Access to Green Spaces in Urban Areas: A Comparative Study of 20 US Cities Using the Protected Area Database - US (PAD-US)

GEOG574
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Introduction

Background

Access to greenspaces is increasingly recognized as an important contributor to physical, mental, and social health. [1, 2, 3] Greenspaces include components of the built environment (e.g. public parks, greenways, gardens, forests, and private yards) and natural areas. [1] These areas promote physical health both directly (through encouraging active lifestyles and providing access to exercise) and indirectly (by improving air quality, moderating temperatures, and even mitigating the effects of severe weather). [1] They also benefit mental health by enhancing cognitive functioning, reducing stress, and increasing measures of well-being and happiness. [1] Access to greenspaces also enhances social health and community building--especially within historically marginalized communities [4]--by providing places for people to gather and interact and reducing other population health risk factors such as crime. Greenspaces are associated with reduced levels of health care spending. [5]

However, access to greenspaces is not evenly distributed across communities. Studies show that, for instance, low-income people in urban regions tend to live farther from larger, higher-quality parks than those who are economically advantaged. [6] Such people often have more limited access to personal vehicles and require public transit for their daily activities; yet they often live further away from regular public transit. [7] A number of studies [7, 8, 9] have begun to assess the impact of transit access on access to greenspaces; our study is intended to add additional analysis to those efforts.

In doing so, we join a number of organizations and efforts that have worked to understand the socioeconomic dynamics at play in regard to park access and who are advocating for increased access through transit and other means. The Wilderness Society's Urban to Wild program "seeks to ensure equitable access to parks and public lands" [10]. Nature for All is a community group that works to "ensure that everyone in the Los Angeles area has equitable access to the wide range of benefits which nature provides" [11]. In 2021, Congressman Jimmy Gomez (CA-34) and Senator Cory Booker (D-NJ) reintroduced a bill in the House and Senate called the Transit to Trails Act "that promotes equitable access to parks, green spaces, and public lands and waters." [12]

Objectives

This database is designed to explore the differences in availability of public transportation between Urban Areas with access to many public protected areas (PPAs) and those with access to few and those Urban Areas' demographic patterns. To do this, the following research questions were answered:

- Which cities intersect the most PPAs, and which intersect the least?
- What is the PPA per Capita for a selected Urban Area?
- How many PPAs are accessible by public transit for a selected Urban Area?
- What percent of PPAs for a selected Urban Area are accessible by public transit?
- Do population diversity and median income predict ease of access to PPAs?

