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Public Participation Geographic Information Systems for Redistricting A Case Study in Ohio

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Abstract: *A geographic information system (GIS) is an important redistricting tool that is used to create the database required to draw boundaries, build district plans, and evaluate alternative plans based on a set of criteria. When augmented with specialized functions, a GIS is a spatial decision support system (SDSS) for redistricting, and when made available to the public through the Internet, it is a public participation GIS (PPGIS). Such a system was implemented in Ohio in 2009 to evaluate how to improve the redistricting process in the state after release of the 2010 census.*

INTRODUCTION

A geographic information system (GIS) is an important redistricting tool that is used to create the database required to draw boundaries, build district plans, and evaluate alternative plans based on a set of criteria.[1] These functions are achieved as a result of the recent availability of great desktop computational power, more easily learned and usable software, and publicly available databases that are necessary for drawing boundaries of political districts that meet multiple criteria. Thus, the development of GIS has greatly automated the political process of redistricting. Internet application of these GIS tools now offers new opportunities for public-interest groups and citizens to be engaged in determining their political landscape.

Traditionally, redistricting often takes place in political backrooms, involving politicians and consultants in making partisan political decisions. Today, more than ever, many "good government" advocates argue that the process should be brought into the open and use widely accepted criteria that are thought to improve the "fairness" of the outcome. Although much attention is paid to the importance and measurement of various criteria of fairness, advances in GIS-related technologies promise the greatest potential for democratization of the redistricting process for it offers the way in which more people can recommend, propose, and evaluate redistricting plans. The issue of who has the ability to make recommendations for district boundary plans and who can evaluate such plans is as important as the criteria and the plans themselves.

A GIS with added decision support tools for redistricting offers the user the ability to build a set of districts through an easy-to-operate graphic interface, while seeing the resulting statistical measures of the redistricting objectives. Although the statistical results of a districting plan can be achieved through a single submission of information and decisions, the more useful and interesting aspect of the GIS application is the way in which the user can adjust boundary decisions one-at-a-time as the results become apparent after each such decision in the process. The interaction of the map with the statistical measures of the redistricting criteria is dynamic. Thus, when customized for redistricting, GIS provides a spatial decision support system (SDSS) for the interactive drawing of political districts that meet target criteria.

Internet delivery of redistricting GIS tools to the electorate and public-interest groups could give them a say in how districts are drawn. This democratization of the process would represent a strong example of the impact of public participation GIS (PPGIS) on society. The public, defined as the stakeholders in the political process, includes almost everyone—including public-interest organizations, grassroots communities, political parties, the electorate, and, indeed, every person who is affected by political representation that is in any part determined by the districting of electoral districts.[2] The type and level of the public's participation is controlled by institutional, statutory, and cultural conditions rather than technical ones (de Man 2003). Regardless of who is statutorily responsible for redistricting, this PPGIS application provides to the public the resources necessary to construct alternative plans and to compare and evaluate them, and thus to challenge the decision makers in ways never possible before.

This paper summarizes the use of GIS in the redistricting process for political election districts, including congressional districts, state legislatures, and local wards.[3] First, the paper discusses the criteria that are said to be important in creating political districts that are fair and competitive. Second, the paper discusses how GIS is used to construct the redistricting database that provides the measures of those criteria. Third, the paper describes a case study in which the Ohio Secretary of State and others tested the feasibility and merits of using a public participation GIS redistricting system to develop alternative district plans aimed at meeting several objectives concerning fair and competitive elections. Finally, the paper concludes with ideas about how GIS will and should play a role in future redistricting.

CRITERIA FOR DRAWING ELECTION DISTRICTS

Redistricting is carried out to achieve a set of political objectives and outcomes. Those outcomes are determined by the geographic configuration of the district plan. Before considering how GIS plays a role in drawing district boundaries, certain concepts that are used as the criteria for meeting the political objectives of drawing election districts must be defined.

Population equality: The U.S. Constitution, as interpreted by federal case law, requires that districts be as equal in population as possible.[4] State legislative districts have been given more leeway with regard to this criterion.[5]

National Voting Rights Act: Federal courts also have held that state district plans must provide for majority-minority congressional districts where feasible to avoid creating districts that deny minorities their legislative representation.[6]

Contiguity: Every part of a district must be reachable from every other part without crossing the district's borders. Geometrically, election districts are polygons and this criterion states that such district polygons must share sides with other district polygons. "Point contiguity," where districts touch at only a geometric point, may or may not be acceptable.

