The background of the upper half of the page is an aerial photograph of a landscape, likely a coastal area, with various shades of blue and green. Overlaid on this image are several irregular, semi-transparent shapes in shades of brown, tan, and blue, which represent legislative redistricting boundaries. These shapes are scattered across the map, with some appearing more prominent than others.

# Redistricting: A Guide for the GIS Community

*Objective: To inspire and help enable the GIS practitioner to engage in an equitable and fair legislative boundary redistricting process at the state and local levels, whether on the job or as a volunteer.*

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# 1 INTRODUCTION

This guide is intended to inspire and help enable the GIS professional and practitioner to engage in an equitable and fair redistricting process for legislative boundaries at federal, state and local levels, whether on the job or as a volunteer. It is written for the [Urban and Regional Information Systems Association \(URISA\)](#), which is the largest association of GIS professionals in North America and connects people and resources in the geospatial community. According to URISA's website, its mission is to be "...a multi-disciplinary geospatial organization that provides professional education and training, a vibrant and connected community, advocacy for geospatial challenges and issues, and essential resources. URISA fosters excellence in GIS and engages geospatial professionals throughout their careers."

It is hoped that this guide encourages the GIS practitioner to participate in the process when possible, and it offers guidance in identifying how to do that. This guide will also be helpful to those involved in redistricting as employees of state legislatures, local governments, redistricting commissions, political parties, consulting firms, or nonprofit voting rights organizations. But other GIS experts can also contribute their skills and time either as volunteers for groups seeking to monitor and evaluate the work of the organizations charged with producing final redistricting plans for state or local communities or as independent citizens with ideas about what fair election districts should look like.

The release of this educational guide in July 2021 is timely since the process for redistricting in the United States, based on the 2020 Census of Population and Housing, is about to take place. While there is a myriad of educational resources on the topic, including videos and other training materials on software techniques and procedures and data management, the guide explains basic concepts and steps in the process. Though there is some discussion of alternative software systems (and links to more information provided), this guide does not provide detail on how to use them; such instruction is generally offered by the software suppliers themselves.

The guide focuses exclusively on the United States and is not intended to provide a complete or definitive set of instructions and information about the redistricting process. Links and references are provided to the valuable resources used in compiling this handbook and to additional ones that provide more depth to an

understanding of the issues surrounding and process of redistricting. This document has benefited from these and other sources.

## 1.1 Definition of redistricting

Before describing the redistricting process, the term needs to be defined. The term *districting* refers to the general process of dividing a geographic area into more than one district. This may occur without prior division of the geographic area, such as when city wards or county councils are created for the first time. An example of this "reapportionment"—the redistribution of congressional seats to the states based on recent Census data—is Montana. Based on 2020 Census data, Montana, which is one of the seven states having only one congressional representative in the current (117th) House of Representatives, will have to draw (divide) the state into two congressional districts for the first time. Thus, Montana will be "districting" the state.

Redistricting, as implied by the addition of the prefix "re," refers to changing the areas delineated by the current division of the geographic area. Thus, it is a special application of the more general districting process. In most states (and cities and counties), redistricting is the process by which legislative district boundaries are revised. Even though there are some cases in which districting of an area takes place for the first time, most districting is done repeatedly, generally after each decennial census. The Census Bureau uses "redistricting" in describing its data and programs. Research and educational publications on the process also generally refer to the process as "redistricting." Most of the specialized software providers also use this term.

This guide offers information, resources, and perspective on both the process of redrawing districts and for creating districts where none have previously existed. Thus, unless citing another's work or when only "districting" is correct, this guide uses the terms interchangeably.

## 1.2 Organization of this guide

The organization of the guide is as follows:

1. Section 2 makes the case for why the redistricting process is of great importance to our society and to the role that the geospatial practitioner can play in it.

2. Section 3 covers the major constitutional principles and key statutes that are used to justify the legal constraints to how political boundaries are drawn.
3. Section 4 describes the process at the federal, state, and local levels, including when it occurs and the scheduling of its steps, and who is responsible for drawing the boundaries.
4. Section 4.4 describes the necessary and optional data, which is at the heart of the process, that are used to develop a set of districts.
5. Section 4.5 identifies the important software functionalities used in the process.
6. Section 5 discusses an important message of this guide: that the process of drawing political/legislative boundaries is not merely a technical one, but that decisions about those boundaries should be informed by their consequences and that, therefore, clear criteria about the objectives in the process should be explicitly understood.
7. Section 5.1 discusses the federally mandated criteria that every redistricting process requires.
8. Section 5.2 covers the use of other, widely-used criteria by states for congressional and state legislative districting.
9. Section 5.3 discusses fairness criteria used to evaluate proposed districts.
10. Section 5.4 provides references and links to reliable sources on the current rules and processes in each state.
11. Section 6 builds on the criteria and processes of redistricting by framing them from an ethical perspective. The GISP Code of Ethics should be considered by those involved.
12. Section 7 discusses ways that the public and GIS practitioner can participate in the process. URISA supports the value of public engagement in governmental and related planning and public service activities (see the work of colleagues in the field of Public Participation GIS), and the use of GIS technologies for drawing election boundaries is no exception.
13. Section 8 recognizes that nothing in the political realm stays the same for very long, providing a description of recent and trending changes to how the process is done across the United States.
14. Section 9 provides final thoughts.
15. A supplement offers some insights into the various specific software system choices available for redistricting, including stand-alone, enterprise, and web-based systems.

## 2 WHY REDISTRICTING IS IMPORTANT

The GIS practitioner often works within or for agencies charged with various aspects of public management and administration and has a unique opportunity to contribute to sound practices and actions that clarify, inform, promote, and ensure sound, equitable, and socially just public policies. One application of GIS technology, where issues of equity and social justice are particularly apparent and important to our democratic ideals, is in the redrawing of political boundaries. These boundaries, periodically created and changed, affect the lives of everyone. Legislative boundaries affect who represents the population in local, state, and federal government. Legislators that are elected in noncompetitive districts may develop policies and programs that represent the interests of only a minority of the population. The ways in which these issues are manifest are discussed in this guide.

When GIS practitioners are directly involved in helping to draw these districts, they have an opportunity and an obligation to understand the impact they will have

on the lives and aspirations of the population and the various social, economic, racial, and ethnic groups residing in those districts. Even when the GIS practitioner is not directly involved in the drawing of these boundaries, he or she can participate in voluntary efforts to evaluate them and can offer alternative districts for consideration. These efforts can make important contributions to society.

For the GIS practitioner, applications like redistricting are not merely technical exercises. As a professional, the [GISP Code of Ethics](#) should be understood and used in exercising one's technical skills. As the professional associations for GIS professionals and practitioners, URISA and the [GIS Certification Institute \(GISCI\)](#) urge members to observe the code and its emphasis on obligations to other persons, colleagues, employers, the profession, and society as a whole. The Code of Ethics is discussed in more detail in section 6.1.

### 3 CONSTITUTIONAL PRINCIPLES<sup>1</sup>

Article 1, Section 2, of the U.S. Constitution requires an enumeration of the “Number of free Persons” every ten years to apportion to the states their number of seats in the House of Representatives, while also providing that each state receive at least one representative. Subsequent amendments and laws eliminated the restrictions on slave and minority group populations. Key statutes affecting apportionment are found in the [Permanent Apportionment Act of 1929](#) and the [Apportionment Act of 1941](#).

While the number of representatives is apportioned to the states, the Constitution leaves to the states how those representatives are to be selected. However, federal law now specifies that in each state, members of the U.S. Congress must represent geographic districts of nearly equal population as of the most recent decennial census, and it provides protections against discrimination for racial and language minority groups. The decennial census of population is conducted as of April 1st in years ending in “0,” and the states usually receive population data used for reapportionment of congressional seats by December 31st of that year. However, due to delays caused by the COVID-19 pandemic, these deadlines have been moved back; the detailed redistricting data are expected by mid-August or the end of September 2021 at the latest.

Importantly, our shared concept of democracy includes two principles considered here: 1) one person, one vote, and 2) the government should not suppress free speech.

First, “One person, one vote” is the rule that, under the *Equal Protection Clause* of the Constitution (Fourteenth Amendment), legislative voting districts must be very close to the same in population size. The idea behind the rule is that, within each state, each person’s voting power ought to be roughly equivalent to that of another. The criteria of population equality are discussed in section 5.1.1.

The second principle is that “viewpoint discrimination” by government that restricts speech with a particular opinion violates the First Amendment. A variety of U.S. Supreme Court cases have held that some such violations of the Constitution can apply to the drawing of electoral districts. Constitutional arguments against partisan gerrymandering (discussed in section 5.3.1) have been based on this principle, though a recent finding of that court failed to consider it (see [Rucho et al. v. Common Cause et al.](#), 2019).

These two principles of our democracy are the basis of litigation about redistricting debated by the courts. Keeping these principles in mind, section 5 considers the criteria used in creating legislative boundaries and how they can influence viewpoint discrimination and the Equal Protection Clause.

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<sup>1</sup>This guide is not intended to be a legal analysis of these topics. Good summaries of the issues are found in [CRS Report R44199](#), “Congressional Redistricting: Legal and Constitutional Issues,” and [CRS Report R44798](#), “Congressional Redistricting Law: Background and Recent Court Rulings.” A comprehensive review is provided by the [National Conference of State Legislatures](#) (NCSL) in its publication [Redistricting Law 2020](#).

## 4 HOW REDISTRICTING IS DONE

Seven states currently have only one congressional seat—Delaware, Hawaii, North and South Dakota, Montana, Vermont, and Wyoming—though the 2020 Census will give Montana a second seat. All the other states must redraw their congressional districts. At the federal level, the Constitution leaves congressional redistricting up to the states. Each state outlines the procedures in its state constitution. In general, there are few rules beyond equal populations though the [Voting Rights Act](#) (VRA) of 1965 mandates that districts must be created in which minority racial, ethnic, and language groups have the opportunity to elect their representative of choice (see discussion below).

In most cases, congressional and state legislative districts are drawn by the state legislature, and the majority party controls the process. The governor's approval may also be required unless the legislature can override a veto; in some states, the governor cannot veto the plan. A few states require bipartisan or nonpartisan commissions to oversee the line-drawing, and the state's governor and majority party leaders often control who is appointed to these commissions. Arizona, California, Idaho, Michigan, and Washington draw districts using independent commissions with regulations limiting direct participation by elected officials. The procedures for redistricting in each state

are available at Ballotpedia's "[State-by-state redistricting procedures](#)" and the blog "[Who draws the lines?](#)". A summary of the states using legislatures and those using commissions is published by the Brennan Center for Justice (January 30, 2019) in "[Who Draws the Maps? Legislative and Congressional Redistricting](#)".

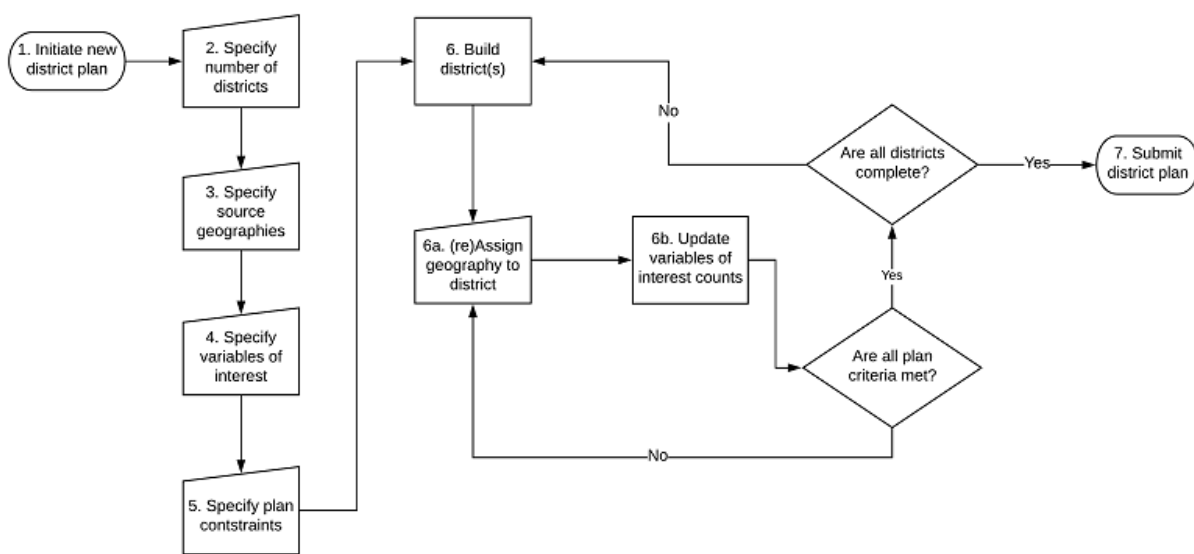
Though there may be some exceptions, local redistricting of city wards and county districts is generally in the purview of the legislatures of those communities.

### 4.1 The process

Figure 1 offers a simplified blueprint of the process employed by GIS districting software systems to develop plans for a set of districts.

Of course, there is much more to the process that requires discussion and is covered in more detail in the sections below. Nevertheless, the basic steps are the following:

1. Determine how many districts are required. With reapportionment, some states will gain congressional seats and others will lose them. In some cities, the number of wards may increase or decrease depending on changes in population.



**Figure 1:** The GIS Districting Software Process. Source: Morgan, J.D., and Evans, J. (2018). "[Aggregation of Spatial Entities and Legislative Redistricting](#)," *The Geographic Information Science & Technology Body of Knowledge* (3rd Quarter 2018 Edition), John P. Wilson (Ed.). Doi:10.22224/gistbok/2018.3.6

2. Determine the criteria if they are not already established. This may provide an opportunity for public input.
3. Get key data, such as census data, existing districts, and other relevant geo-data, possibly including information about communities of interest.
4. Analyze the overpopulation and underpopulation of the districts to get a sense of which districts are likely to require the most significant revisions. Keep in mind that changes to such districts will also require changes to those adjoining them.
5. Create one or more draft districting plans either from scratch or based on redistricting the previous districts.
6. Allow for public review of the draft districting plans and for members of the public to submit their own draft plans.
7. Revise plan(s) based on public and stakeholder input.
8. Repeat steps 5 through 7 as needed.
9. Adopt the final plan.

This process is clearest for single-member districts (SMDs). A single-member electoral district is an electoral district electing only one representative to office and is the primary model in American elections. Congressional districts must be SMDs, and most states also elect their state legislators for SMDs. Exceptions include Arizona, New Jersey, South Dakota, and Washington, which elect all members of their lower state legislative chambers from multi-member districts (MMDs). Some municipalities also utilize MMDs/wards.

There are several methods for determining the winners in MMD elections, including apportioning seats based on the proportional distribution of votes for each party's candidates. Variations of these methods are discussed in [“How Proportional Representation Elections Work.”](#) Arguments for MMDs with proportional representation are that they improve the chance for creating fairer partisan representation and representation of minorities and women (see the FairVote organization’s [“Multi-member districts mean fair representation, less gerrymandering”](#)).

The [National Conference of State Legislatures](#) (NCSL) provides another good reference, [“Into the Thicket: A Redistricting Starter Kit for Legislative Staff,”](#) that details how the process is done for congressional and state districts.

## 4.2 Federal and state legislatures

This section discusses the institutional responsibilities for redistricting; that is, who does it. Broadly speaking, congressional and state legislative districts for each state are drawn by either the state legislature or a commission. However, there are many variations to both methods. Also discussed is the timing of the steps involved in a process that starts well before the decennial census is taken and that ends well after the data are released.

### Overview of State-Level Impact

	LEGISLATIVE	CONGRESSIONAL*	IMPACT OF DELAY
States with general elections in 2021	2	n/a	States may need to use current maps for 2021 elections.
States with set fixed constitutional or statutory deadlines for completing redistricting or deadlines tied to the census year	20	10	To avoid maps being drawn by courts, states will need to adjust deadlines through formal action or, in some cases, through other default processes.
States with deadlines for completing redistricting tied to publication of the census or the state's receipt of redistricting data	11	4	Deadlines will be adjusted automatically but states will still need to complete redistricting in time for 2022 elections. In some states, this will require special sessions.
States with no set redistricting deadlines	12	28	No legal changes are required, but states may need to hold special sessions to complete redistricting in time for 2022 elections.
States required to redistrict in 2022	5	2	No or minimal impact.

\*Numbers do not add to 50 because some states will have only one congressional district and do not need to redraw congressional maps.

**Figure 2:** Overview of State-Level Impact of Census Data Delays. *Source: “How Changes to the 2020 Census Timeline Will Impact Redistricting,” the Brennan Center for Justice, May 4, 2020.*

### 4.2.1 Schedules

Generally, redistricting for election districts must be completed before filing deadlines for the next primary elections, which vary from state to state for state and federal offices and locally for local offices. However, some states have specific redistricting deadlines regardless of the timing of primary elections. Delays in delivering the 2020 Census data for both apportioning congressional seats to the states and the subsequent drawing of districts in 2021 will have major impacts on the process in each state and on local districting.

The NCSL provides current information on schedules for each state (see “[State Redistricting Deadlines](#)”). The [Brennan Center](#) provides a summary of impacts, which are shown in Figure 2. The Princeton Gerrymandering Project’s “[Redistricting Timeline Alert Map](#)” provides information on the possible impacts from delays of congressional and state legislative redistricting. In addition, the reader is advised to consult his or her local and state authorities for the most up-to-date information on deadlines.

Some states and local governments may decide not to wait for the census data due to their own current deadlines for redistricting steps and could turn to using existing districts temporarily, requesting extensions through the courts, delaying primary elections, or using other sources of data to redistrict.

One possible data source being considered is the Census Bureau’s American Community Survey (ACS), which provides estimates of population and population characteristics for relatively small geographic areas (e.g., block groups and census tracts). The ACS estimates for small geographic areas are based on a five-year, continuous survey and the Census Bureau’s [annual population estimates](#) for municipalities that are used to calibrate the data for the smaller geographic units. The ACS estimates at larger scales have relatively large margins of error that would [likely invite lawsuits challenging district plans](#) based on them. The most recently released ACS data are from the 2015–2019 surveys, and the 2020 census data are scheduled for release before release of the 2016–2020 ACS estimates. Census counts are likely to show significant differences with the ACS estimates in many cases (see “[Why using population estimates instead of census 2020 is a bad idea for drawing new congressional districts: Analysis](#),” by Rich Exner, [cleveland.com](#)).

### 4.2.2 Legislatures

Most redistricting is done by state legislatures passing a law the same way any other law is passed, but some states have special procedures: some require the governor’s approval or an override vote while others are not subject to gubernatorial veto, some require a

supermajority, and some provide for a commission as a backup for when the legislature fails to agree by a specified deadline. For example, the Ohio congressional redistricting process provides several opportunities for bipartisan approval, including activation of a commission. Ultimately, however, without buy-in from the minority party, the majority party is still in the driver’s seat.

The National Conference of State Legislatures (NCSL) and Ballotpedia are helpful sources for current information on the laws in each state (see NCSL’s “[Redistricting Systems: A 50-State Overview](#)” and Ballotpedia’s “[Redistricting](#)” <https://ballotpedia.org/Redistricting>).

### 4.2.3 Redistricting Commissions

Partly because of concerns about partisan gerrymandering, some states have adopted independent commissions for conducting redistricting either through legislative action, ballot initiatives, or referenda. (The U.S. Supreme Court upheld the right of such citizen initiatives in its 2015 decision, [Arizona State Legislature v. Arizona Independent Redistricting Commission](#).) These laws specify how commission members are to be appointed and the procedures to be followed in drawing congressional and state legislative districts.

Some commissions redistrict only either congressional or state districts. Some commissions entirely control the process, while other commissions must have plans approved by either the state legislature or the governor, or both. Some commissions are clearly bipartisan, while the partisanship of others depends on the partisanship of those selecting the commission’s membership.

Some states specify criteria to be used, such as contiguity, compactness, respecting communities of interest, or following county, city, township, precinct, or ward boundaries. (See discussion on criteria in section 5.)

Generally, a commission can be classified as one of the following:

- *Advisory commission*, which helps draw lines for legislative districts by recommendation, though the legislature has the final say.
- *Backup commission*, which will step in to draw plans if the legislature cannot agree on a redistricting plan in a timely fashion.
- *Politician commission*, which is independent of the legislature, though may have partisan legislators or other elected officials as members.
- *Independent commission*, which does not include legislators or other public officials, though legislators may have a role in selecting the commissioners.

Congressional redistricting by states using commissions is summarized at NCSL's ["Redistricting Commissions: Congressional Plans."](#) State legislative commissions are discussed at ["Redistricting Commissions: State Legislative Plans."](#)

#### 4.2.3.1 Pros and cons of legislative- versus commission-drawn districts

Some observers believe that having state legislators draw the boundaries too often leads to protecting incumbents, noncompetitive districts, and extreme partisan gerrymandering. Critics of legislatively drawn districts have argued they allow elected officials to effectively choose their constituents and violate democratic principles. Reform efforts by "good government" groups, such as Common Cause and the League of Women Voters, have led to the use of redistricting commissions and have been upheld, for example, by the Florida Supreme Court in [League of Women Voters v. Detzner](#). Though the partisan independence of commissions varies, these efforts have been implemented by individual states; yet proposed federal legislation to promote them has yet to achieve passage.<sup>1</sup>

On the other hand, defenders of the legislative prerogative maintain that, rather than creating a new institution, legislators know their constituents' concerns and can better delineate districts to adequately represent them. Elected legislators are also more directly accountable to the public, whereas commissions are less so. Yet it is also true that legislators may dilute the political voice of those most likely to object to their decisions.

The American practice of allowing legislators to draw their own districts is not typical in other countries. The [Administration and Cost of Elections](#) states that a "substantial majority of the countries that delimit electoral districts employ a specially designated boundary commission or an election management body to draw these boundaries. The legislature serves as the boundary authority in several countries. And in a few countries, government agencies are charged with the task of redistricting." (See the agency's discussion in the section, ["Composition of the Boundary Authority."](#))

Commissions, too, may allow partisan control when they consist of an odd number of partisan members. The process is more likely to be bipartisan when either 1) an equal number of people from each major party sit on a commission and a plan's approval requires at least one commissioner from each party to vote for it,

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<sup>1</sup>As of this writing, H.R. 1, also called the ["For the People Act,"](#) has been passed by the House of Representatives. The act would impose new standards on congressional redistricting, including a prohibition on partisan gerrymandering. See section 8.2.5 for more on H.R. 1.

or 2) the commission includes a tiebreaking member either appointed by the judiciary or selected by the partisan commissioners themselves. Critics are skeptical of purported nonpartisan commissions, claiming that the process might involve people who don't know enough about political communities to make reasoned choices, or that they give commissioners or their consultants or technicians hidden ability to effect partisan results.

#### 4.2.4 Role of courts

In a few states, a judicial official, such as the chief justice of the state's Supreme Court, has some say in determining the legislative lines, either as a backup when the legislature cannot agree on a plan, in appointing one or more of the state's commissioners, or in appointing a tie breaking commission member. The court may also appoint a "Special Master" to draw the boundaries when the lines are deemed illegal. States may also provide that the state's court review the proposed redistricting plan.

#### 4.2.5 Consultants

Political consultants sometimes play significant roles in the process of redistricting. When done by the legislature, legislative staff are usually involved in support of their employer, but they may not have the time or technical expertise or political experience to do it alone. In these cases, the political parties hire consultants to work with the legislators and their staffs. The NCSL offers direct assistance to legislatures by providing review of redistricting processes, helping with contacts for consultants, connecting staff with peers doing similar work, and answering procedural questions.

Commissions, too, may not have staff with sufficient expertise with the data and software required to perform districting, and thus also need the expertise of consultants. Web searches for consultants will produce listings of companies to be considered.

### 4.3 Local electoral districts

State political subdivisions, such as cities and counties with legislative bodies having geographic wards, councils, or other election districts, generally have the same legal standards for redistricting as the states. The U.S. Supreme Court has held that they must adhere to the application of the Equal Protection Clause of the Fourteenth Amendment of the Constitution (i.e., all citizens have the right to equal protection by law), the principles of "one person, one vote" (i.e., equal population), and the Voting Rights Act. These legal parameters are discussed in section 5.1 on federally mandated criteria.

The requirement for equal population, however, is looser than that imposed on congressional and state legislative districts such that the generally acceptable range in population is 10 percent ( $\pm 5\%$ ) for local districts, rather than virtually equal for congressional districts. Regardless of the range of district populations in a districting plan, the plan must demonstrate “...an honest and good faith effort to construct districts...as nearly of equal population as practicable” (see [Hulme v. Madison County](#), the District Court for the Southern District of Illinois).

Voting precinct boundaries are also redrawn or revised periodically by local (county) boards of elections between general elections to balance or adjust the number of registered voters in them or to accommodate changes in the locations of polling places. Precincts serve two functions. One purpose is to provide elected neighborhood representatives for political party committees, which nominate and select candidates for office in the city and county. The second function of a precinct is to serve as the election board’s administrative unit for tabulation of votes during elections. Though the geography of the precincts is the responsibility of the local board of elections, local political parties may have input.

## 4.4 Data

There are two major types of data needed for redistricting—spatial/geographic (geometry) data, which enables boundaries to be drawn and referenced, and population data, which allows for balancing population by district. The latter data also include those on race and Hispanic ethnicity. A third data type often used in the process is recent election results, which can evaluate the likely partisan outcomes in each district. Other data, such as the housing and socioeconomic data collected by the Census Bureau’s [American Community Survey](#) (ACS), can also assist in delineating communities of interest.

The primary geographic files are from the Census Bureau’s [TIGER](#) (Topologically Integrated Geographic Encoding and Referencing) files. Additionally, some districting applications may use other geographic data, such as school, polling, or business locations; topographic features; or other customized local data. The basic population and race/ethnicity data for congressional, state, and local election districts are from the Census Bureau’s [P.L. 94-171 database](#) named for the public law that requires it. These data are tabulated for the shape polygons found in the TIGER shapefiles and, unless the districting software vendor has already done so, require joining to the shapefiles.

However, while the U.S. Constitution provides that the whole number of persons in each state be used for congressional apportionment (also see the current administration’s [Executive Order](#)), the [NCSL reports](#) that “...the Constitution is silent on what data is to be used for redistricting.” Only 21 states explicitly require the use of census data for state legislative and congressional districting, others only require it for congressional redistricting, some are either silent on what data could be used for state legislative districts, and others explicitly allow for the use of other, unspecified data sources. Furthermore, specificity is generally lacking on which census data are to be used—total population, voting age population, or citizenship population (see “[Must States Use Census Data for Redistricting? Not Always](#)”).

Nevertheless, this guide presumes the use of P.L. 94-171 data for the basic population requirements and describes additional data sources that might also be used to meet other criteria.

### 4.4.1 Spatial Data—TIGER

Released in January and February 2021 (delayed due to COVID-19), [TIGER 2020](#) data are used for the 2021 redistricting process. TIGER was developed at the Census Bureau to support its mapping needs for the Decennial Census and other Bureau programs. Shapefiles for 2020 (including previous years) can be downloaded from the Census Bureau’s website.

