, the NPS reported that park visitor spending accounted for over 41 billion dollars in economic impact to the US economy. This spending also supported over 340 thousand jobs\textsuperscript{32}.

Health and safety concerns created by the pandemic have decreased the volume of tourists who shop, get food, and explore local businesses in recreation-dependent towns through declines in site accessibility and visitor desire to spend time and money\textsuperscript{27,30-31}. Declines in visitation and shifts in visitor demographics have and could continue to have marked impacts on the economy in neighboring towns and businesses. This is evidenced by a study on pandemic-related changes to NPs. Researchers found that remote gateway towns in Alaska received less out-of-state visitation in the period March 2020 to mid-2021. This is a negative effect as local visitors to the NPs are less likely to spend the same amount of money to support the tourist-dependent economy\textsuperscript{25}. Another study indicated the negative impact on gateway town economies, resulting from government shutdowns, is evidence that disruptions to key outdoor recreation areas negatively impacts neighboring economies. To illustrate, a shutdown in October 2013 led to a loss of an estimated 414 million dollars in gateway visitor spending\textsuperscript{13}. 

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An early study on the economic impact of COVID-19 described that recreation and tourism were particularly vulnerable to restrictive pandemic safety measures\textsuperscript{30}. This industry relies on mobility but the early stages of the pandemic saw the implementation of non-pharmaceutical health interventions like lockdowns, quarantines, limitations and other restrictions\textsuperscript{30-31}. These strict regulations caused the global tourism trend to shift from ample tourism to virtually no tourism immediately following the WHO’s declaration in March 2020. The subsequent effect on the economy was also immediate\textsuperscript{30}. Another study utilizing Google’s 2020 mobility trend data found that in many countries including the United States, the amount of participation in leisure and recreation activities declined steeply within 60 days after the first reported case. The steep declines slowed and improved following the 60-day mark\textsuperscript{30}.

Tourist-dependent economies have seen increased revenue compared to 2020 as the pandemic has evolved and vaccines have been approved. A 2021 survey on a national sample of adults found that over half of vaccinated U.S adults booked travel plans in the year and a half preceding the survey\textsuperscript{23}. However, although travel and recreation rates are improving, recreation-dependent economies might continue to experience pandemic influences. Of this survey sample, 35% of the respondents also reported that they will spend less money on vacations and travel. Twenty eight percent reported they plan to travel more locally\textsuperscript{23}.

Physical and Mental Health

The COVID-19 pandemic also has implications for physical and mental health in general and in relation to outdoor recreation\textsuperscript{33-35}. Early stages of the pandemic brought mental health stressors like family deaths, isolation, job losses, uncertainty, and fear\textsuperscript{35}. A
study on mental health during the pandemic found increases in symptoms of depression, insomnia, and anxiety with 53.8% of the sampled population reporting the pandemic as having a moderate to severe impact on their mental health\textsuperscript{35}. Outdoor recreation is important in this context given the growing amount of studies linking outdoor recreation and benefits to physical and mental health\textsuperscript{33,36}. For example, a study conducted by Giuntella et al. looked at pandemic-related disruptions to factors like physical activity, sleep, and mental health in college students and young adults. Through the use of health and activity monitoring, the researchers linked observed declines in mental health to the disruption of physical activity. They reported that in the early stages of the pandemic (March-July 2020), study participants at risk for clinical depression ranged from 46% to 61%. This is up to a 90% increase in clinical depression rates compared to pre-pandemic 2019 rates for the same population\textsuperscript{34}.

As outdoor recreation offers mental health benefits like socialization and stress relief\textsuperscript{2}, continuing into the pandemic, many people looked to outdoor recreation as a way to safely engage in physical and social activities. Government officials also promoted that outdoor recreation allowed for recreational engagement with reduced risk of virus transmission\textsuperscript{24-26}. Recent studies on the behavior of outdoor recreationists during the pandemic have shown that recreationists rate mental and physical health benefits above other factors like authority orders, perceived risk, and lifestyle\textsuperscript{24,26}. This indicates that the promotion of personal health is vital to these communities and that outdoor recreation is an outlet for personal health needs.
Degradation to Environment and Visitor Experience

The pandemic heightened issues around resource protection not only through increased visitation but also through declines in management focused on natural resource protection\textsuperscript{10,13,25}. Overcrowding in numbers exceeding carrying capacity is known to lead to increased resource degradation\textsuperscript{6}. In a pre-pandemic study, Bergstrom projected an average increase of about 1.2 million visitors per year to the US NPs would lead to ecological impacts on vulnerable areas. COVID-19 visitation patterns have only exacerbated the preexisting overcrowding and overuse of natural resources, operations, and maintenance in areas experiencing visitation fluctuations\textsuperscript{13,25}.

A study by Miller-Rushing et al. found that disruptions to staffing, funding, housing, and access to scientific research and resource monitoring from COVID-19 have impacted ecological protections in NPs. This includes less access to research facilities and research permits. In 2020, the NPS allotted a fraction (37\%) of previous quantities of research permits and there was a decline in conservation opportunities for youth and graduate students of 70-80\%\textsuperscript{25}. The combination of disruptions to seasonal hiring and shifts in management priorities have also increased resource degradation. For example, in many outdoor recreation areas, managers have had to pull staff from less crowded areas to more crowded areas, to help maintain safety protocols, leaving other areas vulnerable to the effects of overuse\textsuperscript{13,25}. Additionally, staff had to shift from non-essential work such as wildlife monitoring and public engagement programming\textsuperscript{25}.

Overcrowding in the parks not only has the potential to damage ecological resources, it also has the potential to contribute to overall declines in the visitor experience\textsuperscript{6}. Overcrowding increases safety concerns and unease while also increasing
parking and traffic issues. This contributed to reductions in visitor services like educational programming and closed facilities\textsuperscript{9,10,13,25} which increased visitor dissatisfaction in some cases. These reductions were initially heightened due to staffing and funding shortages\textsuperscript{25}. In addition to reductions in services, there was also a shift from in-person messaging, materials, and experiences to virtual programming and written messaging\textsuperscript{9,13,25}. According to park officials and industry partners, this transition was challenging, especially for areas like the NPS where in-person interaction is a primary means of public engagement\textsuperscript{13,25}.

Risk Awareness and Behavior

Despite the risk of transmissibility (restrictive regulations allowing), people visited congested outdoor recreation areas throughout the pandemic\textsuperscript{37} which indicates that there are different factors affecting risk awareness and behavior while outdoor recreating during the pandemic. Multiple studies have been conducted on risk awareness and motivating factors for outdoor recreation behavior during the pandemic. For example, research has found that avid outdoor recreationist households with pre-existing health conditions were more likely to take trips within the first few months of the pandemic than those without pre-existing conditions. This behavior may be attributed to the perception of safety in outdoor recreation or be a reflection of the belief that outdoor recreation has health benefits\textsuperscript{10}.

Other studies looking at risk perception have highlighted the value outdoor recreationists place on physical wellbeing. Mateer et al. looked at risk perception, social norms, health recommendations, and wellbeing as behavioral influences in outdoor recreationists. For survey respondents, personal health ranked as the most important
factor among other factors like health and safety guidelines and social norms\textsuperscript{26}. A preliminary study report by Rice et al. found similar findings. Health recommendations from authority figures were ranked as the next most important factor when evaluating outdoor recreation plans. What these findings indicate is that outdoor recreationists rank physical and mental health above perceptions of health risks. Another preliminary report by Rice et al. found that individuals made changes to their outdoor recreation behaviors in the early stages of the pandemic. The reasoning behind the changes shifted as the pandemic progressed in early 2020. Respondents reported that barriers to transportation became less motivating and both barriers to closed areas and fear of virus exposure became more prominent. Despite these patterns, the frequency of outdoor recreation increased over the first few months of the pandemic after its initial drop\textsuperscript{24}.

Humangain (2021) looked at motivating factors contributing to recreation during the pandemic and overall satisfaction with COVID-19 safety practices at these places. The study suggested that those willing to travel amid the pandemic could be motivated by the search for normalcy or trust in existing safety measures. Results found that at-risk groups reported being more pleased with implemented safety measures than individuals not at risk. Individuals going to more crowded and higher risk areas also reported higher satisfaction with safety measures than those going to more open public lands. Looking at the behaviors of repeat visitors, safety measures had little effect on behavioral intentions. For first-time visitors, behavioral intentions, safety measures, and trip satisfaction were associated\textsuperscript{38}. 
Non-Uniform Changes to Outdoor Recreation and Travel

Academic literature has revealed that COVID-19 impacts on outdoor recreation are not spatially, temporally, or demographically uniform; this can be attributed to regulations and safety measures being irregular across time and space. For example, several national parks closed in the early months of the pandemic, with staged reopenings along different time schedules. This altered recreation accessibility to many outdoor recreationists. There have also been several studies indicating that some demographic groups are more affected than others. Studies surveying outdoor recreationists in the Leave No Trace Center for Outdoor Ethics Community found that some demographic groups were more affected by COVID-19 recreational impacts than others. For example, a study conducted by Rice et al. (2021) found that of the 1,012 respondents, urban outdoor recreationists were less likely to travel long distances to recreate and were less likely to recreate outdoors than members from rural communities. This indicates that the pandemic has had a disproportionate impact on recreation access for people from urban populations compared to those from rural populations. In another study looking at differences between urban and rural communities, researchers found that urban communities valued health and safety recommendations from authority more than urban clusters and rural communities. Urban communities also perceived higher risk to COVID-19 than rural counterparts.

Non-uniform impacts also include those on race and age. Data from a study on the impact of COVID-19 on NP visitation on communities of color suggested that there was a greater impact on diverse communities with most evidence pointing towards a heavy impact on Native American populations. The study also indicates that under COVID-19
conditions, diverse communities have a decreased likelihood to travel further\textsuperscript{28}. Additionally, of those looking to book travel in 2021, younger people between the ages of 18-34 were more likely to book travel (46\%) than older adults and seniors. Individuals over 65 were the least likely to book (27\%) and represent greater health risk from contracting COVID-19\textsuperscript{23}.

Visitor type and behavior also changed in response to the pandemic. Pandemic-related visitation fluctuations may have shifted the overall knowledge base of outdoor recreation users. Notably, there has been an increase in the number of first time recreators who are generally less knowledgeable about threats to the environment and responsible recreation\textsuperscript{13}. This change goes along with another aspect of increased visitation and overcrowding, an elevated volume of recreation related accidents. There are reports that increased visitation has led to management concerns around a greater number of outdoor recreation related injuries\textsuperscript{40}. Places experiencing overcrowding like national parks have had to keep up with physical accidents amid safety concerns around the pandemic. For example, by mid-august 2021, ANP saw an increase in rescues of 65\% over the 2019 season\textsuperscript{40}. Although still undetermined, this increase in accidents could be attributed to the general increase in visitation to Acadia and/or other potential changes like increases in the number of visitors lacking adequate knowledge of safe recreation practices.

\textbf{Managerial Impacts}

\textbf{Managerial Response}

COVID-19 is a novel stressor to outdoor recreation areas. Although public land managers have ample experience tackling physical and managerial stressors like storms,
budget changes, and stakeholder values, the COVID-19 pandemic brought about a unique and novel combination of changes to use, visitation, and health and safety practices within outdoor recreation areas. These changes created a need for adaptive managerial practices\textsuperscript{9,13,25}. The growing emphasis on outdoor recreations' ability to mitigate pandemic effects to mental and physical wellbeing by public health officials has caused managers to weigh the risk of overcrowding with allowing for access to outdoor spaces\textsuperscript{25}. As such, managers have employed a variety of tactics to address providing visitors with public health recommendations and suggesting and regulating recreation behaviors in the parks, while allowing for access. Tactics include limiting use through closed areas and trails, reducing parking areas, reducing use hours, implementing limits through reservation systems, requiring masks, and suggesting plan alterations if areas are too congested. They also include the use of pre-trip practices such as publishing messages promoting local recreation in favor of state or NP visitation and asking visitors to practice recommended health practices in their broader lives\textsuperscript{9,13}.

