

National Park Visitation: A Geodatabase Approach

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Introduction

National parks are seen as treasure in the United States. They are both a popular destination for citizens of the U.S. and an attraction drawing international travelers. The year 2021 saw 297 million visitors to the National Park System (Annual Visitation Highlights, 2022). The top 10 most visited parks in 2021 all received more than 3 million visitors each, with the Great Smoky Mountains National Park receiving over 14 million (figure 1).

Park	Rank	Recreation Visits	% of Total
Great Smoky Mountains NP	1	14,161,548	15.35%
Zion NP	2	5,039,835	5.46%
Yellowstone NP	3	4,860,242	5.27%
Grand Canyon NP	4	4,532,677	4.91%
Rocky Mountain NP	5	4,434,848	4.81%
Acadia NP	6	4,069,098	4.41%
Grand Teton NP	7	3,885,230	4.21%
Yosemite NP	8	3,287,595	3.56%
Indiana Dunes NP	9	3,177,210	3.44%
Glacier NP	10	3,081,656	3.34%

Figure 1. From “Annual Park Ranking Report for Recreation Visits in 2021; Park Type: National Park”. Created by the National Park Service: <https://irma.nps.gov/STATS/SSRSReports>.

Despite the many economic and cultural benefits of national park visitation, the rise in visitor numbers has led to concerns for the National Park System (NPS). Increased visitation increases congestion in many parks, which may cause gridlocks, visitor conflicts, crowding, safety issues, resource damage, emergency response delays, and an overall decline in visitor enjoyment (National Parks Overcrowding, 2021). Understanding the factors that affect visitation is important for implementing measures to lessen the impacts that result from congestion in the nation’s most treasured places. Park visitation is impacted by many factors. Rice and Pan (2021) found that climate influenced park visitation during the spring months. Stevens et al. (2014) suggested that travel costs and park entrance fees can hinder or encourage visiting national parks. Even the park itself plays a role, with nature-based parks more likely to be visited by distant travelers and cultural-based parks by locals (Shen et al., 2019), and more than half of all visits occurring in just the top 23 most visited parks (National Parks Overcrowding, 2021). Even the COVID-19 pandemic had an impact as 2020 saw a decline in park visitation (figure 2).

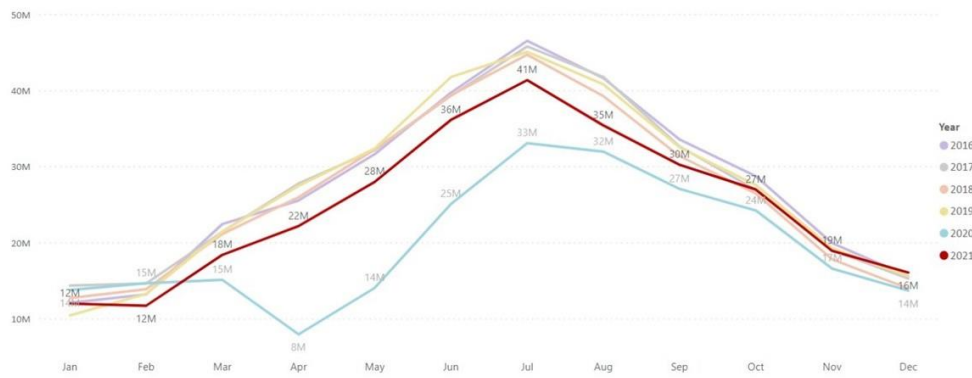


Figure 2. From “Annual Visitation Highlights” by the National Park Service, 2022, <https://www.nps.gov/subjects/socialscience/annual-visitation-highlights.htm>.

To enhance understanding of the factors that influence national park visitation and aim to mitigate the impacts that result from increased visitation, we designed a geodatabase to compare which parks (and states) received the most visitation and whether the nearby transportation networks or nearby population areas had any correlation with visitation.

Database Design

The first process in creating our national parks geodatabase was to create conceptual and logical models of the geodatabase using ERD Plus as the data modeling software. We used an ER diagram for the conceptual model of the geodatabase (figure 3). Our ER diagram used the standard notation of rectangles to represent entities, ellipses to represent attributes (with the primary key attributes underlined for each entity), and diamonds to represent relationships. The national parks entity (polygon type) was placed at the center of the diagram as it had relationships with all the other entities in the geodatabase: a “nearby” relationship with the point entities (cities and airports), a “goes to” relationship with the line entities (roads and railroads), and a “within” relationship with the other polygon entity (states). The two tabular entities (average annual visits and traffic counts) both depended on the national parks entity to exist and thus were weak entities. Most of the relationships had a many-to-many cardinality, except for the relationship between national parks and average annual visits (one-to-one) and national parks and traffic counts (one-to-many).