TIGER data include census statistical units such as census tracts, block groups, blocks, selected political boundaries, and more, as well as roads, railroads, rivers, lakes, and other features. The data are based on the North American Datum of 1983 (NAD 83) Global (geographic) Coordinate System and should be viewed with a map projection suitable for the area being redistricted to avoid distortions in shapes and areas. If area measurements are important, such as calculations of compactness or distance, then it is also advisable to save and use the data in a suitable projection, such as a local state plane system.

While some national-level layers are available (such as state boundaries and metro areas), data needed for districting a state’s congressional and state legislative districts are provided for individual states. Layers are also available by county, which is helpful for city ward or county council districts and other local geography districts. The attribute fields include the feature name, type of feature, and other geographic data. Be aware that these layers do not include demographic data. GIS software is used to join such data using key fields. Districting software tools such as those described in this guide use these data for mapping and aggregating geographic entities (such as census blocks) to create districts and district plans.

Figure 3 provides a listing of the various geographic layers available as shapefiles from TIGER data. Figure 4

provides the web links to these and related geographic data used for districting.

Redistricting Data Program Phase 3 – P.L. 94-171 Redistricting Data Shapefiles	
State-based Shapefile	County-based Shapefile
American Indian/Alaska Native/Native Hawaiian Area	Block
American Indian Tribal Subdivision	Block Group
Alaska Native Regional Corporation	Census Tract
State and Equivalent	County Subdivision
Block	Voting District
Block Group	All Lines
Census Tract	All Roads
113th Congressional District	Area Hydrography
116th Congressional District	Linear Water
Consolidated City	Area Landmark
County and Equivalent	Point Landmark
County Subdivision	Topological Faces (Polygons With All Geocodes)
Place	County-based Relational Tables
Elementary School District	County-based Relationship File
Secondary School District	Address Range-Feature Name
Unified School District	Address Ranges
State Legislative District Lower Chamber	Feature Names
State Legislative District Upper Chamber	Topological Faces-Area Landmark
Subbarrio (Subminor Civil Division)	Topological Faces-Area Hydrography
Voting District	
Urban Growth Area	
Primary and Secondary Roads	

**Figure 3:** Redistricting Data Program Shapefiles. Source: “Interim Joint Committee on State Government,” a PowerPoint presentation by James Whitehorne, Chief - Census Redistricting & Voting Rights Data Office, Census Bureau, 11/17/2020.

Redistricting Data Program Phase 3 – P.L. 94-171 Redistricting Data Geographic Products	
2020 Census P.L. 94-171 Redistricting Data Geographic Products	
Product Type	Census Web Address
Shapefiles	<a href="https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html">https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.html</a>
Maps	<a href="https://www.census.gov/geographies/reference-maps.html">https://www.census.gov/geographies/reference-maps.html</a>
Block Assignment Files	<a href="https://www.census.gov/geographies/reference-files.html">https://www.census.gov/geographies/reference-files.html</a>
Block to Block Relationship Files	<a href="https://www.census.gov/geographies/reference-files/time-series/geo/relationship-files.html">https://www.census.gov/geographies/reference-files/time-series/geo/relationship-files.html</a>
<ul style="list-style-type: none"> <li>Shapefiles – geographic information system geometry files</li> <li>Maps (PDF only) – County Block; State Legislative with Voting District; Tract; School District</li> <li>Block Assignment Files – tables identifying the blocks used to build different geographic entities</li> <li>Block to Block Relationship Files – Crosswalk of 2010 blocks to 2020 blocks</li> </ul>	

**Figure 4:** Redistricting Data Program Geographic Products. Source: *Ibid.*

Most efforts to create or revise election districts use census blocks as the basic unit of geography with which to build or revise districts. Larger units of geography, such as counties, municipalities, townships, or precincts, can also be used when all the blocks in them are to be assigned to a single district. Precinct or ward geographies (and population data in the P.L. 94-171 files) are included for those states that participated in the Census Bureau's [Voting District Project](#) (see section 4.4.1.1).

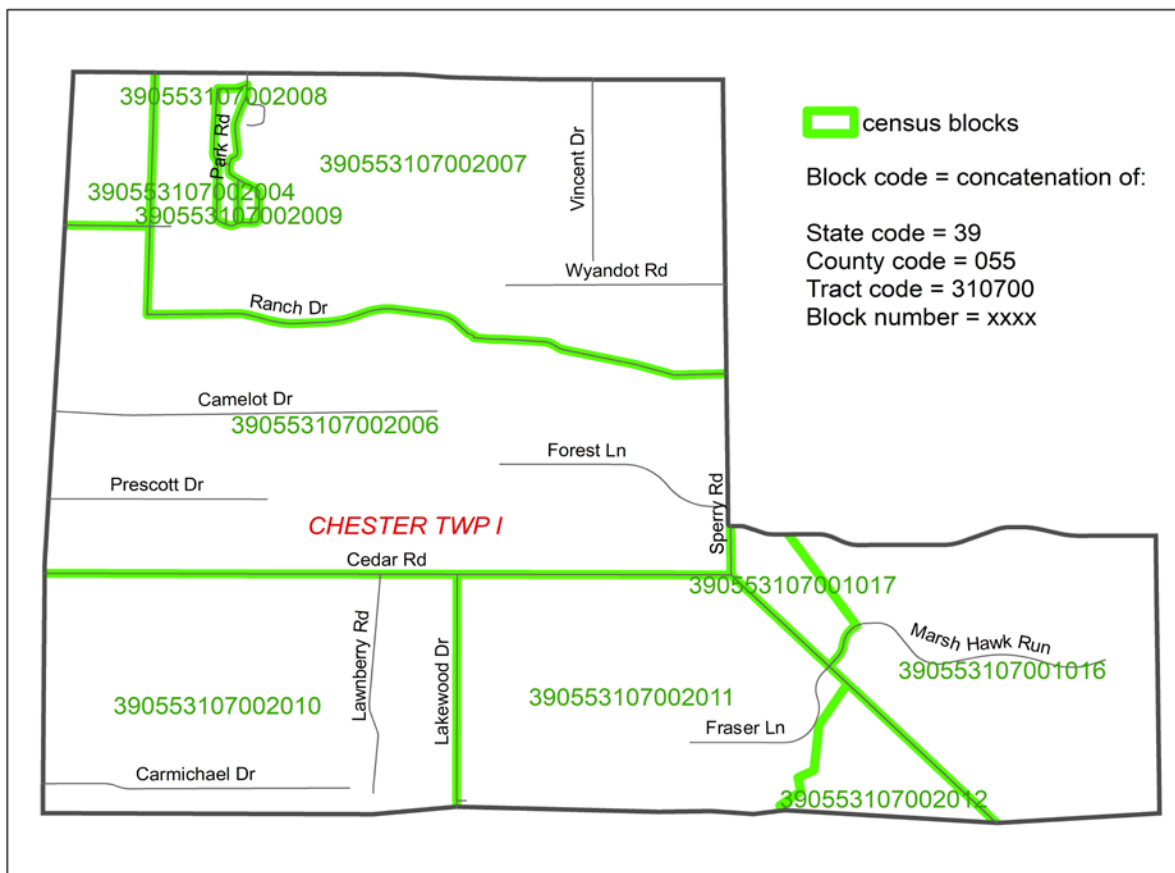
Importantly, for the redistricting process, the block and other polygon shapes used to build districts undergo extensive changes between census years. The Bureau's [Boundary and Annexation Survey](#) monitors annexations and other local boundary changes to municipalities, villages, and townships. With local input, changes to census tracts are also made between decennial census years to account for population changes and changes to the features used to delineate them. In addition, a year or two prior to the decennial Census, the Bureau's [Redistricting Data Project](#) asks state and local entities to recommend boundaries for census blocks and Voting Tabulation Districts (VTDs). VTDs provide a layer that can be used with the state's recent election data. Thus, the layers used for redistricting in prior cycles are all revised for the next cycle, and it is

necessary for the data user to download and use the new TIGER files.

#### 4.4.1.1 Voting Tabulation Districts

Some redistricting processes call for including recent election results, which are tabulated by precinct. The Census Bureau's Voting District Project is designed to accommodate this process by providing states the opportunity to create a voting districts layer in TIGER. The voting districts developed in the Bureau's program are called VTDs. Precinct-level election results data (tabulated by local boards of elections or the state) can be joined to the TIGER VTD shapefiles. Some redistricting software packages will have done this for the user.

The Bureau's program allows participants the ability to use visible and nonvisible edges for voting district boundaries since precincts and wards may be delineated locally based on property lines or other features not normally used to delineate census geography. In VTDs, edges were added to delineate voting districts as needed and were also used in block delineation; thus, census blocks nest within VTDs (see Figure 5). TIGER/Line products for the 2020 Census include the VTD polygons, and the lines are used for block boundary delineation.



**Figure 5:** Nested Census Blocks within "VTD I" of Chester Township. *Source: Author*

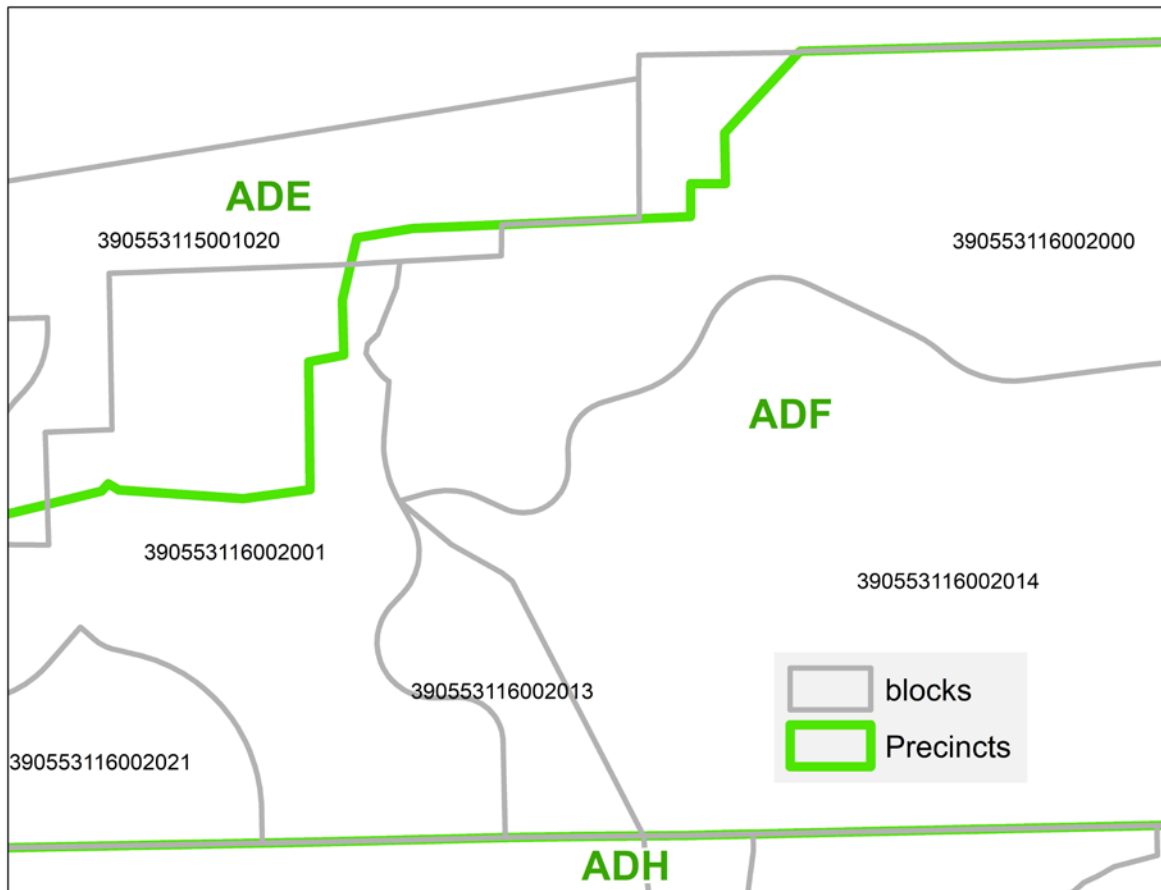
However, the use of VTDs assumes/requires that the precincts for which the election results have been tabulated match the VTDs in name and shape. If the VTD geography does not coincide with the precinct geography for which election results are available, then differences between the VTD and precinct shapes must be reconciled. Additionally, states that are not participating in the Voting District Project, but that plan to include recent election data in the redistricting process, have to reconcile any boundary differences between census blocks and the precincts that split block boundaries.

In such cases, some census blocks are geographically shared by more than one precinct, requiring estimation of the precinct-level election results at the census block level. Several estimation methods are possible, including proportional apportionment of the precinct-level election results data to the blocks based on proportions of area, population, or geocoded registered voters. Figure 6 illustrates the problem when precincts do not line up with census blocks. In the ex-

ample, three blocks are shared by two precincts, ADE and ADF. To allocate the voting results from precinct to the blocks, one might apportion the voting results based on the proportions of precinct areas that are in each block. A block with a third of the area of a precinct would be assigned a third of the election results. Summing at the block level produces an estimate of the voting results in each block. Conversely, block population data can be allocated to the precincts by the proportions of the block area that are found in the precincts sharing the block. If registered voter addresses can be geocoded with high matching rates, the proportions of the registered voters in each block could be used to apportion voting results.

#### 4.4.2 Census demographic attributes

Normally the P.L. 94-171 data are released to the states by March 31st of the year ending in "1" (e.g., 2021). This cycle, however, delays due to the COVID-19 pandemic and issues related to compiling the data accurately have caused delays in this schedule. The Census Bureau announced that the data will be made



**Figure 6:** Example of Precincts (green lines/labels) Not Aligning with Census Block. *Source: Author*

available by September 30, 2021, though there are expectations that they will be released in August.

Potential impacts of these delays are covered in “[How Changes to the 2020 Census Timeline Will Impact Redistricting](#)” (Yurij Rudensky, Michael Li, and Annie Lo, the Brennan Center for Justice, 5/4/2020), and in the NCSL’s report, “[2020 Census Delays and the Impact on Redistricting](#)” (12/10/2020). Another source is “[Impact of COVID-19 on 2020 Census Data & Redistricting](#)” from Common Cause.

The P.L. 94-171 data include voting age and total population by race and Hispanic or Latino ethnicity. The census allows persons to indicate up to six race categories of association:

1. White
2. Black or African American
3. American Indian and Alaska Native
4. Asian
5. Native Hawaiian and Other Pacific Islander
6. Some other race

In addition to counts of persons indicating only one race (e.g., White alone), tabulations also include all combinations of the race categories, for example, White/Black or African American, White/American Indian and Alaska Native, White/Asian, etc., for the two-race categories. Three-, four-, five-, and six-race combinations are also included as tables in the file.

The census includes a separate question on Hispanic or Latino ancestry; thus, persons may be Hispanic/Latino of any of the races and race combinations above. Therefore, Hispanic or Latino persons are also tabulated with all combinations of race. Some detail to the race question was added in 2020; see section 8.1.5 for details.

Tables of housing occupancy and group quarters population are also included. The included tables are shown in Figure 7.

Geographic identifiers in the TIGER files have corresponding codes in the P.L. 94-171 data so that they can be joined easily.

#### 4.4.3 Other data

Many of the population and housing characteristics from the decennial census, such as detailed age and household characteristics, may also be useful for redistricting, but they probably will not be available until the end of 2021 or later.

However, each year, the Census Bureau releases estimates from the [American Community Survey](#) (ACS). These data supplement the census by providing information on more than 40 topics, including education, income, citizenship, health insurance coverage, commute times, occupations, and languages spoken at home. ACS data may be particularly useful for identi-

<b>Redistricting Data Program</b>	
<b>Phase 3 – P.L. 94-171 Redistricting Data Tabulation Product</b>	
<b>2020 Census P.L. 94-171 Redistricting Data Tabulations</b>	
Table P1 – Race	
Table P2 – Race for the Population 18 Years and Over	
Table P3 – Hispanic or Latino, and not Hispanic or Latino by Race	
Table P4 – Hispanic or Latino, and not Hispanic or Latino by Race for the Population 18 and Over	
Table H1 – Occupancy Status (Housing)	
<b>New Table</b>	
Table P5 – Group Quarters Population by Group Quarters Type	
<ul style="list-style-type: none"><li>• All tables produced at multiple geographies including census block</li><li>• Group Quarter types: Correctional Institutions for Adults, Juvenile Facilities, Nursing Facilities/Skilled Nursing, Other Institutional, College/University Student Housing, Military quarters, and other non-institutional</li><li>• Group quarters is total population only, no demographic breakdown</li></ul>	
13	2020CENSUS.GOV
Shape your future START HERE >	
United States Census 2020	

**Figure 7:** Redistricting Data Program P.L. 94-171 Data Tabulation Product. Source: “Interim Joint Committee on State Government,” a PowerPoint presentation by James Whitehorne, Chief - Census Redistricting & Voting Rights Data Office, Census Bureau, 11/17/2020.

fyng and delineating communities of interest, which may be one of the considerations used in the districting process (see section 5.2.4).

The user should understand that the ACS data are *estimates* based on a sample and therefore have margin of errors (MOEs). The MOEs provided with the estimates indicate, with 90 percent confidence, the range of values in which the actual value would lay were the data collected from the universe (e.g., of persons) being measured. To provide estimates for small geographic areas (such as census tracts and block groups) with sufficient reliability (i.e., 90 percent confidence in this case), the Census Bureau uses (combines) five years of survey results to derive the estimates and their MOEs. Estimates for larger populated geographic areas with 65,000 persons or more, such as states, metro areas, and larger counties and cities, are available based on one-year survey totals. The five-year ACS estimates for census tracts and block groups, because the populations being estimated are small, may have relatively large MOEs, and the user is cautioned to consider them in using the estimates. The block group level is the smallest geographic layer for which the ACS estimates are provided, but not all of the estimates available at the census tract level are available at the block group level.

Precinct-based population tabulations are included in the P.L. 94-171 data for states that participated in the Bureau's Voting Precinct Project (see section 4.4.1.1). Election results data showing results by candidate and party, however, are the purview of the state and are not provided by the Census Bureau. That type of data is typically available by voting district (generally known as precincts) from the secretary of state for each state. Experience has shown that the names or codes for these districts may not coincide with those found in the TIGER data (as VTDs), since local precincts are the responsibility of local boards of elections and can change in both their geography and names from one election to the next.

Other helpful sources of precinct geography and election results include the University of Florida's [United States Election Project](#) and the Harvard [Election Data Archive](#). In addition, Tufts University has a crowdsourcing project to digitize precincts: [Project 2: Digitizing Precinct Maps](#).

## 4.5 Plan outputs

Depending on legal requirements in each state or government entity, the final plan of districts includes a description of the plan listing the geographic components of each district (e.g., counties, municipalities, VTDs, or census blocks). A narrative description of the

plan could also be required, such as a detailed street-by-street description of district boundaries ("metes and bounds"). Possible other products include map(s) showing the district boundaries and a report summarizing relevant statistical information for each district in the plan, such as population and racial/ethnicity data, partisan metrics, or compactness scores and other metrics. Sections 4.6 and the Supplement on software options provide more information about software tools for creating these outputs.

## 4.6 Software functionality for redistricting

How does GIS software for redistricting differ from a typical GIS package? After all, if the central process of redistricting is drawing and mapping new geographic districts, shouldn't a GIS be adequate for the job? The traditional vector-based GIS provides a great deal of what is needed, but there are additional features in a redistricting product that bring vital convenience to the process.

The process of creating new districts involves many standard GIS operations. Navigating around an area, adding (and hiding) different layers, examining quantitative attributes of features, selecting and editing polygons, and publishing maps are just a few. Most of the available redistricting software offerings were in fact built on top of a preexisting GIS platform, such as Mapbox, Esri's ArcEngine, Caliper's Maptitude, and QGIS. The following sections describe additional redistricting functions, ranging from the indispensable core tools to the latest cutting-edge functions that may be of use for redistricting practitioners. Specific redistricting software systems are discussed in the Supplement.

### 4.6.1 The most fundamental components

As noted in section 4.4, districts are built from smaller census geographies. Generally, the most basic geographic census unit is the block, though larger geographic entities in the TIGER hierarchical structure, such as county subdivisions and counties, can be used as well. Thus, a district might be a collection of counties, townships and cities, and blocks. VTDs might also be used. At its most basic level though, most districts are simply an aggregation of census blocks.

Accordingly, the most crucial added functionality of redistricting tools to a GIS has to do with the aggregation of the shapes and attributes of a district's component parts.

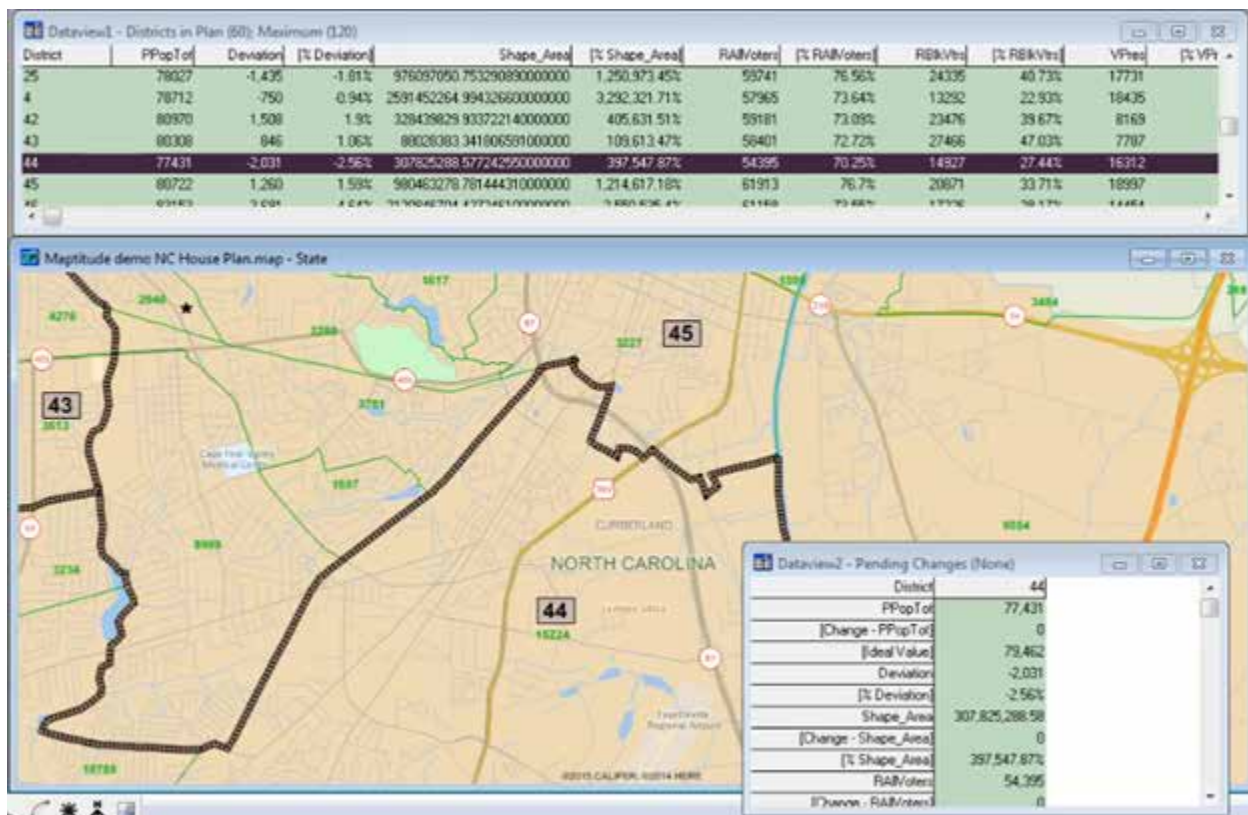
#### 4.6.1.1 Aggregated statistics

The manual process of creating districts involves selecting census geographies that will become part of each district. As discussed in section 5, the primary required objective is population equality among districts (see section 5.1.1). But by automating the process with the use of GIS districting tools, the user will find it tremendously helpful to see—at each step—the total population of the proposed districts as each district is built. Most redistricting software packages display a separate table that shows the aggregated population attributes of each district under construction. Most also provide a column in that table showing how close each district is to the desired ideal population (see description of the ideal population in section 5.1.1.1). Many of them also allow for a preview of the effects of changes before the user has “committed” that edit. Figure 8 provides an example of how one GIS districting system looks.

The total headcount for each district is straightforward (simply the sum of each component part’s population), but computation of some of the other population attributes are a bit more involved. For example, one key metric users might consider when looking to

satisfy the requirements of the Voting Rights Act (see section 5.1.2) is the %BVAP, which is the percentage of the voting age population that is Black. The block-level redistricting data (P.L. 94-171) provide the number of persons aged 18 and over by race and Hispanic ethnicity at every level of geography, but the sum of each of those numbers must be divided by each district’s total population age 18 or over (and multiplied by 100) to yield the voting age percentage of a racial or ethnic minority. The user specifies the desired demographic statistics (such as %BVAP) using configuration settings, and the results are calculated automatically and shown alongside the total population each time the draft districts are updated.

If partisan information is deemed useful to the redistricting process (possibly as a criterion), a similar calculation can be performed based on data that the user (or vendor) supplies on recent election results for the geographic units being combined. A partisan index can be created by dividing the sum of votes for a party’s candidate(s) in previous races by the total number of votes cast (or the two-party total). The resulting fraction provides a sense of how a party’s candidate is likely to perform in a district. As noted in the section



**Figure 8:** Identifying a District in Table and the Pending Changes Window Using Maptitude. Source: Blake Esselstyn, AICP, GISP, Principal, FrontWater, LLC + Mapfigure Consulting

on data, election results are usually available at the precinct level, and some software includes tools to disaggregate those numbers down to the block level. These methods are briefly discussed in the section on VTD data (see section 4.4.1.1) and disaggregation (see section 4.6.2). Figure 9 is an example used in a North Carolina partisan gerrymandering trial in 2019. It shows that the consultant, Dr. Thomas Hofeller, was shading the VTDs in the map based on a partisan index formula like the one described above. RV indicates Republican votes and DV indicates Democratic votes from nine statewide races.

