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FINAL REPORT:  
**Investigating the Relationship  
Between Public Libraries  
and Community Indicators  
in Pennsylvania**

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# Abstract

Public libraries in the U.S. provide communities access to myriad resources and are generally favored by users (Horrigan, 2016). Yet research on public library access and individual and community outcomes is sorely lacking (Gilpin et al, 2021). Although the goal is to produce causal evidence of the impact of public libraries on library users specifically and communities with libraries broadly, first required is a general assessment of where public libraries are located and characteristics of the communities they serve. The present study explores this question of association between public library access and community characteristics and indicators. This study focuses on public libraries in the state of Pennsylvania. **The primary research questions addressed in this study are:**

1. How are libraries in Pennsylvania distributed in relation to community characteristics (e.g., population density, race, income)?
2. How do areas with libraries differ from areas without libraries in terms of educational attainment, poverty rates, and vacancies?
3. How is library expenditure per person related to community characteristics and indicators?

**An additional research question relevant to the Covid-19 pandemic was:**

4. How are libraries situated in relation to residents' access to broadband internet?

To answer these questions, library locations and expenditures were examined in relation to community characteristics and indicators measured at the Census tract level. Data analysis consisted of two aspects: a geospatial aspect and a descriptive and inferential statistics aspect. The geospatial aspect produced a series of maps displaying library locations and expenditures in relation to community characteristics and indicators (i.e., population density, race, income, educational attainment, poverty rates, vacancies, and broadband access). The geospatial maps provide a rich picture of the landscape of library locations and expenditure in relation to community indicators and can be used to inform library, school, and university practices and policies at the local and state level. Inferential statistics compared community indicators for tracts with and without libraries. Significant differences were found for household income, poverty rates, vacancies, and broadband access. Additionally, library expenditure per person was significantly associated with population density, household income, educational attainment, poverty rates, and broadband access. The correlational findings are offered with caution, however, as library branches were excluded from analysis due to missing data. Implications and recommendations for future studies are discussed.

# Investigating the Relationship Between Public Libraries and Community Indicators in Pennsylvania

In the United States, public libraries are dynamic institutions that provide communities access to myriad resources. In addition to their well-known role as provider of books and literacy resources, libraries also provide access to local and global information; access to computers, internet, and broadband services; educational programs for children, families, and community groups; spaces for organizational and community groups to meet; and more (Audunson, 2005; Scott, 2011; Zach, 2011). Public libraries also act as “cultural hubs” by allowing residents to access, share, and create various types of cultural resources regardless of personal circumstances (Summers & Buchanan, 2018). In this way, libraries are argued to be democratic equalizers, “open to all and providing access to information that helps people improve their individual, family, and community lives” (Scott, 2011, p. 191). Additionally, given that broadband internet access has been underscored as a social determinant of health during the Covid-19 pandemic, public libraries may be one avenue for providing broadband access during times of critical need and beyond (Benda et al., 2020).

Research on public perceptions of libraries and the services they provide is promising (Horrigan, 2016), yet research on the impact of library use or access on individual users and communities more broadly is lacking (Gilpin et al., 2021). Prior to conducting causal research, however, it is important to know how public libraries are situated in relation to community characteristics and indicators. Similarities and differences in communities served by public libraries can contextualize future studies that attempt to explain or predict differences in the causal impact of libraries. Further, understanding initial associations between library expenditure per person and community outcomes can inform hypotheses in future studies regarding causal links between expenditure and outcomes.

The present paper addresses the missing link between library access and community characteristics and indicators, as well as between library expenditure per person and community outcomes. Such a study is ecological in scope, meaning the unit of analysis is entire groups of people (i.e., communities) versus



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individuals (i.e., library users). A significant challenge for conducting ecological studies on the impact of libraries stems from how “access” to libraries is defined. For example, nearly 12.5 million (98%) of Pennsylvania residents fall within a public library service area and therefore technically have access to a library. However, these public library service areas vary in size, shape, economy, infrastructure, and myriad other factors that may influence if and how residents utilize the libraries within them. Further complicating the issue is that library service area boundaries do not align with other sources of ecological data (e.g., school district data, county data, Census tract data), making it difficult to compare library data with Census or other preexisting community data.

To overcome these challenges, the present study defines access as residents living in a Census tract with a library. Census tracts are small statistical subdivisions of a county that are intended to provide a stable set of geographic units for statistical analysis (United States Census Bureau, 2022). The number of residents per tract varies based on population density, but on average tracts have around 4,000 residents (United States Census Bureau, 2022). Although tract boundaries do not represent library access boundaries perfectly (i.e., people may use a library in an adjacent tract if their own tract does not have one), it is one clear way for defining access that aligns with existing Census data to allow for analysis. Additionally, Census tracts are intended to be relatively homogenous with regards to population representation and can be tracked over time, making them suitable for examining community characteristics and indicators in relation to library locations and expenditures in future studies as well (Sin, 2010).

The primary goals of the present study are to examine associations between communities’ access to libraries and community characteristics (e.g., population density, race, income) and indicators (e.g., educational attainment, poverty rates, vacancies), as well as examine associations between library expenditure per person and community outcomes. A secondary goal was to explore libraries’ positioning as a provider of broadband access during Covid-19 and beyond. To achieve these goals, we used data from the Pennsylvania Office of Commonwealth Libraries and from the U.S. Census American Community Surveys to conduct geospatial and statistical analyses. Geospatial analysis allows for the exploration of spatialized patterns in library access and community characteristics and indicators across the state, while statistical analysis allows for a more precise comparison of community characteristics and indicators between Census tracts with and without libraries. The following section briefly outlines background literature related to this study.

# Background of the Literature

In the United States, public libraries are popular institutions serving a wide range of residents. A 2016 Pew Report Survey found that just over half (53%) of Americans had interacted with a public library in the past year. This same survey showed that people used public libraries to borrow books, get help from librarians, attend classes or programs, attend group meetings, search online or apply for jobs, use high-tech devices or learn about technology (e.g., 3-D printers), and for leisure (Horrigan, 2016). Public libraries are also generally favored by residents, with 77% of surveyed Americans expressing that their local public library provides them with the resources they need and 66% saying that closing their local library would have a significant impact on their community (Horrigan, 2016). And while 69% of participants said their local library provided a safe space for people to spend time, 69% of Black residents and 68% of Hispanic residents said libraries should provide more comfortable spaces for work and reading, indicating there may be variability in how people of different races experience public libraries (Horrigan, 2016).

Public libraries in the U.S. have an extensive reach. According to the Institute of Museum and Library Services, in 2019 there were 9,057 public libraries across the United States with 16,607 central and branch library locations. Combined, these libraries had around 1.2 billion visits in 2019, with 124.7 million people attending one of the 5.9 million programs offered by public libraries. In Pennsylvania, there are a total of 33 library systems and 478 public libraries with 175 library branches. In 2019, public libraries in Pennsylvania had around 39.2 million visits, and 4.9 million people attending one of the 270,354 programs offered by libraries across the state. Across the U.S., nearly 97% of the population resides in a library service area (Institute of Museum and Library Sciences, 2021), while in Pennsylvania that number is closer to 98%. Thus, libraries are a broadly distributed and widely used public institution.

However, research on the impact of public libraries nationally, and in Pennsylvania in particular, is lacking. In one national study, Bhatt (2010) found an association between library use, reading, and television use such that library use by individuals was associated with a 27-minute increase in reading time per day and a 59-minute decrease in television watching. Library use by children was also associated with an increase in homework completion rates and decrease in misbehavior as recorded in school (Bhatt, 2010). Additionally, numerous studies have found that library users perceive their library experiences positively (Vakkari & Serola, 2012), including a 1998 study by McClure and Bertot examining Pennsylvania library users' perceptions of the benefits of their library use. However, very limited research exists associating library use with explicit indicators such as job attainment, increased academic scores, or increased time spent on hobbies or with community groups.

In addition to research on the impacts of public libraries on individual users is research on the impacts of public libraries on entire communities. Such studies are referred to as ecological studies because the unit of analysis is a group of people or population versus individuals. For example, a 2018 correlational study by Neto on public libraries in the Appalachian region found no association between the number of library program offerings and/or participation in programs and local labor market outcomes (e.g., unemployment rates and labor force participation). Note that this study did not examine associations between library users and their labor outcomes, but rather focused on the ecological level

Research on the impact of public libraries nationally, and in Pennsylvania in particular, is lacking.

of total number of library program offerings and participation and labor outcomes at the group level. Such ecological studies are important because they move beyond individual library users to examine the contextual effects of exposure or access to libraries on a population (Levin, 2003). They are also useful for large-scale comparisons (e.g., between districts or census tracts) that can result in concrete strategies for policymakers and practitioners (Levin, 2003). As another example, a quasi-experimental study by Gilpin et al. (2021) found that an increase in library capital investment was followed by an increase in children's check-outs and attendance in library programs, and an overall increase in total library visits of 21%. Additionally, Gilpin et al. (2021) showed how a \$1,000 or more per-student capital investment in public libraries led to an increase in reading test scores of 0.02 standard deviation. There was no change in housing prices in relation to changes in library capital investment (Gilpin et al., 2021). These findings, as the authors note, provide evidence for the importance of investing in public libraries but also serve to guide what are reasonable expectations of the benefits of libraries. Additional research on the impact of libraries on entire groups or communities, however, is extremely limited.

The primary purpose of the present study is to explore spatialized and statistical trends in library resource allocations in relation to community characteristics and indicators. The impact of libraries on library users, while an important topic for future research as well, is not covered in this study. The community characteristics assessed in this study are population density, percentage of Black residents, and household income. The reason for assessing libraries in relation to population density, percentage of Black residents, and household income is to determine if libraries really are “for all” – that is, are libraries evenly distributed across the state in relation to these community characteristics? If not, then the next question is, how can library services be more evenly distributed. If libraries are distributed evenly across the state, the next question is, do all residents benefit from libraries in the same way regardless of race or socioeconomic status?

The community indicators measured in this study include educational attainment (measured as percentage of residents with less than a high school degree), poverty rates, housing vacancies, and broadband access (percentage of residents without broadband in the home). The reason for educational attainment, specifically attainment of a high school degree, is because educational attainment has been associated with later life outcomes including better health and lower rates of premature death (Hahn et al., 2015; Hummer & Lariscy, 2011), better employment prospects (Levin et al., 2007), and higher income and wealth (Oreopoulos, 2007). Relatedly, poverty rates have been associated with health outcomes, educational attainment, and experienced well-being (Killingsworth, 2021). Housing vacancies have been found to be an important indicator of community physical and social well-being (Owens & Sampson, 2013). Finally, broadband internet access has recently been designated a social determinant of health due to its critical role in connecting residents to educational opportunities, income, housing, and more (Benda et al., 2020). By comparing rates of educational attainment, poverty, housing vacancies, and broadband internet access in tracts with and without libraries, we can begin

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By comparing rates of educational attainment, poverty, housing vacancies, and broadband internet access in tracts with and without libraries, we can begin to understand the impact of libraries on the residents nearest to them.

to understand the impact of libraries on the residents nearest to them. If educational attainment is higher and poverty and vacancy rates are lower in tracts with libraries, then the next question is, “Are libraries directly contributing to these outcomes?” If the reverse is true, then the next question is, “How can libraries best support the residents that are nearest to them in terms of educational attainment, generating income, and housing stability?” Likewise, if the rate of broadband internet access in homes is lower in communities with libraries, the next question is, how can libraries expand their broadband services to meet the needs of residents nearest to them?

In exploring community characteristics and indicators, the present study addresses four primary research questions:

1. How are libraries in Pennsylvania distributed in relation to community characteristics (e.g., population density, race, income)?
2. How do areas with libraries differ from areas without libraries in terms of educational attainment, poverty rates, and vacancies?
3. How is library expenditure per person related to community characteristics and indicators?
4. Given the vital role of internet access during the covid-19 pandemic, how are libraries in Pennsylvania situated in relation to residents’ access to broadband internet?

For each question, associations were identified between public library locations and community characteristics (i.e., population density, race, income) and indicators (i.e., educational attainment, poverty rates, vacancies, and broadband). Next, correlational analyses were conducted to determine if library expenditure was related to community outcomes in Census tracts that had a library. Finally, additional analyses were conducted to explore the positioning of public libraries as broadband access providers and determine the most at-risk populations in need of broadband access.

## Methods

The present study is an ecological study of public libraries in the state of Pennsylvania in relation to community characteristics, indicators, and outcomes measured at the Census tract level. In total, across the state of Pennsylvania there are 478 public libraries and 175 library branches spread across 3,213 tracts in 67 counties. Public libraries (main libraries and branches) and Census tracts were the focus of our analyses.

### Data

Data for this study came from two primary sources, the Office of Commonwealth Libraries (OCL) at the Pennsylvania Department of Education and the U.S. Census. Data for public libraries was provided by OCL for the 2019 year. This data included information on public library access, materials available, collection use, electronic access, programs, program attendance, revenue, and expenses for all libraries in the state of Pennsylvania.

Data for Census tracts came from the 2016-2020 American Community Surveys (ACS; 5-year estimates) conducted by the U.S. Census and retrieved using the Social Explorer tool ([www.socialexplorer.com](http://www.socialexplorer.com)). ACS data retrieved included data on population density (A00002), race (B02001), household income (A14001), educational attainment (A12001), poverty status in the past 12 months (A13005), vacancy status (A10047), and internet in the household (B28002).



## Data Analysis

**Geospatial Analysis.** Geospatial analysis is a way to represent and analyze geospatial data. Geospatial data is data that contains location information (e.g., latitude and longitude) about an object or event and often also includes attribute data for the object or event (IBM, 2022). In this case, the geospatial data includes both Pennsylvania library locations and the attribute data describing those libraries (e.g., expenditure, material circulation, etc.), as well as Census tract locations and attribute data (e.g., population density, educational attainment, etc.). The purpose of geospatial analysis is to “detect spatial patterns in data, to formulate hypotheses which are based on, or which are about, the geography of the data, and to assess spatial models” (Haining et al., 1996, p. 457). In other words, the way that library and/or Census tract data cluster together (or do not cluster together) across a specified area such as a state can add an important level of context to our understanding of how resources are distributed across the state and how this distribution may be impacting community indicators.

In the present study we used exploratory spatial data analysis (ESDA) to examine library and Census tract data. This analysis involved multiple steps. First, geospatial maps were created using QGIS, an open-source geographic information system (QGIS.org, 2002). The maps include spatial data on:

1. library expenditure per person,
2. population density,
3. percentage of Black residents
4. average household income,
5. educational attainment (percentage of residents with less than a high school degree),
6. percentage of resident below the poverty line,
7. residential characteristics (total number of vacant properties), and
8. broadband in the home.

Two statewide maps of population density and percentage of residents without broadband were also created with 10-mile buffers around libraries. These maps show all areas across the state that are not covered by a 10-mile radius around the libraries in relation to population density and residents without broadband. Finally, a cluster analysis was conducted for broadband in the home. A cluster analysis looks for areas across the state with significantly higher numbers (“hot spots”) or lower numbers (“cool spots”) of residents without broadband in the home. To conduct this analysis, we used GeoDa (<https://geodacenter.github.io>), an open-source software tool for analyzing spatial data. This test took place in sequential stages. First, a global (Moran’s I) test was conducted to determine if there was spatial autocorrelation (i.e., clustering) in the distribution of broadband access in the home. A global Moran’s I test returns a coefficient ranging from -1 to 1, with -1 indicating no spatial autocorrelation (i.e., no clustering) and 1 indicating total spatial autocorrelation (i.e., total clustering). If clustering is detected, a local spatial statistic is calculated. The local test would pinpoint where the clustering is on a map.

**Descriptive and Inferential Statistics.** The second aspect of data analysis utilized descriptive and inferential statistics to explore patterns in the spatial data. Descriptive statistics were conducted to describe the Census tracts in relation to the key variables under examination. Inferential statistics included two-sample *t*-tests to determine if there were differences in characteristic and indicator variables between tracts with libraries versus tracts without libraries. As necessary, two-sample Welch’s *t*-tests were conducted when unequal variances were present (Delacre et al., 2017). In addition, correlational analyses were conducted to determine if library expenditure per person was associated with community outcomes. While the correlational findings are presented, they are done so with caution because expenditure per person was not available at the branch level, which means that 105 tracts with only branch libraries (many of which were in Philadelphia and Pittsburgh) were excluded from this analysis. Thus, given Tobler’s First Law of Geography, which states that places near to each other tend to be more alike than those that are distant, it can be assumed that the correlational findings are biased to predominantly non-urban spaces (Longley et al., 2015).

## Results

Of the 3,218 Census tracts in Pennsylvania, 19% (n=601) have either a main library or a library branch or some combination of both. Of the 601 tracts with a library, 577 have one library and 24 have two libraries. Descriptive statistics for variables across Census tracts can be found in Table 1.

