

Forecasting Campground Demand @ Glacier National Park Capstone Project

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June 2020
General Assembly
Data Science Immersive Program
Boston, MA

Topic Introduction

"In the last few years, this huge uptick in visitation has overwhelmed our infrastructure facilities, our trails, our backcountry, it goes on and on and on," said John Marciano, a spokesman for Zion. "We can't sit on our hands anymore. We have to come up with some kind of management plan to be able to preserve resources and to make sure our visitors have a good and safe experience."

"How A Surge in Visitors Is Overwhelming America's National Parks" ([Robbins, 2017, Yale.edu](#))

And if current trends are any indication, the challenges of managing congestion at Glacier National Park will only grow in the years ahead. Annual visitation has more than doubled since 1980, and grew by about 40 percent in the two-year period between 2015 and 2017.

"Managing the crush: Park Service proposes new plan for managing Glacier Park's crowds" ([Murray, 2019, Great Falls Tribune](#))

"...research of campsites in national parks in the United States, which hosted over eight million camping overnight stays in 2017, remains understudied (National Park Service, 2018b). This deficit persists even as demand for national park campsites has reached a fever pitch. As a result, park managers may lack the understanding of what is driving demand, how to meet the increased demand, and how to predict future demand. Further complicating this problem is the unique mission of the National Park Service (NPS), which places preservation as the guiding mission of the agency. Therefore, increasing supply (e.g. building more campsites) is often not a viable management action."

"Forecasting campground demand in US national parks" ([Rice et al., 2019, Annals of Tourism Research](#))

Campground Demand vs Visitors in Glacier National Park

Correlation of 0.89 from 2000 to 2019



Project Goal : Explain Daily Variation Across the Park

Why Examine Glacier National Park?

Glacier National Park is unique in that it reports historic campground fill times

Data available for May to September from 2000 to present

Example: 'Many Glacier' Campground for July 2002

July - 2002						
Sun	Mon	Tues	Wed	Thur	Fri	Sat
	1 6:06pm	2 6:50pm	3 4:30pm	4 7:00pm	5 2:47pm	6 1:16pm
7 6:06pm	8 3:48pm	9 4:10pm	10 2:07pm	11 2:45pm	12 1:00pm	13
14 5:27pm	15 3:48pm	16 12:37pm	17 12:55pm	18 11:04am	19 10:20am	20
21 11:50am	22 12:30pm	23 11:09am	24 10:09am	25 8:43am	26 10:22am	27 12:40pm
28 1:44pm	29 1:58pm	30 11:56am	31			

Current and Historic Campground Fill Times
The current month is always displayed, showing what days and times (in red) the campground filled. If the campground did not fill on a certain day, no time will be displayed.

Use the drop-down menus to select a different month and year to see when this campground filled. Use Avg to display the 5-year average for the month selected.

July 2002

Display fill times

This dataset allows for **Classification**, **Regression**, and **Time Series** analysis

Classification : Will a campground fill up on a given day?

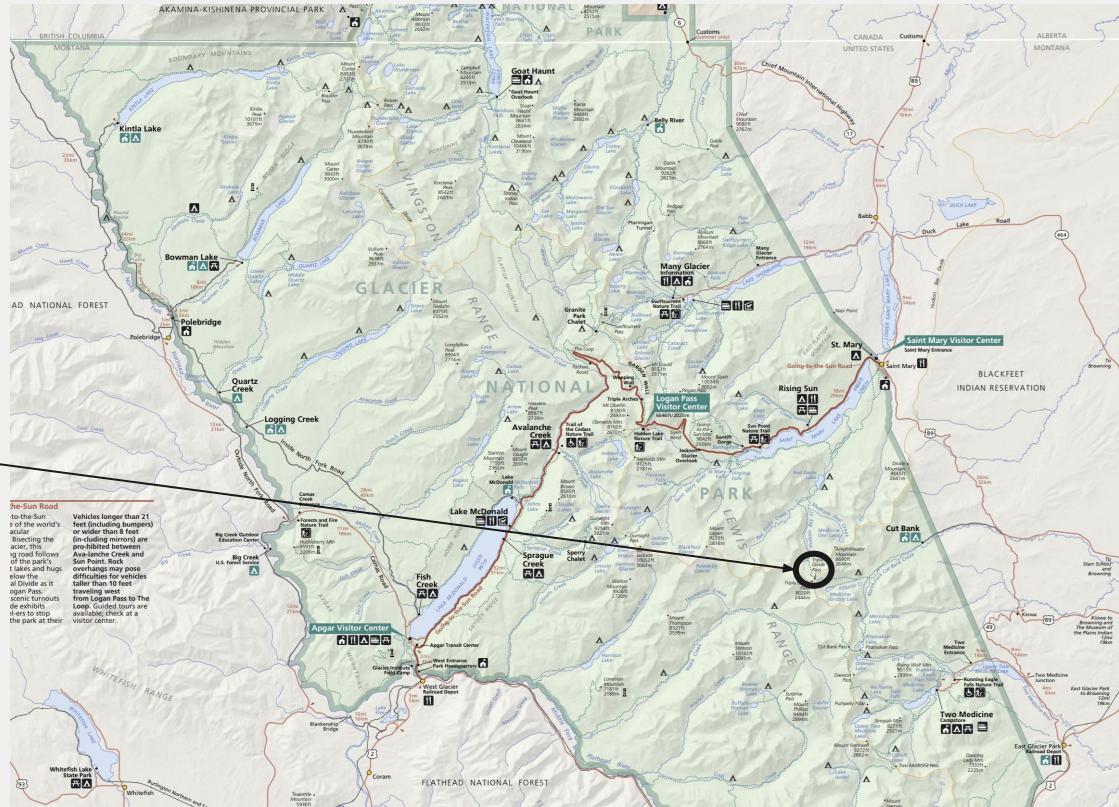
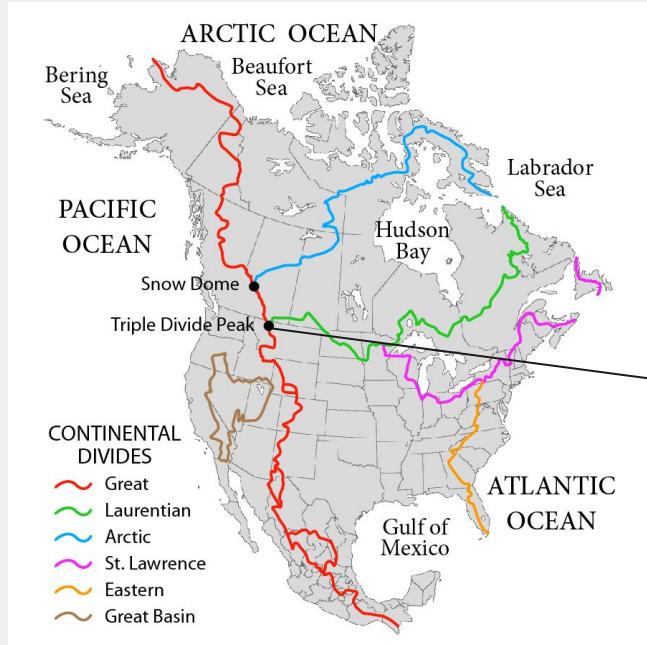
Regression: If so, at what time?