#### 4.6.1.2 Compactness scores

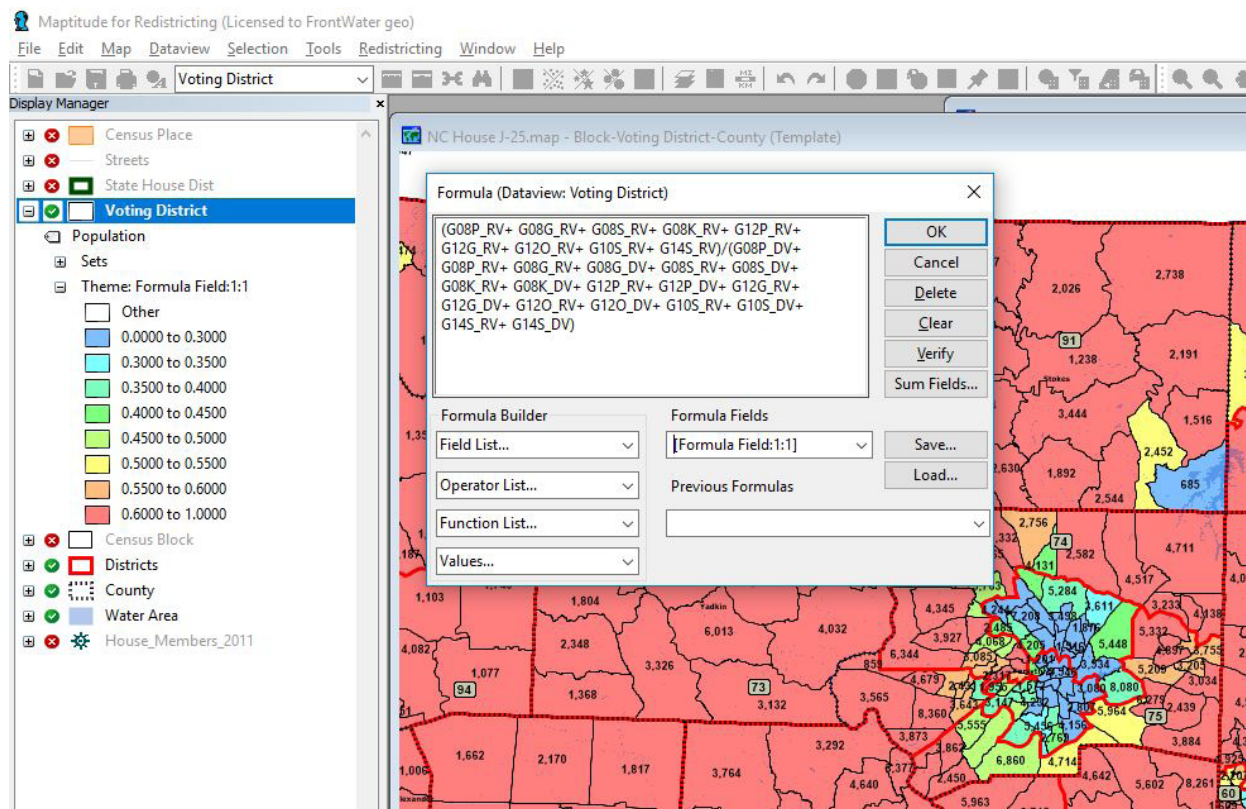
As discussed in section 5.2.1, there are a variety of methods to consider the compactness of a district or the overall compactness performance of an entire districting plan. Most districting software allows for swift calculation of these measures (not a standard tool in a typical GIS). Some states or jurisdictions may require documentation of how districts or plans perform on some of these measures, and similar statistics are often cited in court cases where plans are alleged to have been gerrymandered.

#### 4.6.1.3 Integration of hierarchical data structures

If one is creating a state-level plan, and choosing which counties to include in a district, it would be a tedious, error-prone exercise to manually click on (select) all the voting districts or blocks in each county. Most GIS districting software allows the user to operate at multiple levels by moving back and forth between selected counties, voting districts, or blocks, as one builds districts. Since each of these entities perfectly nests hierarchically within their parents' geographies (note that the TI in TIGER stands for Topologically Integrated), higher-level selections can always be mapped down to blocks. Most districting software systems allow the user to take advantage of this kind of hierarchical spatial data relationship with minimal effort.

#### 4.6.2 Additional helpful features

Without the functions mentioned above, the act of drawing districts would be much more difficult. The features described below, by contrast, are not quite as essential, but certainly add convenience to the districting process:



**Figure 9:** Example of a Partisan Index Calculation. *Source: Blake Esselstyn, AICP, GISP, Principal, FrontWater, LLC + Mapfigure Consulting*

- **A plan management utility**  
Most tools have a dedicated, separate interface for initiating and managing plans, with additional features beyond how other geographic files are managed. Metadata such as the owner, descriptive notes, and date last edited can be easily viewed and compared. At least one software system even provides versioning features.
- **Plan integrity checks**  
One single command can verify whether a plan has any blocks unassigned to a district, or whether any district parts are not contiguous. The same tests could be performed with other standard GIS processing steps, but having the preprogrammed tests makes it easier (and benefits the novice user).
- **Reports**  
Predesigned report templates can provide the user with much useful information, such as a summary of which cities and towns are in which districts, and which of them are divided—including statistics about how each area is divided up. Additionally, preformatted reports provide the user with a relatively easy way to create reports about the demographics of each district, or the compactness statistics, or whether incumbents are paired in a district. Generally, the pricier districting software packages offer more such predesigned reports.
- **Locking of districts**  
When creating a plan, sometimes the user may be satisfied with a particular district—at least for the moment. Being able to lock one or more districts prevents that district or districts from being accidentally modified while working on others. The best versions of locking allow users to select a county (for an active, unlocked district) that already has some subunits assigned to locked districts, and it will assign only the subunits of that county that are not in locked districts.
- **Comparison of districting plans**  
One common part of a redistricting process is evaluating two or more plan candidates to see how they compare. In addition to a simple visual comparison of a plan's maps, some tools allow comparison of various statistics such as overall compactness, population equality, or partisan proportionality. The comparison function can permit the comparison of district attributes and report on which subunits differ between the two plans.
- **Disaggregation**  
As previously mentioned, repetitive aggregation of statistics for geographic units is a crucial piece of

what districting software offers. But some users may want to disaggregate, or to proportionally divide and assign estimated statistics to geographies that are lower in the hierarchy of geographies. More advanced programs have specialized tools for this task. For example, one can use block populations (or perhaps voter registrations) to estimate from a previous election how many votes in a precinct likely came from each block within the precinct.

- **Written descriptions**  
The final legal rendition of a districting plan is usually not a map of the plan but a written description of the districts. Whether this written description is in the form of a listing of each district's component geographic units or in the form of a metes and bounds description of boundaries, some programs will automatically generate this cumbersome language.

### 4.6.3 New bells and whistles for this decade

The Supplement provides more detail on software tools, including a summary of each and a brief description of what sets it apart. In 2021, there are more application options than any previous redistricting cycle, and the list will most certainly continue to grow after publication of this guide. The following list briefly highlights some of the new features that software makers are promoting as significant in the current redistricting cycle:

- **New metrics**  
There are new measures of compactness (see section 8.3.2) as well as many measures purporting to help identify excessive partisan skew, such as the median difference (see section 5.3.1), efficiency gap, and declination (see section 8.3.3).
- **Integrated publishing of plans to the cloud—and commenting thereon**  
Recognizing that citizens have become used to exploring interactive maps, some packages now facilitate the viewing of plans within web portals. Some even provide for viewers to add comments “pinned” to specific spots on the map.
- **Simultaneous collaborative editing**  
Are you used to tools like Google Docs, where multiple people can be editing a document at the same time? At least one app provides a similar option for collaborators working on a redistricting plan.

- **Touch-screen friendliness**  
This is an age of ubiquitous devices steered by fingers touching screens. Some of the new tools sport a reimagined interface to be much more usable via the touchscreen—not only for plan-making on a tablet but also for on a large-screen smartphone.
- **Algorithmic, or automated district creation or editing**

These “smart” automated functions come in multiple flavors, ranging from automated “fixes” (e.g., automatically assigning a stranded donut hole unit to the district that surrounds it) to fully automated creation of plans based on predesignated criteria. One vendor promises to provide automatically generated ensembles (see section 8.3.1) of plans with which to compare officially proposed or approved plans. This allows assessment of whether the official ones are outliers with respect to partisan performance (or conceivably in their protection of minority voting rights).

## 5 CRITERIA

What should a set of district boundaries (i.e., the district plan) achieve? Population equality and minority voting rights have been required by federal statute and the federal courts' interpretations of the Constitution. Beyond these requirements, a commonly held belief is that compact districts are desirable, presumably because they are more likely than not to allow for districts with communities of similar beliefs, customs, and political interests to vote on the same candidates and on the same issues. And less compact districts suggest, though do not mean, that their configuration was created to affect politically or racially motivated outcomes (i.e., they have been gerrymandered—discussed below).

Such concerns indicate that election districts should be drawn “fairly.” But what is fair?

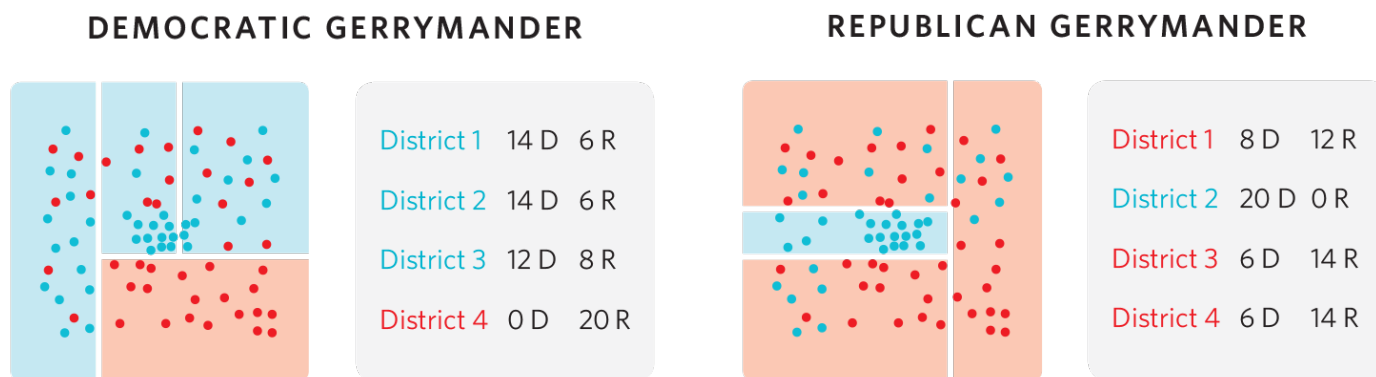
Fairness is subjectively interpreted, so some scholars and others have argued for computer-generated “objective” map making that removes political or other biases. Among others, [Magleby and Mosesson \(2018\)](#) have offered an algorithm that achieves districts that are politically “neutral” and are “...contiguous, balanced (in population) and relatively compact.” Yet, drawing election boundaries is more often seen as (and even preferred to be) a process aimed at achieving political end results. The variety of criteria that may be applied, and which often conflict with one another, makes the process subject to value judgments about which criteria are more important than others. For this reason, some advocates for fair redistricting schemes prefer

to rely on a process for selecting nonpartisan commissions rather than on criteria that are difficult to define in detail.

Districts drawn to unfairly favor individual candidates or a group's political interests over others are commonly referred to as *gerrymandered* (Figure 10) and may be violating the Equal Protection Clause and/or the First Amendment of the U.S. Constitution (viewpoint discrimination). Such districts can be achieved through geographically *packing* and *cracking* certain groups of voters (Figure 11).

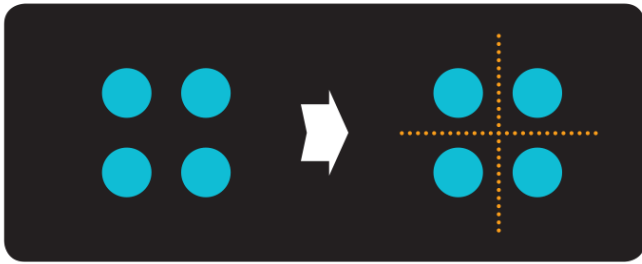
Packing voters who share similar voting behaviors concentrates them into fewer districts. Packing (concentrating) voters with shared voting preferences results in a larger number of “wasted votes,” which are those that exceed the minimum number to win the election. Cracking occurs when boundaries are deliberately drawn to divide a concentration of like-minded voters who share similar voting preferences and disperse them across several districts. Cracking dilutes the voting strength of a group and can prevent its preferred candidates from receiving a majority of the votes.

Congressional redistricting involves, for each state with more than one representative, creating or redrawing geographic boundaries for U.S. House districts. Except for population equality and adherence to the Voting Rights Act (VRA) of 1965, redistricting rules vary and are largely determined by state law. There are, howev-

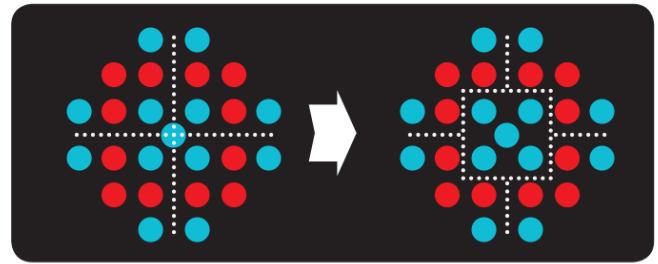


**Figure 10:** Partisan Gerrymandering. Source: *A Citizen's Guide to Redistricting*, the Brennan Center for Justice, 2010 Edition.

## "CRACKING"



## "PACKING"



**Figure 11:** Cracking and Packing. *Source: Ibid*

er, some common standards and criteria. Some of the measurements used in evaluating a district or district plan are discussed here.

See Ballotpedia's "[State-by-state redistricting procedures](#)" and Justin Levitt's blog (now Doug Spencer's) "[How can the public engage?](#)"

## 5.1 Federally mandated criteria

Public Law 90-196 requires single-member districts (SMDs) (voters only vote for a representative in their own district). Other federal requirements are population equality and compliance with the Voting Rights Act of 1965 on racial/language minority protections.

### 5.1.1 Population equality

Over the years, legislative provisions have required that, as nearly as practicable, congressional districts contain an equal number of inhabitants within each state. The U.S. Supreme Court has also established the "equality standard," or "one person, one vote" principle (based on the Constitution's Equal Protection Clause), which requires that congressional districts within a state be drawn to approximately equal population sizes. Mathematically, differences must be as close as possible to an ideal (average) district size.

The courts have required differences in a state's congressional districts to be extremely small (0 or 1 person), since the geographic building units used are census blocks, which may have as few as one (or no) population and make it easy to accomplish. Yet some states, such as Iowa, Ohio, and West Virginia, also require preservation of political subdivisions, such as counties and municipalities. State legislative districts, which often require more requirements than population equality and VRA compliance, can, and always do, allow for more variation in population. Generally, population equality for state legislative districts can vary

by 5 percent around the average district population. In addition, a number also have requirements concerning preservation of political subdivisions.

While the total population seems to be the required numbers to use for congressional districting, it is not a forgone conclusion that this will be true at the state and local levels in 2021. In 2011, all states used the total population for state legislative districting. However, other measures may be tried this cycle, including voting-age population, citizen voting-age population, or registered voters. The "[Guide to Drawing the Electoral Lines](#)" states that: "Each of these alternatives depends on a logic of exclusion, denying representation to those who pay taxes and who are expected to live by our laws. Though the Supreme Court has formally left this question for a future case, their last word in the area left serious question as to whether such measures would be constitutional."

#### 5.1.1.1 Measurement

Population equality is calculated by measuring how much each district's population varies from the number of people each district should have, using the most recent census figures. The greater the variation, the lower the plan scores. There are three statistical concepts involved in measuring population equality. The first is the ideal population, in which the "ideal" district population is equal to the total state population divided by the total number of districts (or representatives in multimember districting plans). The second concept is the deviation or degree to which 1) an individual district's population differs from the ideal, and 2) how much all districts collectively vary in population from the ideal. The deviation for a single district is usually expressed as a percent of the ideal population. Measuring the extent to which populations of all the districts in a plan vary collectively from the ideal is done with either the mean deviation (absolute or percentage) or the overall range of deviations among the districts or between the largest and smallest district.

The chart in Figure 12 provides the formulae for these measures.

## 5.1.2 Compliance with the Voting Rights Act

The Voting Rights Act (VRA) prohibits states (or political subdivisions in the case of wards, for example) from diluting the voting strength of persons based on their race, color, or membership in a language minority. The VRA is intended to prevent viewpoint discrimination against such groups.

Determination of whether the VRA has been violated is ultimately left to the courts, but until recently one practical application of this requirement is that a re-districting plan must draw as many *minority-majority* districts as possible, which are ones in which the majority of the constituents in the district are of a racial or ethnic minority (non-White or Hispanic). Courts have allowed exceptions when there has been a history of high minority turnout and/or crossover voting (e.g., Whites voting for Black-preferred candidates).

The Court noted that the VRA “...does not require a covered jurisdiction to maintain a particular numerical minority percentage. It requires the jurisdiction to maintain a minority’s ability to elect a preferred candidate of choice.” ([“North Carolina Supreme Court Disregards U.S. Supreme Court in Redistricting Case”](#))

But because Black and Hispanic voters have tended to lean Democratic, the VRA has also been used for

partisan gerrymandering by packing minority voters in hyperconcentrated Democratic districts. In recent cases, the courts have moved away from accepting numerical racial targets, instead favoring district lines that demonstrably comply with the VRA.

It is suggested that the reader also review the discussion on recent changes in section 8.2.1.

## 5.2 Additional widely-used criteria by the states

In addition to requirements imposed by the federal government, several other traditional districting principles are commonly used by many states, including contiguity, compactness, observing administrative boundaries or communities of interest, and following physical or natural geographic features. The common criteria for congressional and state redistricting used by each state are provided in [“Redistricting Criteria,”](#) by Ben Williams and Wendy Underhill, *NCSL Newsletter*, September 2017, Vol. 25, No. 34.

Beyond the federally mandated criteria, many states provide that the other criteria, including some found in the section on fairness criteria below, should be used in ranked priority; California does so explicitly in the state constitution. As another example, Ohio prescribes a process for both its state and congressional districts that tries to minimize the splitting of counties and municipalities. Other stipulations call for districts to be compact and not give political party advantage.

IDEAL DISTRICT POPULATION	=	State Population/ Number of Districts
INDIVIDUAL DISTRICTS		
ABSOLUTE DEVIATION	=	District Population - Ideal Population
RELATIVE DEVIATION	=	Absolute Deviation/ Ideal Population
ALL DISTRICTS		
MEAN DEVIATION*	=	Sum of All Deviations/ Number of Districts
RANGE*	=	Largest Positive Deviation and Largest Negative Deviation
OVERALL RANGE*	=	Largest Positive Deviation + Largest Negative Deviation (Ignoring “+” or “-” signs)
*Can Be “Absolute” or “Relative”		

Source: NCSL, 2009.

**Figure 12:** Statistical Terminology for Measuring Population Equality. Source: [“Redistricting Law 2010,”](#) *National Conference of State Legislatures*, November 2009, p. 25.

Measures for these objectives are unspecified. (see “Ohio Issue 1, Congressional Redistricting Procedures Amendment (May 2018)”, *Ballotpedia*.)

### 5.2.1 Compactness

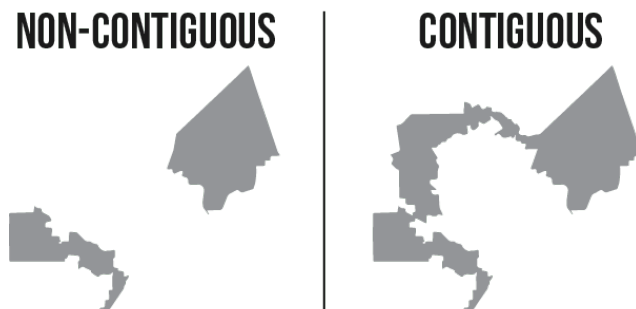
Geographical compactness is an easy concept to understand, but legislation may ignore the fact that measurement methods vary. The goal of having compact districts is to cluster geographically nearby residents into the same district. When compactness is deemed important, shapes like circles, squares, or hexagons are favored over irregular or bizarrely shaped districts. The extent of such irregularly and noncompact districts is often seen as a possible indication of unfair districting such as in the case of partisan gerrymandering.

Proponents of compactness tend to use arguments based on advantages of propinquity, efficiency, and communication. It is argued that compact districts can reflect shared interests within districts or provide more efficiency in legislative activities, such as in campaigning. Yet, irregular districts may be necessary to comply with what may be more important criteria, such as the VRA, maintaining communities of interest or political units, or limitations due to natural features such as mountains and rivers.

There are differing opinions on how to quantitatively define compactness, and there is a plethora of methods. Some compare a district’s length to its width, for example; others compare its area to that of a hypothetical area that may consist of a circle minimally containing the district or a minimum convex polygon containing the district (like wrapping a rubber band around the boundary). Others consider the geographic distribution of the population within the district. Some experts argue that if compactness is to be evaluated it should be based on a combination (perhaps an average) of multiple compactness measures.

### 5.2.2 Contiguity

Most states require that districts have contiguity, that is, that all parts of the district are in physical contact with some other part of the district, even if only at a point. Figure 13 demonstrates the concept. For a district to be contiguous, some would also expect that it generally must be possible to travel from any point in the district to any other point in the district without crossing into a different district. A district may also be considered contiguous if the district is split by a body of water but there is a method of transport over the water, such as a bridge. For example, the eastern and western portions of Ohio’s 9th congressional district is connected by a bridge that spans a bay in Lake Erie. Forty-nine states require state legislative districts to be contiguous, and 23 require congressional districts to be contiguous (see “Where are the lines drawn?”).



**Figure 13:** Non-Contiguous and Contiguous Districts. Source: *RedistrictingOnline.org*, <https://redistrictingonline.org/basics-redistrictingprinciples/>

### 5.2.3 Preserving political or administrative boundaries

Most states specify that existing political boundaries, such as counties, cities, or towns, be considered in drawing state and/or congressional boundaries. These requirements often involve such places not be shared by districts or split only when either population size or other criteria require it. Election administration may be simplified in such cases. Another rationale is that political entities often have agendas that are best served by only one or a few representatives, and that a representative with more than one such entity in his or her district may not prioritize the entity’s interests. On the other hand, it could be argued that a political entity could be better served by having more than one representative. In addition, some states discourage drawing district boundaries that would create electoral contests between incumbent legislators.

Also, some state legislatures require nesting of lower chamber districts within the higher chamber districts. In Ohio, for example, each senate district includes three house districts.

### 5.2.4 Communities of interest

Many geographic areas have a shared background or common interests that may be relevant to their legislative representation, and some states include a requirement (or preference) in their redistricting process. Common interests may be due to social, cultural, historical, racial, ethnic, partisan, or economic factors. In some instances, communities of interest may be preserved by following criteria such as compactness or preserving political subdivisions. However, selective or overuse of this criteria may conflict with a goal to create competitive districts (see section 5.3.3).

### 5.2.5 Following geographic features

Natural features in the geographic landscape, such as rivers, lakes, watersheds, or escarpments, may provide suitable boundaries for legislative districts. Dominant topographical features, such as mountain ranges and bodies of water, may present barriers to transportation and communications that should be avoided in creating cohesive legislative districts. Manmade features too, such as highways or industrial and commercial zones, may be logical features to separate districts. Sometimes, as can be the case with transportation corridors, they provide a logical way to connect otherwise disconnected populations. They also can create communities of interest.

## 5.3 Fairness criteria

The criteria described above do not explicitly consider issues of political partisanship in the drawing of boundaries. But, as noted above, drawing political boundaries (or even some administrative ones) inevitably provides an opportunity for those drawing the boundaries to use the districting process to their advantage and to impose viewpoint discrimination against others. Certainly, “fairness” is in the eye of the beholder and means different things to different people or groups. Some of the criteria that explicitly concern what might be seen as matters of fairness in a redistricting plan are described in this section.

### 5.3.1 Partisan advantage

In a fairly drawn districting plan, one might expect, all other things being equal, that the number of seats won by each political party is at least roughly equal to the proportion of votes the parties’ candidates received. This is commonly referred to as “representational fairness” or “proportional fairness.” Though this makes intuitive sense, scholars point out that 1) there is no constitutional or districting law requiring that the percentages of seats won and votes for a political party be proportional, and 2) there are mathematical reasons concerning what is known as *partisan symmetry* that show why this relationship may be violated beyond any obvious partisan influence. In fact, elections usually generate outcomes in which a majority party’s share of seats tends to exceed its proportion of popular support. Furthermore, it has been shown that *partisan symmetry scores*, which are intended to measure this symmetry, can be misleading. Not surprisingly, geography plays an important part; concentrations of a party’s voters may make proportional fairness difficult or impossible, especially when including other criteria in the process. These issues are discussed after first considering the likely impact when one political party controls the districting process.

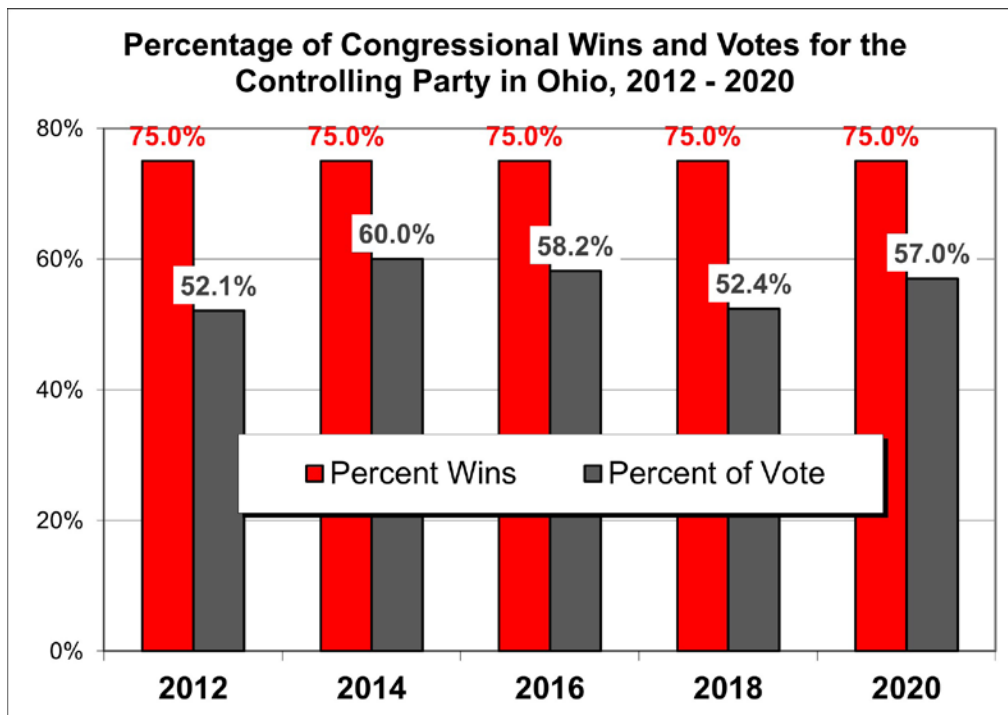
When the districting process is largely controlled by one political party, that party can exert partisan advantage and the result is known as *partisan gerrymandering*. This is the process of drawing the boundaries of electoral districts in a way that gives one party an unfair advantage over its rivals. *Extreme Partisan Gerrymandering* occurs when the goal of a party seeks to draw boundaries that guarantee producing an extremely disproportionate share of seats. This is achieved by geographically *packing* opponent’s supporters in few districts or *cracking* (splitting) geographic concentrations of them into multiple districts. Meanwhile, its own supporters can be spread out into more districts that are therefore likely to attain a majority for the party’s candidate. The result of such a highly partisan districting map is a disproportionate number of seats won by the controlling party compared to the proportion of votes the party’s candidates receive. It has been argued that partisan gerrymandering restricts the expression of political speech of a significant portion of the electorate and therefore violates the First Amendment.

An example of political gerrymandering is found in Ohio, where one party had control of drawing both the state legislative and congressional boundaries after the 2010 census.<sup>2</sup> Figure 14 illustrates the results in the elections of 2012 through 2020. With the percentage of votes for congressional candidates in the controlling party ranging from 52.1 percent to 60 percent in these elections, a consistent 75 percent of the seats were won by that party. Factors such as the advantage of incumbency and possibly having stronger candidates in these elections may have also played roles in the disparity. Theoretically, the geographic concentration of voters for the non-controlling party (such as in dense urban areas) may have also made drawing district boundaries with less partisan results difficult (or easy). However, challenges to the districting plan have shown that more politically proportionate district plans were possible.