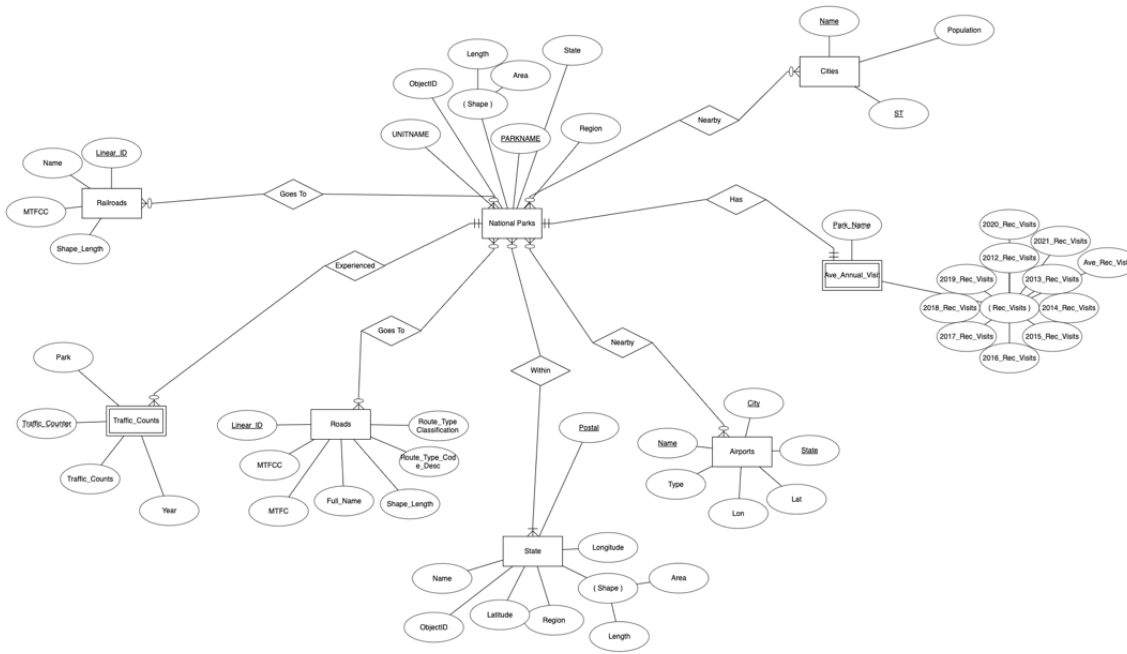


Figure 3. ER Diagram for the National Parks Database

We used a relational diagram as our logical model (figure 4). Because all relations connected with national parks, the primary key for national parks (UNITNAME) became a foreign key with the other relations. The many-to-many relationships had a composite primary key of each participating relation's primary key (i.e., the national parks and the other entity it had a relationship with from the ER diagram), while the weak relations had the foreign key of UNITNAME becoming their primary key since they existed solely because of the national parks.

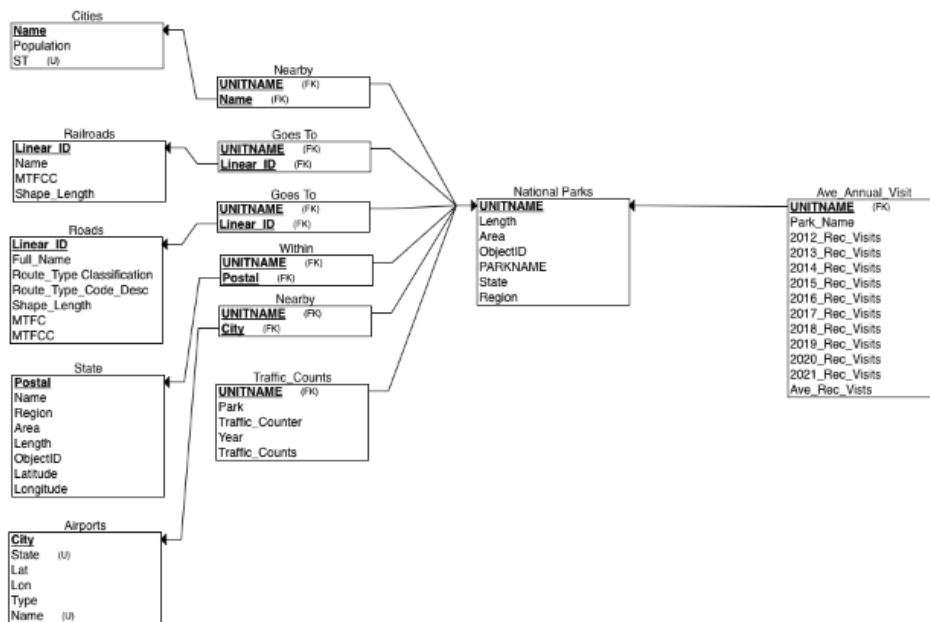


Figure 4. Relational Diagram for the National Parks Database

Database Implementation

We utilized ArcGIS Pro to implement and manipulate our national parks geodatabase. A file geodatabase was created with the name “national_parks.gdb”. From there, the tabular data (average annual visits as ave_annual_visits and traffic counts as traffic_counts) were imported from csv files to tables within the geodatabase. The feature classes were added using the Export Features geoprocessing tool within ArcGIS Pro. Several of the feature classes required queries to remove excess features. We used the following queries for that task: for states we used “WHERE admin = ‘United States of America’” (to only return U.S. states) and for national parks we used “WHERE UNITYTYPE = ‘National Park’” (to only return national parks and not any other NPS units). After all feature classes had been added to the geodatabase, we went through and cleaned up the attributes to match our ER and relational diagrams.

Database Manipulation

Once the geodatabase was created and populated, we ran several example queries on the data to show some of the potential queries that could be run against the geodatabase to understand national park visitation and the factors that could influence visitation. We started by creating a 30-mile buffer around national parks, which represented the area we considered to be “nearby” a national park. Our other queries were as follows:

- To determine how many airports were nearby national parks, we used the Summarize Within tool in ArcGIS Pro to count the number of airports within the 30-mile buffer around national parks (figure 5).

