

Public Participation GIS: The Case of Redistricting

[Forthcoming Proceedings of the 47th Annual Hawaii International Conference on System Sciences, Computer Society Press, 2014]

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Abstract

Recent technological advances have enabled greater public participation and transparency in the United States redistricting process. We review these advances, with particular attention to activities involving open-source redistricting software.

Representative democracy functions through elections whereby citizens elect officials to deliberate, develop policies, and choose among competing public policy proposals. The public may express their preferences over the space of policy options by voting in future elections, responding to public opinion polls, directly contacting representatives, supporting organizations that engage in lobbying, or engaging in demonstrations.

For the most part, the public does not have an active role in developing the menu of policy options. Rarely, the public may participate directly in policy selection by using mechanisms of direct democracy to place ballot initiatives before voters for their approval; in the extreme, the public may overthrow a government, but this is indicative democratic failure, not normal functioning of representative government.

Recent technological innovations have enabled broader public participation in policy formulation. We focus here on redistricting, the periodic redrawing of legislative boundaries. Redistricting provides an attractive area of study because until recently only those with considerable resources could afford the expensive computer systems and software required to develop redistricting proposals. Advances in processing power, increases in online communication speed and availability, and a growing base of mature open-source geographic information system tools passed a critical threshold between 2005 and 2010. The result was that the information computing technology infrastructure allowed greater public participation during the recent United States redistricting, which followed the 2010 census.

Among the recent redistricting innovations is the broad dissemination of software and data that enable interested persons in the public to draw their own districts. We contributed directly to this effort by creating open-source on-line redistricting software called DistrictBuilder. We worked with advocacy partners in states and localities to support their efforts to influence the redistricting process. Hundreds of users created thousands of redistricting plans, some

of which contained ideas that were incorporated into plans adopted by redistricting authorities. Here, we describe experiences in the last round of redistricting, the successes and failures that may lead to improved future inclusion of the public in redistricting.

1. Redistricting Information Technology

Redistricting is the periodic redrawing of legislative districts. Ostensibly, those responsible for redistricting draw new boundary lines to meet apolitical administrative goals, such as balancing districts' populations. However, much more goes on beneath the surface. As Justice White observed in the U.S. Supreme Court majority opinion *Gaffney v Cummings* 412 U.S. 735, 753 (1973), "It requires no special genius to recognize the political consequences of drawing a district down one street rather than another." The incentives are distorted when, as in many U.S. states, the persons in charge of redistricting are the same officials elected from those districts. The temptation to use redistricting to further political goals is so well-understood that a term was coined for it, in dubious honor of an 1812 Massachusetts state Senate district that Federalists claimed resembled a salamander in shape. The legislation was signed into law by Democratic-Republican Gov. Elbridge Gerry, hence, "gerrymander." Gerrymanders have been devised to further the interests of parties and racial groups, protect incumbents' careers, and punish opponents.

With so much at stake, those in charge of redistricting would prefer to draw redistricting plans without interference. Demanding legal requirements have aided this end. Those in charge of redistricting must process immense amounts of geo-spatial, demographic, and election data to meet legal and political goals. In the last course of the half-century, computer geographic information (GIS) systems were devised to manipulate these computationally intensive data. These systems were costly to develop, and thus restricted redistricting to the political parties who had the resources to create these systems [1].

When we examine the trajectory of the role of information technology in redistricting, we note proponents have advocated for a variety of goals, meeting with varying success [2]. We summarize these proposed applications in Table 1.

Geographic information systems are an essential redistricting tool. Redistricting underwent a dramatic

transformation in the mid-1960s when the U.S. Supreme Court articulated in seminal court decisions that districts must be of equal population.¹ Before then, state constitutions commonly required states to draw districts out of large geographic units, such as counties, thereby favoring the integrity of local political boundaries over population equality [3]. The equal population mandate meant that counties and other political boundaries could no longer serve as the basis for redistricting, unless the state could provide a compelling state interest in doing so. The redistricting task suddenly became more complex. A greater number of geographical units would have to be considered when drawing districts. This also led to clashing values between population equality, respect for existing political boundaries, and compactness where these remained in state constitutions [4] [5]. Later the same decade, the federal Voting Rights Act introduced yet another data-intensive redistricting criterion by requiring in certain circumstances that districts be drawn with sufficiently large minority populations to elect a candidate of their choice.

