Mapping the Impact of Public Library Programming on Youth in the Mountain West

Brooks W. Mitchell

Department of Geography, Penn State University

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Abstract

Public libraries in the United States of America are being asked to provide a wider and more diverse set of services than ever before. At the same time, overall public library expenditures and new public library construction have remained stagnant. Libraries and their staff are effectively being asked to do more with less, and those who make decisions about resource allocation to and within public libraries need tools to better understand how different public library services impact communities. Previous research has found a positive correlation between youth testing scores and both public library presence and public library funding. This research, however, has not considered that library system service areas are geospatially unique and dependent on multiple accessibility factors. This exploratory study took the "reality" of library service areas into consideration in looking for correlation between library public programming attendance rates, both alone and in the presence of other demographic and socioeconomic variables, and lagged graduation rates in a study area of Arizona, Colorado, New Mexico, and Utah. It utilized a geographically weighted regression analysis to better understand the relationship between public library programming attendance rates and graduation rates, whether the relationship remained significant in the presence of other variables, and how that relationship changed across localities. Results indicated that a weak positive correlation existed between 2013 public library programming attendance rates and 2017 four-year graduation rates. This weak positive correlation remained statistically significant in consideration with other predictor variables including diversity, health insurance spending, household size, husband-wife households, and multigenerational households. Results also showed that the direction and strength of variable relationships varied within different localities of the study area.

Introduction

Public libraries in the United States currently stand at a crossroads. Now, more than ever, they are expected to provide an ever-increasing number of services for the communities that they serve (Silkey and Rumery, 2013). These services extend far beyond just circulating books, and now include things like job skill development, internet and technology access and training, public forums, and multigenerational public programming (Baek, 2013). A 2015 Pew survey on public libraries (n = 2004) found that of all public library services, the majority of respondents "definitely" wanted their local public library to prioritize the following: childhood literacy programs; more coordination with local schools; digital access and training; cybersecurity and privacy training; active military and veteran-focused programming; dedicated working and reading spaces; programs specifically for immigrants; economic development opportunities for local businesses; and Makerspaces. Public libraries have become the community "public square" by providing a free of charge learning ecosystem where all members of a community can gather and take advantage of information, educational programming, and policy discussions (The Aspen Institute, 2014; Dusenbery, 2014; American Library Association, 2018).

Communities have asked for more from public libraries, and public libraries have responded. Public Library Survey (PLS) data from the Institute of Museum and Library Services (IMLS) indicated that nationwide public library programming attendance increased by 41.5% between 2010 and 2018, with young adult program (programs designed for ages 12-18) seeing the largest growth. During that same period, registered library users increased by 1.5% and public library "open hours" increased by 2.8%. While overall book circulation numbers decreased by 11.7%, physical video collections grew by 28.8% and ebook collections grew by 2901.2%. The PLS even began tracking the circulation of physical items in 2016 to account for public libraries that had begun checking out state park passes, scientific equipment, home
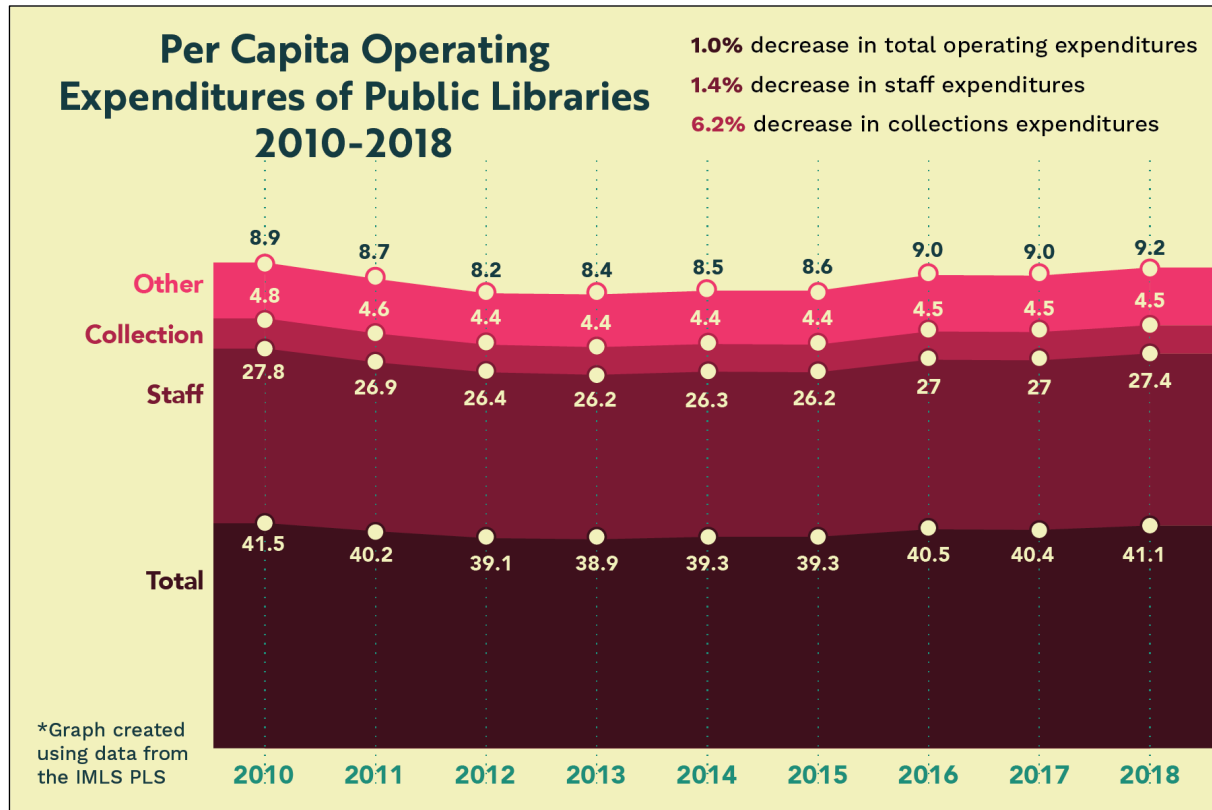
repair tools, and other "nontraditional" items. Nearly 1.9 billion of these items were circulated by 9,261 library systems in 2018.
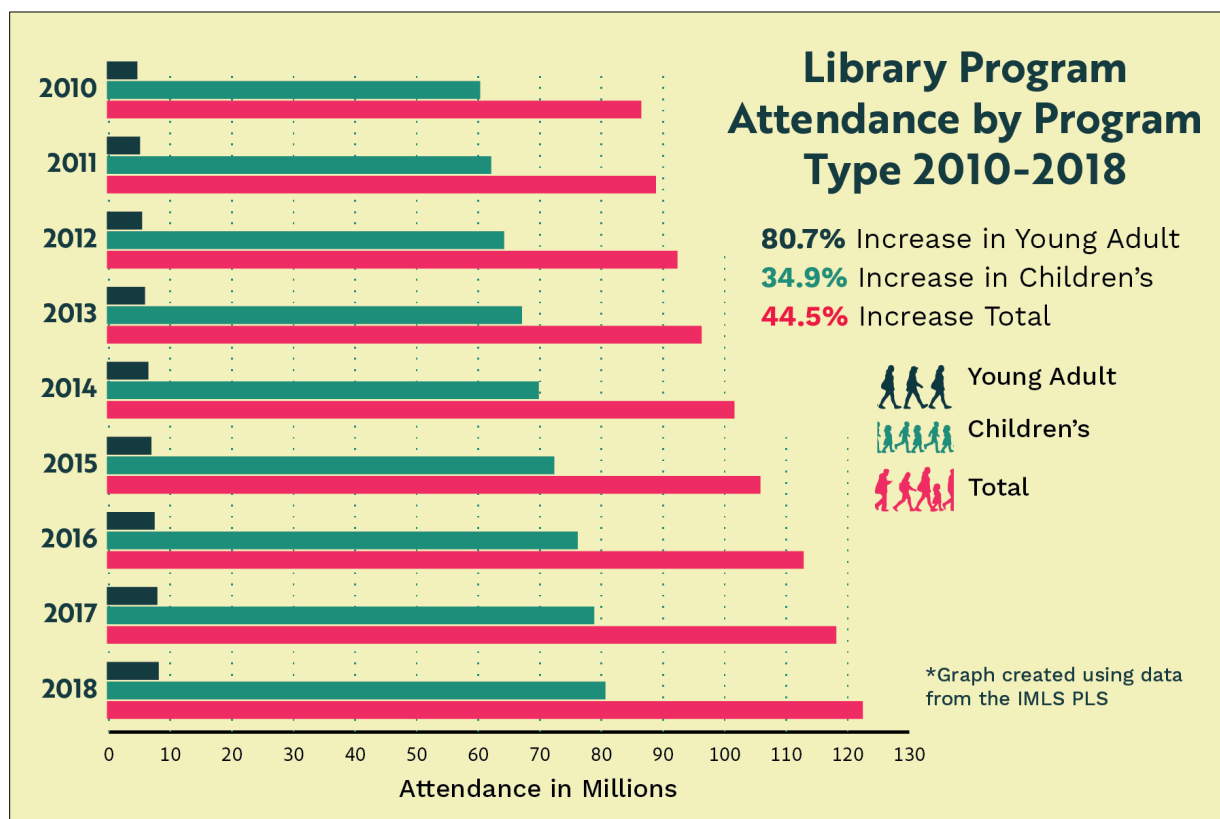
Figure 1. Public Library Survey data shows a steady increase in library programming attendance from 2010-2018. Image courtesy of the Space Science Institute.