Time Series: Do prior times predict future times?

Motivation for Analysis

- Topic of personal interest to author
 - I've been to Glacier National Park (GNP) twice, 16 nights total (2016 & 2017)
- Untapped dataset
 - Presumably, internet search did not reveal anything
 - Project involves creation of a unique dataset from scratch
- Project encompasses several distinct elements covered in DSI
 - Webscraping, data wrangling, exploratory data analysis
 - Dataframe allows for regression, classification, and time series modeling
- Results of interest (hopefully) to both NPS and campers

A Primer on Glacier National Park



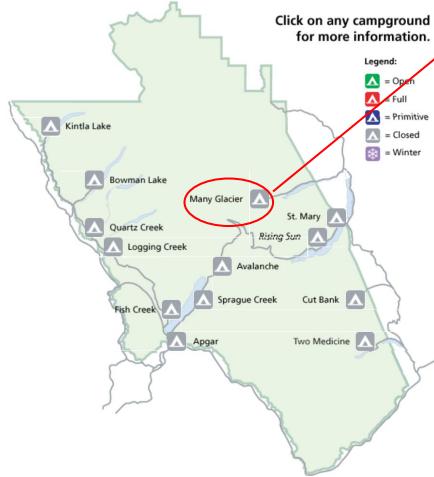
Gathering the Data



Extracting Target Data

From Home Page

Glacier National Park Campground Status
as of 8:35AM Mountain Time on 5-30-2020



Select Campground

Many Glacier Campground - 2020



Adobe Flash Player is blocked

Due to current and anticipated staffing and operational limitations related to the COVID-19 outbreak, combined with identified safety and health risks, the opening of frontcountry campgrounds will be delayed. While opening dates have not been established for park campgrounds, reservations have been cancelled at St. Mary Campground, Fish Creek Campground, and group sites at Apgar Campground through June 11, 2020. Refunds have been issued through recreation.gov and no further action is required by reservation holders at this time. The park is evaluating possible frontcountry campground opening dates and operations based on staffing levels, current conditions, and the latest health guidance. Please continue to check the park website for updated information.

Dates of Operation

Additional Information

Summer Fee	\$23.00 / night
Number of Sites	10*
Flush Toilets	Yes
Showers	No
Disposal Station	Yes
Reservations	No
*13 sites will accommodate up to a 35 foot RV or truck and trailer combination.	

Campground layout

Approximate driving distance:
St. Mary 21mi

The campground is situated within trees for tent and RV campers, though there are only 13 sites that can accommodate vehicle lengths up to 35 feet in length. Sites 88 through 102 are generator free. Potable water is accessible in the campground, and restroom facilities are equipped with flush toilets and sinks with running water. Be sure to join a ranger for nightly evening programs. Please see our ranger guided activity schedule for more information.

The nearby Swiftcurrent Motor Inn houses a combination gift shop and camp store, and in the summer of 2020 will offer take-out food service only. A fee-based shuttle service with GlacierPursuit and Glacier National Park Lodges will also be available here to connect you to east side destinations. In past years showers have been available at the Swiftcurrent Motor Inn, for a fee. They will not be available for the 2020 summer season. The historic Many Glacier Hotel, situated on Swiftcurrent Lake, is located down the road from the campground.

Bring your binoculars, as there are opportunities to view wildlife like bighorn sheep, moose, and bears. Many Glacier also provides access to some of the best day hikes in the park, including a hike to one of the park's largest glaciers, so don't forget your hiking boots.

Current and Historic Campground Fill Times

The current month is always displayed, showing what day(s) the site(s) in the campground filled. If the campground did not fill on a certain day, no time will be displayed.

Use the drop-down menus to select a different month and year to see when the campground filled. Use Avg to display the 5-year average for the month selected.

