Big Data spatial analysis of camper preferences: A proposal

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Understanding what drives demand for outdoor recreation within protected areas and how recreationists make decisions about recreational opportunities are queries that have generated a significant body of theory and literature in park and recreation research (Loomis & Walsh, 1997). Of late, this area of research has received considerable interest to address management issues emerging from the increased use of recreational facilities in U.S. national parks (i.e. Bullock & Lawson, 2008; Richardson, Huber, & Loomis, 2017; Sessions, Wood, Rabotyagov, & Fisher, 2018; Timmons, 2019). However, most of this research relies upon stated choice measures of demand. That is, recreationists’ actual behavior is not observed. Instead, stated responses are collected regarding hypothetical scenarios concerning the conditions of the ecological, managerial, or social environments of park settings (Tietenberg & Lewis, 2015). It is thus the aim of this study to analyze revealed preference data for recreational facilities that have experienced record demand in recent years—campgrounds.

# Specific Aims

This research aims to understand how recreationists reach decisions on the selection of campsites and what aspects of the recreational setting drive this demand. Specifically, I aim to understand what managerial, social, and ecological aspects of the setting most influence decision-making prior to visitation to protected areas. If successful, results from this analysis will enable park managers to be more informed in future alteration of campsite distribution, access to recreational amenities, and the management of campsite allocation based on relative demand.

I have selected Watchman Campground in Utah’s Zion National Park as the study area for this analysis, due to its increasing demand (see Timmons, 2018) and data availability. In order to see how various amenities influence demand, I have gathered data for various components of the campground setting. Each of the setting attributes is grouped within a larger setting category derived from the facets of recreational settings presented by Driver and Brown (1978). To this end, a research question and hypothesis have been derived for the predictive power of various aspects of the setting:

R1: What aspects of the setting are strongly predictive of campsite demand?   
H1: Price, distance to the nearest neighboring campsite, distance to the nearest road, distance to the Virgin river, and percent of the official campsite photo filled by a vista of canyon walls

To understand broadly what setting category is most important to recreationist decision-making, I have also formulated a second research question—and subsequent hypothesis.

R2: What setting category is most predictive of campsite demand?

H2: Ecological amenities are most predictive of campsite demand.

# Background and Literature Review

This research seeks to build on an already extensive body of literature concerning recreation decision-making by incorporating revealed-preference data from campsite reservations to examine what aspects of the setting are most impactful in driving demand for particular campsites. In building from previous research, this study thus relies upon existing means of modeling and measuring recreation decision-making and camping recreation as a whole.

## Understanding Recreation Decision-Making

Driver and Brown (1978) provided an early framework for how recreationists make decisions concerning their participation in recreation activities through their Recreation Opportunity Demand Hierarchy. This framework posits that recreationists’ awareness of their demand of the various components of the recreational experience decreases across a hierarchy of demand that flows from activity to setting to motivations to benefits (Driver & Brown, 1978). Important to the present study—and consistent with other recreation decision-making models—the author’s conceptualization of setting is divided between the managerial, social, and ecological. Krumpe and McLaughlin (1982) presented another early model—the Recreation Decision Model—in which decisions are reached via an elimination process of recreation options. This model was later applied by Brunson and Shelby (1990) to demonstrate how campsites are chosen. The authors presented three stages of decision-making in which options are systematically eliminated by recreationists over three stages—based on their necessity, experience, and amenity attributes (Brunson & Shelby, 1990).

Additional, valuable models for recreation decision-making have been proposed in the wake of Krumpe and McLaughlin (1982). Clark and Downing (1985) provided an alternative framework in which decisions are reached based on substitutability. More recently, Park, Lee, and Peters (2017) presented an extended structural model of goal-directed recreation choices adapted from Perugini and Bagozzi (2001). While these models were developed specifically to examine the decision-making of recreationists, it is important to note that other models and theories were simultaneously developed and have been applied within recreation research, such as the Theory of Reasoned Action (Fishbein & Ajzen, 1975) and the Theory of Planned Behavior (Ajzen, 1991).

## Measuring Recreation Decision-Making

### Stated vs. revealed preference

No matter the chosen model, measurement must follow. There are two overarching methods of measuring recreationist demand for various factors that influence decision-making: stated and revealed preference measures (Adamowicz, Louviere, & Williams, 1994). Principally, stated preference methods rely on survey data, while revealed preference methods rely on actual observed behaviors (Kaval & Baskaran, 2013). For each overarching method, a variety of specific methodologies exist.