Model design

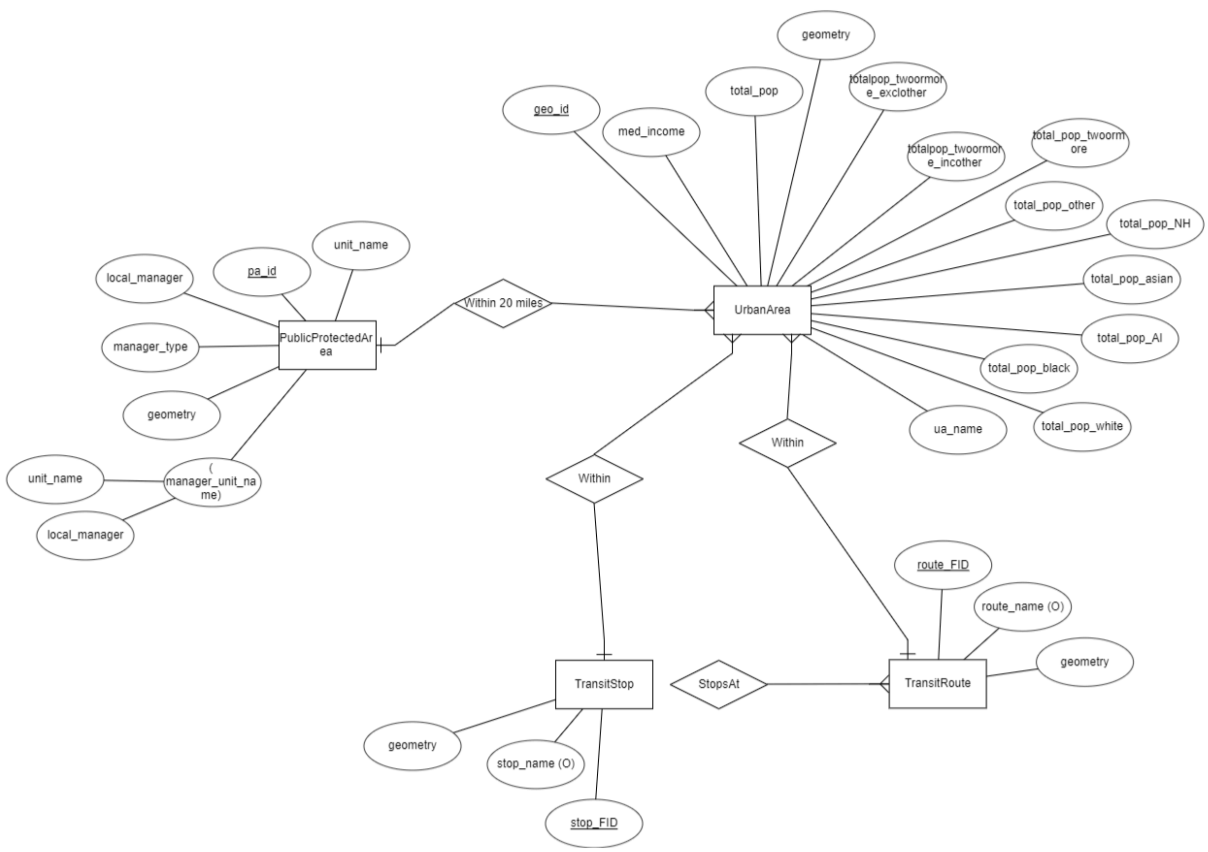

Figure 1. *Entity Relationship model created using ERDPlus*

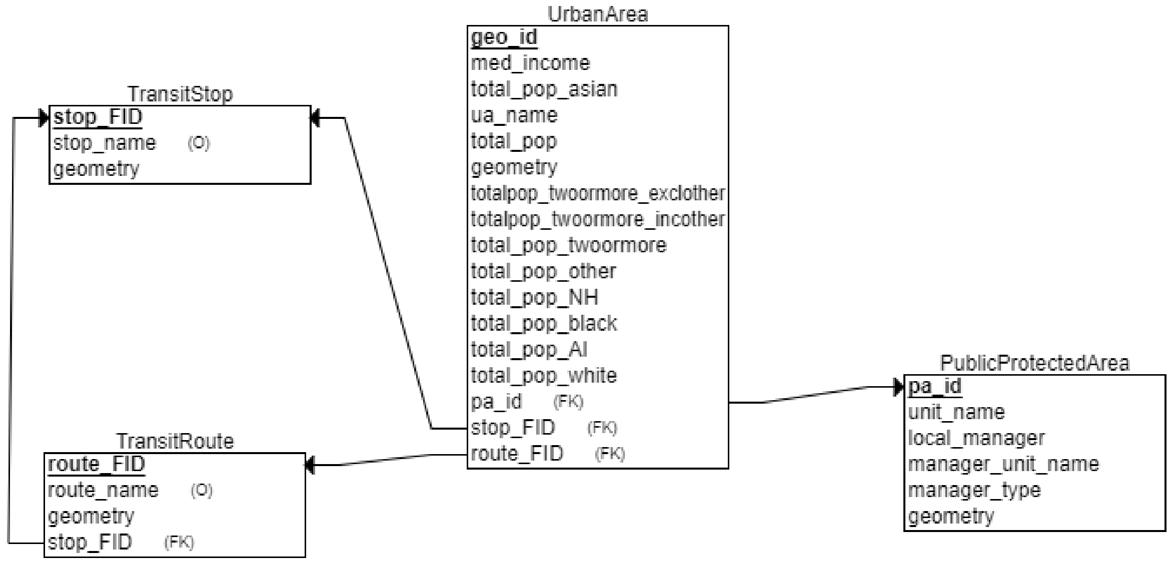

Figure 2*. Relational model created using ERDPlus*

We created a conceptual model (Figure 1) and logical model (Figure 2) using ERDPlus. We modeled four entity types: UrbanArea, PublicProtectedArea, TransitRoute, and TransitStop. The most complex entity type is UrbanArea, which has 16 attributes and 3 foreign keys, described in Table 1.The attributes of PublicProtectedArea are described in Table 2. This entity type includes one composite attribute, manager_unit_name; the unit_name alone was not unique across PPAs (e.g. there are a number of "Vietnam War Memorials") but a combination of managing organization and unit name was unique. Lastly, the attributes of TransitStop and TransitRoute are explained in Tables 3 and 4, respectively. FID is the primary key in TransitStop and TransitRoute as the dataset does not have a unique attribute that could serve as the primary key.