Month Year

Display fill times

[◀ Return to Campground Status](#)

Select Month/Year

Many Glacier Campground - 2020



Adobe Flash Player is blocked

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The campground at Many Glacier is one of the most popular campgrounds in Glacier National Park. In 2020 and 2021 the entire Many Glacier Campground will be reservation only. The Many Glacier Valley will be closed to access until at least June 11, 2020, due to road construction activities.

The campground is situated within trees for tent and RV campers, though there are only 13 sites that can accommodate vehicle lengths up to 35 feet in length. Sites 88 through 102 are generator free. Potable water is accessible in the campground, and restroom facilities are equipped with flush toilets and sinks with running water. Be sure to join a ranger for nightly evening programs. Please see our ranger guided activity schedule for more information.

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July 2009

Display fill times

[◀ Return to Campground Status](#)

Review of Extracted Data

- Data extracted via `requests.posts`
 - 20 years * 5 months* 13 campgrounds → 39_780 observations (rows) and 8_595 recorded fill times
 - Incidence rate is at least 21%
- Two sources of false negatives
 - Campgrounds vary in their opening and closing dates (not all open from 1 May for 30 Sep)
 - Park newsletter states specific dates for campgrounds but archives not available online (only past 4 years)
 - Earliest opening date calculated as min of [earliest fill date, newsletter opening date]
 - Same approach for determining latest closing date
 - This removes ~9000 campground-dates
 - Closures due to wildfires in the park
 - Notable Fires: 2003 Robert Fire, 2015 Reynold's Creek Fire, 2017 Sprague Fire, 2018 Howe Ridge
 - Dataframe excludes all of 2003 (see next slide)
 - 398 specific dates removed for recent fires

Working Dataset is 29K Observations

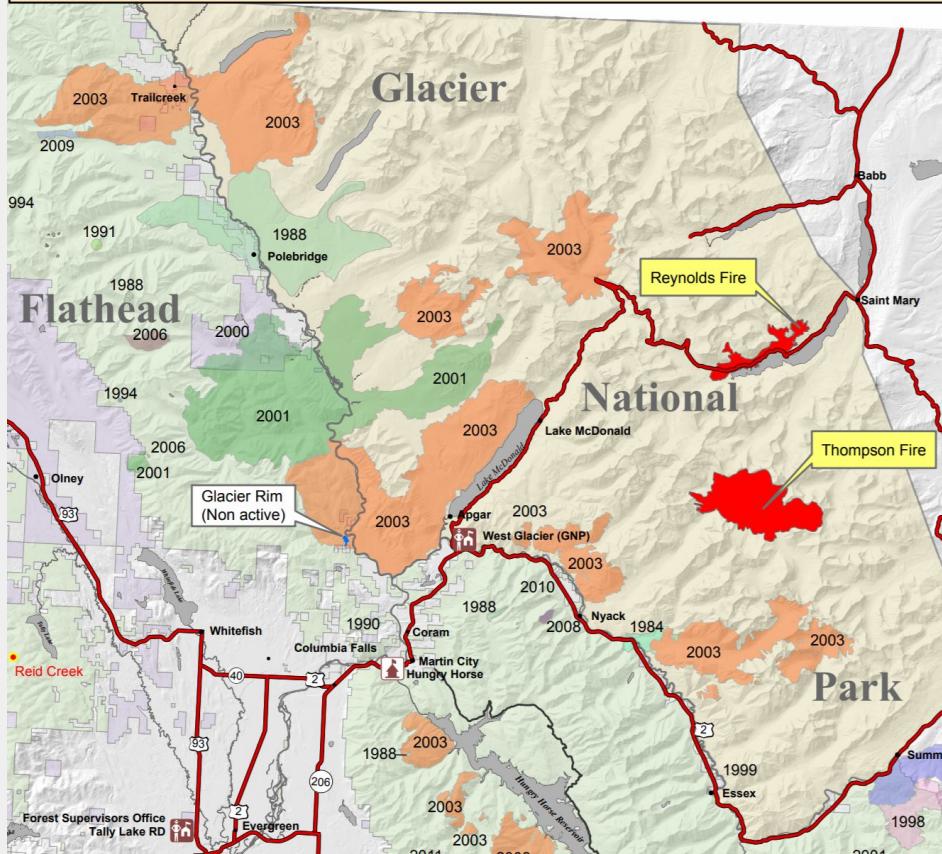
FIRE HISTORY

Flathead National Forest & Glacier National Park

1984 - 2015

Scale 1:575,000

N



What Features Can Explain our Variance?

- **Time**
 - Year over year increase in attendance
 - High season vs Low season
 - Weekdays vs Weekends
- **Supply**
 - Availability
 - Closures
- **Demand**
 - Campground attributes
 - Weather (sun, temperature, precipitation)
 - Air quality (wildfires)



Case Study A - Two Medicine CG Sept 2017

September - 2016						
Sun	Mon	Tues	Wed	Thur	Fri	Sat
				1 6:33pm	2 3:59pm	3
4	5	6	7	8	9	10 6:26pm
11	12	13 4:50pm	14 3:23pm	15 3:33pm	16 6:17pm	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

MTZ009-112230-
NORTHERN ROCKY MOUNTAIN FRONT-
INCLUDING THE CITIES OF...BROWNING...HEART BUTTE...DUPUYER...
EAST GLACIER PARK...KIOWA
455 AM MDT SUN SEP 11 2016

...WINTER WEATHER ADVISORY IN EFFECT FROM NOON TODAY TO NOON MDT
MONDAY FOR ELEVATIONS ABOVE 5000 FEET...

