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A new decade of uses for geographic information systems (GIS) as a tool to research, measure and analyze library services

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A new decade of uses for geographic information systems (GIS) as a tool to research, measure and analyze library services

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A New Decade of Uses for Geographic Information Systems (GIS) as a Tool to Research, Measure, and Analyze Library Services

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A new decade of uses for geographic information systems (GIS) as a tool to research, measure, and analyze library services

Introduction

Ten years ago, a literature review explored library research that utilized geographic information systems (GIS) as a tool to measure and analyze library services (Bishop and Mandel, 2010). The original review's purpose was to determine the work that had been done in libraries since the advent of GIS and establish future directions for the research area. GIS "are the collection of hardware, software, output devices and practices are that used to analyse and map spatial entities and their relationships" (Schuurman, 2009, p. 277). "If one considers productivity software (e.g., Microsoft Word) as central to processing, manipulating, and visualizing textual information, then a GIS (e.g., ArcGIS) is central to processing, manipulating, and visualizing GI" (Bishop and Grubestic, 2016, p. 22).

Ten years of advancement in technology, increased availability of geospatial data, and increased education of GIS in library and information science programs provided incentive to revisit this topic and compare changes (Bishop and Grubestic, 2016). GIS, the study of its uses, geographic information science, and the many domains that use GIS has greatly expanded. In the last decade, there has been greater functionality of web-based mapping applications, location-based applications on mobile devices, and expanded and democratized access to the creation and use of geospatial data. For example, Google's MyMaps package allows anyone with a Google account to create a map using street addresses. This does not require specialized cartographic knowledge, and it results in maps that lack traditional cartographic elements like a legend. Figure 1 shows an example of a map depicting the locations of all public libraries in Rhode Island, with-using address data pulled from the IMLS Public Library dataset. This increase in access to geospatial data gives libraries and their communities more power to shape the world around them, but not embracing this potential empowerment might lead to marginalization (Byrne and Pickard, 2016). Figure 2 uses GIS to visually compare the square footage of public libraries in Davidson County, Tennessee with the size of the African American population served by those library facilities. Libraries need to remain on the map and this literature review provides some examples of what research has been conducted in the last ten years to that end.

Figure 1. Map of Rhode Island public library locations.

<insert Figure 1 here>

Figure 2. Map of Davidson County, TN public library facility sizes and African American population served.

<insert Figure 2 here>

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The one constant of GIS over these past years remains the multitude of meanings and uses. One GIS literature review showed a high degree of cross-fertilization of ideas, methods, and approaches in numerous fields—all linked by the versatility of geospatial technologies (Wei *et al.*, 2015). That literature review searched “geographic information systems” in all three Web of Science (WOS) indices (i.e., Citation Index Expanded (SCI-EXPANDED), the Social Science Citation Index (SSCI), and the Art & Humanities Citation Index (A&HCI)) over the years 2003-2012 and retrieved 3,290 articles. To conduct a review of the studies that used GIS as a tool in library research requires a more manual approach. There are expanding roles for information professions related to digital curation of geospatial data, but those papers are outside the scope of this review. The purpose of this research paper is to update the exploration of library research that employs GIS as a tool to measure and analyze library services in order to assess the current trends of this research area, and, a decade later, to again suggest new directions.

24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 **Background**

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Roger Tomlinson (1998) coined the term “geographic information systems” while leading the first industry-scale computer-based GIS, known as the Canadian Geographic Information System in the early 1960s (Wade and Sommer, 2006). Nearly thirty years of advancement in the technology and methods using GIS led to Michael Goodchild (1992) proposing “Geographic Information Science” as a term that encompasses the scientific questions, methods, and knowledge that transcend the technology of any particular geographic information system. This contribution conflated the use of the term as the common acronym in geography (i.e., GIS) now meant at least both things to the same community. The term is further complicated in a literature review of library research due to the fact that information professionals also provide services and resources related to organizing, accessing, and using geospatial data (Bishop and Grubestic, 20016). The collective term for this part of GIS in library literature is geographic information librarianship (Weimer and Reehling, 2006). GIS offers other areas of research within LIS beyond geographic information librarianship or utilization of GIS as a tool to measure and analyze library services.

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The uses of GIS vary, but put simply GIS allows real-world phenomena to be mapped and analyzed for more informed decisions. The technology has been used in a wide array of disciplines (Blaschke and Merschdorf, 2014), with a great explosion of research in the geohumanities as an increasing amount of historic data becomes or is born digital, as evidenced by the creation of *GeoHumanities* journal in 2015. Some examples of geohumanities work in libraries include application of GIS to a genealogical information system that embeds spatial analysis into the tracing of migration patterns and family trees (Chang, 2018), the use of desktop GIS to georeference archival aerial

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3 photographs (Kim, 2018), and the use of GIS to analyze and visualize historic Chinese
4 chronicles (Zhu and Bao, 2015).