While the scope of public library services has expanded, financial and facility resource support during this time has remained stagnant. Data from the American Academy of Arts and Sciences' *Humanities Indicator* reveals that, when adjusted to 2018 dollars, total library expenditures from 2010 to 2018 decreased by 1.0%, staff expenditures decreased by 1.4%, and collections expenditures decreased by 6.3%. PLS data shows that the total number of physical library outlets decreased by 0.9% during this time. Libraries are being asked to do more with less, and those that make strategic decisions about resource allocation towards and within libraries (such as

policy makers, grant administrators, library directors, and library staff) need quantitative analysis on the ways in which various public library services impact communities.

Per Capita Operating Expenditures of Public Libraries 2010-2018

1.0% decrease in total operating expenditures
1.4% decrease in staff expenditures
6.2% decrease in collections expenditures

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Other	8.9	8.7	8.2	8.4	8.5	8.6	9.0	9.0	9.2
Collection	4.8	4.6	4.4	4.4	4.4	4.4	4.5	4.5	4.5
Staff	27.8	26.9	26.4	26.2	26.3	26.2	27	27	27.4
Total	41.5	40.2	39.1	38.9	39.3	39.3	40.5	40.4	41.1

*Graph created using data from the IMLS PLS

Figure 2. PLS data shows minimal change in operating expenditures amongst public libraries from 2010-2018. Figure courtesy of the Space Science Institute.

Youth academic success is one potential benefactor of public library services. Schools are traditionally thought of as *the* place for children and young adults to develop disciplinary knowledge; however, they are just one piece of a community ecosystem of learning that also includes public libraries, museums, businesses, and the home setting (Baek, 2013). Informal learning environments like libraries play a vital role in engaging youth to learn about the natural world and to develop the skills

needed for learning (NRC, 2009; Bevan et al., 2010; Fenichel & Schweingruber, 2010). Research shows that well-funded libraries positively impact youth testing scores in the communities that they serve. *The Returns to Public Library Investment* (Gilpin et al., 2021) looked at youth (grades 3-8) testing scores in school districts located within five miles of public libraries that received a small-scale capital investment of $1,000 or greater per-student. It found that youth saw a gradual increase in reading test scores in the years following a library capital spending shock, with maximum gains occurring in years 5-7. This effect was larger in smaller school districts and in districts with lower school capital improvement spending per-student, suggesting that public libraries may have helped compensate for lower school funding and that their impact may have been stronger in communities where their presence was more salient. In comparison with prior research, Gilpin et al. found that average test score increases from library capital spending shocks were 29% the size of the increases from school capital spending shocks while at only 15% of the cost.