Table 1. *UrbanArea Attribute Descriptions*

Field Name	Field Type	Field Length	Description
geo_id	INT	-	Unique ID for each record
ua_name	VARCHAR	100	Urban Area name
total_pop_white	INT	-	Total population White alone
total_pop_black	INT	-	Total population Black or African

			American alone
total_pop_ai	INT	-	Total population American Indian and Alaska Native alone
total_pop_asian	INT	-	Total population Asian alone
total_pop_nh	INT	-	Total population Native Hawaiian and Other Pacific Islander alone
total_pop_pther	INT	-	Total population Some other race alone
total_pop_twoormore	INT	-	Total population Two or more races
totalpop_twoormore_incother	INT	-	Total population Two races including Some other race
totalpop_twoormore_exclother	INT	-	Total population Two races excluding Some other race, and three or more races
total_pop	INT	-	Total Population
med_income	INT	-	2021 Median Household Income for 4 person households
geometry	Geometry	-	Polygon spatial reference data provided by ArcGIS

Table 2. *PublicProtectedArea Attribute Descriptions*

Field Name	Field Type	Field Length	Description
pa_id	INT	-	Unique ID generated for each record
unit_name	VARCHAR	100	Common name of protected area
local_manager	VARCHAR	75	Governmental or other entity that manages protected area
manager_type	VARCHAR	50	General land manager description (e.g. Federal, Tribal, State, Private)
visit_manager_unit_name	VARCHAR	100	Unique identifier incorporating unit name
geometry	Geometry	-	Polygon spatial reference data provided by ArcGIS

Table 3. *TransitStop Attribute Descriptions*

Field Name	Field Type	Field Length	Description
FID	INT	-	Unique identifier assigned by ArcGIS

			Pro
stop_name	VARCHAR	75	Name of the transit stop
geometry	Geometry	-	Point spatial reference data provided by ArcGIS

Table 4. *TransitRoute Attribute Descriptions*

Field Name	**Field Type**	**Field Length**	**Description**
route_FID	INT	-	Unique identifier assigned by ArcGIS Pro
route_name	VARCHAR	75	Name of the route
geometry	Geometry	-	Polyline spatial reference data provided by ArcGIS

Database implementation

Datasets

We utilized four different datasets from a range of governmental sources. 2020 Census data was used to generate UrbanArea. Urban Areas "represent densely developed territory, and encompass residential, commercial, and other non-residential urban land uses" [14]. From the Census Urban Area data, we selected Urban Areas with a population greater than or equal to 15,000. These Urban Areas include locations outside of the contiguous US (Puerto Rico, Hawaii, and Alaska). The UrbanArea dataset includes demographic data on race, income, employment, and transportation to work.

A modified version of the Protected Areas Database of the U.S. (PAD-US) was used to generate PublicProtectedArea. PAD-US is a national inventory of U.S. land and marine protected areas focused on preservation of biological diversity and other natural, recreation, and cultural uses. It includes public lands, parks, wilderness areas, wildlife refuges, reserves, conservation easements, and more. It is published by the U.S. Geological Survey in collaboration with Boise State University through coordination with many federal, state, and non-governmental organization data managers. For this project, we used the Protected Area Database US - Accessible Recreation (PAD-US-AR), a curated dataset of publicly accessible lands that are specifically managed for outdoor recreation in the continental United States only; the authors filtered out lands from PAD-US v2.1 that are not accessible or fit for public recreation in order to capture lands that people may have as a resource for recreation and activity. This dataset includes the name of the units, the managing organization, the type of organization, the location/geographic information, and more.

National Park visitation data was obtained from the National Park Service's Integrated Resource Management Applications (IRMA) Portal, specifically its STATS (Park Visitor Use Statistics) page, which provides information on historic, current, or forecast park visitor use. The Annual Visitation Report by Years: 2013 to 2023 dataset provided us information on the most recently completed year (2023) and ten-year averages for all National Park units that have those records.

The data for TransitRoute and TransitStop originate from the National Transit Map Routes and the National Transit Map Stops, both of which were produced by the US Department of Transportation Bureau of Transit Statistics. National Transit Map Stops includes the location of transit stops, areas where passengers board and disembark, as well as stations and station entrances/exits. We filtered the data to include just transit stops. Additionally, three stops were excluded, as they were erroneously located outside of the US.

Implementation

All of our datasets had shapefiles available, which we first imported to ArcGIS Pro. We used ArcGIS Pro to clean the data and join tables. Next, we utilized a combination of ArcGIS Pro and PostGIS to manipulate the data. Lastly, we produced visualizations in ArcGIS Pro and Microsoft Excel.

Data Manipulation and Results

Number of Public Protected Areas per Urban Area

First, we focused on UrbanArea and PublicProtectedArea to compile a list of Urban Areas with access to many protected areas and those with access to few. Below are the queries we used:

- 10 Urban Areas that intersect the most PPAs (Table 6)

```
SELECT ua.ua_name, COUNT (*) as PPA_Count
FROM urbanarea ua, publicprotectedarea ppa
WHERE ua.geom && ppa.geom
```

```
AND ST_Intersects(ua.geom, ppa.geom)
GROUP BY ua_name
ORDER BY PPA_Count DESC;
```

- 10 Urban Areas that intersect the fewest PPAs (Table 7) *excludes Urban Areas w/ 0 PPAs

```
SELECT ua.ua_name, COUNT (*) as PPA_Count
FROM urbanarea ua, publicprotectedarea ppa
WHERE ua.geom && ppa.geom
AND ST_Intersects(ua.geom, ppa.geom)
GROUP BY ua_name
ORDER BY PPA_Count ASC;
```

With these cities selected, we calculated the PPA Acreage per Thousand Population (Tables 5 and 6) using UrbanArea's attribute table in ArcGIS Pro to view population and acreage of PPAs that intersect the Urban Area.