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6 Any discussion of analyzing libraries' service area populations with GIS should
7 begin with Koontz's (1997) *Library Facility Siting and Location Handbook* and her
8 preceding work (Koontz, 1992, 1995). In the more than twenty years since Koontz's
9 pioneering work in using GIS for library location siting, facility location models, and in-
10 library use, GIS use in library research has grown as she and colleagues continued to
11 further this area (Jue *et al.*, 1999; Koontz and Jue, 2004; Koontz *et al.*, 2009). This
12 literature review looks even further into the future as more uses for GIS within and
13 outside of all types of libraries are found. Early work was conducted mostly in the U.S.,
14 but the GIS library research in this literature review shows many more projects globally
15 than in the 2010 review.

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17 As Xia (2004) indicates, GIS requires a high level of expertise in computers and
18 geography to utilize and uncover significant results. The purpose of this paper is to
19 explore the type of LIS research that does require geospatial technologies software
20 expertise and cartographic and geographic principles to conduct, which is research in
21 which data about the library and its services are analyzed and/or displayed spatially via
22 GIS. The LIS research that is utilizing GIS to analyze library data falls into two primary
23 categories: (1) analysis of library service populations and related adjustments to
24 facilities and services based on user demographics and other variables and (2) analysis
25 of collections, in-library, and other facilities-based use. One way to consider this
26 categorization is that LIS research falling into the first category focuses primarily on
27 variables *outside* the library, and LIS research falling into the second category focuses
28 primarily on variables *inside* the library.

29 30 31 32 33 34 35 **Methodology**

36 *Database Information*

37 One of the databases utilized in the previous study was *Library Literature and*
38 *Information Full Text*. The authors discovered that, when attempting to access *Library*
39 *Literature and Information Full Text*, they were redirected to *Library and Information*
40 *Science Source*, which is owned and maintained by EBSCO. An acquisitions librarian
41 informed the authors that, when EBSCO purchased H. W. Wilson, EBSCO merged their
42 databases with Wilson's, creating new "source" databases. *Library Literature and*
43 *Information Full Text* still exists but its content is now contained under this new source
44 database, *Library and Information Science Source*.

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48 Sources identified in both databases and quantities are listed in Table 1. Thirteen
49 unique categories were identified between both, with four of those being unique only to
50 *Library and Information Science Source*. Quantities in both columns identify the number
51 of sources searched in each database for a given query based on the category. After
52 retrieving the articles, the authors sorted them into these categories to identify what
53 articles would be relevant to the study. Articles identified as Academic Journal were
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3 further categorized based on the authors' criteria mentioned in the Results section
4 below.
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6

7 Table 1. Categorization of Types of Sources in LISS and LISTA Databases
8 <insert Table 1 here>
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10 11 *Literature Review Methodology*

12 This study reviewed the literature on the use of GIS in library research, searching
13 full text for *geographic information system** in two library-related databases available at
14 the researchers' institutions, *Library and Information Science Source* (formerly *Library*
15 *Literature and Information Full Text*, used in the 2010 literature review) and *LISTA*
16 *Library, Information Science & Technology Abstracts*. LISTA indexes over 500
17 academic journals (Garg et al., 2019) and LISS is the database resulting from the
18 merger of Library & Information Science Retrospective: 1905-1983 and Library
19 Literature & Information Science Full text databases (Figureola et al., 2017; Garg et al.,
20 2019). As these were also the two library-related databases at the researchers'
21 institutions, this wide net approach was used to ensure that any article related to
22 utilizing GIS within these library databases would be captured. Other less frequently
23 used derivations of GIS in the United States, such as *geographical information systems*,
24 would also appear with a full text search of *geographic information systems*. Also, this
25 was the same methodology used for the 2010 literature review (Bishop and Mandel,
26 2010), and every effort was made to replicate that study for this one.
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32 The titles and abstracts of these results were analyzed to determine the content
33 of the articles. Articles were marked that related to using GIS as a tool to measure and
34 analyze library services, facilities, and use. Most of the records found with "*geographic*
35 *information system*"* did not match this categorization scheme. Most of the GIS articles
36 retrieved discuss geographic information librarianship with other papers related to the
37 societal context of geospatial technologies, introducing GIS-enabled library
38 programming and services, and utilizing GIS as a tool in other disciplines besides library
39 services (i.e., the articles in the GIS journals indexed in *LISTA*).
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43 The initial study search was conducted in September 2019. The authors then
44 conducted an additional review using the same approach for the remaining articles
45 published in the last quarter of 2019 at the end of January 2020 (i.e., publication date
46 filter September 2019 - December 2019).
47