While prior work has been done to understand the "return on investment" of public libraries as a whole and importance of their funding, there has been little research on the role of public library *programming* and its potential impact on the academic success of young people. Public library programs include activities such as storytimes, book clubs, STEM activities, engineering design challenges, solar and night sky viewing, Makerspaces, coding clubs, robotics, crafts, adult learning classes, and much more. These programs are typically led by a library staff, occasionally with help from a community partner or content expert. Public library programs are a more-accessible alternative to other informal learning programs from museums, science centers, and zoos and aquaria, and they are well-positioned to help close the learning gap that underserved and underrepresented youth often face (Afterschool Alliance, 2014; NRC, 2015). The benefit of public library programming extends far beyond programs targeted just at children or young adults; library programs designed for adults, families, and older persons all contribute to an ecosystem of learning for youth. Research shows that when families, schools, and communities work together to

support learning, students perform better academically and stay in school longer. When families are engaged in their children's science, technology, engineering, and math (STEM) learning, for instance, youth enjoy stronger early STEM abilities and are often more likely to take higher-level science and math courses and consider STEM-focused careers (Maltese & Tai, 2011; Caspe et al., 2018). A family's attitude of learning as a positive experience is the single most important predictor of student success, and public library programs can provide positive learning opportunities for all family members (Henderson and Mapp, 2002; Harackiewicz et al., 2012).

To provide decision makers with needed information to make strategic choices about library services, this exploratory study used geospatial analysis to answer the following questions for a defined study area and time range:

1. *What is the relationship between public library programming and graduation rates?*
2. *What does that relationship look like in the presence of other socioeconomic variables?*

Based on review of prior literature and personal experience, it was hypothesized that a positive correlation existed between public library programming and graduation rates. This relationship was hypothesized to be weaker in urban areas with other informal learning environments (museums, science centers, etc.) in proximity and stronger in rural areas where public library services were more salient. It was also hypothesized that this relationship may be hard to interpret in traditionally underperforming school districts where libraries have responded to long-existing community needs (such as low graduation rates).

This research built upon the work of Chew et al. (2020) in looking at SAT scores as a response to socioeconomic and demographic predictor variables through multivariate and geographically weighted regression. The non-library predictor variables used within this study were deemed significant through the work of Chew et al. Although the methods were different, this study also built upon the work of Park

(2012) in providing a more realistic representation of the geographic service area of a library. Official library service areas (LSAs), whether they exist on a municipal, county-wide, or specialized basis, may not be representative of who is *actually* visiting a public library and/or attending a public library program. Library cards are often reciprocal statewide and libraries do not typically restrict who can attend programs based on geography (Colorado State Library, 2017). Distance, road networks, public transportation, and perceived "niceness" of a public library all impact the actual geographic service area that a library reaches.

Methods

In this section, I describe the defined study area and timeframe from which data was analyzed. I also detail data sources and describe processes for geospatial analysis.

Study Area

This research's study area consisted of Arizona, Colorado, New Mexico, and Utah, states located within the Mountain West physiographic region and colloquially referred to as "The Four Corners." These states have similar population dynamics: each contains both heavily populated metropolitan areas (e.g., Albuquerque, NM; Denver, CO; Phoenix, AZ; and Salt Lake City, UT) and isolated rural areas. Populations in the study area vary widely regarding size, density, and racial diversity. The Mountain West physiographic region is generally rapidly growing and rapidly diversifying, mirroring a nationwide trend of a lessening of majority white populations (Beavers et al., 2020; Benzow, 2022). In terms of terrain, this study area contains a variety of physiographic regions (figure 3). A common theme is expansive, arid terrain with intermittent tall mountain peaks.
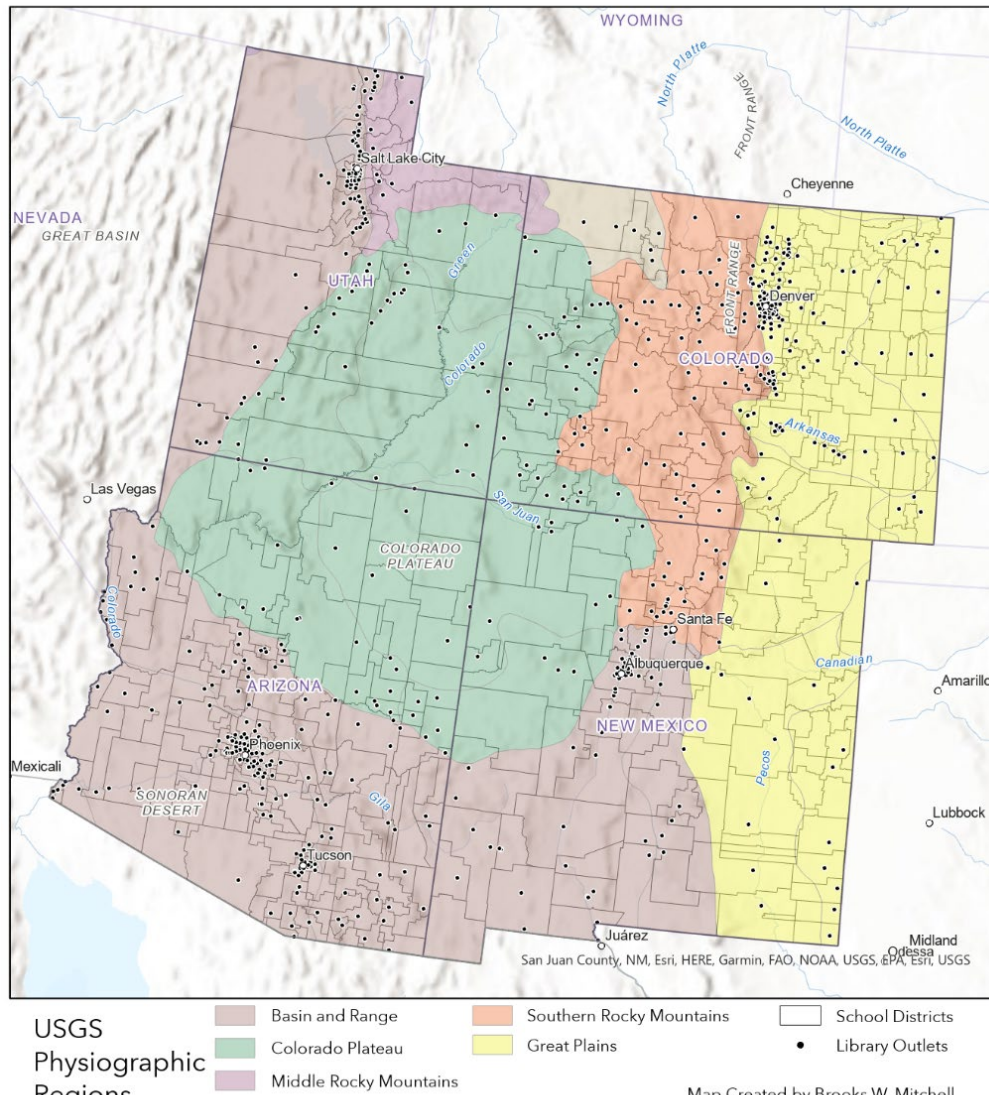
Figure 3. School districts, library outlets, and physiographic regions within the research study area