Table 5. *Urban Areas Intersecting the Most Public Protected Areas*

Urban Area (UA)	Number of PPAs Intersecting UA	Acreage of PPAs Intersecting UA	Population of UA	PPA Acreage per Thousand Population
New York--Newark, NY--NJ--CT	9,876	261,145	19,441,575	13.4
Boston, MA--NH--RI	7,332	142,890	4,507,488	31.7
Chicago, IL--IN	6,705	221,725	8,728,576	25.4
Portland, OR--WA	4,668	59,923	2,076,078	28.9
Denver--Aurora, CO	3,510	85,448	2,687,114	31.8
Philadelphia, PA--NJ--DE--MD	3,349	81,292	5,655,035	14.4
Los Angeles--Long Beach--Anaheim, CA	3,314	93,633	12,455,090	7.5
Minneapolis--St. Paul, MN--WI	2,947	69,478	2,899,457	24.0
Seattle, WA	2,934	66,403	3,535,223	18.8
Hartford, CT	2,503	36,309	929,730	39.1

Table 6. *Urban Areas Intersecting the Fewest Public Protected Areas*

Urban Area (UA)	Number of Public Protected Areas (PPAs) Intersecting UA	Acreage of PPAs Intersecting UA	Population of UA	PPA Acreage per Thousand Population
Lake Conroe Westshore, TX	1	17	22,958	0.7
Berea, KY	1	55	17,681	3.1
Orosi, CA	1	11	15,784	0.7
Gun Barrel City, TX	2	10	16,218	0.6
Breaux Bridge, LA	2	144	16,450	8.8
Marion Oaks, FL	2	17	19,691	0.9
Springfield, TN	2	38	19,441	2.0
Archer Lodge--Clayton, NC	2	60	21,097	2.8
Buckeye, AZ	2	24	26,135	0.9
Discovery Bay, CA	3	23	16,411	1.4