At about the same time as the reapportionment revolution was sweeping the country, researchers and practitioners began to explore using computers to draw districts. Tomlinson [6] was the first to propose, in 1962, that computers could generally be programmed as geographic information systems. In the following decades, state governments sometimes expended millions of dollars to build redistricting databases and to develop software to manipulate them on mainframe computing systems [1].

By the 2000s, advances in computer hardware and the development of commercial software decreased the cost of redistricting system from millions to thousands of dollars. Florida went further, creating a desktop application known as the Florida REDistricting System (FREDS) which was sold for \$20, as compared to the several thousands of dollars typical of commercial software license.²

These technical advances allowed well-funded organizations, such as the NAACP, to be increasingly involved in the process and permitted courts to draw their own plans when legal defects were discovered, rather than relying on plans submitted by litigants. However, the difficulty of creating redistricting plans remained high, even for organized interest groups such as NAACP and League of Women Voters, and

consequently very few legal submissions were created outside of the legislature and the courts.

By the 2010s, continued advances in computing power, communications infrastructure, and open source platforms enabled the development of redistricting software hosted on servers that users could access through their web browsers. These innovations meant that GIS novices no longer needed to learn how to install redistricting software and databases on their computers. Furthermore, while redistricting remains a complex problem, these new applications could be designed to guide a novice user to draw plans that comply with legal requirements.

A number of applications were developed. We, along with our software development partner Azavea, created an open-source web-hosted redistricting application called DistrictBuilder which we deployed in several states and localities throughout the country.³ David Bradlee created the freely available, but closed source, Dave's Redistricting app, which was popular among DailyKos bloggers.⁴ Commercial vendors such as ESRI and Maptitude created proprietary online redistricting applications.⁵ And both chambers of the Florida legislature, independently created their own online applications to replace FREDS, which in a bit of evolutionary convergence were called MyDistrictBuilder and District Builder, respectively.⁶ These applications were loaded with the necessary redistricting data by system administrators, relieving novice end-users of that task.

Quantitative indicia are often calculated by GIS software. These include summaries of demographic characteristics of districts, predictions of election results, and district features such as their shape and intersection with other geographies. Scholars have gone beyond calculation to argue that impermissible gerrymanders might be detected through calculation of indicia that are correlated with gerrymandering.

When there is a bright legal line, quantitative indicia can identify constitutional defects. Perhaps the easiest measure to calculate is the total population of a district, and its deviation from the ideally equal population district, calculated by dividing the resident population of a jurisdiction by the number of seats.⁷ The federal courts generally allow a ten percentage

¹ See *Wesberry v. Sanders* 376 U.S. 1 (1964) and *Reynolds v. Sims* 377 U.S. 533 (1964).

² "Florida Legislature Unveils Redistricting Software." Press release from Florida House of Representatives Office of Speaker Tom Feeney, July 12, 2001. http://www.leg.state.fl.us/cgi-bin/View_Page.pl?Tab=legislators&Submenu=1&File=h33_071201b.html&Directory=Legislators/house/033/press/, accessed Feb. 27, 2013.

³ <http://www.districtbuilder.org/>

⁴ <http://gardow.com/davebradlee/redistricting/launchapp.html>

⁵ <http://resources.arcgis.com/en/communities/redistricting/>; http://www.caliper.com/redistricting/Online_Redistricting.htm

⁶ <http://www.floridaredistricting.org/>,

<http://www.flsenate.gov/Session/Redistricting/Plans>

⁷ Larger deviations must be justified to meet some other compelling state interest. See *Karcher v. Daggett*, 462 U.S. 725 (1983). The federal courts have overturned congressional plans for even smaller deviations, so it is standard practice for those drawing districts to draw as equal of population districts as possible, down to one or zero persons.

point population deviation from the largest to smallest state legislative district and a one percentage point deviation between the largest and smallest congressional district. Historically rural legislators used larger population deviations, a practice known as malapportionment, to their benefit by allocating fewer people to rural districts and more to urban districts. In his memoirs, Justice Earl Warren [7] called the equal population rulings of the 1960s the most important decisions he made as a Justice of the Supreme Court. It was a civil rights issue since outlawing malapportionment shifted representation and policymaking from rural to urban areas, where African-American communities could be found [8].