Timeframe

A longitudinal study looking at individual student activities and academic achievement over a multiyear period would have been an ideal way to pursue this research. Without access to such data, however, this study relied on the concept of space-for-time substitution. Space-for-time is typically used when it is necessary or

more convenient to look at spatial relationships over temporal relationships. Space-for-time may not have the same degree of accuracy as longitudinal studies but can still be utilized effectively with larger datasets (Picket, 1989; Brown, 2019). This study did utilize a temporal element, however, in looking at the relationship between public library programming attendance rates and graduation rates. Graduation from high school is the culmination of multiple years of community support, and youth and family public library programming attendance would likely impact graduation rates in the years preceding graduation. Therefore, this study looked at public library programming from 2013 and lagged graduation rates from 2017. Other socioeconomic variables were taken from 2016-2020 averages.

Data Sources

The Institute of Museum and Library Services' (IMLS) annual Public Library Survey (PLS) collects important statistics about the nation's approximately 9,057 public library systems and their 17,427 public library outlets. A distinction should be made between library **systems** and library **outlets**. A public library system may contain just one library (as is often the case in smaller communities) or may contain several stationary or mobile ("bookmobile") branches/outlets. In 2019, on average nationwide, a library system contained 1.8 stationary branches/outlets. Decisions about individual library outlet budgets and programming efforts are often made on a library system-level. While the PLS provides a list of all public library outlets, it only collects system-level data about public programming (as of this writing in November of 2022). This study included 373 total library systems and their associated 2013 programming data. Total programming attendance numbers for each library district were weighted by the system's perceived LSA population. As an example, a library system with 1,000 total program attendees and a perceived LSA population of 2,000 received a rate of 0.5.

School district boundaries were obtained through the National Center for Education Statistics and any school district not containing a high school was removed, leaving 420 total. These school district boundaries were appended with graduation rate data from individual state education departments. Further processing removed any school district with extreme outlier 2017 graduation rates and any district with less than ten 2017 graduates, leaving 372. This study looked at total graduates, and not demographic or socioeconomic subgroups, to keep the study size as large as possible. The decision to include graduation rates as a response variable as opposed to standardized testing stems from the work of Chew et al., who acknowledged in their discussion that including only standardized testing may not be the most holistic approach to determining academic success.

Socioeconomic and demographic data, including average household size, diversity index, health insurance spending, husband-wife household percentage, and multigenerational household percentage, were taken from American Community Survey 2016-2020 averages and appended to school district boundaries through ArcGIS Pro's "Enrich" geoprocessing tool. Road network files were taken from the Arizona Geographic Information Council, Colorado Department of Transportation, University of New Mexico, and Utah Geospatial Resource Center.

Analysis

A major obstacle in comparing library system data and school district data is that each entity has a unique geographic "service area." Library systems do not all have official service boundaries, and as discussed earlier, those that do often see patrons from outside of official boundaries. Previous related research has used a straight-line or Euclidean method of associating library data with school districts (e.g., "all libraries within five miles of a school district"). However, this ignores the complexity of public library accessibility discussed by Park et al. A five-mile radius in a major urban

area (e.g., Denver, CO) has different accessibility implications compared to a five-mile radius in a rural area (e.g., Cochise, AZ). Geographic information system (GIS) geoprocessing tools give us the ability to create data-rich, realistic library service areas that can be accurately associated with school districts.

Using Cost-Distance Weighted (CDW) allocation, this study created library service areas with boundaries weighted by the presence of other library systems and road networks. A distance allocation assigned every blank space (or "cell") in the study area to the library that it was closest to "as the crow flies." A CDW allocation did the same, but considered the influence of highways, major roads, and local roads in defining "close" (Figure 4).

Figure 4. Library system service areas that were developed through a road network-weighted distance allocation.

These library system service areas were then associated with school districts through the Zonal Statistics as Table geoprocessing tool. This tool determined how much of each school district was covered by each library service area and calculated an average "programming attendance rate" value based on library coverage. As an example:

> *School district A is covered 50% by library system one (LS1) and 50% library system two (LS2). LS1 has an average attendance rate of 0.3 and LS2 has an average attendance rate of 1.3. School district A would have a library program attendance rate value of 0.8.*

Afterwards, socioeconomic and demographic data from the American Community Survey was appended to the school districts through the use of ArcGIS Pro's "Enrich" geoprocessing tool.