A timely managerial response to the pandemic has been shown to increase the recovery of visitation to recreation areas. In a study conducted on tourism and leisure, Fang et al. looked at mobility data and found that areas that implemented strict health regulations saw an initial decline in visitation; however, the recovery to these areas was much more rapid than in areas where there was no public health intervention. Visitation was at 70% of pre-pandemic levels for areas with health interventions vs 40% for areas without interventions after 13 weeks. Despite its importance, managerial response and efficacy have varied across outdoor recreation areas\textsuperscript{31}. In an exploratory study on the managerial response to COVID-19 in Utah, Templeton et al. administered surveys to

tourism directors, NPS employees, and tourism operators. Respondents reported that managers had to handle a lack of communication and preparedness for the pandemic as there were no existing management guidelines to handle the frequent changes of the pandemic scenario.\textsuperscript{13}

\textbf{Site-Specific Regulations and Management Measures}

On March 18, 2020, the NPS office of communications announced a temporary suspension of entrance fees at open parks to encourage recreation and improve access to the outdoors during the initial stages of the pandemic.\textsuperscript{41} Since then, outdoor recreation areas like Acadia NP and the WMNF have seen a revolving door of guidelines, regulations, and closures since the beginning of the pandemic.

In Acadia, the popular park shuttle bus the Island Explorer stopped service for the entirety of 2020. The 2021 summer season saw its return with limited capacity and fewer routes.\textsuperscript{42} All major roads, parking lots, and buildings closed in Acadia on March 26, 2020, and much of it reopened on June 1st at similar timing with Maine state parks.\textsuperscript{39} In the WMNF, key facilities like restrooms, cabins, and visitor centers were also closed on March 26th along with additional trailheads and day-use areas closed on April 24th.\textsuperscript{43,44} Trail and day-use closures in the WMNF did not last as long. Trailhead reopenings began a week later on May 1st due to illegal parking concerns and safety issues.\textsuperscript{45} A phased reopening following NH COVID-19 guidelines saw campgrounds opening late May-June.\textsuperscript{46}

Current guidelines as of February 2022 still exist and vary in many outdoor recreation areas. For example, masks remain required in all buildings and crowded sidewalks where distancing is not possible in Acadia NP.\textsuperscript{47} The Appalachian Mountain
Club recommends wearing a mask per CDC guidelines in any of their White Mountain facilities, including the Pinkham Notch Visitor Center at the base of Mt. Washington.48

Traditional Use Monitoring

Why Monitor Visitation/Use in Outdoor Recreation Areas?

Obtaining information on outdoor recreation use and visitation has been an issue at the forefront of recreation management for many years.49-51. Visitation estimates are important for outdoor recreation management. Estimates give insight into potential overcrowding and overuse issues.51-53 which can have implications for both resource degradation and health and human safety.8,54,55 With the onset of the COVID-19 pandemic, understanding both of these impacts has become more important as pandemic conditions brought both overcrowding and a need for social distancing to outdoor spaces.9,13,25. Understanding when and where high use occurs could also give insight into future management actions to address relevant issues like concerns over transmission and spread of diseases similar to the COVID-19 virus.

Traditional Methods of Use Monitoring

Outdoor recreation managers have employed many different techniques and methods to obtain visitation estimation data in outdoor spaces. Use studies show the utilization of more traditional techniques for deriving data such as direct, indirect, and automated observation methods.50-52. Methods include in-person intercept surveys, online surveys, automated trail and road counters, cameras, entrance fee counting, and remote sensing.8,49,52,55-56. These forms of estimation methods are difficult for understaffed, underfunded, or undermanaged outdoor recreation areas8 as they often require a significant amount of equipment, manpower, and/or a significant amount of time for data
The onset of the COVID-19 pandemic exacerbated resource issues in many outdoor recreation areas with organizations like the NPS experiencing staffing shortages and shifting management focuses at the beginning of the pandemic\textsuperscript{25}. As such, disruptions like these could have long-lasting impacts on the availability of use data for future management needs.

Individual counting methods have advantages and disadvantages that determine their situational usefulness\textsuperscript{51}. For example, tools like cameras allow for real-time monitoring and high temporal flexibility; however, they can be costly, can run out of battery, and require time-consuming setup and maintenance\textsuperscript{52,54}. Traffic counters are another potentially useful electronic tool as they monitor use on a defined section of road. However, counters can sometimes fail, leading to inaccuracies in the visitation data\textsuperscript{4,52}. For example, a traffic counter on the ANP Loop Road failed to collect data for over 3 weeks in March of 2018, this meant that managers had to use estimates based on the previous year’s visitation data\textsuperscript{4}.

In comparison to these electronic tools, in-person surveying has fewer equipment needs and technological constraints; but it generally requires more man-hours and is less temporally accurate\textsuperscript{52}. For example, a study conducted by Binkley and Hanemann (1978) demonstrates some of the limitations of in-person surveying. In this study, researchers used at-home surveys to conduct their research on recreation demand and the benefits of water quality improvement on recreation in the Boston area. This method was both time-consuming (as trained professional interviewers had to dedicate large amounts of time to move from home to home) and relied on interaction with recreators (making it subject to an individual’s willingness to participate)\textsuperscript{50}. Additionally, the researchers asked
respondents questions about the frequency of their visits, how many people made the trips with them, and how long they stayed at the sites, in order to quantify attendance to Boston recreation sites\textsuperscript{50}. This meant that the use estimates were derived from personal accounts/memory and not physical measurements. A lack of physical measurements introduces increased opportunities for estimation error and bias\textsuperscript{51}.

Data gathering within outdoor recreation areas varies based on the nature and size of the site\textsuperscript{5,52,55} as well as the available resources and established protocol for the area\textsuperscript{21,49,52}. For example, a 2020 report on use statistics for the NPS described that methods for deriving NP visitation statistics vary from park to park. Methods at the individual NP level also evolve so statistical adjustments need to be made if managers are comparing data to historical estimates\textsuperscript{5}. In 2020, 21 NP units needed special adjustments to their data in order to both be comparable to earlier data sets and be compiled into the NPS national report. These adjustments were a result of changes to visitor use counting procedures\textsuperscript{5}.

Additionally, in general, areas where there is a defined entry and exit point are relatively easier to obtain visitation counts via traditional methods than areas where there are several diffuse entry and exit points\textsuperscript{8,51}. For example, a study conducted by Hollenhorst et al. (1992) on methods for obtaining use information in dispersed backcountry and wilderness areas discussed several different methods for use monitoring in these regions. They found that methods such as agency and self-issued permits, visitor registration, and the combination of electrical counting devices with visitor surveys all have the potential to be effective methods in backcountry areas. However, these methods all have potential limitations. Permit systems can be costly and aggravating to the visitor,
whereas electrical counting and surveys can be more time-consuming. What method is best, depends on the specific resources and layout of the area\textsuperscript{51}.

**Site-Specific Monitoring Techniques**

**Acadia.** Currently, ANP staff use a combination of techniques to compile visitation estimates and they have park-specific programs dedicated to the monitoring of use throughout the park\textsuperscript{57}. Existing methods of visitation monitoring include the use of traffic counters placed on major sections of the Park Loop Road. For example, there is a monitor near the Sand Beach Entrance Station which counts use on that section of the road. Predetermined multipliers are used with the vehicle counts to compile estimates on total recreational visits. For use in areas not supported by traffic counters, estimates are derived through calculations based on the Park Loop counter\textsuperscript{58}.

**White Mountains.** In the WMNF, visitation estimates are made through the National Visitor Use Monitoring Program using a methodology standardized and employed across the USFS by the year 2000\textsuperscript{21}. The USFS 2015-2020 report on visitation to WMNF describes that forest managers across the USFS conduct a visitation study 1 year out of a 5-year interval at each unit. Although monitoring methods have changed and improved with time, (the USFS warns that data from the first period from 2000-2003 should not be compared against any subsequent data as the methodology has improved greatly since program implementation), the USFS currently uses a mixture of in-person visitor surveys and traffic counts for their monitoring program. Data is collected in a random sample of locations and dates throughout a single survey year and includes information on trip qualities, visitor satisfaction, and visitor demographics\textsuperscript{21}. Unlike ANP which does provide some site-specific data, USFS data only provides information at the...
national, regional, and forest level\textsuperscript{4,21}. For example, the 2015-2020 report on total recreation visits to the WMNF does not provide information about specific spots like popular Sabbaday Falls or the Mt. Washington trailheads, it only gives estimates on basic categories like day-use and overnight-use areas and total visitation to the forest\textsuperscript{21}. This leaves a gap in their visitor use knowledgebase.

**Problems Associated with Traditional Methods**

Although useful, understanding behavior and visitation differences over time is difficult using traditional methods\textsuperscript{8,54,56}. For starters, traditional methods of visitation estimation are often time-consuming and can require a large amount of manpower\textsuperscript{8,54,56,59}. Management personnel must transport, set up, monitor, and collect data from various equipment like cameras and sensors. If using in-person surveys, additional time and staff commitment are needed to engage with visitors and record responses and once the data is collected, resources are needed to compile, analyze, and validate the data to make it understandable and applicable to recreation needs\textsuperscript{8,59}. The traditional methods used, manhour needs, and cost needs differ across recreational areas based on location and recreation area layout. Typically, larger more geographically dispersed areas require more effort to monitor\textsuperscript{8,55,60}.

Traditional methods can also fall short of management needs in outdoor recreation areas\textsuperscript{8,54,56}. Managers looking to compare visitation estimates will have difficulties because broad application and comparison between data sets collected with traditional methods can vary greatly depending on site characteristics\textsuperscript{49,54-55}. Methods can also vary in terms of the strength and extent of their techniques\textsuperscript{55}. Data accuracy with traditional methods is dependent on how reliable the people and equipment are. For
example, equipment that fails will lead to inaccuracies and inconsistencies in the data. Similarly, in-person surveys need to be accurate, consistent, and unbiased to produce useful depictions of visitation trends. Areas relying on single sensors or cameras will lack data if the single system fails. Areas with more than one data collection method will have gaps when a sensor fails but not a complete lack of data.

**Mobile Device Big Data**

**Active Mobile Data**

Mobile data can be both active and passive. Active mobile data can overcome many of the difficulties of traditional methods like the possibility for retroactive analysis. Forms of active mobile data include data derived from posting images to social media networks and downloading tracking apps. Studies have looked at the use of social media and geotagged photos as a means of estimating visitation to outdoor recreation areas with varied success. A study by Wood et al. (2020) on the use of social media to estimate visitation to outdoor recreation areas found that social media can fill in gaps from traditional monitoring as social media use was positively correlated with recreational activity. It was also found that social media could improve visitor estimates in unmonitored sites, but it was not a substitute for traditional methods. Social media and geotagged photos do not replace traditional methods because they convey a subset of the population and are not an accurate representation of the outdoor recreation population as a whole. This is because georeferenced imagery on social media only includes data from people who are willing to post to Social media accounts. Georeferenced imagery also lacks temporal precision as posting dates can vary from actual visitation.
dates. Thus, traditional or other methods of mobile data collection are needed to gain a more accurate representation of visitation to outdoor recreation areas.