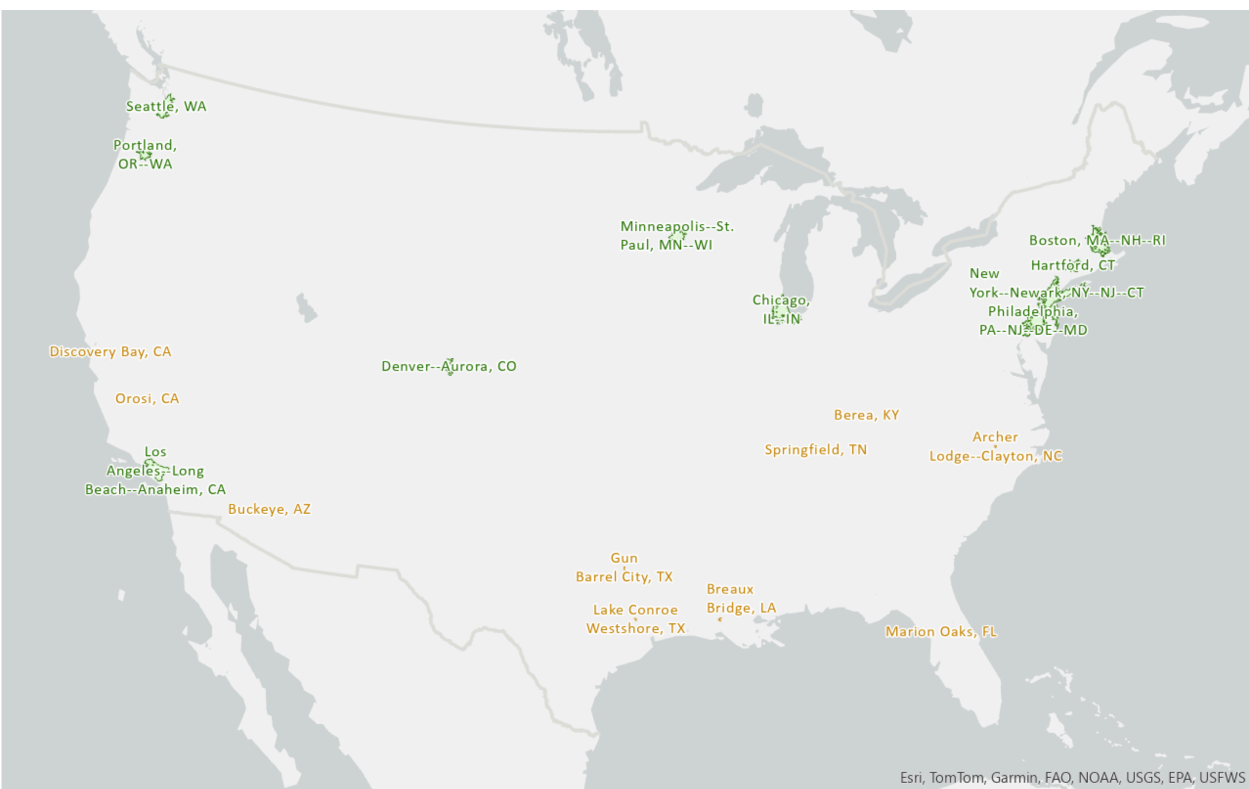

***Figure 3**. Locations of the ten Urban Areas (pop. > 15000) that intersect the most PPAs (green) and the ten that intersect the fewest (orange).*

Access to Public Protected Areas via Public Transportation

Next, we brought in TransitStop and TransitRoute to explore our second objective: How does the availability of public transportation affect access to protected areas? What is the impact of car ownership on the availability of public transportation? First, we created half mile buffers (804 m = 0.5 mi) around transit stops using this query:

```
ALTER TABLE transitstop
ADD buffer_geom geometry
UPDATE transitstop
SET buffer_geom = ST_Buffer(geom, 804)
COMMIT;
```

We chose this distance because it seems to be a widely-accepted standard for proximity of greenspaces to a given point, translating to roughly a 10-minute walk [6,13]. With the cities from Table 5 and these buffer zones, we used ArcGIS Pro to analyze the number and percent of PPAs that intersect TransitStop as shown in Table 7. Appendix A contains full visualizations of the 20 Urban Areas and their PPAs and transportation systems. The Urban Areas in Table 6 did not have transit systems.

Table 7. *Urban Areas Intersecting the Most Public Protected Areas Accessible by Public Transit*

Urban Area (UA)	**Number of PPAs Intersecting UA**	**Number of PPAs Accessible by Public Transit**	**Percent of PPAs Accessible by Public Transit**
New York--Newark, NY--NJ--CT	9,876	5,277	53.4
Boston, MA--NH--RI	7,332	3,638	49.6
Chicago, IL--IN	6,705	3,445	51.4
Portland, OR--WA	4,668	3,436	73.6
Denver--Aurora, CO	3,510	2,378	67.7
Philadelphia, PA--NJ--DE--MD	3,349	2,316	69.2
Los Angeles--Long Beach--Anaheim, CA	3,314	2,659	80.2
Minneapolis--St. Paul, MN--WI	2,947	1,359	46.1
Seattle, WA	2,934	2,050	69.6
Hartford, CT	2,503	1,061	42.4

Discussion

A comparison of diversity of populations can be calculated through many methods; here we use the Simpson's Diversity Index (initially intended to describe biodiversity but now increasingly used for social categories of diversity) to compare seven census-derived racial categories for each of our 20 Urban Areas.

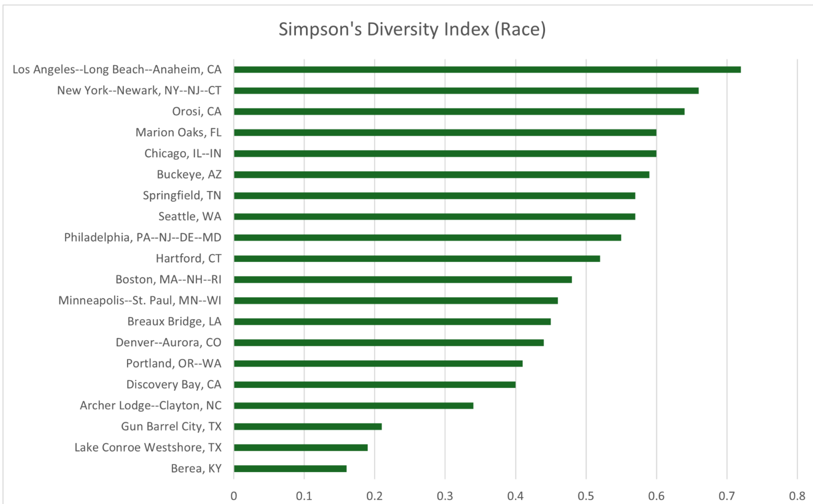

***Figure 4**. Simpson's Diversity Index for all twenty Urban Areas in our study based on seven census-derived racial categories.*

We found that population diversity is a relatively good predictor of access to PPAs, however, this is likely due to the fact that the most diverse Urban Areas also have large populations, and thus more resources to build PPAs and public transportation. Of the Urban Areas that have the most PPA acres per thousand people, nine are large Urban Areas and have a population over one million; the one less-populous Urban Area on that list is Breaux Bridge, LA. Los Angeles has the highest percent of PPAs accessible by public transportation at 80.2% and a total of 7.5 PPA acres/thousand people. Though Breaux Bridge, LA has only 2 PPAs, they make up 144 acres, giving Breaux Bridge a PPA acreage per thousand people of 8.8, virtually the same PPA acres per thousand people as LA. In addition to having a transit system that most effectively reaches PPAs, Los Angeles also scores the highest among the 20 Urban Areas on the Simpson's Diversity Index. Berea, KY, scores the lowest, only has one 55-acre PPA, lacks a transit system, and has just 3.1 PPA acres per thousand population. This may reflect a greater tradition of parks in large urban settings but further research might reveal other patterns at play.