Measuring the disparity between percentage of votes cast and seats won by each political party is often accomplished using *partisan symmetry scores*. One such measure is the *mean-median difference metric*, in which a party’s mean percentage of votes across all the districts in an election is subtracted from the median percentage. The difference indicates any non-symmetry between percentages of votes and seats obtained and how far short of half of the votes

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<sup>2</sup> For a discussion of the partisan control of the districting process in Ohio, see “Redistricting Congressional Districts in Ohio, An Example of a Partisan Process with Long-Lasting Consequences,” by Mark Salling, in Miller, William J. and Jeremy D. Walling, Eds., *The Political Battle Over Congressional Redistricting*, Lanham, MD: Lexington Books, 2013.



**Figure 14:** Example of Poor Representational Proportionality. *Source: Author*

a party can fall while still winning half the seats. The relationship between these percentages is known as the *seats-votes curve*, and measuring how many seats were won or lost as a result of non-symmetry is called the *partisan bias* metric. Note again, however, that scholars have found these metrics can be misleading depending on the distribution of a party's voters among the districts. A greater range of voting percentage discrepancies can lead to more majority party wins than intuitively expected, while a narrow range can even suggest the wrong party's advantage in the metrics. Nevertheless, such metrics can be used to call for an examination of the causes of the discrepancies.

The conclusion reached is that the relationship between seats won and percentage of votes obtained may be the result of partisan gerrymandering, however, understanding the extent of the disparity is complex.

### 5.3.2 Incumbent protection and maintenance of core area

Incumbent protection during the redistricting process refers to either 1) any effort to avoid combining portions of former districts that would result in competition between incumbents, or 2) attempting to ensure that an incumbent is likely to win in a newly drawn dis-

trict by retaining at least the "core" of the incumbent's previous district. Partisan gerrymandering particularly favors incumbents because they generally influence the drawing of the voting boundaries to avoid competition. An argument for such practices is that it results in continuity of representation. Some states allow intentional incumbent protection and others prohibit it.

### 5.3.3 Competitiveness

In a competitive district, a candidate from either major party usually has a realistic chance to win the general election. Thus, one might seek to increase partisan competitiveness among districts as a goal for partisan symmetry. In addition, electoral competition has long been associated with greater interest in elections and greater incentives to vote, and thus higher voter participation rates. It is thought to be a crucial link in ensuring a connection between public opinion and responsiveness in the political system.

In "When does redistricting matter? Changing conditions and their effects on voter turnout" (*Electoral Studies*, August 2018, 54:128-138), Charles Hunt affirms a history of extensive research that shows that partisan redistricting, through packing and cracking, causes individual districts to vary heavily in how much election competitiveness changes among districts from one election to another. Electoral competitiveness is also linked to related goals such as partisan propor-

tionality, more effort of candidates to take moderate policy positions, more importance of each vote, and fewer “wasted votes,” which occur when an election is won with a far greater number of votes than the necessary minimum.

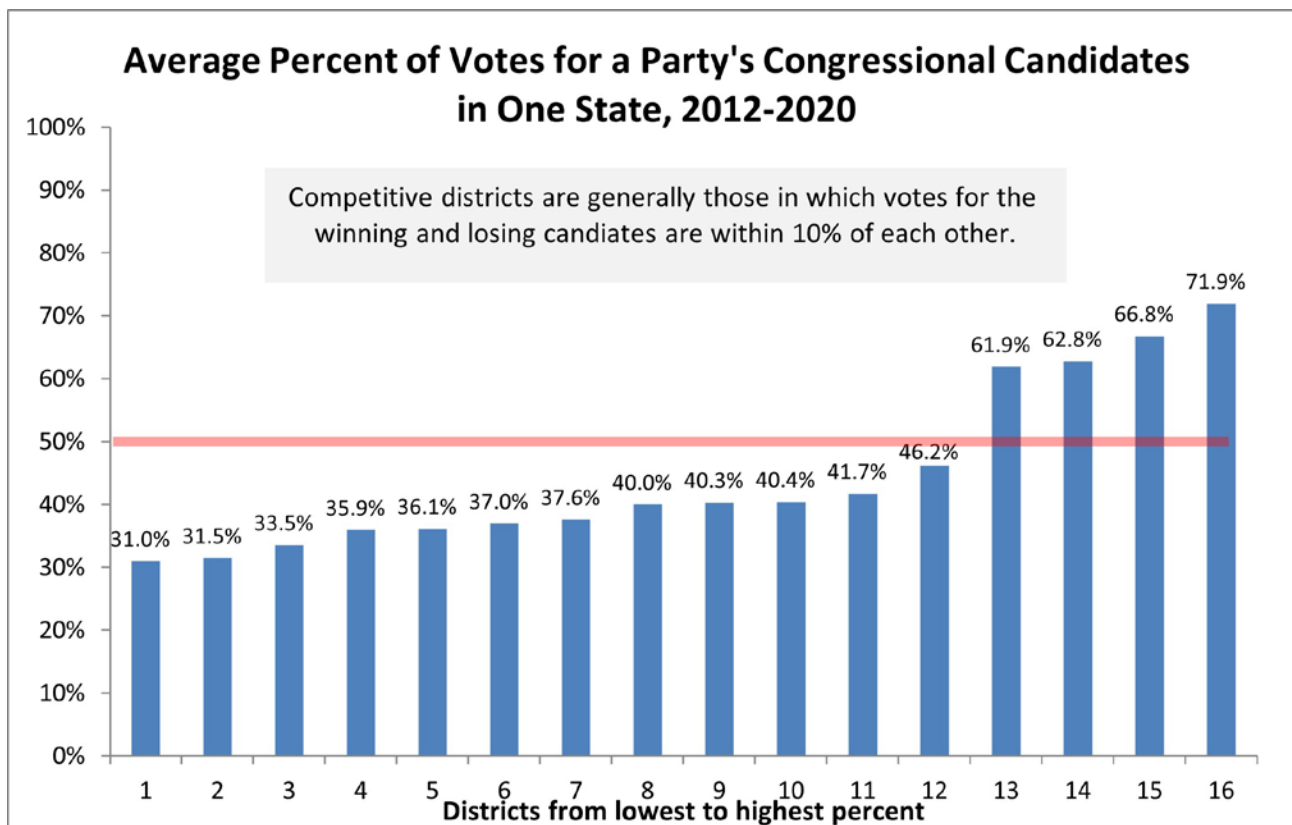
Figure 15 shows the proportion of votes by candidates of one political party in a state in which the other major party was in control of redistricting at the start of the decade. Among the 16 districts, only one, with an average of 46.2 percent of the vote for the party’s candidates, would be considered competitive using a criteria of a 10 percent margin of victory for the winning candidate. The result was that the party in control of redistricting consistently won 12 of the 16 seats and no district flipped in the winning party over the 80 races of the decade. Noteworthy too is that two races in 2012 and one in 2014 were uncontested, a further indication of lack of competitiveness.

Arguments in favor of creating competitive districts include the following:

- Voters get excited by elections that are seen as competitive and candidates will spend more time and effort contacting voters and mobilizing them to vote, thus increasing turnout.

- Districts with an even partisan balance should theoretically cause incumbent legislators to cater more attentively to a wider range of their constituents, because they would be more worried that they might lose a close election.
- Evenly balanced districts tend to elect more moderate legislators, because the candidates have to aim for the middle of the political spectrum to increase their chances of getting elected.
- More qualified candidates may be encouraged to challenge incumbents.
- More voters feel that their vote made a difference, that is, fewer votes might be considered to have been unnecessarily cast, or “wasted.”

A counterargument, however, to the belief that competitive districts are to be preferred asserts that “... non-competitive districts lead to smaller ideological differences between the positions of district median voters and their representatives, voters being ideologically closer to their legislators in absolute terms, and a distribution of ideology in the legislature that is closer to the distribution of ideology in the electorate” (see [“The Case Against Competitive Congressional Districts,”](#) by Justin Buchler, *Journal of Theoretical Politics*, 2005; 17(4):431–463).



**Figure 15:** Example of Competitiveness. *Source: Author*

### 5.3.4 Politicians' preferences

In general, incumbent legislators express their preferences on changes to their districts. When legislatures decide boundaries, the political parties frequently must negotiate conflicting preferences among the candidates.

### 5.3.5 Prison population

The Census Bureau counts persons incarcerated in state and federal correctional facilities as residents of the district where they are confined. These counts are reported at the census block level as part of the P.L. 94-171 redistricting data program. Most states use these population counts in drawing districts. However, a handful of states have changed their procedures and now reallocate prisoners from the prison location to their residence prior to incarceration. Without reallocation, representatives of a district with a significant number of prisoners would represent fewer eligible voters than those without such populations (prisoners cannot vote in most states).

Assigning incarcerated persons to their place of residence prior to incarceration requires acquiring and geocoding their addresses and assigning them to the census blocks or other geographic units used in the process (i.e., the TIGER geography). Acquiring accurate address data depends on planned collaboration between agencies and authorities at the state and local levels and must be initiated well before the release of the P.L. 94-171 data. To assist state officials in reallocating prisoner and other group quarters (e.g., student dorms, military barracks, and group homes) populations to census blocks, the Bureau offers [Geocoder](#), a geocoding website.

The National Conference of State Legislatures's (NCSL's) ["Reallocating Incarcerated Persons for Redistricting"](#) provides up-to-date information on changes to state laws on the reallocating of incarcerated persons for redistricting. See also the [Prison Gerrymandering Project](#).

### 5.3.6 Military members and households

Most military households stationed or living in the United States were responsible for responding to the 2020 Census. People were counted where they lived and slept most of the time as of April 1, 2020 (Census Day). For many, if not most, they were counted in the barracks or housing at a military base. However, they may be registered to vote elsewhere, such as their hometowns. Also, in the 2020 Census, the Census Bureau followed a new policy that counted deployed troops and families living with them as residents of the areas from which they were assigned away. The Bureau used administrative data from the Department of Defense to count those living overseas at their home base (see ["Why Deployed Troop Counts Are a 'Wildcard' in 2020 Census Results,"](#) NPR, April 23, 2021). Thus, districts having bases with large military personnel and families and those with troops and their families living abroad may be politically overrepresented.

### 5.3.7 Fundraising potential

Potential campaign contributions to political parties and individual legislators can influence how boundaries are drawn. Wealthy citizens and business enterprises make contributions to candidates they believe will better represent their interests; thus, having those potential contributors in a legislator's district may influence the redistricting process.

## 5.4 Variations by state

The NCSL's ["Redistricting Systems: A 50-State Overview"](#) provides summaries of the redistricting responsibilities, currently used criteria, and public access and input rules for redistricting. In addition, the Brennan Center provides a summary for each state in its report, ["50 State Guide to Redistricting."](#) Also useful, Ballotpedia provides links to each state's laws at [ballotpedia.org](#) (search "redistricting criteria" and the state).

## 6 ETHICAL CONSIDERATIONS

Redistricting is one of the most important applications of GIS in maintaining a democratic, equitable, and socially responsible society. As a professional, the GIS practitioner should recognize the impact of his or her work on society as a whole and on subgroups of society, including geographic (e.g., those without adequate transportation) and demographic minorities and future generations. To that end, the profession has established a Code of Ethics, which is found in the requirements for professional certification by the [GIS Certification Institute \(GISCI\)](#). The Code serves as a guide to members of URISA (and other GIS professionals) to “...make appropriate and ethical choices. It should provide a basis for evaluating their work from an ethical point of view. By heeding this code, GIS professionals will help to preserve and enhance public trust in the discipline.” The duty to act morally and to understand and consider consequences of decisions and actions in the redistricting process is imperative.

### 6.1 GIS Professional (GISP) Code of Ethics

The [GIS Code of Ethics](#) requires consideration of the impact of one’s actions on other persons and groups of persons and to modify one’s actions to reflect respect and concern for them. It also emphasizes obligations to colleagues and the profession, to employers, and to society. It calls for awareness of consequences, good and bad, of one’s use of information and GIS tools.

The Code asserts that the GIS professional will do the best work possible by

- being objective, using due care, and making full use of education and skills;
- practicing integrity and not being unduly swayed by the demands of others;
- providing full, clear, and accurate information;
- being aware of consequences, good and bad; and
- striving to do what is right, not just what is legal.

The Code of Ethics also calls on the GIS professional to

- contribute to the community to the extent possible, feasible, and advisable by making data and findings widely available;
- strive for broad citizen involvement in problem definition, data identification, analysis, and decision-making;

- call attention to the unprofessional work of others, first taking concerns to those persons and if satisfaction is not gained and the problems warrant, then additional people and organizations should be notified; and
- speak out about issues and donate services to the community.

Ideas on how to volunteer to fair and equitable redistricting efforts are offered below.

We hope that these propositions will provide guidance to GIS practitioners engaged in the practice of redistricting by drawing attention to the fact that there *are* ethical choices. Whether the person is involved in the redistricting process for an employer, a client, or as a volunteer, the choices should include being transparent, documenting criteria, and speaking out and advising others about what might be unfair to a disadvantaged population.

### 6.2 Transparency

Among the [recommendations to improve the redistricting process](#), the Brennan Center advocates for transparency in the process: “Transparency is the key to accomplishing the process reforms necessary for communities to become effectively engaged in meaningful communication with redistricting authorities.” In “[Redistricting Transparency](#),” from a practical perspective, Rebecca Green’s research shows that “[a] thoughtful approach to redistricting transparency can both improve resulting maps and stave off litigation” (*William & Mary Law Review*, 2018; (59)5, p. 1787).

Despite demands for greater transparency by fair elections organizations and the public, legislation requiring public hearings before draft plans are proposed is found in few (19) states, and even fewer (8) provide for citizens to propose district plans (based on the author’s count using the NCSL’s “[Redistricting Systems: A 50-State Overview](#)”). In other cases, citizens can petition the courts to correct alleged errors or violations in the law.

As the GIS Code of Ethics asserts, the GIS professional should, to the extent possible, feasible, and advisable, make data and findings widely available and strive for broad citizen involvement in problem definition, data

identification, analysis, and decision-making. In the context of redistricting, efforts by a decision maker, with the aid of a GIS practitioner, to hide the process from the public would violate this requirement.

## 6.3 Equity and social justice

One can think of social justice in terms of the distribution of wealth, opportunities, and privileges within a society. It is typically associated with ideas of equality, freedom, and common good. According to the [Center for Economic and Social Justice](#), “Social justice also imposes on each of us a personal responsibility to collaborate with others, at whatever level of the ‘Common Good’ in which we participate, to design and continu-

ally perfect our institutions as tools for personal and social development” (see [“Defining Economic Justice and Social Justice”](#)).

This guide focuses on the democratic institution of redistricting, which has an immeasurable impact on and implications for matters of equity and social justice.

For more insight on how the GIS community might better use its skills for equity and social justice, see Greg Babinski’s [“GIS for Equity and Social Justice.”](#) See also [“The Role of the GIS Professional in Issues of Equity and Social Justice”](#) (Mark Salling, Greg Babinski, and Nicole Franklin, *GIS Professional*, January/February 2019; 287:1-5. A publication of the Urban and Regional Information Systems Association).

## 7 HOW THE PUBLIC CAN ENGAGE

Thanks largely to the increased partisan polarization in the United States and efforts of nonpartisan voting rights organizations, the public has become increasingly aware of the importance of redistricting. As a result, states have incorporated more opportunities for public input into the process, whether under the authority of the legislature or a commission. These opportunities, however, vary considerably. For example, Missouri's state demographer, who submits legislative maps to a legislatively appointed commission, provides an online portal where citizens can view, submit, and comment on proposed maps and plans. California requires that publicly available map-drawing software be available to citizens. At least six other states are expected to provide for public submission of redistricting plans. In Ohio, redistricting map proposals must be made public before officials vote to approve them and public hearings for citizen input are also required, as they are in some other states.

Additionally, several companies, nonprofit entities, and some states have created free, publicly available map-drawing software for citizens to use to participate in the redistricting process. The Supplement provides information and discussion on specific redistricting software.

The National Conference of State Legislatures (NCSL) describes the following five categories of citizen input that some states offer:

1. allowing citizens to contribute maps of their own design to redistricting authorities,
2. allowing citizens to comment on proposed plans throughout the map-drawing process,
3. giving the public access to redistricting authorities through hearings and available information,
4. providing public notice of redistricting-related actions and meetings, and
5. prescribing a procedure for citizens to seek court review of enacted plans.

These categories and which states employ them are discussed in NCSL's "[Public Input into Redistricting](#)."

### 7.1 Getting involved as a GIS practitioner

The expertise of GIS practitioners provides a special opportunity for getting involved in this important work. One way to get involved is by helping to create precinct geography for counties. The [Princeton Gerrymandering Project](#) is using crowdsourcing methods to build these files throughout the United States. In addition, the project provides the current status of various efforts of redistricting reform. It also helped create a free, open-source tool for creating maps for communities of interest (see "[Representable.org](#)").

Another way to get involved is through fair elections advocacy redistricting competitions. The [Public Mapping Project](#) has developed DistrictBuilder, "an open-source software redistricting application designed to give the public transparent, accessible, and easy-to-use on-line mapping tools." The vision is to enable citizens to compare their districting plans to those of the redistricting authorities. Plans built to better meet chosen criteria can be numerically scored and used to publicly, and potentially legally, challenge the plan put forth by the authorities. The Public Mapping Project has supported fair election organizations in several states and plans to do more. The GIS practitioner would be able to help propose plans for such competitions.

The number of states with opportunities for the public to review and comment on proposed plans has grown in the past several years. A handful explicitly provide for the public to submit plans for consideration and many others require opportunities for the public to comment on plans posted for review on websites. Open meetings also are required in some states. These same opportunities often exist in local communities when city wards and county districts are proposed. In addition, administrative or service area districting, such as for school attendance zones, can benefit from the use of GIS technologies and experts.

All of these are ways in which GIS practitioners, as citizens, can use their skills to get involved and to make a difference in the process. As section 4.6 (on redistricting software) points out, the socially responsible and independent GIS practitioner has many tools specifically designed to help build and evaluate districting plans in his or her own communities and states.

## 8 RECENT CHANGES

This section provides a discussion of recent changes, especially for the benefit of those who are experienced from previous cycles but should know what has changed. The discussion may also help the GIS practitioner inform the community with which he or she is working about such changes.

### 8.1 The Census and demographics

Demographic and spatial data from the Census Bureau provide the fundamentals for developing districting plans, thus it is appropriate to start with changes related to those data.

#### 8.1.1 Timing of data delivery and its format

The spring of 2020 was planned to be the peak time of census data collection, but the coronavirus pandemic delayed the process due to both reducing field operations and a shortage of staffing. State totals used for apportionment, usually issued by December 31 of the census year, were released by April 30, 2021. The redistricting data (P.L. 94-171), usually issued in February and March after the census year, were announced as available by September 30, 2021, if not sooner. (See James Whitehorne's "[Timeline for Releasing Redistricting Data](#)".)

However, Ohio's Attorney General brought suit in federal court to require release of the data by March 31 ([The Washington Post, 2/25/2021](#)). It was [dismissed by another federal court](#) and, though appealed, the state put a hold on its case when the Census Bureau agreed to provide the data in a "legacy format" by August 16, 2021 (see "[Ohio agrees to pause lawsuit over census deadline](#)," by Tara Bahrapour, *Washington Post*, May 25, 2021.)

The legacy format consists of several text-formatted files that can be imported and used with relational database software to extract tables by race, Hispanic ethnicity, and voting age and at various geographic summary levels. Prototype P.L. 94-171 Redistricting Data Summary Files (in the legacy format) are now available for downloading at the Bureau's "[Redistricting Data Program Management](#)" web page. An MS Access shell with a few example queries are also provided. The Bureau plans to provide the 2020 data tables in a more user-friendly format (and accessible at its [data.census.gov](#) website) by the end of September 2021.

Preparing now for the actual 2020 data with the prototype data is advisable. As noted earlier, the shape files needed are already [available](#). Redistricting consultants, software providers, and those charged with redistricting this year will certainly acquire the legacy-formatted data as soon as it is available.

The delay, whether by August 16 or September 30, will have ramifications—ranging from mild to relatively consequential—for governments across the country. New Jersey and Virginia elect their legislatures in odd years; their 2021 redistricting and elections under new districts cannot proceed as usual. Candidate filing periods for odd-year elections typically would begin before the redistricting data is now expected to be available. California requires completion of its maps by August 15 but has extended the deadline to December 15. Other states have similar deadlines that must be adjusted. Even a hyper-expedited redistricting process would not be fast enough.

Local governments or full-time legislatures with even-year elections will find their schedules compressed, which could limit opportunities for meaningful public involvement. In addition, many local governments across the country also elect their officials in odd years and will be forced to adjust their schedules.

State legislatures with part-time elected officials and limited-length sessions may have to schedule special sessions for the redistricting process later in 2021. Some states have statutory or constitutional deadlines that will not be met, requiring changes in their schedules.

For more information, see the National Conference of State Legislatures's (NCSL's) "[2020 Census Delays and the Impact on Redistricting](#)" or the Brennan Center's "[How Changes to the 2020 Census Timeline Will Impact Redistricting](#)." The NCSL also offers ideas about how to handle the delays in "[5 Ways to Handle Census Delays and Redistricting Deadlines](#)." In addition, see the NCSL's "[State Redistricting Deadlines](#)" for a state-by-state listing of redistricting deadlines.

#### 8.1.2 Census geography files

The Census Bureau's TIGER files (section 4.4.1) are updated annually with changes to streets and other features and improvements to spatial accuracy. Since 2010, the Census Bureau has striven to update the

comparatively coarse representations of feature geometry of early TIGER data so that they are more likely to align closely with features on the ground and with local and state centerline and other GIS files, which were often used by the Bureau to make such changes.

Even more importantly for the redistricting process, the census block and other polygon shapes used to build districts undergo extensive changes between census years. The Bureau's Boundary and Annexation Program monitors annexations and other local boundary changes to municipalities, villages, and townships. With local input, changes to census tracts are also made between decennial census years to account for population changes and changes to the features used to delineate them. In addition, a year or two prior to the decennial Census, the Bureau's Redistricting Data Project asks state and local entities to recommend boundaries for census blocks and voting tabulation districts (VTDs) in order to provide a layer for the states to use recent election data. Thus, the layers used for redistricting in prior cycles are all revised for the next one, and it is necessary for the data user to download and use the new TIGER files.

### 8.1.3 Differential privacy, a.k.a. disclosure avoidance

The growing social concern about data privacy, particularly in the digital age, is shared by the Census Bureau. In fact, the Bureau has the legal responsibility, through [Title 13 of the U.S. Code](#), to protect the privacy of information about individuals and households that it collects. In the past few cycles, the data have been adjusted in relatively small measures, such as switching data between adjacent or nearby census blocks. But for the 2020 census, the data are being subjected to more complex computer algorithms that are referred to as the *differential privacy* technique.

Differential privacy is designed so that larger “parent” geographic units, such as census tracts and VTDs, will have relatively smaller deviations from the measured value than their component “child” census blocks. The method attempts to balance accuracy with avoiding potential identification of individuals or households. The method is controversial since more inaccuracy is introduced for the sake of data confidentiality (see [“New system to protect census data may compromise accuracy, some experts say,”](#) by Tara Bahrapour and Marissa J. Lang, *The Washington Post*, June 1, 2021).

### 8.1.4 The use of other data

As noted in section 4.4, only 21 states explicitly require the use of census data for state legislative and congressional districting and some only require it for congressional redistricting. While standard practice

in the states has been to use the federal decennial census data, delays in release of the 2020 census data for redistricting may lead some states and local governments to turn to other sources. Furthermore, heightened political and partisanship considerations may also influence decisions to use voting age population, citizenship population ([from the Census Bureau's American Community Survey](#)), or possibly registered voter data, rather than total population.

### 8.1.5 Racial and ethnic diversity

Racial and Hispanic/Latino ethnicity questions were the same in 2020 as they were in 2010 with the exception that those who identify as White, Black/African American, and/or American Indian or Alaska Native were asked to provide more specificity about their racial origins. White respondents, for example, could indicate German, Irish, Lebanese, or other possible origins. Black/African American individuals were asked to print their specific origin (e.g., African American, Jamaican, Haitian, Nigerian, Ethiopian, Somali, etc.). As they were previously, write-in options were also available for “Other Asian” and “Some other race” categories.

## 8.2 The law

The past decade brought with it several landmark legal decisions, some in federal courts and others in state courts. How changes to the legal landscape might be relevant to the GIS practitioner are briefly reviewed here (with reference to other more authoritative sources).

### 8.2.1 Nullification of section 5 of the Voting Rights Act (VRA)

In the prior decades, redistricting plans from certain parts of the country were subject to a “preclearance” review by the U.S. Department of Justice before they could go into effect. Section 5 of the U.S. Voting Rights Act of 1965 identified several states—as well as selected localities within other states—with a prominent history of racial or ethnic discrimination as meriting extra scrutiny by the U.S. Department of Justice. In 2013, the U.S. Supreme Court's [Shelby County v. Holder](#) decision effectively negated the preclearance requirement. While the controversial 5-4 opinion did not prohibit the use of a preclearance process, it did rule that the formula that had been used to identify the areas of the country that needed extra scrutiny was outdated, and that Congress would need to replace it before a preclearance constraint could again be imposed.

There are three important implications of the Shelby decision for the GIS practitioner:

1. Across the country, redistricting plans still must satisfy section 2 of the VRA. Now, however, for a

plan to be struck down, a legal challenge is typically required after its adoption. The new situation adds a costly burden for voting rights organizations, and potentially could allow for a problematic plan to be adopted and used for elections before the litigation can run its course.

2. The absence of the preclearance process frees up a little more time to construct and enact a plan in the formerly scrutinized parts of the country—something that could be significant given the compressed time frame discussed above in section 8.1.1.
3. New federal legislation in 2021 could possibly reinstate preclearance and is discussed briefly below.

Additionally, in recent years, Hispanic or Latino and Asian populations have grown significantly, and some experts are predicting that voting rights proponents may argue for the creation of more districts with multi-racial and multiethnic coalitions (see “[The Redistricting Landscape, 2021–22](#),” by Michael C. Li, the Brennan Center for Justice, February 11, 2021).

## 8.2.2 Racial gerrymandering

Several significant racial gerrymandering cases made their way to the U.S. Supreme Court in the 2010s. In the [Cooper v. Harris](#) case from North Carolina, voting rights attorneys successfully argued that in places where minority-preferred candidates would also attract votes from White voters, a “50% plus one” requirement led to excessive packing and prevented minorities from being able to have influence in other districts. Consequently, remedial districts were drawn (and upheld) in the second half of the decade with Black voting age population percentages closer to 40 percent (see “[Restricting Race-Conscious Redistricting](#),” by Daniel Tokaji, *The Regulatory Review*, July 31, 2017).

Additionally, many areas of the country have become more racially and ethnically diverse. There are regions where one minority group may not be populous enough to justify drawing a district to provide the opportunity for that group to elect their representative of choice. But if their population is taken in conjunction with another minority group, the calculus could change. If people of color in an area are likely to support similar candidates, the potential for “coalitional” voting might be taken into consideration. Indeed, some experts are predicting that voting rights proponents may argue for the creation of more districts with multiracial and multiethnic coalitions (see “[New Tools Are Needed to Protect Communities of Color in Redistricting](#),” by Michael Li and Yuriy Rudensky, the Brennan Center for Justice, November 25, 2019).