**Passive Mobile Data**

The disadvantages from using traditional methods of visitation monitoring and active mobile data have led to a growing number of studies based on the use of more centralized passive mobile data or “big data”. This avenue of research is still relatively new in the outdoor recreation field. Passive data is helpful in many regards; it allows for greater spatial observation and temporality, it involves little to no interaction with the visitors which is especially useful in pandemic era times, and it allows for the use of retroactive data making it possible to examine visitation trends for which there are insufficient or no data collected. There are several different sources of passive mobile visitation data including LBS and GPS navigational data. Companies offering the use of big data have the potential to cut down on staffing and equipment costs along with data processing hours. Other benefits are that passive mobile data does not require the same setup and time commitments of traditional methods and that the opportunities for bias are reduced compared to that of methods like in-person surveys.

**Sources of Big Data**

There are many established or emerging companies that offer access to big data. Big data like this, could be useful for looking at disruptions and changes to outdoor recreation during the pandemic; many park operations were altered or suspended during the initial onset of the pandemic and pandemic conditions caused a dramatic shift to visitation patterns in many outdoor recreation areas.
**AirSage.** AirSage is a company that deals with the distribution of passive mobile data. AirSage currently uses GPS, real-time mobile signals, and other location data sources to produce their anonymous data points. However, they have been an established company since 2000 and used to rely on anonymous telecom data to triangulate cell tower pings for their products. AirSage's data has become more accurate over time. Current mobility datasets come from over 120 million devices and about 30% of the US population. To use the software, users send in defined areas to the data provider, the data is processed, aggregated, and anonymized, and the provider returns the processed data in a CSV file to be analyzed in consumer data processing software. AirSage data by itself might not be as accurate as land managers need. For example, a study conducted by Merrill and colleagues (2020) looked at visitation estimates to water recreation areas in New England through the use of AirSage technology and data. Researchers described that the data provider had unclear location information processing methods and that AirSage data needed calibration and validation against existing data collected through traditional methods to produce the desired visitation estimates. With calibration, the data were found to hold high spatiotemporal resolution useful for deriving visitation estimations.

**SafeGraph.** SafeGraph is another company offering anonymized passive mobile data to consumers. SafeGraph has a comprehensive dataset of POIs or points of interest which include location information, geographic coordinates, and business attributes. SafeGraph data is primarily obtained through mobile device apps that ask users for location information. SafeGraph provides information on the foot traffic level and is focused more on activity within POIs than vehicle traffic. Data from SafeGraph has
been used in numerous mobility studies, some of which focus on mobility and POIs during the pandemic\textsuperscript{28,54}. For example, one study conducted by Alba et al. (2021) used SaphGraph data sets to analyze whether people from diverse communities were more negatively impacted by mobility restriction\textsuperscript{28}. Another study looked at SaphGraph in a more exploratory manner. Kupfer et al. (2021) used SaphGraph mobile device data to look at spatiotemporal patterns in select NPs following the onset of the global pandemic. SaphGraph offers access to different specialized datasets\textsuperscript{65}. This study used data from SafeGraph’s pandemic-related Social Distancing Metric dataset which is composed of aggregate and anonymized foot traffic data to POIs in North America\textsuperscript{54}. Researchers hoped to assess whether the mobile data could effectively capture visitation patterns in select national parks by comparing NPS data with SafeGraph data. The results show that there was a high correlation between NPS-generated monthly visitation and SafeGraph data. The visitation pattern also followed closely with park management practices\textsuperscript{54}. In the origin-destination analysis, the origin of visitors shifted from farther away to closer from 2019 to 2020\textsuperscript{54}.

Based on current studies, SafeGraph presents consumers with the opportunity to improve spatiotemporal data as it relies on geographic location pings and is available at a daily timestep\textsuperscript{28,54,65}. However, as many studies have shown, passive mobile data is not a replacement for on-the-ground data\textsuperscript{8,54-55,60}. Specifically, Kupfer et al. (2021) found that there were some noted difficulties for working with the SafeGraph data. Difficulties include that local travel via slow-moving vehicles was hard to distinguish from foot traffic along park edges. Additionally, the data set ignores the presence of international
travelers which can represent a significant portion of traffic to large NPs, especially in pre-pandemic years\textsuperscript{54}.

**StreetLight.** StreetLight (a focus for this paper) is another company that offers anonymized big data. StreetLight gets its data from navigational GPS data and LBS\textsuperscript{7}. GPS data comes from vehicle navigation systems and is supplied by the company INRIX. It has a very high spatial precision. In comparison, LBS data comes from mobile device app activity in the foreground and background and is supplied by the company Cuebiq. It has higher spatial precision than LBS data but a smaller data pool. In total, StreetLight GPS and LBS data are sourced from over 110M devices which compose about \( \frac{1}{3} \) the population of the US and Canada. Once the data is collected, StreetLight cleans, contextualizes, and normalizes it before it becomes available to the user\textsuperscript{7}.

Unlike SafeGraph which is geared towards POI and foot traffic analysis\textsuperscript{54}, StreetLight data is primarily obtained for transportation monitoring\textsuperscript{66}. StreetLight was designed with the intention to shed light on transportation behavior and is now commonly used by transportation organizations and companies like the Maine Department of Transportation\textsuperscript{8,66}. There are options for looking at pedestrian traffic; however, vehicle analysis is looked at in terms of volume whereas pedestrian and bike traffic can only be analyzed using index values\textsuperscript{7}. For data analysis, unlike AirSage which compiles data into a CSV file upon data processing\textsuperscript{64}, Streetlight offers the use of the Streetlight *InSight* interface which simplifies analysis and helps users to visualize data\textsuperscript{7}. The completed analysis can also be downloaded into CSV format for further analysis by the consumer.

A growing number of studies have been done involving the use of StreetLight for visitation\textsuperscript{8,59} and transportation monitoring/planning\textsuperscript{56} in outdoor recreation areas. For
example, research conducted by Monz et al. (2020) looked at how passive mobile device data from StreetLight could be applied in the study of Parks and Protected Areas (PPA) visitation. The researchers found that StreetLight estimates for visitation in Orange County parks were not significantly different from the visitation estimates calculated through traditional methods at key recreation areas. Orange County parks are composed of a patchwork of land pieces, similar to the organization of ANP and the WMNF. Thus, the results from this study support that StreetLight can be a suitable source for managers to gather use estimates in complex use areas like these.

The NPS employed the use of StreetLight to answer questions about transportation in some of the Colorado parks. They looked at how visitors utilized transportation, where they entered and went within the park, how local vs non-local travel differed, and how long visitors stayed in an area. The analysis revealed that big data were useful in examining visitor use and travel patterns. The information included an origin-destination analysis of how visitors traveled between destinations and data on dwell time and total volume of visitation at a location. Overall, NPS officials found that using StreetLight provided more robust data sets, and using it was more time and cost-efficient than traditional methods like intercept surveys and manual counting for analysis at such a large spatial scale.

Another Study by Creany et al. (2021) looked at the use of StreetLight in trail use monitoring in Orange County California. Rather than vehicle volume, this study looked at pedestrian traffic available on StreetLight. They compared StreetLight estimates to established automatic trail counting and GPS-based monitoring methods, finding that the StreetLight estimates were not significantly different from those obtained using...
The results of the study again showed that StreetLight can be useful in determining use patterns in outdoor recreation. However, this study did highlight some discrepancies which indicate potential weaknesses in using StreetLight data to estimate pedestrian traffic. The researchers attributed discrepancies to either small intercept areas for GPS users or the inaccurate designation of vehicles as pedestrians (a similar issue as found in the Kupfer et al. (2021))

**Big Data Drawbacks**

Although useful and promising, there are disadvantages to using big data. Big data often requires calibration and validation. Studies on the efficacy of big data use for estimates on visitation to outdoor recreation areas indicate that big data is not a complete replacement for traditional on-the-ground visitation measurements; rather, big data should be used to supplement, and expand upon existing data. A study utilizing big data in visitation estimates found that the growing use of big data furthered the need for more accurate data from traditional methods. Traditional data serves to validate big data’s efficacy. For example, StreetLight InSight uses traditional methods like traffic counters in select locations to validate their traffic data.

Another potential disadvantage to the use of big data is that it relies on the cellular range of mobile devices for obtaining data. This can be a tricky issue in outdoor recreation areas as they often have spotty cell signals. This issue is lessened by the growing use of cellphones and expanding cell phone range. For example, the US Census Bureau reported that about 84% of households had cell phones in 2018. Additionally, cellular coverage is expanding across the country and into more outdoor recreation areas. This is true for national parks as well, which have plans to expand cell towers in several
different parks like the Grand Teton and Sequoia NP\textsuperscript{68}. In Maine, AT&T expanded wireless networks through investments totaling nearly $150 million from 2018 to 2020. As a result, the company took over as the largest network in Maine for 2021\textsuperscript{69}.
PART II: EXPLORATION OF STREETLIGHT *INSIGHT* IN THE WHITE MOUNTAIN NATIONAL FOREST

**Background**

This section of the study seeks to explore the research question on how the COVID-19 pandemic affected trends in outdoor recreation areas while also exploring the use of StreetLight *Insight* to evaluate visitation trends in the WMNF. I had three main objectives while using StreetLight *Insight* software. These objectives were to explore how visitation volume has changed in the WMNF from before the onset of the COVID-19 pandemic to 2021, explore how the pandemic has impacted visitation to the nearby villages Bethel and Gorham (where the risk of transmission may be greater) compared to and from the WMNF, and explore whether or not visitor demographics have changed within the period from 2018-2021. I had access to the study area shown in figure 1. Any land area within the pink border was available for analysis through StreetLight. The blue shape overlays represent land within the WMNF. In total, the access area contained slightly less than 40% of the total WMNF area.

![Figure 1: Region of access in StreetLight *Insight* user Platform.](image-url)
Methodology

To achieve the three objectives, I used the StreetLight InSight analysis platform to analyze mobility data for select zones in my area of interest within the region of access seen in figure 1. StreetLight provides data from both GPS and LBS data sources. For the purposes of this study, I used LBS data sources in the analysis, specifically through the use of the All Vehicles mode of travel. LBS data is composed of information from mobile device apps that have users opt-in to LBS. Individual zone analyses were all done using StreetLight All Vehicle volume values. StreetLight Volume is an estimate of real-world trips. For All Vehicle volume, LBS data is processed with a vehicular bias that filters trips based on whether they behave like motorized vehicles. I choose to look at StreetLight All Vehicle volume and ignore pedestrian, commercial truck, bicycle, and rail travel that is available in the form of StreetLight InSight Index data, as unlike StreetLight Volume values, StreetLight Index values do not represent trip count estimates. Instead, StreetLight Index provides a relative volume of trip activity and is not recommended for comparing values across time.

Six unique zones were identified within the study area as either nearby village centers (Gorham NH and Bethel ME) or popular outdoor recreation areas (the Mount Washington Summit (MWS), Dolly Copp Campground (DCC), The Pinkham Notch Visitor Center (PNVC), and the total WMNF area within the area of access) based on existing knowledge of the areas and preliminary research on WMNF recreation sites. Once the areas were identified, polygons were created around the zones using the StreetLight InSight platform digital map interface. From there, individual analyses were
conducted in an attempt to explore each of the three research objectives. I used three different types of StreetLight data analysis methods available on the InSight platform, (Zone Activity, Origin-Destination, and Trips to or from Pre-set Geography) to understand activity within and to/from my areas of interest. Although StreetLight InSight allows users to analyze a wide range of data periods, for the purposes of this study, the data is focused on peak summer months (June 1st -September 30th) as they have the most concentrated outdoor recreation/visitation volume in the forest.