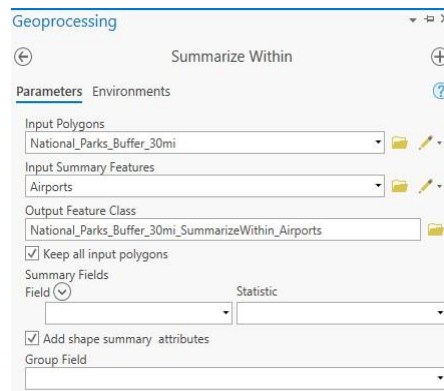


Figure 5. ArcGIS Pro input for the Summarize Within tool to get the number of airports within 30 miles of national parks.

- We also used Summarize Within to get a count of major cities (greater than 10,000 people) within 30 miles of national parks. Our input polygon layer was again the 30-mile national park buffer layer and our input summary feature layer was the cities layer. We did not need to query the cities layer to limit it to cities with at least 10,000 people because the layer already represented cities with a population greater than 10,000 people.

- Another query we were interested in was comparing the number of national parks found in each state. The Summarize Within tool again proved useful; we used states instead of using the park buffer as our input polygons and the national parks layer as our input summary features.
- To compare parks based on average annual visitation, we used the Make Query Table tool to build a table from the ave_annual_visits table that sorted the parks based on average_rec_visits (average recreational visits). We excluded rows that did not have a name and did not have a number for average_rec_visits (figure 6).

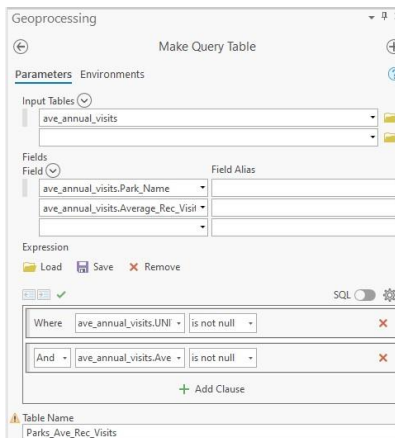


Figure 6. ArcGIS Pro input for the Make Query Table tool to get the average annual recreation visits for each national park.

- As an example query to view traffic counts based on information from the traffic_counts table, we used the Make Query Table tool to view the traffic counts at one of the entrances in Acadia National Park during July 2021. We included the Park, Year, Month, Traffic_Counter, and Traffic_Counts fields. Our expression was, “WHERE traffic_counts.Park = ‘Acadia National Park’ AND traffic_counts.Traffic_Count >= 0 AND traffic_counts.Year = 2021 AND traffic_counts.Month = 7 AND traffic_counts.Traffic_Counter = ‘TRAFFIC COUNT AT SAND BEACH’”.
- For determining railroads that “go to” national parks, we used a combination of the Summarize Within and Make Query Table tools. Summarize Within was used to get a count of the number of railroads that could be found within each national park boundary. Our input polygons layer was the national parks layer with the railroads layer as the input summary features. The Make Query Table tool created a table to summarize those results with the fields of UNITNAME and Count and an expression of “WHERE Count > 0” to exclude parks with no railroads from our result table.
- A similar process to the one used for the railroad query was used to determine roads that “go to” each national park. Summarize Within was again used to get a count for the number of roads within by using the national park boundary layer for the input polygons and the roads layer for the input summary features. The Make Query Table tool was used to output those results into a table with the fields of UNITNAME, Count, and Sum_Length_MILES (total length of roads within each national park boundary

in miles). We again used the “WHERE Count > 0” to exclude parks with no roads within their boundaries from our results table.

Results

Our queries led to initial insights for visitation to national parks. The top 5 most visited parks (sorted from most-visited first) were Great Smoky Mountains National Park (NP), Grand Canyon NP, Rocky Mountain NP, Yellowstone NP, and Yosemite NP. The least visited (sorted from least visited first) were Gates of the Arctic NP, Kobuk Valley NP, Lake Clark NP, Isle Royale NP, and NP of American Samoa (figure 7). We used these parks to analyze the results from the queries.



	Park Name	Average_Rec_Visits
1	Great Smoky Mounts...	11273036
2	Grand Canyon Natio...	5127243
3	Rocky Mountain Nati...	397662
4	Yellowstone National...	3942249
5	Yosemite National Park	3893142
6	Zion National Park	3885887
7	Grand Teton National...	3199407
8	Olympic National Park	3077846
9	Acadia National Park	3058594
10	Glacier National Park	2610485
11	Cuyahoga Valley Nati...	2319242
12	Joshua Tree National...	2314889
13	Indiana Dunes Nation...	1998202
14	Bryce Canyon Nation...	1965920
15	Gateway Arch Nation...	1676237
16	Hot Springs National...	1506193
17	Hawaii Volcanoes Nat...	1483487
18	Arches National Park	1433041
19	Shenandoah National...	1376908
20	Mount Rainier Nation...	1332293
21	Death Valley National...	1216998
22	New River Gorge Nati...	1203560
23	Sequoia National Park	1102968
24	Capitol Reef National...	1012016
25	Haleakala National P...	982553
26	Badlands National Park	980491
27	Everglades National P...	958669
28	Saguaro National Park	834439
29	Theodore Roosevelt...	657558
30	Canyonlands Nationa...	648967
31	Petrified Forest Natio...	647389
32	Crater Lake National...	633201
33	Wind Cave National...	587090
34	Kings Canyon Nation...	573849
35	White Sands National...	551700
36	Biscayne National Park	526424
37	Mammoth Cave Nati...	515745
38	Mesa Verde National...	515088
39	Denali National Park...	472183
40	Lassen Volcanic Natio...	469784
41	Glacier Bay National...	443975
42	Redwood National Pa...	437180
43	Carlsbad Caverns Nat...	403913
44	Big Bend National Park	401247
45	Great Sand Dunes Na...	397864
46	Virgin Islands Nation...	324022
47	Channel Islands Nati...	313952
48	Kenai Fjords National...	298814
49	Black Canyon of the...	269810
50	Voyageurs National P...	238363
51	Pinnacles National Pa...	222818
52	Guadalupe Mountain...	180426
53	Congaree National P...	138096
54	Great Basin National...	127429
55	Wrangell-St. Elias Nat...	68038
56	Dry Tortugas National...	65099
57	Katmai National Park...	41139
58	North Cascades Nati...	26911
59	National Park of Ame...	25651
60	Isle Royale National P...	20389
61	Lake Clark National P...	15728
62	Kobuk Valley Nationa...	13085
63	Gates of the Arctic N...	9589