Compactness: This criterion seeks to limit gerrymandering, which captures or excludes certain populations to benefit one party over another through the use of irregularly shaped districts.

Communities of interest: In the context of redistricting, the term community refers to those geographic regions whose identities merit keeping them in one district. These regions may be counties, municipalities, wards, or other areas that give residents a sense of place and shared interests. This criterion is based on a rationale similar to that for majority-minority districts and seeks to minimize the number of districts that divide such communities.

Competitiveness: An alternative approach to the one offered by communities of interest is a criterion that values diversity within districts and is based on the notion that democracy thrives when the marketplace of political ideas is competitive. This measure seeks to maximize the number of legislative districts that could be won by either party, thus providing each individual voter with a stronger voice in choosing representatives.

Representational fairness: Another approach to competitiveness is ensuring that a redistricting plan does not unfairly favor one party over another. This measure seeks to minimize the difference between a party's representation in the state's total votes and its representation in the legislature.

Each of these criteria has merit but deciding how to use them in combination remains a political challenge.

It is also a technical challenge. Using GIS does not provide an "objective" or maximizing solution to the process of redistricting, though some researchers have tried. Morrill (1976) provided an early analysis of using computers to improve on manual methods using population equality and travel minimization as criteria. In addition to reducing aggregate travel times within districts, the computer-produced district plans were found to provide more compact districts. Nagel (1965) demonstrating that three factors—population equality, compactness, and political balance of power—could be optimized using computer-generated methods, but only after assigning arbitrary weights to these three factors.

Despite these and other early calls for computational districting solutions that maximize some assumed universal set of objectives, some argue that optimal solutions are intractable, given the computational difficulties of using multiple criteria and the large numbers of possible outcomes.

> "In practice, a redistricting plan must simultaneously satisfy several, often conflicting criteria, such as equal population, compactness, the Voting Rights Act, and (depending on each state's constitution) other goals such as respect for existing political boundaries and communities of interest. Current commercially available automated software can only maximize one criterion and cannot balance between competing criteria . . . Our selected trials of these packages, as well as anecdotal reports by users and software developers, suggests that even with regard to a single criterion, software performance fell well short of what an expert could achieve." (Altman 1997)[7]

More importantly, decisions about which criteria to use and how to weigh these criteria are political in nature. But GIS does offer the promise of uncomplicating and providing transparency to multiple criteria solutions.

CREATING THE REDISTRICTING DATABASE— THE USE OF GIS AND ESTIMATION

GIS plays a particularly important role in developing databases that combine demographic information from the decennial census with election results from state or local sources. Noting that census data alone are insufficient for redistricting, Altman et al. (2005) point out, "Redistricting often involves integration and analysis of additional data including voter registration statistics and election returns. In many cases, there is no direct relationship between census and electoral geography, and election data may be collected within two separate geographies: registration and election precincts."

Thus, understanding conceptually how a redistricting database is created is important when considering the requisite precision of the measures that are used as criteria for redistricting, such as compactness, competitiveness, and representational fairness. How the database is created also affects the accuracy of population equality and majority-minority district criteria. Therefore, accuracy and precision of the data affect the accuracy and precision of the criteria metrics and, in turn, the plan that is selected.

At one level, the Census Bureau uses GIS to build geographic and population databases. The Census Bureau's geographic database—TIGER[8]—was developed to assist both data-collection operations and reporting. The smallest geographic unit of data collection and reporting is the census block. Blocks are polygons that are built from linear features such as roads, rivers, rail lines, topographic ridges, as well as other polygonal features such as lakes, Indian reservations, and municipal, township, county, and state boundaries. The characteristics of housing units and population found within the area bounded by the streets and other features around them are tallied to the census block summary level. Typically, census blocks correspond to what most people understand as a city block.

Although the Census Bureau creates the census blocks, delineation of precincts is the purview of local boards of elections (BOE).[9] For the census to include population data by precinct, the Census Bureau must collect precinct geography from each state. The state must collect precinct boundaries from the local BOE, compile them using the TIGER base map, and submit them to the Census Bureau more than a year before a census is taken. The 2010 census marks the first time that the Census Bureau has allowed the states to submit precinct boundaries that split existing census blocks. New blocks will be created when precincts split existing blocks. Thus, precinct geography will figure into the creation of new census blocks. The Census Bureau provided specialized GIS software to assist the states and to ensure that the data meets the bureau's specifications.