Initial euphoria that the equal population mandate would slay the gerrymander [9] gave way to reality. As Gelman and King [10] argue, “population equality guarantees almost no form of fairness beyond numerical equality of population.” Politicians could still work within the equal population framework to execute effective partisan and racial gerrymanders [11] [12]. The search began for other quantitative indicia that could be used to detect gerrymandering, or in the converse, could be applied to prevent gerrymandering.

One popular class of indicia is compactness measures. Proponents claim that compact districts have no political biases. However, there are two major problems with this claim. The first exposes a general weakness of most quantitative indicia. A survey of compactness measures over two decades ago found scholars had proposed over thirty different measures [13], and several have been proposed since. Proposed compactness measures often evaluate a district's shape in comparison to a circle (the most compact shape), the length of its perimeter, the geographic location of its population, or some combination of these. Disagreement can be resolved by choosing a measure, but only Colorado formally defines compactness in Article V § 47(1) of its constitution and only a handful of other states have defined it by statute. In litigation elsewhere, without firm guidance, courts have generally applied visual inspection to arrive at subjective judgments of compactness violations. Thus, despite many attempts to formally measure compactness, compactness remains in the eye of the beholder.

The second problem with quantitative indicia is that a districting plan drawn to be best, or at least within some tolerance range, on a proposed metric may still have systematic political biases. Responding to proponents who argue compactness and other supposedly politically-neutral criteria are a cure for gerrymandering, Chief Justice Brennan noted the opposite, that “this politically mindless approach may produce, whether intended or not, the most

grossly gerrymandered results.”⁸ In an example related by Parker [14], Hinds County, Mississippi supervisorial districts were drawn to equalize population and road mileage, with the rationale that county supervisors were responsible for maintaining the county's roads. This combination of criteria split the African-American community in Jackson, Mississippi such that the communities could not elect a candidate of their choice, and in subsequent litigation the federal courts declared the plan an impermissible racial gerrymander.

Numerous observers have noted that application of a nominally neutral formula may lead to outcomes with predictable biases. Nozick [33] sums up these issues cogently, and refers to such bias and self-interested preferences over rules as “second-order.” (pg 103) Generally, then, any quantitative indicia may be a gerrymander in sheep's clothing if the proposed indicia correlates positively, rather than negatively, with maximizing a political goal.

Another class of proposed quantitative indicia attempt to put the proverbial horse in front of the cart by measuring the intended political outcome, be it the degree to which partisan, incumbent, or racial interests are affected by a proposed redistricting plan. These statistical methods are used extensively in voting rights litigation to determine the effect of a redistricting plan on the ability of minorities to elect a candidate of their choice [15]. Similar methods have also been used to evaluate partisan gerrymandering [16], and even have been implemented by the New Jersey commissions to promote partisan fairness [17] and by the Arizona commission to promote district competition [18].

A problem is that these are predictive measures and may not be inferentially related to gerrymandering. Unlike other quantitative indicia, *predictive* models have a degree of uncertainty and are only as good as the data that are incorporated in them. They may not be *inferentially* related to gerrymandering, meaning that second-order bias is turned on its head. An unbiased plan may exist, but only one that violates other legal requirements. There are examples where such predictive measures have been implemented. New Jersey's state legislative commission uses human judgment to balance a partisan fairness criterion against other criteria, thereby minimizing this issue. In Arizona's commission, however, district competition is subsumed to other legal requirements, and the resulting redistricting plans have not met with reformers' expectations of heightened competition. Illustrating the clash of criteria, a maximally competitive state legislative plan drawn under court

⁸ Gaffney v. Cummings, 412 U.S. 735, 753 (1973)

order violated the Voting Rights Act, compactness, and respect for political and community boundaries.

Automated redistricting was proposed in the early 1960s, about the same time that geographic information systems were first conceived. Vickrey [19] advocated that computers could be programmed to automatically draw redistricting plans using neutral criteria, thereby divorcing redistricting from politics. Many others have since echoed this proposal, among them then future-President Ronald Reagan, who once said, “There is only one way to do reapportionment—feed into the computer all the factors except political registration.”⁹

Nagel [20] was the first to program an automated redistricting algorithm and attempted to draw California’s legislative districts. His and other early attempts at automated redistricting met with disappointing failure. The programs tended to draw shoe-string districts that violated notions of compactness and preservation of communities. We are authors of the first open-source automated redistricting algorithm, called BARD [21]. Our experimentations discovered redistricting in the American context of balancing multiple criteria is an exceedingly difficult mathematical partitioning problem that defies automation for all but the simplest problems. Computers have been programmed to draw equal population, contiguous, and maximally compact districts, but these districts violate other legitimate goals, such as respecting local political boundaries, communities of interest, and the Voting Rights Act.¹⁰

Because automation is so challenged, there is no guarantee that an algorithm has found the global optimum. The criteria programmed into the algorithm and subtle details of the algorithm’s implementation may furthermore exhibit intended or unintended second-order bias. This is perhaps the best argument for incorporating human judgment in redistricting, since humans are capable of deliberating tradeoffs when criteria are in conflict.