Figure 7. Result table from the Make Query Table for the query to return average annual recreation visits for each national park. The results are organized in descending order with order number to the left of each park name.

In terms of nearby cities, Great Smoky Mountains NP and Rocky Mountain NP both had nearby cities, while none of the rest of the top 5 parks had cities within 30 miles (figure 8). None of the parks at the bottom of the visitation list had any nearby cities.

OBJECTID_1 *	Shape *	UNIT_NAME	STATE	REGION	PARKNAME	BUFF_DIST	ORIG_FID	Shape_Length	Shape_Area	Count of Points	
1	51	Polygon	Everglades National P...	FL	SE	Everglades	48280.416561	51	714633.488592	35894753956.124947	64
2	60	Polygon	Cuyahoga Valley Nati...	OH	MW	Cuyahoga Valley	48280.416561	60	415212.372176	13225985967.477551	62
3	31	Polygon	Biscayne National Park	FL	SE	Biscayne	48280.416561	31	425967.105414	14192731058.852377	61
4	24	Polygon	Indiana Dunes Nation...	IN	MW	Indiana Dunes	48280.416561	24	465647.790928	15811839968.174372	51
5	26	Polygon	Gateway Arch Nation...	MO	MW	Gateway Arch	48280.416561	26	309598.584204	7624777630.929295	45
6	3	Polygon	Mount Rainier Nation...	WA	PW	Mount Rainier	48280.416561	3	546245.069568	21838889692.248486	18
7	59	Polygon	Saguaro National Park	AZ	IM	Saguaro	48280.416561	59	503788.761834	17761606523.525435	13
8	1	Polygon	Congaree National P...	SC	SE	Congaree	48280.416561	1	373163.979607	10908462980.852917	12
9	2	Polygon	Channel Islands Nati...	CA	PW	Channel Islands	48280.416561	2	806224.312339	32288196260.182449	12
10	34	Polygon	Joshua Tree National...	CA	PW	Joshua Tree	48280.416561	34	635670.122736	29201042904.118528	11
11	17	Polygon	Shenandoah National...	VA	NE	Shenandoah	48280.416561	17	610585.150049	24552734255.268074	7
12	21	Polygon	Great Smoky Mounta...	TN	SE	Great Smoky Mounta...	48280.416561	21	573667.875026	24382644517.979649	5
13	42	Polygon	Pinnacles National Pa...	CA	PW	Pinnacles	48280.416561	42	360961.184283	10318171014.048647	5
14	15	Polygon	Haleakala National P...	HI	PW	Haleakala	48280.416561	15	368920.254878	10732987468.064644	4
15	22	Polygon	Sequoia National Park	CA	PW	Sequoia	48280.416561	22	517942.637119	20782285398.008957	4
16	23	Polygon	Hawai'i Volcanoes Na...	HI	PW	Hawaii Volcanoes	48280.416561	23	527443.970244	20819682593.111046	4
17	8	Polygon	Crater Lake National...	OR	PW	Crater Lake	48280.416561	8	762014.711152	23659336744.848724	3
18	13	Polygon	Hot Springs National...	AR	MW	Hot Springs	48280.416561	13	333481.166043	8825280640.581884	3
19	27	Polygon	Zion National Park	UT	IM	Zion	48280.416561	27	450932.981565	15645883103.665705	3
20	4	Polygon	Rocky Mountain Nati...	CO	IM	Rocky Mountain	48280.416561	4	478057.726474	17877792404.802971	2
21	35	Polygon	Mammoth Cave Nati...	KY	SE	Mammoth Cave	48280.416561	35	389594.86142	11934826302.273006	2
22	47	Polygon	Redwood National Pa...	CA	PW	Redwood	48280.416561	47	554973.23338	20999457224.255424	2
23	10	Polygon	Black Canyon of the...	CO	IM	Black Canyon of the...	48280.416561	10	374233.428004	11020896114.326031	1
24	25	Polygon	Carlsbad Caverns Nat...	NM	IM	Carlsbad Caverns	48280.416561	25	394244.368723	1208111746.936226	1
25	32	Polygon	White Sands National...	NM	IM	White Sands	48280.416561	32	420907.319523	13885112626.102142	1
26	39	Polygon	Dry Tortugas National...	FL	SE	Dry Tortugas	48280.416561	39	676342.442388	18325603204.852394	1
27	46	Polygon	Grand Teton National...	WY	IM	Grand Teton	48280.416561	46	530234.846465	21322432467.742626	1
28	48	Polygon	Olympic National Park	WA	PW	Olympic	48280.416561	48	877005.797407	49346938201.601212	1
29	56	Polygon	Death Valley National...	CA	PW	Death Valley	48280.416561	56	1017177.624493	65511173145.129471	1

Figure 8. Result table from the Summarize Within query to return the number of cities within 30 miles of each national park, sorted in descending order.