Objective 1: How has visitation volume changed in the WMNF from before the onset of the COVID-19 pandemic to 2021?

To address questions around changes to visitation volume during the onset of the pandemic, I first used InSight to conduct Zone Activity Analysis on each of the 6 zones created on the map interface for 2018-2021. The Zone Activity Analysis produces weekly trip volume data for trips that originate in, end at or pass through the zones72. For the purposes of this study, I focused only on weekly trips that originate or end in the zones. From there, I used the InSight generated trip values to calculate the percent change in the volume of trips to and from Gorham, Bethel, and the WMNF zones between summers through 2018-2021. Within these zone activity analyses, I used the option to separate trip volume by day types (days of the week) to see how the proportion of total weekly tip volume changes from day to day and gain information on movement throughout the three zones.
Objective 2: How has COVID-19 impacted travel/visitation to Bethel and Gorham from the WMNF?

To address questions around potential impacts on travel/visitation between the villages and WMNF during the onset of the pandemic, I first looked at the Zone Activity Analysis previously conducted on each of the 6 zones using the map interface on the InSight platform to calculate additional percent changes in the volume of trips in MWS, PNVC, and DCC. I used this to compare visitation trends across village centers and outdoor recreation areas. I then used InSight to conduct Trips to or from Pre-set Geography Analysis on the WMNF for 2018 to 2021. The Trips to or from Pre-set Geography Analysis provides information about where trips that originate in a zone end based on standard geographies like zip codes. From there, I used the InSight generated trip information to see how the proportion of trips between recreation areas and the known geographies Gorham and Bethel changed from 2018-2019.

The final way I looked at impacts on travel/visitation between the villages and WMNF during the onset of the pandemic was through Origin-Destination Analysis on tips between WMNF and Gorham and Bethel. Origin-Destination Analysis provides information on trips that start, stop, and pass through the destination. For the purposes of this study, I focused only on trips that start or stop in the specified zones. From there, I used the InSight generated trip information to see how the proportion of trips between WMNF and Gorham and Bethel changed from 2018-2019 by calculating the percent change in trip volume and looking at the trip purpose information described below.
Objective 3: Have Demographics been affected by COVID-19?

To address questions around potential impacts to outdoor recreationist demographics during the onset of the pandemic, I first looked at the traveler attributes information provided in both the Zone Activity Analysis and Origin-Destination Analysis conducted in my zones. Traveler attributes produced by analyses include information on traffic by trip purpose, education of the head of household, family status, household income, and race. StreetLight does not provide information on other demographics like traveler age or gender. For this study, I used InSight values to look at trip purpose, household income, education of the head of household, and family status. These metrics are derived from 2010 US census data. The trip purpose metric provides the percentage of trips that are Home-Based Work (HBW) (travel between home and work locations), Home-Based Other (HBO) (travel to or from home locations to locations other than work), and Non-Home Based (NHB) (travel that is neither to nor from home locations). I used the trip purpose metric to derive information on the proportion of potential local travel within the areas of interest.

Results and Analysis

Objective 1: How has visitation volume changed in the WMNF from before the onset of the COVID-19 pandemic to 2021?

COVID-19 impacted the volume of visitation within the study area as measured by average weekly summer trip volume in Gorham, Bethel, and WMNF. Figures 2-4 show the percent change in the average weekly summer trip volume for trips starting and ending in Gorham, Bethel, and WMNF. In Gorham and Bethel, trip volume declined
from 2018-2019 and again from 2019-2020 (Figures 2 and 3). The most significant decline for both villages occurred from 2019-2020 with a 15.5% decline in Gorham and a 22.4% decline in Bethel from the previous year. Trip volume began to rebound in both villages from 2020-2021 with a 2.1% increase in Gorham and a 9.5% increase in Bethel from the previous year. However, volume did not return to pre-pandemic levels (Figures 2 and 3). In WMNF, trip volume changed differently than in the two villages. Trip volume increased from 2018-2019 and then decreased from 2019-2021 (Figure 4). The most significant decline occurred from 2019-2020 with a 25.2% decline in trip volume from the previous year. Unlike trip volume in the two village areas, trip volume in WMNF did not rebound from 2020-2021 and it continued to decline by a significant amount (20.1%) (Figure 4).

![Figure 2: Percent change in the average weekly volume of trips starting and ending in Gorham NH between the years 2018-2021.](image)
Visitation as measured by trip volume did not only change at the larger WMNF level. Table 2 shows the recorded average weekly summer trip volume within Gorham, Bethel, and WMNF with the addition of select areas of outdoor recreation, MWS and the PNVC. Trip Volume within MWS followed the trends seen at the larger WMNF level.
and increased from 2018-2019 (1,844→2,011) then decreased from 2019-2021 (2,011→1,326→1,190). PNVC trip volume declined throughout the entire 2018-2021 period (559→381→296→263) (Table 1).

**Table 1:** Weekly Average Summer Trip Volume for Gorham NH, Bethel ME, the WMNF, MWS, and PNVC.

<table>
<thead>
<tr>
<th>Year</th>
<th>Gorham</th>
<th>Bethel</th>
<th>WMNF</th>
<th>Mount Washington Summit</th>
<th>Pinkham Notch Visitor Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>35,866</td>
<td>18,592</td>
<td>35,585</td>
<td>1,844</td>
<td>559</td>
</tr>
<tr>
<td>2019</td>
<td>33,627</td>
<td>16,918</td>
<td>40,454</td>
<td>2,011</td>
<td>381</td>
</tr>
<tr>
<td>2020</td>
<td>28,401</td>
<td>13,131</td>
<td>30,259</td>
<td>1,326</td>
<td>296</td>
</tr>
<tr>
<td>2021</td>
<td>29,001</td>
<td>14,374</td>
<td>24,174</td>
<td>1,190</td>
<td>263</td>
</tr>
</tbody>
</table>

StreetLight *InSight* can provide information on trip volume based on day parts (time of day) and day types (day of the week). Figures 5, 6, and 7 show how the distribution of trips across day types changes from 2018-2019 in Gorham, Bethel and WMNF. The blue lines represent the percentage of trip volume in 2018, the red lines represent the percentage of trip volume in 2019, the purple lines represent the percentage of trip volume in 2020, the yellow line represents the percentage of trip volume in 2021. The difference in the proportion of trips on the weekend vs weekdays becomes smaller from 2018 to 2020 in Gorham and Bethel. In Gorham, the day with the lowest percentage of trip volume is Sunday with 12.4% and the day with the highest percentage of trip volume is Friday with 17.5% this is a difference of 5.1% in 2018. In 2021, the day with the lowest percentage of trip volume is Sunday with 13.2% and the day with the highest percentage of trip volume is Friday with 15.8% this is a difference of 2.6% (Figure 5).
Similarly, in Bethel, the day with the lowest percent of trip volume is Sunday with 11.7% and the day with the highest percentage of trip volume is Friday with 18.4% this is a difference of 6.7% in 2018. In 2021, the day with the lowest percentage of trip volume is Sunday with 12.4% and the day with the highest percentage of trip volume is Friday with 16.8% this is a difference of 4.4% (Figure 6).

Figure 5: Percent of average weekly summer trip volume by day of the week in Gorham NH.
To compare, figure 7 shows that in WMNF, the difference in the proportion of trips on the weekend vs weekdays becomes the greatest in 2020 when COVID-19 regulations began. The difference then became the smallest in 2021. The day with the lowest percentage of trip volume is Tuesday with 9.9% and the day with the highest percentage of trip volume is Saturday with 24.2% this is a difference of 14.3% in 2020. In 2021, the day with the lowest percent of trip volume is Wednesday with 11.4% and the day with the highest percentage of trip volume is Saturday with 21.3% this is a difference of 9.9%, a much smaller difference (Figure 7).
Objective 2: How has COVID-19 impacted travel/visitation to Bethel and Gorham from the WMNF?

Changes in visitation in and around the WMNF varied between 2018-2021. The data from StreetLight InSight zone activity analysis seen in figure 8 shows a decline in the average weekly summer trip volume between the pre-COVID-19 period to 2020 for Gorham, Bethel, MWS, PNVC, and DCC (18.3%, 26.0%, 31.2%, 37.2%, and 34.2%). This decline occurred in conjunction with the onset of the pandemic. From 2020-2021, trip volume increased in both Bethel and Gorham (2.1% and 9.5%) while continuing to decline in the outdoor recreation areas MWS, PNVC, and DCC (10.3%, 11.1%, and 30.0%). DCC had the highest decline in the average weekly summer trip volume between...
the pre-COVID-19 period to 2021 with volume declining 34% from the pre-COVID-19 period to 2020 and another 30% between 2020 and 2021 (Figure 8).

Figure 8: The Percent change in StreetLight InSight zone activity volume for trips entering and leaving Gorham NH, Bethel ME, MWS, PNVC, and DCC. The Pre-COVID-19 trip volume is an average of 2018 and 2019 volume.

Data derived from StreetLight InSight Pre-set Geography Analysis for outdoor recreation areas shows the proportion of trips leaving the outdoor recreation areas MWS, PNVC, and DCC and ending in Gorham or Bethel also varied pre and post-COVID-19 between the period 2018-2021 (Table 2). From 2018-2019, the proportion of trips ending in Gorham and Bethel and leaving MWS decreased (18.2→16.8%) while the proportion of trips ending in Gorham and Bethel and leaving PNVC and DCC increased (39.9→44.3% and 71.1→76.3%). From 2019-2020, the proportion of trips ending in Gorham and Bethel and leaving MWS and PNVC increased (16.8→17.1% and 44.3→46.3%) while the proportion of trips ending in Gorham and Bethel and leaving DCC declined (76.3→66.7%). From 2020-2021, the proportion of trips ending in Gorham and Bethel and leaving MWS and DCC increased (17.1→20.0% and
66.7→80.0%) while the proportion of trips ending in Gorham and Bethel and leaving PNVC decreased (46.3-45.4) (Table 2).

Table 2: Proportion of weekly average summer trips ending in Gorham or Bethel.

<table>
<thead>
<tr>
<th>Origin</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mount Washington</td>
<td>18.2%</td>
<td>16.8%</td>
<td>17.1%</td>
<td>20.0%</td>
</tr>
<tr>
<td>Pinkham Notch Visitor Center</td>
<td>39.9%</td>
<td>44.3%</td>
<td>46.3%</td>
<td>45.4%</td>
</tr>
<tr>
<td>Dolly Copp Campground</td>
<td>71.1%</td>
<td>76.3%</td>
<td>66.7%</td>
<td>80.0%</td>
</tr>
</tbody>
</table>

Travel between WMNF and Gorham and Bethel changed from 2018-2021. The average weekly summer trip volume for trips between WMNF and Gorham and Bethel follows a similar distribution as the total average weekly summer trip volume for trips starting or ending within the WMNF (Figure 9). The volume of trips increases between 2018-2019 and declines from 2019-2021. However, there are some differences. Trips between WMNF and Gorham and Bethel increased by nearly 28% from 2018-2019 whereas, average weekly summer trip volume for all trips in the WMNF only increased by about 14% (Figures 4 and 9). The decline in trip volume was also greater from 2019 to 2020 (~25%) and 2020-2021 (~20%) for all trips in the WMNF compared to trips between WMNF and Gorham and Bethel (Figure 4). Trips between WMNF and Gorham and Bethel declined by only 6% and 10% respectively (Figure 9).
Figure 9: Percent change in the average weekly summer trip volume for trips between the WMNF and the villages Bethel ME and Gorham NH.