Of the stated preference methodologies, contingent valuation and choice modeling are most common in eliciting amenity values (Kaval & Baskaran, 2013). Contingent valuation involves asking recreationists what they would be willing-to-pay, or willing-to-accept, to have a particular experience or enact some change in their experience (Kaval & Baskaran, 2013). A depth of protected area and outdoor recreation management research has utilized this valuation method, as evidenced through a number of reviews of the literature (i.e. Barrio & Loureiro, 2010; Brander & Koetse, 2011; Ghermandi & Nunes, 2013). Recreation research employing choice modeling has been similarly prolific (e.g. Hanley, Wright, & Koop, 2002; Lawson & Manning, 2002; Newman, Manning, Dennis, & McKonly, 2005; Pettebone et al., 2011). Choice modeling requires that recreationists be “faced with a variety of alternatives and may be asked to select their most preferred alternative from a choice set (choice experiment), group their preferences (contingent grouping), rate their preferences (contingent rating), or rank their preferences (contingent ranking)” (Kaval & Baskaran, 2013, p. 32).

No matter the stated preference method employed, a variety of assumptions and limitations potentially impair their reliability. As reported by Bartkowski and Lienhoop (2018), three core assumptions underlie stated preference research: 1) respondents hold full information concerning the good or service of interest, 2) respondents are self-interested (largely disregarding the interests of others), and 3) respondents hold pre-defined preferences. Overlapping these assumptions is the larger assumption of rationality and the presumption that respondents can translate their preferences into monetary or otherwise stated terms (Bartkowski & Lienhoop, 2018). Given these assumptions, revealed preferences—when available—are usually preferred to stated preferences (Cameron, 2011).

In contrast with stated preferences, revealed preference methodologies are based on observations of actual behavior (Kaval & Baskaran, 2013). In protected area management and outdoor recreation research, a number of revealed preference methodologies are common, including the travel cost method (e.g. Amoako-Tuffour & Martínez-Espiñeira, 2012), hedonic pricing (e.g. Nelson, 2010), and Big Data analysis (e.g. Keeler et al., 2015).

### Big Data measurements

In recent years, Big Data revealed preference measures of recreation behavior have become increasingly popular (see Tenkanen et al., 2017). Big Data is broadly defined as information that has low value density—having a relatively low value per unit, but a large volume (Gandomi & Haider, 2015). Given significant computational power, high value can be extracted from these large datasets (Gandomi & Haider, 2015). In outdoor recreation contexts, Big Data has been used to address a number of management issues (see Pickering et al., 2018). Buxton et al. (2017) utilized data on hundreds of thousands of protected areas in the U.S. to examine how noise permeates park borders. Rice, Newman, Miller, and Taff (2020) similarly used this protected area data to examine how park conservation status, ownership, and access impacts the provisioning of ecosystem services such as noise abatement and exclusion. And using 13,600 Instagram and Flickr photographs, Hausmann et al. (2018) were able to identify recreationist biodiversity preferences.

A number of other studies have used Big Data specifically to measure outdoor recreation demand. Schirpke, Meisch, Marsoner, and Tappeiner (2018) utilized approximately 10,000 Flickr images to examine supply and demand of ecosystem services in the European Alps. Similarly, Graham and Eigenbrod (2019) used Flickr data to model supply and demand for recreation across natural areas and protected areas in the United Kingdom. Utilizing data from tens of thousands of campground reservations, Rice, Park, Pan, and Newman (2019) forecasted demand for national park campgrounds to allow managers to allocate resources more effectively. Moving forward, this method of data collection is projected to grow as a means of informing visitor use management (Pickering et al., 2018).

### Spatial measurements

In addition to Big Data, emerging spatial analysis methods have also been applied to recreation demand. Regression-based spatial analysis has the ability to harness the power of large datasets to create predictive models, while accounting for spatial autocorrelation (Chi & Zhu, 2019). Spatial autocorrelation is a phenomenon described by Tobler (1970) in which near items are likely to more similar than faraway items. Utilizing a spatial lag model, Poudyal, Bowker, Green, and Tarrant (2012) estimated how various components of hunting demand increased supply of private hunting land in Georgia, U.S. Wang, Thill, and Meentemeyer (2012) used a spatial error model to assess how social, environmental, and geographic factors influence demand for open space in North Carolina, U.S. More recently, Lee and Schuett (2014) used geographically-weighed regression to assess what socio-economic attributes predict national park visitation among Texas (U.S.) residents.