Before this decennial census, states could only supply voting district boundaries that incorporated whole census blocks. When such voting districts do not reflect actual voting districts, they are termed pseudo districts and their use means that population counts are inaccurate for such voting districts. Even though the Census Bureau now permits block splitting, some states did not have the time nor the resources to fully participate in the program and submitted pseudo districts for at least portions of their state.[10] To the extent that populations in split blocks are substantial, census data for pseudo precincts will not accurately reflect their population.

Furthermore, because the 2010 census program required submission of precinct boundaries a year and a half before the taking of the census, some precincts changed by the time of the census. States that wish to use more current election results and election geography will have to continue maintaining more current precinct geography and estimating the census data for those precincts that change after the time that the Census Bureau acquired the precinct boundary data from the states. Precinct geography was provided to the Census Bureau based on the fall of 2008 elections. However, at least some states will use both 2008 and 2010 election results for decision making concerning political competitiveness. Precinct-level census data delivered by the Census Bureau will not reflect the 2010 precinct geography. Therefore, states will adjust the census data at the precinct level through estimation methods, after the census data have been delivered by the bureau in early 2011.

For example, Ohio will develop a statewide precinct boundary database current as of the fall of 2010 general elections. The state will estimate the populations of precincts that have changed since the fall of 2008 elections or were submitted to the Census Bureau as pseudo districts. Election results for both the fall of 2008 and 2010 also will be estimated for census blocks. The resulting database, including geographic boundary layers, population by race and voting age, and the election results, is referred to as the "Ohio Common and Unified Redistricting Database."[11] The use of GIS will facilitate this estimation. To estimate population in precincts that have changed boundaries between 2008 and 2010, census populations that are in a split block are apportioned between precincts sharing those blocks based on proportions of the block's street length found in each precinct.[12] Meanwhile, the voting results for precincts are distributed to the block level using the block-level voting-age population. This is performed for both the 2008 and 2010 election precincts. Thus, the data to be used for redistricting in Ohio and other states is estimated using GIS and assumptions about the geographic distribution of population and election results within census blocks. The effect of producing data for redistricting that are subject to estimation error may be an important issue, potentially affecting the various criteria used to draw the lines.[13] Research should be conducted on this issue.

THE OHIO SECRETARY OF STATE'S REDISTRICTING COMPETITION

In partnership with several interested organizations and experts,[14] Ohio's Secretary of State (SOS) undertook a project in the spring of 2009 to test and evaluate a presumably fairer process of redistricting that would be open to the public.

In Ohio's existing process of redistricting, congressional districts are drawn by the General Assembly through legislation. There are no rules or criteria to meet, other than federal case law on equal population[15] and minority representation.[16] State legislative districts are drawn by an Apportionment Board consisting of the governor, secretary of state, state auditor, and a member of each of the two major parties in the state legislature. There are limited rules in the state's constitution regarding compactness, equal population, and maintaining county, municipal, and ward boundaries. For simplicity, the SOS's project addressed only congressional redistricting.

The project provided for open competition to see if a process could be implemented in which persons with access to software and data and some limited training could create a districting plan that achieved a number of goals concerning criteria thought to contribute to a fair districting plan. It was assumed that a "good" redistricting process would seek to preserve Ohio communities, promote political competition, result in an accurate reflection of the political leanings of the electorate, and provide an open and transparent process. The purpose was to enable stakeholders, as represented by public-interest groups, grassroots community organizations, or just any voter or citizen, to participate in testing a decision-making process that would affect the political geography of the state and, therefore, the political outcomes of many future elections.

Because data for 2010 were not available, the competition used a precinct-level database from the state's 2001 redistricting data program. Some modifications to the database were necessary, including smoothing some highly irregular coastal boundaries and combining islands in Lake Erie to reduce the possible impact of such areas on compactness scores.

Software and data were supplied by Ohio State University (OSU) via Terminal Services.[17] Thus, anyone with an Internet connection could access and use the required resources. ArcGIS, with its Districting software extension, was used as the GIS software. Users registered with the SOS to receive user accounts to access the system; approximately 80 accounts were created.