For nearby airports, the top visited parks ranged from 6th most airports (Great Smoky Mountains NP) to 37th (Yellowstone NP). The least visited parks were all in the bottom ten for number of nearby airports with Kobuk Valley NP and Isle Royale NP both at the bottom of the list as each had only one nearby airport (figure 9).

OBJECTID_1*	Shape*	UNIT_NAME	STATE	REGION	PARKNAME	BUFF_DIST	ORIG_FID	Shape_Length	Shape_Area	Count of Points
1	Polygon	Cuyahoga Valley National Park	OH	MW	Cuyahoga Valley	48280.416561	60	415212.372176	1322583967.477531	88
2	Polygon	Shenandoah National Park	VA	NE	Shenandoah	48280.416561	17	610585.150049	24552734255.268074	68
3	Polygon	Everglades National Park	FL	SE	Everglades	48280.416561	51	714633.488592	35894753956.124947	67
4	Polygon	Indiana Dunes National Park	IN	MW	Indiana Dunes	48280.416561	24	465647.790928	15811839968.174372	63
5	Polygon	Biscayne National Park	FL	SE	Biscayne	48280.416561	31	425967.105414	14192731058.852377	47
6	Polygon	Great Smoky Mountains National Park	TN	SE	Great Smoky Mounta...	48280.416561	21	573667.875026	24382644517.979649	46
7	Polygon	Gateway Arch National Park	MO	MW	Gateway Arch	48280.416561	26	309598.584204	7624777630.929295	42
8	Polygon	Mount Rainier National Park	WA	PW	Mount Rainier	48280.416561	3	546245.869568	21838889692.348486	37
9	Polygon	Olympic National Park	WA	PW	Olympic	48280.416561	48	877005.797407	49346938201.601212	33
10	Polygon	Black Canyon of the Gunnison National Park	CO	IM	Black Canyon of the...	48280.416561	10	374233.428004	11020896114.326031	32
11	Polygon	Congaree National Park	SC	SE	Congaree	48280.416561	1	373163.979607	10908462980.852917	27
12	Polygon	Joshua Tree National Park	CA	PW	Joshua Tree	48280.416561	34	635670.122736	29201042904.118526	27
13	Polygon	Crater Lake National Park	OR	PW	Crater Lake	48280.416561	8	782014.71152	23695936744.848724	24
14	Polygon	Rocky Mountain National Park	CO	IM	Rocky Mountain	48280.416561	4	478057.726474	17877930404.802971	23
15	Polygon	Channel Islands National Park	CA	PW	Channel Islands	48280.416561	2	806224.312339	32288196260.182449	22
16	Polygon	Saguaro National Park	AZ	IM	Saguaro	48280.416561	59	503788.761834	17761606523.535435	22
17	Polygon	Grand Canyon National Park	AZ	IM	Grand Canyon	48280.416561	30	1056234.636027	55045918096.489143	21
18	Polygon	Death Valley National Park	CA	PW	Death Valley	48280.416561	56	1017177.624493	65511773145.129471	21
19	Polygon	Zion National Park	UT	IM	Zion	48280.416561	27	450932.981365	15645883103.665705	18
20	Polygon	Denali National Park	AK	AK	Denali	48280.416561	16	1612060.009321	169703421954.143799	17
21	Polygon	Wrangell-St. Elias National Park	AK	AK	Wrangell - St Elias	48280.416561	58	2884676.60542	305593884513.525574	17
22	Polygon	Glacier Bay National Park	AK	AK	Glacier Bay	48280.416561	18	1347573.340857	110071069626.185654	16
23	Polygon	Glacier National Park	MT	IM	Glacier	48280.416561	40	733555.538613	37830522160.57901	16
24	Polygon	Acadia National Park	ME	NE	Acadia	48280.416561	57	512993.317948	1882181596.752777	15
25	Polygon	Mammoth Cave National Park	KY	SE	Mammoth Cave	48280.416561	35	389594.86142	11934826302.273006	14
26	Polygon	Great Sand Dunes National Park	CO	IM	Great Sand Dunes	48280.416561	12	412011.16366	13333876669.081438	12
27	Polygon	Big Bend National Park	TX	IM	Big Bend	48280.416561	28	605949.579349	26978261475.096478	12
28	Polygon	Canyonlands National Park	UT	IM	Canyonlands	48280.416561	33	546264.551958	22203624948.748478	12
29	Polygon	Yosemite National Park	CA	PW	Yosemite	48280.416561	9	575122.371766	29689201526.83477	11