### Measurements specific to camping

Specific to camping, a variety of aspatial models and measures of decision-making have been put forward over the past forty years. Stated preference methods include semi-structured interviews (Lime, 1971; Pfister, 1977), relevance-determinance analysis of campsite amenities (Mikulić, Prebežac, Šerić, & Krešić, 2017), exploratory factor analysis of campsite amenities (Gursoy & Chen, 2012), choice modeling of campsite setting attributes (Oh, Park, & Hammitt, 2007), and multinomial logit modeling of camper characteristics (McFarlane, 2004) and campsite setting (Stewart, Larkin, Orland, & Anderson, 2003). A number of studies have also examined specific setting characteristics or amenities and their importance to the camping experience or campsite selection, including campfires (Lillywhite, Simonsen, & Fowler, 2013), price (Bamford, Manning, Forcier, & Koenemann, 1988), shading from forest overstory (James & Cordell, 1970), ecological impacts (White, Hall, & Farrell, 2001), and proximity to other campers (Twight, Smith, & Wissinger, 1981). However, spatial and revealed preferences methods have yet to be employed to examine campers’ observed behavior in choosing a campsite. Therefore, this study seeks to harness a Big Dataset of campsite choice behavior to spatially examine what aspects of the managerial, social, and ecological setting are most influential in decision-making among campers in Zion National Park.

# Methods

## Study Site

Zion National Park (Zion) is located in Southwestern Utah, U.S. Over-crowding in Zion has been well-documented in recent years, leading to visitor use issues including ecological impacts, strains on infrastructure, and safety concerns (Timmons, 2019). Watchman Campground is the largest campground in Zion, boasting 178 campsites. It sits near the park’s southern entrance, just north of the town of Springdale. It contains access to the following amenities for all campers: an interpretive amphitheater, drinking water, a liquid waste disposal (or dump) station, flush toilets, utility sinks, a campground host, a pet-friendly policy, a ranger station, recycling, trash collection, private fire rings, private picnic tables, and parking. Some campsites also have electricity access, wheelchair accessibility, and/or direct access to the Virgin River (Recreation.gov, n.d.). At the time of this writing, single campsites were listed at either $20 or $30 per night depending on if they had electricity. Demand for Watchman’s campsites is extremely high, often requiring that reservations be made six months in advance (Timmons, 2019).

## Data

Reservation data from 2019 for Watchman Campground will be used in this study. Data is currently being collected and stored for public use via the Recreation Information Database (RIDB) through a multi-agency effort led by the U.S. Forest Service and National Park Service. The RIDB database contains information about all reservations made through Recreation.gov, an interagency online platform where reservations can be made for campsites, unique lodging experiences, and ranger-led tours, lotteries can be entered for recreation opportunities, and permits can be purchased (DeLappe, 2018). In 2017, Recreation.gov facilitated 4.8 million transactions. In 2019, all 178 of Watchman’s campsites were reservable through Recreation.gov from February 28th to December 1st (peak season) (Recreation.gov, n.d.). Within the Recreation.gov platform, visitors can select a site based on available amenities, geographic placement, price, and a photograph of the site (Figure 1.a). Visitors can also filter sites based on amenities (Figure 1.b).

a

b

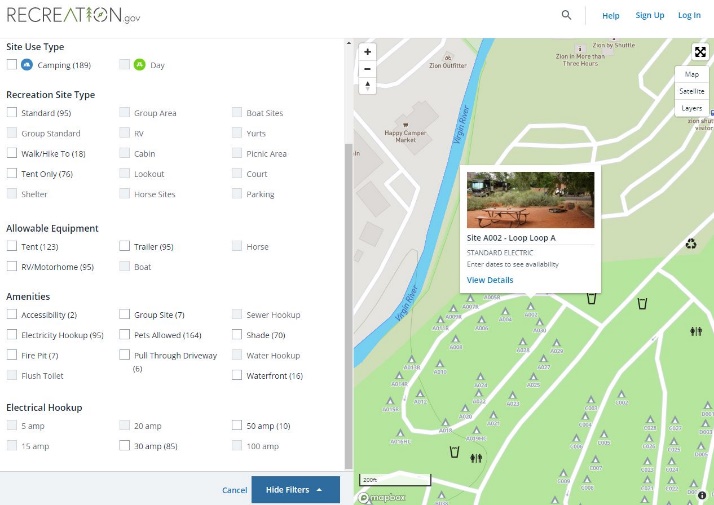
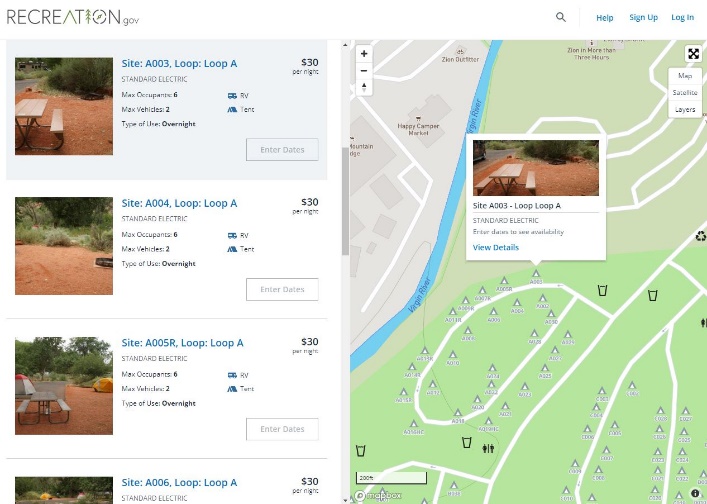