Geospatial analysis commenced by running public library programming and the five variables identified as significant by Chew et al. (diversity, health insurance spending, household size, husband-wife percentage, and multigenerational household percentage) through a univariate regression analysis to determine whether their relationships were linear or non-linear. Next, predictor variables were checked for collinearity through Rstudio software and were then run through a multivariate regression analysis with nonlinear variables being splined. Insignificant variables were removed, and this process was repeated until only significant variables remained. The multivariate regression residuals were then checked for spatial autocorrelation and explored further through ArcGIS Pro's Geographically Weighted Regression (GWR) tool, which ran a regression analysis for every feature in a dataset as opposed to one regression analysis for the entire dataset. The "Golden Search" method, which is based on minimizing the value of Akaike Information Criterion (AICcs), determined that 96 was the ideal number of neighbors to use for this GWR analysis.
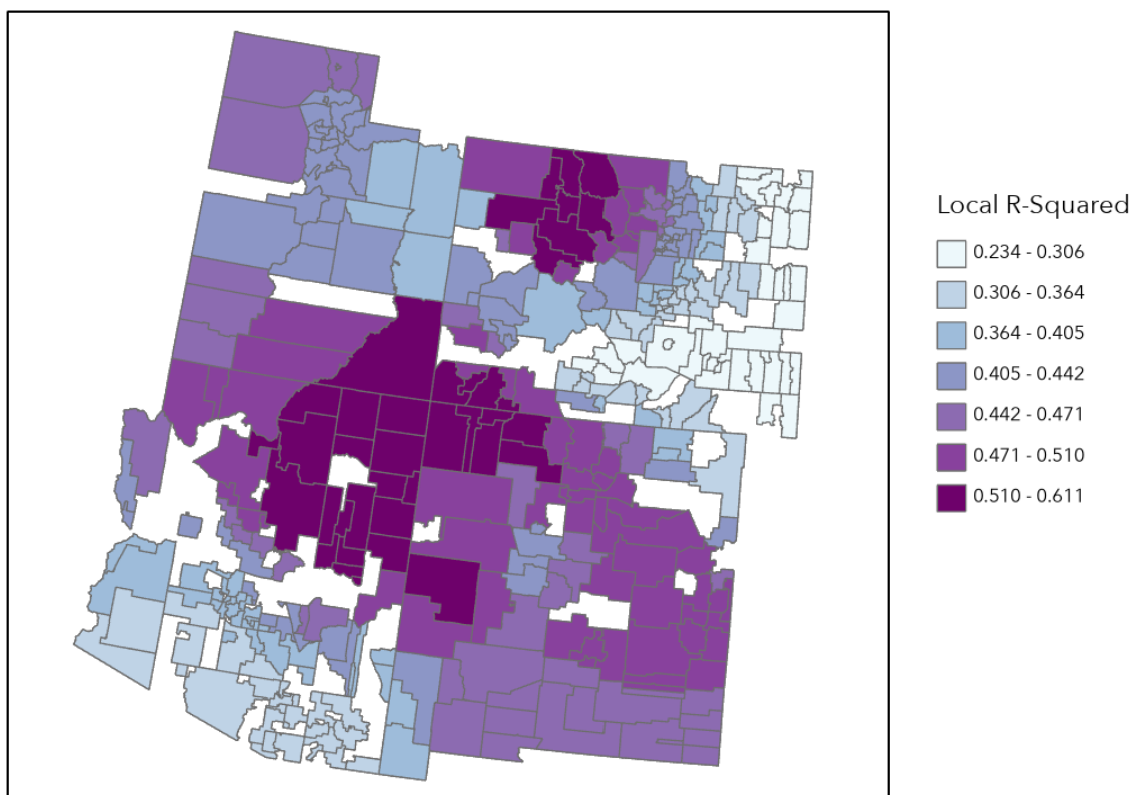
Results

A univariate regression analysis of 2013 public library program attendance rates and 2017 graduation rates in AZ, CO, NM, and UT revealed a weak positive correlation. The linear r^2 value was .007, meaning that the regression line explained 0.7% of the variation in graduation rates. When corrected for nonlinearity through simple polynomial methods, the r^2 almost doubled to .013. Although the correlation was weak, deeper exploration revealed that it varied in direction and strength from state to state: Arizona exhibited a negative correlation with an r^2 of .024 while Colorado exhibited a positive correlation with an r^2 of .045. Correlation was relatively nonexistent in New Mexico (r^2 of .0004) and Utah (r^2 of .002). What geospatial factors in Arizona and Colorado could have led to such differing results? Univariate analysis confirmed the positive correlation between graduation rates and both husband-wife household percentage and health insurance spending. It also confirmed the negative correlation between graduation rates and diversity, household size, and multigenerational household percentage first revealed in Chew et al. (2020). Of these regressions, the positive relationship between health insurance spending and graduation rates exhibited the highest r^2 value at .125.

A multivariate regression analysis revealed that, when combined with five other predictor variables, library programming remained very significant alongside multigenerational households, husband-wife households, and household size. Significance means that we could be highly certain (above 99% certain in this case) that the coefficient did have an impact on the response variable. When these four variables were run in a multivariate regression together, an r^2 of .29 and adjusted r^2 value of .27 were achieved. The residuals from this regression analysis were then run through Global Moran's I to check for, and ultimately reveal, spatial autocorrelation with a score of 3.13. This means that there was systematic spatial variation in how the model performed; areas where the model underestimated the correlation were clustered together and areas where the model overestimated the correlation were
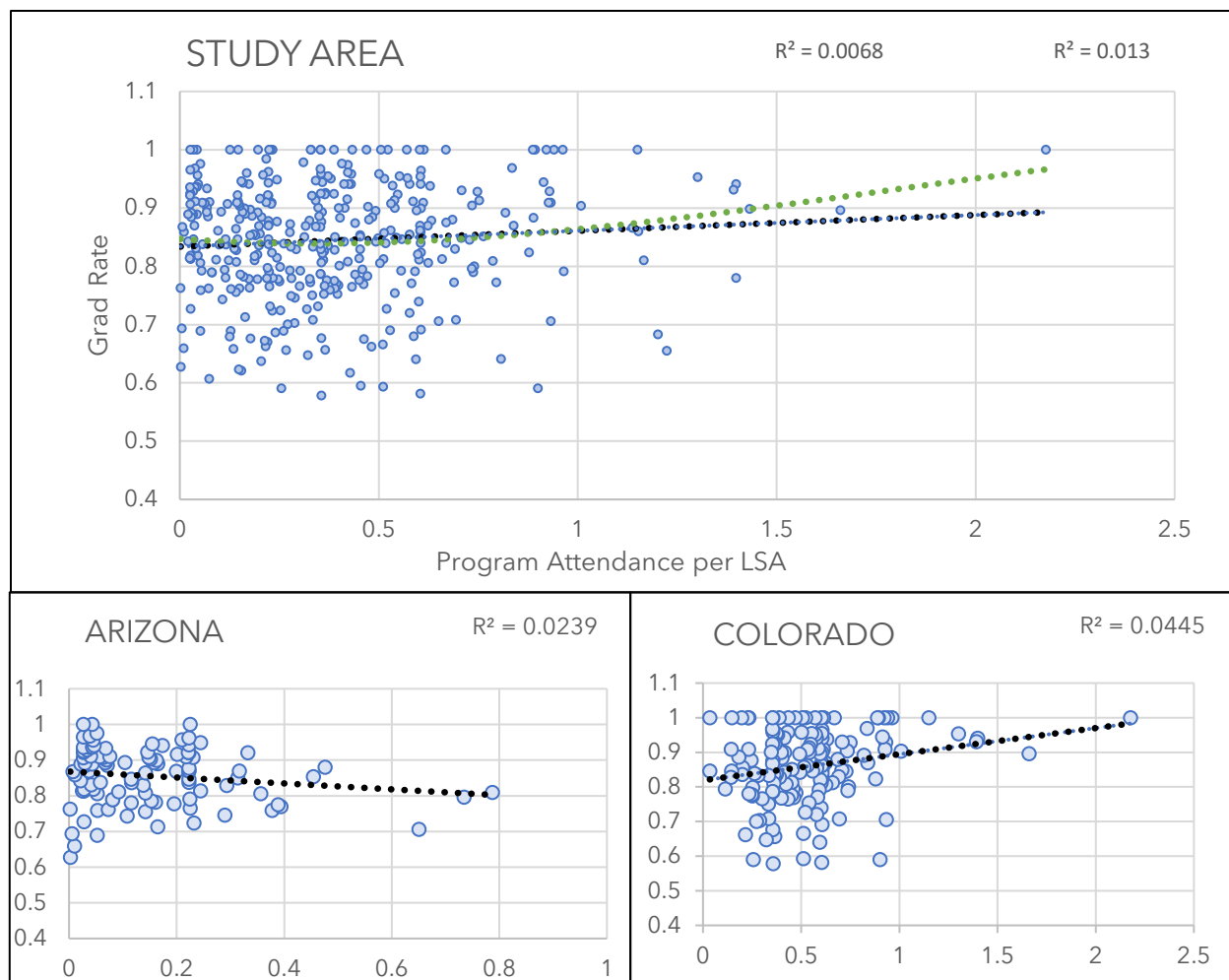
Figures 5 (top) shows the results of a single variate regression between library programs and graduation rate; figures 6 (lower) and 7 (lowest) highlight the relationship in Arizona and Colorado.