30	Polygon	Grand Teton National Park	WY	IM	Grand Teton	48280.416561	46	530234.848485	21323432467.742626	11
31	Polygon	Kings Canyon National Park	CA	PW	Kings Canyon	48280.416561	44	569318.803758	24210043004.643208	10
32	Polygon	Sequoia National Park	CA	PW	Sequoia	48280.416561	22	517942.637119	2078238398.008957	9
33	Polygon	Wind Cave National Park	SD	MW	Wind Cave	48280.416561	37	374396.906922	1108926216.209974	9
34	Polygon	Arches National Park	UT	IM	Arches	48280.416561	41	405166.16968	1286280690.627747	9
35	Polygon	Pinnacles National Park	CA	PW	Pinnacles	48280.416561	42	360961.184283	10318171014.048647	9
36	Polygon	Bryce Canyon National Park	UT	IM	Bryce Canyon	48280.416561	52	394479.267715	12077322143.893642	9
37	Polygon	Yellowstone National Park	ID	IM	Yellowstone	48280.416561	55	860743.058529	52558113516.667557	9
38	Polygon	Hot Springs National Park	AR	MW	Hot Springs	48280.416561	13	333481.166043	8825280640.581884	8
39	Polygon	Redwood National Park	CA	PW	Redwood	48280.416561	47	554973.23338	20999457224.255424	8
40	Polygon	Virgin Islands National Park	VI	SE	Virgin Islands	48280.416561	53	369445.464072	1065379750.60001	8
41	Polygon	Badlands National Park	SD	MW	Badlands	48280.416561	19	600437.48598	25808173683.240643	7
42	Polygon	Lake Clark National Park	AK	AK	Lake Clark	48280.416561	20	1395727.758952	10833327062.440857	7
43	Polygon	Hawai'i Volcanoes National Park	HI	PW	Hawaii Volcanoes	48280.416561	23	527443.970244	20819692593.111046	7
44	Polygon	White Sands National Park	NM	IM	White Sands	48280.416561	32	420907.319523	13885112626.102142	7
45	Polygon	Kenai Fjords National Park	AK	AK	Kenai Fjords	48280.416561	29	912995.610223	51601746396.535126	6
46	Polygon	Guadalupe Mountains National Park	TX	IM	Guadalupe Mountains	48280.416561	38	400128.956447	12600452988.871197	6
47	Polygon	North Cascades National Park	WA	PW	North Cascades	48280.416561	43	644913.277042	29659291374.15033	6
48	Polygon	Mesa Verde National Park	CO	IM	Mesa Verde	48280.416561	50	385593.406708	11795080271.742445	6
49	Polygon	Voyageurs National Park	MN	MW	Voyageurs	48280.416561	61	526891.703813	20507243629.655586	6
50	Polygon	Theodore Roosevelt National Park	ND	MW	Theodore Roosevelt	48280.416561	11	628991.337239	23436798114.22346	5
51	Polygon	Dry Tortugas National Park	FL	SE	Dry Tortugas	48280.416561	39	678342.442368	18325603204.852394	5
52	Polygon	Katmai National Park	AK	AK	Katmai	48280.416561	5	1317372.01076	116993886852.97702	4
53	Polygon	Gates of the Arctic National Park	AK	AK	Gates of the Arctic	48280.416561	6	2728101.91206	349891846202.886108	4
54	Polygon	Great Basin National Park	NV	PW	Great Basin	48280.416561	14	400537.207839	12617704191.475109	4
55	Polygon	Haleakala National Park	HI	PW	Haleakala	48280.416561	15	368920.254878	10732987468.064644	3
56	Polygon	Carlsbad Caverns National Park	NM	IM	Carlsbad Caverns	48280.416561	25	394244.388723	1208111746.936226	3
57	Polygon	Capitol Reef National Park	UT	IM	Capitol Reef	48280.416561	49	611706.974844	24212470473.938797	3
58	Polygon	Lassen Volcanic National Park	CA	PW	Lassen Volcanic	48280.416561	54	483853.152599	14657646710.089674	3
59	Polygon	National Park of American Samoa	SA	PW	National Park of Ame...	48280.416561	62	693548.476262	18974794281.770828	3
60	Polygon	Isle Royale National Park	MI	MW	Isle Royale	48280.416561	7	983309.773	37869260504.487152	3
61	Polygon	Petrified Forest National Park	AZ	IM	Petrified Forest	48280.416561	36	491509.165731	18472793619.47757	1
62	Polygon	Kobuk Valley National Park	AK	AK	Kobuk Valley	48280.416561	45	1217563.676002	103440843367.625854	1