Cleveland State University (CSU), which provided the database and its modifications, also added customized utilities that computed measures of compactness and county fragmentation to the ArcGIS application.[18]

CSU also provided training and a manual on how to access the OSU system and how to use the GIS functions and districting tools to complete and submit a plan. A one-day training workshop was held in Columbus, Ohio. A video of the training was made accessible on the SOS Web site,[19] along with the manual and other information about the competition. CSU also provided technical assistance over the telephone and by e-mail, scored results for each participant, and produced final maps and results to the SOS.

Three threshold conditions had to be met before other criteria were scored:

- Population equality: Each district had to be within one half of one percent (0.50 percent) of the average population of all districts.
- Contiguity: Every part of a district had to be reachable from every other part without crossing the district's borders. Overlaps or gaps between districts were not allowed and the entire state had to be covered. Water contiguity was permitted for districts containing Lake Erie islands.
- Minority representation under the National Voting Rights Act: All plans had to provide for at least one majority-minority congressional district.

Once these three conditions were met, plans were evaluated using four additional criteria:

- Compactness: Compactness was measured by the ratio of district area to the square of its perimeter.
- Communities of interest: For simplicity in this demonstration project, communities of interest were measured by the number of counties that are "fragmented"—i.e., have two or more districts. A few exceptions to counting fragments were made. Districts that are entirely within one county were not counted as fragmenting the county. In addition, a few cities, such as Columbus, cross county boundaries and retaining them in one district did not count as fragmenting counties.
- Competitiveness: This measure sought to maximize the number of legislative districts that could be won by either party as measured by the percentage difference in votes in a district for Democratic and Republican presidential candidates in the 2000 election. There were four categories of competitiveness, ranging from very competitive to not competitive.

Figure 1. One of the winning plans and the current congressional districts in Ohio

- Representational fairness: This measure compared the difference between proportions of statewide votes for the political parties in recent elections with the congressional seats likely to be won by those parties.

Each criterion was assigned different weight. Compactness and commonalities of interest were considered twice as important as competitiveness and representational fairness.

The competition began on April 10, 2009, and concluded on May 11, 2009. Though some 80 user accounts were requested, only 14 plans were submitted. Three were disqualified because they did not meet all the threshold conditions concerning a majority-minority district, equal population, and contiguity.

Three plans with the highest scores were declared the winners. As an example of the results, one winning plan (see Figure 1) had the following characteristics:

- nine Republican-leaning and nine Democratic-leaning districts,
- 11 competitive districts,
- 20 county fragments, and
- the sixth-highest compactness ratio.

For comparison, the current congressional plan for the state (also shown in Figure 1) has these characteristics:

- a partisan split of likely representation, with 13 Republican-leaning and five Democratic-leaning districts,
- seven competitive districts,
- 44 county fragments, and
- a compactness score lower than all the submitted plans.

According to these criteria, the winning plans were superior to the current congressional district plan. In fact, even the worst-scoring plan submitted in the competition was quantitatively "better" than the redistricting plan implemented in 2001.

The competition was judged by the SOS, its partners, and others to be successful, though it also was acknowledged that improvements would be necessary should a similar redistricting process be put into practice for the state.

HOW WILL GIS BE USED IN THE NEXT ROUND OF REDISTRICTING—WHAT MORE NEEDS TO BE DONE?

At this writing, the next round of redistricting is imminent. By April 1, 2010, the Census Bureau released the redistricting database for each state. States such as Ohio are using GIS to prepare election results databases that will be merged with the census data—but only after adjusting for geographic discrepancies and estimating some data. Several PC-based software systems exist that enable the building of district geography while summing population and election results data. Web-based systems offer the possibility for greater public participation in the process.

Significant advances in redistricting have occurred over the past two decades. The Census Bureau, for example, now allows states to provide precinct boundaries even if they split previously established census blocks. GIS facilitates estimating data where necessary. GIS-based districting software advanced significantly between 1990 and 2000 and has continued to improve in functionality and ease of use. Web-based application of the technology is a major improvement over the possibilities offered ten years ago when public participation was limited to the few who had access to a PC loaded with the necessary software and data.

