

Drawing Better Lines:  
Comparing Commissions to Legislatures on Compactness and Coterminosity

by

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To my daughter, Jasmine Sunrise

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## **List of Abbreviations**

CDP	Census designated place
GIS	Geographic information system
IRC	Independent redistricting commission
VRA	Voting Rights Act

## **Abstract**

Electoral districts drawn by independent commissions are seen by political reformers to be preferable to those drawn by state legislatures. The overtly partisan interests of elected officials, say the reformers, lead to oddly-shaped, and gerrymandered districts. To test this, shapes of districts in states with commissions are compared to those within the same state prior to the commission's establishment. Additionally, shapes of districts in states with commissions are compared to those in a selected group of states without commissions. This study tests hypotheses on two methods of measuring compactness, Reock and Polsby-Popper, and coterminosity, the congruence of district lines and pre-existing political boundaries. The study finds that each state with a commission shows no significant difference in mean compactness compared to its pre-commission form. However, in aggregate, all post-commission districts show a significant increase in mean Reock compactness compared to all pre-commission districts, and all districts in states with commissions show significantly less Polsby-Popper compactness than districts in non-commission states. The study also finds no significant difference in coterminosity between commission states and non-commission states. Though the true effect of commissions may not be discernible from averages, other redistricting criteria also need to be controlled for and evaluated over time.

## **Chapter 1 Introduction**

The House of Representatives is the most direct link between the people and the federal government. When we elect a member of congress, we expect that person to faithfully represent all of his or her constituents and to be gracious in defeat as the political winds change. However, state legislators draw congressional districts, and the party in power can draw the boundaries in their favor. In an effort to increase their party's power and to diminish the strength of rivals, legislators are too often tempted to pack in more likely supporters and to break apart threatening voting blocs, leading to irregularly shaped and sometimes noncontiguous districts (O'Neill 2005).

Gerrymandering, as this process is called, undermines the public's faith in political institutions by creating a sense that the system is rigged. Districts tend to become less competitive, giving incumbents an even greater advantage against challengers than they already hold just by virtue of incumbency (Forgette and Winkle III 2006). Fortunately, states have begun to take measures to stop gerrymandering and undo the damage. One such measure is the redistricting commission, which takes the power to draw districts out of the hands of unbalanced state legislatures where majority political parties would directly benefit. Instead, districts are drawn by bipartisan and nonpartisan committees composed of individuals who, in most cases, are not currently elected to any office (Levitt 2010).

### **1.1 Response to Gerrymandering**

One major problem in combatting gerrymandering is that there is no definitive way to identify it. Irregular boundaries may exist for entirely innocuous reasons, primarily geography. For example, states with lengthy and complex coastlines like Maryland may appear on objective measures of compactness to have gerrymandered districts when viewed out of context. Also,

Hawaii's congressional districts must be noncontiguous, as the state's population is concentrated mostly onto one of four so-called "basic island units."

One way redistricting commissions attack the gerrymandering problem is by eliminating the partisan advantage that nearly always exists within state legislatures. Those with a Republican majority have the incentive to vote along party lines for redistricting plans that favor Republicans candidates. For Democrats, the same incentive exists to use their majority to favor Democratic candidates. In all states with commissions for congressional districts, they are structured as either nonpartisan or evenly bipartisan (Levitt 2010).

The rules placed on the commissioners themselves are another feature of redistricting commissions intended to help eliminate gerrymandering. In general, these rules increase the political distance between the commissioner and the redistricting process. Common rules for commissioners prohibit currently elected officials, as well as those who have served within the past few years, from appointment to the commission. As a result, state legislators cannot draw their own districts, nor can they give a helping hand to congressional candidates from their party (McDonald 2008). The question this study seeks to answer is: Are redistricting commissions working to reduce the problem of gerrymandering?

In order to know whether these commissions are working, there must be some basis on which to evaluate them. Analyzing elections and their outcomes is one way, which has been the focus of much of the literature on the subject. By contrast, GIS and spatial analysis tools allow us to evaluate commissions by analyzing their product, i.e. congressional district maps. Using the commissions' own criteria for how districts should be drawn, we can spatially evaluate how well redistricting commissions are performing.

Compact shapes are those with the most efficient use of space. These are basic geometric shapes like circles and squares because their boundaries are smooth and the points within are packed as close together as possible. District compactness is a common theme among redistricting debates, and is cited directly by most commissions as an important factor in how the lines are drawn. Research has shown that gerrymandered districts tend to be non-compact (Altman 1998). While it is unlikely that a congressional district could be drawn as a perfect square or circle, spatial analysis can be used to compare the compactness of districts.

Another principle commissions use to draw districts is that boundary lines should be physical features (geographic or man-made) or pre-existing political boundaries. Using physical features makes it easy for voters to identify district boundaries, while maintaining pre-existing political boundaries is another form of respecting the common interests that residents share. The term “coterminous” is used in this study to refer to the overlap of district lines and pre-existing political boundaries. Spatial analysis can also be used to determine the extent to which this expectation is met.

## 1.2 Gerrymandering History and Techniques

As previously mentioned, gerrymandering refers to the process of drawing electoral districts that privilege the interests of politicians and parties over the interests of residents and voters. In essence, gerrymandering enables politicians to choose their voters rather than the opposite. As defined below, partisans accomplish this by “packing” and/or “cracking” voters for maximum partisan efficiency (McGhee 2014, 57). Each of these strategies results in districts that are oddly shaped to the naked eye.

Packing is a gerrymandering technique whereby a voting bloc is intentionally grouped into one district when it could have reasonably been divided among more than one district. The

purpose of packing is to give rival candidates far more votes than they need to win, thereby “wasting” the excess votes and confining that voting bloc’s influence to single district (McGhee 2014, 57). Cracking accomplishes just the opposite. A voting bloc that may constitute the majority in one district is intentionally split among multiple districts in order to dilute its influence (McGhee 2014).