Semi-automatic redistricting has a more modest goal than automated redistricting. To his credit, Nagel understood the limits of automated redistricting and did not advocate for automated redistricting as a substitute for human judgment. He proposed that automated redistricting might help reveal a greater range of options that would inform the public policy debate.

Mexico employs semi-automatic redistricting for their federal districts. In 2004 and again in 2013, Mexico’s electoral commission, the Instituto Federal

Electoral (IFE), has used an automated algorithm in consultation with the national political parties to generate a redistricting plan for the single-member Chamber of Deputies districts. Mexico’s problem is more computationally tractable than the United States because larger units, both in terms of geography and population, are the base geography, which means fewer of these units need to be assigned to districts. The political parties work with IFE to devise criteria and their weights, which are incorporated into an objective function. These criteria are population equality, contiguity, compactness, municipality integrity, travel distance, and respect for indigenous communities [22]. A plan is then generated using a simulated annealing algorithm. Although this is claimed to be “open”, many algorithmic details are unspecified, and the code is not available – substantially diminishes external reproducibility [23]. These plans are then deliberated upon by the political parties and IFE, who modify the plan based on their expert judgment. Revealing limitations of automated redistricting, these modified plans often improve the algorithm’s scoring function. The process is opaque since the deliberations occur behind closed doors and only the adopted plan is announced to the public.

Related scholarly efforts have used semi-automated redistricting methods to evaluate counterfactual arguments in the pursuit of assessing redistricting motives. Cirincione, Darling, and O’Rourke [24], rediscovered Vickrey’s [19] proposed automated algorithm to assign census blocks to districts based on their population and proximity. These authors randomly generate hundreds of plans using the algorithm to argue if a large number of redistricting plans do not have as many majority-minority districts as the congressional plan adopted by South Carolina, then race must have been the predominant factor in drawing the districts, thus raising legal scrutiny of the plan. Rodden and Chen [25] employ a similar algorithm, adapted from our BARD algorithm [21], to argue that Florida’s Democrats are inefficiently concentrated in urban areas, which creates second-order bias favoring Republicans when compact districts are drawn. Second-order bias continues to be a problem for semi-automated redistricting algorithms. Furthermore, as computer programming textbooks warn [26], just because random number generators are used to provide starting seeds (in this case, for building districts) or as a component of the optimization algorithm, that does not mean that the algorithm produces random outcomes (in this case, redistricting plans). These scholars claim their algorithms sample the space of feasible redistricting plans, and they must do so because enumeration is intractable. But without true random sampling, we

⁹ Tom Goff, *Governor Urges Redistricting Plan Without Partisan Politics*, L.A. TIMES, Jan. 21, 1972, at A3 (quoting Governor Ronald Reagan of California).

¹⁰ See, Brian Olsen <http://bdistricting.com/2010/>

cannot assess if bias is present in the redistricting criteria or in the implementation of the optimization algorithms. Thus, all of these scholars' findings are suspect of being biased to an unknown degree.

Open Access to the public has recently become more feasible, made possible by advances in information technology. A primary goal of open access is similar to that of semi-automated redistricting, to generate a wider range of plans to stimulate a robust public policy debate. A primary difference is that where only experts are allowed access to GIS systems or are capable of programming optimization algorithms, open access empowers the general public to participate in public policy formation. There are some important consequences that emerge from this difference. When only policy makers have access to redistricting tools and data, the process becomes opaque, and it is difficult for the public, media, and courts to evaluate the plan that is eventually adopted and to assess what trade-offs were possible and contemplated by policy makers. Furthermore, open access stimulates public awareness of redistricting issues, thereby leading to a better informed and more engaged public.