**TABLE 1. Descriptive Statistics for Census Tracts in Pennsylvania (N=3,218)**

	<i>n</i>	<i>M</i>	<i>SD</i>
Total population	3218	3974.99	1796.55
Population density (per sq. mile)	3217	5033.84	7731.169
Percentage of Black residents	3197	12.21	21.41
Average household income (in U.S. dollars)	3190	81976.41	38196.65
Educational attainment (percentage of residents over 25 with less than a high school degree)	3196	9.81	7.45
Poverty rates (percentage of residents below the poverty line)	3193	13.75	12.15
Vacancy (total number of vacant housing units)	3218	198.95	237.61
No broadband (Percentage of residents without broadband access in the home)	3190	19.15	9.46

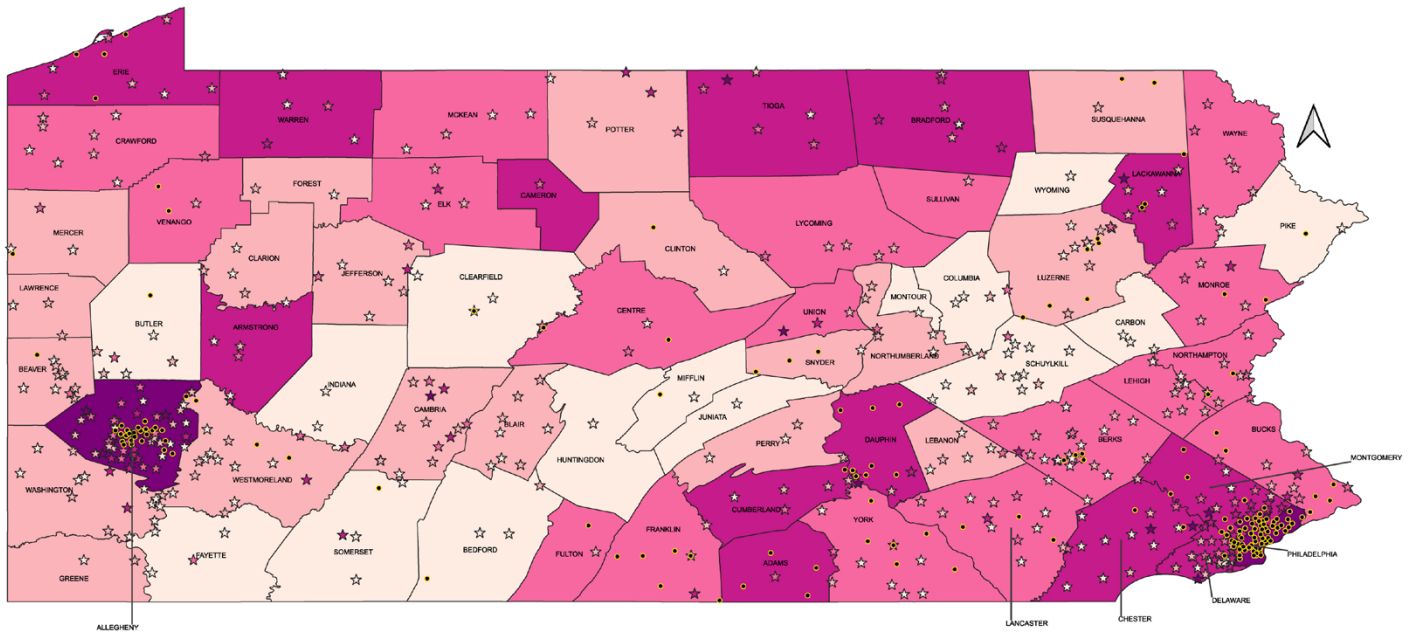
Results from the geospatial analysis produced eight sets of maps with 27 individual maps created in total. Each set of maps focuses on one key variable (e.g., population density, educational attainment, etc.) across the entire state and includes close-up maps of the greater Pittsburgh and Philadelphia areas. In the population density and broadband access map sets, additional maps depicting 10-mile radius buffers around library locations and/or cluster maps are included. In each map, it is useful to look at both library locations (main libraries are depicted as stars and library branches as circles) and library expenditure per person (for main libraries only, depicted by color). Below are key takeaways from each set of maps and accompanying inferential analyses. Table 2 displays inferential *t*-test statistics and Table 3 displays correlational statistics. For ease of interpretation, both types of analysis (geospatial and inferential) are presented together for each set of maps.

# Results by Variable

## Set 1: Expenditure Per Person

The mean expenditure per person (EPP) for all libraries across Pennsylvania was \$24.13 (SD=17.05). The range of EPPs was \$3.99 to \$105.00. This range is reflected in the variation of library colors across the state in the Set 1 maps. In some cases, there is wide variation in EPP within the same county (e.g., Jefferson County, Tioga County), but most counties appear to have rather homogenous EPPs (e.g., Lehigh County, Blair County).

### Library Expenditure Per Person, By County



0 25 50 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

Library (main) location – expenditure per person

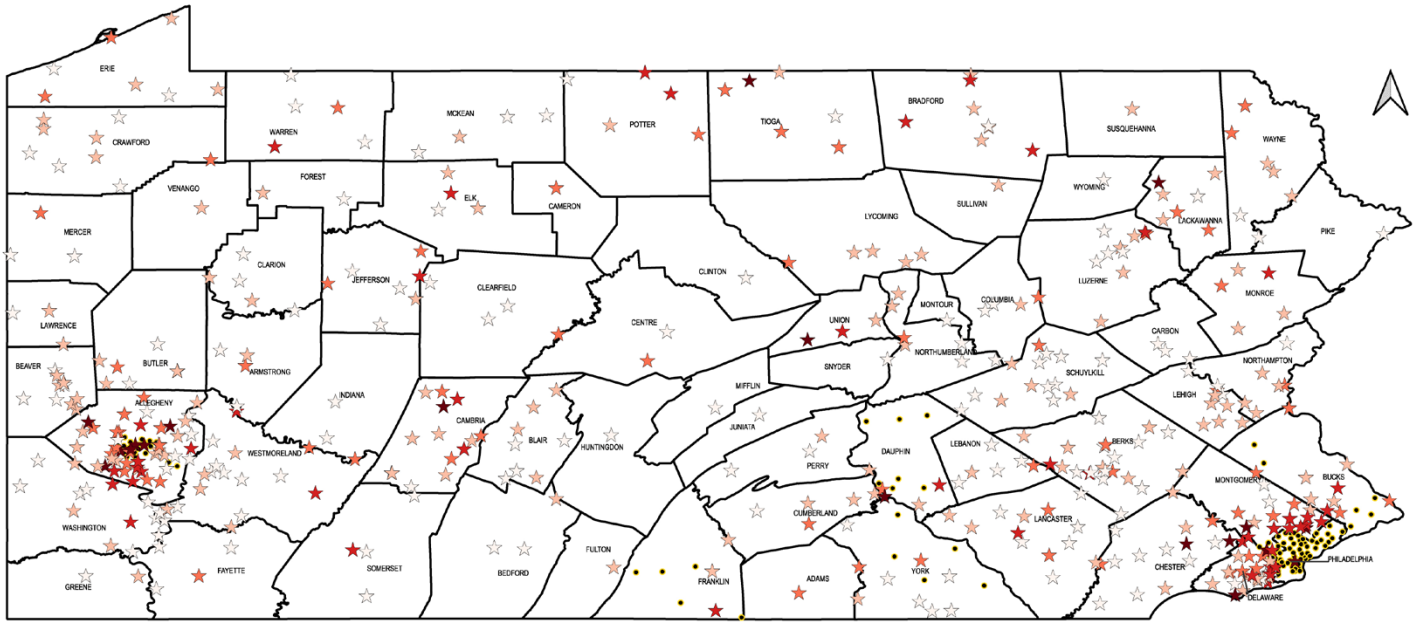
- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105

● Library branch

Library expenditure per person – averaged across all libraries in the county

- 8 – 13.2
- 13.2 – 18.5
- 18.5 – 25.2
- 25.2 – 36
- 36 – 66.3

# Library Expenditure



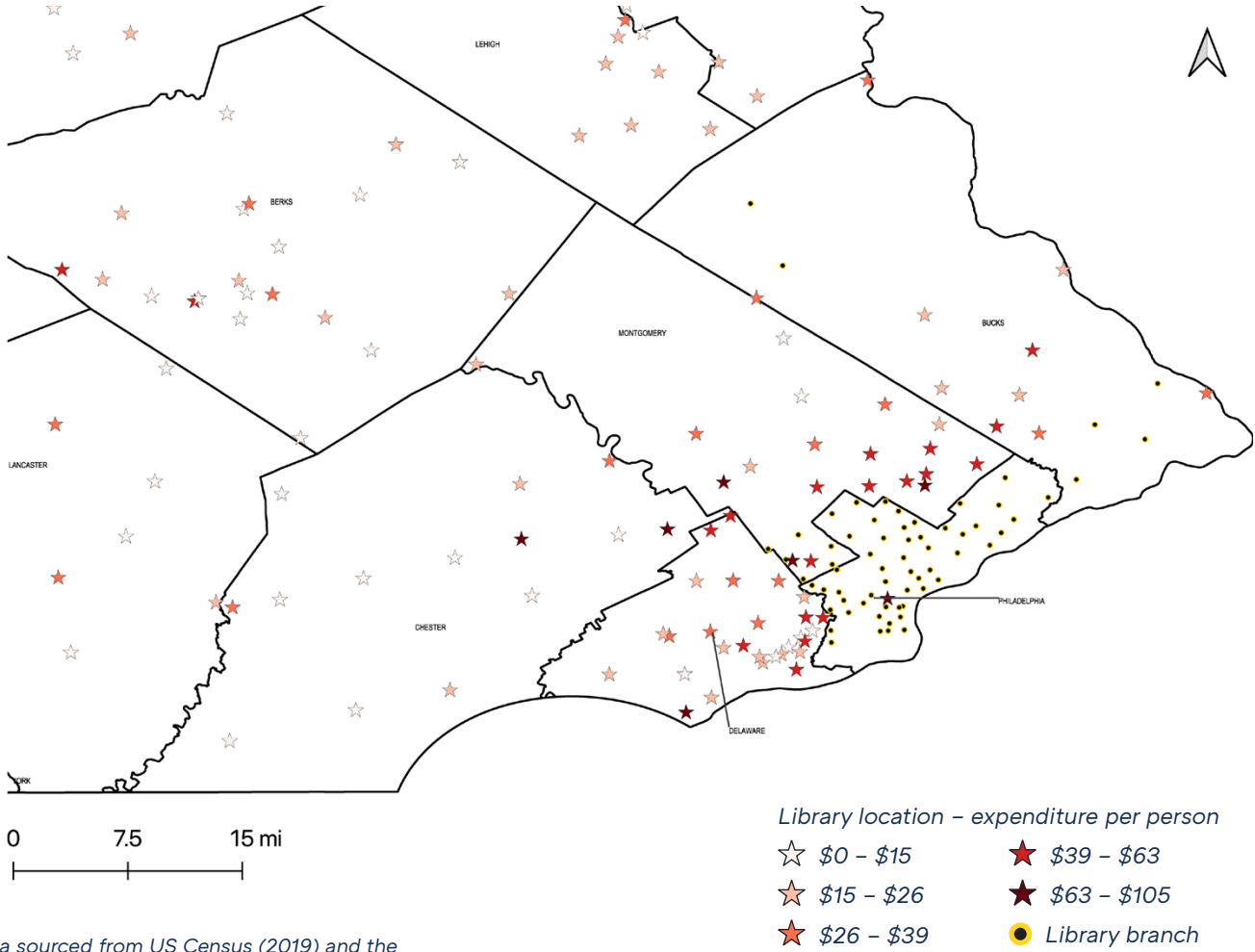
0 25 50 mi

Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

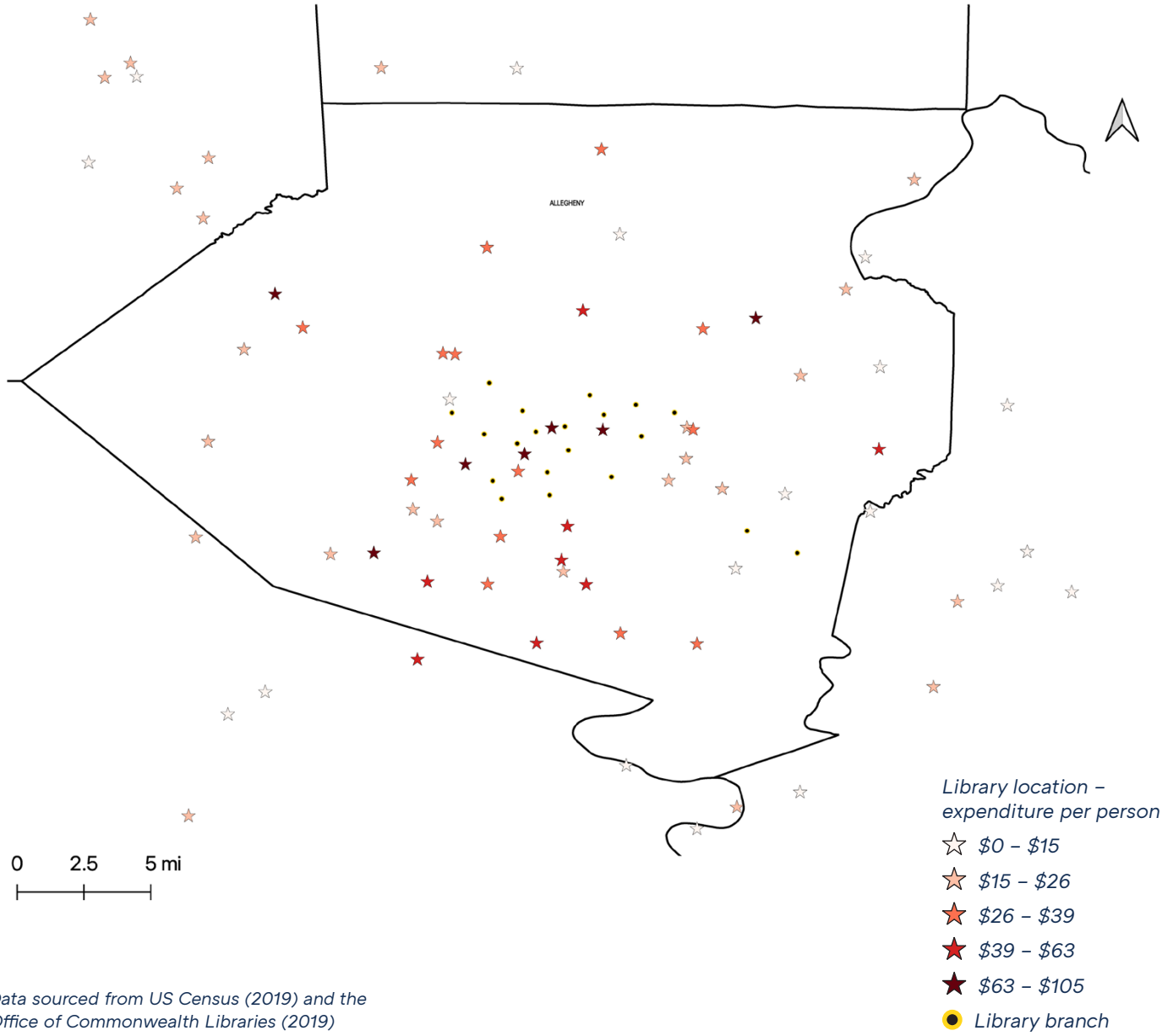
Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

# Library Expenditure – Philadelphia Region



Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

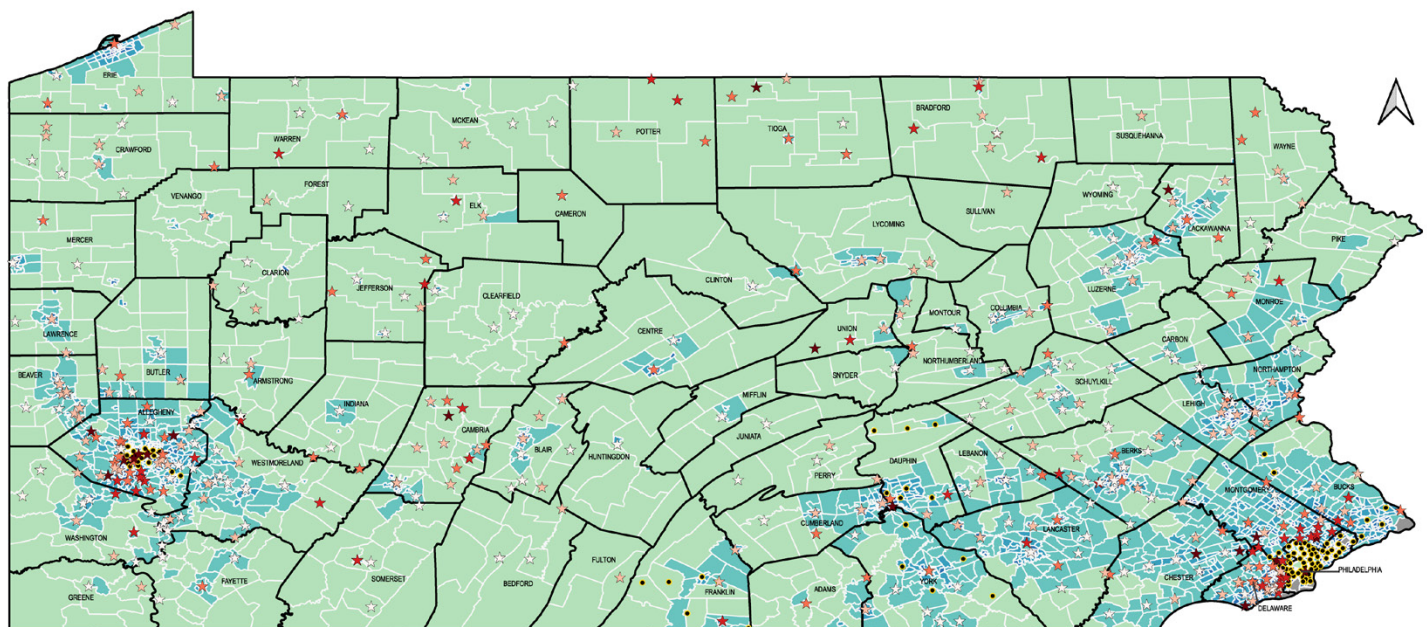
# Library Expenditure – Allegheny County



## Set 2: Population Density

Libraries were widely distributed across the state in relation to population density. Most tracts in Pennsylvania are covered by at least one 10-mile buffer around the libraries, and the tracts that are not covered tend to be lower in population density. Some exceptions exist (e.g., parts of Pike County, Monroe County, and McKean County). Topographical maps could be used in comparison with these maps to determine if there are other spatial factors at play here. Although the average population density was higher for tracts without a library (5129.61) than tracts with a library (4617.01), an independent *t*-test found this difference was not significant ( $t=1.62, p=.11$ ). This indicates that library locations are distributed evenly across the state with regards to population density. Additionally, population density was not significantly associated with expenditure per person. This is reflected in the maps as library expenditure per person does not appear to be related to population density. That is, there is no clear pattern that libraries in more highly dense tracts have higher expenditures per person or vice-versa. As noted above, these correlational tests should be interpreted with caution because expenditure per person was not available at the branch level, which means that 105 tracts with only branch locations (and no main libraries) were excluded from this analysis.