48 **Results**

49 After analyzing the titles and abstracts and browsing articles' content, 441
50 articles qualified from *Library and Information Science Source* and 432 articles qualified
51 from *LISTA Library, Information Science & Technology Abstracts* (n=873). Of these, 345
52 articles are unique to *Library and Information Science Source*, 336 articles are unique to
53 *LISTA Library, Information Science & Technology Abstracts*, and 96 articles were found
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3 in both databases. Overall, the search yielded 777 unique articles, which were first
4 screened as to whether or not they mentioned geospatial or geographic information
5 systems in libraries. This screening reduced the number of eligible articles to 449.
6 Articles were then assessed for eligibility to be included in the dataset and coded as
7 ineligible, potentially eligible, and eligible. The code was assigned on the basis of
8 whether the articles contained information on libraries utilizing GIS to improve their
9 services (eligible) rather than just offering the service for use to patrons (ineligible).
10 This list was then reviewed by all authors to determine if potentially eligible articles were
11 eligible or ineligible. Figure 3 outlines the process taken to identify the articles used in
12 this study. This process resulted in 36 unique entries.

13 Those articles meeting the authors' established requirements were analyzed
14 based on the abstract and categorized using the same categories used in the 2010
15 literature review (see Table 2):

- 16 1) Analyzing service area populations (n=21; 58.3%), and
- 17 2) Managing facilities and collections (n=11; 30.6%).

18 Two new categories were found:

- 19 3) Both analyzing service area populations and managing facilities and collections
20 (n=2; 5.6%), and
- 21 4) Literature review (n=2; 5.6%).

22 The 2010 literature review found 34 unique articles, 26 in the analyzing service area
23 population category (76.5%) and eight in the managing facilities and collections
24 category (23.5%).

25 Figure 3. Outline of article categorization and selection.

26 <insert Figure 3 here>

27 Table 2. Categorization of Articles Using GIS in Library Research

28 <insert Table 2 here>

29 Findings

30 The following section discusses the findings from the data collection looking at
31 the articles published per year, a framework of the different types of studies conducted
32 in LIS that use GIS as a tool to measure and analyze library services, facilities, and use
33 data, and a brief review and analysis of those studies.

34 *From a Relatively Stable Number of Articles Per Year to a Constant Swing*

35 Looking at the articles per year (Figures 4 and 5) shows relative stability across
36 the previous literature review and greater instability in the number of articles per year in
37 the current literature review. The previous review found 0-2 articles per year for 1992-
38 2003, a major spike in 2004 (n=8; the highest number of articles per year found in both
39 literature reviews), followed by a growth in the yearly range to 2-4 articles per year for
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3 2005-2009. The current review found a much wider swing year to year. Starting from the
4 two articles in 2009, there was a jump to five articles in 2010 and six in 2011, then a
5 yearly decline to a low of one article in 2014, followed by an increase to five articles in
6 2015. That increase was again followed by a decline to 2-3 articles per year for 2016-
7 2019.
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11 Figure 4. Breakdown by Year of Articles Using GIS in Library Research from Previous
12 Literature Review

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16 Figure 5. Breakdown by Year of Articles Using GIS in Library Research from Current
17 Literature Review

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21 *Categorizing the Research in Libraries Using GIS*

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23 The number of articles in the last decade is about the same as the total of all
24 articles found in the previous review (Bishop and Mandel, 2010), but the distribution of
25 the articles by category has shifted. Analyzing service area populations is reduced to
26 comprising about 2/3 of the articles instead of 3/4 and managing facilities and
27 collections is increased to comprising about 1/3 of the articles instead of 1/4. There is
28 also the addition of the previous literature review and the three articles that fit into both
29 analyzing service area populations and managing facilities and collections. Neither the
30 literature review nor the “both” categories were found in the previous review, so these
31 are two new categories of literature on utilization of GIS in LIS.
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34 *Studies That Utilized GIS to Analyze Service Area Populations (Data from Outside* 35 *Libraries)*