Figure 10 shows how the proportion of trips between WMNF and Gorham and Bethel by trip purpose changed from 2018-2021. The blue bar represents non-home based (NHB) travel, the orange bar represents home-based other (HBO) travel, and the gray bar represents home-based work (HBW) travel. There was a higher proportion of trips to or from home locations since the onset of the pandemic in 2020 compared to pre-pandemic years. The proportion of NHB trips increased from 2018-2019 and decreased from 2019-2021. The proportion of HBO trips simultaneously decreased from 2018-2019 and increased from 2019-2021. HBW trips also decreased from 2018-2019 and increased from 2019-2021 (Figure 10).
Objective 3: Have Demographics been affected by COVID-19?

StreetLight InSight provides information on traveler attributes or demographics in their analyses. Figures 11-16 show trends in demographics for travelers within WMNF between 2018-2019. Zone analysis on travel within Gorham, Bethel and WMNF reveals that trip purpose changes from pre-pandemic to pandemic years. Figures 11-13 show the proportion of average weekly trips by trip purpose from 2018-2021 in Gorham, Bethel and WMNF. The blue bar represents NHB travel, HBO travel, and the gray bar HBW travel. Although the proportion does not dramatically change between the time period, there is some variation.

In Gorham, there was an overall increase in the proportion of HBW travel from 11.6% in 2018 to 16% in 2021 as shown in figure 11. HBO travel slightly decreased from 2018-2019 (41.6% → 40.2%) and again from 2020-2021 (43.4% → 40.0%). HBO increased from 2019-2020 (40.2% → 43.4%). NHB declined from 2018-2020 (46.9% →
46.2% → 42.4%). It then increased from 2020-2021 (42.4% → 44.14%) but not back to pre-pandemic levels (Figure 11). In Bethel, there was an overall increase in the proportion of HBW travel from 8.1% in 2018 to 11.7% in 2021 as shown in figure 12. HBO slightly increased from 2018-2019 (40.2% → 40.6%) and again from 2019-2020 (40.6% → 42.2%). HBO travel slightly decreased from 2020-2021 (42.2% → 41.0%). NHB declined from 2018-2021 from 51.7% in 2018 to 47.4% in 2021 (Figure 12).

**Figure 11:** The proportion of average weekly trips by trip purpose from 2018-2021 in Gorham, New Hampshire.

**Figure 12:** The proportion of average weekly trips by trip purpose from 2018-2021 in Bethel, Maine.
The proportion of HBW travel within WMNF declined slightly from 2018-2019 (3.2% → 3.0%) and again from 2019-2020 (3.0% → 2.7%) (Figure 13). HBW increased from 2020-2021 (2.7% → 3.4%) past pre-pandemic levels. The proportion of HBO travel declined from 2018-2019 (14.0% → 12.3%) and again slightly from 2020-2021 (15.2% → 15.0%). HBO increased from 2019-2020 (12.3% → 15.2%). Compared to the 2 villages, the proportion of NHB trips within the WMNF was significantly higher. NHB travel increased from 2018-2019 (82.8% → 84.7%). It then decreased from 2019-2021 from 84.7% in 2019 to 81.6% in 2021 (Figure 13).

**Figure 13:** The proportion of Average Weekly Trips by trip purpose from 2018-2021 in the WMNF.

Additional demographic data from zone analyses in WMNF can be seen in Figures 14-16. These depict changes in the proportion of average weekly summer trips by household income, education level of the head of the household, and family status from 2018-2021. In all three figures, the blue bar represents trips in 2018, the red bar represents trips in 2019, the gray bar represents trips in 2020, and the purple bar represents trips in 2021. Figure 14 shows that the proportion of traffic by household
income did not vary dramatically between 2018-2021. Trips from individuals with a household income of 50-75k were the most common, composing about ~18% of the trip volume. The next most common were trips from individuals with a household income of 75-100k (~14%). Trips from individuals with a household income of 125-150k were the least common, composing about ~6% of the trip volume (Figure 14).

![Figure 14](image)

**Figure 14:** Proportion of average weekly summer trips to and from WMNF by household income in 2018-2020.

The proportion of traffic by the education level of the head of the household did not vary dramatically between 2018-2021 either (Figure 15). Trips from individuals with a high school diploma were the most common, composing about ~29% of the trip volume. The next most common were trips from individuals with some college (~26%). Trips from individuals with no high school diploma were the least common, composing about ~9.5% of the trip volume (Figure 15).
Figure 15: Proportion of average weekly summer trips to and from WMNF by the education level of the head of the household in 2018-2020.

Figure 16 shows data centered around another demographic, family status. The proportion of traffic by family status slightly changes from 2018-2020. The proportion of trips from individuals with kids slightly increased between 2018-2021 from 31.5% in 2018 to 33.8% in 2021. Simultaneously, the proportion of trips from individuals without kids decreased between 2018-2021 from 68.5% in 2018 to 66.2% in 2021. Nearly 2x the number of trips were taken by individuals without kids (4-year average ~67%) as trips taken from individuals with kids from 2018-2021 (4-year average ~33%) (Figure 16).
Discussion

The StreetLight InSight analyses provided useful information on visitation and demographic trends in the WMNF and surrounding area from 2018-2021. While there may not be preexisting data collected in the WMNF or Bethel and Gorham to compare the StreetLight InSight analysis results to, the general trends in visitation still reveal that COVID-19 likely had an impact on the volume of outdoor recreation within WMNF and Bethel and Gorham. Additionally, the results indicate changes in demographics following the start of COVID-19 regulations. Because StreetLight data allows for retroactive analyses, it was possible to look at trends where traditional methods of use monitoring were not employed and at a more refined spatiotemporal level. StreetLight data does not provide reasoning behind their data trends. However, it is possible to look at how trends correlate with occurrences like the onset of COVID-19 to see if there could be a
relationship. The following discussion explores potential reasoning behind the trends seen in the results.

Objective 1: How has visitation volume changed in the WMNF from before the onset of the COVID-19 pandemic to 2021?

In trying to explore how visitation volume changed in the WMNF from before the onset of the COVID-19 pandemic to 2021, I found that visitation volume was different after the onset of the pandemic. Results from figures 2-4 show a large decline in trip volume from 2019-2020 in Gorham, Bethel, and WMNF. This decline occurs in conjunction with the onset of COVID-19 and subsequent safety measures. Safety measures limited mobility for people around the globe\textsuperscript{13,25} and are a likely a contributing factor to the overall decline in traveler volume seen within the study site. From 2020 to 2021, volume increased in both of the villages while continuing to decline in WMNF (Figures 2-4). This pattern could indicate that activity within the two village centers began to rise in conjunction with lessening health and safety mobility restrictions\textsuperscript{23}. Activity within outdoor recreation areas does not follow the same patterns (Figure 4). This could be due to the fact that lessening restrictions also meant more recreation could be done in urban and indoor spaces than in 2020. Although the total volume of travel may have increased around the US\textsuperscript{23}, so did the opportunities for travel to areas other than outdoor spaces meaning that outdoor recreation would continue to decline. It is also possible that the trends in trip volume within the areas of the study area (~40% of the total WMNF) are unrepresentative of total trends in visitation to the park as a whole.

Looking at how visitation volume changed from 2018-2019 across day types (days of the week) also provides information on the potential effects of COVID-19 on
changes to visitation volume. The distribution across day types changes from year to year in the study period. In the villages, the difference between weekend and weekday visitation lessened after the onset of COVID-19 (Figure 5 and 6). A potential reason for this trend could be the higher proportion of individuals working from home with flexible schedules due to existing pandemic health and safety concerns. In a United States 2020 survey of employed individuals, the proportion of respondents working remotely for 5+ days per week increased from 17% to 44% between pre-pandemic to post-pandemic periods. The weekly trends differ in the WMNF with the highest difference between weekend and weekday visitation occurring in 2020 and the lowest occurring in 2021(Figure 7). This difference could be reflective of the types of trips dominating each of these zones. The villages have a higher proportion of home-based trips than the WMNF (Figures 10-12). The WMNF sees a large proportion of NHB trips so a higher proportion of visitation of the weekends vs the weekdays during the first year of the pandemic could be a reflection of the larger proportion of local home-based recreators seen in other outdoor recreation studies. The decline in difference between the weekend vs the weekday trips in 2021 might also be representative of lessened safety restrictions.

Objective 2: How has COVID-19 impacted travel/visitation to Bethel and Gorham from the WMNF?

Exploring how COVID-19 impacted travel/visitation to Bethel and Gorham from the WMNF through the use of Zone Activity Analysis, Origin-Destination Analysis, and Trips to or from Pre-set Geography Analysis, did not reveal that visitation in the villages was disproportionately or more negatively impacted by the onset of the pandemic than
the outdoor recreation areas. A disproportional decline in trips between the villages and outdoor recreation areas would likely represent a disproportionate loss in the economy of these border towns as border towns like these rely on tourism to support the economy.

The declines in trip volume in outdoor recreation areas from 2020 and 2021 correspond with restrictions placed within those years. For example, DCC was partially closed due to renovations in 2020 with Sites opening in segments June-September\textsuperscript{76}. Similarly, the Cog Railway (a usually popular route up to MWS) was closed until July 1 eventually opening with limited capacity\textsuperscript{77}. New Hampshire also had stay at home orders in May through June which limited non-essential travel and can explain a decrease in trips within the village centers \textsuperscript{77}. In 2021, DCC was closed until July 1st then opened with a phased reopening plan\textsuperscript{76}. This meant that there was a shorter time period for summer visitation compared to 2020 which explains why visitation continued to decline by such a high proportion (Figure 8). Additionally, trips on the Cog Railway continued to operate at a reduced capacity into the summer of 2021\textsuperscript{77}.

Looking at trips from WMNF to the villages, the volume of trips from 2019 to 2021 also declined along with declines in trip volume for all trips within WMNF. However, these declines do not show a smaller relative proportion of trips going to the villages than would be expected. For example, the declines in trip volume represented by the percent changes in volumes in Figures 4 and 9 do not indicate declines in movement between WMNF and the villages. If this were the case, the expected trend would be a greater percent decline in trip volume for trips going between WMNF and the villages (Figure 9) than the percent declines seen in the WMNF trips to any area (Figure 4). This
does not occur. In fact, the percent change in trip volume is less for trips going between WMNF and the villages compared to those going to all areas (Figures 4 and 9).

Although movement between the villages and outdoor recreation areas did not seem disproportionate, the types of trips between these areas also changed. This change in trip purpose could have increased negative impacts to the economy in addition to the overall decline in travel resulting from the onset of the pandemic. For example, Figure 10 shows that from 2019-2021, the proportion of home-based trips between WMNF and the villages increased while the proportion of NHB trips decreased. This could be representative of a higher proportion of locals compared to tourists moving between recreation and village areas. Local travelers would not have the same spending habits and might not stop in the villages for souvenirs and restaurants the same way as travelers from farther distances do$^{13,32}$. This would have an increased negative impact on the economy than if the proportion of local travelers remained constant.

**Objective 3: Have Demographics been affected by COVID-19?**

In exploring how the pandemic might have impacted the demographics of outdoor recreationists in the WMNF and surrounding areas, I looked at the traveler attributes trip purpose, household income, education of head of household, and family status. Looking at how the proportion of travel by trip purpose changes from 2018-2021 can provide additional insight into demographic changes during the pandemic. Figures 11-13 show that there was an overall increase in the proportion of HBW travel within both Gorham and Bethel but not within WMNF. This could be a reflection of the closure of non-essential businesses like visitor centers, gift shops, and attractions such as the Cog Railway. Gorham and Bethel have a larger proportion of essential businesses like...
restaurants, grocery stores, and gas stations so work trips might not have declined as they
did in WMNF. Additionally, there was also an increase in HBO travel in all three zones,
this could be representative of the same higher proportion of locals compared to tourists
recreating or going to village centers as seen in other COVID-19 outdoor recreation
studies\textsuperscript{13,25} and in Figure 10.