The term Gerrymandering comes from Massachusetts Governor Elbridge Gerry, who in 1812 signed into law newly drawn state senatorial districts, including a number of oddly-shaped districts designed to benefit his fellow Jefferson Republicans (Martis 2008). One particularly odd district, said to resemble a salamander, caught the attention of the Boston Gazette, who published a cartoon lampooning the district by giving it wings, claws, and the head of a dragon (Figure 1), and titled it “The Gerry-mander”, after Governor Gerry (Martis 2008).



Figure 1 The Original Gerrymander (Martis 2008)

### **1.3 Gerrymandering and the Courts**

Redistricting criteria have been argued in court as early as 1960, often in response to claims of civil rights and voting rights violations. The concept of compactness was brought before the Supreme Court in *Gomillion v. Lightfoot* (1960), where the plaintiffs argued that the new boundaries of Tuskegee, Alabama, were drawn in order to intentionally exclude black residents. Formerly described as a square, the new city boundaries comprised an "uncouth 28-sided figure" (*Gomillion v. Lightfoot* 1960). The court ruled that the new boundaries violated the Fifteenth Amendment by denying the black residents' right to vote (*Gomillion v. Lightfoot* 1960). Though the case did not concern legislative districts, it is significant because the shape of the city was cited as evidence of wrongdoing.

In 1964, the Court identified compactness, contiguity, and adherence to existing political boundaries as appropriate criteria for state legislative districts, suggesting that violating these may invite political gerrymandering (*Reynolds v. Sims* 1964). That same year, the Court ruled that congressional districts must, "as nearly as practicable," be of equal population (*Wesberry v. Sanders* 1964). The Court later clarified the term "as nearly as practicable" to mean that state legislatures must make a "good faith effort" to achieve mathematical equality for congressional districts, and must provide justification for any variances (*Kirkpatrick v. Preisler* 1969). These decisions ensured that all redistricting bodies, be they commissions or state legislatures, make population equality a significant factor.

*Thornburg v. Gingles* (1986) established rules intended to help identify minority voting blocs to ensure that redistricting criteria stay in line with the Voting Rights Act of 1965, allowing the use of race as a factor in certain instances. However, in 1993, the Court heard a North Carolina case in which the plaintiffs argued that two districts, one highly irregular in shape, were

drawn solely on the basis of race, without consideration to “traditional” criteria like compactness, contiguity, and maintaining the integrity of existing political boundaries (Shaw v. Reno 1993). While recognizing the soundness of these criteria, the Court nonetheless ruled that the districts would be allowed to stand.

When political interests dominate the redistricting process, the results are often quite strange-looking districts, the worst cases being instinctually offensive to the eye. Figure 2 shows North Carolina’s 12th Congressional District as it existed in 1993 when the Supreme Court heard and decided Shaw v. Reno. Though gerrymandered for a just and ultimately legal cause, to ensure a majority black district, these boundaries, which wander through more than 100 miles of central North Carolina, for the sole purpose of accumulating predominantly black towns, represent what is visually objectionable about districts drawn for reasons other than geography.

## **1.4 Commissions**

A redistricting commission is an organization whose sole purpose is to draw new district boundaries, given the specified criteria and population data. Typically, these districts pertain to the U.S. Congress and to each state’s legislature.

Currently, six states solely use commissions to draw new congressional districts: Arizona, California, Hawaii, Idaho, New Jersey, and Washington (Levitt 2014). Alaska and Montana also mandate congressional redistricting by commission, but these states each have only one district (Levitt, All About Redistricting - Who Draws the Lines 2014).