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37 In the previous literature review, the discussion begins with Koontz’s seminal
38 work on library facility siting (1997). Use of GIS to analyze library facility site locations
39 remains a prolific area of research using GIS in LIS. Koontz *et al.* (2009) investigate
40 reasoning behind public library closures in a variety of communities, based on a 2000
41 U.S. Census dataset. Johnston and Bishop (2011) draw attention to utilizing GIS in
42 school libraries to analyze the spaces available to both teachers and students, which
43 would help future planning and design of school libraries. Park (2012a, 2012b) uses GIS
44 to determine actual travel distances to libraries from a patron’s home and other
45 statistical and descriptive analyses such as demographics, finding that travel distance to
46 a library influences a patron’s decision to physically visit the library. Donnelly (2014)
47 studies the geographic distribution of libraries around the U.S., noting areas of interest
48 where library concentrations are high and low in both service areas and use.
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51 GIS was also used to visualize data related to public library internet connectivity.
52 Bishop, Mandel, and McClure (2011) report on two projects using GIS in this capacity.
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3 One project used GIS to visualize a national public library internet connectivity dataset.
4 The second project used GIS to visually compare broadband access and speeds at
5 libraries and other anchor institutions across rural counties in Florida.
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7 Library facility site research using GIS is reported around the world. Malec (2012)
8 uses GIS to identify gaps of library services in a coastal region of Slovenia using data
9 based on library physical and mobile locations and population distribution. Vodeb and
10 Vodeb (2015) use GIS technologies to conduct a spatial analysis of the Public Library
11 Network in Slovenia, analyzing the spatial accessibility across the country to expose
12 underserved areas, identify driving times to libraries from patrons' residences.
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15 Several articles report on using GIS to conduct geographic analysis of a
16 community or communities. Sin (2011) uses GIS to identify inequalities and variations
17 among the US's 9000 library systems. They evaluated funding and services against
18 neighborhood income and urbanization levels and found a wide distribution among
19 them, especially in staff with higher education, programs, and digital materials access.
20 Thorne-Wallington (2013) investigates general library access based on library location
21 and other socioeconomic factors in the St. Louis, MO area to show the "role of libraries
22 in providing universal access to new media resources" and raise "new questions about
23 how libraries are distributed across the St. Louis area" (p. 53). Bowen Ayre (2015)
24 discusses the benefits of utilizing geospatial data to enhance library services because it
25 can help libraries understand the communities they serve and their needs.
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30 GIS work beyond the U.S. appeared in this decade of research. Hashmi (2019)
31 uses GIS to survey the geographical characteristics of communities to determine how
32 well libraries in Islamabad, Pakistan, serve their communities through education and
33 political engagement. Vidiček and Novljan (2010) use GIS to add demographic data to
34 geographical data to support community analysis and library service planning in
35 Slovenia.
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38 In addition to using GIS to analyze the geographic characteristics of a
39 community, GIS can be incorporated into community outreach work. Futterman and
40 Michaelson (2012) describe a customer-focused strategy to utilize GIS technologies in
41 increasing and updating library services. Higgs *et al.* (2013) use GIS to investigate
42 library services areas and how they can improve services for patrons in the UK,
43 particularly in digital services with the aim of promoting digital engagement in libraries
44 throughout the UK. Sweeney (2016) recommends utilizing community organizing
45 systems to manage online systems, recommending GIS for community outreach efforts,
46 determining where users and non-users are, and finding gaps. Lindsay *et al.* (2016)
47 studied how mapping software could assess the impact of health information literacy
48 outreach programs in medical libraries.
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52 Only including articles indexed by *Library and Information Science Source* or
53 *LISTA* leaves out some research known to the authors that bears mentioning. For
54 example, Rosichan (2019) discusses how to use GIS in translating information on
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3 community outreach programs, to bring services to areas that need it most, and to show
4 what areas are lacking services (Rosichan, 2019). Also, Higgs *et al.* (2016) published
5 another paper on their work assessing service access in South Wales, UK in
6 *Environment and Planning C: Politics and Space*, which is not indexed in LISTA or LISS
7 but shows that library research utilizing GIS as a tool for spatial analysis of service area
8 populations is being read by a wider audience than LIS.
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11 As with the previous literature review, this review also found that mapping
12 physical locations of users was not the full extent of GIS use in analyzing service area
13 populations; it is also being used in research on virtual reference. Mon *et al.* (2009)
14 track the IP addresses of users of a statewide reference librarian chat service, as well
15 as how and why they access the chat to identify patterns across the state. Bishop,
16 Mandel, and McClure (2011) also research the geographic dispersion of users of a
17 statewide chat reference service. Bishop, Sachs-Silveira, and Avet (2011) studied and
18 discussed weaknesses in a Florida reference chat consortium, noting that, while it is
19 cost-saving, not having the local knowledge the user may need is a major weakness.
20 There are likely many studies that conduct research related to geography that do not
21 use GIS and spatial analyses.
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23 *Managing Facilities and Collections (Data from Inside Libraries)*