Click to add new row.

Figure 9. Result table from the Summarize Within query to return the number of airports within 30 miles of each national park, sorted in descending order.

Interestingly, the top visited parks were all located in different states, ranging from the state with the greatest number of parks (Yosemite NP in California) to a state with only one park (Great Smoky Mountains NP in Tennessee). Three of the five least visited parks were in Alaska, which was the state with the second highest number of parks (figure 10).

OBJECTID	Shape	name	region	postal	latitude	longitude	Shape_Length	Shape_Area	Summarized...	Count of Polygons
5	Polygon	California	West	CA	36.7496	-119.591	40.977735	41.632387	9566.899391	9
1	Polygon	Alaska	West	AK	65.3609	-151.604	327.463968	278.050553	49350.664698	8
45	Polygon	Utah	West	UT	39.5007	-111.544	19.966484	22.963116	1312.808576	5
6	Polygon	Colorado	West	CO	38.9998	-105.543	22.055089	28.105324	718.059771	4
4	Polygon	Arizona	West	AZ	34.3046	-111.935	22.666232	28.910255	2374.705906	3
10	Polygon	Florida	South	FL	28.1568	-81.6228	37.25635	13.593643	1571.669319	3
48	Polygon	Washington	West	WA	47.4865	-120.361	33.288066	20.70922	2550.627201	3
12	Polygon	Hawaii	West	HI	21.4919	-157.999	11.809638	1.404695	598.952714	2
27	Polygon	Montana	West	MT	46.9965	-110.044	32.932378	45.025942	1796.14627	2
33	Polygon	New Mexico	West	NM	34.5002	-106.024	23.750316	30.914287	304.734633	2
34	Polygon	Nevada	West	NV	39.4299	-117.02	23.437241	30.008102	294.413472	2
42	Polygon	South Dakota	Midwest	SD	44.4711	-100.255	22.219106	22.440878	432.285451	2
44	Polygon	Texas	South	TX	31.131	-98.7607	53.869039	65.144192	1338.51609	2
51	Polygon	Wyoming	West	WY	42.9999	-107.552	22.04249	28.087948	3624.120306	2
3	Polygon	Arkansas	South	AR	34.7563	-92.1428	16.486215	13.564716	8.526653	1
14	Polygon	Idaho	West	ID	43.7825	-114.133	26.521529	24.407742	59.327534	1
15	Polygon	Illinois	Midwest	IL	39.946	-89.1991	19.125184	15.867247	0.303793	1
16	Polygon	Indiana	Midwest	IN	39.8874	-86.1396	14.489712	9.950381	24.886213	1
18	Polygon	Kentucky	South	KY	37.3994	-85.5729	19.2995	10.612554	80.773481	1
22	Polygon	Maine	Northeast	ME	45.148	-69.1973	17.328434	9.589464	36.765836	1
23	Polygon	Michigan	Midwest	MI	43.4343	-84.9479	27.344773	28.475954	859.980587	1
24	Polygon	Minnesota	Midwest	MN	46.0592	-93.364	28.047514	26.275092	293.518027	1
28	Polygon	North Carolina	South	NC	35.6152	-78.866	31.563687	12.783487	441.456424	1
29	Polygon	North Dakota	Midwest	ND	47.4675	-100.302	20.532868	21.715699	110.095816	1
36	Polygon	Ohio	Midwest	OH	40.0924	-82.6719	15.148464	12.338831	51.12583	1
38	Polygon	Oregon	West	OR	43.8333	-120.386	24.031196	28.221693	285.238516	1
41	Polygon	South Carolina	South	SC	33.8578	-80.6471	13.866896	7.793663	41.262479	1
43	Polygon	Tennessee	South	TN	35.7514	-86.3415	19.738673	10.88135	367.997379	1
46	Polygon	Virginia	South	VA	37.7403	-78.2431	28.236786	10.48191	309.218335	1
2	Polygon	Alabama	South	AL	32.8551	-86.7184	17.256145	12.908675	0	0
7	Polygon	Connecticut	Northeast	CT	41.6486	-72.7594	5.55938	1.36713	0	0
8	Polygon	District of Columbia	South	DC	38.8922	-77.0113	0.584081	0.014856	0	0
9	Polygon	Delaware	South	DE	38.8657	-75.4112	4.134342	0.550551	0	0
11	Polygon	Georgia	South	GA	32.8547	-83.4078	17.688986	14.655679	0	0
13	Polygon	Iowa	Midwest	IA	42.0423	-93.3891	17.742136	15.730465	0	0
17	Polygon	Kansas	Midwest	KS	38.5	-98.3309	20.716587	21.887584	0	0
19	Polygon	Louisiana	South	LA	30.5274	-91.9991	25.008996	11.306508	0	0
20	Polygon	Massachusetts	Northeast	MA	42.3739	-71.9993	12.40937	2.317208	0	0
21	Polygon	Maryland	South	MD	39.3874	-77.0454	20.475501	2.615287	0	0
25	Polygon	Missouri	Midwest	MO	38.5487	-92.446	21.67814	18.720165	0	0
26	Polygon	Mississippi	South	MS	32.8657	-89.7189	16.35194	11.916485	0	0
30	Polygon	Nebraska	Midwest	NE	41.5002	-99.6855	22.381674	21.617865	0	0
31	Polygon	New Hampshire	Northeast	NH	43.5993	-71.6301	7.509127	2.701478	0	0
32	Polygon	New Jersey	Northeast	NJ	40.0449	-74.4653	8.5207	2.074756	0	0
35	Polygon	New York	Northeast	NY	43.1988	-75.3242	26.605729	15.125125	0	0
37	Polygon	Oklahoma	South	OK	35.452	-97.1309	23.851449	17.961207	0	0
39	Polygon	Pennsylvania	Northeast	PA	40.8601	-77.6094	16.976627	12.751283	0	0
40	Polygon	Rhode Island	Northeast	RI	41.6242	-71.5082	3.269421	0.281846	0	0
47	Polygon	Vermont	Northeast	VT	44.0886	-72.7317	7.997755	2.761973	0	0
49	Polygon	Wisconsin	Midwest	WI	44.3709	-89.5831	21.297769	19.212033	0	0
50	Polygon	West Virginia	South	WV	38.6422	-80.7128	15.771397	6.477875	0	0

Figure 10. Result table from the Summarize Within query to return the number of national parks within each state, sorted in descending order.

Of the most and least visited parks, only Grand Canyon NP had railroads within its park boundaries (figure 11). Only ten parks in total had railroads.

Rail Counts in National Parks		
Field:	Add	Calculate
Selection:	Select By Attributes	
UNIT_NAME	Count of Lines	
1	Indiana Dunes National Park	23
2	Cuyahoga Valley National Park	13
3	Petrified Forest National Park	8
4	Grand Canyon National Park	6
5	Glacier National Park	5
6	Gateway Arch National Park	4
7	Mount Rainier National Park	3
8	Congaree National Park	1
9	Denali National Park	1
10	Shenandoah National Park	1

Figure 11. Result table from the Summarize Within and Make Query Table queries to return the number of railroads within each national park boundary, sorted in descending order.