### Library Expenditure and Population Density, By Tract



0 25 50 mi

Data sourced from US Census (2019)  
and the Office of Commonwealth  
Libraries (2019)

Library location –  
expenditure per person

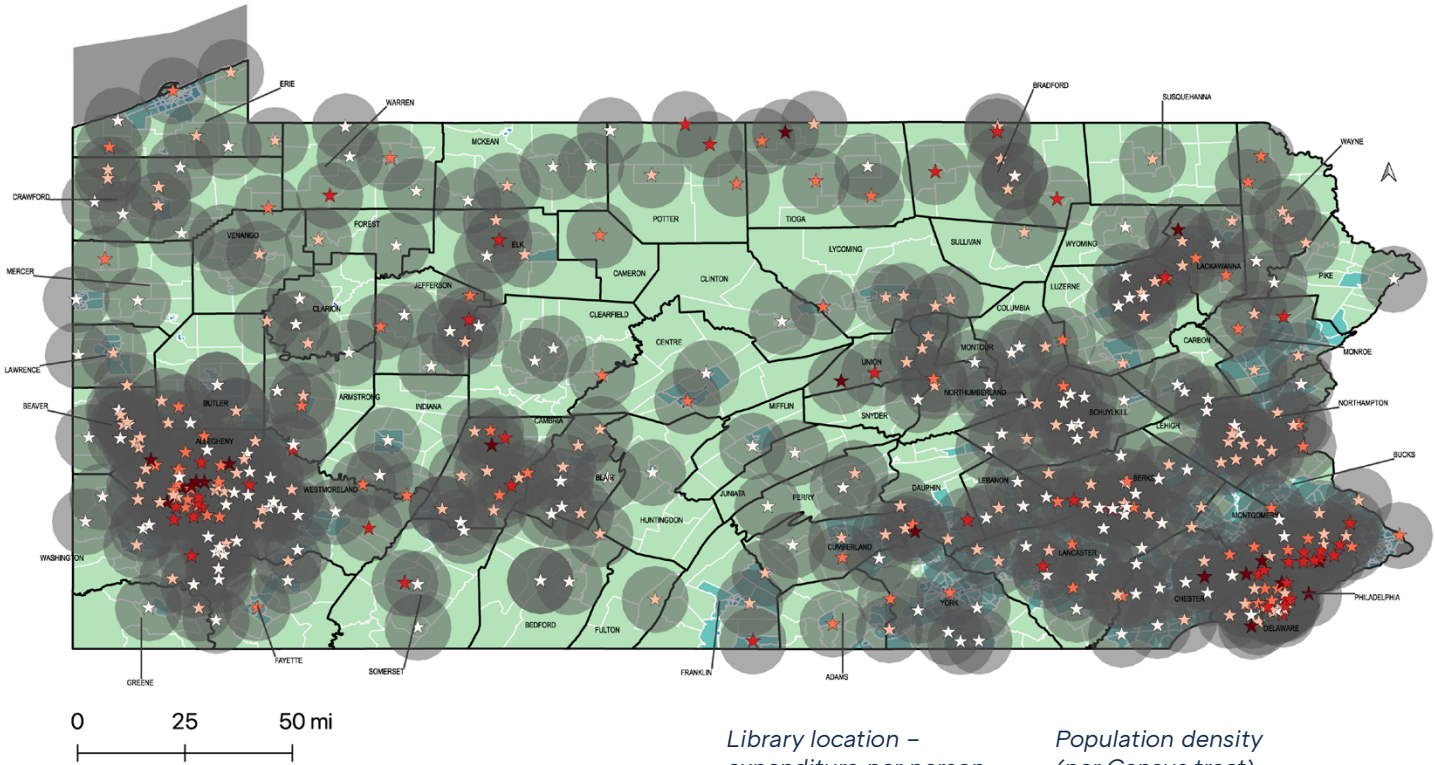
- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

Population density  
(per square mile)

- No data
- 0 – 223
- 223 – 1302
- 1302 – 3317
- 3317 – 7191
- 7191 – 87238

# Library Access and Population Density

Libraries are depicted with a 10-mile radius circle around them.



*Library location – expenditure per person*

- ☆ \$0 – \$15
- ☆ \$15 – \$26
- ☆ \$26 – \$39
- ☆ \$39 – \$63
- ☆ \$63 – \$105
- 10-mile buffer

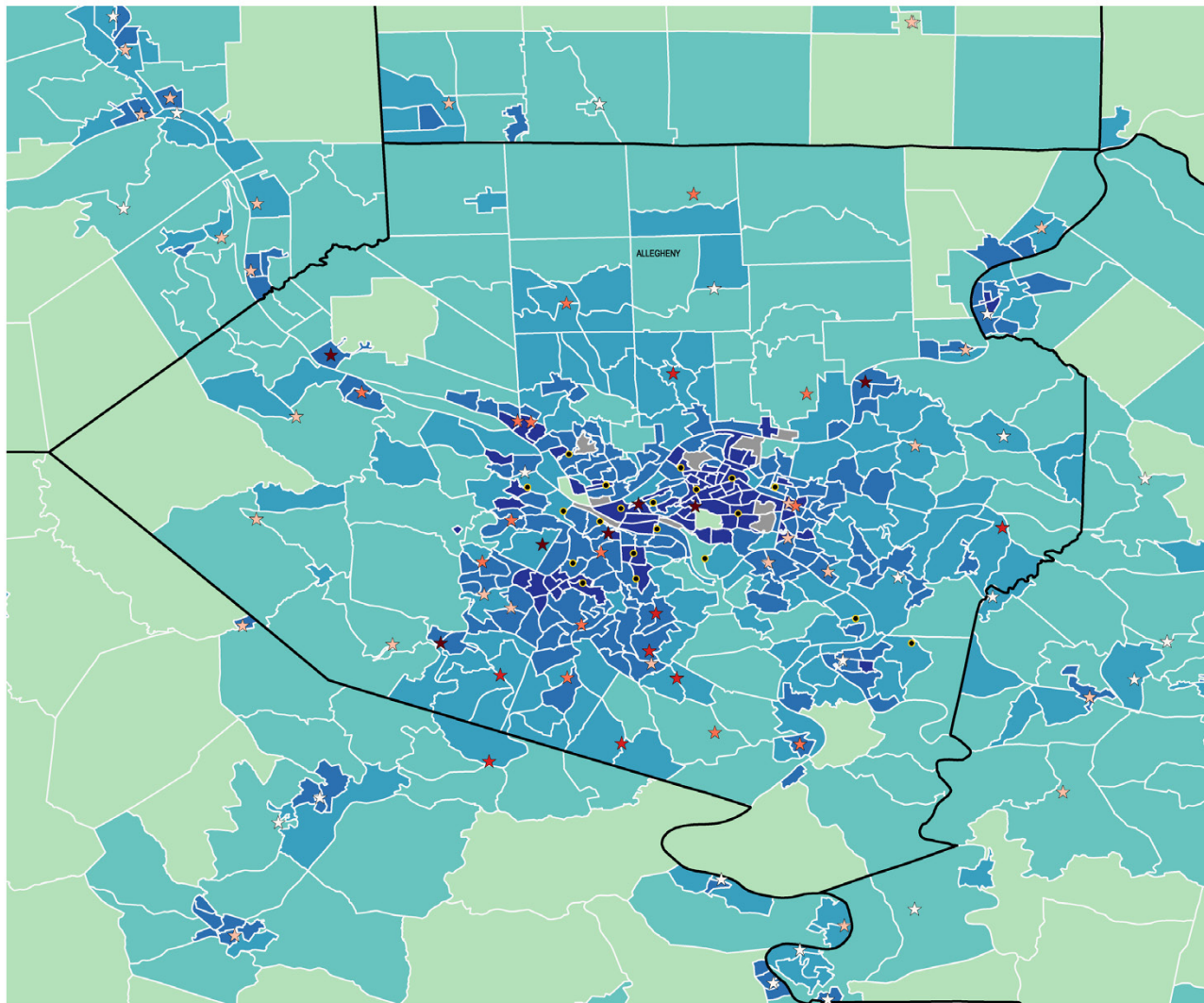
*Population density (per Census tract)*

- No data
- 0 – 223
- 223 – 1302
- 1302 – 3317
- 3317 – 7191
- 7191 – 87238

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)



# Library Expenditure and Population Density, By Tract – Allegheny County



0 2.5 5 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

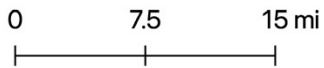
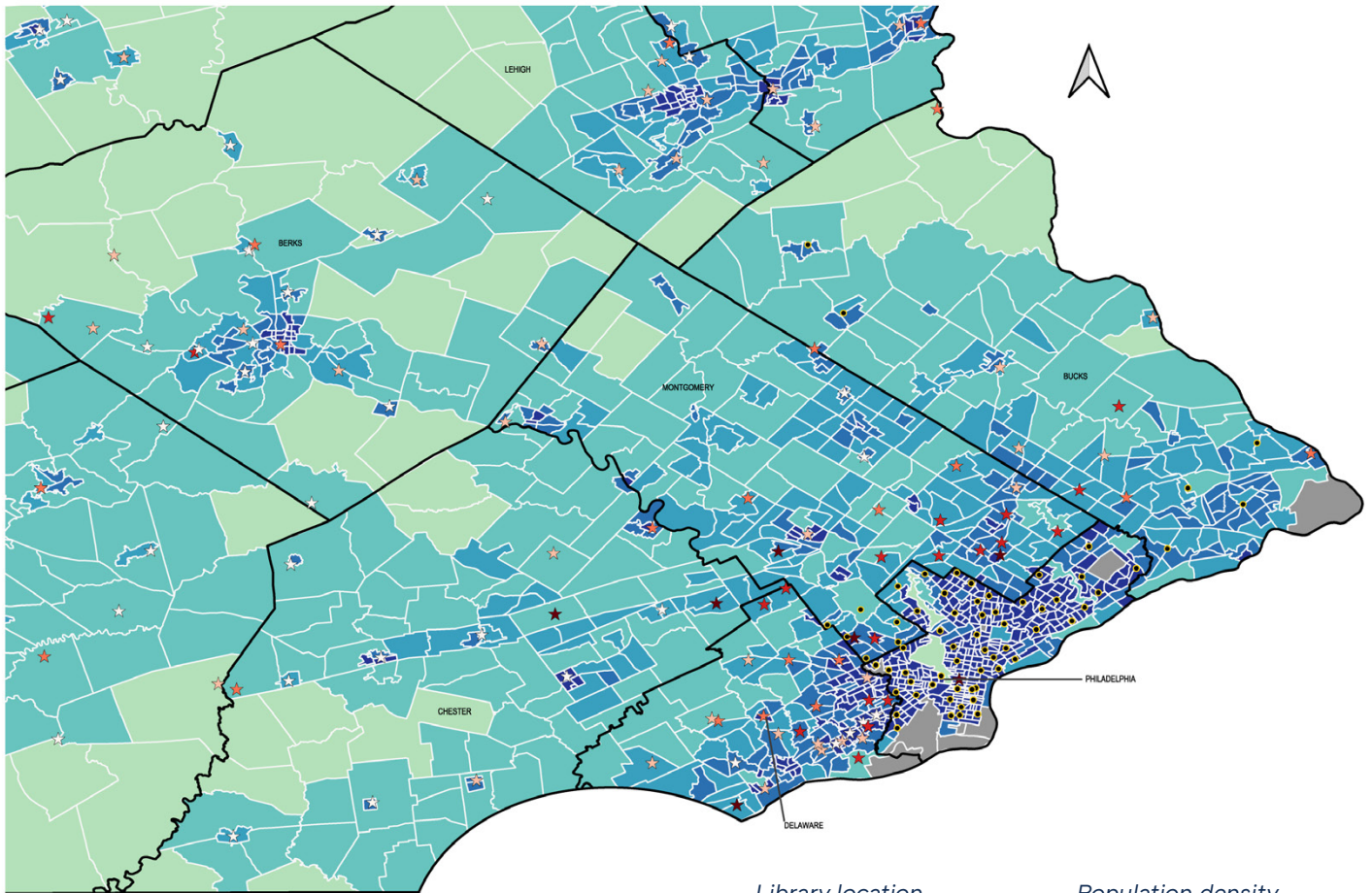
Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

Population density (per square mile)

- No data
- 0 – 223
- 223 – 1302
- 1302 – 3317
- 3317 – 7191
- 7191 – 87238

# Library Expenditure and Population Density, By Tract – Philadelphia Region



Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

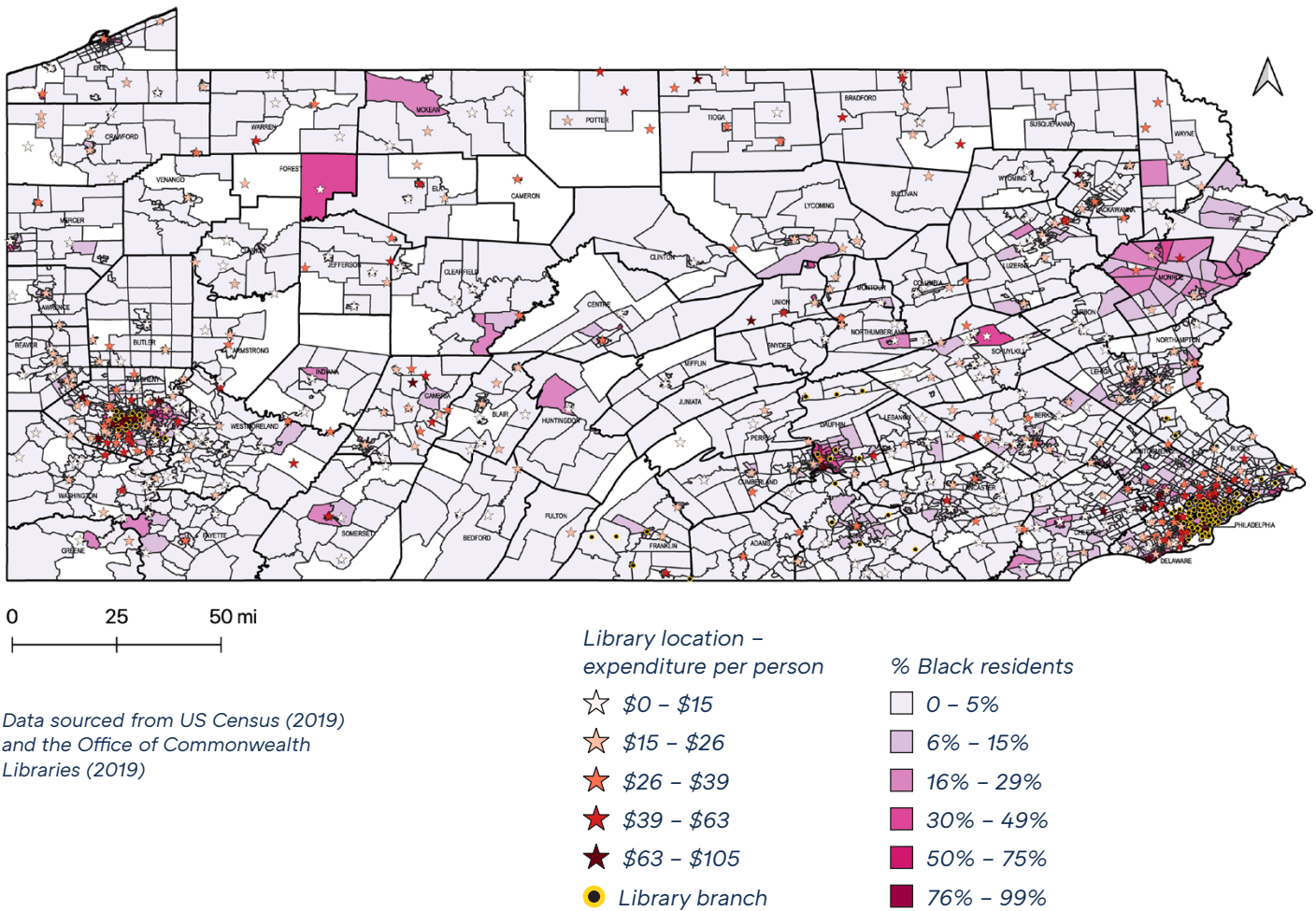
Population density (per square mile)