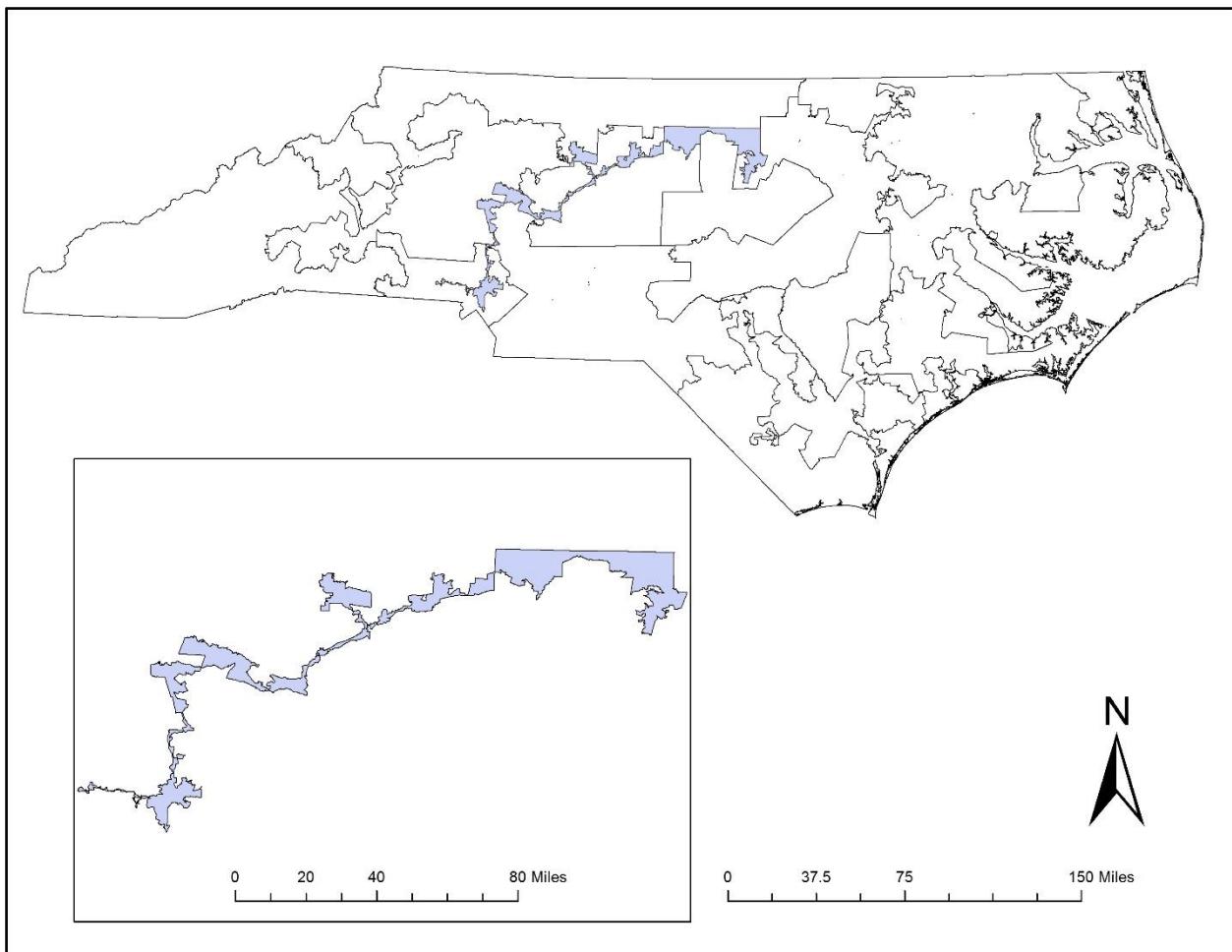


Figure 2 North Carolina 12<sup>th</sup> District after 1990 Census

Six other states use commissions for congressional districts as an advisory to the legislature or governor, but whose recommendations are not binding: Iowa, Ohio, Maine, New York, Rhode Island, and Virginia (Levitt 2014). Two states employ commissions in the event that the state legislature is unable to reach a decision: Connecticut and Indiana (Levitt 2014). The structures of commissions differ from one to the next, but fall into two general categories: independent commissions, which draw and implement districts without pre-approval from legislators or governors and dependent commissions, which must seek approval from elected officials (Levitt 2010).

Arizona's independent redistricting commission (IRC) is composed of five members who must be registered voters, no more than two of which can be from the same political party, or reside in the same county (Arizona Constitution, art. 4, part 2). Anyone who served in any elected or appointed office other than school board, or operated as a lobbyist, campaign officer, or party official in the preceding three years is disqualified from appointment to the commission (Arizona Constitution, art. 4, part 2). The commission on appellate court appointments established a pool of candidates, who are then chosen by the highest-ranking officers of each party in the state House and Senate (Arizona Constitution, art. 4, part 2). The initial four appointees then choose the fifth member to serve as chair (Arizona Constitution, art. 4, part 2). Voters passed Proposition 106 in November of 2000, amending the state's constitution to create this commission.

California's IRC consists of 14 members, including five from each of the two largest political parties in the state, and four from neither of those two parties (California Constitution, art. 21, sec. 2). The Applicant Review Panel, appointed by the State Auditor, selects 60 of the most qualified applicants, including 20 from each of the top two political parties, and another 20 from neither of those two parties (Voters FIRST Act, sec. 4). Party leaders in the state Senate and Assembly are allowed to remove up to 24 candidates from the pool of 60, the remainder of which are referred back to the State Auditor, who then randomly selects names until three from the most popular party, three from the second most popular party, and two from neither of those parties are chosen (Voters FIRST Act, sec. 4). These initial eight commissioners then select the remaining six (Voters FIRST Act, sec. 4). Commission members are ineligible for all elected office within 10 years, and all appointed office within five years after appointment to the commission (Voters FIRST Act, sec. 4). Voters approved Proposition 11 in November 2008,

which created the California Citizens Redistricting Commission to draw Board of Equalization and state legislative districts. The passage of Proposition 20 in 2010 extended the commission's duties to congressional districts, making it the newest IRC in the nation.

Hawaii's IRC, however, is the oldest, having been established in 1978 after a constitutional convention and voter approval. The initial eight commissioners appointed by the two major party leaders of the state house and senate then select the ninth member to serve as chair (Hawaii Constitution, art. 4, sec. 2). While this commission does not prohibit currently elected or appointed officials, commission members are ineligible to be candidates for the state legislature or U.S. Congress in the two elections following their service on the commission (Hawaii Constitution, art. 4, sec. 2).

Idaho's IRC was approved by voters in 1993. The two major party leaders in the state house and senate each select one member, while the remaining two are appointed by the state chairman of the two largest political parties (Idaho Constitution, art 3, sec. 2). Commission members cannot be an elected or appointed official in the state of Idaho, and are not allowed to serve in the state legislature for the following five years (Idaho Constitution, art 3, sec. 2).

New Jersey's IRC was created in 1995 when voters amended the state constitution. It consists of 13 members, eight appointed by the two major party leaders in the house and senate, and four appointed by the state chairmen of the party whose candidate for governor received the two largest number of votes (New Jersey Constitution, art. 2, sec. 2). The chairman, selected by a majority vote of the initial 12 appointees, must have not held any public or party office within the past five years, however, the initial 12 are prohibited only from being current members or employees of congress (New Jersey Constitution, art. 2, sec. 2).

Washington's IRC was approved by voters in 1983, and consists of five members who may not currently be any elected official or political party official, or have been within the previous two years (Washington Constitution, art. 2 sec. 43). The first four members, who are appointed by the leaders of the two largest parties in the house and senate, select the fifth member to serve as chair (Washington Constitution, art. 2 sec. 43).