## 8.2.3 Partisan gerrymandering

For more than two centuries, partisan gerrymandering had been decried as distasteful and even inimical to democracy—though probably not illegal. Then, in 2019, many redistricting reform advocates pinned their hopes on multiple partisan gerrymandering cases that went before the U.S. Supreme Court on the same day. In combining court cases from North Carolina ([Rucho v. Common Cause](#)), involving acknowledged partisan gerrymandering by Republicans, and the [Benisek v. Lamone](#) case from Maryland, with acknowledged partisan gerrymandering by Democrats, the Court’s opinion acknowledged that extreme partisan gerrymandering might be a problem, but it held that it was not an issue for federal courts to decide. Importantly though, it did explicitly leave the door open for legislative restrictions on partisan map-drawing (see discussion of H.R. 1 in section 8.2.5) or for litigation in state courts. For more on the ruling, see “[Supreme Court Rules Partisan Gerrymandering Is Beyond the Reach of Federal Courts](#)” (NPR, June 27, 2019).

Around the same time as these and other cases were progressing through the federal judicial system, two cases in state courts, one in Pennsylvania and one in North Carolina, challenged redistricting plans there as violating elections clauses in their constitutions. Ultimately, the plaintiffs prevailed in both cases, establishing precedents that districts could be struck down for unduly favoring one political party. However, not all states have similar “free and fair elections” clauses in their constitutions allowing for such a challenge. The NCSL’s [Free and Equal Election Clauses in State Constitutions](#) provides a list of the ones that do.

## 8.2.4 Ranking and scoring criteria

With greater attention paid to how redistricting is done, who does it, and the outcomes, there is an increased interest in deciding what criteria are used. As is apparent from the discussions above about the criteria, aside from adherence to the equal population and VRA requirements, there are many considerations possible. Many states, especially those having seen recent reform movements, have moved to include more objectives in their redistricting laws and rules. An increased use of multiple criteria and considerations, each with their own influence on outcomes, makes the process very complex. Without clear priorities and transparency, the outcomes are not likely to be any more understandable or acceptable to the public than they have been, nor are they likely to represent the will of the people.

Some advocates for fairer and more representative districting (e.g., [Better Boundaries in Utah](#)) and political scientists (e.g., “[Redistricting by Formula: An Ohio Reform Experiment](#),” by Micah Altman and Michael

McDonald, *American Politics Research*, 2018, 46(1):103–131) argue for systems that measure, rank (prioritize), and even score the criteria used. This could be administered by the legislature, redistricting commission, or appointed master. Addressing the number of possible criteria used by the states, the NCSL states, “No matter who draws the maps—legislators or a commission—balancing a list of criteria may require prioritization.” (See also “[Redistricting Criteria](#),” by Ben Williams and Wendy Underhill, *NCSL Newsletter*, September 2017, Vol. 25, No. 34).

To date, no state or federal redistricting law has required both prioritizing and scoring of plans. Some experiments have been tried, however. Ohio’s Secretary of State, in a proof-of-concept experiment, ran an open, web-based congressional redistricting competition in 2010 in which criteria were weighted and scored to determine the winning plan(s). In addition to population equality, contiguity, and VRA compliance, criteria included compactness, communities of interest, competitiveness, and representational fairness. More than 70 participants submitted 14 plans sufficiently complete to be scored. Three plans were declared winners, each scoring higher than the existing districting plan for the state. Notably, all 14 submitted plans scored higher than the legislature’s congressional district plan! (See “[Ohio’s Use of Geographic Information Systems to Demonstrate Public Participation in the Redistricting Process](#),” by Mark Salling, *The Duke Journal of Constitutional Law & Public Policy*, 2010; 5:113-123.) Another web-based demonstration project on Ohio’s congressional map was run by the Midwest Democracy Network (now defunct) in which 53 maps were submitted and scored, all scoring better than the existing map.

### 8.2.5 New legislation from Congress

When Democrats took the majority in the U.S. House of Representatives after the 2018 election, their first proposed legislation, For the People Act (also referred to as “H.R. 1”), was a sweeping bill with changes they mostly characterized as democracy reforms. With Democrats now in control of Congress and the White House, the bill has passed the House and is due for consideration in the Senate. The reader can keep in touch with its composition and its progress at <https://www.congress.gov/bill/117th-congress/house-bill/1/text>. As currently composed, it would have national implications for redistricting.

Among other things, the legislation would do the following:

- Require that populations of districts be calculated using the total population, rather than voting age population or eligible voters.
- Require adherence to a number of districting criteria such as prohibition of partisan gerrymandering,

respecting communities of interest, neighborhoods, and political subdivisions to the extent practicable (given population and VRA compliance).

- Require that congressional districts be drawn by independent, nonpartisan commissions. (This probably would not affect 2021.)
- Impose processes for public engagement and for timely legal challenges.

A bill referred to as “H.R. 4,” or the “John Lewis Voting Rights Advancement Act,” passed the House in 2020 and is meant to restore the court-invalidated formula from [section 5 of the Voting Rights Act](#), which was used to determine which state or political subdivision would be subject to federal review. The bill’s content and progress can be monitored at <https://www.congress.gov/bill/116th-congress/house-bill/4>. While such a new law is likely to be challenged in court, it is theoretically possible that the preclearance requirement negated by *Shelby County v. Holder* could again be in effect in some parts of the country by the fall of 2021.

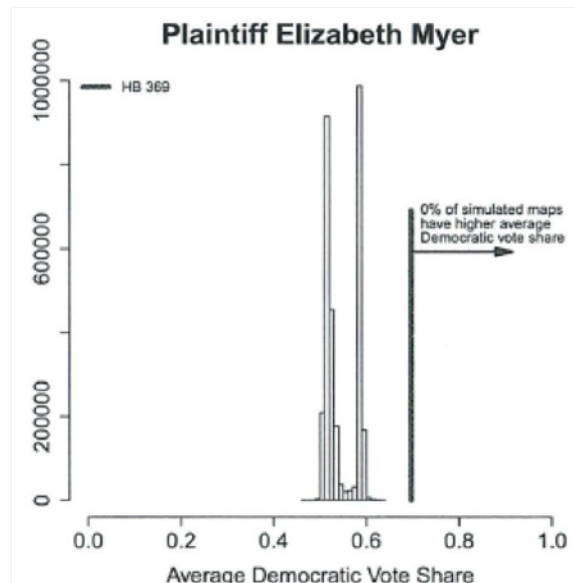
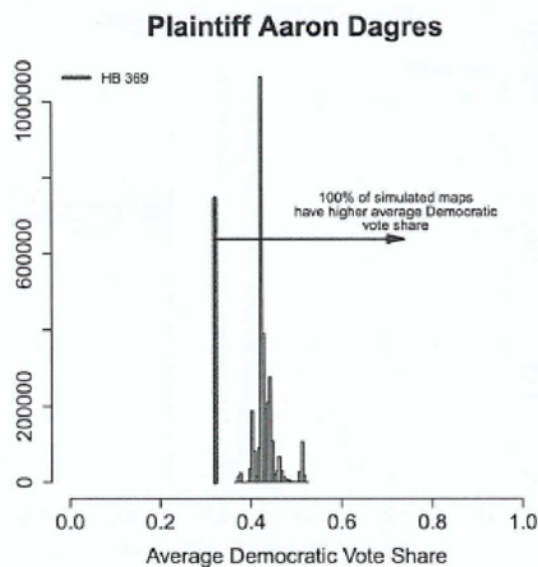
## 8.3 Math

A new and noteworthy feature of most of the partisan gerrymandering cases referenced above was their inclusion of significant testimony from witnesses whose expertise lies not so much in political science, history, or even election statistics, but in advanced mathematics. There are three broad areas where new quantitative methods may determine how this decade’s plans get measured, as well as a category of measures that attracted significant interest late in the decade but may be of less use in successful litigation.

### 8.3.1 Ensembles

One recurring question related to partisanship in map making is how to determine if a plan just happens to favor one party by chance rather than being an excessive partisan gerrymander. Mathematicians are using Markov chain Monte Carlo (MCMC) computer algorithms to generate large numbers of alternative redistricting plans without using partisan data. The approach provides a sampling of compliant plans from the enormous universe of possible plans. It aims to represent a benchmark against which to compare a human-created plan under consideration. If the human-drawn plan is an outlier compared to the large ensemble (sample) of other possible plans, experts can assert that it is “extreme” and tremendously (statistically) unlikely to have been created without undue focus on partisan advantage.

For one study brought to court, Figure 16 shows a graphic representation of two districts compared to ensembles (samples) produced for them using only



**Figure 16:** Examples of Visualizations Comparing Partisan Results for Challenged District Versus Simulated Non-partisan Districts. Source: [Ohio A. Philip Randolph Institute, et al. v. Larry Householder, Speaker of the Ohio House of Representatives, et al., United States District Court for the Southern District of Ohio, Plaintiffs' Proposed Findings of Fact, pages 132 and 136.](#)

the required criteria—population size, VRA compliance, and minimizing county and subdivision splits. The votes for the Democratic party candidates in the enacted (actual) districts lie well outside the range of compliant nonpartisan plans. In one (Plaintiff Elizabeth Myer) there are far more votes for the Democratic party candidate than necessary to win, and in another (Plaintiff Aaron Dages) there are far fewer votes needed to win the district for the Democratic candidate. In fact, such distributions are apparent for all 16 of the state's congressional districts, providing strong evidence of the packing and cracking that leads to noncompetitive districts and proportional bias in the election outcomes.

### 8.3.2 Compactness measurement

Geometers (that is what geometry experts are called!) have worked for centuries to measure compactness properties of two-dimensional shapes. As discussed in section 5.2.1, a number of these measures have been applied to district shapes, including some that consider the distribution of the population. This past decade has seen two new approaches to quantifying compactness as it relates to electoral districts:

1. The *cut edges approach* uses a set of polygon centroids (such as those for census blocks) and adds connections (edges) between them for their adjacent polygons. Weighted by population, these

points are iteratively aggregated into the specified number of districts of equal population by cutting the edges. The plan with the fewest cuts that creates districts with equal population is the most compact. This method does not initially consider the shape of the polygon district boundary; it measures how many cuts (deletions) of edges are required to derive the number of districts. Visualizations of the method can be seen at "[What I learned applying data science to U.S. redistricting](#)," a Storybench website by Floris Wu at Northwestern University. Further explanation is provided by Shawn Doyle's, "[A Graph Partitioning Model of Congressional Redistricting](#)" (*Rose-Hulman Undergraduate Mathematics Journal*, Vol 16, Issue 2, Article 3, 2015).

2. "[KIWYSI](#)" (know it when you see it) is another new approach to compactness measurement. Citizens' perceptions (including those of judges!) of whether a district is compact can be significant for establishing public faith in the fairness and efficacy of election districts, as well as for court decisions. One proposal in "[How to Measure Legislative District Compactness If You Only Know it When You See It](#)" involves "...a statistical model that predicts, with high accuracy, solely from the geometric features of the district, compactness evaluations by judges and public officials responsible for redistricting" (by Aaron Kaufman, Gary King, and Mayya Komisarchik, forthcoming in *American Journal of*

*Political Science*). It takes human psychology into account, and it assesses shapes based on how human subjects rate their visual compactness. The researchers found, for example, that more symmetrical shapes are perceived as more compact, even if their perimeter may be more irregular.

### 8.3.3 New fairness metrics

Recent court challenges to partisan gerrymandering of districts have used new measures of the partisan bias of district boundaries. The *mean-median difference* discussed in section 5.3.1 is one such recent measure.

Another measure, the efficiency gap (EG), counts the number of votes over the minimum necessary for the winning candidate. Votes cast for a losing candidate are considered wasted, as are all the votes cast for a winning candidate more than the number needed to win. The formula for this metric is as follows:  $EG = (\text{total party A wasted votes} - \text{total party B wasted votes}) / \text{total votes}$ . For more details, see “[How the Efficiency Gap Works](#)” (by Eric Petry, the Brennan Center for Justice). The efficiency gap metric was introduced in *Gill v. Whitford* to respond to U.S. Supreme Court Justice Anthony Kennedy’s prior request for a sound metric to definitively find (extreme) partisan gerrymandering. However, the Court passed on considering the constitutionality of the issue in federal courts.

A third approach is found in the declination measure, which examines the percentage distribution of votes across the state’s districts for the candidates of each party. The approach assumes a relatively smooth increase in the slope of percentage of votes for each party when the districts are lined up from most Democratic to most Republican. Packing the supporters of one party in a small number of districts creates a jump in the party’s percentage of votes in the graph, with a few districts having vote shares significantly higher than the 50 percent necessary to win and many districts with shares well below the 51 percent target. The method uses the ratio between a straight slope and the actual one. Figure 14 in section 5.3.1 illustrates this discontinuity. Additional explanation can be found in Political Calculations’ “Math to Detect Partisan Gerrymandering” (April 11, 2018).

Recent court proceedings, however, seem to suggest that these simpler measures are being replaced in favor of more complex ones, such as the ensembles approach discussed above, which can include other criteria in judging the relative impact of partisanship in the process.

## 8.4 Technology

Every recent decade has brought remarkable changes in technology. The world of redistricting has been no stranger to such advances. More detail about software offerings is available in the Supplement, but a review of overarching themes is presented here.

### 8.4.1 Apps for power users

For the past two cycles, companies have offered specialized, fully featured redistricting software for sale for thousands of dollars. These products are again available and have been considerably improved. New features such as dynamically linked data visualizations, generation of ensembles, seamless integration of various basemaps, and the addition of new metrics enable capabilities that were not possible ten years ago.

One other option for the GIS power user looking for a highly customizable desktop experience is QGIS, which offers a free and open-source redistricting plugin. The plugin does not provide the number of prefab features as the commercial offerings, but for the seasoned GIS specialist, many of the same ends are achievable with a little extra effort and creativity.

### 8.4.2 Specialized code and utilities

For the GIS practitioner who also is comfortable with writing and running code, there are many more resources available than in the past. Groups from Duke University, Tufts University, and MIT have published code allowing those with programming skills to, for example, create sets of algorithmically generated plans, do analysis of racially polarized voting, apply partisan bias metrics to districts based on their election data, and streamline the processing of geospatial data related to precincts and census blocks.

New utilities exist for non-coders as well. The [PlanScore.org](#) site provides a prototype web-based service to swiftly score uploaded plan geometry (Shapefile, GeoPackage, or GeoJSON formats) using metrics that may indicate partisan imbalance. As of this writing, it is not clear how many states this service will include. Several tools mentioned in the following sections will also allow a plan to be imported and analyzed (even if one is not interested in using the more prominent plan-drawing capabilities).

### 8.4.3 Public apps

In the 2011 cycle, two free open-source, web-based apps, Dave’s Redistricting App and DistrictBuilder, provided users access to free redistricting tools, and Maptitude and Esri offered web-based tools for a fee. In 2021, the two free apps are back, but with completely revamped designs, and Districtr has joined the

mix as well. These apps vastly expand the capabilities available to those wanting to either try their hand at or just better understand the plans being put forth by government entities. Note that they are described in more detail in the Supplement.

A key service being provided by some is the drawing of communities of interest by the public. Jurisdictions that want to understand how their residents view areas of shared concerns or characteristics can use [Districtr](#) or [Observable.org](#) (and possibly others by press time) to let users easily draw a community of interest's extent in a browser-based interface and submit it in a geographic format that can be imported into GIS software.

In early 2021, Dave's Redistricting App reported that in 2020, its users had created more than 550,000 redistricting practice maps using 2010 census data. Not all of them were complete or valid, but they provide a clear sense of the tremendous interest in participating in the process.

## 8.5 Public engagement

It is all but certain that the level of engagement by people other than government officials, consultants, and other specialists will be much higher than in previous decades due to greater attention to partisan issues by the news media, election reform organizations, and the general public. Reforms in some states will also drive interest up, and improved technologies will greatly facilitate public engagement and attention to the process.

### 8.5.1 Commissions and other reforms

Just in the past few years, state-level reforms have occurred in Colorado, Michigan, Missouri, Ohio, Utah, and Virginia. Generally, these reforms allow for more public involvement, and in several of these states, citizens are now serving on commissions that will draw the lines.

California, which already had a citizens' commission for drawing statewide plans, has also recently enacted legislation requiring scores of local governments to use independent commissions for districting. Further, they have added requirements to the process such as

- a 7-day period after plans are made public before they can be considered in a public hearing, so that citizens have time to review them;
- a 21-day period after the redistricting data are released before jurisdictions publish new drafts—to allow members of the public to draft their own plans; and
- standards for accessible redistricting-specific web pages, language translation services at meetings, timing, and quantity of meetings, etc., in the name of encouraging and facilitating public engagement.

### 8.5.2 Focus on communities of interest

Greater public understanding of redistricting and its issues has significantly increased in recent years, and as a result, it has elevated the importance of creating districts that represent communities of interest. The Brennan Center's "[Creating Strong Rules for Drawing Maps](#)," for example, identifies communities of interest as a criterion that should be considered above compactness, competitiveness, and the integrity of political subdivisions. Other "good government" organizations are also advocating for the prominence of communities of interest, and they are training people how to consider, map, and include them in the process.

### 8.5.3 General level of interest and interest in the GIS community

In 2011, public awareness of issues in redistricting was not as high as it is today. Many voting rights and fair elections organizations have taken these issues to the public with media campaigns. Celebrities like Arnold Schwarzenegger and John Oliver have devoted significant time to discussions on the subject. Grassroots, nonpartisan reform effort for redistricting-related ballot initiatives in Michigan, Ohio, and other states were highly successful in gathering signatures and generating enthusiasm.

Presentations at URISA's GIS Pro conferences and readers of its publication, the *GIS Professional*, have brought some of the issues to the GIS professional educational experiences (e.g., see "[Boundaries That Matter: Partisan Gerrymandering of U.S. Congressional Districts](#)," by Mark Salling, *GIS Professional*, January/February 2018, 281:1-4).

## 9 CONCLUSION

Redistricting is an important application of GIS, the application of the technology will be especially useful during the next year or two, and use of GIS will change the nation's political geography, with major changes affecting all of our lives well beyond that. New, specialized GIS software tools are making it relatively easy for even the less-experienced user to get involved in drawing the boundaries. Additionally, the Internet is making these abilities accessible to concerned citizens and voting rights organizations. These developments expand the reach of GIS in the political realm, and GIS professionals and practitioners should be encouraged that the technology offers increasing opportunities for more GIS practitioners and citizens to play important roles in the process.

But it is not a vacuous observation that the redistricting process is complicated. It is complicated by the manner of collection and management of the data, the requirements and decisions about which data to use, the software selection and use, the laws and criteria that vary from place-to-place and over time, and the competing perspectives and values of those who do it. The GIS professional comes into this quagmire with important skills, but also with much to learn and understand in order to play a productive role in achieving competently and fairly drawn district boundaries. It is hoped that this guide provides the assistance needed for that role.

# 10 ACKNOWLEDGMENTS

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**Regardless of these contributions, the author assumes full responsibility for errors, omissions, and opinions.**

# 11 ABOUT THE AUTHOR

Mark J. Salling, Ph.D., GISP, is a Senior Fellow in the [Maxine Goodman Levin College of Urban Affairs, Cleveland State University](#). Though semi-retired, Dr. Salling continues an active career in applied urban geography and demography. He has more than 35 years of experience in data management and analysis and has conducted studies in urban migration, poverty, housing, economic development, voting rights, and redistricting. He led teams that developed databases used for redistricting in Ohio after the 1990, 2000, and 2010 censuses.

Dr. Salling has been active in the Urban and Regional Information Systems Association ([URISA](#)) since 1982, is a past board member, and was the editor of *URISA Conference Proceedings* from 1986 to 2004. He was the recipient of URISA's 1988 and 2000 Service Awards and was a member of the test question review team of the Geographic Information Systems Professional Certification Institute ([GISCI](#)). He is a past member of the Core Committee of URISA's [GISCorps](#), and he served on the Council of the Ohio Geographically Referenced Information Program ([OGRIP](#)), representing higher education.

Dr. Salling has published papers on demography; redistricting; voting rights; GIS methods; public participation GIS; residential mobility; computer applications in planning; poverty; environmental equity; urban economic development; and social, neighborhood, and health indicators. In addition, he has taught courses on GIS, urban geography, research methods, and demography.



# Redistricting Software Applications, Data, and Related Tools: A Supplement to Redistricting, a Guide for the GIS Community

By [Blake Esselstyn, GISP, AICP](#)  
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# INTRODUCTION

The landscape of redistricting software, like so much related to redistricting—and GIS—is constantly changing. As a consultant, I strive to stay abreast of all the tools that might be useful to me or my clients, as well as to the public. In spring of 2019, I first published a [curated listing of redistricting tools](#) online, and it has required numerous updates since then. The information below reflects my current awareness about the state of the tools, but some aspects will inevitably have evolved again by the time the reader sees this guide.

*[NCSL also offers a listing of vendors at <https://www.ncsl.org/research/redistricting/redistricting-vendors.aspx> and videos from 2020 for four of their products at <https://www.ncsl.org/research/redistricting/redistricting-software-vendor-presentations.aspx>. Additionally, the Redistricting Data Hub offers a listing at [Mapping Tools—Redistricting Data Hub](#).*

Some readers may be wondering, “Why would someone need specialized redistricting software? What will it offer that you can’t find in a standard GIS?” Section 4.6 of the guide devotes several pages to addressing exactly those questions. This supplement provides more information about specific offerings and how they differ from each other.

The listings below are separated into desktop client applications and web-based applications, followed by brief coverage of other related utilities, data resources, and coding resources. The descriptions of the applications provide more detail than online listings, but providing about a page for each product means that not all distinctive features can be included. For the tools that aren’t free, costs of operation typically depend on the number of licenses, whether the buyer is a nonprofit organization, optional functions beyond the basic product, and additional services (such as support). Final pricing often is subject to negotiation with the vendor.

## 5.1 Desktop client applications for making redistricting plans

The desktop applications listed below range from descendants of the first PC-based redistricting tools born in the 20<sup>th</sup> century to offerings built from scratch in the past three years. The ordering is alphabetical, based on the name of the vendor or developer.

## 5.1.1 DISTRICTSolv (by ARCBridge)

ARCBridge Consulting and Training, a small Northern Virginia-based firm founded in 1994, produces a redistricting tool called DISTRICTSolv. DISTRICTSolv is designed as an add-on to ArcGIS Desktop and works within the widely used ArcMap interface. The tool is geared towards human-driven custom district creation, although it also offers some rudimentary options for automatically creating equally populated districts—perhaps for use as a starting point for a plan, for example.

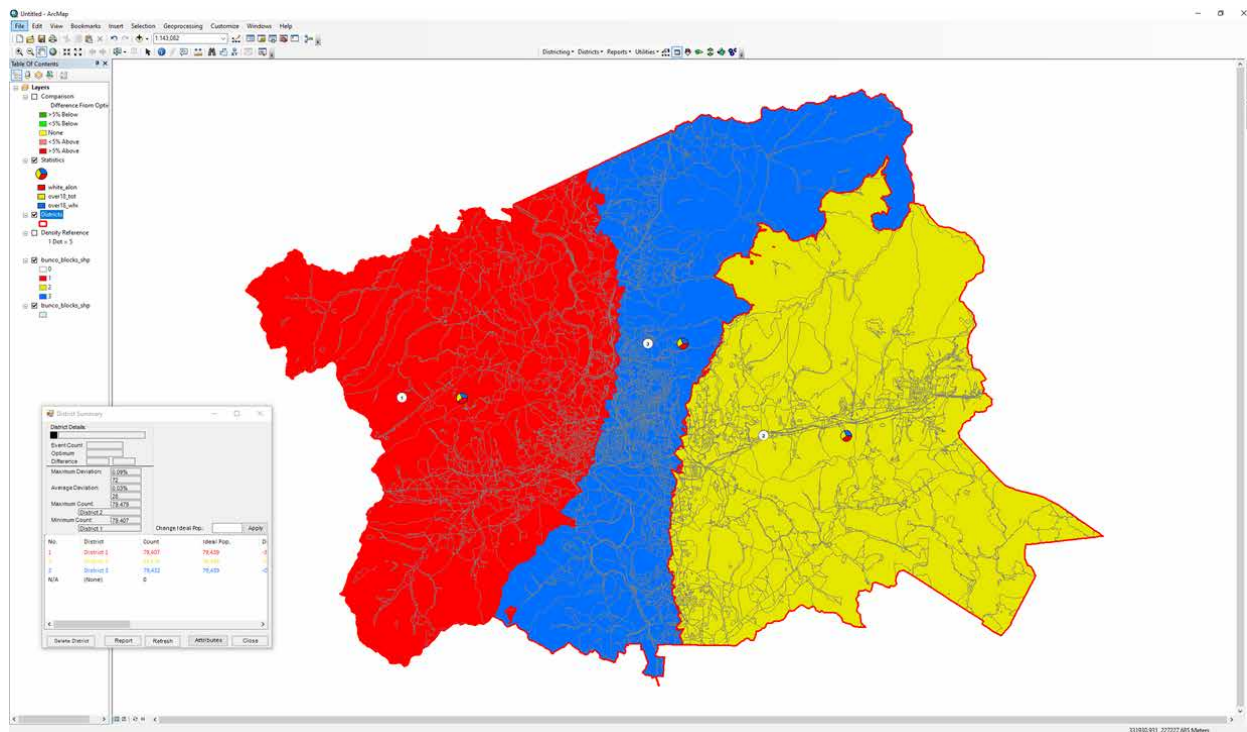


Image source: Blake, 2020

A few distinguishing features of DISTRICTSolv:

- A hugely frequent task in refining a redistricting plan is moving the base geographic units (like census blocks or VTDs) from one district to another. DISTRICTSolv makes this simple and intuitive by allowing the user to drag-and-drop the selected units from district to district.
- Different ways of visualizing the districts and their demographic statistics (such as dot density symbology and pie charts) are provided by default and easily toggled by turning layers in the table of contents on and off.
- The software is designed with smaller states or government entities in mind; performance would suffer if used for a block-level statewide plan in a state with hundreds of thousands of census blocks, for example.
- For a typical customer of DISTRICTSolv, who would already have licensed ArcGIS Desktop, the additional cost of getting the redistricting functionality would likely be lower than for acquiring other paid products that ship with their own GIS.

## S.1.2 Maptitude for Redistricting (by Caliper)

Caliper Corporation, founded in 1983 near Boston, first released their GUI-driven Maptitude GIS for Microsoft Windows in 1995. The [Maptitude for Redistricting](#) product, built to integrate with that GIS, was introduced before the 2000–2001 redistricting cycle and quickly became one of the mainstay options as governments moved to PC-based redistricting. The general interface and workflow of the 2021 product remains similar to previous generations, but a number of additional features have been added.