- No data
- 0 – 223
- 223 – 1302
- 1302 – 3317
- 3317 – 7191
- 7191 – 87238

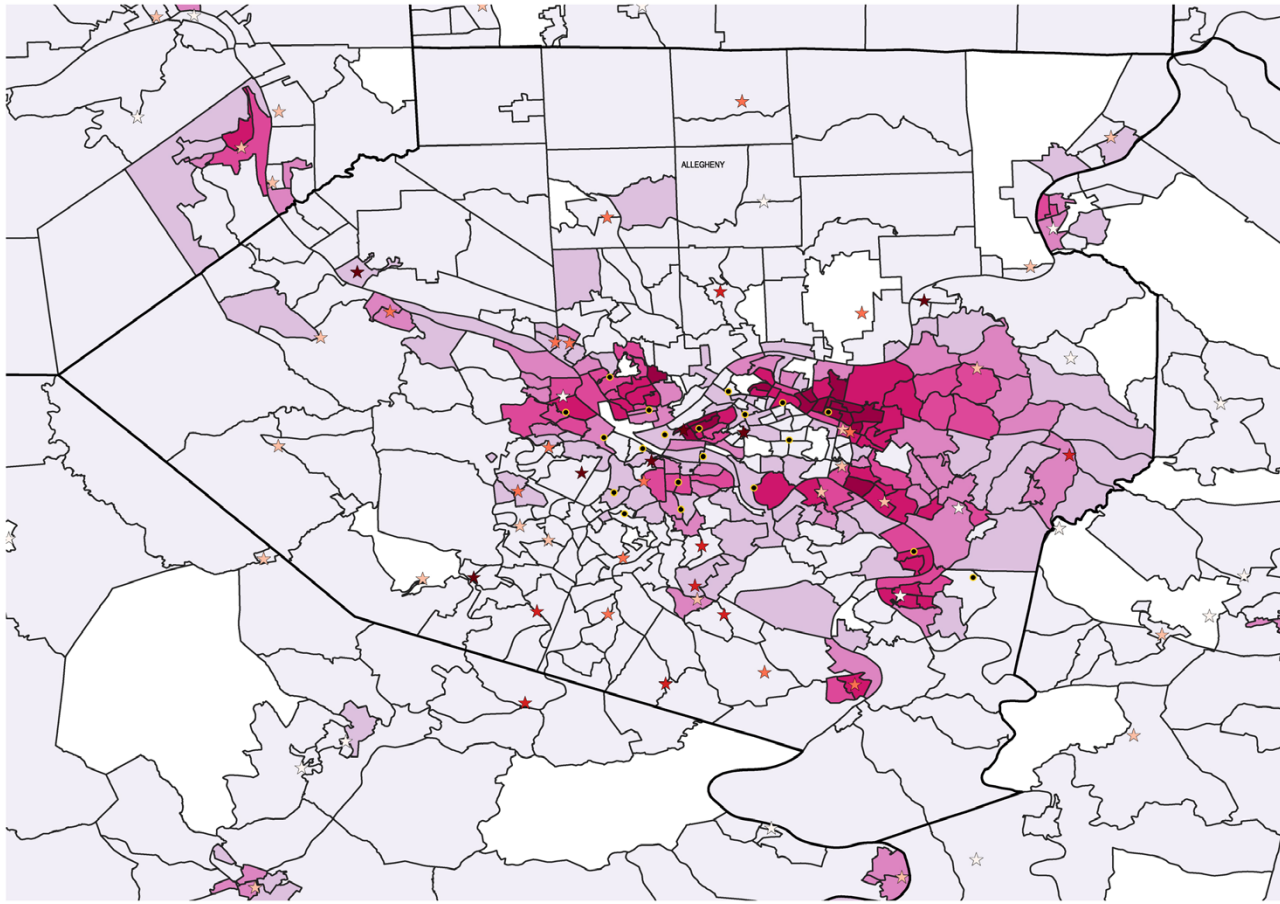
### Set 3: Black Residents

Tracts with higher percentages of Black residents tended to be focused around the major urban areas (e.g., Pittsburgh, Philadelphia). Building on Set 2, the parts of Pike County, Monroe County, and McKean County that also fall outside of a 10-mile library buffer also appear to have higher percentages of Black residents. Although the percentage of Black residents was higher for tracts without a library (12.54%) than tracts with libraries (10.81%), an independent *t*-test found this difference was not statistically significant ( $t=1.86, p=.06$ ). In other words, libraries tended to be evenly distributed across the state with regards to percentage of Black residents. Further, percentage of Black residents was not correlated with expenditure per person. This finding is reflected in the maps, as there does not appear to be a clear pattern between the percentage of Black residents and library expenditure per person. As noted previously, these correlational tests should be rerun in future studies when branch data for EPP becomes available.

### Library Expenditure and Percentage of Black Residents, By Tract



# Library Expenditure and Percentage of Black Residents, By Tract – Allegheny County



0 2.5 5 mi

Library location – expenditure per person

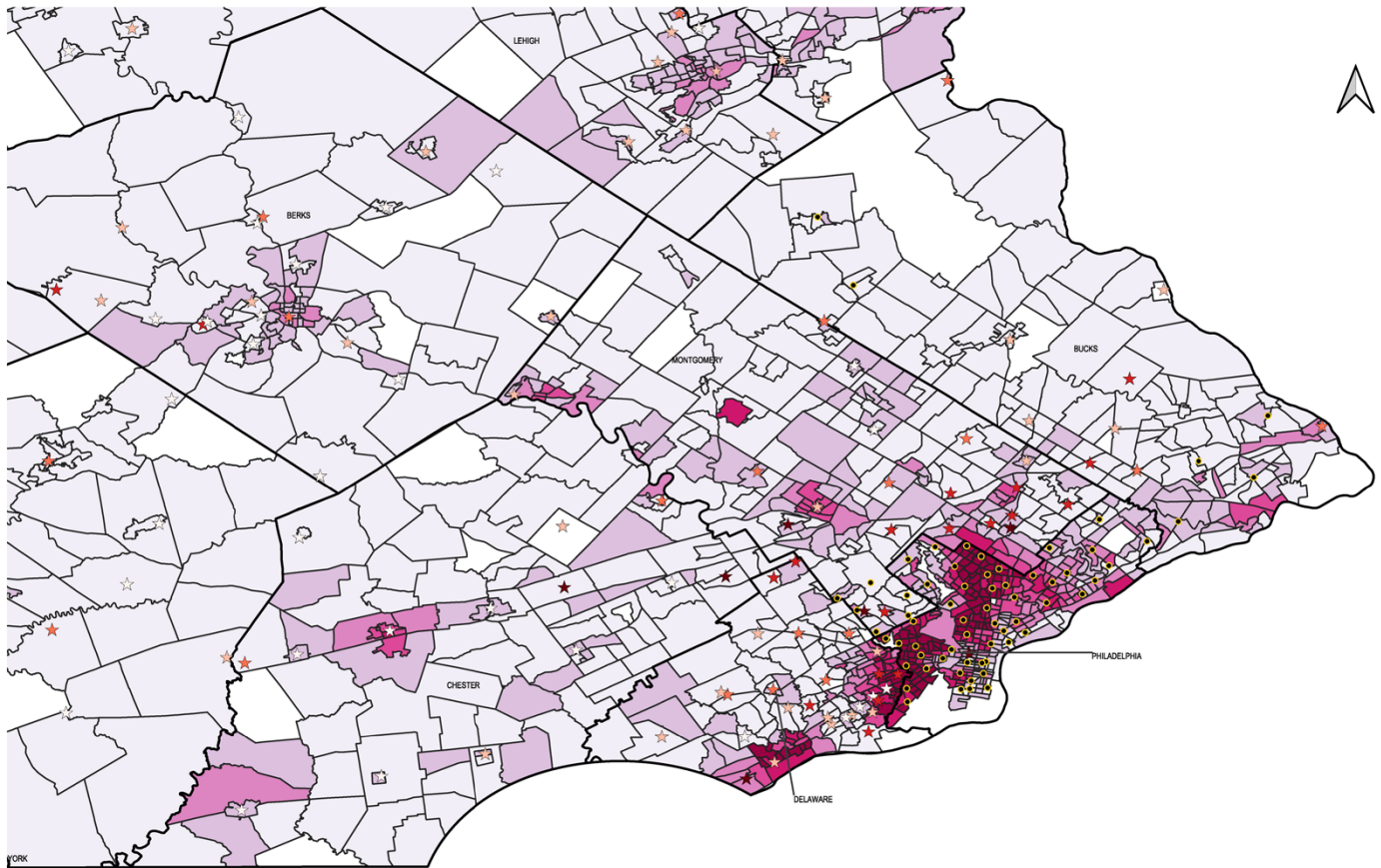
- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

% Black residents

- 0 – 5%
- 6% – 15%
- 16% – 29%
- 30% – 49%
- 50% – 75%
- 76% – 99%

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

# Library Expenditure and Percentage of Black Residents, By Tract – Philadelphia Region



0 7.5 15 mi

Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

% Black residents

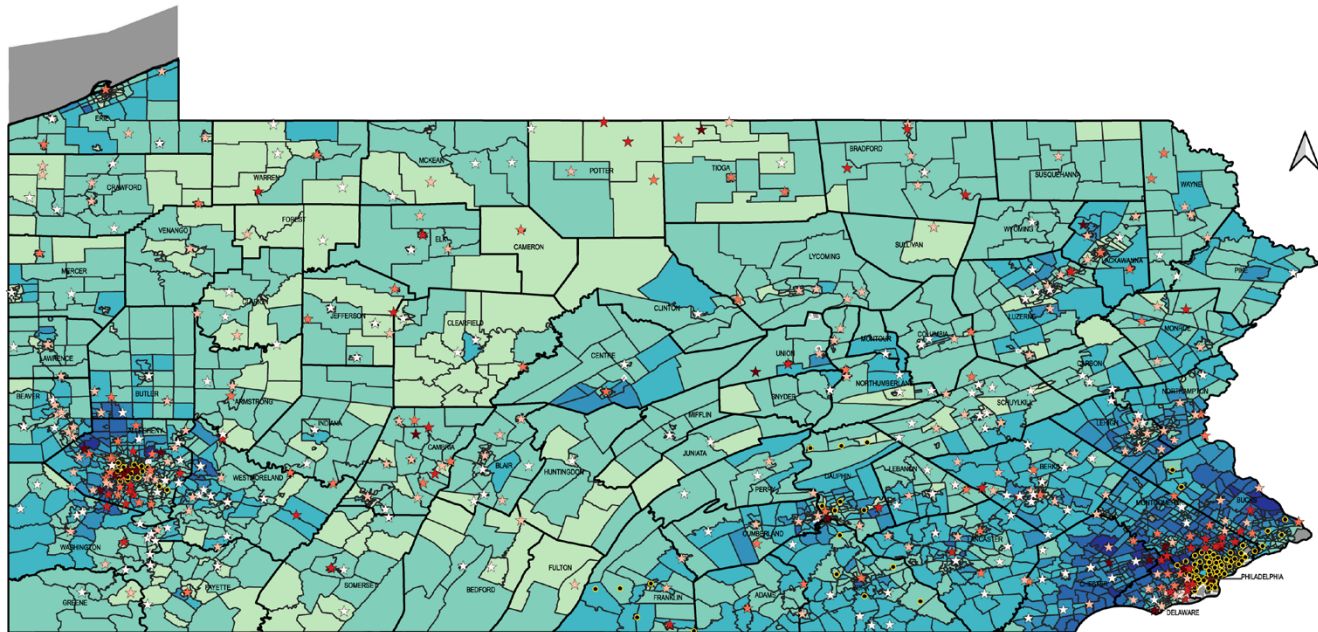
- 0 – 5%
- 6% – 15%
- 16% – 29%
- 30% – 49%
- 50% – 75%
- 76% – 99%

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

## Set 4: Average Household Income

Average household income was lower in tracts with a library (\$76,022.63) versus tracts without a library (\$83,358.50). An independent samples t-test found that this difference was significant ( $t=4.25, p<.001$ ). When viewing the household income maps, libraries tended to be in tracts with lower average household incomes (i.e., the lighter shades of blue-green). Expenditure per person was significantly associated with average household income, such that higher EPP was associated with higher average household income ( $r=.29, p<.001$ ). It does appear that in the higher income tracts surrounding the city centers of Pittsburgh and Philadelphia, library expenditure per person also appears to be higher. As noted previously, these correlational tests should be rerun in future studies when branch data for EPP becomes available.

### Library Expenditure and Household Income, By Tract



0 25 50 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

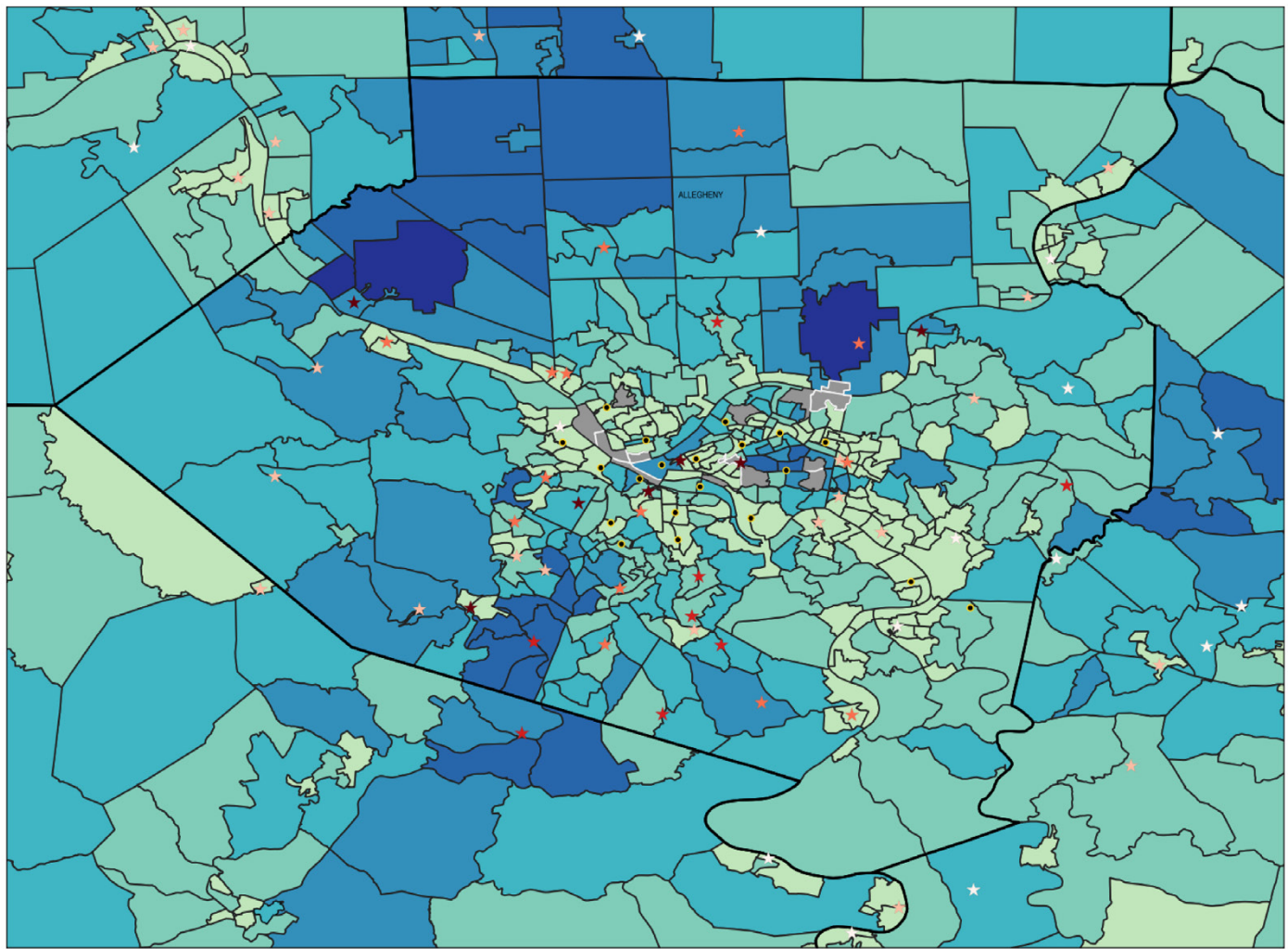
Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

Average household income

- No data
- 0 – \$62,300
- \$62,300 – \$83,300
- \$83,300 – \$110,000
- \$110,000 – \$151,300
- \$151,300 – \$221,600
- \$221,600 – \$390,000