.TODAY...COOLER. RAIN THIS MORNING...THEN RAIN AND SNOW THIS AFTERNOON. SNOW ACCUMULATION OF 2 TO 5
INCHES. HIGHS 40 TO 50. NORTH WINDS 5 TO 15 MPH. GUSTS UP TO 30 MPH THIS AFTERNOON.
CHANCE OF PRECIPITATION NEAR 100 PERCENT.

.TONIGHT...COLDER. RAIN LIKELY. SNOW. SNOW ACCUMULATION OF 2 TO 5 INCHES. SNOW LEVEL 5000 FEET. LOWS 25 TO
35. NORTH WINDS 10 TO 15 MPH WITH GUSTS UP TO 35 MPH. CHANCE OF PRECIPITATION 90 PERCENT.

.MONDAY...MOSTLY CLOUDY. A 50 PERCENT CHANCE OF SNOW AND RAIN IN THE MORNING. HIGHS 40 TO 45.
NORTHEAST WINDS 10 TO 15 MPH. GUSTS UP TO 30 MPH IN THE MORNING.

.MONDAY NIGHT...PARTLY CLOUDY. LOWS 25 TO 30. NORTHEAST WINDS 5 TO 15 MPH...BECOMING SOUTH 5 TO 10 MPH
AFTER MIDNIGHT.

.TUESDAY...NOT AS COOL. SUNNY. HIGHS 50 TO 60. SOUTHEAST WINDS 5 TO 15 MPH.

.TUESDAY NIGHT AND WEDNESDAY...MOSTLY CLEAR. LOWS AROUND 35. HIGHS 60 TO 65.

.WEDNESDAY NIGHT THROUGH FRIDAY...MOSTLY CLEAR. LOWS 40 TO 45. HIGHS 60 TO 70.

.FRIDAY NIGHT...MOSTLY CLEAR. LOWS AROUND 45.

.SATURDAY...PARTLY CLOUDY. HIGHS 60 TO 70.