Historically, determined members of the public could draw their own plans with paper and pencil. Prior to the equal population rulings of the 1960s, redistricting was simpler because districts were comprised of large geographic units. Interested organizations or individuals could draw their own plans, if they could obtain access to maps and other data, primarily to meet state constitutional requirements.¹¹ Yet, the anecdotal evidence of such activities suggests that outside groups had limited effect on policy making.

Following the equal population rulings and adoption of other policies such as the Voting Rights Act of 1965, redistricting became more complex. Prohibitively expensive GIS systems and data were needed to draw redistricting plans, blocking participation by all but well-funded interests. By the 1990s, redistricting authorities might provide public access to their redistricting systems at public terminals located in government buildings, typically in the state capital [1]. An interested member of the public would have to travel to the government site where the terminal was housed, a geographic limitation that effectively limited public participation to a handful. There is little evidence that such terminals resulted in meaningful public participation.

By the 2000s, commercial vendors entered the scene, dropping the price point for a redistricting system by orders of magnitude from millions to

thousands of dollars. Yet, in locations where the software was the most inexpensive, Florida's experience was typical of other states: The public submitted only four plans to the state legislature, three of which were submitted jointly by Common Cause and the League of Women Voters [27].

Public participation in redistricting increased by orders of magnitude in 2010. Web deployment appears to have been a key factor to stimulating greater public participation in redistricting since it is the only major way in which access to redistricting systems changed in the last decade. Interested members of the public could now access redistricting software through their web browsers without needing to install software or data.

And they could submit completed plans with the click of a button. In Florida, the number of public submissions increased from 4 using the 2000 online system to 179, using the state's newly developed online application. Elsewhere, thousands of users created thousands of redistricting plans using other applications. The scope of participation expanded; these new players were not redistricting experts but were college and high school students, retirees, community groups, bloggers, and many others who simply had an interest in redistricting.

In some cases, the public's ideas influenced public policy debate. The citizen who had perhaps the most impact on redistricting was Amanda Holt,¹² a piano teacher who used Dave's Redistricting app to draw a Pennsylvania state legislative plan that the state Supreme Court agreed demonstrated the state redistricting commission's adopted plan failed to meet state constitutional requirements of compactness and respect for political boundaries.¹³ Courts were particularly welcoming of public submissions. In Minnesota, when the state government failed to produce a congressional plan, a court became the first in history to accept public plans, which among them were plans developed using DistrictBuilder.¹⁴ In New York, a court similarly tasked with congressional redistricting welcomed public submissions and drew districts similar to those presented in a winning student competition plan and by Common Cause. In Minneapolis, Somali and Latino community groups used DistrictBuilder to draw city council districts that best served their communities, which the newly

¹¹ For example, see: "League Tackles Redistricting Study." *The Washington Post, Times Herald*, Apr. 23, 1961, p. F22.

¹² Patriot News Editorial Board, "Amanda Holt is Pennsylvania's Citizen Activist of the year," *Patriot News*, December 31, 2012. http://www.pennlive.com/opinion/index.ssf/2012/12/amanda_holt_is_pennsylvanias_citizen_activist_of_the_year.html

¹³ *Holt v. 2011 Legislative Reapportionment Comm'n*, No. 7-MM-2012 (Pa. Sup. Ct.)

¹⁴ <http://www.hometown-pages.com/main.asp?SectionID=26&ArticleID=39637>

constituted citizen commission incorporated into their adopted plan.¹⁵ In Virginia, college students who participated in a redistricting competition used our software to demonstrate how to promote racial representation for congressional and state legislative district and the governor's advisory commission incorporated these ideas into their plans [28].

Publicly generated plans serve as an important counterpoint to those created by self-interested politicians. We observed in analyses of Virginia's [28] and Florida's [27] redistricting that the public approaches redistricting differently than politicians on representational goals and legal requirements. The public and the media can use the public's plans to benchmark an adopted plan against other legal alternatives on how well they achieve representational goals such as partisan fairness, district competition, and minority representation; they can evaluate how well the plans meet legal requirements, such as compactness and respect for communities, and how well those plans meet good-government criteria and align with locally-defined community boundaries. Editorial boards across the country have used the public maps to argue redistricting can be done better.¹⁶

An unexpected byproduct of our efforts, particularly of the redistricting competitions that were held in four states and one locality, was media attention. Public mapping reframed the redistricting story from a dry-process dominated by insiders to one where average people struggled to achieve competing goals. Public mapping efforts received attention in prominent media such as USA Today,¹⁷ The Washington Post,¹⁸ National Public Radio, among other national media organizations, along with many local media outlets.