The study that follows compares districts drawn by IRCs to those drawn by state legislatures. The overarching objective of the study is to provide evidence for whether IRC's reduce gerrymandering by comparing the shape of the districts. Chapter 2 will review the literature on redistricting outcomes and processes. Chapter 3 details the methods used to measure the compactness and coterminosity of districts and prepare the measurements for comparison, with the analysis to follow in Chapter 4. Chapter 5 discusses the conclusions drawn from the analysis, and suggests areas for future research.

## **Chapter 2 Related Work**

Gerrymandering, redistricting processes, and redistricting criteria have been the subjects of criticism and research for decades. The redistricting process refers to who draws and authorizes the district boundaries, and the criteria refer to the how the decision-makers are supposed to evaluate potential districts. As mentioned above, there are two primary approaches to the redistricting process. IRCS implement their plans without approval from the state legislatures, who remain the final arbiter in states without IRCS. Commonly used redistricting criteria, in addition to the constitutional mandate of population equality and adherence to the Voting Rights Act, include: compactness, contiguity, the use of existing political boundaries and geographic features, and respect for communities of interest (Arizona Constitution, art. 4, part 2; California Constitution, art. 21, sec. 2; Hawaii Constitution, art. 4, sec. 6; Idaho Code 72-1506; Washington Constitution, art. 2 sec. 43).

Research in the field of redistricting tends to fall into a few general categories: studies that analyze the electoral outcomes of gerrymandering and different redistricting methods; studies investigating redistricting automation; demographic studies, studies that evaluate methods and criteria, and studies aimed directly at commission effectiveness. Few studies fall into this final category; and of these few, the studies are conducted at the level of individual states (Kogan and McGhee 2012) and narrow time frames (Miller and Grofman 2013). This study takes advantage of this blind spot within the literature as it attempts to answer crucial questions about how all the currently existing IRCS may have influenced the drawing of congressional districts.

## **2.1 How Commissions Affect Elections**

The degree of electoral competition has been the primary focus of studies that look for ways to gauge the effects of new redistricting methods and criteria. Together, these studies comprise a comprehensive view of competition, including the winner's margin of victory, incumbent reelection rate, and the strength of challengers, in terms of financial backing.

Lindgren and Southwell (2013) examined the average margin of victory in U.S. House races for all states between 2002 and 2010. The district maps for these elections were drawn using various methods, including state legislatures, commissions (backup, advisory, partisan, and independent), courts, and the states with only one district (Lindgren and Southwell 2013). Their results indicate that elections in states that use backup commissions and independent commissions have the lowest average margin of victory, making them the best at drawing competitive districts among all methods employed during that period of time (Lindgren and Southwell 2013).

Carson and Crespin (2004) also investigated the competitiveness of U.S. House elections in 1992 and 2002, with respect to redistricting method. With “competitive” defined as two-candidate elections where the winner receives less than 60% of the vote, this study finds that districts drawn by commissions have a greater percentage of competitive seats than those drawn by courts or state legislatures (Carson and Crespin 2004). A follow-up study that broadened the time frame of the analysis confirmed the results of the original (Carson, Crespin and Williamson 2014).

Friedman and Holden (2009) analyzed the rate at which incumbents are reelected and have identified its upward trend over the past several decades. However, their analysis of other factors that may affect the incumbent reelection rate, such as economic growth, party control,

and whether the election was a midterm year or general election year, leads to the conclusion that gerrymandering is unlikely to be the cause of this increase (Friedman and Holden 2009). Many other factors must be controlled for when using rates of incumbent reelection as a metric to evaluate the competitiveness of districts.

Cottrill (2012, 34) also studied the effects of “non-legislative approaches” to congressional redistricting, which he defined as those methods whereby the legislature’s influence on the redistricting process is the smallest. For example, Cottrill’s (2012) study included the IRCS of Arizona, Washington, and Idaho. At the time of Cottrill’s (2012) study, California had not yet held any elections using its IRC-drawn maps. Using campaign and election data between 1982 and 2008, the effects he identified include an increase in the frequency of challenges to incumbent Congressmen, and a tendency toward challenges from more experienced and well-financed candidates after the states adopted their IRC than those prior (Cottrill 2012).

## **2.2 Redistricting Automation**

With so many ways for politics to unfairly influence the drawing of district maps, the desire to develop new methods that minimize, or altogether eliminate, human decision-making is understandable. In a 2013 study, Rincón-García et al. developed a multi-objective algorithm for use with GIS systems in drawing electoral districts in Mexico. The algorithm was designed to perform better than the single-objective model that had already been used to create districts in 2006 (Rincón-García et al. 2013). Using population equality, with an acceptable variance, and compactness, as a ratio of the perimeter of the district to the perimeter of a square with the same area as the district, the authors’ multi-objective algorithm was able to aggregate geographic sub-

units into electoral districts that considered more than just population equality (Rincón-García et al. 2013).

Similar ground was covered a year earlier by Joshi, Soh, and Samal (2012) who also developed a redistricting algorithm based on clustering together small polygons until they fit the criteria for a congressional district. However, their study used radial compactness to assess the compactness of the polygon clusters by taking the sum of the distance between each polygon's centroid and the cluster's centroid (Joshi, Soh and Samal 2012). Also, the authors devoted a significant portion of analysis on the problem of how to select the best seeds or initial starting points for the algorithm to begin clustering polygons (Joshi, Soh and Samal 2012).

Recognizing the indispensability of human judgement, Guo and Jin (2011) developed a method of redistricting that combines the speed and variety of automatically drawn district maps with human visual analysis. First, the tool generates a predetermined number of random maps that take into account contiguity and any user-defined polygons to be handled as indivisible units (Guo and Jin 2011). Then, the plans are optimized by user-defined weighting of other criteria, such as compactness and population equality (Guo and Jin 2011).