<https://mesonet.agron.iastate.edu/wx/afos/p.php?pil=ZFPTFX&e=201609120321>

Rain Sun & Mon → Did not fill

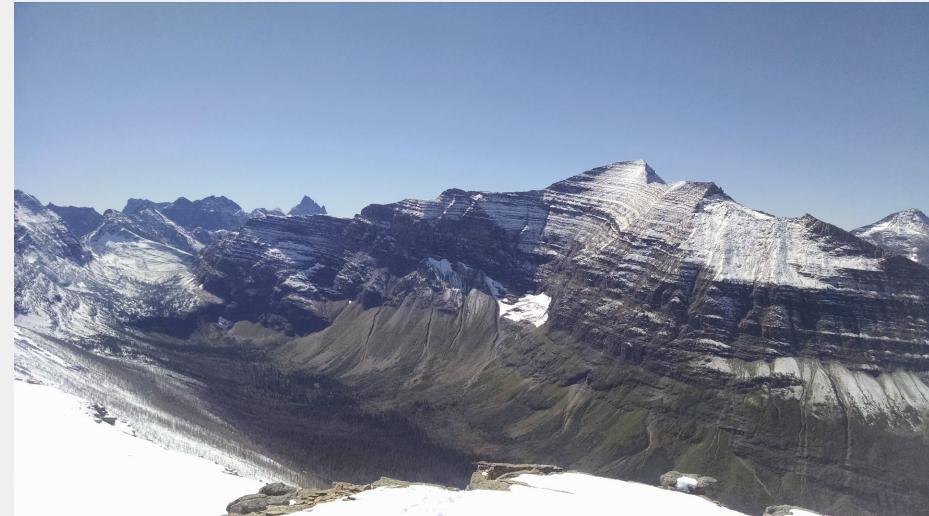
Sunny Tues-Thurs → Filled

Weather makes a massive difference in the experience

Summit of Swiftcurrent Mountain
09 Sep 2016



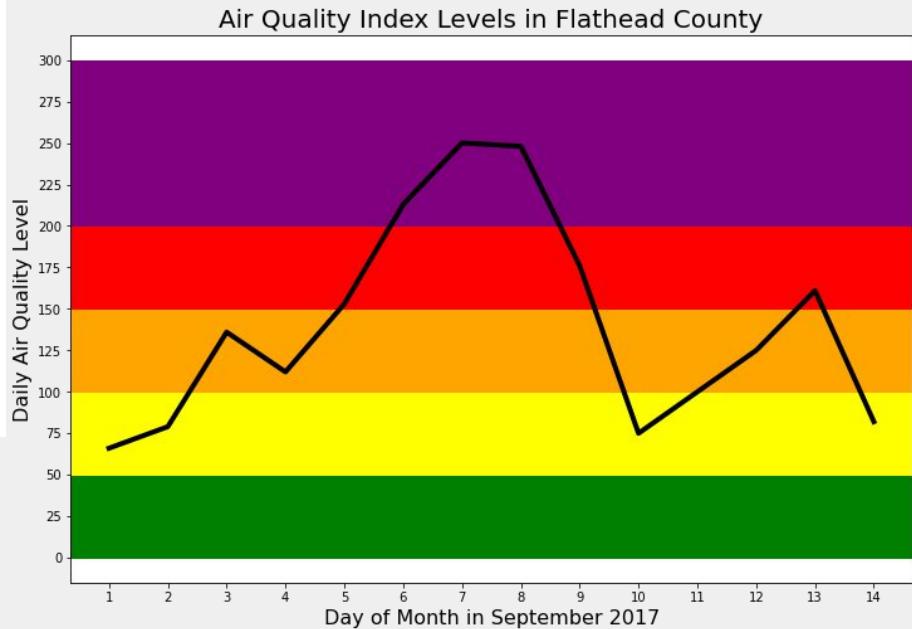
View from Pitamakan Pass
13 Sep 2016



Case Study B - Many Glacier CG Sept 2017

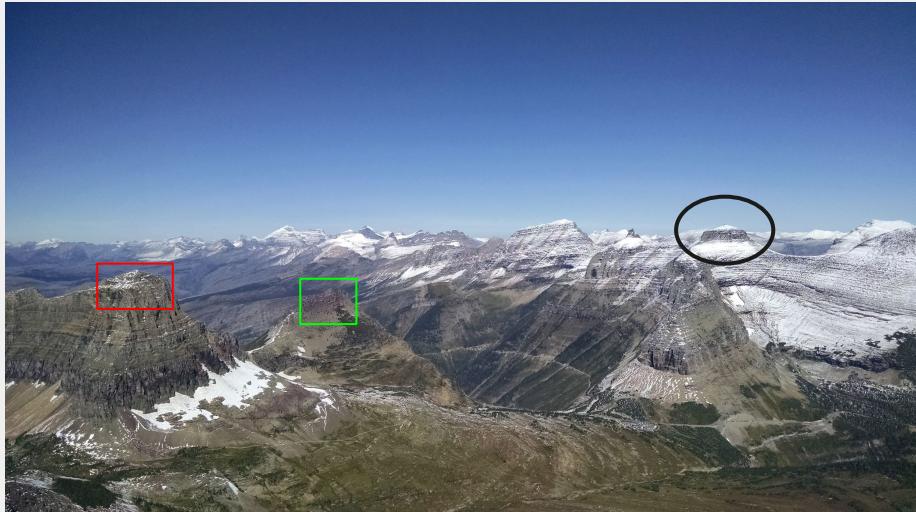


Effects of Sprague Fire on demand at GNP's most popular campground



Wildfires both limit park access and degrade the experience

September 14th, 2016
Air Quality Index (AQI) of 29



View (North) of Logan's Pass from Reynold's Mountain

September 5th, 2017
AQI ... 153

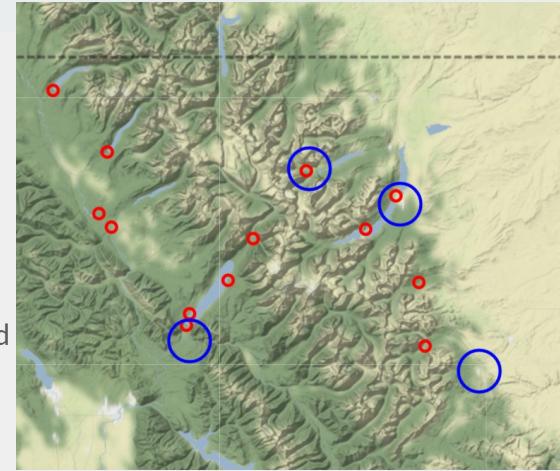


View (West) of Logan's Pass from Pollock Mountain

*Black Circled Peaks Reflect where the Opposite Picture was Taken From
Peaks in Colored Squares are Same in each Picture*

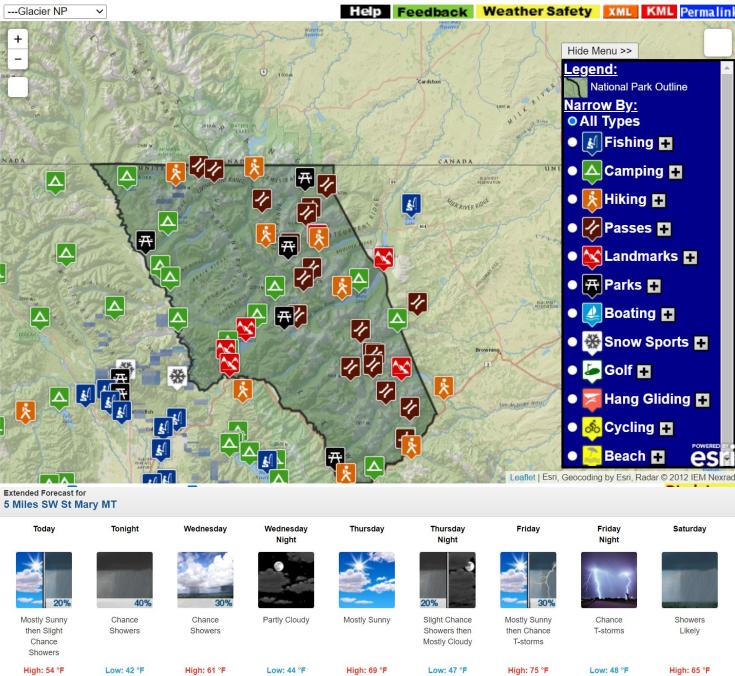
Feature Creation

- **Historical Weather Data**
 - Source - NOAA Climate Data Office
 - Four weather stations in Glacier National Park, assign to nearest campground
 - Archived consists only of temperature and precipitation values
- **Historical Air Quality Data**
 - Source - EPA Air Quality Index Values
 - Archived data reported at county level, only one county adjacent to GNP reports AQI
- **Historical Monthly Visits**
 - Source - National Park Service Visitor Use Statistics
 - Measured by month for the total park
- **Campground Attributes**
 - Source - NPS Website for GNP
 - Assumption that no fundamental changes over time frame



Archived Data Significantly Less Detailed than What is Available Real Time

Weather Information Available Real Time



Weather Information Available for Past

Daily Summaries Station Details

STATION DETAILS	
Name	MANY GLACIER, MT US
NetworkID	GHCND:US0013A275
Latitude/Longitude	48.8°, -113.67°
Elevation	1493.5 m
PERIOD OF RECORD	
Start Date ¹	1976-09-30
End Date ¹	2020-06-03
Data Coverage ²	100%

ADD TO CART



Station Data Inventory, Access & History

Data & Inventory
View Data
Available Data Types
Air Temperature
Precipitation
Water

View Station Data

View current station data by selecting the desired options below and clicking the "View Data" button.