So what more is there to be done? Four areas need improvement: the user interface to the software, integration of the computations of criteria metrics with the district drawing function, Web-based availability, and changes in how the data are produced.

USER INTERFACE

Software is the most obvious area for improvement. The user interface determines how easily the application can be used by a nonexpert in GIS. Most of the software systems have been designed as extensions of GIS software for which users require several days of workshop training to become minimally proficient. The number and complexity of functions that may be useful for districting are daunting to the novice.

The Ohio competition experience proved that with the proper tools and training, a novice can produce a redistricting plan. But it also showed that the task was very difficult, took many hours, and caused considerable frustration among even the most proficient participants. While 14 plans were submitted by 12 persons, approximately 80 accounts were set up, possibly indicating that many persons who wanted to participate could not. CSU also provided approximately eight hours of telephone and e-mail consulting with participants to clarify steps and functions, and another 24 hours making corrections to submitted plans with minor errors attributable to user inexperience. These corrections included adding omitted areas to districts where they obviously were intended.[20]

The districting software extension could be mastered by GIS professionals with a few hours of practice because of their familiarity with the concepts of data layering, spatial queries and selection, spatial topology, proximity analysis, thematic mapping, and more. For others, however, training in the specific tasks that constitute the minimal steps to create a plan, along with a well-detailed and specific set of instructions, are required—and still do not make the process sufficiently easy for the public. GIS-based software systems other than the one chosen for the Ohio demonstration may be more easily learned and navigated by novices, but there is a long way to go before almost anyone can participate in the process with just a reasonable degree of difficulty. A more equitable PPGIS application would enable more stakeholder participation.

INTEGRATION OF THE CRITERIA METRICS

The Ohio competition required adding specialized tools to compute compactness scores and community fragmentation counts. Though the Ohio competition did not do it, competitiveness for each district also could have been calculated interactively, in much the same way that the percent of the minority population in each district was reported as districts were built. These measures can be calculated within the GIS software because they involve computations on data for each district. But putting these metrics into a final set of scores for evaluating an entire plan required exporting the data from the GIS software to a spreadsheet in which final measures for the plan were calculated. Another operation was required to merge all the plans, rank them on each criterion, weight each criterion rank, and sum the weighted ranks to determine which plans were judged better than others.

Other software systems may supply tools without the need for special programming to calculate metrics for each district,[21] but the author knows of none that output a set of overall measures such as average or median competitiveness, the number of districts within specified competitiveness ranges, or the number of Republican-leaning or Democratic-leaning districts resulting from a plan.

The next generation of districting software and data systems should provide the overall plan's results on such criteria as degree of representational fairness, number of fragmented communities, and number of majority-minority districts. Furthermore, the ideal system would offer the user a choice of standard methods for measuring compactness, competitiveness, and other criteria. Customization of these measures also could be offered to those users wanting to use nonstandard or newer methods. These calculations should be provided by a districting software system both as the plan is being built and for the final plan. The integration of these functions and tools will further the use of GIS as a true SDSS.

Another step in the right direction of making the process transparent would be the ability to see other plans and compare their results. A clearinghouse for redistricting plans would make alternative proposals publicly accessible. This is technically possible and is receiving attention because of the availability of the Internet.

AVAILABILITY VIA THE INTERNET

The Internet is important for making the political redistricting process more democratized and transparent. Making alternative proposed plans available over the Internet is a critical step in bringing the redistricting process out into the open.

The Ohio experience was successful in making proprietary vendor software available on the Internet via a terminal server. The cost of the project might have been prohibitive had it required leasing computer laboratories around the state with the necessary PC-based software to give participants access to the required resources. Districting software specifically designed as a Web application should further reduce costs and expand accessibility.

The Internet offers more than just access to the software and data; it can provide easy and economic access to training and consulting services as well as enable sharing and discussion of plans. Some GIS redistricting venders already provide published plans on the Internet, but envisioning a software system that easily imports alternative plans, enables others to revise them, and then runs comparative analyses based on alternative criteria selected by the user seems easily enough developed. Even though such exchange of ideas and suggestions might be seen as potentially disruptive to the decision-making process, this process would facilitate the transparent selection of a final plan. This exchange of ideas also could be channeled into discussions about future improvements to the redistricting process.