2. Public Mapping Success and Failure

While there were many notable success stories with public mapping redistricting, there were failures,

too. Understanding the nature of these successes and failures will help future efforts to increase public participation in redistricting. We identify two major factors predicting the success of public mapping. The first is the capacity of local grassroots organizations to organize and coordinate advocacy efforts. The second is the permeability of redistricting authorities to public input. We observe the greatest effects of public participation where grassroots organizations have the capacity to organize and where redistricting authorities welcome public participation.

We observed varying capacities of local grassroots organizations to use online redistricting tools as a component of their redistricting advocacy efforts. We had a long-standing partnership with advocacy partners in the Midwest, such as state chapters of the League of Women Voters and Common Cause, which are organized under an umbrella organization known as the Midwest Democracy Network. The Joyce Foundation organized the Midwest Democracy Network in the early 2000s for good government advocacy groups located in Ohio, Michigan, Indiana, Illinois, Wisconsin, and Minnesota, which is the sphere of the Joyce Foundation's activities. The Joyce Foundation also supported redistricting education efforts by one of the authors, Dr. McDonald. The resulting synergy created a collaborative framework for Midwest Democracy Network member organizations and the principle investigators of the Public Mapping Project. When the time came to contemplate redistricting advocacy efforts, the groups had already bought into the concept of using technology to empower participation. We had similar buy-in from Virginia reformers, who had been active during the 2000s, primarily through the support of leaders in Virginia's business community. Dr. McDonald had spoken at these reformers' events, so when these reformers approached Dr. McDonald in the summer of 2010 for redistricting, they were willing to consider the concept of public mapping. We also sought buy-in from national advocacy groups such as Common Cause and the League of Women Voters by inviting them to participate in an oversight advisory board for our software development.

In contrast, we entered New York redistricting in a partnership with Fordham University at the behest of the Sloan Foundation, the primary sponsor of the DistrictBuilder software development, because the Sloan Foundation has a special civics mandate for New York. We did not have support from the major reform organizations in New York, the state chapter of Common Cause, or Citizens Union. Common Cause worked with the Long Island newspaper, *Newsday*, to promote their maps.

In conversations we had with the Common

¹⁵ <http://www.minnpost.com/two-cities/2012/03/first-ever-public-process-minneapolis-redistricting-gets-positive-reaction>

¹⁶ E.g., Joe Hallett, "With a little thought, it's obvious these things make no sense." Columbus Dispatch, January 29, 2012, <http://www.dispatch.com/content/stories/editorials/2012/01/29/wit-h-a-little-thought-its-obvious-these-things-make-no-sense.html>; Bernie Niemeier, "General Assembly dodges latest attempts at redistricting reform." *Virginia Business*, June 29, 2011, <http://www.virginiabusiness.com/index.php/opinion/article/general-assembly-dodges-latest-attempts-at-redistricting-reform>;

¹⁷ Gregory Korte, "Technology allows citizens to be part of redistricting process." USA Today, March 21, 2011, http://usatoday30.usatoday.com/news/washington/2011-03-21-redistricting21_ST_N.htm?csp=34news;

¹⁸ Michael McDonald and Micah Altman, "Pulling Back the Curtain on Redistricting" *The Washington Post*, July 9, 2010, <http://www.washingtonpost.com/wp-dyn/content/article/2010/07/08/AR2010070804270.html>.

Cause/*NewsDay* partners, they informed us that they were not willing to allow machine-readable data representing their proposed plan to be available through other systems in order to allow for evaluation and modification. When we obtained the publicly available Common Cause plans and disseminated precise block-level boundaries corresponding to these plans through our web-based system, *Newsday* threatened to sue us for copyright infringement. We disagreed, since bare facts are not subject to copyright, and the data we proposed to release simply comprised the facts describing a publicly proposed set of boundaries. Furthermore, there is a strong case to be made that distributing the proposed maps for political commentary is both fair use and protected speech. Notwithstanding, we decided to remove the offending plans so as not to detract from redistricting advocacy efforts that we supported in principle, even though doing so was in tension with transparency, a principle we share with Common Cause.