### **2.3 Demographics and Redistricting**

Demographics, i.e. who the lines are drawn around, directly affect how the lines are drawn. Since no racial, ethnic, or socioeconomic cross section of the U.S. population is evenly distributed, there exists a spatial component to every imaginable subgroup.

Exploring the concept of one person, one vote, Rosenberg (2009) argues that no universal standard exists for which group of people to count for the purpose of making electoral districts equal in population. Since the Supreme Court has defined the concept by the two somewhat contradictory principles of equal representation and equal weight of votes, Rosenberg further

argues that the courts should defer to the states on this question (Rosenberg 2009). How this question is decided has direct implications on the drawing of electoral districts.

Another take on the demographic aspects of redistricting comes from Stephanopoulos (2012) in which he contends that a moderate level of spatial diversity in a region is better for representation than either extreme homogeneity or heterogeneity. The former leads to the tendency to draw districts with a high concentration of voters favoring one party or another (packing), while the latter leads to districts that often disregard geographic features and pre-existing political boundaries for partisan advantage (Stephanopoulos 2012). What Stephanopoulos is measuring here are the demographic factors of a given district such as race, age, and income, among others, and how these factors are spatially distributed within the district.

Belin, Fischer, and Zigler (2011) developed a method of balancing population density across districts in order to evaluate redistricting plans. Their density-variation/compactness score combines a method of determining how population density varies with Reock compactness scores, and is positively correlated with estimates of partisan bias (Belin, Fischer and Zigler 2011).

## **2.4 Measuring Compactness and Gerrymandering**

Studies designed to analyze the physical characteristics of electoral districts tend to focus on the various methods of measuring compactness, or attempt to identify gerrymandering. Oddly enough, the study that forms the basis for one of the most popularly used compactness measures comes not from the field of geometry or geography, but geology. E.P. Cox's (1927) attempt to quantify the roundness of grains of sand using the ratio of the area of a cross-section of one grain to the area of a circle whose circumference equals the perimeter of that cross-section. Eventually,

this ratio was appropriated, or perhaps reinvented, for the purpose of measuring other polygons, such as legislative districts.

Possibly the simplest way to identify a non-compact shape is to compare it to another shape that is known to be compact. Reock (1961) does this very thing in suggesting his method of measuring the compactness of congressional districts. Using this method, he calculates the compactness of districts in 10 selected states, then attempts to identify a threshold for which a district should be given additional scrutiny for possible gerrymandering (Reock 1961).

Three studies in this category take on the task of evaluating multiple methods of measuring compactness. MacEachren (1985), Young (1988), and Niemi et al. (1990) each survey the pros and cons of the various methods, while MacEachren and Niemi et al. go the extra step of applying these methods to actual districts and political jurisdictions for comparison.

Fryer and Holden (2011, 495) developed yet another method of measuring compactness they term the "relative proximity index." This method calculates the distance between voters within a district, and compares it to the minimum distance possible (Fryer and Holden 2011). Touting the advantages of their index over previously existing methods, the researchers make the case that a single method can be used as the standard across states and time.

Another unique take on measuring compactness comes from Montero and Bribiesca (2009) who take the argument out of the world of smooth, continuous lines and into the digital world of pixels and connected points. The most common methods of measuring compactness are rooted in comparing districts to geometric shapes such as circles and squares. Their analysis covers the methods of measuring compactness where a circle, the most compact geometric shape, is not possible. These digital methods of measuring compactness were determined to have

fewer drawbacks than the methods that rely on a circle as the shape to which districts are compared (Montero and Bibiesca 2009).

In addition to analyzing the concept of gerrymandering in the context of the natural give and take of partisan politics, Polsby and Popper (1991) argue that compactness consistently restrains partisan gerrymandering. Additionally, the method of measuring compactness which bears their name is introduced. Their justification for the selection of this particular method is that unlike the various other methods, theirs measures the specific quality of a shape that gives it "antigerrymandering power" (Polsby and Popper 1991, 343).

Then, there are studies that claim to have found a means of identifying and/or combatting gerrymandering, including Polsby and Popper's study, as mentioned above. Building on Polsby and Popper's assertion that increasing compactness acts as a deterrent to partisan gerrymandering, Apollonio et al. (2006) devised an experiment to demonstrate the effect. By applying their model to the electoral districts of three regions of Italy, the team concludes that population equality, compactness, and coterminosity all suffer when the perfect gerrymander is created (Apollonio et al. 2006). Additionally, while maximizing compactness alone is an effective way to prevent gerrymandering, the study recommends that all traditional districting criteria be followed for best results (Apollonio et al. 2006).

Levin (1988) suggests an interesting method of measuring the extent to which a districting plan is gerrymandered. A perfect gerrymander is any arrangement of district lines that are drawn to give a political party the maximum number of seats possible, given that state's particular population distribution. By comparing the number of seats won to the minimum and maximum number of seats possible, the "gerrymander index", a number between 0 and 1, is

established, where 1 equals a perfect gerrymander (Levin 1988, 67). Levin's gerrymander index may be a useful tool given that gerrymandering is still difficult to quantify.

In order to assess the appearance of congressional districts in light of the Shaw vs Reno decision, which allows for the defense of bizarrely-shaped districts if they pass "strict scrutiny" (Shaw v. Reno 1993), Pildes & Niemi (1993) applied both a dispersion method and a perimeter method of measuring compactness to districts nationwide. Starting with the offending 12th District of North Carolina, the researchers compared its compactness to the other districts in the state and found it to be the least compact by both measures, indicating that its peculiar shape was indeed out of the ordinary for the state (Pildes and Niemi 1993). Additionally, the study compared all post-1990 districts with post-1980 districts nationwide, finding that more states saw a reduction in mean compactness than an increase, by both measures (Polsby and Popper 1991).