# Library Expenditure and Household Income, By Tract – Allegheny County



Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

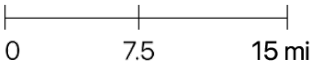
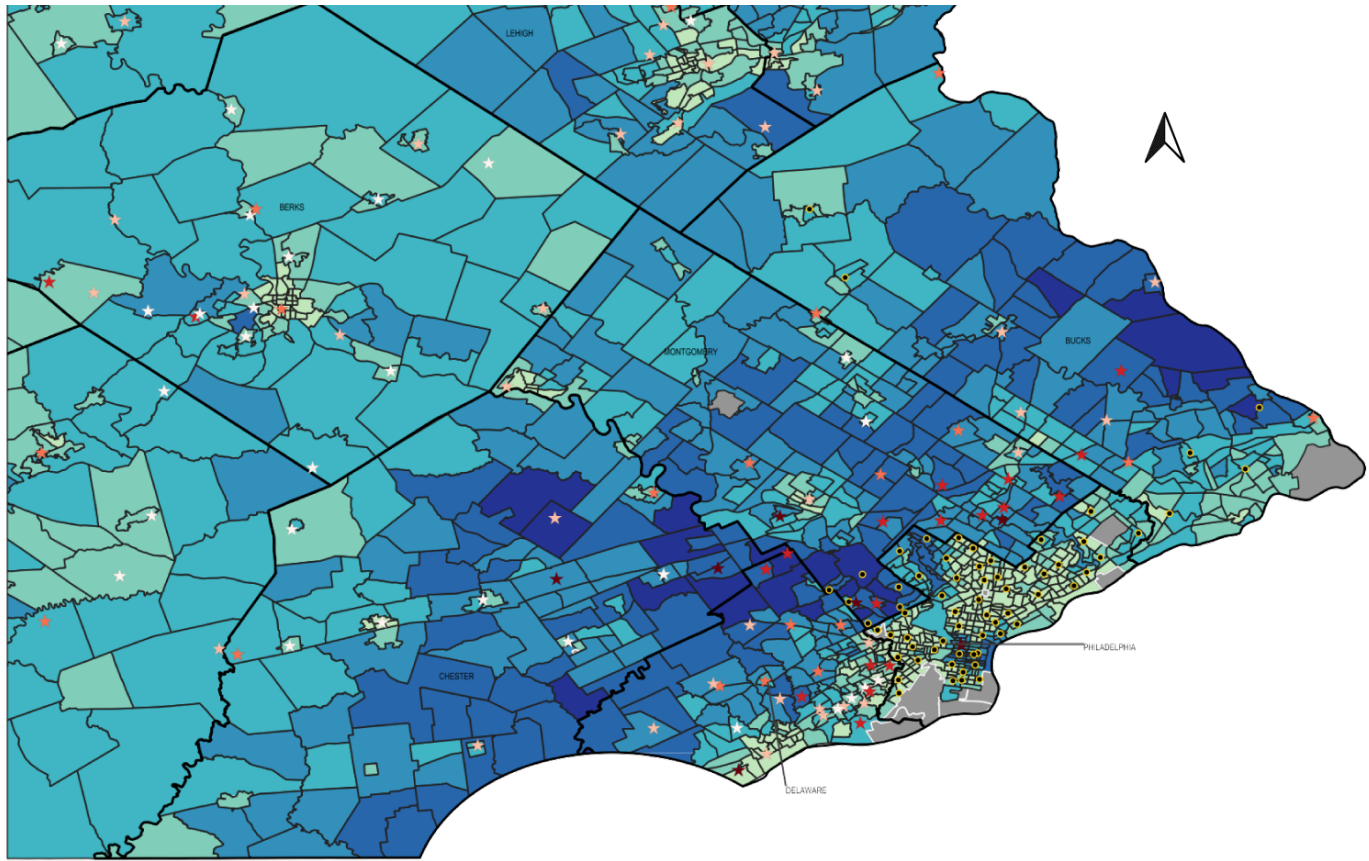
Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

Average household income

- No data
- 0 – \$62,300
- \$62,300 – \$83,300
- \$83,300 – \$110,000
- \$110,000 – \$151,300
- \$151,300 – \$221,600
- \$221,600 – \$390,000

# Library Expenditure and Household Income, By Tract – Philadelphia Region



Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

- Library location – expenditure per person*
- ☆ \$0 – \$15
  - ★ \$15 – \$26
  - ★ \$26 – \$39
  - ★ \$39 – \$63
  - ★ \$63 – \$105
  - Library branch

- Average household income*
- No data
  - 0 – \$62,300
  - \$62,300 – \$83,300
  - \$83,300 – \$110,000
  - \$110,000 – \$151,300
  - \$151,300 – \$221,600
  - \$221,600 – \$390,000

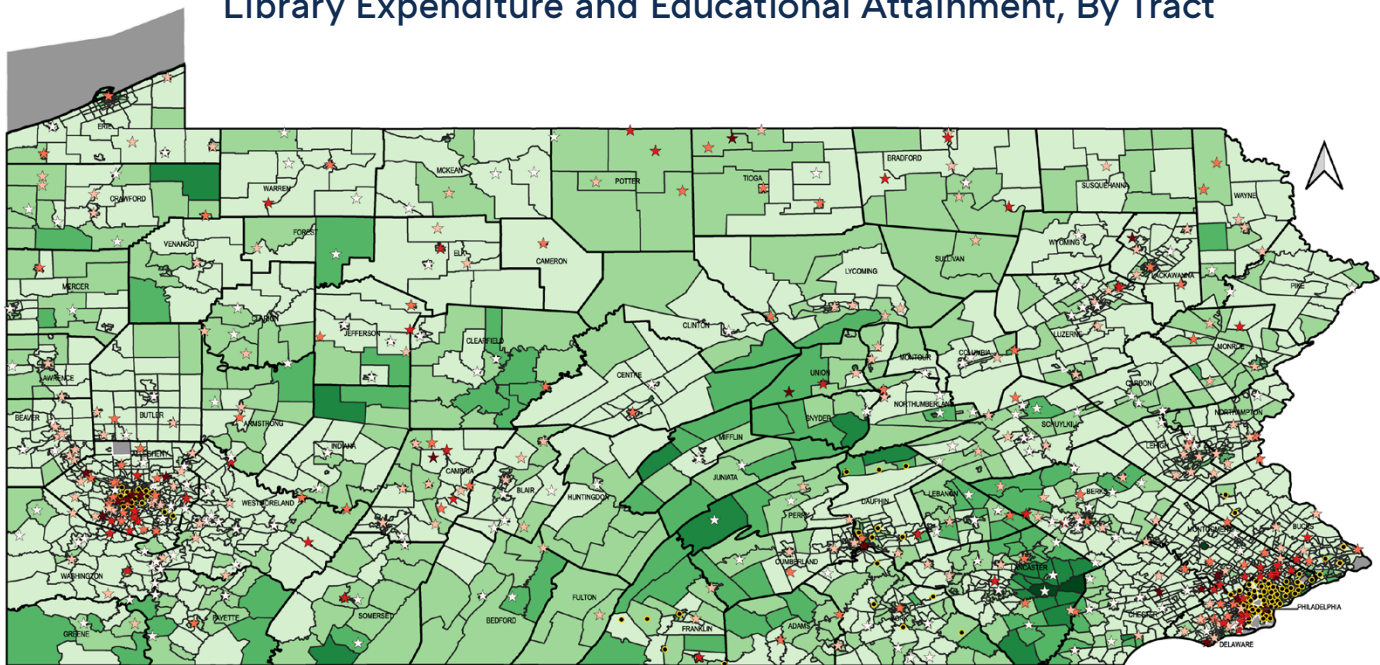


## Set 5: Educational Attainment

Educational attainment was measured as percentage of residents in a tract with less than a high school degree. There does not appear to be a pattern to the distribution of residents without a high school degree in relation to library locations. This was confirmed with an independent samples *t*-test: the percentage of residents with less than a high school degree was higher in tracts with libraries (10.23%) than without libraries (9.71%), but this difference was not significant ( $t=-1.55, p=.12$ ). Expenditure per person was significantly negatively associated with percentage of residents with less than a high school degree, such that higher EPP was associated with lower percentages of residents with less than a high school degree ( $r=-.19, p<.001$ ). As noted previously, these correlational tests should be rerun in future studies when branch data for EPP becomes available.

To further explore educational attainment, an independent *t*-test was conducted for residents with a high school degree in tracts with versus without libraries. The average percentage of residents with a high school degree in tracts with a library (36.56) was statistically higher than those in tracts without a library (34.74) ( $t=-3.28, p=.001$ ). Further, the average percentage of residents with a bachelor's degree or higher was lower in tracts with a library (28.32) versus tracts without a library (30.95) ( $t=3.27, p=.001$ ). For added clarity, a low-income variable was created for tracts with 20% or more residents living in poverty (Benzow, et al., 2020). This variable was a significant predictor of differences in educational attainment measured as the percentage of residents without a high school degree, with a high school degree, and with a BA or higher. Taking all of this together, educational attainment seemed more closely related to economic status, which was explored next.

### Library Expenditure and Educational Attainment, By Tract



0 25 50 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

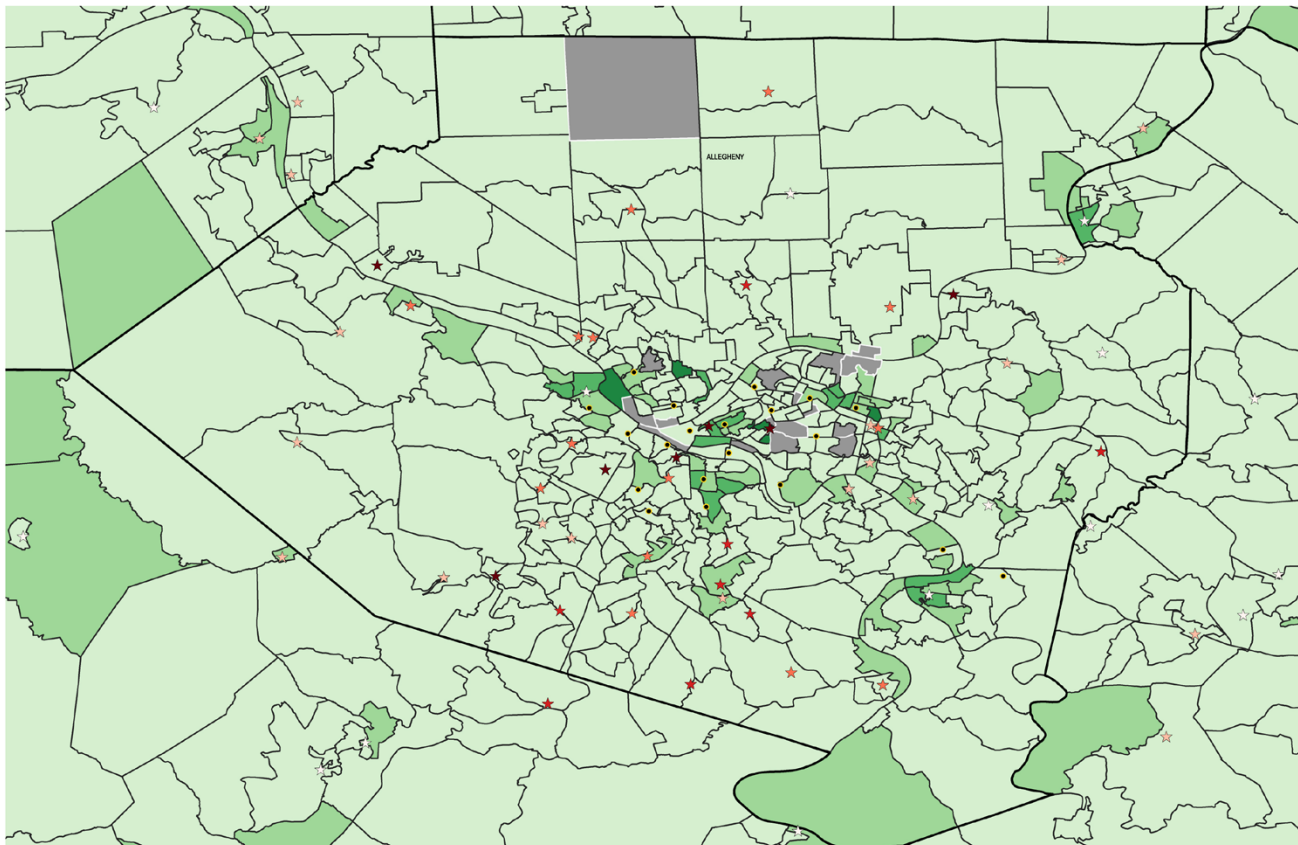
Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

% Residents with less than a high school degree

- no data
- 1% – 10%
- 11% – 16%
- 17% – 27%
- 28% – 35%
- 36% – 56%

# Library Expenditure and Educational Attainment, By Tract – Allegheny County



0 2.5 5 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

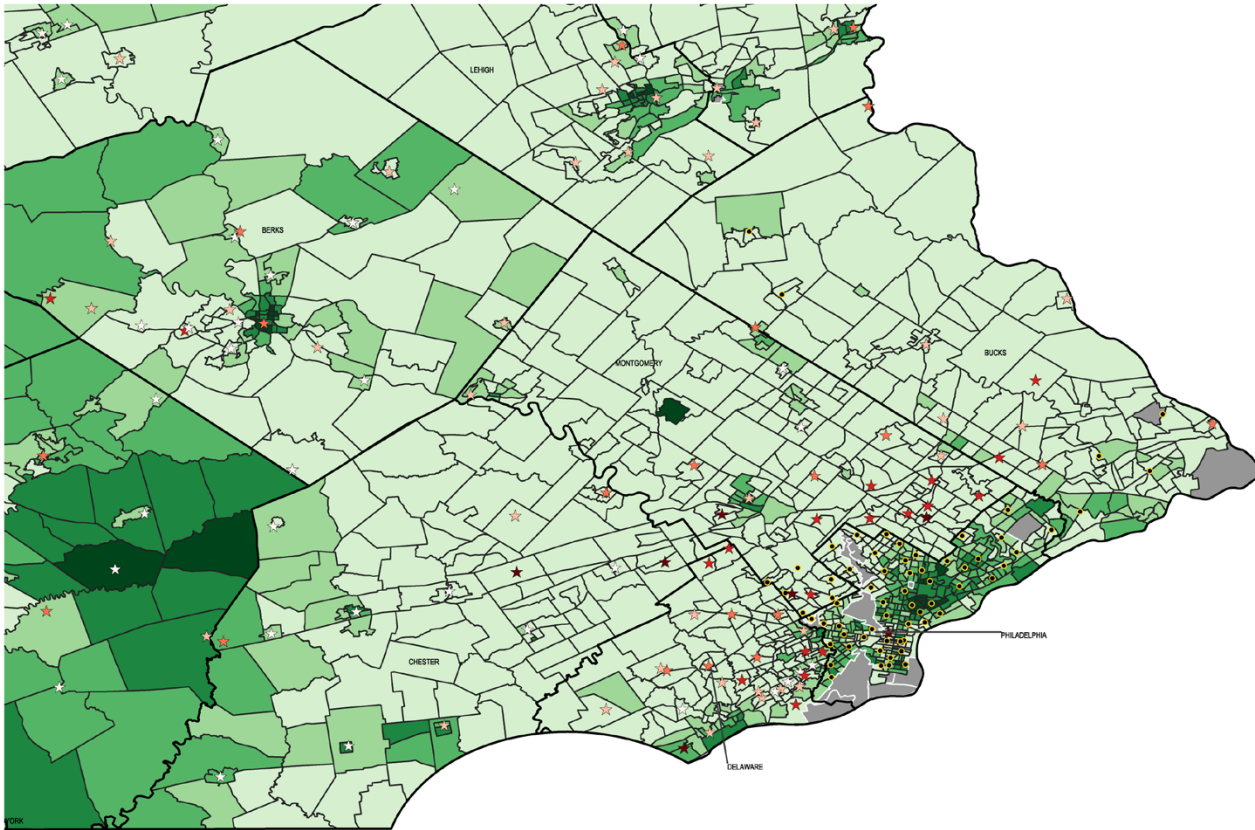
Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