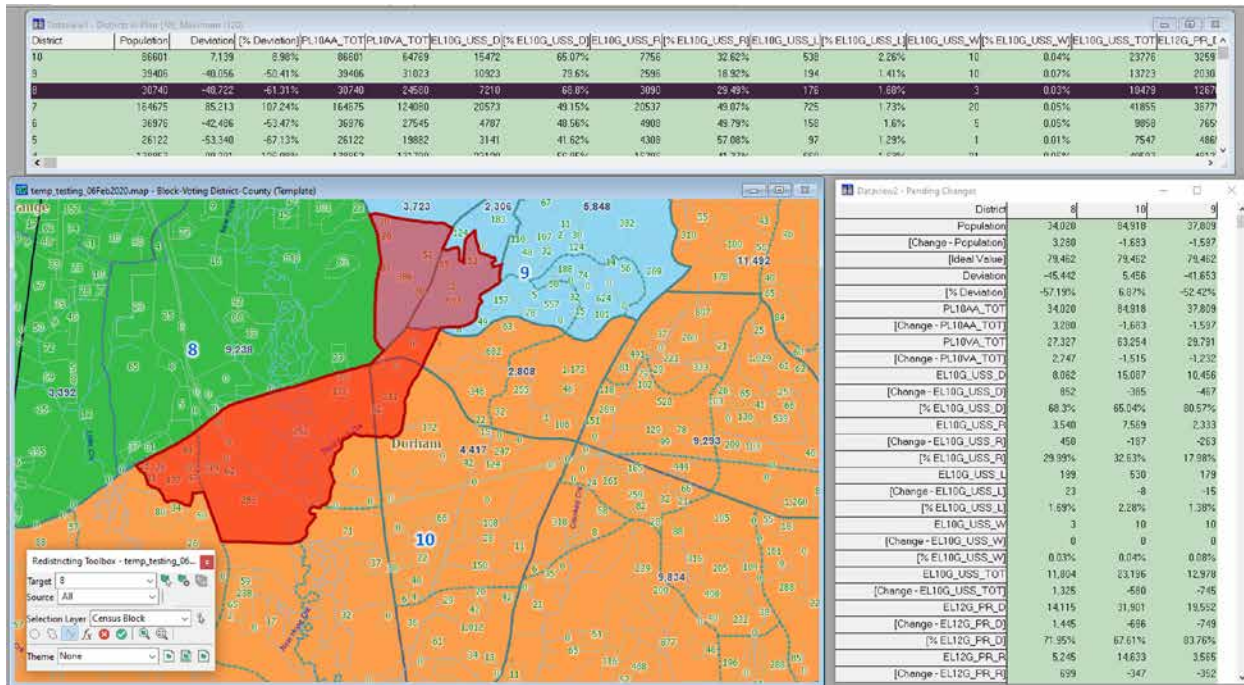


Image source: Blake, 2020

A few distinguishing features of Maptitude for Redistricting:

- Often described as “professional grade,” Maptitude for Redistricting offers just about every function and report that a redistricting practitioner (or their client) might ask for. These are mostly located in a Redistricting menu and its sub-menus or in the dockable Redistricting Toolbox.
- New features that this author is not aware of in any other product (as of this writing) include “travel contiguity”—which determines not only if all of a district is in one piece, but if every area can be reached by car without having to leave the district—and a range of compactness and partisan skew metrics that have gained attention and adherents since 2010.
- It uses proprietary data formats for key files, including the Maptitude CDF and DBD file formats.
- Caliper also offers a companion web-based product, [Maptitude Online Redistricting](#) (summarized in section S.2.2), which provides many of the functions of the desktop tool, thereby allowing customers to let members of the public draw and review redistricting plans that can then be interchanged in formats fully compatible with the desktop software.

Note: The Caliper Corporation website also lists an [ArcMap extension](#) for redistricting, but conversations with their staff indicate that very few of their customers are still using this option.

### S.1.3 AutoBound (by Citygate GIS)

Citygate GIS is a small Annapolis, Maryland-based firm, which, like Caliper above, got into PC-based redistricting in the 1990s. The company, an Esri partner, now offers what it bills as a [complete enterprise redistricting solution](#). The core full-featured plan-creation product is called **AutoBound** (so named because the initial concept was intended to provide algorithmic district creation—an approach later de-emphasized in favor of human-driven plan design, but the name had stuck). For the 2020–2021 cycle, AutoBound will come in two flavors, a new standalone “Edge” product based on Esri’s ArcGIS Runtime (Windows) platform, and, secondarily, an extension to ArcGIS Desktop, more similar to the AutoBound product from past cycles, for clients who would like to stick with the familiar.

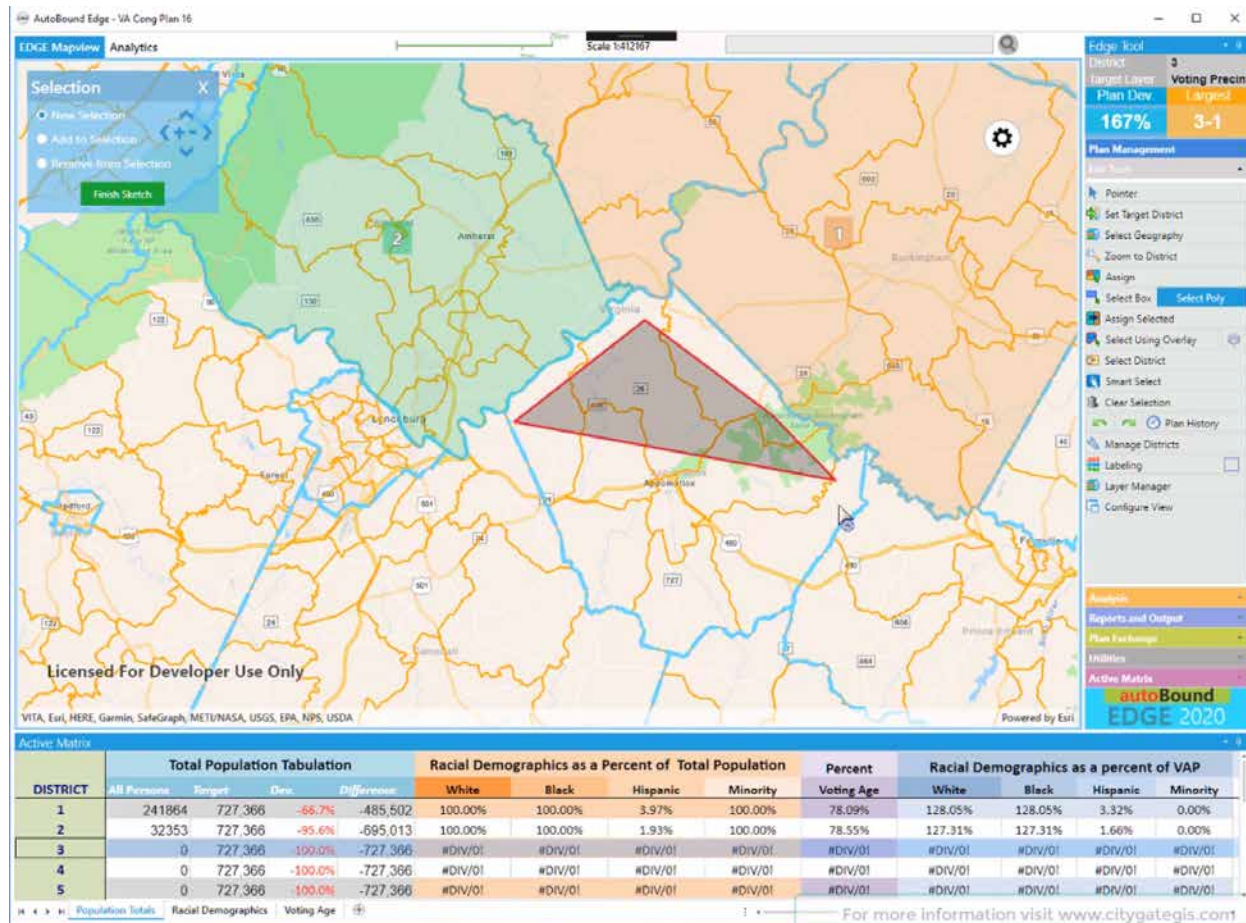


Image source: [https://citygategis.com/videos/NCSL/NCSL\\_Citygate\\_player.html](https://citygategis.com/videos/NCSL/NCSL_Citygate_player.html), 2020

A few other distinguishing features of AutoBound EDGE:

- The product has a novel user interface with many color cues, integrated charts with dynamic [brushing and linking](#), an accordion-style panel housing most of the commands, and the floating wheel widget for quick access to common tasks/options.
- It includes a feature-rich plan manager allowing the user to examine—and in some cases, filter by—the plans’ last edited dates, last editor, percent completeness, thumbnail images, and a visual timeline history of edits.
- The district attribute table, a key component of any redistricting software, offers many of the features of an Excel spreadsheet, unlike a typical table in a GIS. See, for example, the custom formatting and sheet tabs in the provided image.
- Built upon an Esri technology, the app offers 11 styles of base maps (and familiar smooth panning and zooming behavior), and other Esri-supported feature services can be added in as layers.
- The desktop product is supposed to integrate with related web-based products that allow for other redistricting-related functions that government entities may want to be able to provide to their constituents. For example, web pages would allow the public to view, compare, comment on, and look up addresses in proposed plans. (The web tools are based on Google Maps and allow for Google Street View and other imagery.)

## S.1.4 Two possibly useful desktop offerings from Esri

Esri, the multinational GIS powerhouse, is primarily promoting its [web-based redistricting solution](#) for 2021 (see section S.2.4), but it does offer two desktop tools that may be practical for a certain subset of the GIS community.

### S.1.4.1 Districting for ArcGIS

Esri offers [Districting for ArcGIS](#), a free extension for ArcMap. As stated above, the company is no longer strongly promoting this offering, but staff confirm that it is “still out there” and could be useful “for very small jurisdictions.” As of this writing, the [documentation](#) appears not to have been updated since early 2011. But for an ArcMap-loving GIS person wanting to explore redistricting options in a small jurisdiction, and not needing a wide array of features, this might be just what the doctor ordered.

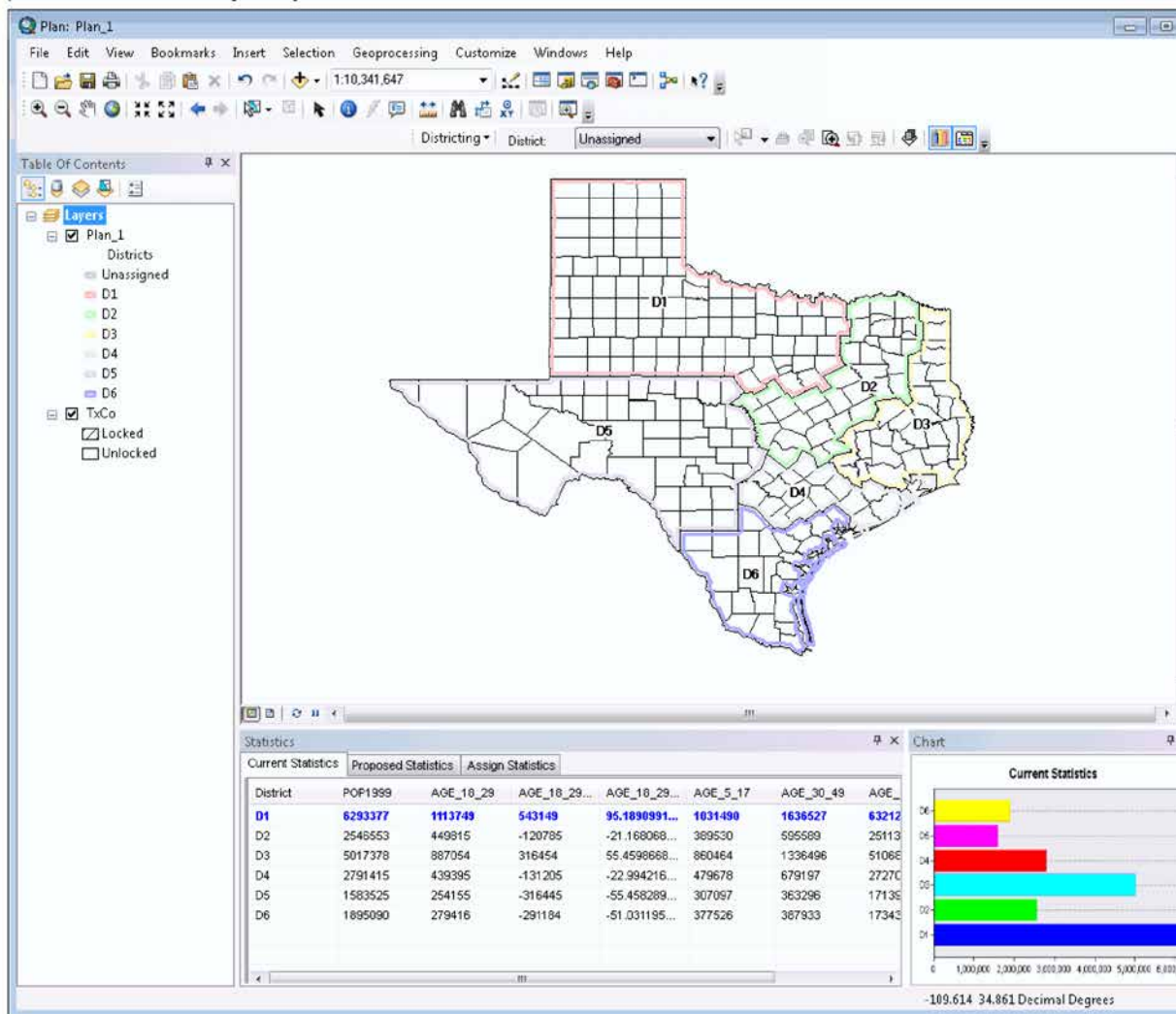


Image source: [http://help.arcgis.com/en/redistricting/pdf/Districting\\_for\\_ArcGIS\\_Help.pdf](http://help.arcgis.com/en/redistricting/pdf/Districting_for_ArcGIS_Help.pdf)

### S.1.4.2 Business Analyst's Territory Design Toolbox

This option would be available for readers who have licenses for both ArcGIS Pro *and* Business Analyst. Again, this option is not being promoted by Esri for redistricting, and the authors of this document have not tried this tool themselves, but the Business Analyst [Territory Design Toolbox](#) purports to provide relevant functionality. The tool allows for automated territory (read: district) creation based on user-defined balancing criteria (like population), and also allows for interactive manual “fine-tuning” of the districts as well.

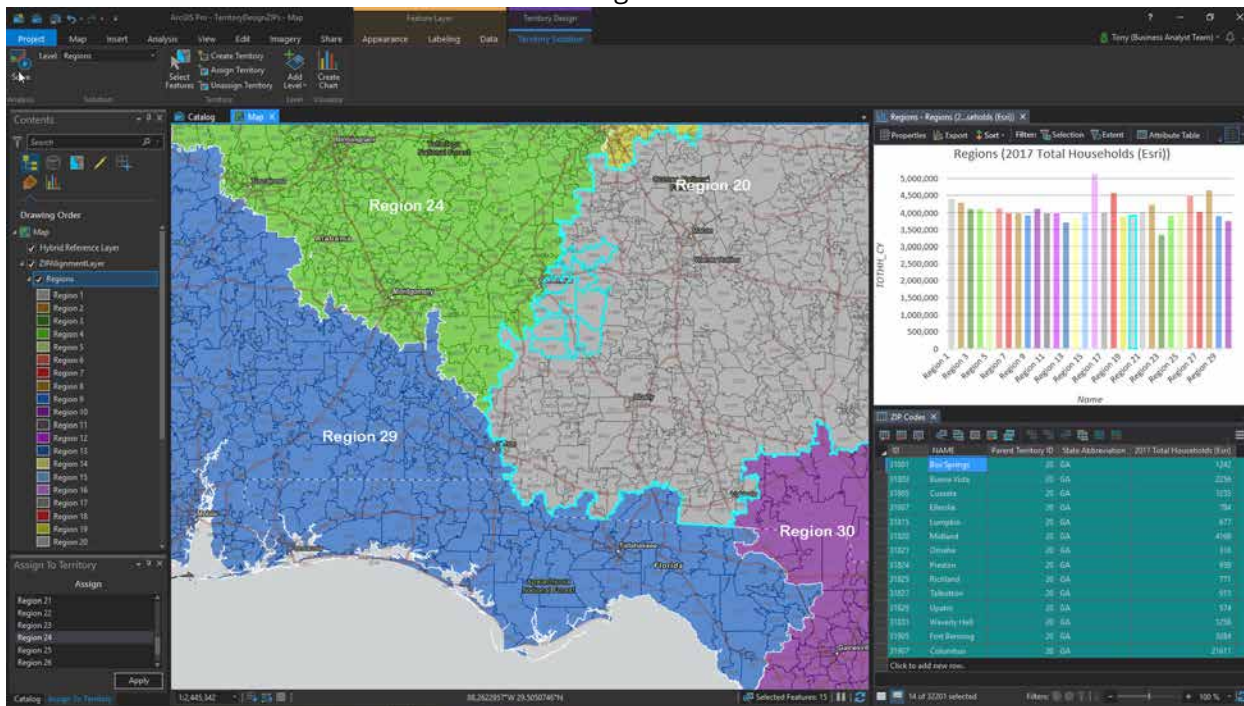


Image source: <https://www.esri.com/arcgis-blog/products/bus-analyst/analytics/ba-pro-22-territory-design/>

### S.1.5 Auto-Redistrict (by Kevin Baas)

**Auto-Redistrict** is a free and open source application built as a labor of love by Milwaukee-based developer Kevin Baas. Unlike the other offerings discussed so far, it does not include or connect to a conventional GIS. It offers a fully algorithmic approach to drawing districts—no manual modification options are provided. Users can specify not only their criteria, but also the weight that should be given to those criteria (see sliders in image).

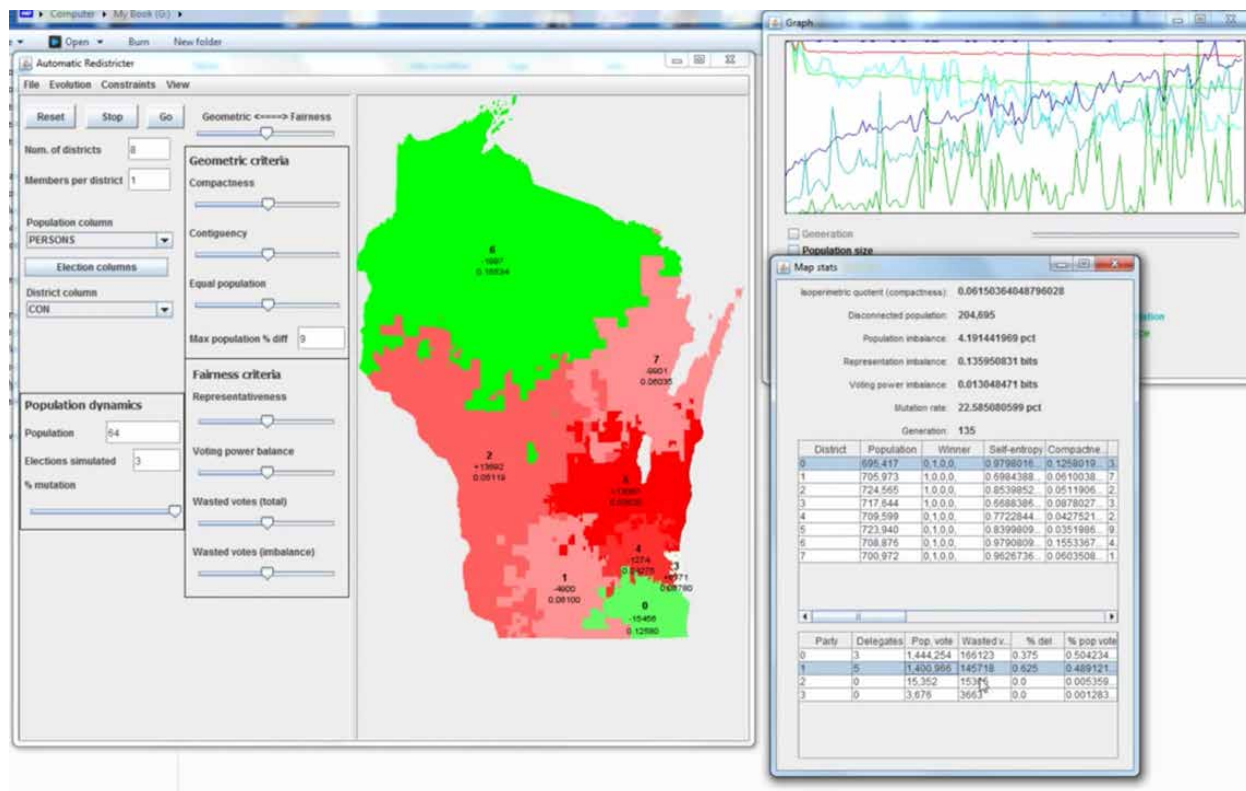


Image source: <http://autoredistrict.org/documentation.php>

A few other distinguishing features of Auto-Redistrict:

- The Java-based application is platform-agnostic.
- Among the criteria offered are several measures intended to address fairness.
- The program can be configured to accommodate multi-member districts.
- Generated plans can be exported for use within other applications.

## S.1.6 QGIS redistricting plugin (by Statto Software)

Readers hopefully have already heard of [QGIS](#), a robust, widely-used cross-platform free and open source GIS. [Statto Consulting](#), a small company with a globe-trotting leader, recently developed the free [QGIS Redistricting Plugin](#), identified in the official QGIS plugin repository as the [Statto Redistricter QGISv3](#). Intended for GIS power users, the plugin provides an array of features specific to redistricting, but expects that the user will be able to fall back on existing GIS skills for other tasks. For example, there's not a "Generate Split Municipalities Report" button, but you can use a QGIS Intersection tool to obtain the same information, or if the municipality status is populated as an attribute for your census blocks, the plugin provides a convenient crosstab feature.

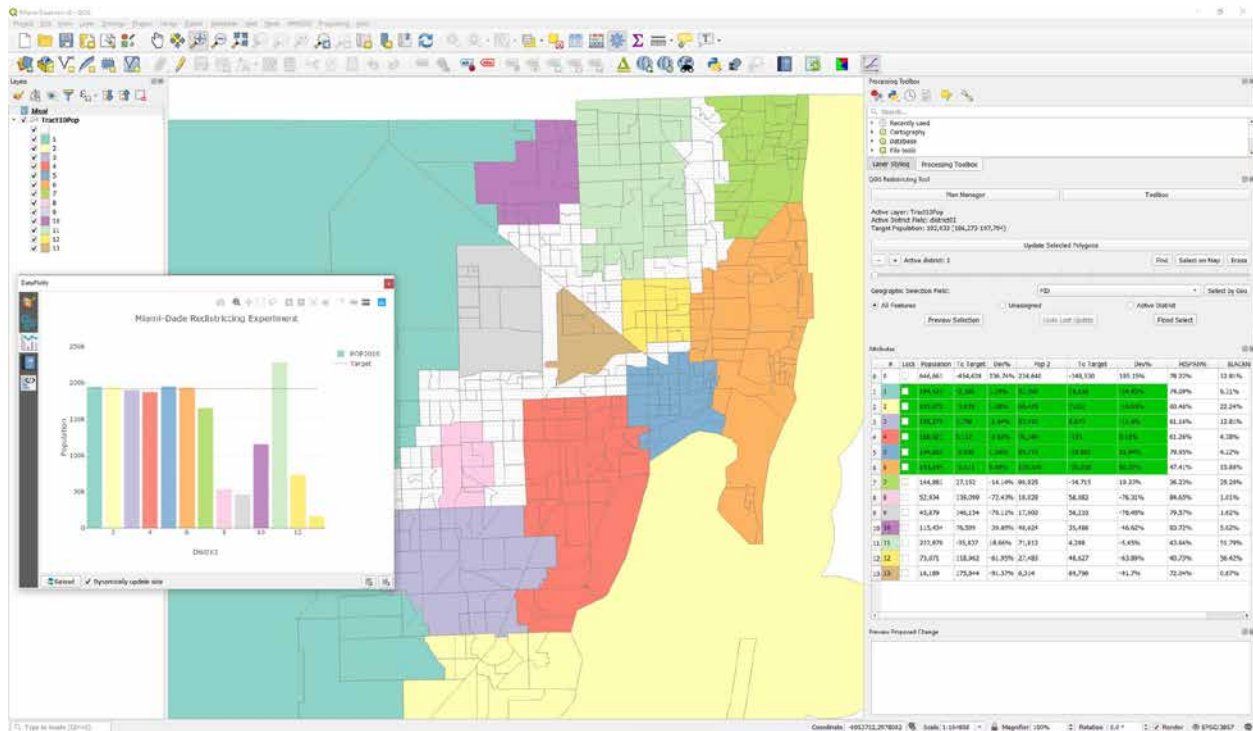


Image source: Blake, 2020

A few other distinguishing features of the QGIS Redistricting Plugin:

- Though it doesn't include the option of working with nested hierarchical selectable component layers (such as blocks within tracts within counties) the way some other packages do, it includes a "select by geography" button that makes it very easy to select all the blocks in a county, for example.
- Do you like working with GeoPackages? You can use any editable vector format supported by QGIS for your base layer(s).
- It is not designed to readily show how new districts would have performed in multiple past elections, in order to discourage partisan gerrymandering. It also accommodates international use and has been used in Australia.
- It can be used in conjunction with other free plugins, like DataPlotly (pictured), to provide highly customizable dynamic data visualizations of changing district attributes.

## S.1.7 RedAppl (Texas Legislature)

In the past, some states have opted to develop their own redistricting application “in-house.” We are only currently aware of one such state, Texas, with a desktop client for this 2021 cycle. The Windows-based application is called RedAppl, a name said to be a shortening of Redistricting Application. As of this writing, it appears that access to the tool, previously made available to the public through workstations in the Capitol, is still “[under consideration](#)” due to the pandemic and uncertainties about the timing of the release of census data. Readers, therefore, may have limited opportunities to use the program, but may be interested to know that:

- It offers a ribbon-based interface.
- Their [website](#) specifies that the public can use other tools and submit their plans as a block equivalency file.
- The State does offer a [web-based tool for reviewing](#) designated district plans.