Meanwhile, Citizens' Union opted not to engage with our efforts, since their reform goal was to change the process rather than to produce alternative maps. Although we lacked buy-in from the New York advocacy groups, we successfully executed a student redistricting competition through Fordham, and approaches in the winning congressional plan were reflected in a plan drawn by a court.

For strategic reasons, primarily related to limited resources, we supported public mapping only in states where there was grassroots advocacy interest in deploying our software. There were instances where we explored partnerships that did not pan out. For example, we discussed software deployment for Pennsylvania with a group of Philadelphia-based organizations, but these organizations lacked the necessary funding. Fortunately, these efforts were not wasted. Our software development partner, Azavea, subsequently supported a pro-bono effort for the Philadelphia city council, since Philadelphia is their home city, and these organizations were thus able to partner in the project. In states such as Massachusetts, Oregon, and Rhode Island, our initial conversations with grassroots advocates never progressed beyond their initial phase.

We observed varying degrees of interest among redistricting authorities in welcoming public input. The majority of redistricting authorities have at least window-dressing public meetings across their jurisdiction where those in charge of the redistricting process politely listen to citizens' redistricting concerns [1]. When legislatures hold these public forums, they often do so before the redistricting data are released, such that no legally valid maps can be presented. When legislatures accept plans, they often require a legislative sponsor. Commissions, at least

the citizen commissions in Arizona and California, are required to hold open meetings and hear citizen input through all stages of redistricting.

We had the greatest success where a redistricting authority was open to public involvement. In Minneapolis, a newly constituted citizen commission for city council districts saw public participation as a component of their mandate. Our Minnesota Midwest Democracy Network advocacy partners worked with the commission and local community organizations to educate them about the existence of the DistrictBuilder software and to provide training. In fact, many commissioners used the software themselves, since it was accessible off-site, while their commercial vendor software was available only on one desktop machine. The commission ultimately adopted a plan that incorporated ideas from the community organizations developed using DistrictBuilder to increase minority representation on the city council. This was our greatest success, since the tool gave a voice to community organizations that they would not have otherwise had.

We met limited success in Virginia, where the prospect of a student competition prompted Gov. McDonnell to form his Independent Bipartisan Advisory Redistricting Commission (IBARC). IBARC was created without funding and thus looked to the student competition infrastructure for support. Dr. McDonald served as a mapping consultant to the commission, and as a conduit for student ideas to the commission. William and Mary law school students actively aided the drawing of the commission's congressional districts -- and their plan was the first to demonstrate how minority representation might be increased in the state's congressional delegation. While we consider the IBARC's adoption of plans developed using our software a success, none were seriously considered by the legislature, despite legislators sponsoring the commission and winning student competition plans as bills.

Besides ignoring the public's ideas, redistricting authorities can also resist public participation and transparency in the way they make redistricting information available to the public. Redistricting authorities that do not wish to have the potential political consequences of their plans evaluated publicly will not provide election results merged with census geography — although they assuredly use such merged information for internal evaluation of their plans. For example, we encountered active resistance to our efforts in places such as New Jersey, where the state legislative commission, predominantly composed of elected officials, not citizens, refused to share such redistricting data with us. We reluctantly declined to become involved in that state despite interest from grassroots advocacy

groups to get involved in the process. Through separate data collection, we were able to create databases that merged election results with census geography in other states. We also experienced data issues with Ohio, and spent several thousands of dollars updating the DistrictBuilder software for new releases of the state's redistricting data, some of which fixed problems we reported.

Redistricting authorities may purposefully restrict the scope of other information they make available, as well. For example, a number of states chose to make only information available related to the approved plan. Others made available only plans submitted as legislative bills. Only a few redistricting authorities, such as Arizona, California and Utah, made available the boundaries for all plans submitted. Publishing only the approved plan limits the ability for the public to observe trade-offs.

Another subtle way by which redistricting authorities can hinder transparency is by publishing plans in a non-machine-interpretable formats. Almost all GIS packages accept and exchange a format known as shape files, which can easily be used to store all the coordinates of district boundaries, and associated information. Another popular format specifically used in redistricting is a block equivalency file, which is a simple text file that lists the district associated with a unique identifier for each census block. When redistricting authorities wish to be opaque, they publish image-renderings of their plans (typically in the form of Adobe PDF documents, or JPEG images). These images cannot be loaded into a GIS system, forcing those who wish to evaluate the plans to recreate the districts in their GIS software. Such renderings often lack the fine detail needed to understand exactly where the boundaries fall in dense urban areas. Another opaque representation is what is known as a legal description, which is a listing of the census geography (metes and bounds) associated with each district. While this is similar to a block equivalency file, it is a different format that is difficult to reshape into a block equivalency file – in part because there is no reliable publicly available database that translates metes and bounds into census geography.