Select Year: Select Month:

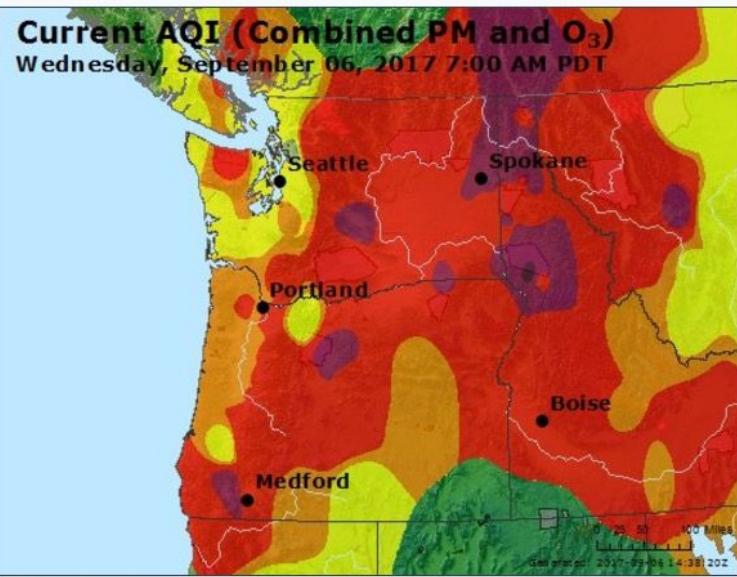
[VIEW DATA](#)

View Station Data Help

View Station Data is a web based interface which allows easy access to NCDC's station databases. Data coverage is stored based on observations over a specific period of time whether annually, monthly, or daily. The date range changes based on the selected dataset.



Air Quality Info Available Real Time



Good Moderate USG Unhealthy Very Unhealthy Hazardous ! Action Day

Air Quality Info Available for Past

1. Pollutant

All AQI Pollutants

2. Year

2017

3. Geographic Area

Select a City (defined as CBSA) ...

-- or --

MT - Flathead

Geographic Area: Flathead County, MT

Pollutant: Overall

Year: 2017

[About this report](#)

that are not available from AQS. AQs data, as it becomes available, replaces any AirNow data. The AirNow data are not fully verified and validated through the quality assurance procedures monitoring organizations use to officially submit and certify data on the EPA AQs (Air Quality System) and, therefore, cannot be used to formulate or support regulation, guidance or any other Agency decision or position.

The following data links are active for the next 10 minutes, after which you must resubmit your query.

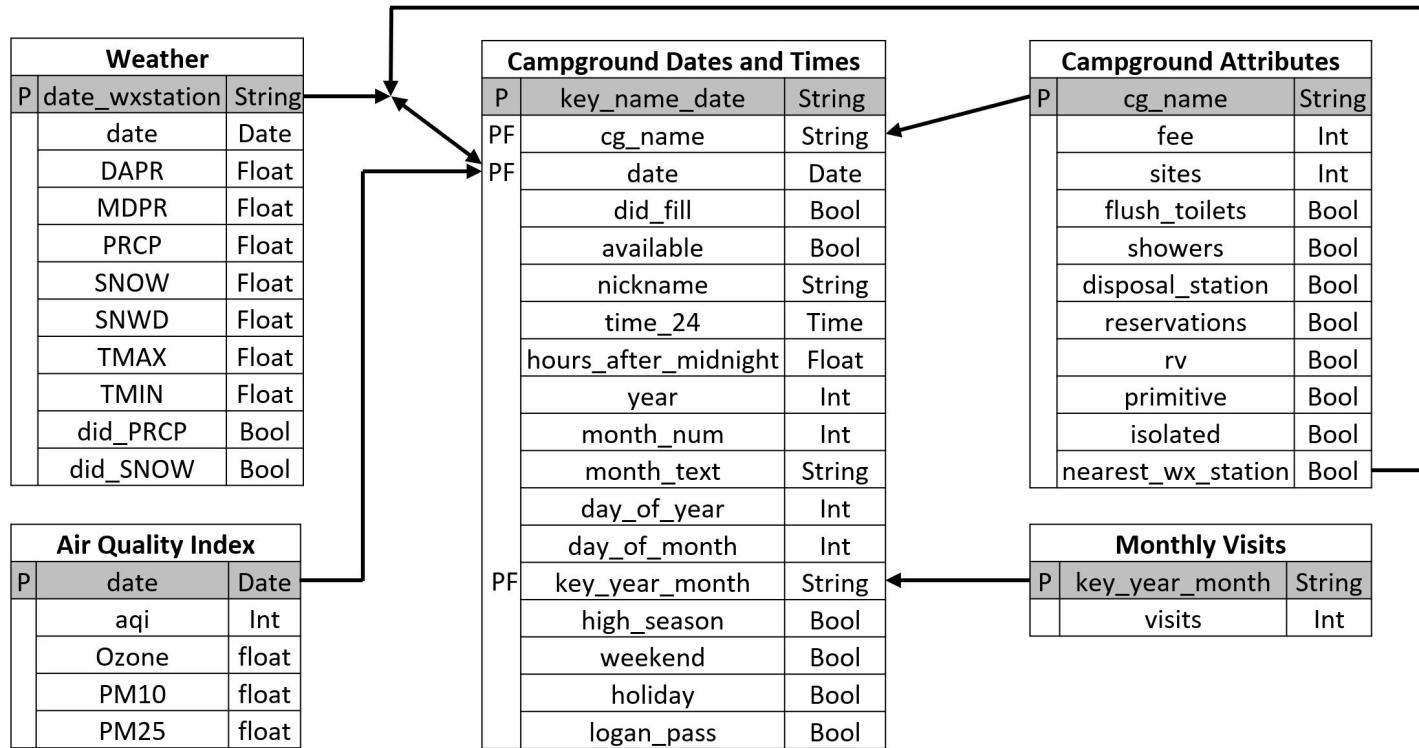
[Download PDF \(printable page\)](#)