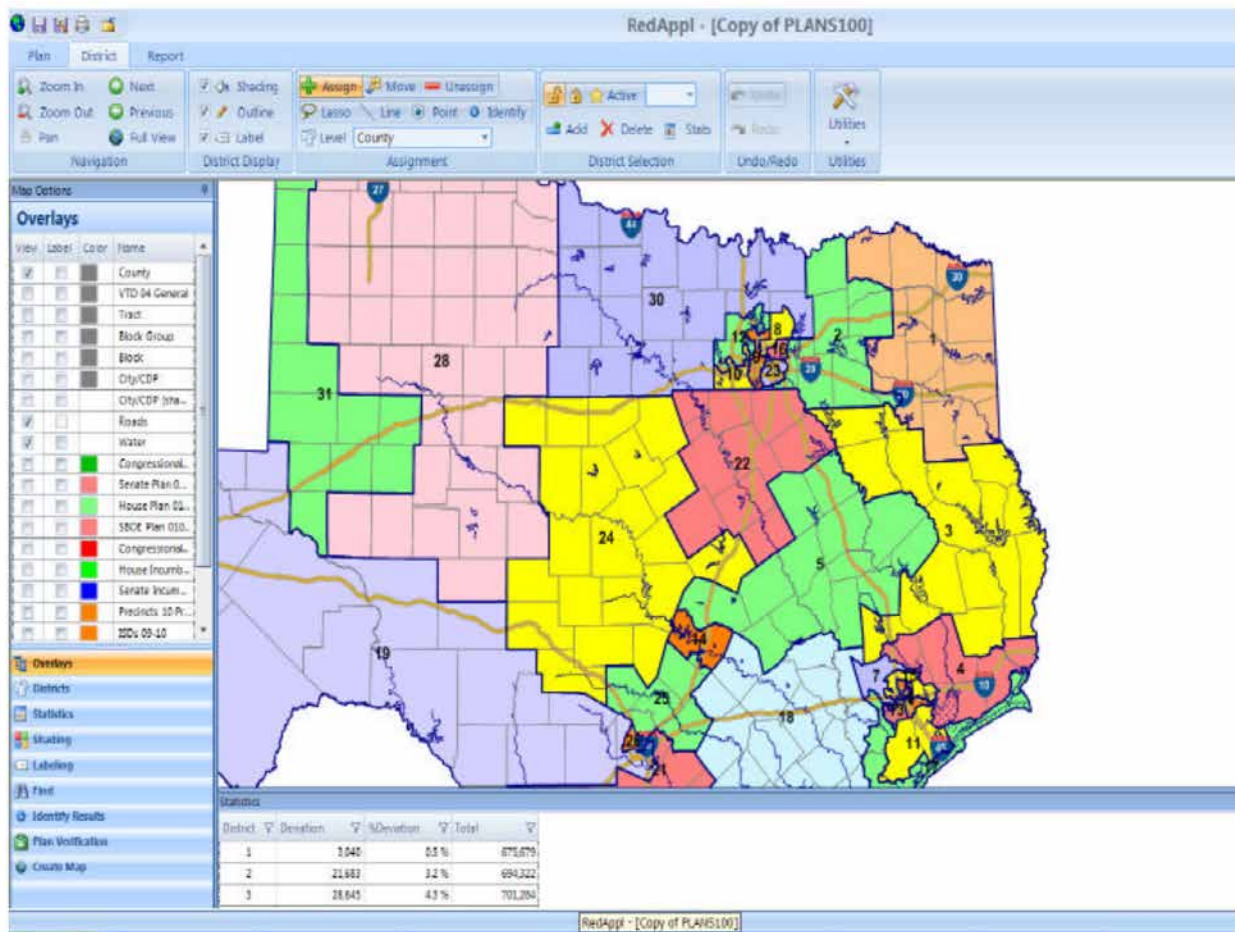


Image source: [https://redistricting.capitol.texas.gov/pdf/Redistricting%20101\\_web.pdf](https://redistricting.capitol.texas.gov/pdf/Redistricting%20101_web.pdf) (2011)

### S.1.8 iRedistrict® (ZillionInfo)

ZillionInfo is a small company with offices in Columbia, South Carolina. Its redistricting offering, iRedistrict, does not include or integrate with a conventional GIS. Like Auto-Redistrict, the application is cross-platform and is designed to generate plans algorithmically based on user-specified criteria—including political criteria. iRedistrict, however, is a paid product with a number of features beyond what Auto-Redistrict offers.



Image source: <http://www.zillioninfo.com/product/iRedistrict/> 2020

A few other distinguishing features of iRedistrict:

- By default, the tool generates a suite of plans, then lets the user evaluate how they compare to each other based on criteria such as compactness and population equality (see XY scatterplot on image).
- Though the primary means of creating plans is automated, districts can be manually edited.
- Communities of interest can also be manually specified on the map within the interface.
- The software is optimized for smaller geographic entities, such as local governments or states with fewer base units. ZillionInfo staff confirm that many of iRedistrict's users are local governments, and that the tool is also used for automated creation of non-electoral districts such as school attendance districts and police patrol districts.
- A web-based version is also available for purchase, which allows for sharing of proposed plans with the public.

## S.2 Web applications for making redistricting plans

Browser-based mapping has evolved rapidly since 2011, and redistricting tools largely have kept pace. All of the offerings listed here have been either newly created, wholly redesigned, or substantially upgraded in recent years, and newly added features are still being announced. These are also listed alphabetically by provider.

Please note that the options listed here either exist only on the web or are significantly different from the desktop-based product the vendor offers. ZillionInfo's browser-based version of iRedistrict (profiled in the previous section) mostly offers the same functionality as the desktop client.

## S.2.1 DistrictBuilder (by Azavea)

Philadelphia-based [Azavea](#) created the first implementation of their open source [DistrictBuilder](#) web app for the 2011 redistricting cycle in conjunction with the [Public Mapping Project](#). That version was implemented in a number of states and communities, providing freely available redistricting tools with a goal of promoting transparency, expanding citizen participation, and allowing mapmaking competitions. The app's current version, released in 2020, adopted a completely new architecture and aims to provide mapping functionality for all 50 states. It's available at no cost to individuals, but to obtain a customized interface for an organization—for example, hosting a coordinated competition using the tool—Azavea would charge for setup.

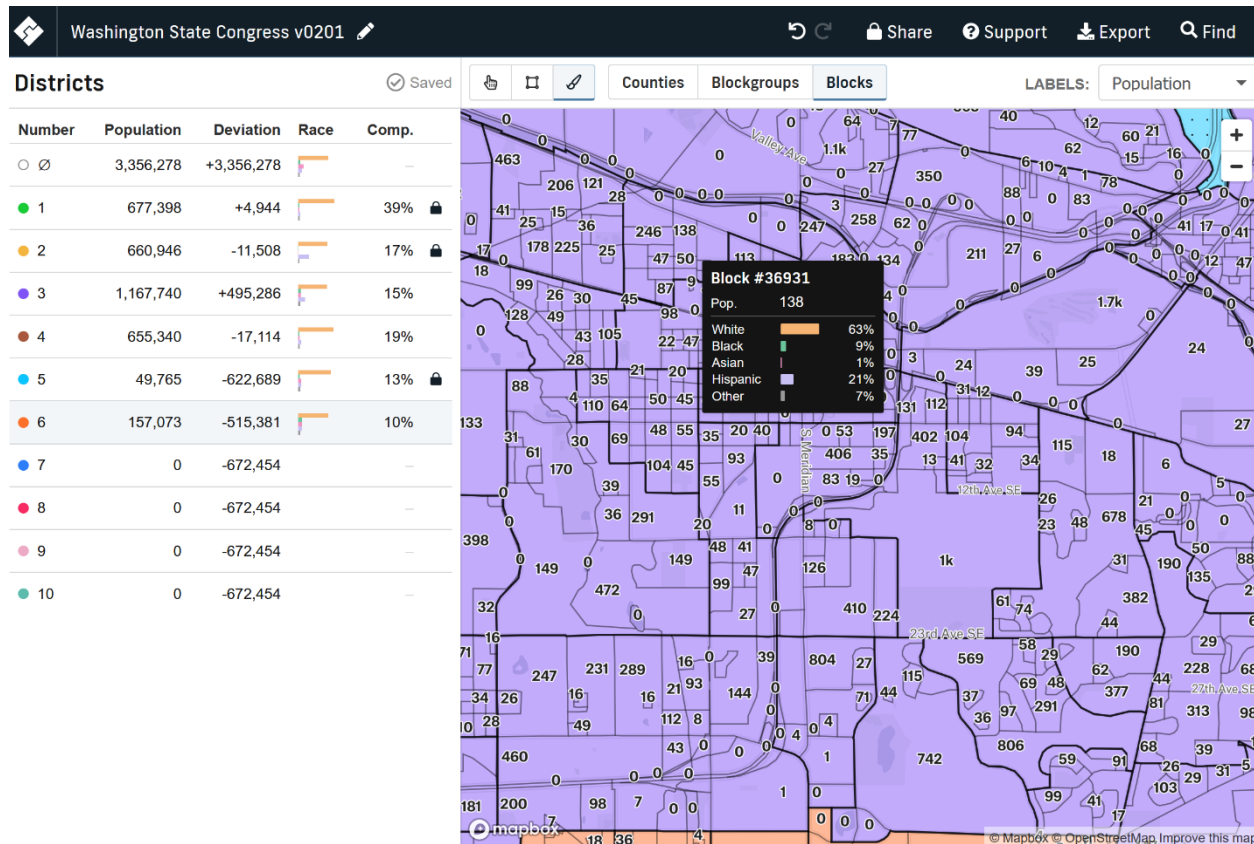


Image source: Blake, 2021

A few other distinguishing features of DistrictBuilder:

- DistrictBuilder was the first free web tool to allow drilling down and making choices at the census block level—even for statewide plans.
- Compactness scores (at least by one measure) and contiguity issues for districts are visible instantly in the main interface.
- A hover-style tool tip graphic (pictured) visually shows simplified demographic stats for the unit or units under consideration right next to the cursor while the user is navigating in the map. A similar mini-bar chart shows demographic composition of districts.
- Unlike other free tools that use the painting metaphor, DistrictBuilder by default allows you to see the effects on district statistics of a potential modification before accepting that change. This behavior applies whether one is selecting by clicking multiple units, painting, or using the rectangle selection. One can even easily choose to add the selected units to a different district.
- As of this writing, DistrictBuilder does not include partisan data or metrics of any kind.

## S.2.2 Maptitude Online Redistricting (by Caliper)

Caliper Corporation, the maker of one of the most widely recognized desktop redistricting software packages, Maptitude for Redistricting, also offers [Maptitude Online Redistricting](#), sometimes referred to as MORE. In most cases, Caliper would make the online tool available (at a cost) for government entities or consultants using the desktop software, as a complementary offering that will allow for public engagement or for less expert users to work with plans.

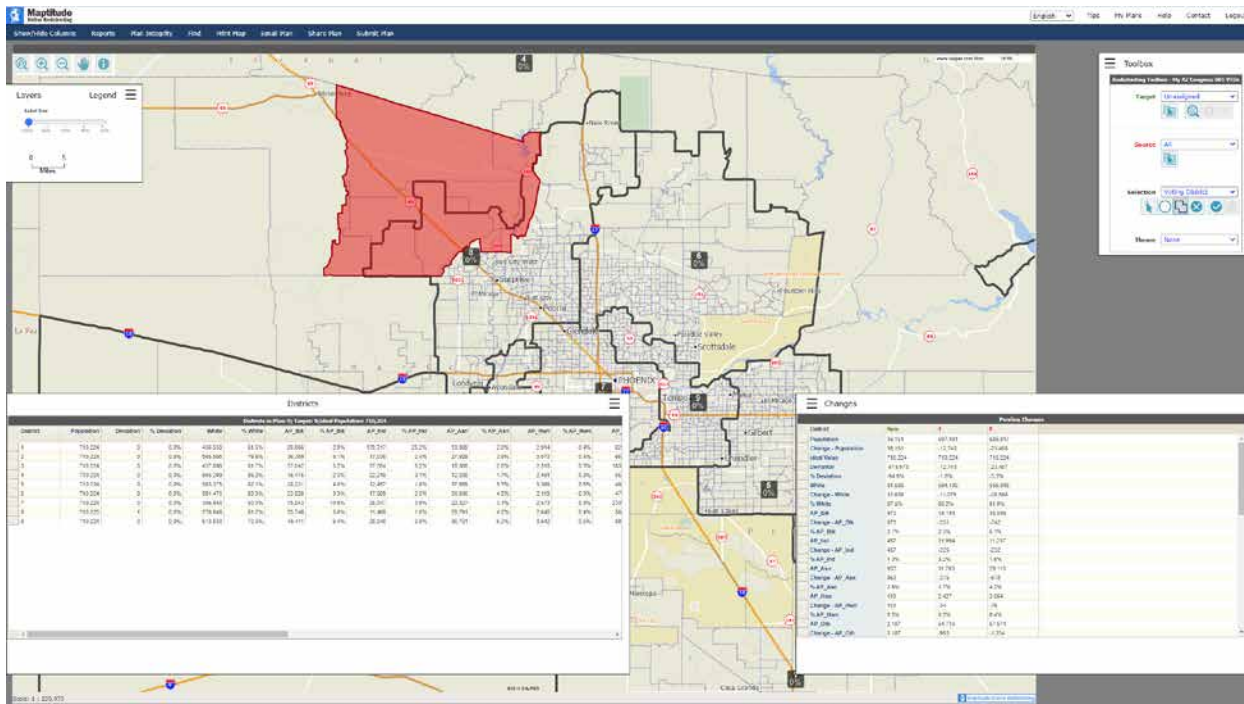


Image source: Blake, 2021

A few other distinguishing features of Maptitude Online Redistricting:

- As a close relative to the fully-featured Maptitude for Redistricting, the software offers a similar user interface, and many (though not all) of the features.
- Caliper offers the Online tool in a Legislator Edition, allowing for interested lawmakers or their staffs to interact with plans, but without all of the administrative options (and complexities) that working in the desktop provides.
- The online edition can export plan files in Caliper's proprietary format for plans, enabling the desktop tool to recognize plan metadata, for example—something that wouldn't be as straightforward if exporting a plan from another web-based tool.
- While other web-based tools use more familiar modern web mapping platforms from Mapbox and Esri, Maptitude uses a platform (perhaps proprietary?) not familiar to this author.

### S.2.3 Dave's Redistricting App, aka DRA 2020, (by Dave Bradlee and friends)

In 2011, former Microsoft engineer Dave Bradlee, acting purely on a volunteer basis, released a web tool called [Dave's Redistricting App](#). The app allowed users to freely create plans for all 50 states, included a range of features, and attracted a loyal following. For the new, totally rewritten iteration, now branded DRA 2020, Bradlee has enlisted a team of developers. The resulting app, while retaining elements of the original user interface, offers multiple areas of functionality beyond what its predecessor did. As of this writing, DRA 2020 has the most extensive list of features of the freely available web apps, with many options for custom configuration.

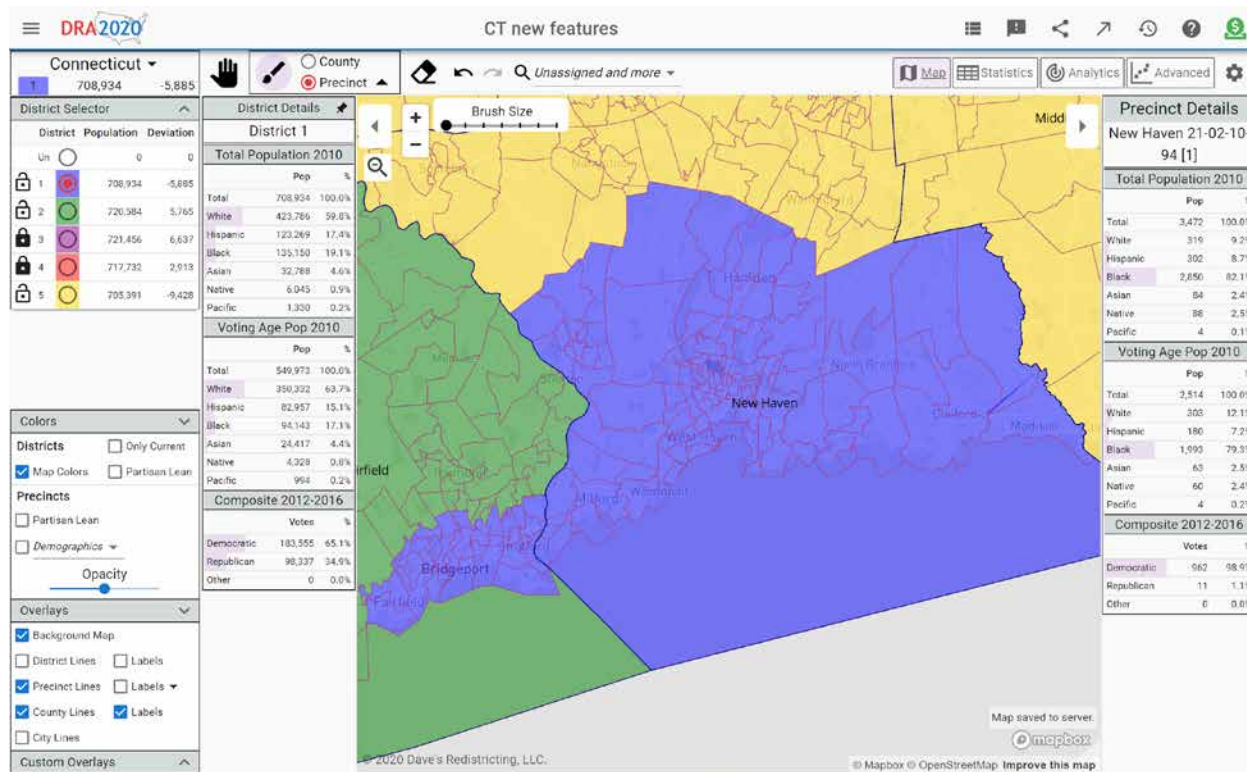


Image source: Blake, 2021

A few other distinguishing features of DRA 2020:

- The app allows for multiple users to be collaboratively editing the same plan simultaneously, as people have gotten used to with web apps like Google Docs.
- The "Custom Overlays" feature allows users to bring their own features into the map, either as Shapefiles or GeoJSON files.
- For any plan, users can view basic statistics, as well as an [analytics](#) page rating the plan on a suite of five criteria, and an advanced analytics page that provides interactive charts focusing mostly on partisan metrics.
- Even without an account, people can review a gallery of plans for states and see which plans rank highest for which criteria.
- It appears to be the only app of its kind offering the new "Know It When You See It," or KIWYSI, compactness metric.

## S.2.4 Esri (Online) Redistricting Solution

Starting with the 2010 redistricting cycle, Esri, the multinational GIS juggernaut, chose a different path from the other vendors providing software at a cost. Their primary application for redistricting, called *Esri Redistricting*, is a web-based product. Instances can be deployed on customers' own servers, but the more typical setup would be for the application to be hosted on Esri's cloud infrastructure. The actual plan creation part of the application integrates with other public-facing plan management, sharing, and comparison tools, leading the company to label its offering as "a modern enterprise approach."

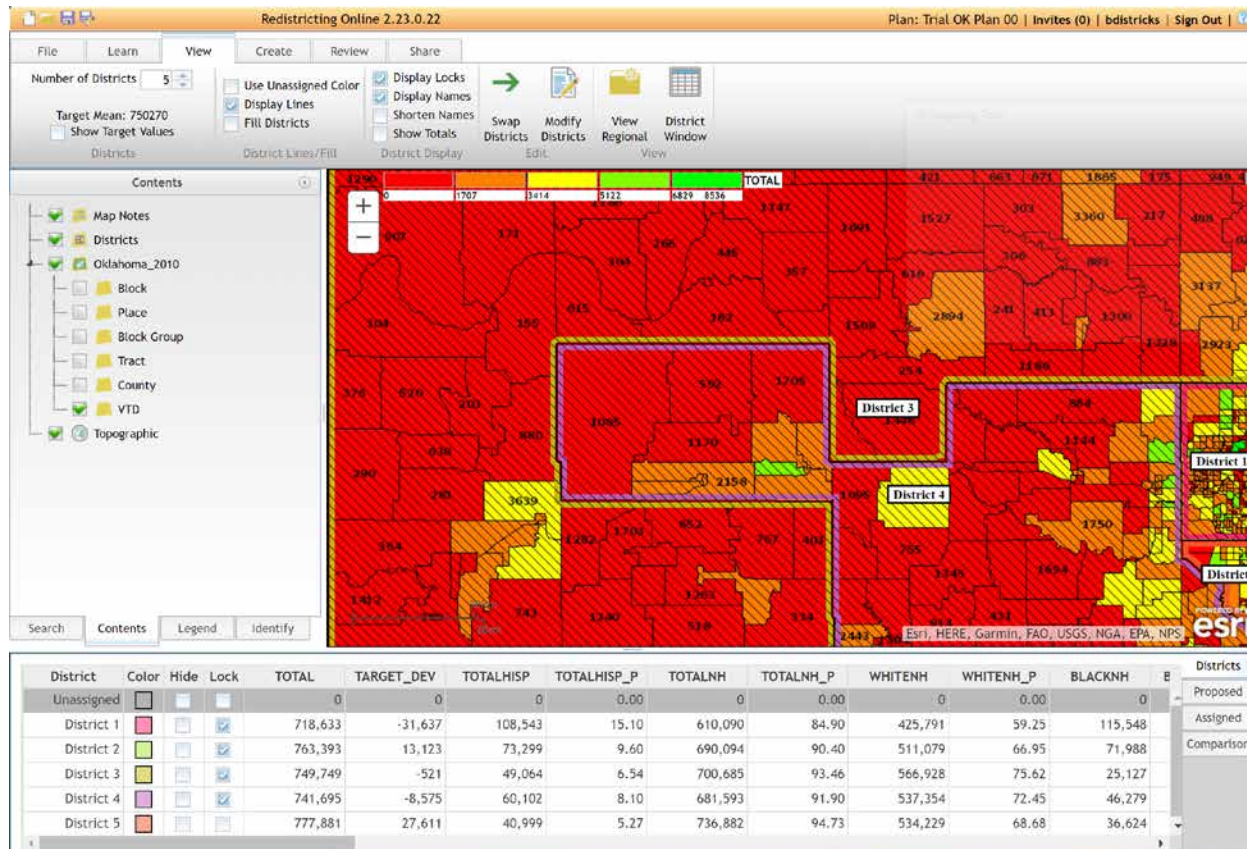


Image source: Blake, 2021.

A few other distinguishing features of the Esri Redistricting Solution:

- As of this writing, Esri's application appears to be the most fully-featured browser-based option. Other options from commercial vendors (such as Maptitude Online Redistricting) with a desktop counterpart omit some features from their web-based offerings.
- The standard offering does not include election or partisanship data, unlike free tools such as DRA 2020 or Districtr.
- Fans of the ribbon-style interface from ArcGIS Pro will find a familiar user experience, as well as basic map navigation and selection functions similar to those from other Esri products.
- Unlike most other web-based tools, the Esri application lets you select a custom base area for your plan, for example, choosing a city or county to redistrict—even if the geography is non-contiguous.
- You can easily generate an atlas, or "map book," with individual printable maps of all the districts in your plan.

## S.2.5 District Scenario Modeler (by FLO Analytics)

FLO Analytics, Inc., a firm with offices in four U.S. cities that also offers redistricting consulting services, has very recently developed a tool in-house that it calls the [District Scenario Modeler](#). The application is currently exclusively being used by the FLO team and their redistricting clients, but it is in active development and the company hopes to soon be able to provide a standalone version (at a cost) to other users, as well as to enable its government clients to embed it in their websites for public participation in the map-drawing process.

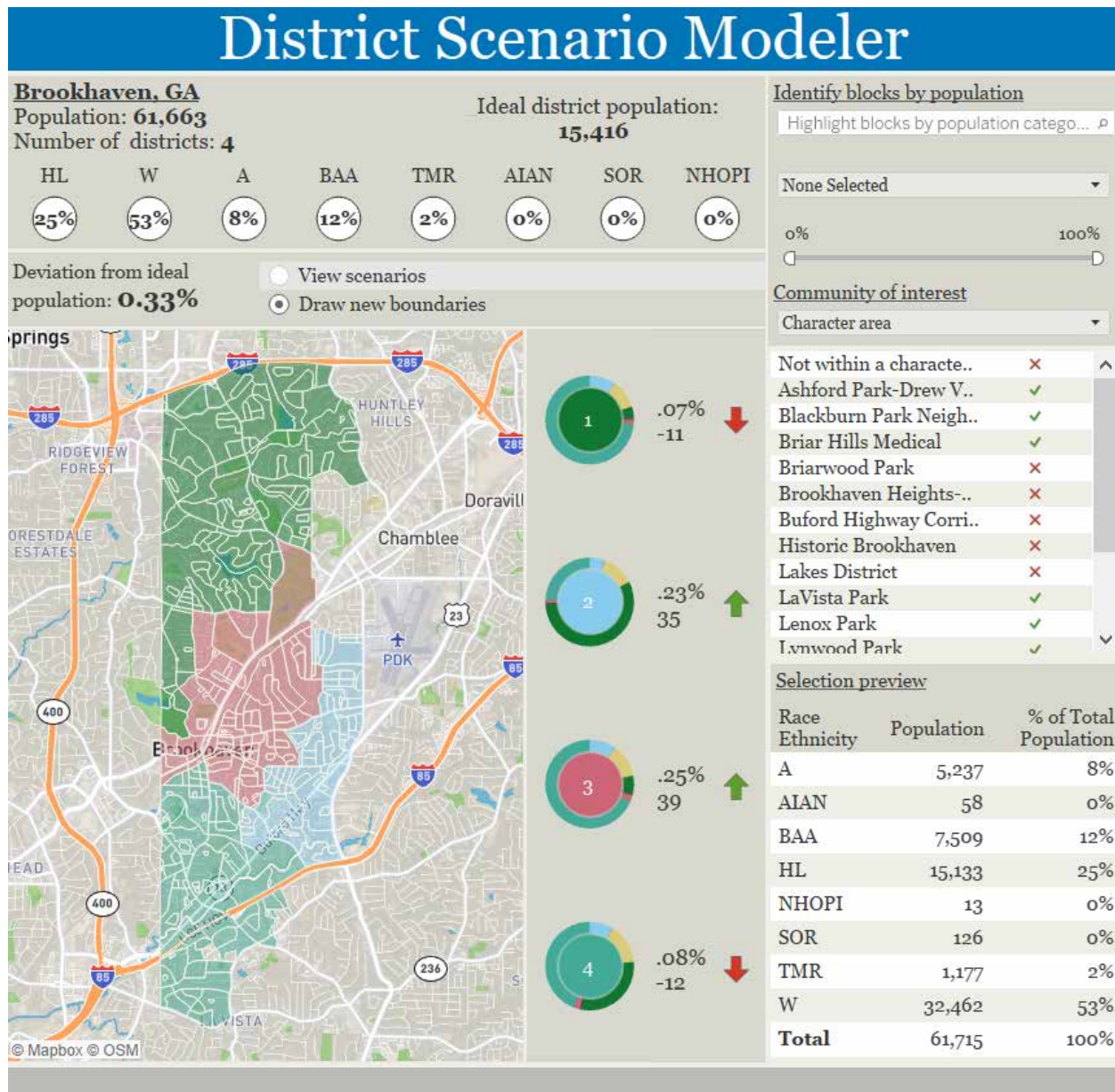


Image source: courtesy of FLO Analytics, Inc., 2021

A few other distinguishing features of the District Scenario Modeler:

- The app uses a Tableau front end with MapBox basemaps, as well as backend reliance on ArcGIS Online and the Alteryx platform for modeling and analytics.
- Communities of interest (COIs) play a central role in the application, as can be seen in the image, and the application readily provides statistics about how the COIs are (or ideally aren't!) divided as well the collective demographic characteristics of the COIs or their fragments.
- Its design includes embedded forms (not pictured) that allow the user to provide a narrative of why they are making a decision the way they are or to comment on aspects of the plan—and then those comments are linked to the elements of the plan to provide context.

## S.2.6 Districtr (by MGGG Redistricting Lab)

If the District Scenario Modeler is in its infancy, then [Districtr](#), introduced in 2019, is the new teenage kid on the block, the only widely available web-based tool that didn't have a predecessor in the 2011 cycle. The [Metric Geometry and Gerrymandering Group](#) (or MGGG), affiliated with Tufts University, spawned a "redistricting lab" that works on numerous projects, including Districtr. Accessibility and ease-of-use were primary design principles, but it includes a lot of powerful features as well.