DATA IMPROVEMENTS

Before concluding this discussion of how GIS will and should improve how redistricting is accomplished, the grist with which the redistricting software does its work must be considered—the data. The data to be used for redistricting in Ohio and other states will be estimated using GIS and assumptions about the geographic distribution of population and election results within census blocks and precincts. The effect of producing data for redistricting that are subject to estimation error may be an important issue, potentially affecting the various criteria used to draw the lines. A number of ways exists to reduce the potential for data discrepancies. First, because the data needed for redistricting include both the population data from the census and recent election results from the local elections offices, it is essential that the Census Bureau, state and local BOEs work more closely and effectively to make the data consistent.

The Census Bureau should improve its Boundary and Annexation (BAS) program so that its geographic database is more current and is consistent with the boundaries that local elections officials recognize. In Ohio, it was found that the boundaries recognized locally are too often not the ones used by the Census Bureau in collecting and reporting population data. That may be because of incomplete or poor participation by the local engineers who are asked to participate in the BAS program. These local engineers are periodically asked to inform the bureau about annexation or corrections to local political boundaries, but the boards of elections are not part of that dialogue. As a result, the boundaries recognized by the Census Bureau may be incorrect or out-of-date, and may not agree with precinct geography. Indeed, the boards of elections may assign some voters to incorrect election districts, and, thus, for the wrong candidates and issues. Greater involvement by the boards in the early buildup to the decennial census would help reduce many of these errors and inconsistencies.

An improved process, including better use of the Internet to collect local boundary data, would improve the data and limit the degree to which population estimation would be required once the census data are released. The technology offered by Internet mapping and map editing eventually could make this suggestion for precinct boundary data collection through the Internet a reality.

Another improvement in data for redistricting would be in using neighborhood-level socioeconomic and housing data collected through the American Community Survey (ACS). These data will become more readily available and provide important alternative definitions of communities of interest. For example, redistricting programs that choose to use small-area data (such as census blocks, block groups, and tracts) will provide the geographic specificity needed to carve out either very homogeneous or very heterogeneous districts.

Unfortunately the ACS data for census tracts and block groups will not be in the 2010 geography until late 2011 and therefore may not be available in time for the current redistricting process.

In summary, this paper suggests that improvements in GIS as a SDSS technology for redistricting with public participation requires significant improvement in its user interface, Web accessibility, inclusion of alternative and flexibly computed criteria metrics, and more accurate, current, comprehensive, and integrated data. Some of these improvements may be developed and implemented in time for the 2011 redistricting process, but others will have to await redistricting in 2021.

POSTSCRIPT

Despite proposals in 2010 from both Democratic and Republican leadership in the Ohio legislature to modify the redistricting process in Ohio that would make it less partisan and would use criteria such as those discussed in this paper, the two sides could not agree on a final version to put before the electorate. The redistricting process in Ohio will continue, though probably with much more public scrutiny than before.

About the Author

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He is the State of Ohio's liaison to the Census Bureau for its redistricting data programs and represents higher education on the Council of the Ohio Geographically Referenced Information Program (OGRIP). A past URISA board member, Salling served as editor of the URISA Conference Proceedings from 1986 to 2004. He is a member of the Core Committee of GISCorps and a recipient of URISA's 1988 and 2000 Service Awards.

He has a B.A. and Ph.D. in geography from Kent State University, Kent, Ohio, and an M.A. in geography from the University of Cincinnati.

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(Endnotes)

1 Redistricting is the process of changing existing geographic boundaries. In the context of political boundaries in the United States, redistricting of congressional, state legislative, or local (ward) districts generally results from changing demographic distributions and the requirement to establish electoral districts that are similar in total population. As noted in this paper, other criteria also are often included among the requirements concerning newly configured geographic districts.

2 Using Schlossberg and Shuford's (2005) techniques-oriented matrix of public and participation, the domain of public that this PPGIS application pertains to is the "affected individuals" and the participation technique is the interactive Web page.

3 Other districts such as special districts for libraries, schools, taxation, policing, and even precincts, for example, also can benefit from the application of GIS tools, but this paper concerns districts for which candidates for federal, state, or local office are designed.