Looking at other demographic data on trips by household income and by
education of head of household within WMNF, changes during the period between pre
and post-COVID-19 are harder to see. The proportion of trips by both household income
and education of the head of household did not vary dramatically between 2018-2021
(Figures 14 and 15). Although the comparison between years does not reveal much in
terms of COVID-19 effects, it does provide information on the demographics of outdoor
recreationists in the WMNF. For example, according to the results, the most common
household income for individuals was $50-75k (Figure 14). This falls within expectation
based on national patterns as the median US household income for 2020 was $67,521 and
falls within this range\textsuperscript{78}. Additionally, the highest proportion of trips was taken by
individuals with lower household incomes (less than $75k) compared to the proportion
taken by individuals with higher household incomes (greater than $75k) (Figure 14).

The demographic data also reveals information on the level of education for
outdoor recreationists in WMNF. Figure 15 shows that the distribution of trips by the
education level of the head of the household somewhat matches expectations based on
national education statistics with some deviations. The US Census Bureau reports that in
2021, 8.9% of the population did not have a high school diploma, 53.2% had a high
school diploma and some college, and 37.9% had a bachelor's degree or more\textsuperscript{79}. In
comparison, the distribution seen within the WMNF was that 9.5% had no high school
diploma, 55.6% had a high school diploma and some college, and 34.9% had a bachelor’s
degree or more (Figure 15). This distribution is a slight shift towards a lower level of
education than the national percentage.

In comparison to demographic data on the level of education and household
income, demographic data for trips based on family status did show a trend between pre-
COVID-19 and post-COVID-19 years. The proportion of trips from households with kids
increased between 2018-2021 while the proportion of trips from households without kids
decreased (Figure 16). These patterns could be indicative of a response by parents to the
physical and mental health stressors caused by the pandemic\textsuperscript{33,34} in an attempt to utilize
outdoor recreation health benefits\textsuperscript{26,36}. However, it could also have more to do with a
general trend like a higher proportion of established families seeking to recreate
(unrelated to the pandemic). The CDC reports that the average age at first birth is 26
years old\textsuperscript{80}, so a shift towards a higher proportion of families with kids could also
indicate a shift towards an older average age of recreators within WMNF.
PART III: ANALYSIS OF 2020-2021 ACADIA SURVEY

Background

In this third section of the study, I sought to address my research question on how the onset of COVID-19 influenced trends in outdoor recreation areas by analyzing a subset of survey questions answered by visitors in ANP. The overall survey that this subset was derived from addressed stakeholder values around ANP water resources. The survey was deployed throughout the park on stationary signage and was accessible through either a QR code or a survey link. A picture of the survey board can be seen below (Figure 17). Respondents had the option to receive an Acadia postcard as an incentive upon completion of the survey. For the purposes of this study, I only looked at select questions related to visitation, visitor demographics, and behavioral responses to COVID-19. The 11 questions used can be seen in Table 3 below. Like in the previous section, I had three main objectives while conducting analyses on the survey data. They included looking into what the demographics were for survey respondents, if COVID-19 impacted respondent behaviors and feelings of risk, and whether any demographic variables could explain differences in outdoor recreation behaviors.

Figure 17: ANP water resources survey board.
<table>
<thead>
<tr>
<th>Question</th>
<th>Possible Answers</th>
</tr>
</thead>
</table>
| **1** BEFORE your trip to Acadia National Park, to what extent did you think you would be at risk to COVID-19 while visiting Acadia National Park? | A. Not at all at risk  
B. Low risk  
C. Moderate risk  
D. High risk |
| **2** Now that you are here, to what extent do you think you are at risk to COVID-19 while visiting Acadia National Park? | A. Not at all at risk  
B. Low risk  
C. Moderate risk  
D. High risk |
| **3** In general, are you spending MORE or LESS time outdoors because of the COVID-19 pandemic? | A. Less  
B. More |
| **4** Does your trip include more or less outdoor recreation because of the COVID-19 pandemic? | A. Less  
B. More |
| **4a** Why? Select all that apply.                                      | 1. I am avoiding other people and Acadia NP can be crowded.  
2. My access to Acadia NP is limited by public transportation closures.  
3. Other |
| **4b** Why? Select all that apply.                                      | 1. Outdoor recreation is low risk for COVID-19 transmission.  
2. During quarantine, I started to do more outdoor recreation and liked it.  
3. Other |
| **5** Because of COVID-19, I am NOT swimming in Acadia NP.              | A. Agree  
B. Disagree |
| **6** During this trip to Acadia National Park, please indicate all of the places you visited or plan to visit. If you are not taking this survey while visiting Acadia National Park, please choose N/A | A. Cadillac Mountain  
B. Sand Beach  
C. Thunder Hole  
D. Jordan Pond  
E. Bass Harbor Head Lighthouse  
F. Schoodic Peninsula |
| **7** How old are you?                                                  | A. 18-21  
B. 22-30  
C. 31-40  
D. 41-50  
E. 51-60 |
Methodology

To achieve the three objectives for analyzing the survey results, data were entered into SPSS for analysis. All questions not pertaining to the research objectives were removed from the data set. When picking the research questions, I chose questions centered around behaviors during the pandemic, feelings of risk to COVID-19 from recreation, and demographics. Like with StreetLight, I used the survey to look at trends during COVID-19. However, unlike with StreetLight, I was unable to look at trends from pre to post-pandemic years as the survey data only span from summer 2020 to 2021. Once the data were entered and filtered in SPSS, I then calculated descriptive statistics and ran statistical tests. In total 460 respondents answered at least one question on the
survey. However, not all respondents answered each question so missing values were designated when needed for all SPSS analyses.

**Objective 1: What were the demographics for ANP survey respondents from 2020-2021?**

To address the first objective, I looked at questions involving personal descriptor, home location, gender, age, and education level. In SPSS I first obtained the frequencies for these demographics. For the personal descriptor, the categories educator, research, and student were grouped and environmental steward and natural resource manager were grouped for figure clarity. For home locations, states were assigned to zip code values, and frequencies based on these assignments were made. Home locations were only separated into states in the New England Region. All other zip codes were grouped into a category labeled “Outside New England”. Frequencies on gender, age, and level of education were created using only the responses answering all three questions in order to be able to directly compare differences for the same respondents. All other responses were removed from this particular analysis. Once the analyses were run, the frequencies were then transferred to Microsoft Excel for graphing.

**Objective 2: Did COVID-19 impact respondent behaviors and feelings of risk?**

To address questions about respondent behaviors and feelings of risk in ANP during the pandemic, I looked at questions involving behavioral changes, perceptions, and visitation. In SPSS I first compared reported feelings of risk before and while visiting ANP by first deriving answer frequencies and then calculating the frequency at which each respondent’s feelings of risk changed from before they visited to during their visit. This was done using a new set of values calculated from the difference between risk
feelings before and during visitation. Risk levels were assigned numerical values (1=not at risk, 2=low risk, 3=moderate risk, and 4=high risk). For each respondent, [(risk before)-(risk during)] was calculated. The frequencies for these results were then graphed in Excel.

Frequencies were also derived for responses to questions around time spent outdoors, changes to outdoor recreation during visits, the reasoning behind these changes, and changes in swimming behaviors. These results were then copied and graphed in Excel. The final step of this analysis was to find the frequency of visitation to recreation sites within ANP from the question about visitation. For this frequency analysis, cases where respondents did not answer whether they had been to each of the 6 locations (Cadillac Mountain (CM), Sand Beach (SB), Thunder Hole (TH), Jordan Pond (JP), Bass Harbor Lighthouse (BHL), and Schoodic Peninsula (SP)), were removed so results could better be compared across the locations. Like with the other frequency data, information was transferred into Excel and graphed.

Objective 3: Were there any demographic variables that could explain differences in outdoor recreation behaviors?

To address the final question around demographic variables and changes to recreation behaviors, a series of Pearson Chi-squared tests in SPSS were run. The results from these tests provided the asymptotic significance for relationships between the responses. This analysis involved running the test to look at the relationship between responses to question 6 with responses to questions 1, 2, 3, 4, and 5 from Table 3. It also involved running the test to look at the relationship between responses to questions 1, 2,
Results and Analysis

Objective 1: What were the demographics for ANP survey respondents from 2020-2021?

Questions in the ANP survey revealed information on visitor demographic distribution such as types of visitors, home locations, ages, genders, and levels of education. The proportion of visitors to ANP varied based on personal descriptor and reported home locations (Figures 18 and 19). The distribution in figure 18 shows the proportion of respondents by type of visitor for the 438 total respondents to the question. When asked to “choose which [personal descriptor] best describes you”, only a small proportion of respondents reported being local residents of Mount Desert Island (6.6%). The vast majority of respondents reported they were a “visitor to Acadia National Park” (81.1%). The remaining 12.4% of respondents reported that they were environmental stewards, natural resource managers, educators, researchers or students (Figure 18). Figure 19 shows how respondents varied based on reported home locations. Of the 256 respondents who provided their home zip code, a little less than half reported they were from New England (38.3%) and a little over half reported they were from outside of New England (61.7%). Within the 38.3% visiting ANP from New England, 30.6% reported they were visiting from within Maine. This represents 11.7% of the total respondents to the question (Figure 19).
Figure 18: The proportion of respondents by type of visitor. Figure based on the 438 respondents who chose to describe themselves.

Figure 19: Proportion of respondents by home zip code. Figure based on the 256 respondents who identified their home zip codes.

Answers to questions 7-9 seen in Table 3 provided information on the gender, age, and level of education distributions for respondents. Of the 307 respondents answering all three demographic questions, a slight majority (57.7%) reported being female while only (42.3%) reported being male (Figure 20a). Figure 20b shows the age distribution of respondents when asked “How old are you?”. A majority of ANP survey
respondents during this time were younger than 41. Most respondents fell in between the ages of 22-30 (33.6%) with the next highest frequency of respondents falling in between the ages of 31-40 (16%). Individuals 61 years and older represent the fewest number of respondents (10.4%). When asked “Which degrees have you received or are you in the process of completing”, the proportion of respondents which reported having been in the process of completing a college degree. A much smaller proportion reported having a master’s degree (28.7%) and those reporting having a high school diploma, PHD, or being a professional represented the least amount of respondents (8.8%, 3.9%, and 7.2% respectively) (Figure 20c).

![Figure 20](image)

**Figure 20**: proportion of respondents by demographic for the 307/460 respondents answering all three demographic questions. (20A) The frequency of reported genders. (20B) The frequency of reported ages. (20C) The frequency of reported degree levels. For reported degree levels in figure 20C, HS represents high school degree, MA represents master’s Degree, and PHD represents doctorate degree.
Objective 2: Did COVID-19 impact respondent behaviors and feelings of risk?