% Residents with less than a high school degree

- no data
- 1% – 10%
- 11% – 16%
- 17% – 27%
- 28% – 35%
- 36% – 56%

# Library Expenditure and Educational Attainment, By Tract – Philadelphia Region



0 7.5 15 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

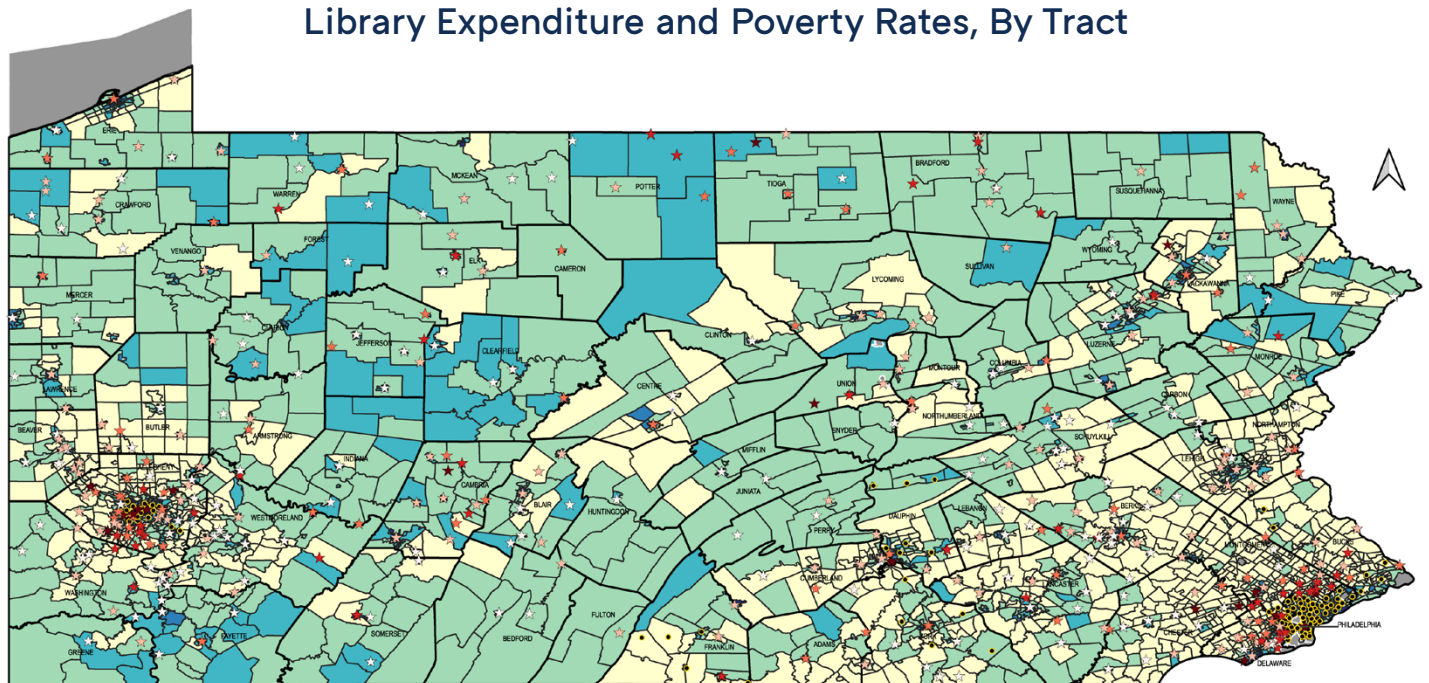
% Residents with less than a high school degree

- no data
- 1% – 10%
- 11% – 16%
- 17% – 27%
- 28% – 35%
- 36% – 56%

## Set 6: Poverty Rate

Poverty rate is the percentage of residents living below the poverty threshold in a tract. The poverty threshold is measured for each resident or family in relation to their household size and income (U.S. Census Bureau, 2022). Not surprisingly, when looking at the maps, poverty rates across the state seem to be inverse to average household incomes (Set 4). The average poverty rate was higher for tracts with a library (14.57%) versus tracts without a library (13.56%). An independent samples *t*-test found that this was a significant difference ( $t=-1.99, p=.047$ ). This is reflected in the poverty rate maps where libraries tend to be in the darker green-blue tracts. Indeed, 449 of public libraries are in tracts with greater than 7% poverty, while the remaining 152 are in tracts with 7% or less poverty. Across the green and blue tracts (i.e., >8% poverty), 373 libraries are in tracts with 8%-26% poverty while 76 libraries are in tracts with greater than 26% poverty. Expenditure per person was significantly negatively associated with poverty rates, such that higher EPP coincided with a lower percentage of residents experiencing poverty ( $r=-.14, p<.001$ ). As noted previously, these correlational tests should be rerun in future studies when branch data for EPP becomes available.

### Library Expenditure and Poverty Rates, By Tract



0 25 50 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

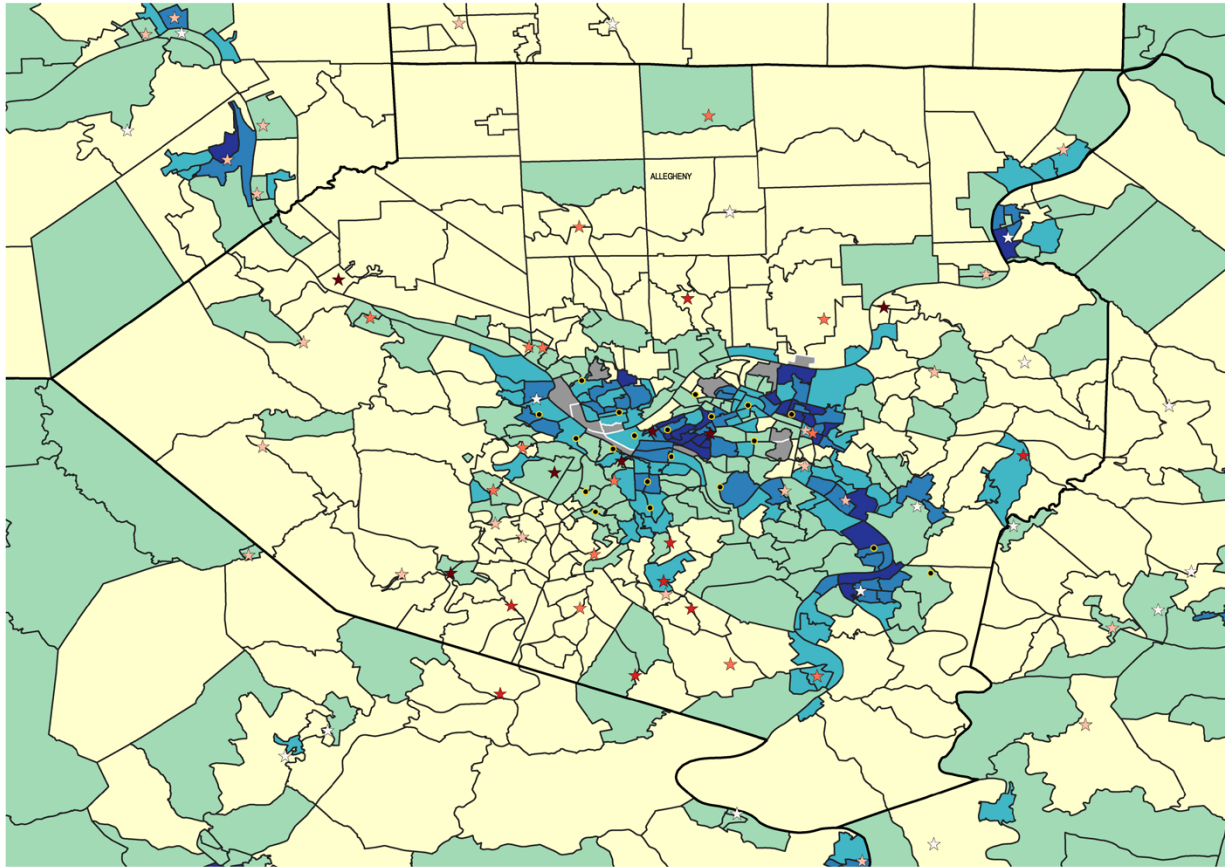
Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

% Residents below the poverty line

- no data
- 0 – 7%
- 8% – 15%
- 16% – 26%
- 27% – 44%
- 44% – 100%

# Library Expenditure and Poverty Rate, By Tract – Allegheny County



0 2.5 5 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

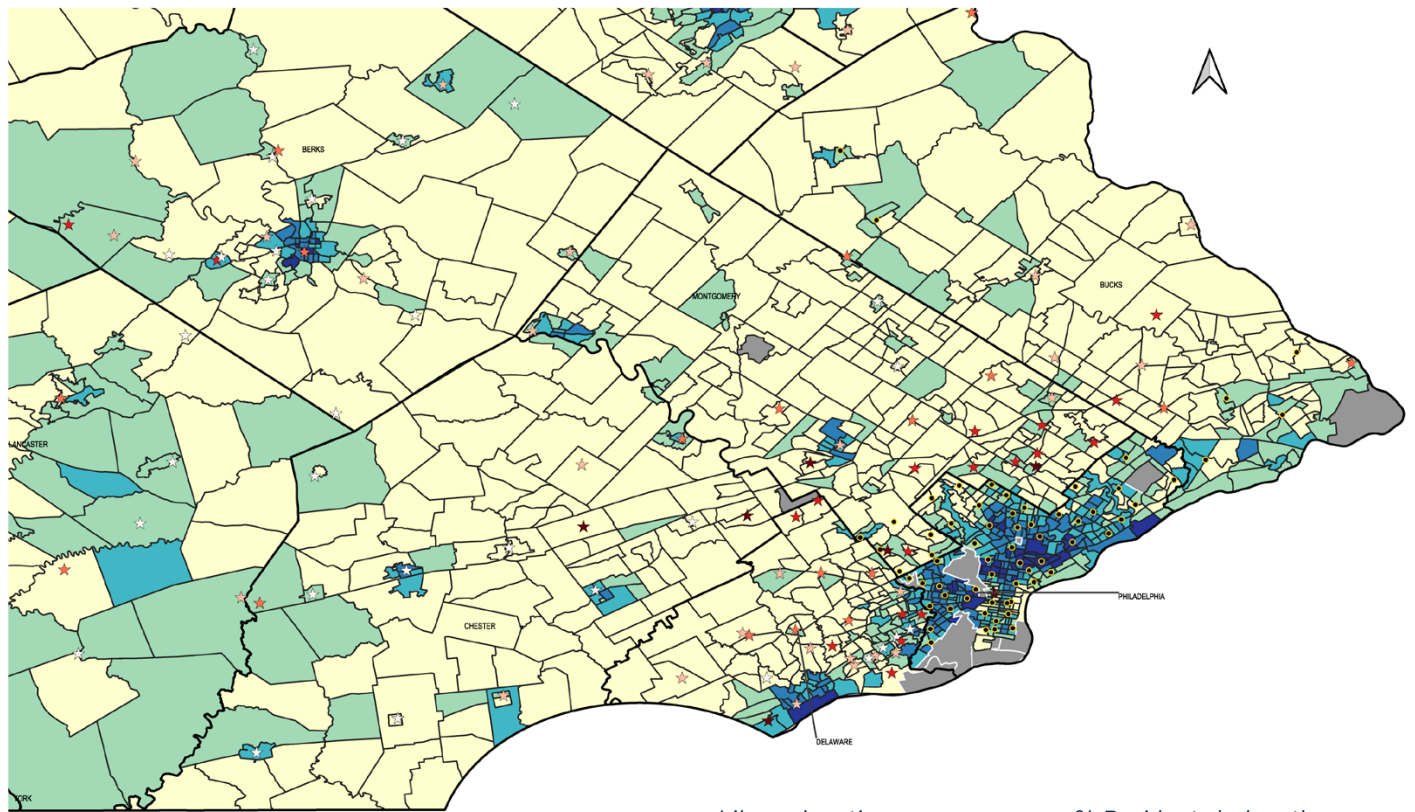
Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

% Residents below the poverty line

- no data
- 0 – 7%
- 8% – 15%
- 16% – 26%
- 27% – 44%
- 44% – 100%

# Library Expenditure and Poverty Rates, By Tract – Philadelphia Region



0 7.5 15 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

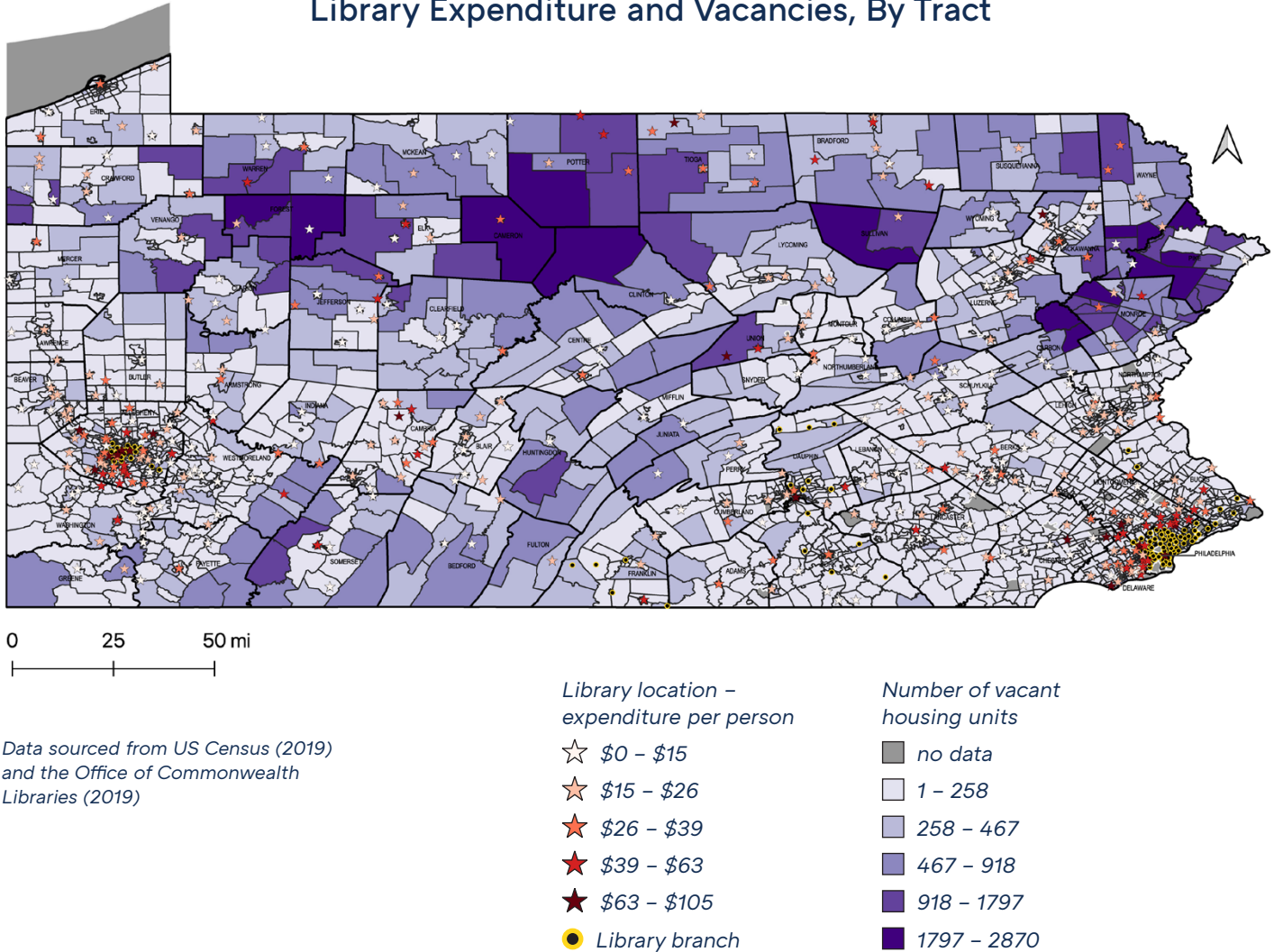
% Residents below the poverty line

- no data
- 0 – 7%
- 8% – 15%
- 16% – 26%
- 27% – 44%
- 44% – 100%

## Set 7: Vacancy

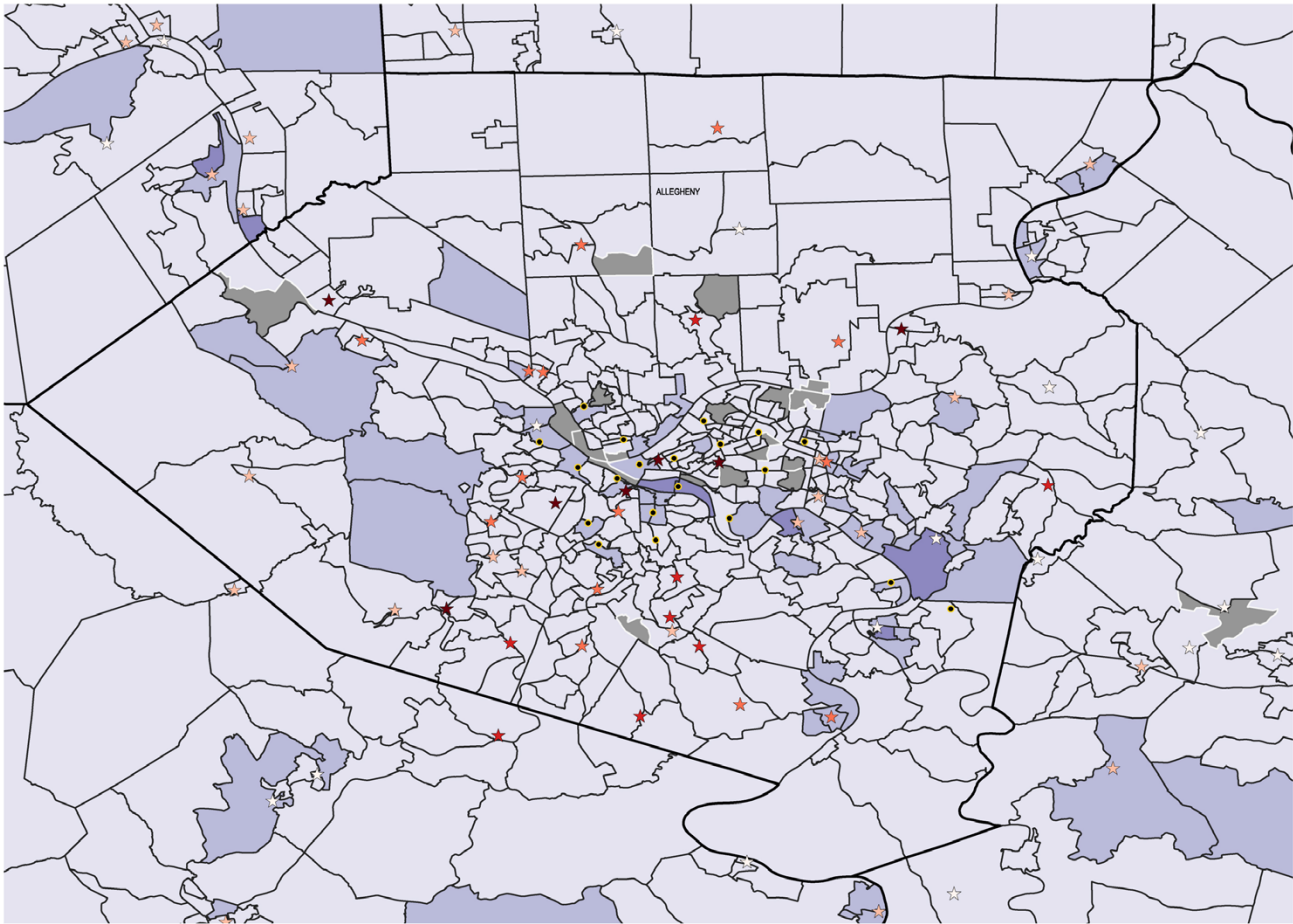
Vacancy is the total number of vacant housing units in a tract. The average number of vacancies in tracts with libraries was 244.05 and the average number in tracts without libraries was 188.59. An independent samples *t*-test confirmed that this difference was statistically significant ( $t=-4.82, p<.001$ ), indicating that tracts with libraries had significantly more vacant properties than tracts without libraries. Although expenditure per person was not associated with vacancy, as noted previously, these correlational tests should be rerun in future studies when branch data for EPP becomes available.