In terms of roads, four of the most visited parks were in the top 10 for greatest number of roads. Yellowstone topped the charts with 57 roads totaling almost 470 miles in length. Great Smoky Mountains NP followed in 2nd with 56 roads, Yosemite in 4th with 33 roads, and Rocky Mountain NP in 10th with 18 roads. Four of the five least visited parks lacked roads. American Samoa did have 2 roads with a total of 3.5 miles, placing it 39th overall (figure 12).

Roads in National Parks			
Field:	Add	Calculate	
Selection:	Select By Attributes	Zoom To	SW
UNIT_NAME	Count of Lines	Summarized Length in MILES	
1	Yellowstone National Park	468.727874	
2	Great Smoky Mountains National Park	95.758429	
3	Acadia National Park	27.855456	
4	Yosemite National Park	198.696325	
5	Shenandoah National Park	27.760285	
6	Indiana Dunes National Park	27.342677	
7	Redwood National Park	68.312816	
8	Cuyahoga Valley National Park	9.004832	
9	Lassen Volcanic National Park	59.987117	
10	Rocky Mountain National Park	115.913932	
11	Virgin Islands National Park	39.380974	
12	Mount Rainier National Park	41.128873	
13	Death Valley National Park	231.074696	32
14	Olympic National Park	66.568501	33
15	Kings Canyon National Park	21.385599	34
16	Haleakala National Park	38.313774	35
17	Sequoia National Park	65.333486	36
18	Hawai'i Volcanoes National Park	34.784152	37
19	Grand Canyon National Park	0.526739	38
20	Mammoth Cave National Park	11.130415	39
21	Grand Teton National Park	164.936793	40
22	Theodore Roosevelt National Park	9.27129	41
23	Badlands National Park	35.666469	42
24	Zion National Park	22.515244	43
25	Hot Springs National Park	5.340067	44
26	Petrified Forest National Park	8.699532	45
27	Wind Cave National Park	20.085093	46
28	Guadalupe Mountains National Park	7.973659	
29	Pinnacles National Park	7.869381	
30	Mesa Verde National Park	2.390292	
31	Everglades National Park	7.908161	
32	Crater Lake National Park	3	33.605484
33	Great Basin National Park	2	1.434378
34	Carlsbad Caverns National Park	2	13.783111
35	Gateway Arch National Park	2	1.281649
36	White Sands National Park	2	0.544345
37	Bryce Canyon National Park	2	3.775612
38	Voyageurs National Park	2	1.125363
39	National Park of American Samoa	2	3.544158
40	Congaree National Park	1	2.247241
41	Black Canyon of the Gunnison National Park	1	0.703475
42	Denali National Park	1	6.732271
43	Big Bend National Park	1	0.004495
44	Glacier National Park	1	3.519192
45	Arches National Park	1	0.370127
46	Capitol Reef National Park	1	14.545609

Figure 12. Result table from the Summarize Within and Make Query Table queries to return the number of roads within each national park boundary, sorted in descending order.

Based on these results, the factors that had the greatest correlation with visitation were airports and roads. The top visited parks were all near the top for number of airports within 30 miles and number of roads within the park

boundaries, while the least visited were all near the bottom of each list. Further analysis could be conducted to explore this correlation in greater depth. One query could be to only return airports and roads of a certain type (i.e., international airports or highways respectively). Exploring types of airports and roads could help provide insight into whether certain types of airports or roads trend toward greater or less visitation.

Further, traffic counts at the parks could be explored to examine which roads at each park saw the greatest traffic counts and determine which roads and entrances are more heavily trafficked than others. For example, a simple query we conducted for one traffic counter in Acadia NP showed that Sand Beach saw 83,880 vehicles in July 2021 alone (figure 13). Further queries could look at other months of 2021, sums for years, and compare with other traffic counters in Acadia NP. The same analysis can be conducted at other parks as well.

Park	Year	Month	Traffic_Counter	Traffic_Count
Acadia National Park	2021	7	TRAFFIC COUNT AT SAND BEACH	83880

Figure 13. Result table from the Make Query Table query to return the traffic counts for the Sand Beach traffic counter in Acadia NP for July 2021.

The fact that only two of the 10 parks examined had nearby cities and only one had railroads made it harder to see correlations between visitation and those factors. Expanding the park buffer to a greater distance might yield more data for cities. Additionally, further queries could look at lodging options within the parks. A lack of nearby cities with lots of lodging options in the parks with the greatest visitation could indicate that those parks are more likely to be visited by distant travelers. A lack of nearby cities and lodging options for the least visited parks could indicate that the lack of places to stay hinders visitation. Since only 10 parks in total had railroads that were within their boundaries, we determined that railroads were not as important of a factor contributing to park visitation for most U.S. national parks.

Because three of the five least visited parks were in the state with the second highest number of parks (Alaska) and the most visited park in a state with only one national park (Tennessee), we determined that the number of parks in a state had less of an influence on park visitation than overall location of that state (as Alaska is more remote and Tennessee closer to large population centers). Adding additional data to our geodatabase relating to location could provide greater insight than simply looking at the number of parks within a state alone.

These initial queries were promising for pointing out additional factors correlating with visitation to national parks. Further exploration through additional queries on the national parks geodatabase will help further understand possible factors correlating with increased or decreased visitation to national parks. The results will help implement measures to mitigate potential impacts to these U.S. treasures.

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