Answers to questions 1-6 in Table 3 give insight into respondent changes to behaviors and feelings of risk to COVID-19 within ANP. They also give insight into travel to specific sites within the park during the pandemic. Most respondents did not have increased feelings of risk while recreating. Of the 335 respondents answering questions 1 and 2 from Table 3, the majority of survey respondents felt that they would be or were at low risk of contracting the virus while recreating in ANP. When asked “BEFORE your trip to Acadia National Park, to what extent did you think you would be at risk to COVID-19 while visiting Acadia National Park?” 56.1% reported feeling low risk during the visit compared to the 63.0% of respondents reporting low risk when asked “Now that you are here, to what extent do you think you are at risk to COVID-19 while visiting Acadia National Park?”. This meant that there was a slightly higher proportion of respondents reporting feeling at low risk during their visit than feelings before their visit (56.1% → 63%). There were also slightly fewer respondents reporting moderate risk, high risk, and not at all at risk (19.7% → 15.5% , 2.1% → 0.9%, and 22.1% → 20.6% respectively) (Figure 21). Overall, a majority of respondents reported no change in feelings of risk from before their visit to during their visit (74.6%) as can be seen in figure 22. Small proportions reported increased feelings of risk (14.3%), and decreased feelings of risk (11.1%) (Figure 22).
Figure 21: Proportion of respondents by the level they felt at risk to COVID-19 in ANP before and while visiting.

Figure 22: The proportion of respondents reporting changes of feelings of risk to COVID-19 in ANP while visiting compared to feelings of risk before visiting. The risk feeling categories were high risk, moderate risk, low risk, and not at all at risk.

COVID-19 appears to have affected time spent outdoors and time spent recreating in respondents. When asked “Does your trip include more or less outdoor recreation
because of the COVID-19 pandemic?” and “In general, are you spending MORE or LESS time outdoors because of the COVID-19 pandemic?”, a majority of respondents reported that they spent more time outdoors during the pandemic (85.4%) and took part in more outdoor recreation in ANP during their trip (88.5%). Only a relatively small proportion reported spending less time outdoors or less time outdoor recreating (14.6% and 11.5% respectively) (Figure 23).

![Figure 23: Proportion of respondents reporting more or less outdoor recreation during their trip and reporting more or less time spent outdoors since the beginning of the pandemic.](image)

Respondents to question 4 were also asked to provide reasoning for their response which can be seen in Tables 4 and 5. Of the 28 respondents that reported less outdoor recreation during their trip and provided a reason, a majority (82.1%) reported that “I am avoiding other people and Acadia NP can be crowded”. In comparison, access to public
transportation was less of a contributing factor (10.7%) (Table 4). Of the 283 respondents that reported more outdoor recreation during their trips and provided a reason, a majority (61.1%) reported that “outdoor recreation is low risk for COVID-19” was their reasoning behind seeking more outdoor recreation (Table 5). An additional 20.8% of the respondents reported both that “outdoor recreation is low risk for COVID-19 transmission” and that “during quarantine, I started to do more outdoor recreation and liked it” (Table 5).

Table 4: Reasons for reporting less outdoor recreation during trips to ANP.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am avoiding other people and Acadia NP can be crowded.</td>
<td>23</td>
<td>82.1%</td>
</tr>
<tr>
<td>I am avoiding other people and Acadia NP can be crowded.</td>
<td>1</td>
<td>3.6%</td>
</tr>
<tr>
<td>My access to Acadia NP is limited by public transportation closures.</td>
<td>1</td>
<td>3.6%</td>
</tr>
<tr>
<td>My access to Acadia NP is limited by public transportation closures.</td>
<td>3</td>
<td>10.7%</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 5: Reasons for reporting more outdoor recreation during trips to ANP.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>During quarantine, I started to do more outdoor recreation and liked it</td>
<td>19</td>
<td>6.7%</td>
</tr>
<tr>
<td>During quarantine, I started to do more outdoor recreation and liked it</td>
<td>20</td>
<td>7.1%</td>
</tr>
<tr>
<td>Outdoor recreation is low risk for COVID-19 transmission.</td>
<td>173</td>
<td>61.1%</td>
</tr>
<tr>
<td>Outdoor recreation is low risk for COVID-19 transmission.</td>
<td>59</td>
<td>20.8%</td>
</tr>
<tr>
<td>Outdoor recreation is low risk for COVID-19 transmission.</td>
<td>3</td>
<td>1.1%</td>
</tr>
<tr>
<td>Outdoor recreation is low risk for COVID-19 transmission.</td>
<td>9</td>
<td>3.2%</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>283</td>
<td>100%</td>
</tr>
</tbody>
</table>

One additional behavior I looked at was whether the pandemic impacted feelings of risk around swimming in ANP (question 5 in Table 3). When asked to agree or disagree with the following statement “because of COVID-19, I am NOT swimming in Acadia NP”, most respondents disagreed (86.7%) (Figure 24). Additionally, when looking at responses from individuals that reported either visiting SB or not visiting SB,
there was no significant difference between individuals agreeing or disagreeing with the swimming statement. Results from a Pearson Chi-Square test for both questions resulted in an asymptotic significance of .687.

**Figure 24:** The frequency of respondents agreeing and disagreeing with the statement “Because of COVID-19, I am NOT swimming in Acadia NP”.

Recreationists continued to visit popular recreation sites within ANP during the pandemic. Figure 25 shows the number of respondents visiting each recreation site for the 243 individuals that fully answered the question. The blue bar represents respondents that reported having been to the site or planned to go to the site during their visit, the red bar represents respondents that reported having been to the site, and the gray bar represents respondents that were unsure if they had or if they were going to go to the site. When asked “during this trip to Acadia National Park, please indicate all of the places you visited or plan to visit”, a majority of respondents indicated visiting CM, SB, TH, and JP, with very similar proportions of respondents visiting SB, TH, and JP (73.7, 73.3, and
74.0\% \text{ and } 51 \text{ respectively). The highest proportion of respondents visited CM (81.5\%) and a much smaller proportion of respondents reported visiting both SP and BHL (49\% and 53.1\%) (Figure 25).

Figure 25: Number of respondents visiting, not visiting, or unsure of their visitation to popular recreation sites in ANP.

Objective 3: Were there any demographic variables that could explain differences in outdoor recreation behaviors?

I was unable to discover any demographic variables that could explain differences in the outdoor recreation patterns above. Running Pearson Chi-squared tests in SPSS on demographics and reported visitation behaviors for all respondents that answered listed questions resulted in the asymptotic significance levels listed in Table 6 and 7 below. These significance tests do not result in values <.05 and thus indicate that feelings of risk, outdoor recreation habits, and time spent outdoors were not significantly related to whether people recreated at certain popular ANP sites (Table 6). Additionally, the
demographics age, degree level and gender, were not significantly related to feelings of risk, outdoor recreation habits, or time spent outdoors (Table 7).

**Table 6**: Results for SPSS Pearson Chi-squared tests on reported visitation behaviors and ANP site visitation.

<table>
<thead>
<tr>
<th></th>
<th>Visited CM</th>
<th>Visited SB</th>
<th>Visited TH</th>
<th>Visited JP</th>
<th>Visited Schoodic</th>
<th>Visited BHL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk While Recreating</td>
<td>0.087</td>
<td>0.373</td>
<td>0.611</td>
<td>0.486</td>
<td>0.779</td>
<td>0.4</td>
</tr>
<tr>
<td>Risk Before Recreating</td>
<td>0.157</td>
<td>0.906</td>
<td>0.324</td>
<td>0.739</td>
<td>0.9</td>
<td>0.24</td>
</tr>
<tr>
<td>More or Less outdoor recreation</td>
<td>0.121</td>
<td>0.422</td>
<td>0.357</td>
<td>0.116</td>
<td>0.035</td>
<td>0.378</td>
</tr>
<tr>
<td>More or less time spent outdoors</td>
<td>0.551</td>
<td>0.817</td>
<td>0.453</td>
<td>0.988</td>
<td>0.362</td>
<td>0.696</td>
</tr>
</tbody>
</table>

**Table 7**: Results for SPSS Pearson Chi-squared tests on demographics and reported visitation behaviors in ANP.

<table>
<thead>
<tr>
<th></th>
<th>Risk While Recreating</th>
<th>Risk Before Recreating</th>
<th>More or less outdoor recreation</th>
<th>More or less time spent outdoors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.076</td>
<td>0.18</td>
<td>0.106</td>
<td>0.738</td>
</tr>
<tr>
<td>Degree Level</td>
<td>0.52</td>
<td>0.479</td>
<td>0.092</td>
<td>0.64</td>
</tr>
<tr>
<td>Gender</td>
<td>0.263</td>
<td>0.99</td>
<td>0.149</td>
<td>0.178</td>
</tr>
</tbody>
</table>

**Discussion**

The survey analysis data provides useful information on visitation, behaviors, and demographic trends for visitors to ANP in 2020-2021. Not all of this information is obtainable through technological use monitoring methods like cameras and sensors or even through big data analysis with StreetLight InSight. While there may not be pre-pandemic survey data to compare these analysis results to, the reported changes in
behavior as well as demographic and visitation information still reveal information on COVID-19 that might be useful for recreation managers or data comparisons moving forward. The following discussion explores potential reasonings behind these trends seen in the results. Additionally, the results highlight gaps in the use of big data analyses that need to be filled through the supplementation of data derived from traditional methods of use monitoring. More specifically, the ANP survey provides insight into the reasoning behind certain behaviors and perceptions of ANP outdoor recreationists where StreetLight data could not in the WMNF.

Objective 1: What were the demographics for ANP survey respondents from 2020-2021?

The survey results revealed information on the types of visitors to ANP. When looking at the personal descriptors for survey respondents seen in Figure 18, the vast majority of respondents self-described as visitors to ANP with only a small proportion describing themselves as local residents of Mount Desert Island. These results could indicate that most recreationists in ANP are not local residents. This would mean that mobility restrictions implemented during the pandemic did not stop visitation from outside of the local areas. However, these reported results could be skewed and not an actual representation of local visitation. For instance, those reporting their status as a researcher, educator, student, environmental steward, or natural resource manager, might also live locally. Additionally, although respondents might not be from Mount Desert Island, many nearby towns off of the island could represent unaccounted local visitation as well. Another potential influence on the proportion of reported local respondents could be the incentive for taking this survey. Although incentives have been shown to improve
response rates when conducting surveys\textsuperscript{81-82} there is also existing literature that the type of incentive matters when targeting specific audience groups\textsuperscript{82-83}. Respondents of this survey were sent an Acadia postcard as a reward upon completion. This may have disproportionately attracted non-local visitors, as a higher proportion of non-local visitors may have desired a souvenir from their trip where local visitors did not.

There is no data on local and non-local visitation available on the NPS Visitor Use Statistics web page\textsuperscript{4} to compare these results to, so it is difficult to know if the proportion of respondents is an accurate representation of true visitation patterns. Comparing these results to the home location responses seen in Figure 19, a higher proportion of respondents were reported as being from the Maine area; however, this includes towns that are farther distances than would be considered local. Of the 38.3% visiting ANP from New England, 30.6% reported they were visiting from within Maine. Based on literature citing increases in local or state visitation from COVID-19 and the quarantine periods in place for travelers outside of Maine in summer 2020\textsuperscript{13,84}, this figure seems a little low. However, since this represents the only NP in areas around New England, it may have drawn out-of-state tourists who wanted to recreate outdoors like many health officials were advertising\textsuperscript{2,41,84}. Additionally, quarantine requirements did ease nearing the end of the summer season\textsuperscript{84}.

Like with StreetLight, I was able to derive useful demographic information from survey responses. The graphs in figure 20 are representative of some of these demographics (gender, age, level of education). Age is not something StreetLight InSight traveler attribute metrics provide information on. Based on the survey results, most of the visitors to ANP appear to be under the age of 40 (63.6%). These results are similar to
findings from the Outdoor Foundation’s 2020 report on outdoor recreation participants (64% of participants were below the age of 44)\textsuperscript{85}.  