clustered together. This warranted further analysis with methods that accounted for spatial autocorrelation. A geographically weighted regression analysis of select predictor variables (library, health, diversity, husband-wife, and household size) achieved an r^2 of .451 and an adjusted r^2 of .334, considerably higher than the multivariate regression. The r^2 value exhibited regional trends, with the model showing stronger fit (r^2 of 0.51-0.61) in the "four corners" region where all the states share a border. The model performed much lower (r^2 of 0.23-0.36) at the eastern portion of Colorado and the southern region of Arizona (figure 8).

Figure 8. A geographically weighted regression model produced variations in local r^2 value throughout the study area.

Analysis of the resulting GWR coefficients revealed that the direction of the relationship between predictor variables and graduation rates changed throughout the study area. For example, the relationship between library programming and graduation rates was positive in most of Colorado and northern New Mexico and negative in most of Arizona. These visualizations can be seen on the following pages.
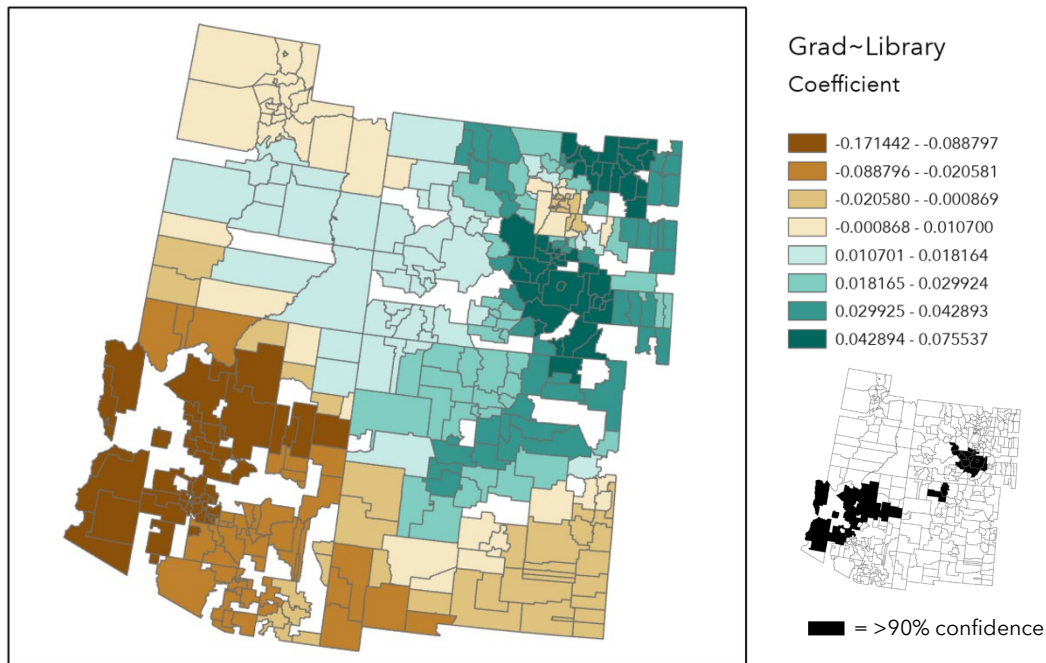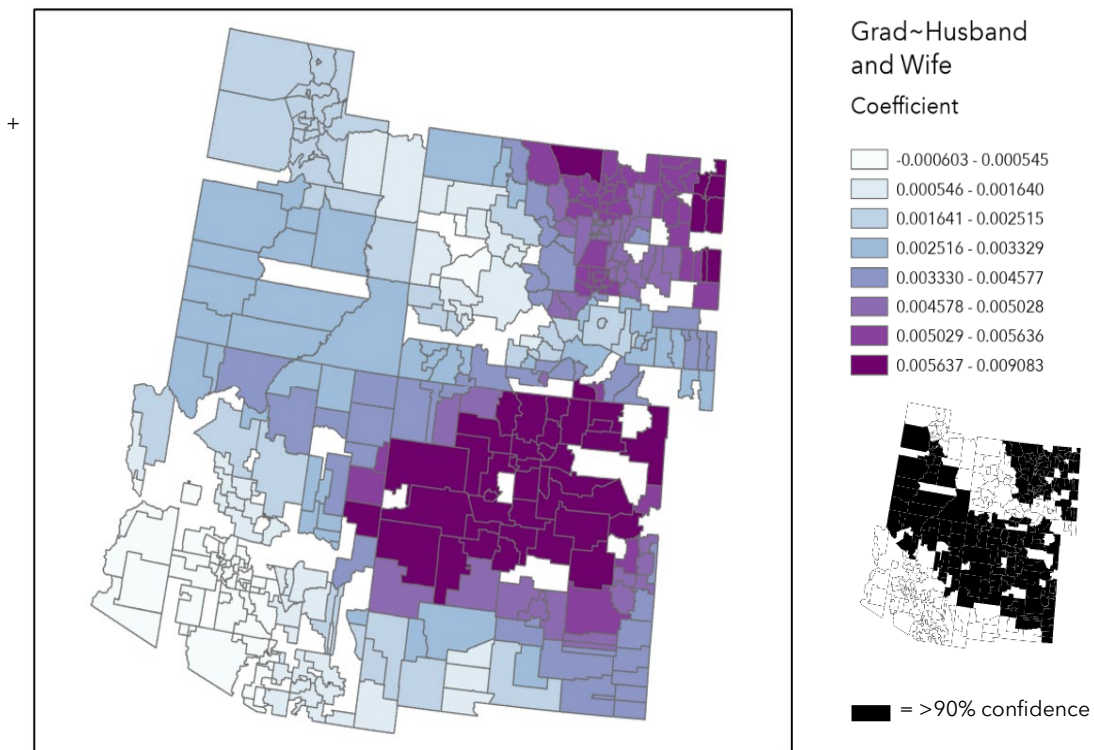
Figure 9. Coefficients of the correlation between library programming attendance and graduation rates. Green indicates a positive relationship and brown indicates a negative relationship.
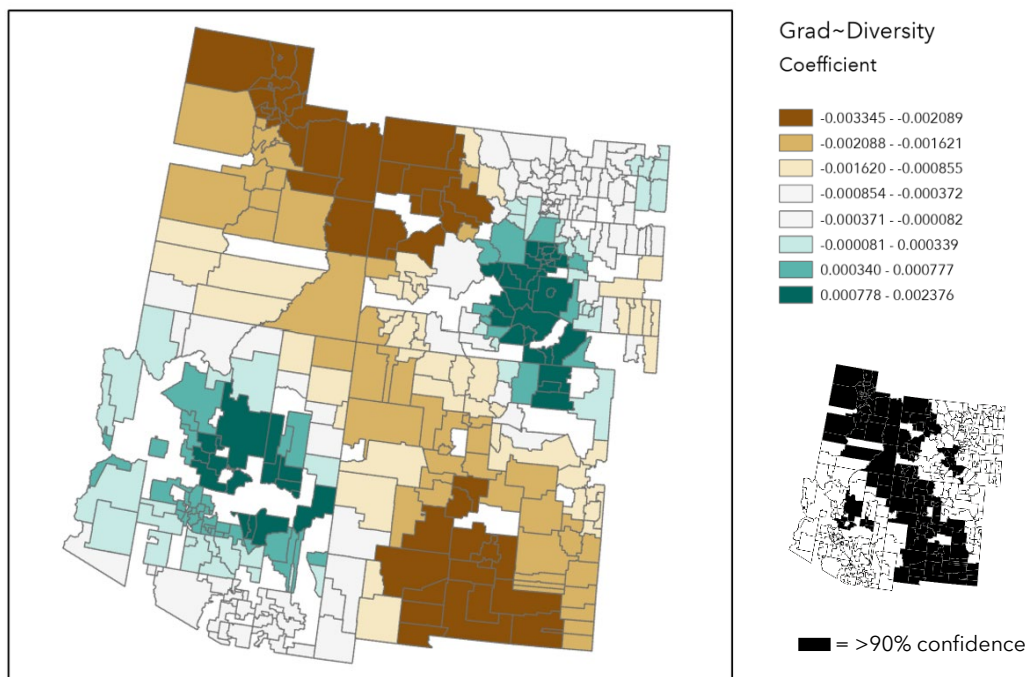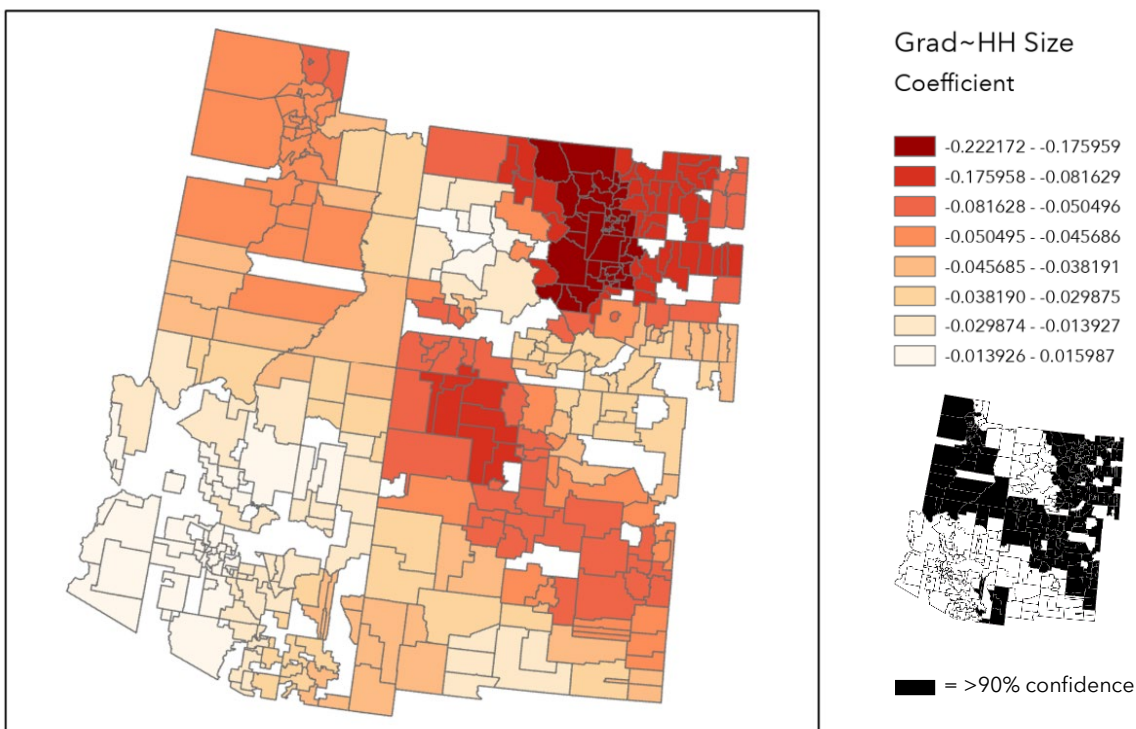