Median household income is a slightly less consistent indicator of access to PPAs: Discovery Bay, CA, and Lake Conroe Westshore, TX, rank in the top five for median income but have no transit to PPAs and offer only a 1.4 and 0.7 PPA acres per thousand population respectively.

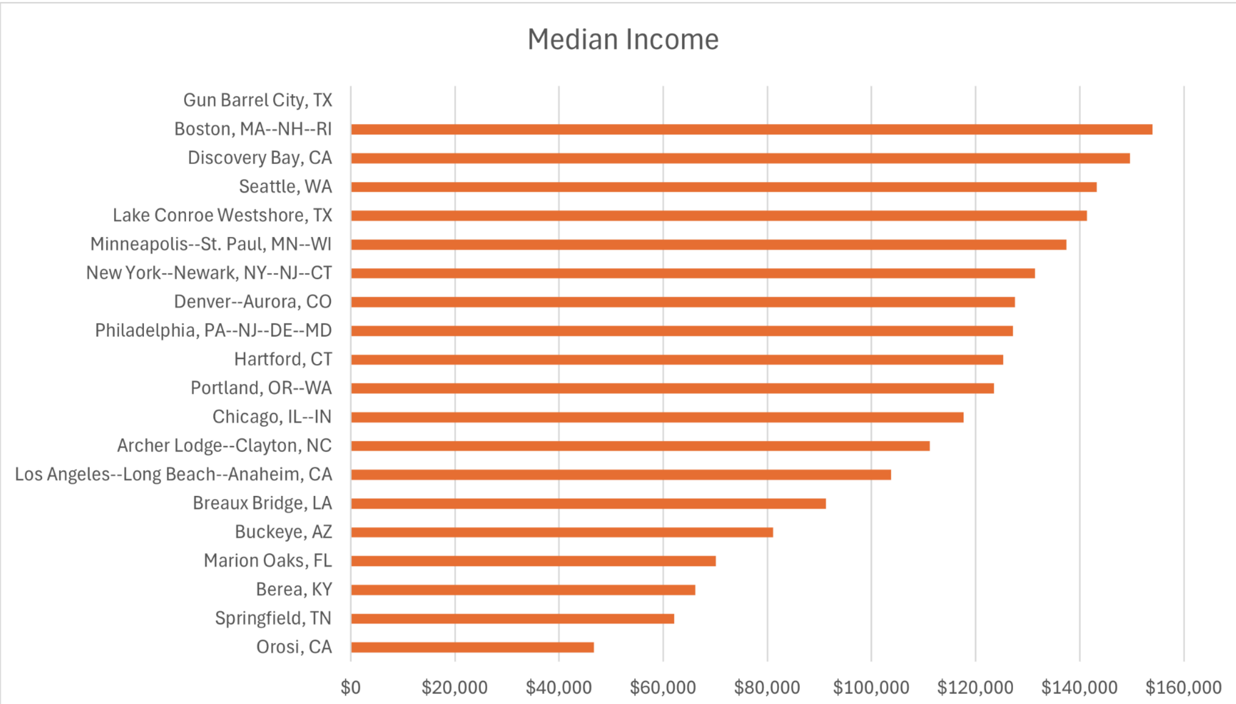

Figure 5. *Median Income for nineteen Urban Areas in our study based on census data (info unavailable for Gun Barrel City, TX).*

Conclusion

As shown above, population diversity (as revealed by Simpson's Diversity Index) turned out to be a relatively good predictor of access to PPAs. This was not something we had expected at the start of our project based on existing research. That research, however, is often more granular than ours, looking at diversity measures at smaller levels such as census blocks in the environs of specific greenspaces. The measures in this study were of entire Urban Areas, and though we cannot point to clear causation, it seems likely that there is a correlation between population size, diversity, and those higher numbers of public protected areas. Median household income was as noted a less consistent indicator of access to PPAs; again, the fact that it was a single value for an entire Urban Area blunted its effectiveness when compared to a more granular analysis.