### Library Expenditure and Vacancies, By Tract



Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

# Library Expenditure and Vacancies, By Tract – Allegheny County



0 2.5 5 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

Library location – expenditure per person

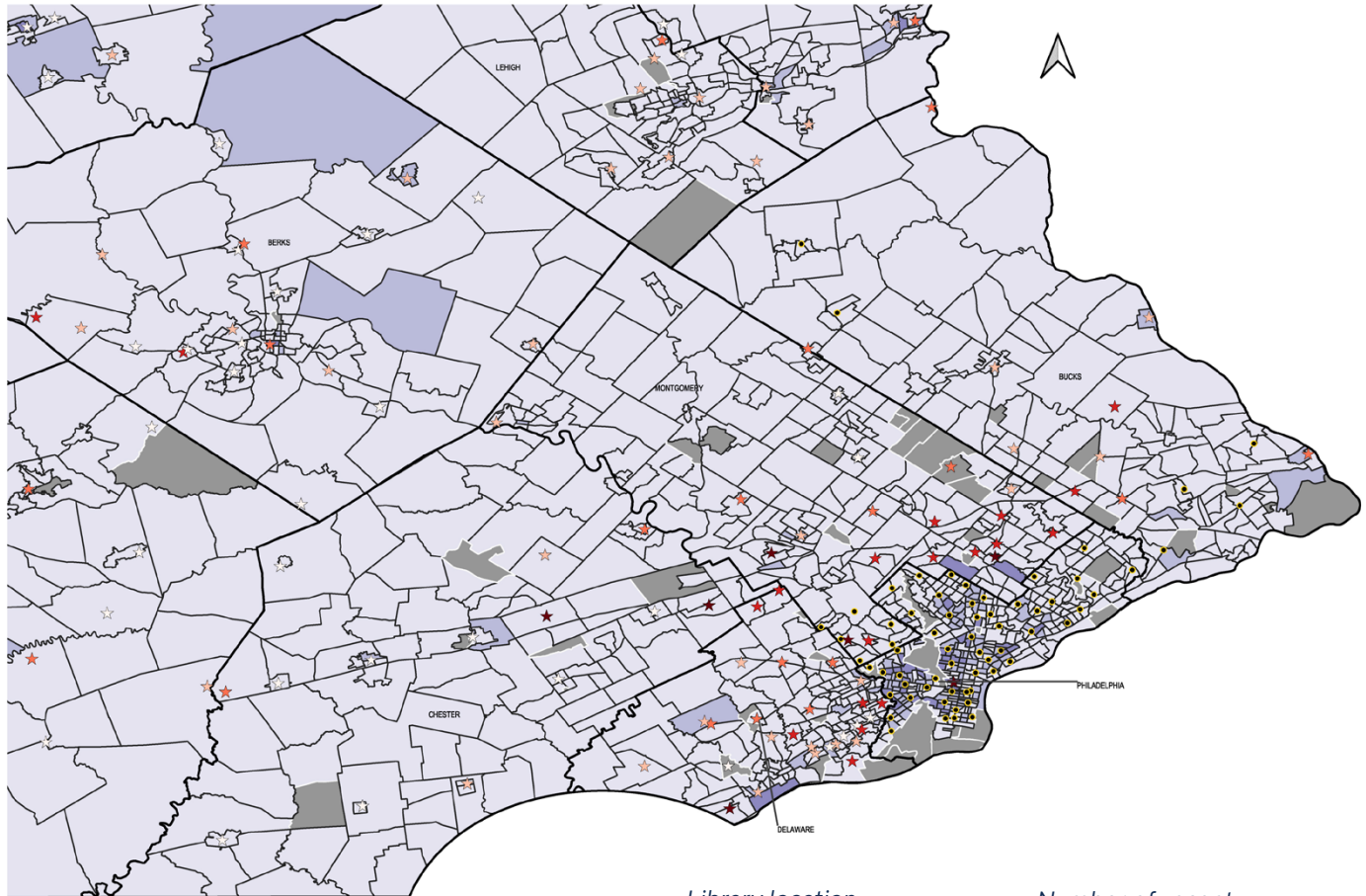
- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

Number of vacant housing units

- no data
- 1 – 258
- 258 – 467
- 467 – 918
- 918 – 1797
- 1797 – 2870



# Library Expenditure and Vacancies, By Tract – Philadelphia Region



0 7.5 15 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

Library location – expenditure per person

- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

Number of vacant housing units

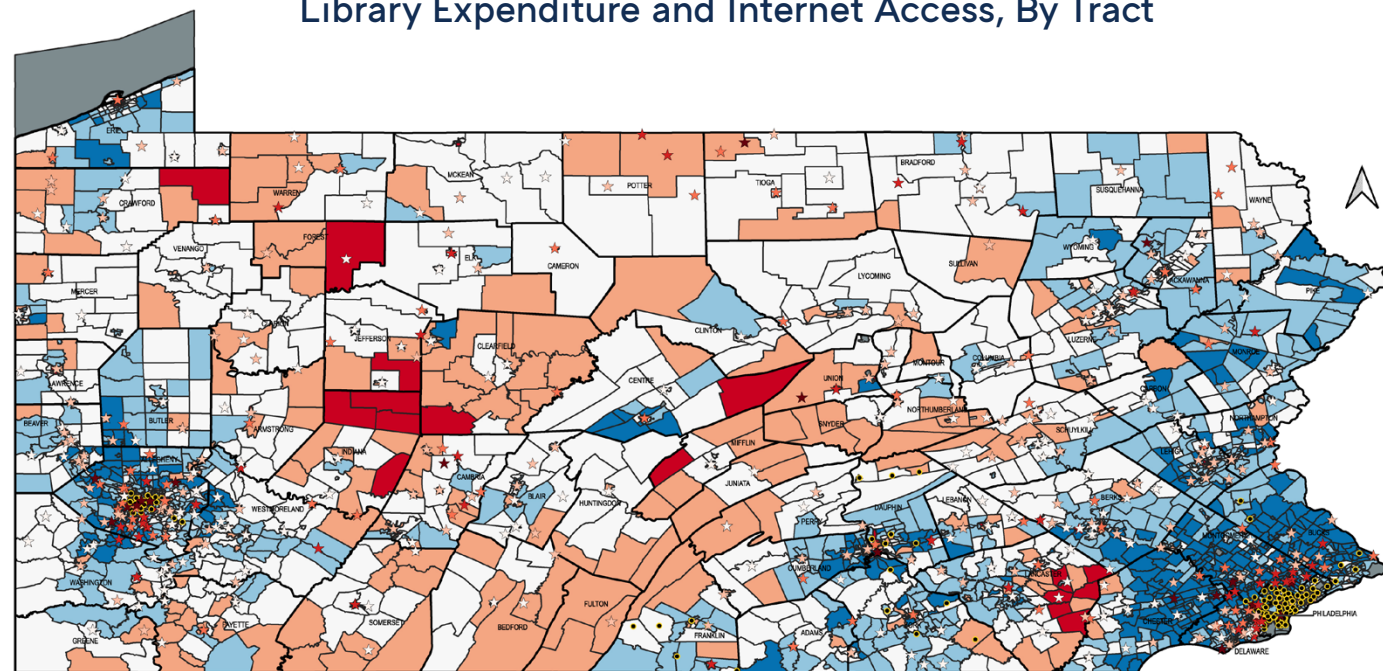
- no data
- 1 – 258
- 258 – 467
- 467 – 918
- 918 – 1797
- 1797 – 2870

## Set 8: Broadband in the Home

Broadband access is represented as the percentage of residents without broadband access in the home. The average percentage of residents without broadband in the home was higher in tracts with a library (21.46%) versus tracts without a library (18.61%). An independent samples *t*-test confirmed that this difference was significant ( $t=-6.69, p<.001$ ). In the maps presented, libraries appear in white and orange-red shaded tracts more than blue tracts. Expenditure per person was significantly negatively associated with broadband in the home, such that higher EPP coincided with lower percentages of residents without broadband in the home ( $r=-.20, p<.001$ ). That is, main libraries with lower EPP tended to be in tracts with higher percentages of residents without broadband in the home. As noted previously, these correlational tests should be rerun in future studies when branch data for EPP becomes available.

To further explore broadband access, a cluster analysis was conducted. The global Moran's *I* was .524 (pseudo *p*-value  $<.001$ , 999 permutations), indicating significant spatial autocorrelation. In other words, tracts with higher and lower numbers of residents without broadband in the home tended to cluster together. A local spatial statistic, the *G*star (*G*\*), was calculated. The *G*star indicator map is included in map Set 8. The blue tracts ("cool spots") are tracts with statistically lower percentages of residents without broadband in the home. The red tracts ("hot spots") are those with statistically higher percentages of residents without broadband in the home.

### Library Expenditure and Internet Access, By Tract



0 25 50 mi

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

Library location – expenditure per person

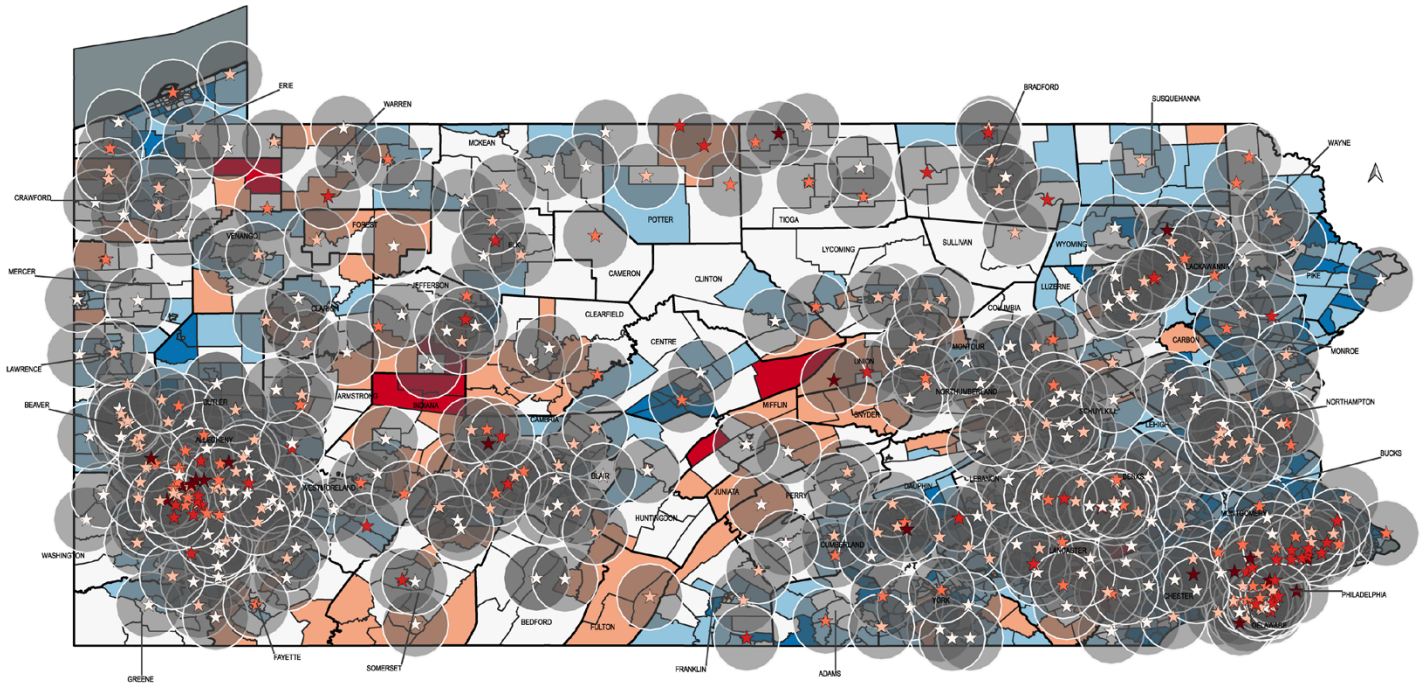
- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- Library branch

% Residents without broadband in home

- no data
- 0 – 10%
- 11% – 17%
- 18% – 25%
- 26% – 36%
- 37% – 64%

# Library Access and Broadband

Libraries are depicted with a 10-mile radius circle around them.



0 25 50 mi

Library location – expenditure per person

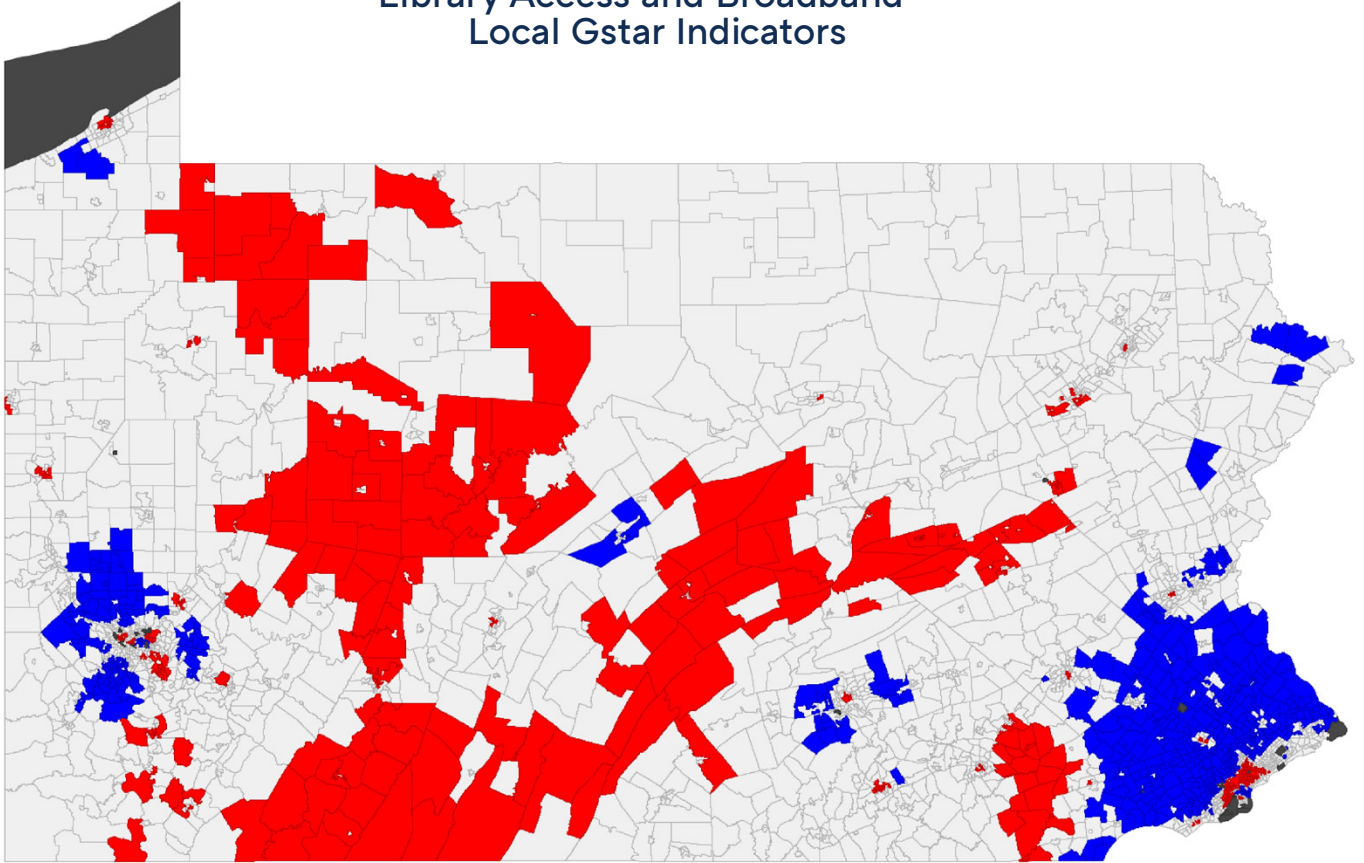
- ☆ \$0 – \$15
- ★ \$15 – \$26
- ★ \$26 – \$39
- ★ \$39 – \$63
- ★ \$63 – \$105
- 10-mile buffer