Bozeman, Pyrik, and Theoret (2008) challenge the visual appearance of legislative districts using a measurement of convexity (the authors take issue with the use of term "compact" as its common usage conflicts with its mathematical definition, preferring instead mathematical "convexity"). Their findings indicate that "nicely shaped" districts are ones that are nearly convex, while "poorly shaped" ones are not (Bozeman, Pyrik and Theoret 2008, 345).

## 2.5 Evaluating Commissions

The final category belongs to studies whose primary objective is to evaluate a specific commission or commissions in general. In an analysis of a specific state's redistricting commission, Kogan and McGhee (2012) compare California's state senate, assembly, and congressional districts drawn by the newly-formed Citizens Redistricting Commission in 2011 to those drawn by the state legislature in 2001. Using the commission's own criteria, primarily minority representation, as a proxy for Voting Rights Act compliance, the number of times city

and county boundaries are split, for maintaining the integrity of existing political boundaries, compactness, and the nesting of assembly districts into senate districts, the authors conclude that although the commission did not fully achieve any of its goals, the 2011 districts are a clear improvement over those from 2001 (Kogan and McGhee 2012). By assessing the commission's own criteria, this study blends the demographic factors, such as the amount of minority representation, with the spatial factors, such as compactness.

Lastly, the work of Miller and Grofman (2013) must be noted for its comparison of multiple IRC states to non-IRC states on the basis of compactness, competitiveness, and the integrity of political subdivisions. This study examines congressional districts drawn in 1992, 2002, and 2012. For compactness, only the Polsby-Popper method is used, for which the authors find no relationship to the redistricting body (Miller and Grofman 2013). In order to determine how well district boundaries conform to existing political subdivisions, the authors count the number of cities and counties that belong to more than one district, presented as a percentage (Miller and Grofman 2013). Together with the bi-annual proportion of competitive House districts, the authors find little to suggest that commissions produce better results than state legislatures (Miller and Grofman 2013).

Among the vast amount of research in the field of gerrymandering and redistricting in general, the primary claims made about commissions are those which state a particular political effect of the newly drawn districts, and those which assert a change in district compactness, mostly from the perspective of one state's commission, comparing a single set of pre-commission districts to a single set of post-commission districts. Few studies have compared the results of multiple commissions simultaneously, and rarely do they extend their reach beyond the immediate pre/post commission dataset.

Fewer still are studies that assess coterminosity, or how well district lines conform to existing political subdivisions. Bowen (2014) does this outside the context of commissions, as do Miller and Grofman (2013), and Kogan and McGhee (2012) in their analysis of California's commission.

This study will fill the gap in the literature by questioning whether or not commissions live up to their own standards. In order to determine if IRCs are working to reduce gerrymandering, the study analyzed each state with a commission using multiple decades of pre and post commission data to find any significant difference in compactness between districts drawn by state legislature or commission. Additionally, by comparing states with IRCs to a selection of states without IRCs, this study attempts to identify any effect commissions have on district coterminosity.

## **Chapter 3 Methods**

The purpose of this study is to evaluate the effectiveness of independent redistricting commissions (IRCs). Two particular goals of IRCs are, whenever possible, to create districts that are both compact in shape and respectful to the integrity of preexisting political subdivisions. These goals are directly referenced by the laws establishing the commissions in question. Using compactness measurements over time, this study analyzes the pre-commission and post-commission measurements in order to determine what effect, if any, commissions have had on the compactness of districts. Additionally, this study will assess how well congressional district boundary lines in states with commissions conform to existing local political subdivisions like cities and counties, or their degree of “coterminosity,” compared to the districts in similar non-commission states.

This chapter will briefly review why the selected criteria are important to the redistricting process, and propose hypotheses for how to assess commission effectiveness. It will then explain the processes taken to obtain and prepare the datasets necessary for analysis through flowcharts and detailed descriptions. Lastly, this chapter will introduce the methods by which the data will be analyzed in order to test the hypotheses regarding the effects of commissions on district shapes and boundaries.

### **3.1 Compactness**

As referred to above, compactness denotes the shape of a district – the smoothness of its borders and how close its center is to all the points that are within the district. For congressional districts, compactness is an important factor to consider for two reasons. First, the idea of local representation is predicated on close geographic proximity. Constituents who live close by each other tend to have more in common than those who live farther apart. Transportation and

education concerns, quality of life issues such as pollution and parks and recreation, and local economic development are a few examples of commonalities that residents of a specific region share. Therefore, districts should be drawn in such a way that minimizes their internal distance, i.e. to make them spread as little as possible. Second, non-compact districts are a sign that gerrymandering may be taking place. When boundary lines are manipulated to include a certain group while excluding another, the result is often identifiable visibly as the boundary makes seemingly unnecessary protrusions, twists, and turns.

In order to determine if IRCs draw more compact districts than state legislatures, I developed null ( $H_0$ ) and alternative ( $H_1$ ) hypotheses:

$H_0$ : District compactness is not affected by IRCs.

$H_1$ : District compactness is increased by IRCs.

### 3.2 Compactness Measures

This study uses two different methods of measuring compactness to assess the districts: the Polsby-Popper (P) and the Reock (R). The Polsby-Popper method uses the area and perimeter of the district to create a value between 0 and 1, in which values approaching 1 are more compact and values approaching zero are less compact:

$$P = \frac{\text{area of district}}{\text{area of circle with circumference equal to district perimeter}} \quad (1)$$

Or, this can be expressed according to Niemi et al. (1990) as:

$$P = 4\pi \times \frac{\text{area of district}}{\text{perimeter of district}^2} \quad (2)$$

This method of measuring compactness highlights the variations in perimeter that cause the compactness score to drop as the district boundary line becomes less smooth. This focus on perimeter variations makes the Polsby-Popper method sensitive to geography, i.e. coastlines.