Figure 1. The Recreation.gov site selection interface for Watchman Campground, Zion National Park

In 2018, over 28,000 reservations were made for campsites in Watchman Campground. It is assumed that a similar amount of reservations will be made in 2019. For the purposes of this analysis, average booking window for each campsite in 2019 will be used as the dependent variable. For each reservation, the booking window will be calculated by subtracting the first date of the reserved stay from the date a campsite was booked. The independent variables will be the various setting attributes for each campsite that can be discerned from Recreation.gov (Table 1). A large portion of this data is publically available as shapefiles for download via the National Park Service data store. For the number of trees present at campsites and the percent of campsite photos filled by vistas of canyon walls, image analysis of the photos available through Recreation.gov will be necessary. All of the distances from campsites to varying aspects of the setting will be completed using spatial analysis completed in ArcGIS Pro. The values for all of the amenities and demand associated with each campsite will be summarized in a single table and transferred to Geoda for statistical analysis.

Table 1

Summary of variables and data sources

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Unit of Analysis** | **Number of Units** |  | **Source** | **File format** |
| Campsites | 178 |  | Zion National Park | .shp |
| *Independent Variables* | | | | |
| **Setting Category** | **Aspect of the Setting** | **Code** | **Source** | **File format** |
| **Managerial** |  |  |  |  |
|  | Distance to nearest amphitheater | AMPH | Zion National Park | .shp |
|  | Distance to campground host site | HOST | Zion National Park | .shp |
|  | Distance to nearest dump station | DSTA | Zion National Park | .shp |
|  | Distance to nearest dumpster | DUMP | Zion National Park | .shp |
|  | Distance to nearest restroom | REST | Zion National Park | .shp |
|  | Distance to nearest road | ROAD | Zion National Park | .shp |
|  | Distance to nearest trailhead | TRHD | Zion National Park | .shp |
|  | Distance to nearest trail segment | TRSG | Zion National Park | .shp |
|  | Distance to nearest water spigot | WATR | Zion National Park | .shp |
|  | Price | PRCE | Recreation.gov | n/a |
| **Social** |  |  |  |  |
|  | Distance to nearest neighboring campsite | NEHB | Zion National Park | .shp |
| **Ecological** |  |  |  |  |
|  | Number of trees present at campsite | TREE | Recreation.gov | .jpg |
|  | Distance to Virgin River | RIVR | Zion National Park | .shp |
|  | Percent of campsite photo filled by vista of canyon walls | VSTA | Recreation.gov | .jpg |
| *Dependent Variable* | | | | |
| **Unit** | **Definition** | **CODE** | **Source** | **File format** |
| Demand | Average booking window (in days) | BOWI | Recreation.gov | .csv |

## Analysis

To analyze how well various campsite setting attributes predict demand, I will employ Ordinary Least Squares (OLS) and spatial regression methods to account for any autocorrelation existing between campsites, as outlined by Chi and Zhu (2019). This approach contains four principal steps: 1) establish a spatial weight matrix to serve as a neighborhood structure, 2) test for autocorrelation, 3) establish the nature of spatial dependence (if present), and 4) run the final spatial regression formulated from the results of the previous steps.

### Establishing a spatial weight matrix

Prior to testing autocorrelation and spatial dependence, a spatial weight matrix must be defined to express how campsites relate to their neighbors (Chi & Zhu, 2019). Spatial weight matrices provide a neighborhood structure for the data, that is which campsites are neighbors to which campsites (Chi & Zhu, 2019). Given that the official campsite data published by Zion are centroids—or point data—a distance-based spatial weight matrix is required (Plummer, 2010). Following the protocols of Chi and Zhu (2019), a number of spatial weight matrices will be tested. Distances considered for further analysis must have 1) a relatively low number of isolated campsites having no neighbors and 2) no clusters of isolated campsites (Bivand & Portnov, 2004). The distance-based spatial weight matrices that meet these criteria will then be assessed based on their Moran’s *I* statistic. The distance that produces the strongest Moran’s *I* will be used in the following spatial analysis (Chi & Zhu, 2019).