A more subtle, but substantial barrier is the *interface* through which representations of plans are made available. Some states, such as Texas, made data, plans, related information available through a single, simple mechanism, the “web directory” – all plans could be downloaded through a single web (http) and/or file (ftp) URL referring to a single archive (e.g. “zip” file) or simple directory structure. Other states, such as Iowa, made plans available only through proprietary web interfaces that did not offer access to plans in bulk or through automated

mechanism. For example, in Idaho one could retrieve publicly submitted plans only by registering for the system, obtaining credentials, navigating a proprietary user interface, and initiating a request for e-mail each plan – and the system imposed an undocumented daily cap. Some states, such as Wyoming, limited both format and access mechanism – maps were only available singly through a proprietary application, and only as screen captures.

Wisconsin was perhaps the most hostile to our planned advocacy efforts. State law required localities to perform their redistricting first, followed by the state. However, with the prospects of Republicans losing control of the state Senate due pending to recall elections, the Republican legislature voided state law and enacted their plans first. Our advocacy partners were taken by surprise by this turn of events, and we were unable to respond quickly enough before the new plans were adopted.

In Michigan, Ohio, the New York Legislature, Philadelphia, and Virginia, redistricting authorities ignored public input. There is little evidence that public mapping had an effect on adopted plans in places where we were not active, such as Dallas, Florida, Idaho, Utah, and Wyoming. One reason is that when the political stakes are high, particularly for state legislative or congressional redistricting, politicians have greater incentive to maintain control of the redistricting process.

3. Conclusion

Redistricting has traditionally been the domain of political insiders. Reform advocates on the outside have typically only able to ridicule adopted districts for their funny shapes, but have been otherwise helpless to show how the process could be different in their state. This opaque process, closed to the public, has benefited those in power.

In the most recent round of redistricting, following the 2010 census, infrastructure changed. Redistricting software and data became more accessible to the public. Public participation increased by orders of magnitude and enabled the public and the media to evaluate redistricting plans in ways that went well beyond simple ridicule to more sophisticated analyses that demonstrated how deficiencies could be addressed. Yet, except in a few exemplary cases, politicians continued to ignore the public. Politicians do so at their own risk, as 2012 litigation in Pennsylvania demonstrated, where the state Supreme Court found a plan drawn by a piano teacher to be superior to the state legislature's on constitutional grounds. We imagine that continued information technology advances and better preparation by advocacy groups will increase the future role of public participation.

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Table 1. Information technology applications in redistricting

<i>Type of use</i>	<i>Description</i>	<i>Goal</i>	<i>Early Studies</i>	<i>Current Maturity</i>
<i>Geographic Information Systems</i>	Systems that aid in capturing, managing, visualizing and analyzing spatial information	Aid in the efficient creation of maps associated with data.	Tomlinson [6]	Reached maturity in the 2000 round of redistricting.
<i>Fully Automatic redistricting</i>	Creation of legal, impartial redistricting plan entirely by computer.	Eliminate unfairness in redistricting.	Vickrey [19]	Not yet reached maturity and faces fundamental challenges.
<i>Semi-automatic redistricting</i>	Creation of legal plans by automated systems, based on criteria provided by the user.	Increase transparency in the redistricting process.	Nagel [20]	Available as a research prototype, however still faces inherent limitations.
<i>Quantitative Indicia^a</i>	Automatically identify gerrymanders through geographic or statistical analysis of proposed redistricting plans.	Detect egregious gerrymanders.	Harris [29], Reock [30], and Tufte [31]	Prediction of electoral characteristics of proposed plans has reached maturity. ^b
<i>Open Access</i>	Computerized systems to offer access to plans, data for constructing plans, and tools to create plans.	Enhance transparency of redistricting facilitate public participation.	Altman and McDonald [1]	Emergded in 2000 round of redistricting.

Notes: *a.* Examples include geographic compactness and predicted seats-votes relationship. *b.* However, predictive methods provide no statistical evidence that gerrymandering caused a particular outcome [32], and these models have not been widely accepted as reliable identifiers of impermissible gerrymanders.