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27 There are two primary areas of library research using GIS to analyze and
28 visualize data about facilities and collections: how patrons use the library and collection
29 management. How patrons use the library includes both studies on where patrons are in
30 the library and what they do while they are in the library and studies on how patrons find
31 their way within the facility (wayfinding). In the previous literature review, these articles
32 comprised only a small number of the articles in the Inside Libraries category whereas
33 collection management comprised the majority of the articles in the Inside Libraries
34 category. The results are the opposite now: articles reporting the use of GIS to analyze
35 how patrons utilize the library outnumber articles reporting the use of GIS for collection
36 management.
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41 Regarding library space usage by patrons, Mandel (2010a), introduces
42 MapWindow, an open source GIS, as a free and easy-to-use tool for librarians and LIS
43 researchers to use in analyzing and displaying data about where library users sit, read,
44 congregate, and otherwise use the library facility. Gore (2010) reviews Mandel's
45 proposed methodology. Coyle (2011) describes the benefits and uses of internal
46 mapping of libraries to help librarians understand their patrons' needs and how their
47 libraries operate to increase efficiency and monitor collection development, use, and
48 tracking. Given and Archibald (2015) utilize the visual traffic sweep (VTS) methodology
49 to collect observational data on patrons' in-library use of the facility. Their methodology
50 is designed to help researchers understand users' activities within a library setting to
51 better serve them. Godfrey and Stoddart (2016) suggest advancing from relying on
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3 desktop GIS technologies to web-based GIS technologies to manage in-library use
4 data.
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6 Another study known to the researchers but not found in the review is a paper
7 that combined the methods described by Mandel (2010a) and Given and Archibald
8 (2015). Mandel (2016) used Given and Archibald's VTS method to collect observational
9 data about where patrons were sitting in an academic library during a study week, then
10 employed Mandel's earlier proposed method for mapping in-library use to visualize the
11 results.
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14 Wayfinding was the focus of only one paper reported in the previous literature
15 review. Here, it is the focus of four papers. Mandel (2010b) uses GIS to analyze and
16 spatially display the routes library users taken as they wayfind through the entry area of
17 a public library facility. Hahn *et al.* (2011) investigate library use on mobile devices, such
18 as mapping a route to a sought-after item to provide a blueprint for creating wayfinding
19 systems within libraries. Aguilar-Moreno *et al.* (2016) also report on the development of
20 mobile apps to assist user wayfinding while seeking books in an academic library. Luo
21 (2018) studies habitual wayfinding, identifying repeated patterns of library users as they
22 use the library in order to identify traffic patterns to aid in redesigning academic library
23 spaces. There is another study known to the authors that uses GIS to map library users'
24 routes on the first floor of a public library but did not appear in the search results
25 because it was published in a journal not indexed in LISTA or LISS (Mandel, 2013).
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28 Regarding collection management, Pournaghi (2017) looks at using GIS to study
29 collection maintenance, development, and weeding. They used ArcGIS to create library
30 floor plan maps and individual bookshelf maps to best display the current layouts and
31 evaluate their efficiency in an effort to support redesigned facilities that would improve
32 efficiency and collection management. Shen (2018) uses GIS to map the locations of
33 each book in the library through the library-space information model which includes
34 bookshelves, reading room layouts, and reference desks. This model serves as both a
35 wayfinding resource by helping users accurately find the physical locations of books and
36 a readers' advisory resource because librarians can use this technology to track
37 circulation data and recommend similar titles to inquiries.
38

39 *Both Categories*

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41 Two studies utilized GIS to analyze both inside library data and outside library
42 data. Lim and Park (2015) developed a database that includes data on library site
43 location planning, service area population demographics, and library space
44 requirements based on the size of the population served. This includes note only the
45 total recommended facility size, but also allocations by department such as reference,
46 children's and storage. Lund (2017) explores the employment opportunities made
47 available to librarians willing to step away from an urban landscape to a rural landscape,
48 comparing the service area populations and collection sizes, as well as salary ranges,
49 for rural and urban libraries.
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Literature Reviews on Utilization of GIS as a Library Research Tool

The previous systematic literature review on GIS use in LIS identified two main categories of use of GIS in LIS research (Bishop and Mandel, 2010): analyzing service area populations (data from outside libraries) and facilities management (data from inside libraries). Aguilar-Moreno and Grannell-Canut (2013) reviewed the literature on uses of GIS in libraries. They categorized the work into three groups: visualizing information to help libraries in making decisions, search interfaces, and incorporating GIS data as a library resource. Clearly, the second literature review covers broader topics of GIS in LIS than the first. Research such as spatial discovery and spatial data management remain important, but very different than the studies using GIS as a tool.

Slow Pace of Growth in Utilization of GIS in LIS Research

Xia (2004) had predicted the emergence of GIS utilization in LIS research because of its benefits, such as generating maps to convey more information than tables and text alone and allowing librarians to spatially analyze library services. In addition to these benefits, GIS software shifted from a mainframe computer to a PC desktop setting to web-based applications, experienced reduction of overall costs and more open source options, and seen advances in usability of the systems, all of which were predicted to make the technology more accessible for librarians to use (Donnelly, 2010).

However, this literature review did not find substantial growth in use of GIS in LIS research as compared to the previous literature review. There has been some growth in the studies published using GIS in library research (from 34 between 1992-2010 to 36 between 2009-2019, not counting the two literature reviews found in this study). The spike in studies published in 2015 is promising, but it was followed by a rapid decline back to 2-3 articles per year for the rest of the period under review. The question of why this pace of growth is slow is a big one for LIS to ask itself.

A study found during this review, but not counted as part of the dataset because it did not actually employ GIS as a tool for library research, looked at factors that lead to an ideal setting for library research using GIS (Pournaghi and Babalhavaeji, 2013). These factors are library type (public, academic, special, children's, and institutional); access to collections; activity level of the library based on services offered, patrons served, and number of staff; collection size and breadth; size and space of the library; equipment in the library; and "compatibility," which includes security, environmental factors, and physical appeal of the building. Based on these factors, Pournaghi and Babalhavaeji found academic libraries to be more appropriate for using GIS.