Figure 10. Coefficients of the correlation between diversity index and graduation rates. Medium and dark green indicate positive relationships and neutral and brown tones indicate a negative relationship.
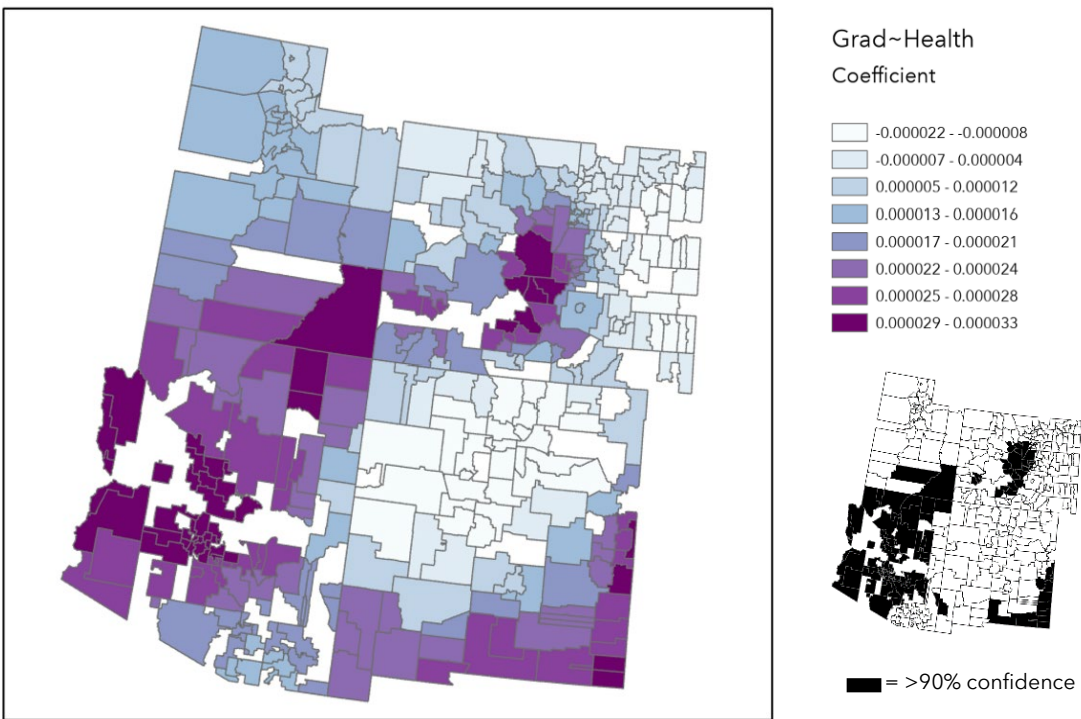
Figure 11. Coefficients of the correlation between health insurance spending and graduation rates. The direction of the relationship was more steeply positive in areas of dark purple.

Figure 12. Coefficients of the correlation between husband wife household percentage and graduation rates. The direction of the relationship was more steeply positive in areas of dark purple.

Figure 13. Coefficients of the correlation between household size and graduation rates. Darker shades of red indicate areas where the relationship was more steeply negative.

Discussion

The study found contrasting relationships between public library programs and graduation rates in Arizona (negative) and Colorado (positive). These results may represent two completely different scenarios. In Arizona, graduation rates have been below the national average for the last two decades and even decreased from 2011-2019. The influence of other social and economic factors may have been too strong to keep graduation rates from rising, but public libraries may have been trying to help compensate by increasing public programming efforts. In Colorado, on the other hand, graduation rates have matched national trends and risen steadily since 2011 (figure 14). If public library programming impacts were to be observed, it would likely be in a state with an upward trajectory of graduation rates. (It should be noted that

graduation rates also rose in New Mexico and Utah, however, where correlation was practically nonexistent.) With a large enough sample size, further research could look at correlations on a state-by-state basis and seek to better understand what unique geospatial factors may lead to differences.

High School Graduation Rate
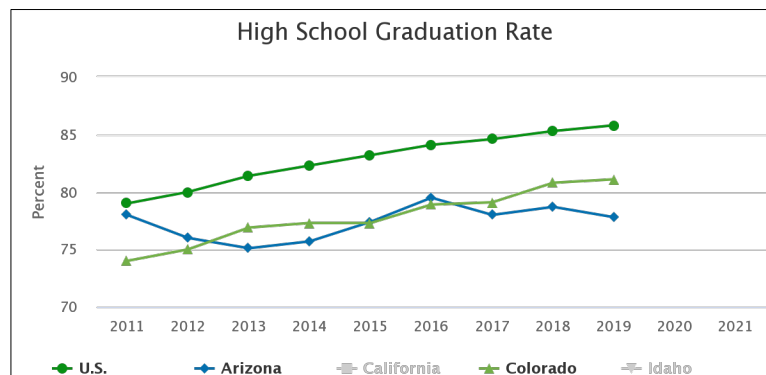
Figure 14 shows graduation rates in the US and in Arizona and Colorado from 2011-2019 (MAP, 2022)

In terms of r^2 values, the overall fit of this study's GWR was lower than the 2020 Chew et al. study by a considerable margin (.45 to .71). This margin could have been due to several factors, one of which being the replacement of "access to educational services" with "public library programming attendance" as a predictor variable. Another possible explanation for this margin is that the two studies geospatially associated predictor and response variables in different ways. Chew et al. created a 1-mile buffer zone around individual schools while this study looked at true school district boundaries. As such, the Chew et al. study looked at specific subset of students – those that lived within relative walking distance of schools. This study, on the other hand, looked potentially at all students within a public school district. Students within walking distance may have been more impacted by the selected predictor variables compared to students outside of walking distance; future research could examine these relationships.

The methods presented in this research, in terms of associating library system data with school district data, are unique and could open new ways of analyzing public library impact. Future work could refine the distance allocation methods presented here and incorporate factors like public transportation networks and library-open hours into the weighting mechanism. Other research could look at the impact of public library services on response variables like crime, homelessness, and economic

development at a census block level. Potential research could even take a more longitudinal approach and measure the *change* in public library programming with change in graduation rates over a period of time. Other major predictor variables for graduation rates exist that were not covered within this study, such as teacher competencies, student motivations, and technological access. The methods and results presented within this research, however, could be useful for those that need to make decisions about public library services now and those that want to explore deeper in the future.

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Data Sources

Academic Success Response Variables

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