There is also a gender gap among survey respondents in ANP (Figure 20b). Similar to age, gender is not something StreetLight InSight traveler attribute metrics provide information on. A majority of respondents were female which indicates a higher proportion of female visitors compared to males during the pandemic. This higher majority of female respondents is consistent with surveys conducted on the LNT outdoor community\textsuperscript{2,26}; however, it is inconsistent with national outdoor participation recreation trends. The Outdoor Foundation’s 2020 report reports a higher proportion of outdoor recreation among males than females (54% and 46% respectively). This discrepancy could indicate that ANP visitors follow trends outside of the general national outdoor recreation community or reveal a gender response bias for this survey.

The final demographic used to address the question for objective 1 looked at the level of degree earned by respondents. Most respondents to the survey were of college education or more. In total, a much lower proportion of visitors to ANP than those to WMNF (based on StreetLight volume), reported having a high school degree as the highest form of education (8.8% vs 29%) (Figure 20c and 14). It is difficult to see if respondents to the ANP survey follow national trends reported by the US Census Bureau as there is no option for “No Degree” in the Acadia Survey. As such, the results could be skewed as to the actual education level of visitors in ANP and are only representative of those having earned or are in the process of earning their degrees.
Objective 2: Did COVID-19 impact respondent behaviors and feelings of risk?

Results from the survey questions revealed information on behavior and reasoning within ANP that other methods like StreetLight analysis and automated counters cannot provide. Most recreationists visiting ANP did not have increased feelings of risk while recreating. Looking at the results from the feelings of risk analysis, the majority of respondents felt at low risk for COVID-19 before and during their trip, and feelings centered around risk primarily remained the same even after respondents encountered crowded conditions (Figures 21 and 22). These results match conclusions in other COVID-19 recreations studies which state that outdoor recreationists place physical and mental health benefits from outdoor recreation above perceptions of health risks to COVID-19 and recommendations made by health officials. People visiting the park would already be part of the population willing to travel during the pandemic, so feelings of risk could be smaller among ANP visitor respondents than in the general population.

The question about swimming within the park during COVID-19 also reveals that ANP recreationists did not feel particularly at risk of contracting COVID-19 while recreating. Most respondents disagreed that COVID-19 would impact their plans to swim within the park and results from the Pearson Chi-Square test show that these feelings were not related to whether or not they had visited the popular swimming area Sand Beach (Figure 24).

When asked about behaviors regarding both time spent outdoors since the pandemic, and time spent recreating during their trip to ANP, the majority of respondents reported more time spent outdoors and more outdoor recreation during the pandemic (Figure 23). This could be reflective of both the value respondents place on the benefits
of recreation and the health and safety measures closing other areas of recreation and non-essential businesses like movie theaters and museums. In the follow-up questions on time spent recreating in ANP, of the respondents reported more time spent outdoors, the primary reasoning was that “outdoor recreation is low risk for COVID-19” (Table 5). Even with the crowded conditions, it would make sense that more individuals would report higher levels of outdoor recreation and feelings of low risk given that many officials publicized outdoor recreation as being a safer option for recreation in pandemic conditions.

Although not to the same extent as StreetLight software, the survey also provided information on movement within ANP during the study period. A majority of respondents reported visiting the popular recreation sites CM, SB, TH, and JP and a smaller number reported visiting SP and BHL (Figure 25). SB, TH, and JP are all located along the Park Loop Road (PLR), which is the most heavily trafficked area in the park. SB and TH are within one mile from one another along a one-way section of the road and JP is located at the end of the one-way section. Because of this, it would make sense that visitors might go to each of the destinations in a similar proportion. CM is located on an offshoot road from the PLR, can receive traffic from both directions, and is also easily accessible from the park’s main entrance and nearby Bar Harbor. The two other locations, SP and BHL, are in separate park sections of the park requiring ~40 to 90-minute drives respectively if leaving from the main section of the park. Schoodic is located on the mainland, requires the most driving (if traveling from Mount Desert Island), and had the least amount of reported visitation from respondents (49%) (Figure 25). While the responses about visitation to these areas do not provide true volume
estimates, they do show that most visitors continued to recreate in these popular areas despite the risks of contracting COVID-19.

Objective 3: Were there any demographic variables that could explain differences in outdoor recreation behaviors?

Results from the Pearson Chi-squared tests appear to show that feelings of risk, outdoor recreation habits, and time spent outdoors did not significantly affect whether respondents recreated at certain popular ANP sites (Table 6). Nor did the demographics age, degree level, or gender significantly affect feelings of risk, outdoor recreation habits, or time spent outdoors (Table 7). There is no apparent relationship between reported perceptions of risk and travel to locations within ANP. The lack of relationship is further support that individuals choosing to recreate within ANP during the pandemic are likely already willing to accept risks associated with high use areas, so whether or not respondents chose to visit locations was likely influenced by other kinds of factors. For example, visitation to these sites could have to do with their popularity on things like social media and other web-based sources. Studies have shown that information on social media and internet sites can have a significant impact on trip planning\textsuperscript{86-88}. The ANP sites listed in the survey question are some of the most well-known and popular spots for recreation within the park and are often seen on internet trip advice lists as “must-see” destinations in the park\textsuperscript{89-90}.

The level of risk felt and behaviors exhibited in outdoor recreation are similarly not significantly related to respondent age, degree level, or gender, so differences between respondents are likely influenced by other factors. For example, those who reported generally spending more time outdoors since the pandemic could live in
proximity to outdoor recreation areas. Literature has suggested that pandemic mobility restrictions have impacted people differently across urban and rural areas. Those living in rural areas have increased access to outdoor recreation compared to their urban counterparts².
CONCLUSION

Ultimately, the three parts of this thesis answer the research question by 1) revealing COVID-19 impacts on outdoor recreation within the United States; 2) uncovering trends within the WMNF pre to post-pandemic through the use of StreetLight big data, and how similar methods could be useful for monitoring use in similar diffuse recreation spots; and 3) showing how behaviors and feelings of risk in outdoor recreationists affected visitors within ANP. The literature review shows that overall, COVID-19 effects on outdoor recreation have been widespread and varied. These effects differ both spatially and temporally. The two analysis sections add further information on pandemic effects. In Acadia, NPS statistics reported a large influx in visitation starting in October of 2020 and extending through 2021 which is also reflected in the lack of risk perception by visitor respondents to the survey. In comparison, visitation to the WMNF continued to decline a significant amount into 2021 based on StreetLight analysis. Additionally, the literature revealed COVID-19 to be a novel stressor to outdoor recreation. Its continued development revealed limitations to new and existing use monitoring methods.

StreetLight results were able to show visitation volume trends in the WMNF pre and post-pandemic and the Survey in ANP provided both visitor demographics and information on visitor behaviors. However, both methods of use monitoring looked at in this study are not without their limitations and biases, so the efficacy and accuracy of these use monitoring methods can vary. For example, StreetLight data is limited to areas where there are sufficient traffic levels. In the WMNF, StreetLight volume estimates
were most useful when looking at the most popular outdoor recreation areas like MWS and PNVC, as they had enough visitation to allow for more accurate representations of trip volumes and could be compared against certain recorded site closures. Traditional methods like cameras, sensors, or counters would not have this limitation.

Additionally, although StreetLight is a useful tool in looking at mobility and volume trends, some analysis data that StreetLight does not provide are information on trend causation or actual physical counts. These two important sets of data can currently only be achieved through more traditional means. For example, with the ANP survey, it was possible to know if an individual was recreating in the park, where they had gone within the park, and why they may or may not have felt at risk of transmission. Whereas with StreetLight, it was possible to see if a certain volume of unknown visitors took trips within the recreation area, not where specific users went or why they recreated the way they did. The ANP survey revealed that for the most part, respondents were not deterred from their recreation by the pandemic, nor did their feeling around the pandemic affect their willingness to recreate in popular recreation areas. These behaviors might reflect other recreation patterns seen in COVID-19 studies and demonstrate the overall importance outdoor recreationists place on the mental and physical health benefits of recreation outdoors.

StreetLight analysis can also provide information that a survey cannot. For example, StreetLight data is retroactive. The potential for retroactive analysis is especially useful when preexisting monitoring is non-existent or disrupted like traditional surveys were during the pandemic. In the study in the WMNF, there were no annual or site-specific use data published by the Forest Service during the pandemic, so using
StreetLight was one of the few ways to examine pandemic trends starting before the pandemic occurred.

The potential sources for inaccuracies in both big data and traditional methods highlight the need for traditional use monitoring methods to supplement big data sources as reported in many other StreetLight use studies. As it stands, big data is a potential source of valuable information but should not be used to replace use monitoring via traditional means altogether. In this study, Streetlight InSight analysis was useful in providing user information in the study section of the WMNF; however, the lack of preexisting data made it difficult to know the accuracy of the results or whether or not big data limitations such as cellular range and carriers could have altered the visitation trends obtained via the StreetLight interface. The literature shows that StreetLight data are more useful when there is preexisting data to validate big data outputs. In places where such information exists such as in ANP, the use of StreetLight could improve use monitoring on a spatial scale. Thus, results from the analysis of outdoor recreation trends during COVID-19 would be vastly improved were there existing data to compare it to. For example, being able to compare StreetLight volume against existing visitation volume in ANP or compare reported demographics in Acadia to those derived by StreetLight methods would add validity to use monitoring results.

There are some additional important things to keep in mind while using StreetLight for recreation management. StreetLight volume is an estimation of vehicles and not an estimation of individuals or devices so analysis using this platform might be more useful for management concerns centered around transportation. This is not to say that the data derived from StreetLight is not useful in looking at other types of questions.
like those addressed in the three research objectives looked at in this study. Because it is
centered around vehicles, it could become a very useful tool in popular outdoor recreation
areas like ANP where overcrowding concerns have heightened the need for vehicle
management.

StreetLight also offers many additional types of mobility data and analyses that
were not examined in this paper. These methods include travel estimates via index values
for pedestrians, commercial trucks, buses, and bicycles that could also provide valuable
information on use patterns within outdoor recreation areas. Although still emerging, data
on pedestrian movements could be extremely valuable to resource managers trying to
address crowding and resource degradation in areas along trails, paths, and foot traffic
destinations. This could mean using the information on trail traffic to identify top routes
and prioritize maintenance tasks to those routes, or identifying areas which see the most
foot traffic and thus have increased threats to natural resource degradation via
overcrowding pressure.

Overall, the literature and data analyses presented in this study revealed that the
pandemic altered aspects of outdoor recreation within the first few years. Results from
the study also showed how big data sources such as StreetLight InSight might aid in use
monitoring in diffuse outdoor recreation areas where traditional use monitoring methods
are difficult and/or non-existent. The trends seen in use monitoring throughout the course
of the pandemic might be able to better prepare managers for interruptions to outdoor
recreation in the event that a pandemic-level disturbance should occur. Visitor surveys
remain valuable because of the insights they provide in visitor knowledge and attitudes.
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AUTHOR’S BIOGRAPHY

Andrea Knapp was born in Jackson, Wyoming and moved around to some of the nation’s various ecologically important areas with her National Park Ranger parents. She eventually settled in Franklin Maine, graduating Valedictorian at Sumner Memorial High school. From there, she went on to attend the University of Maine, majoring in Ecology and Environmental Sciences with a concentration in Marine Ecosystems and a minor in Fisheries. During her time at the University, Andrea has worked as a Summit Steward in Acadia National Park where she further developed her passion for conservation and public lands. She also pursued a study abroad experience in the Caribbean Ocean which exposed her to numerous threats facing ocean ecosystems today. Following graduation, Andrea hopes to pursue her career in resource management in the National Parks, eventually returning to graduate school to earn a master’s degree in a related field.