These findings and our work with this data point to a number of other potential areas of further research. We had originally intended to explore visitator statistics for PPAs, but the data were not readily available to give a meaningful examination of visitation patterns and equity. We did analyze National Park units and found that the numbers of PPAs managed by the National Park Service and the number of our selected Urban Areas with which they intersected were too low to draw out meaningful patterns. To be truly useful for such an analysis, visitation stats would need to be gathered for all PPA types--local, state, and federal. With those statistics in hand, further comparison of transit access and visitation might tease out further patterns of interest.

Another avenue of research would be to expand the sample size. Twenty Urban Areas–ten with a high concentration of PPAs and ten with low–provided interesting comparisons, but a larger collection of Urban Areas would yield a more detailed analysis. Other attributes of PPAs and Urban Areas such as cost of entry, age demographics, additional modes of transport, and analysis of exurban PPAs would also enrich studies such as these.

References

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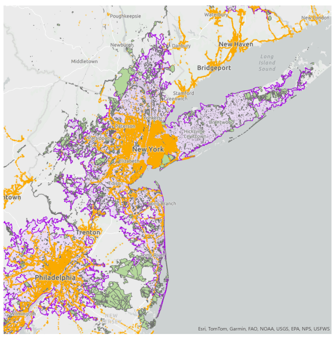
Appendix A

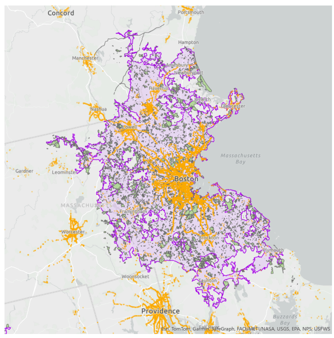
The Twenty Urban Areas

In order of number of Public Protected Areas Intersecting Urban Area

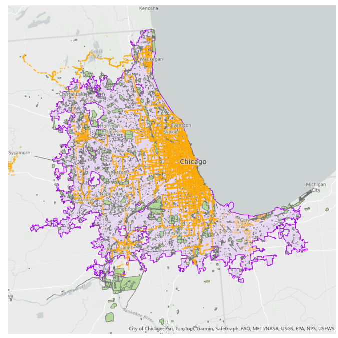
Urban Area   Public Protected Area   Transit Stops



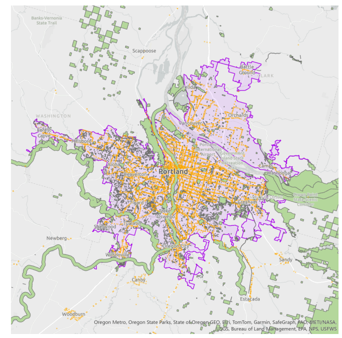
New York--Newark, NY--NJ--CT
9,876 PPAs
1:1,466,000



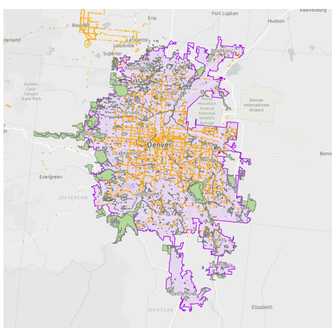
Boston, MA--NH--RI
7,332 PPAs
1:884,000



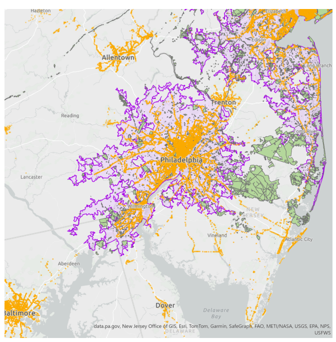
Chicago, IL--IN
6,705 PPAs
1:900,000



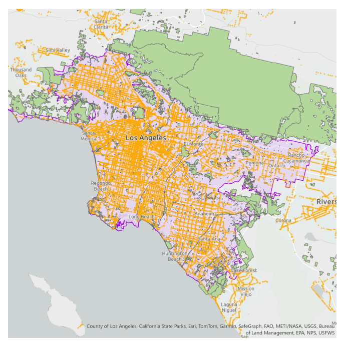
Portland, OR--WA
4,668 PPAs
1:445,000



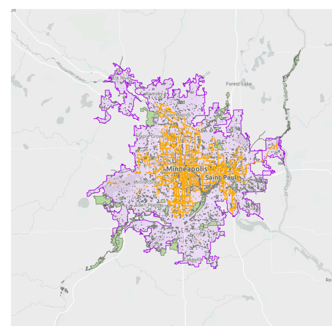
Denver--Aurora, CO
3,510 PPAs
1:500,000



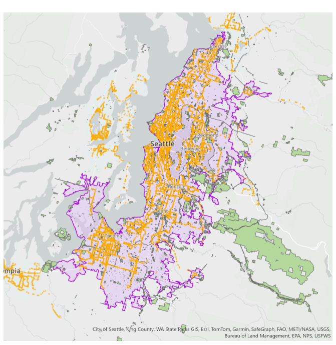
Philadelphia, PA--NJ--DE--MD
3,349 PPAs
1:1,150,000