A search of LISTA for the five library types as subject terms, limited to peer reviewed journals found 6,902 results for "public libraries," 14,535 results for subject "academic libraries," 1,351 results for "special libraries," 282 results for "children's libraries," and 70 results for "institution libraries." Since academic libraries appear to be

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3 where the majority of library research occurs, that does not seem to be a factor related
4 to the slow growth of utilization of GIS in library research.

6 **Limitations**

7 The main limitation of this literature review is that the results are from two library
8 literature databases, available at the institution of the authors, and only include the
9 publications indexed within them. Untold numbers of consultation projects may have
10 been conducted at local levels to assess library use and facility site location with GIS,
11 but this paper only reviews the publications indexed in these databases. Using
12 additional databases, inaccessible to these authors at their institution, such as *Library*
13 *and Information Science Abstracts (LISA)* might have provided further articles that
14 match the literature review's criteria. In addition, more consultation projects utilizing GIS
15 may be findable when sought through search engines; however, this avenue was not
16 explored for this literature review.

17 An additional limitation is that this review looked only at library *research* that used
18 GIS. Other publications exist that detail assessment and other projects libraries
19 undertake in which they utilize geospatial technologies, but that do not constitute
20 research. In a column for *Public Libraries*, Sharma (2015) reports on how GIS is
21 primarily used in public libraries. Like Bishop and Mandel (2010), Sharma (2015)
22 identifies that GIS is used for in-library usage and collection development (data from
23 inside libraries) and an assessment and strategic planning tool focused on service area
24 analysis (data from outside libraries). Sharma's examples demonstrate practical uses of
25 GIS in library decision-making that do not meet the rigors of empirical research.

32 **Implications**

33 Over 15 years ago, Xia (2004) predicted an increased use of GIS in LIS
34 research. Ten years ago, Donnelly noted that GIS technology was becoming more
35 accessible to librarians (2010), and Bishop and Mandel (2010) recommended wider use
36 of as a tool in researching library service populations, virtual library services, collections
37 management, facilities management, and wayfinding. Some of that has occurred with
38 the growth in wayfinding research in libraries that uses GIS to visualize the data and the
39 continued work in service population analysis, virtual reference, collections and facilities
40 management.

41 In 2010, Bishop and Mandel had also suggested that future LIS research using
42 GIS might consider geocaching activities, evaluations of marketing effectiveness, and
43 use of GIS in the LIS curriculum. This review found no research on any of those topics.
44 A review from the past decade (2009-2019) of the LIS research that utilized GIS to
45 visualize variables internal and external to the library facility shows minimal growth from
46 the preceding decade (2000-2009). The authors are left wondering why that is. While
47 we (and the literature) recognize the knowledge and skills required to use GIS as a
48 visualization tool, it is not actually more difficult to use GIS software than it is to use
49 statistical software like SPSS or R. Is it just that the specialized knowledge related to
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3 geography and cartography is outside the knowledgebase of many LIS researchers? Or
4 that GIS appears more difficult to use? If either of those conditions are true, then why
5 don't LIS researchers partner with GIS specialists in their cities or universities to
6 collaborate on projects that use GIS to analyze LIS data?
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10 There are many areas where GIS can be a useful tool in library research. In
11 addition to the studies enumerated above and in the previous literature review, there are
12 numerous ways libraries can utilize GIS. For example, GIS can be used to research
13 where bookmobiles are needed based on patron demographics and the most efficient
14 routes for them to take through neighborhoods. Libraries could use GIS to research past
15 natural disasters to assist in planning for the response and recovery to future natural
16 disasters and anthropogenic hazards. Libraries could also incorporate GIS into
17 genealogical and historical research as many aspects of this research relates to places
18 and place history. The power of GIS to support library research is almost limitless given
19 the connection of places to many information needs.
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22 We strongly agree with Xia (2004) that, because maps convey more information
23 than tables and text and allow spatial analysis of library facilities and services, GIS
24 should be used as a tool more frequently in LIS. The authors speculate that the
25 specialized geographic knowledge and expertise required to utilize GIS as a tool limits
26 the quantity of LIS research utilizing GIS as a data analysis and display tool. A few
27 authors of papers found in this literature review seemed to be making concerted efforts
28 to make GIS seem accessible to LIS researchers, such as Lund (2017) and Mandel
29 (2010a).
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32 The 2010 review by Bishop and Mandel had also noted that many of the articles
33 in that review lacked details of their methodology and visualization strategies and steps
34 that made replication difficult. That remains an issue today, as the articles reviewed
35 here also lack such details. Some of that may be due to word limits for submissions to
36 peer-reviewed journals so perhaps authors can include appendices or share their
37 methods online through personal websites or social media. For example, Luo (2018)
38 includes an appendix with the steps for how they visualized patron routes in ArcMap.
39