[Download CSV \(spreadsheet\)](#)

To sort a column in the table below, click on the column heading.

Date	Overall AQI Value	Main Pollutant	Ozone AQI Value	PM2.5 AQI Value	SO2 AQI Value	NO2 AQI Value	PM10 AQI Value	CO AQI Value
09/07/2017	250	PM2.5	.	250	.	.	137	.
09/08/2017	248	PM2.5	.	248	.	.	137	.
09/06/2017	213	PM2.5	35	213	.	.	114	.
09/09/2017	176	PM2.5	.	176	.	.	100	.
09/13/2017	161	PM2.5	54	161	.	.	102	.

Dataframe Construction



Feature Set Available for Modeling

Features	Grouping	Data Type	Description	Variation Across Time	Variation across Campground
high_season	Date	Boolean	1 if July or August, else 0	Monthly	None
weekend	Date	Boolean	1 if Fri or Sat, else 0	Weekly	None
holiday	Date	Boolean	1 if holiday, else 0	Daily	None
logan_pass	Date	Boolean	1 if Logan's pass open, else 0	Daily	None
aqi	Air Quality	Int	Air Quality Index by date	Daily	None
ozone	Air Quality	Int	daily avg concetration of ozone	Daily	None
PM10	Air Quality	Int	daily avg concentration particulate matter smaller than 10 mm	Daily	None
PM25	Air Quality	Int	daily avg concentration particulate matter smaller than 2.5 mm	Daily	None
visits	Unique	Int	Monthly visitors to GNP by year	Monthly	None
fee	Campground Attribute	Int	Total supply of other campground sites	None	Yes
sites	Campground Attribute	Int	Number of sites at campground	None	Yes
flush_toilets	Campground Attribute	Boolean	1 if campground has flush toilets	None	Yes
showers	Campground Attribute	Boolean	1 if campground has showers	None	Yes
disposal_station	Campground Attribute	Boolean	1 if campground has disposal stations	None	Yes
reservations	Campground Attribute	Boolean	1 if campground takes reservations	None	Yes
rv	Campground Attribute	Boolean	1 if campground allows RVs	None	Yes
primitive	Campground Attribute	Boolean	1 if campground is primitive	None	Yes
isolated	Campground Attribute	Boolean	1 if campground is isolated (none others close by)	None	Yes
cg_supply	Unique	Int	Total supply of other campground sites	Daily	None
DAPR	Weather	Int	Number of days in multiday precipitation total	Daily	Partial
MDPR	Weather	Float	Multiday precipitation total	Daily	Partial
PRCP	Weather	Float	Daily precipitation (inches)	Daily	Partial
SNOW	Weather	Float	Daily snowfall (inches)	Daily	Partial
SNWD	Weather	Float	Snowdepth (inches)	Daily	Partial
TMAX	Weather	Int	Daily temperature max	Daily	Partial
TMIN	Weather	Int	Daily temperature min	Daily	Partial
did_PRCP	Weather	Boolean	1 if rained on date	Daily	Partial
did_Snow	Weather	Boolean	1 if snowed on date	Daily	Partial

Classification Modeling



Predict if a Campground Fills Up (Classification)

Classification	Observations	Prevalence	Majority	Train Acc	Test Acc	Test Acc vs Majority	Test F1
RandomForest	29046	0.29	0.71	0.96	0.88	0.18	0.79
AdaBoostClassifier	29046	0.29	0.71	0.87	0.86	0.15	0.75
SVC	29046	0.29	0.71	0.84	0.83	0.12	0.68
Neural Net Classifier	29046	0.29	0.71	0.85	0.83	0.12	0.7
LogisticRegression	29046	0.29	0.71	0.82	0.82	0.11	0.66
BernoulliNB	29046	0.29	0.71	0.73	0.73	0.02	0.62

Classification Models are 10% to 20% Improvement over Baseline
ADABoost is Best Model that is not Overfit