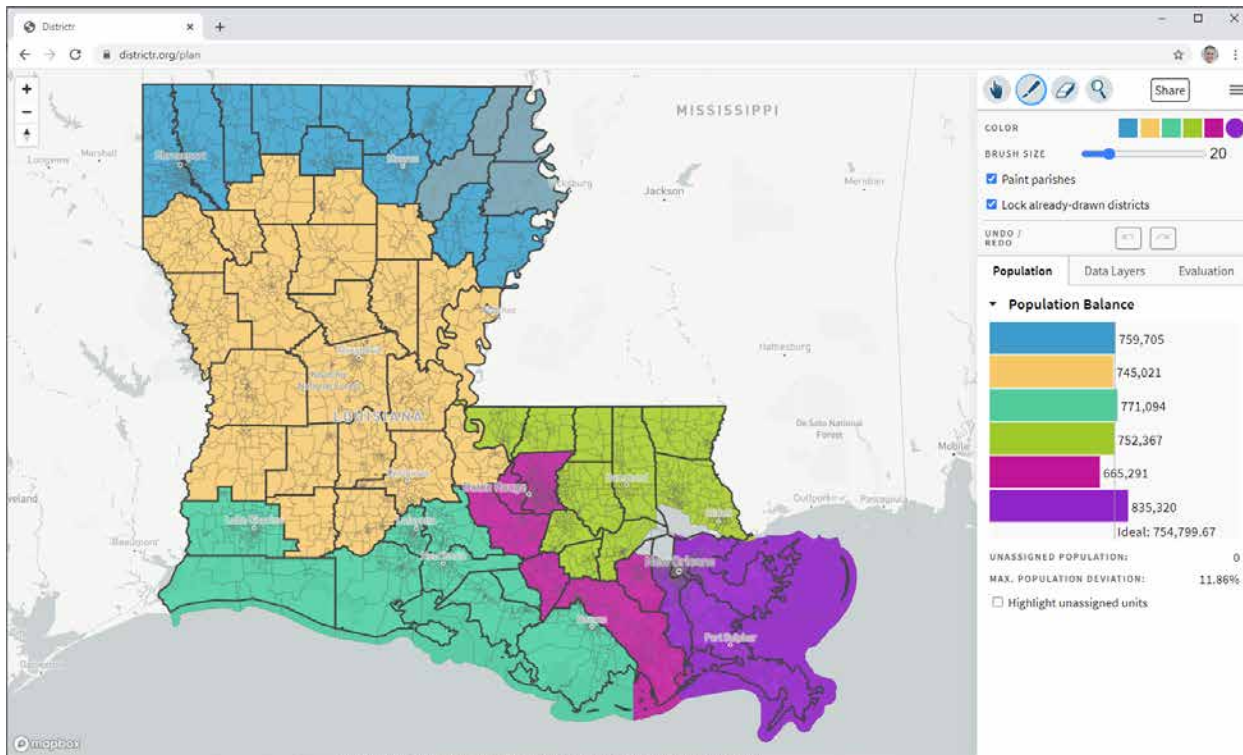


Image source: Blake, 2021

A few other distinguishing features of Districtr:

- Because there is no need to (or way to) create an account, there is no need to log in. New users can be drawing a map literally within seconds of opening the site. If a user wants to preserve and/or share a plan, one click generates a persistent URL that will enable its retrieval.
- In addition to a mode for drawing districts, Districtr was the first web tool to offer a mode for simple custom drawing of COIs on the map, which can then be shared in familiar geospatial formats. This feature enables residents to provide representations of their COIs in something that can immediately be integrated by map-makers using other systems, unlike people submitting hand-drawn paper maps.
- The Data Layers tab offers a "Coalition Builder" tool to allow the user to look at statistics for a combination of races and ethnicities, which may be relevant for creating districts to comply with the Voting Rights Act (VRA).
- Demographics and partisan lean of the building block units can be shown not only with shading of the polygons, but also with variably sized circle symbols.
- In addition to modules for statewide plans, Districtr offers modules for a growing number of counties and municipalities. Some of these modules offer different features than others, meaning not all modules offer all the same data or features—AND meaning there may be functions in modules we haven't seen and therefore aren't aware of.

### **S.2.7 Proprietary state options**

As of this writing, it seems that the custom-building of web-based redistricting software for one particular state, previously a rarity, is now fully a thing of the past. For the 2011 redistricting process, Florida's House of Representatives commissioned the creation of a proprietary web-based district-drawing tool called MyDistrictBuilder, which was made available to citizens. As far as this author is aware, that tool will not be revived for the 2021 cycle.

## **S.3 Other utilities and sources for additional data**

GIS practitioners considering active involvement in redistricting could also benefit by looking at tools and data beyond the plan creation applications and the census data that have already been described.

### **S.3.1 Web-based interactive resources**

The following selected resources, listed in alphabetical order, provide a range of free online geo-centric ways that anyone can learn more about redistricting plans and about the process, as well as ways for the public to take steps towards engagement.

### S.3.1.1 FiveThirtyEight Atlas of Redistricting

In 2018, FiveThirtyEight.com created its [Atlas of Redistricting](#), a collection of suites of congressional district plans for all the states that have more than one US House district. Users can compare plans, each drawn to prioritize one of seven different criteria, and see not only their shapes but also a series of thoughtfully designed charts and tables that respond to user selections. As a bonus, all the plans are [available for download as shapefiles](#), too!

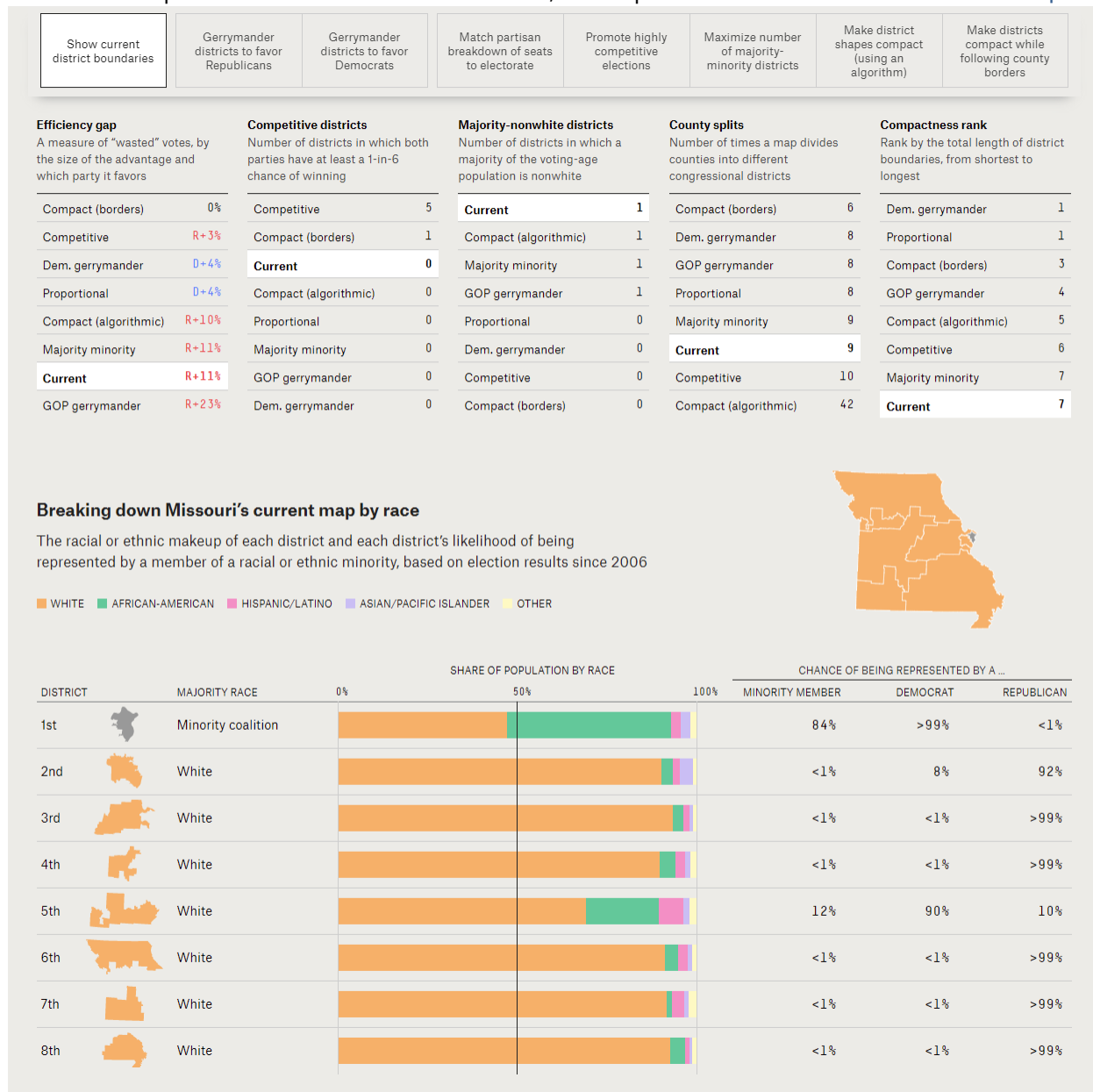


Image source: <https://projects.fivethirtyeight.com/redistricting-maps/missouri/>

### S.3.1.2 PlanScore

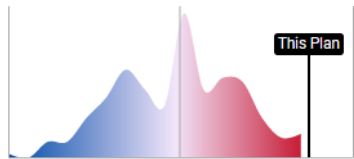
[PlanScore.org](#), as the name suggests, is an online tool for scoring redistricting plans. Users can upload state congressional or legislative plans in Shapefile, GeoJSON, or Geopackage format, and the utility will score the plan on multiple partisan fairness metrics, as well as provide a table of demographic and partisan statistics for each district.

## Oklahoma State House Proposal (Proposed\_20210420)

Oklahoma State House plan uploaded on 4/21/2021

PlanScore bases its scores on predicted precinct-level votes for each office (State House, State Senate, and U.S. House) built from past election results and U.S. Census data. [More information about the predictive model used to score this plan.](#)

### Efficiency Gap: 12.8%



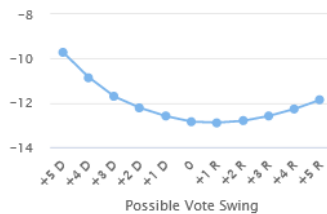
Votes for Republican candidates are expected to be wasted at a rate 12.8% lower than votes for Democratic candidates. The expected gap favors Republicans in 99% of predicted scenarios. [Learn more](#) >

### Partisan Bias

The parties' statewide vote shares are 43.4% (Democratic) and 56.6% (Republican) based on the model. Partisan bias is shown only where the parties' statewide vote shares fall between 45% and 55%. Outside this range the metric's assumptions are not plausible.

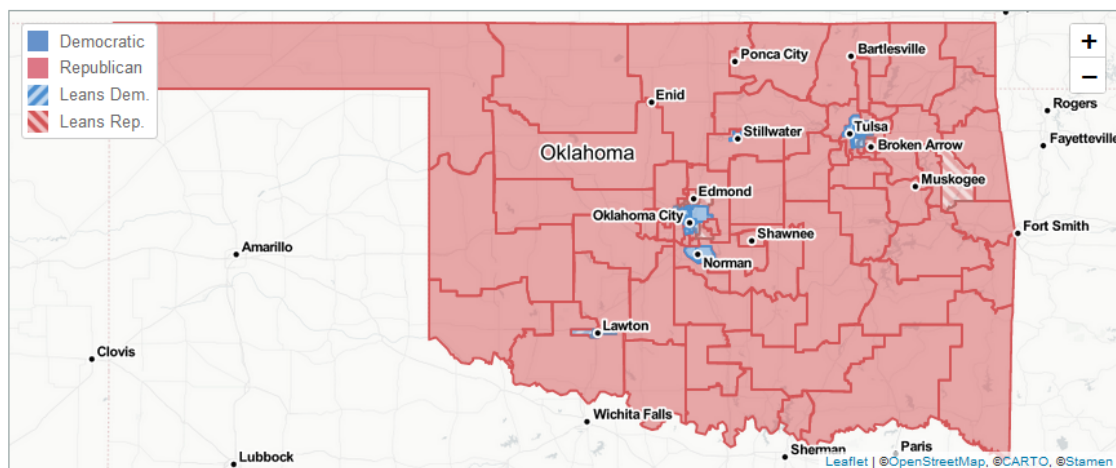
### Mean-Median Difference

The parties' statewide vote shares are 43.4% (Democratic) and 56.6% (Republican) based on the model. The mean-median difference is shown only where the parties' statewide vote shares fall between 45% and 55%. Outside this range the metric's assumptions are not plausible.



### Sensitivity Testing

Sensitivity testing shows us a plan's expected efficiency gap given a range of possible vote swings. It let us evaluate the durability of a plan's skew.



District	Candidate Scenario	Population 2010	Population 2018	Black Population 2018	Hispanic Population 2018	Citizen Voting-Age Population 2018	Chance of Democratic Win	Predicted Vote Shares	US President 2016: Clinton (D)	US President 2016: Trump (R)
1	Open Seat	39,654	39,762	9.1%	5.8%	29,347	<1%	34% D / 66% R	2,171	10,343
2	Open Seat	39,314	39,031	2.9%	4.1%	29,408	2%	37% D / 63% R	2,754	9,905
3	Open Seat	37,720	37,836	3.0%	7.5%	27,579	1%	35% D / 65% R	2,540	10,159

Image source: <https://planscore.org/plan.html?20210421T190932.018394874Z>

### S.3.1.3 Redistricting & You

In 2021, a team at the Graduate Center at the City University of New York introduced [Redistricting & You](https://www.redistrictingandyou.org/), an interactive site that lets users look at current congressional and legislative plans from around the country and see which districts are underpopulated and overpopulated—and by how much (as of this writing, based on ACS estimates). Other statistics and information are also provided.

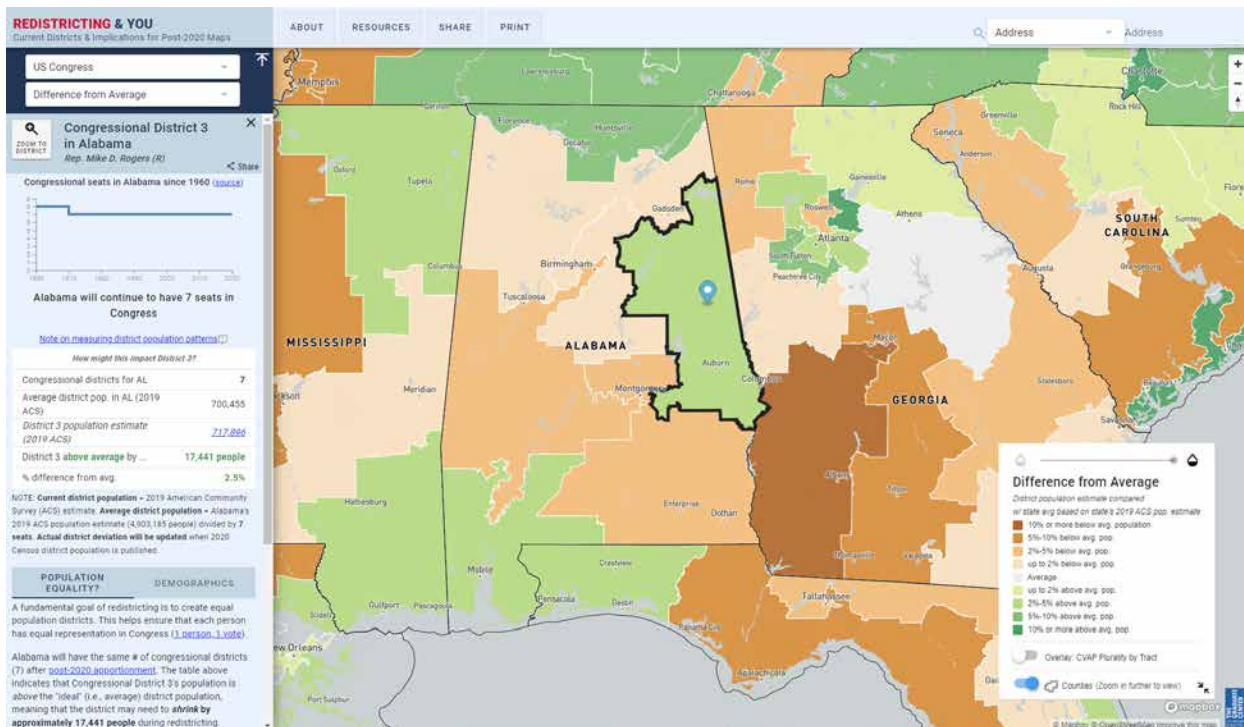


Image source: <https://www.redistrictingandyou.org/?districtType=congress&mapData=deviation&marker-L=33.2159%2C-85.5673&geoid=0103#map=6.63/32.424/-86.417>

### S.3.1.4 Representable

**Representable**, a tool that grew out of a student project at Princeton University, serves to let people, including folks without mapping experience, map their communities of interest. Users can be independent or create organizations that other users can join. Submitted geographies can be shared via the site or also delivered in GeoJSON format to mapmakers.

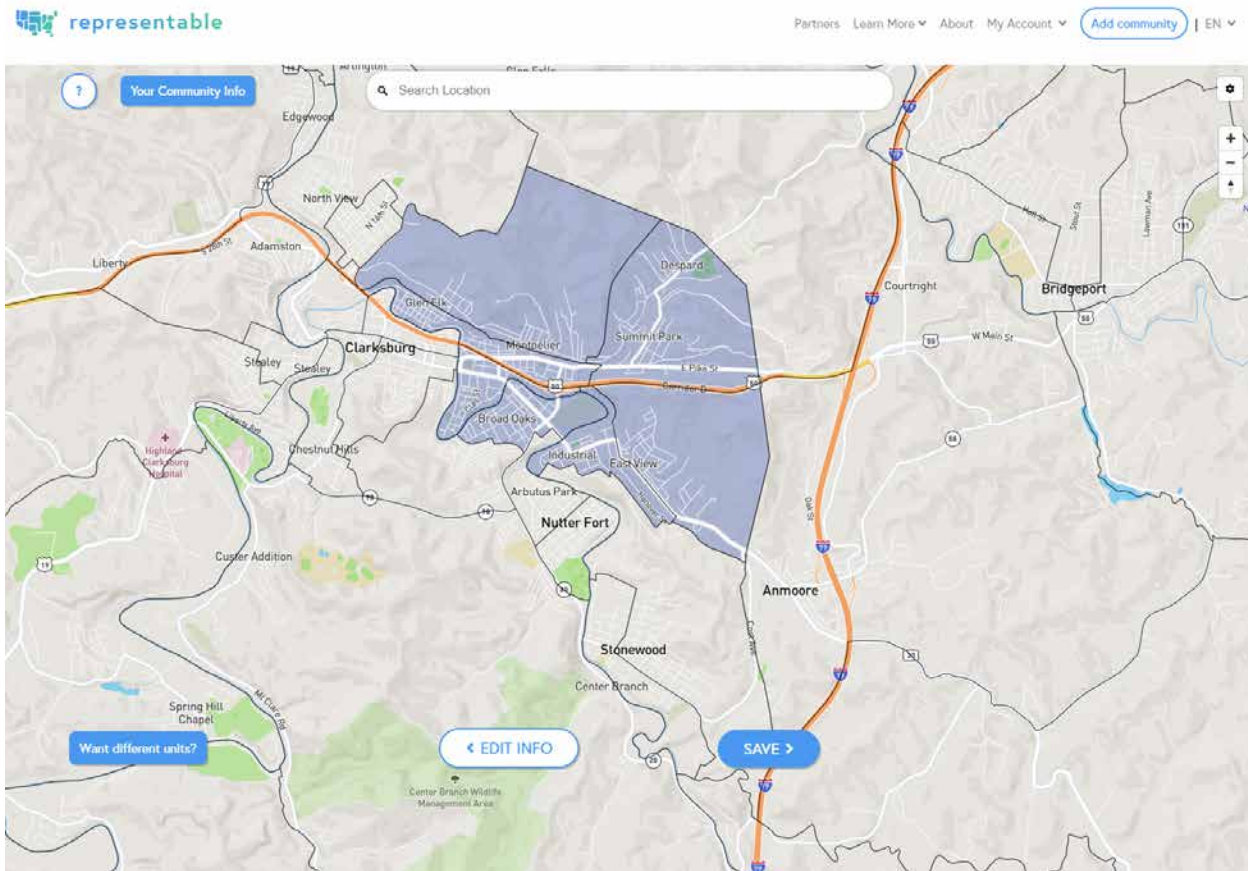


Image source: <https://www.representable.org/entry/ww/>

### S.3.1.5 The ReDistricting Game

The **ReDistricting Game**, created at the USC Annenberg Center in advance of the 2010/2011 redistricting cycle, is a browser-based game. The game challenges the user to draw districts (in fictional U.S. states) that not only meet technical standards but also satisfy fictional opinionated hard-to-please elected officials. Designed to entertain as well as educate, it provides a learning experience about the politics of redistricting that other mapping tools and software cannot.

The original game was developed with the now-defunct Flash technology. As of this writing the game is still in the process of being updated for this decade's cycle.

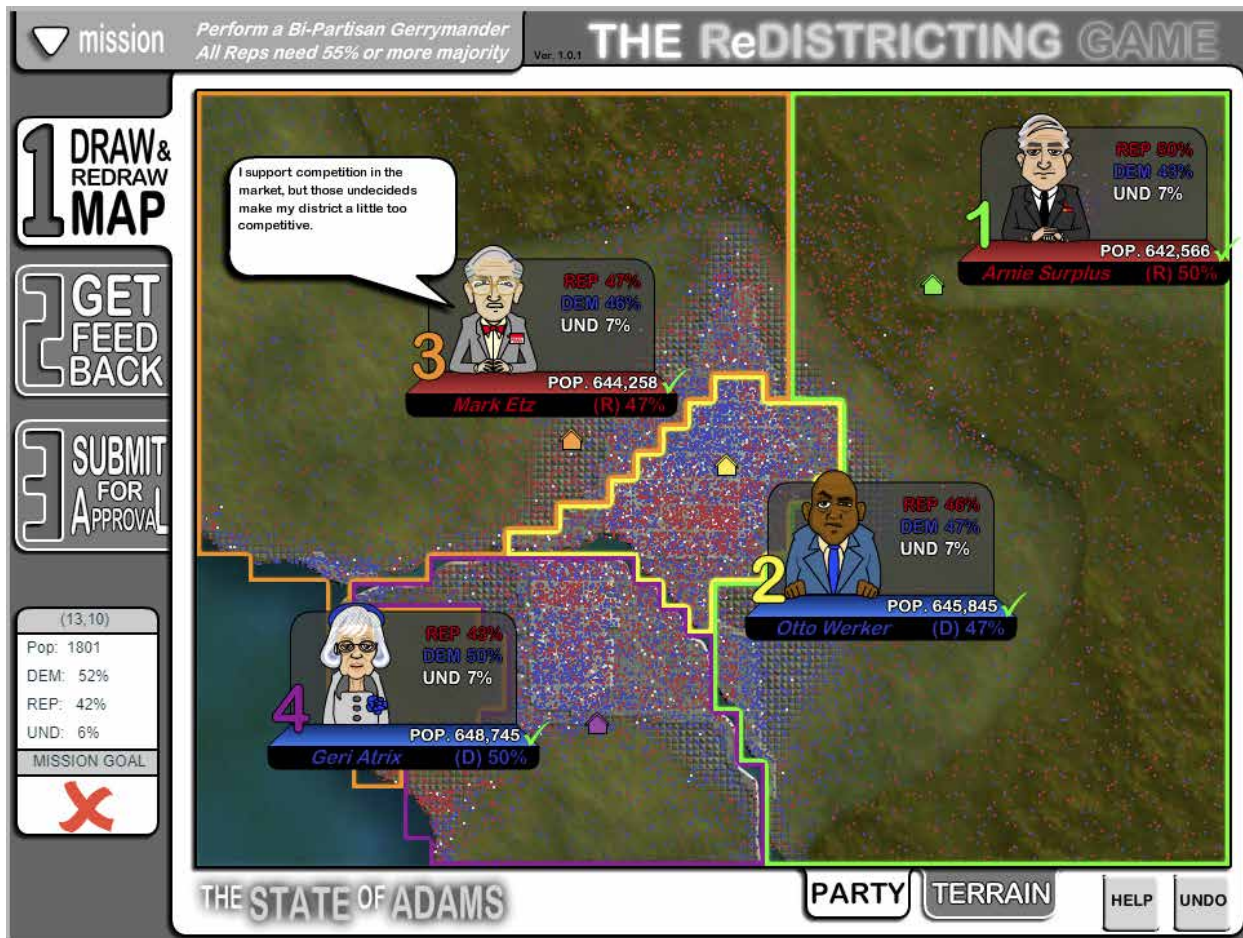


Image source: <http://www.redistrictinggame.org/>

### S.3.2 Data Resources

While the Census Bureau provides most of the mission-critical foundational data for redistricting, other geographic features must be obtained elsewhere. Precinct boundaries, which in many cases can differ from the Census Bureau's Voting Tabulation Districts (VTDs), can be important for map-drawing and analysis of others' maps. Representations of areas that might be useful in COIs of interest could come from any number of different sources. Representable.org (mentioned just above) offers to provide a central location where declared COIs can be accessed.

After the 2011 cycle, many observers lamented the inconsistent availability and quality of election-related GIS data across states, and significant effort has gone into the creating the following freely available offerings. Readers should be aware that methodologies can vary between the various data compilers—some may pay less attention to topology, for example, or some may strive to align precincts with census block boundaries, even if that departs slightly from the precinct's "true" shape as depicted by the local board of elections. If these distinctions matter to you, don't hesitate to inspect the metadata!

- [MGGG Redistricting Lab](#)  
(Data from the team that also makes the Districtr web app)
- [OpenElections](#)  
(Offering tables with precinct-level election results but not shapefiles)
- [OpenPrecincts](#)  
(Aiming to provide precinct geography aligned to census data and election results)
- [Redistricting Data Hub](#)  
(As the name suggests, an effort to provide a central clearinghouse for redistricting-related data—one recent addition is incumbent residence addresses for state- and federal-level districted elected officials)
- [Voting and Election Science Team](#), aka VEST  
(Collaboration of the Harvard Dataverse, University of Florida, and Wichita State University)

### S.3.3 Coding resources

For readers with programming skills who want to adapt tools beyond the open-source plan creation applications noted above, you've got options! There are code repositories shared by researchers working with ensemble generation, analysis of racially polarized voting, alternative compactness measures, and more. The listing below is by no means comprehensive but should provide useful starting points

- [Duke University Quantifying Gerrymandering Group](#) (which also offers a [blog](#))
- ["Know it when you see it" compactness](#) (via Aaron Kaufman, one of the creators)
- [Metric Geometry and Gerrymandering Group](#) (affiliated with Tufts and MIT)
- Princeton Gerrymandering Project's [metrics for quantifying gerrymandering](#)
- [Simulation Methods for Legislative Redistricting](#) (from Harvard [ALARM team](#))