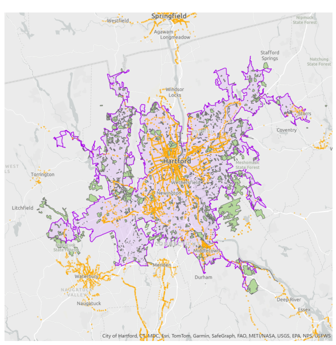
Los Angeles--Long Beach--Anaheim, CA
3,314 PPAs
1:725,000



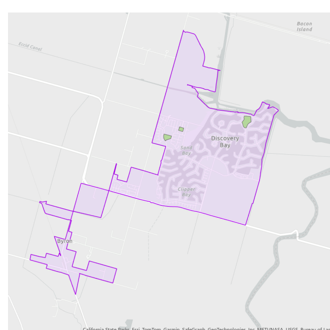
Minneapolis--St. Paul, MN--WI
2,947 PPAs
1:707:000



Seattle, WA
2,934 PPAs
1:681,000

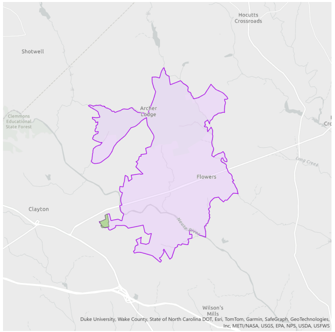


Hartford, CT
2,503 PPAs
1:472,000

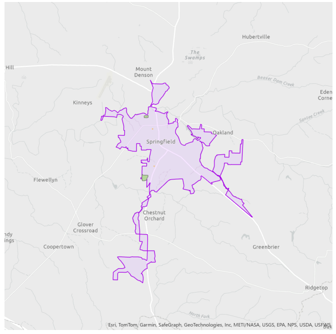


Discovery Bay, CA
3 PPAs
1:50,000

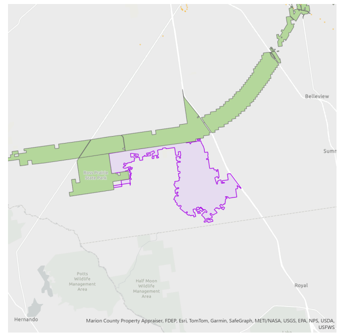
Buckeye, AZ
2 PPAs
1:82,000



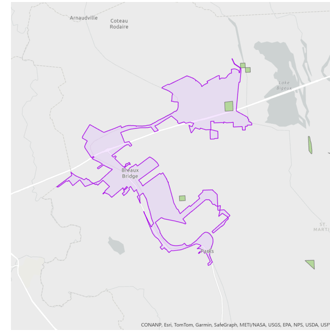
Archer Lodge--Clayton, NC
2 PPAs
1:108,000



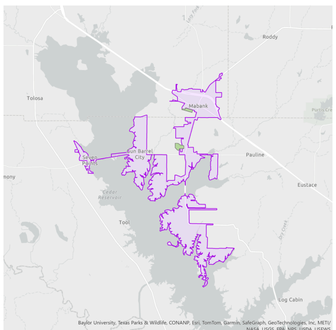
Springfield, TN
2 PPAs
1:126,000



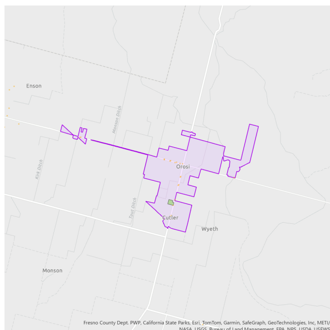
Marion Oaks, FL
2 PPAs
1:178,000



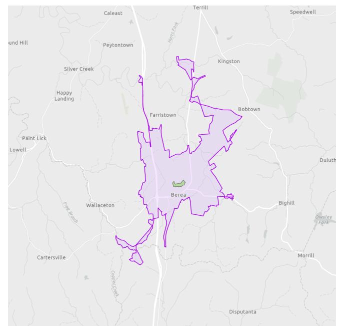
Breaux Bridge, LA
2 PPAs
1:153,000



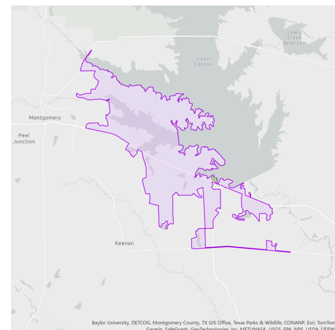
Gun Barrel City, TX
2 PPAs
1:143:000



Orosi, CA
1 PPA
1:78,000



Berea, KY
1 PPA
1:130,000



Lake Conroe Westshore, TX
1 PPA
1:111,000