Classifier by Subgroup - Campgrounds

Campground	Observations	Incidence	Prevalence	Majority	Train Acc	Test Acc	Test Acc vs Majority	Test F1	Sensitivity	Specificity	PPV	NPV
Many Glacier	2,489	1,293	0.52	0.52	0.92	0.89	0.37	0.89	0.90	0.87	0.88	0.89
Rising Sun	1,903	889	0.47	0.53	0.87	0.85	0.31	0.84	0.86	0.84	0.82	0.87
Sprague Creek	2,614	1,463	0.56	0.56	0.87	0.84	0.28	0.86	0.89	0.79	0.84	0.84
Fish Creek	1,814	693	0.38	0.62	0.91	0.84	0.23	0.78	0.74	0.91	0.83	0.85
Avalanche	1,748	757	0.43	0.57	0.83	0.80	0.23	0.76	0.74	0.84	0.78	0.81
St. Mary	2,896	743	0.26	0.74	0.92	0.90	0.16	0.81	0.78	0.95	0.84	0.93
AdaBoostClassifier	29,046	8,444	0.29	0.71	0.87	0.86	0.15	0.75	0.71	0.93	0.80	0.89
Two Medicine	2,356	690	0.29	0.71	0.88	0.85	0.15	0.72	0.65	0.94	0.81	0.87
Apgar	2,828	644	0.23	0.77	0.91	0.90	0.13	0.77	0.71	0.96	0.84	0.92
Kintla Lake	2,299	540	0.23	0.77	0.85	0.83	0.06	0.59	0.53	0.92	0.66	0.86
Cut Bank	2,318	298	0.13	0.87	0.91	0.91	0.03	0.56	0.47	0.97	0.70	0.92
Bowman Lake	2,299	260	0.11	0.89	0.94	0.91	0.02	0.51	0.43	0.97	0.62	0.93
Logging Creek	1,691	82	0.05	0.95	0.96	0.94	-0.01	0.14	0.10	0.99	0.25	0.95
Quartz Creek	1,791	92	0.05	0.95	0.96	0.93	-0.02	0.06	0.04	0.98	0.11	0.95

- All rows calculated with ADABoost uniquely fit to that subgroup
- Inverse relationship between Prevalence and performance vs baseline
- Feature set has no explanatory power for unbalanced classes (the five campgrounds at the bottom)
- False positives more common than false negatives in model

A wide-angle photograph of a majestic mountain range under a clear blue sky. The central peak is rugged with distinct horizontal sedimentary rock layers and patches of white snow clinging to its upper slopes. In the foreground, a grassy hillside with scattered evergreen trees slopes down towards the viewer. The overall scene is bright and sunny.

Regression Modeling

Predict When a Campground Fills Up (Regression)

Regressor	Observations	Y_Bar	StdDev	Train R2	Test R2	Train MSE	Test MSE	Train MAE	Test MAE
SVR	8444	14.1	3.8	0.40	0.41	8.8	8.9	2.4	2.4
AdaBoostRegressor	8444	14.1	3.8	0.32	0.35	9.9	9.8	2.7	2.6
LinearRegression	8444	14.1	3.8	0.31	0.34	10.2	9.9	2.6	2.6
Ridge	8444	14.1	3.8	0.31	0.34	10.2	9.9	2.6	2.6
Neural Net Regression	8444	14.1	3.8	0.32	0.33	10.0	10.0	2.6	2.6
Gamma GLM	8444	14.1	3.8	0.30	0.32	10.3	10.1	2.6	2.6
KNeighborsRegressor	8444	14.1	3.8	0.51	0.31	7.1	10.4	2.1	2.6

Feature Set has Weak Explanatory Value in Predicting Fill Time
Mean Absolute Error is ~2.5 hours (e.g. 2 hours, 30 mins)

Regression by Subgroup - Campgrounds

Campground	Observations	Y_Bar	StdDev	Train R2	Test R2	Train MSE	Test MSE	Train MAE	Test MAE
Rising Sun	889	14.9	3.8	0.57	0.52	6.1	6.5	1.9	2.0
Sprague Creek	1463	14.3	3.4	0.53	0.50	5.4	5.7	1.8	1.9
Avalanche	757	15.5	3.4	0.49	0.42	5.9	6.3	1.9	2.0
SVR	8444	14.1	3.8	0.40	0.41	8.8	8.9	2.4	2.4
Many Glacier	1293	12.4	3.4	0.39	0.39	6.8	7.1	2.0	2.1
St. Mary	743	12.1	4.6	0.49	0.38	10.9	12.1	2.6	2.8
Cut Bank	298	16.5	2.9	0.37	0.37	5.2	4.7	1.7	1.8
Fish Creek	693	11.9	4.5	0.41	0.31	11.9	13.1	2.7	2.9
Apgar	644	15.1	3.5	0.44	0.27	6.8	9.4	2.1	2.6
Quartz Creek	92	17.0	2.1	0.39	0.25	2.6	3.5	1.1	1.6
Two Medicine	690	15.0	3.3	0.40	0.23	6.9	7.3	2.1	2.1
Kintla Lake	540	14.8	2.7	0.30	0.09	5.3	6.1	1.8	2.1
Bowman Lake	260	16.5	2.4	0.40	0.06	3.6	4.7	1.5	1.6
Logging Creek	82	17.0	2.2	0.53	-0.02	2.2	5.6	1.0	1.5

- All rows calculated with SVR uniquely fit to that subgroup
- Units for Y_Bar, StdDev, MSE, and MAE are hours from midnight (e.g. 14.88 = 02:53 PM)
- Regression model is highly overfit for some of the same campgrounds on which Classification performed poorly
- SVR performs worse on campgrounds with less variation in their fill time

Conclusions



Conclusions and Recommendations

- The models documented can explain some of the variation in daily campground demand at Glacier National Park
 - Factors thought to influence real time campground demand not available in archived online data
 - Specifically, detailed forecasts by park area and air quality map
- For classification, predicting if a campground fills up, most variation explained by time factors
 - Seasonal variation (high season July/August) and year-over-year increase in visitation
 - Popularity of campgrounds can be self-perpetuating
- For regression, predicting when a campground fills, models can explain less than half of the variance
 - Mean Absolute Error is ~2.5 hours for models
 - Unclear what's true noise vs weak features
- Recommendations for Future Analysis
 - Time Series modeling → main obstacle is discontinuity (e.g. days where a campground doesn't fill)
 - Incorporate archival text forecasts and archival air quality maps for more campground specific granularity