However, what makes this method useful for examining districts is that the method is also sensitive to the kind of potential gerrymandering identified by deliberate inclusion and exclusion of certain neighborhoods that may result in ragged boundaries in a given area.

The Reock method of calculating compactness begins with drawing the smallest possible circle around the entirety of the district. It then compares the area of the district with the area of the circle. This is expressed by Reock (1961) as:

$$R = \frac{\text{area of district}}{\text{area of smallest circle confining the district}} \quad (3)$$

This method of measuring compactness focuses on how dispersed the area within each district is from its center. Figure 3 shows two examples of California districts within the smallest possible circle. In inset box 3A, the district almost completely fills the circle. By contrast, in inset box 3B, most of the circle is unoccupied by district territory. The Reock method is less sensitive to the contours of district boundary lines, but proximity to the district's geographic center takes precedence, making this method useful for identifying districts that are unnecessarily far-flung. Using both the Polsby-Popper and Reock methods of measuring compactness provides a well-rounded assessment of district shape that no single method could do alone (Niemi et al. 1990).

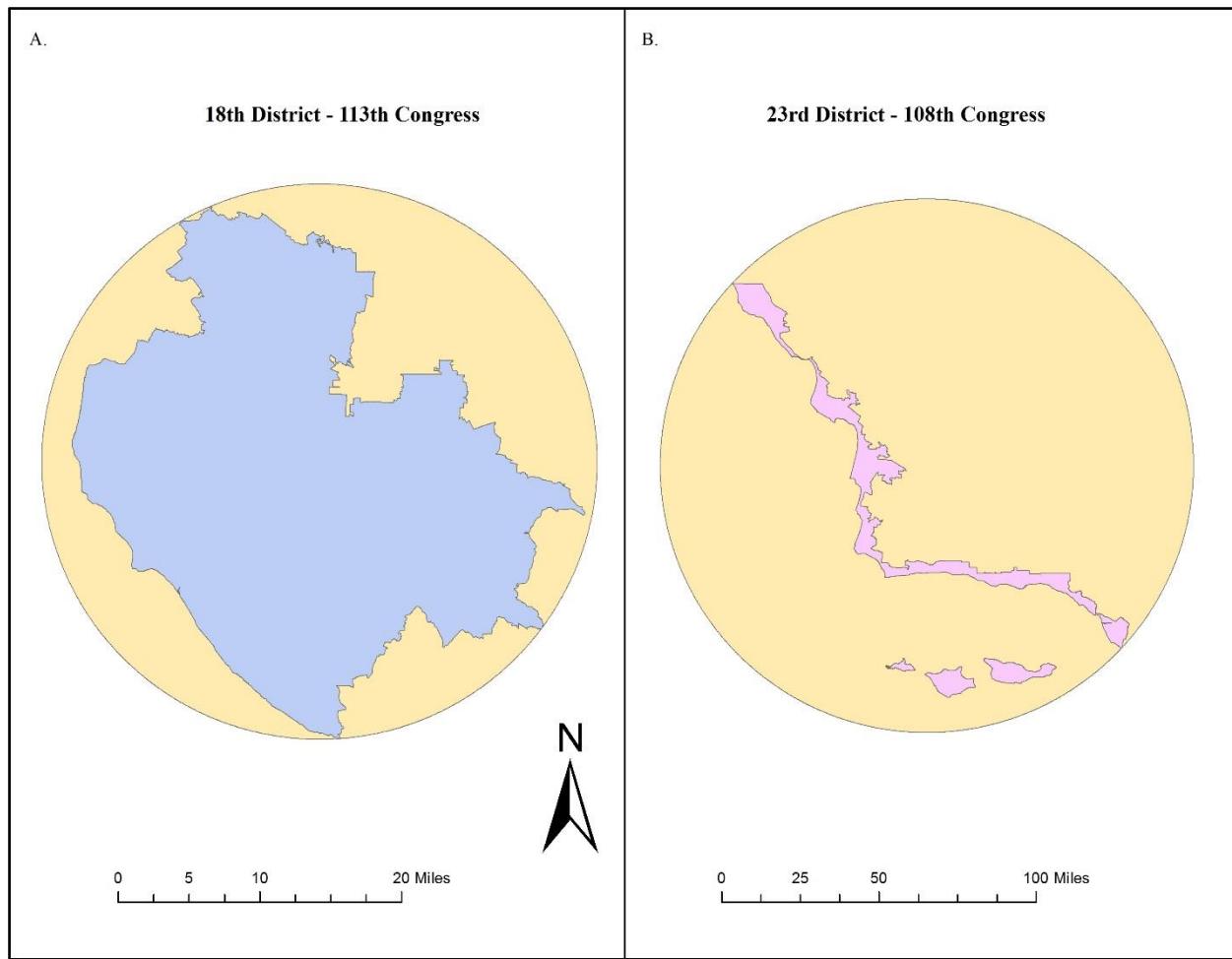


Figure 3 Illustration of the Reock Method of Measuring Compactness

### 3.3 Coterminosity

Common among the rules redistricting commissions have established for drawing district boundaries is a desire to maintain existing political subdivisions. The main idea is to avoid splitting cities, towns, villages, and counties wherever possible. For the purposes of this study, only the legally defined boundaries of counties, as well as incorporated cities, incorporated towns, and incorporated villages, hereafter referred to as “cities,” were used to represent these local political jurisdictions. District lines that coincide with other pre-existing political boundaries are said to be “coterminous” with them. This is an important factor for commissions

to keep in mind because these jurisdictions are often whole communities in and of themselves.

With the exception of large entities whose population would require multiple districts, these communities should be kept intact. Maintaining the integrity of a geographically close group of people with similar concerns and interests is the very purpose of organizing representation geographically rather than by proportional methods.