% Residents without broadband in home

- no data
- 0 – 8%
- 9% – 16%
- 17% – 24%
- 24% – 35%
- 35% – 60%

Data sourced from US Census (2019) and the Office of Commonwealth Libraries (2019)

## Library Access and Broadband – Local Gstar Indicators



*Autocorrelation with neighboring tracts in terms of percentage of residents without broadband access in the home*

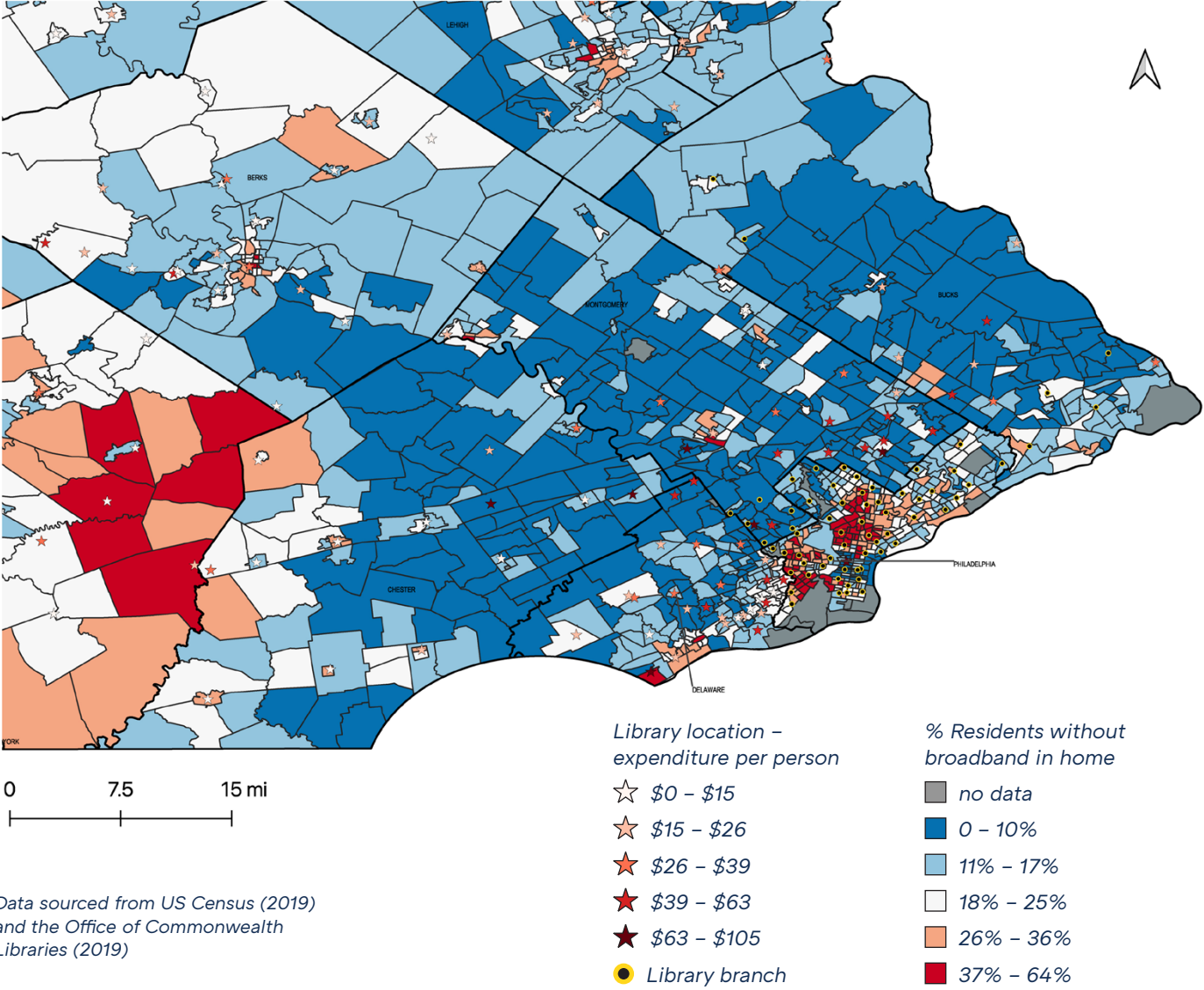
□ **Not Significant** (2117)

■ **High:** Tracts that are similar to their neighbors in terms of high numbers of residents without broadband access in the home (440)

■ **Low:** Tracts that are different from their neighbors in terms of high numbers of residents without broadband access in the home (633)

■ **Undefined** (28)

# Library Expenditure and Internet Access, By Tract – Philadelphia Region



**TABLE 2. Mean Statistics and Independent Samples t-tests (N=3,218)**

VARIABLE	NO LIBRARY		WITH LIBRARY		df	t	p-value
	M	SD	M	SD			
Total population	3934.65	34.38	4150.65	70.49	3216	-2.66	.01
Population density (per sq. mile)	5129.61	155.12	4617.01	276.10	1016.68	1.62	.11
Percentage of Black residents	12.54	.43	10.81	.82	947.81	1.86	.06
Average household income (in U.S. dollars)	83358.50	753.85	76022.63	1506.82	3188	4.25	<.001
Educational attainment (percentage of residents over 25 with less than a high school degree)	9.71	.15	10.23	.29	3194	-1.55	.12
Poverty rates (percentage of residents below the poverty line)	13.56	.24	14.57	.45	986.62	-1.99	.047
Vacancy (total number of vacant housing units)	188.59	4.52	244.05	10.60	832.24	-4.82	.002
No broadband (Percentage of residents without broadband access in the home)	18.61	.18	21.46	.38	3188	-6.69	<.001

**TABLE 3. Correlations Between Library Expenditure Per Person and Census Tract Variables (N=450)**

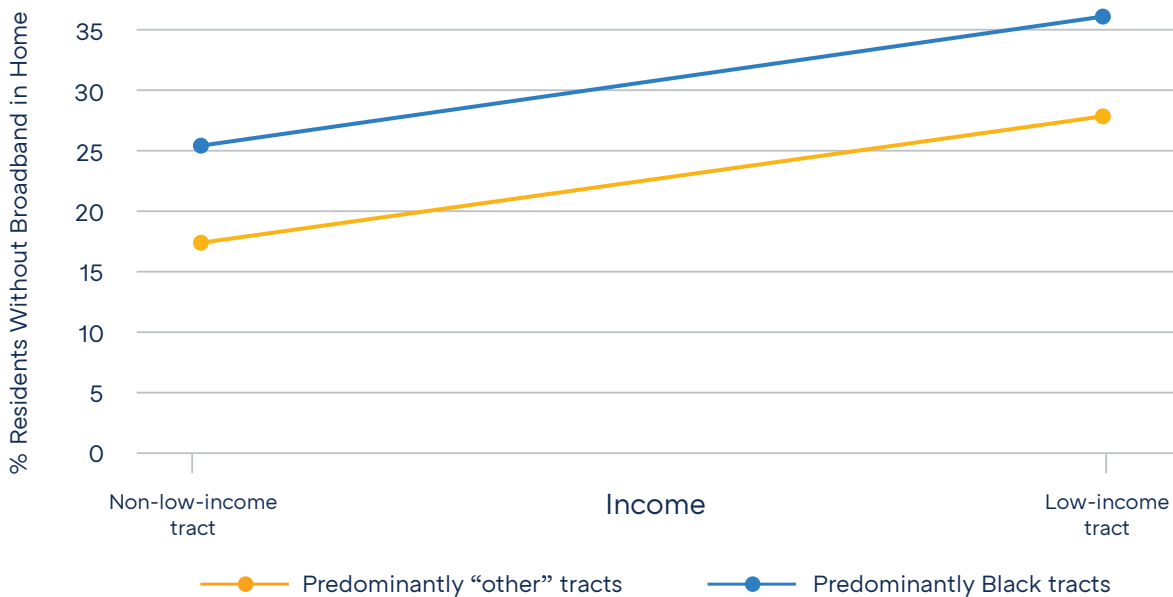
VARIABLE	1	2	3	4	5	6	7	8	9
1. Library expenditure per person	-								
2. Total population	.004	-							
3. Population density (per sq. mile)	.11*	-.16***	-						
4. Percentage of Black residents	.06	-.17***	.36***	-					
5. Educational attainment (percentage of residents over 25 with less than a high school degree)	-.19***	-.10*	.16***	.21***	-				
6. Average household income (in U.S. dollars)	.29***	.36***	-.21***	-.22***	-.52***	-			
7. Poverty rates (percentage of residents below the poverty line)	-.14**	0.35***	.44***	.41***	.51***	-.65***	-		
8. Vacancy rates (percentage of vacant housing units)	-.04	-.06	-.16***	.05	.18***	-.025***	.20***	-	
9. No broadband (Percentage of residents without broadband access in the home)	-.20***	-.33***	.12*	.61***	.62***	-.68***	.64***	.26***	-

\* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

Note. Analysis was conducted with tracts with main libraries only. Tracts with only branch libraries ( $n=105$ ) were excluded from this analysis due to missing expenditure data for branch locations. As such, the results from this correlational analysis should be interpreted with caution.

To further explore trends in access to broadband, particularly in relation to income and race, an additional two-way analysis of variance was conducted. For this analysis, two additional independent variables were created: (1) “low-income” indicates a tract with greater than 25% of residents living in poverty (Office of Policy Development & Research, 2022) and (2) “predominantly Black” indicates tracts with 75% or more Black residents (Scholl, 2021). As can be seen in Figure 1, the mean percentage of residents without broadband in the home was higher for tracts with predominantly Black residents, a difference which held even when looking across low- and non-low-income tracts. In short this means tracts with predominantly Black residents begin and end with higher percentages of residents without broadband, a difference that holds across income levels. In Figure 1, the blue circle on the lefthand side indicates that around 25% of residents in tracts that are predominantly Black and non-low-income do not have broadband in the home. In fact, there are 39 tracts that are predominantly Black and not low-income that fit into this circle. Of these tracts, 7 have a library in them. The blue dot on the righthand side indicates that over 36% of residents in tracts that are predominantly Black and low-income do not have broadband in the home. In fact, there are 101 tracts that are predominantly Black and low-income that fit into this blue circle. Of these tracts, 12 have a library in them. The implications of these findings are discussed below.

**FIGURE 1. Residents Without Broadband in Home (by Income, Race)**





# Discussion and Implications

Overall, findings from the present study indicate that public libraries in Pennsylvania are, at least spatially, “open for all” (Scott, 2011, p. 191). That is, library locations are evenly distributed across the state with regards to population density and race in terms of Black residents. This is an important finding that supports the argument of libraries as “democratic equalizers”, allowing for individuals from different backgrounds to utilize libraries for a variety of informational, educational, and labor needs (Summers & Buchanan, 2018). Libraries also tended to be in tracts with lower average household incomes. This contrasts with findings from Cheng et al. (2021) which showed spatial inequity in library access for socially disadvantaged populations in three U.S. cities (Washington D.C., Baltimore, and Chicago). In their study, Cheng et al. (2021) found that Census tracts with higher percentages of socioeconomically disadvantaged populations (i.e., those in extreme poverty) tended to be located further from public libraries. Findings from the present study find the opposite, indicating that public libraries in Pennsylvania may in fact be well-positioned to serve those who need their services and resources the most.

Library expenditure per person varied widely across the state with correlational tests showing it was positively associated with income and negatively associated with poverty rates. In other words, tracts with less poverty are receiving more expenditure per person. This is not surprising as 85% of libraries in Pennsylvania are designated as federal 501(c)(3) not-for-profit corporations and rely on fundraising (H. Sharpe, personal communication, February 23, 2021), which may produce varied funding results in relation to community income and poverty rates. However, the correlational tests should be rerun once branch-level expenditure per person data becomes available to confirm if this finding holds when including libraries in the greater Pittsburgh and Philadelphia areas.

With regards to educational attainment, tracts with libraries had higher numbers of residents without high school degrees, although this difference did not reach statistical significance. This is an interesting finding given that the 2016 Pew Report found that 40% of people who said that if their local library closed it would have no impact on them were residents without high school degrees (Horrigan, 2016). Thus, residents most at-risk for not earning a high school degree could be the target of library interventions to both build relationships with these residents while also supporting their journey to a high school degree. Further, given that economic status appears to be associated with educational attainment at the tract level, and since libraries are in tracts with lower average incomes and higher poverty rates, it stands to reason that public libraries are well-positioned to support at-risk residents with earning a high school degree through targeted interventions.

The number of vacant housing units in tracts with libraries was significantly higher than tracts without libraries. Given that high vacancy rates have been associated with lower rates of neighborhood cohesion and residential stability (Owens & Sampson, 2013), libraries are potentially well-positioned to leverage themselves as “cultural hubs” to bring residents together and create cohesion by offering programming, services, and space for community members to create and share resources (Summers & Buchanan, 2018). However, the 2016 Pew Report also found that Blacks and Hispanics said libraries should be more comfortable for them to read and work (Horrigan, 2016). Engaging in culturally responsive and racially affirming ways with Black and Hispanic residents to ensure that libraries are providing comfortable and safe spaces for community members could be one potential focus area for libraries.

Public libraries were in tracts with significantly higher percentages of residents without broadband in the home. In other words, libraries may be well-positioned to provide broadband access to those who need it most. The “hot spots” from the cluster analysis can be used to guide decisions about which libraries could be leveraged to expand broadband access to residents most in need. Alternatively, tracts with predominantly Black residents also had higher percentages of residents without broadband in the

home, a difference that held across income levels. Given the critical role of broadband access as a social determinant of health (Benda et al., 2020), and the ongoing effects of systemic racism experienced by many Black residents (Paradies et al., 2015), libraries could target tracts with predominantly Black residents, particularly those designated as low-income, to expand broadband access.

The geospatial maps created through this study also present a unique addition to our understanding of how public libraries and public library resources are distributed across the state of Pennsylvania. These maps highlight areas that are saturated with public library access (i.e., that have multiple libraries within a 10-mile radius), as well as areas with limited or no library access within ten miles. They also provide a visual representation of library locations in relation to tracts with lower educational attainment rates, higher poverty rates, and lower access to broadband internet. As such, these maps may provide guidance on which areas of the state to target with specific programs or services. Attending to the expenditure per person also adds a layer of understanding to what libraries in these areas of interest can provide. Grant or fundraising opportunities at these specific locations might utilize these maps to demonstrate need in the broader state context. Public library staff may also use these maps to better understand the demographic nature of the communities they serve. In short, the geospatial findings from the present study shed “socio-spatial light” on the range of important issues facing residents and public libraries alike in the state of Pennsylvania (Neuman et al., 2021, p. 821).

## Limitations

There are three main limitations to this study. First, library access was defined as having a library in a Census tract. While this definition allowed us to utilize the rich data sets provided by the U.S. Census, it does not fully capture library service areas. Library service areas, as noted, are much larger areas than Census tracts. Although they are well-defined, they present their own challenges. First, they do not align with preexisting data sets, making it hard to conduct ecological studies. Second, people may still use libraries in adjacent service areas and not the library in their designated service area. These challenges would need to be addressed in future studies that do not use Census tracts or other readily available spatial boundaries to define access.

Second, the present study was mainly descriptive. As such, it does not provide causal evidence for the impact of libraries on communities. To make causal claims about library impacts at the ecological level, we would need a clear definition of library access that corresponds to data from either a preexisting source or that is collected as part of the study (e.g., a random sample of residents from each library service area), and that is available over time.

Third, the correlational analyses conducted in this study, although interesting, were completed without data for library branches, many of which are in the greater Pittsburgh and Philadelphia areas. As such, the findings from these analyses are likely biased to non-urban spaces and should be rerun when library data becomes available at the branch level.

## Future Directions

Although the findings from this study provide rich contextual information for libraries in Pennsylvania, there remains much work to be done. As Gilpin et al. (2021) argue, despite the abundance and popularity of libraries, we know relatively little about them from a research perspective. One avenue for expanding the research presented here would be to obtain library data for the branches (specifically expenditure per person) and rerun the correlational analyses to see if the findings hold. A second avenue with regards to broadband access is to survey and interview residents in predominantly Black and low-income tracts to find out what their self-reported needs are regarding broadband access. A third avenue would be to research the impact of public library broadband access in communities that lack it. A fourth avenue would be to explore if all residents in Pennsylvania benefit in the same way from library services (e.g., are there differences by race or income?). Relatedly, a question explored could be, how are residents' library experiences impacted by having library staff and librarians that look like them? These potential avenues for research are all in addition to studies on the impact of library use on users specifically, which is also an understudied area.

Although the findings from this study provide rich contextual information for libraries in Pennsylvania, there remains much work to be done.

## Conclusion

In conclusion, public libraries are widely distributed public institutions that serve diverse communities across Pennsylvania. Libraries also appear well-positioned to support those most in need with regards to income, educational attainment, neighborhood characteristics (i.e., vacancy rates), and broadband access. Given this potential, more research is needed to understand libraries' impact on library users specifically and community members at large.

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