40 41 **Conclusion**

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43 The literature of a field is constantly evolving. Ten years ago, a review was
44 published of the literature for uses of GIS in library research (Bishop and Mandel, 2010).
45 This review explored what has been published in this area in the decade since finding
46 that the bulk of the literature in this area remains categorizable into two areas: research
47 looking at variables inside the library and research looking at variables outside the
48 library. Two new categories emerged: research that looks at variables both inside and
49 outside the library (this is, in essence, an expansion of the previous review's findings)
50 and literature reviews in the topic area. There has been a slight change in the
51 breakdown of research that investigates variables inside versus outside the library, with
52 slight growth in the percentage of published papers on library research using GIS to
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investigate variables inside the library and a corresponding slight decline in the percentage of published papers on library research using GIS to investigate variables outside the library. As was found in 2010, the continued proliferation of technology and data analytics within libraries and library researchers still does not appear to be resulting in any substantial growth of the use of GIS as a research tool in LIS. GIS offers many areas of research for LIS so the reasons why GIS is not utilized more as a tool in library research bears further investigation--however, with more training, easier access to data and tools, including open source software, another decade will likely provide new creative uses to evaluate library services and resources.

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A new decade of uses for geographic information systems (GIS) in library research

Table 1. Categorization of Types of Sources in LISS and LISTA Databases

Source Type	LISS	LISTA
Academic Journal	1120	472
Blog Entry	1	1
Book / Monograph	1021	29
Conference Papers Collection	2	2
Conference Proceedings Collection	24	57
Country Report	1	n/a
Database	2	n/a
Encyclopedia	1	n/a
Magazine	965	221
Newspaper	5	2
Pamphlet	1	n/a
Report	10	3
Trade Publication	122	45
<i>Total Number of Sources</i>	<i>3275</i>	<i>832</i>

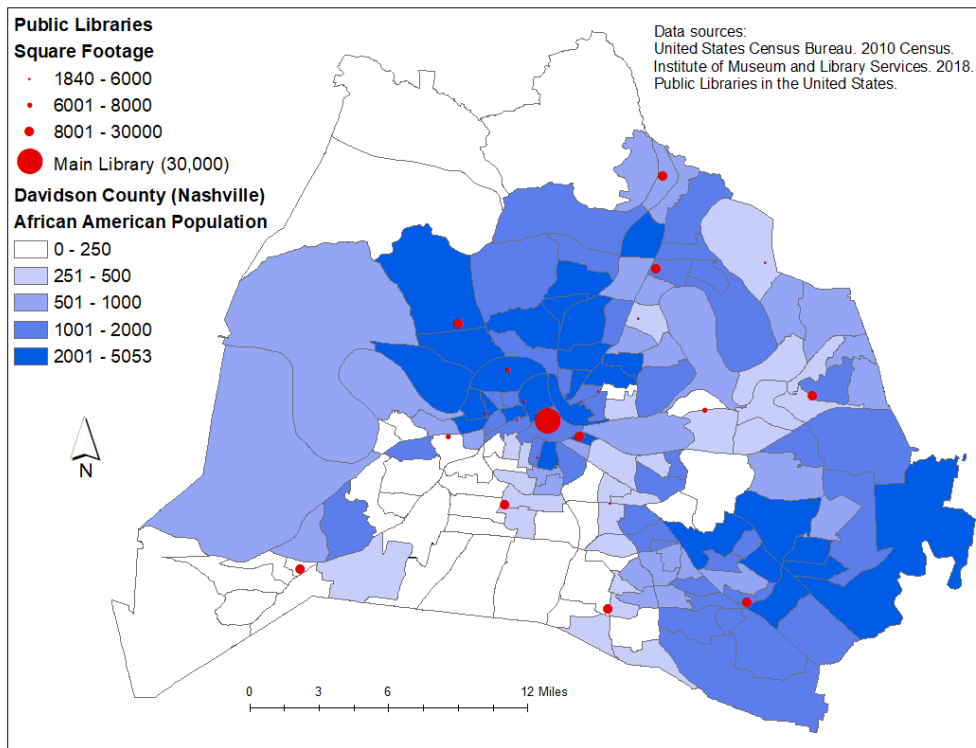
Table 2. Categorization of Articles Using GIS in Library Research