4 Wesberry v. Sanders, 376 U.S. 1, 18 (1964).

5 Reynolds v. Sims, 377 U.S. 533, 577 (1964).

6 Shaw v. Reno, 509 U.S. 630, 657 (1993) ("Racial gerrymandering, even for remedial purposes, may balkanize us into competing racial factions; it threatens to carry us further from the goal of a political system in which race no longer matters—a goal that the Fourteenth and Fifteenth Amendments embody, and to which the Nation continues to aspire. It is for these reasons that race-based districting by our state legislatures demands close judicial scrutiny.").

7 See also Micah Altman, et al., From Crayons to Computers: The Evolution of Computer Use in Redistricting, 23 Social Sci. Comp. Rev., 334, 8 (2005).

8 TIGER stands for Topologically Integrated Geographically Encoded Reference database. See U.S. Census Bureau, TIGER Overview, at http://www.census.gov/geo/www/tiger/overview.html (last visited April 5, 2010). The Census Bureau used this geographic database to locate housing units and aggregate data on them to various units of geography, such as census blocks and tracts.

9 Though not the subject of this paper, we note that the drawing of precincts, if performed as a partisan process, could affect the redistricting of federal, state, or local (ward) election districts if precincts are used as the building blocks of those districts. The same holds true for wards as well. They could be gerrymandered to concentrate voters of one party or another and thus affect how the larger election districts are created. The impact of the selection of geographic units is the modifiable areal unit problem. The issue also applies to the use of census blocks, though the potential for partisan influence on their creation is nil and the scale of measurement is too large to have much of an influence on political

districting for congressional and statewide geographies.

10 Because of delays in initiating the effort in Ohio, for example, the state submitted 67 of its 88 counties as pseudo districts.

11 Though the research has not been done to confirm it, it is likely that many if not all states face a similar problem and will be taking steps to develop their own redistricting databases.

12 Other methods to estimate population for split blocks and precincts were considered, including counting registered voters and their designated precincts in each part of a split block. Voters were located by geocoding their addresses. However, geocoding is imperfect and often incomplete, especially in rural areas.

13 How the data are collected and the errors in and the static nature of the census population data also could be important issues, though they are not the focus of this paper. For example, a particularly heated controversy exists over where prison populations are counted. They have been and will continue to be enumerated at the site of the prison, though a decision has been made by the Census Bureau to flag census blocks that include such populations. See Advocates Commend Census Bureau for Enhancing States' Access to Data on Prison Populations in 2010 Census, Prisoners of the Census News, Feb. 10, 2010, available at http://news.prisonpolicy.org/T/ViewEmail/r/6B7E1876801298F9/99E6DC117A524C84F6A1C87C670A6B9F. On a practical level, other geographic issues also are potentially important to consider, including errors in the Census Bureau's geographic database. Possibly the most egregious potential for error is in the delineation of municipal boundaries. The experience in Ohio is that county boards of elections sometimes use some municipal boundaries that are different than the ones shown on census maps. This most often happens in areas of annexation that the Census Bureau has not included in its geographic database. The Census Bureau tries to keep current and accurate information through its Boundary and Annexation (BAS) program, in which local officials are asked to report updates of municipal boundaries. If there is a populated area bounded differently on local and census maps, the problem can either be that the board of elections is assigning voters to the wrong elections or the Census Bureau is incorrectly reporting the populations of those places.

14 Partners included former State Representative Joan Lawrence, the League of Women Voters of Ohio, State Representative Dan Stewart, Ohio State Political Science Professor Richard Gunther, Ohio Citizen Action, and Common Cause Ohio.

15 Baker v. Carr, 369 U.S. 186 (1962), and Reynolds v. Sims, 377 U.S. 533 (1964).

16 Shaw v. Reno, 509 U.S. 630 (1993).

17 Terminal Services is Microsoft's implementation of thin-client terminal-server computing. Windows applications are made accessible to a remote client machine.

18 Early planning of the project included counting fragmentation of municipalities, but this was later dropped from the competition criteria.

19 Ohio Redistricting Competition, http://www.sos.state.oh.us/SOS/redistricting.aspx (last visited Apr. 1, 2010).

20 In one case, the SOS asked CSU to convert a contestant's paper maps of the designed plan to the software system and run all the required functions to produce resulting measures. In communications with the user, it was clear that he understood the districting process well but, despite attempts, could not use the software.

21 Caliper's Maptitude for Redistricting, for example, computes compactness and reports which communities are fragmented.