### Test of autocorrelation

Moran’s *I* will also serve as the measure of autocorrelation within the dependent variable (Chi & Zhu, 2019). Values between -1 and -0.3 will be deemed negatively autocorrelated—exhibiting a “checkerboard” pattern—and values between 0.3 and 1 will be deemed positively autocorrelated—exhibiting a clustered pattern (O’Sullivan & Unwin, 2010). Values between -0.3 and 0.3 will be deemed to have no autocorrelation—exhibiting a random pattern.

### Define spatial dependence

If no autocorrelation is found in the dependent variable, only an OLS regression will be run (Chi & Zhu, 2019). If autocorrelation is found, an OLS regression will be run followed by either a Spatial Error Model or Spatial Lag Model regression—dependent on the results of the OLS (Chi & Zhu, 2019). Robust Lagrange Multiplier (LM) tests of spatial error and spatial lag on the OLS results will determine the nature of spatial dependence in the model and which type of regression should be run in order to address this dependence (Chi & Zhu, 2019).

### Spatial regression

Based on the results of the LM tests, a Spatial Error or Spatial Lag Model regression will be run using the independent and dependent variables identified in the study (Chi & Zhu, 2019). This will determine the degree to which each of the attributes of the setting influence campsite demand.

# Anticipated Results

Table 2 lists my anticipated results of the regression analysis. All aspects of the setting are labeled with their anticipated push or pull effects on recreation demand. Some of these hypotheses are based on previous camping literature, such as the number of trees present (James & Cordell, 1970), price (Bamford et al., 1988), running water (Oh, Park, & Hammit, 2007), and distance to the nearest neighboring campsite (Twight, Smith, & Wissinger, 1981). Others are based on the outdoor recreation literature at large: visitor soundscape preferences (e.g. Lera-López, Faulin, & Sánchez, 2012), interpretation preferences (e.g. Yamada & Knapp, 2010), and viewshed preferences (e.g. Agimass, Lundhede, Panduro, & Jacobsen, 2018). Distance to the nearest restroom is the only variable which I have hypothesized as none predictive, as I feel that it has equally strong push and pull effects. I hypothesize that campers want to be near enough to restrooms as to prevent long walks in the middle of the night, but far enough way as to not have to smell any assoicated odors or hear doors opening and closing throughout the night. No matter the results, this research will enable park managers at one of America’s most densely visited national parks to better allocate campsites and manage the surrounding setting based on actual visitor behavior.

Table 2

Recreational amenities included in the analysis and their anticipated influence on demand

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Setting Category** | **Aspect of the Setting** | **Pull /Push** | **Hypothesis** | **Literature used to derive hypothesis** |
| **Managerial** |  |  |  |  |
|  | Distance to nearest amphitheater | Pull | Mildly negatively predictive | Yamada & Knapp, 2010 |
|  | Distance to campground host site | Pull | Mildly negatively predictive | Lillywhite, Simonsen, & Fowler, 2013 |
|  | Distance to nearest dump station | Push | Mildly positively predictive | Mikulić et al., 2017 |
|  | Distance to nearest dumpster | Push | Mildly positively predictive | Mikulić et al., 2017 |
|  | Distance to nearest restroom | N/A | None predicative |  |
|  | Distance to nearest road | Push | Strongly positively predictive | Lera-López, Faulin, & Sánchez, 2012 |
|  | Distance to nearest trailhead | Pull | Mildly negatively predictive | White, Hall, & Farrell, 2001 |
|  | Distance to nearest trail segment | Pull | Mildly negatively predictive | White, Hall, & Farrell, 2001 |
|  | Distance to nearest water spigot | Pull | Mildly negatively predictive | Oh, Park, & Hammit, 2007 |
|  | Price | Push | Strongly negatively predictive | Bamford et al., 1988 |
| **Social** |  |  |  |  |
|  | Distance to nearest neighboring campsite | Push | Strongly negatively predictive | Twight, Smith, & Wissinger, 1981 |
| **Ecological** |  |  |  |  |
|  | Number of trees present at campsite | Pull | Mildly positively predictive | James & Cordell, 1970 |
|  | Distance to Virgin River | Pull | Strongly negatively predictive | White, Hall, & Farrell, 2001 |
|  | Percent of campsite photo filled by vista of canyon walls | Pull | Strongly positively predictive | Agimass, Lundhede, Panduro, & Jacobsen, 2018 |

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