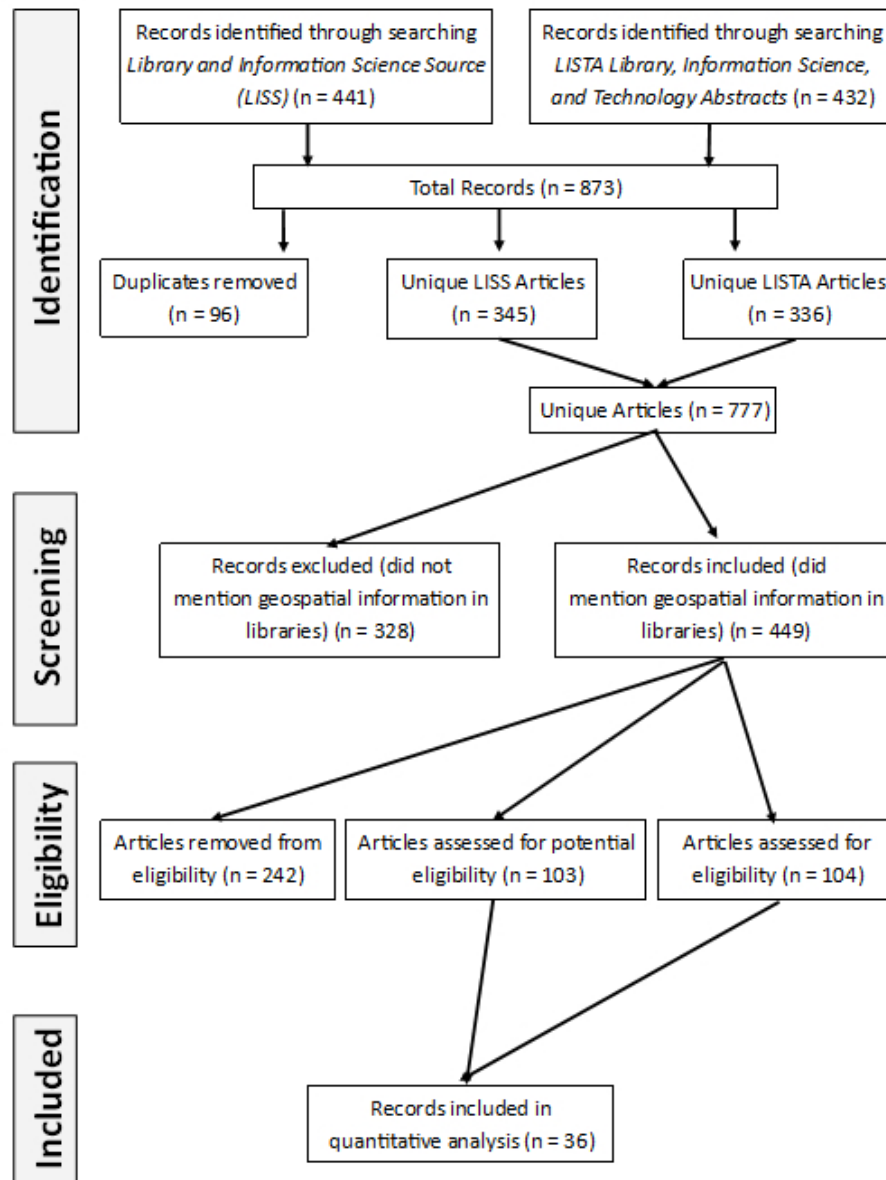
Category	# of Articles
Analyzing service populations	21
Managing facilities and collections	11
Both "Analyzing..." and "Managing..."	2
Literature review	2

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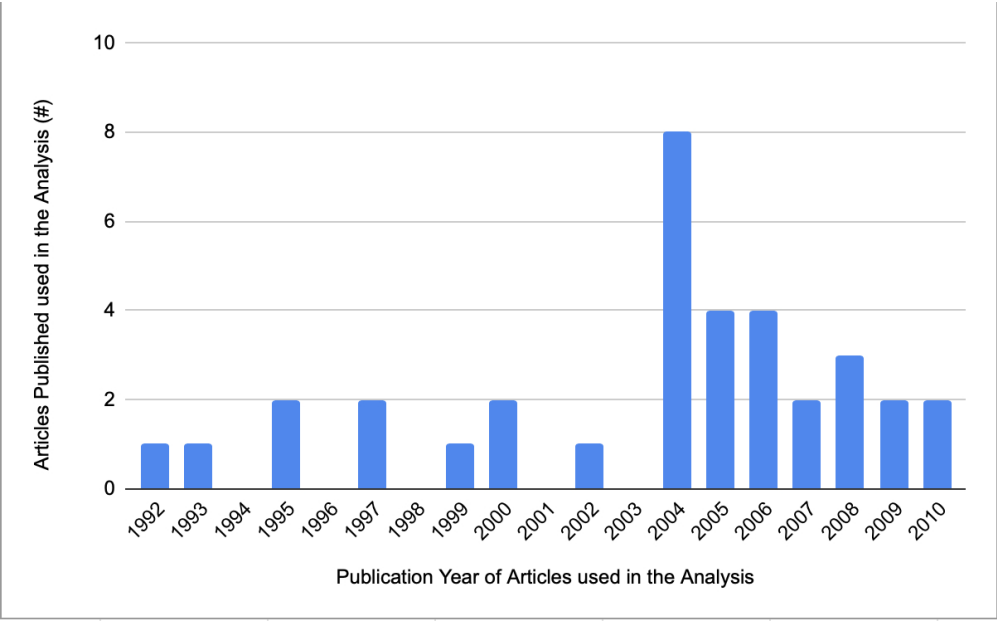
Library Hi Tech

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