In order to determine if commissions draw district lines that are more conterminous with city and county lines than do state legislatures, I offer two hypotheses:

$H_0$ : States with redistricting commissions have the same degree of coterminosity as states without commissions.

$H_1$ : States with redistricting commissions have districts with greater coterminosity than states without commissions.

Measuring coterminosity requires calculating how much of each district boundary coincides with city and county boundaries. The mapping of district boundaries is already described above. City and county shapefiles were obtained from the U.S. Census Bureau for the year 2010. However, the city files were a combination of what the census calls “places,” including entities like cities, towns, villages, and “census designated places” (CDPs). These CDPs are populated locations with names officially recognized by the Census Bureau, but whose boundaries lack legal standing (U.S. Census Bureau 2012). All non-incorporated places were removed from the dataset, including CDPs. For this reason, Hawaii has been excluded from the coterminosity analysis. None of its populated areas are incorporated. All are classified as CDPs.

### 3.4 Geoprocessing

All visualization and geoprocessing operations for this study were performed using ArcMap 10.3, and all shapefiles were projected using the USA Contiguous Albers Equal Area Conic, with the exception of Hawaii, which used the NAD 1983 UTM Zone 4N. Figure 4 outlines the geoprocessing operations taken to prepare the data for calculating compactness.

After obtaining congressional district shapefiles for all years from Digital Boundary Definitions of United States Congressional Districts, 1789-2012 (Lewis et al. 2013), and examining them for each state in the study, I noticed that there were differences in the smoothness of state boundaries from one Congress to the next. For example, for California the shapefiles for the 88th, 93rd, and 98th Congress were digitized with a higher level of detail than the 103rd, 108th, and 113th. Figure 5 shows the San Francisco Bay area as depicted by the 88th and 113th Congresses. In the 113th Congress, the far south and northeast portions of the bay show land in places that should be water. Some islands are consolidated into the mainland, and various other inlets are filled in. In order to standardize the boundaries across all years, the 88th Congress was selected as the template to which all years would conform. Using the 88th Congress shapefiles, district boundaries for each state were dissolved, creating polygons for each. These state polygons were then used to clip the district shapefiles for all remaining congresses.

District and state shapefiles were then imported into a geodatabase, which then added and calculated the “Shape\_Length” (perimeter of district) and “Shape\_Area” (area of district) fields. To find the Polsby-Popper compactness for each district, the field “PP\_Compact” was added to each feature class. The values for this field were calculated using

$$\text{PP_Compact} = (4 * 3.14159265359 * [\text{Shape\_Area}]) / ([\text{Shape\_Length}]^2) \quad (4)$$

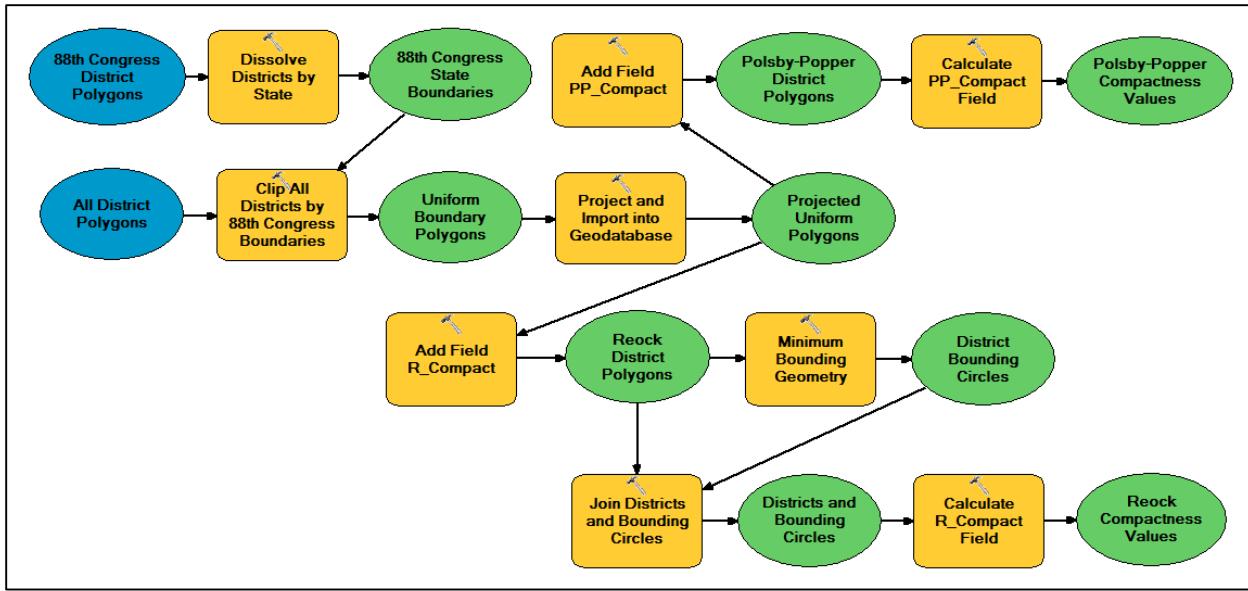


Figure 4 Compactness Calculation Flowchart

For the Reock calculations, an additional feature class was first created using the “minimum bounding geometry” tool in the data management toolbox. This tool creates polygon features in the shape of circles that represent the smallest possible circle capable of containing each district. These bounding circle polygons were also populated with the “Shape\_Length” and “Shape\_Area” fields, and each was joined with its corresponding district polygon. The field “R\_Compact” is added to each and calculated using:

$$R_{\text{Compact}} = [Shape\_Area]/[Shape\_Area\_1] \quad (5)$$

Shape\_Area represents the district, and Shape\_Area\_1 represents the bounding circle. Tables containing both compactness measurements and district numbers for each congress and state were then exported for analysis.

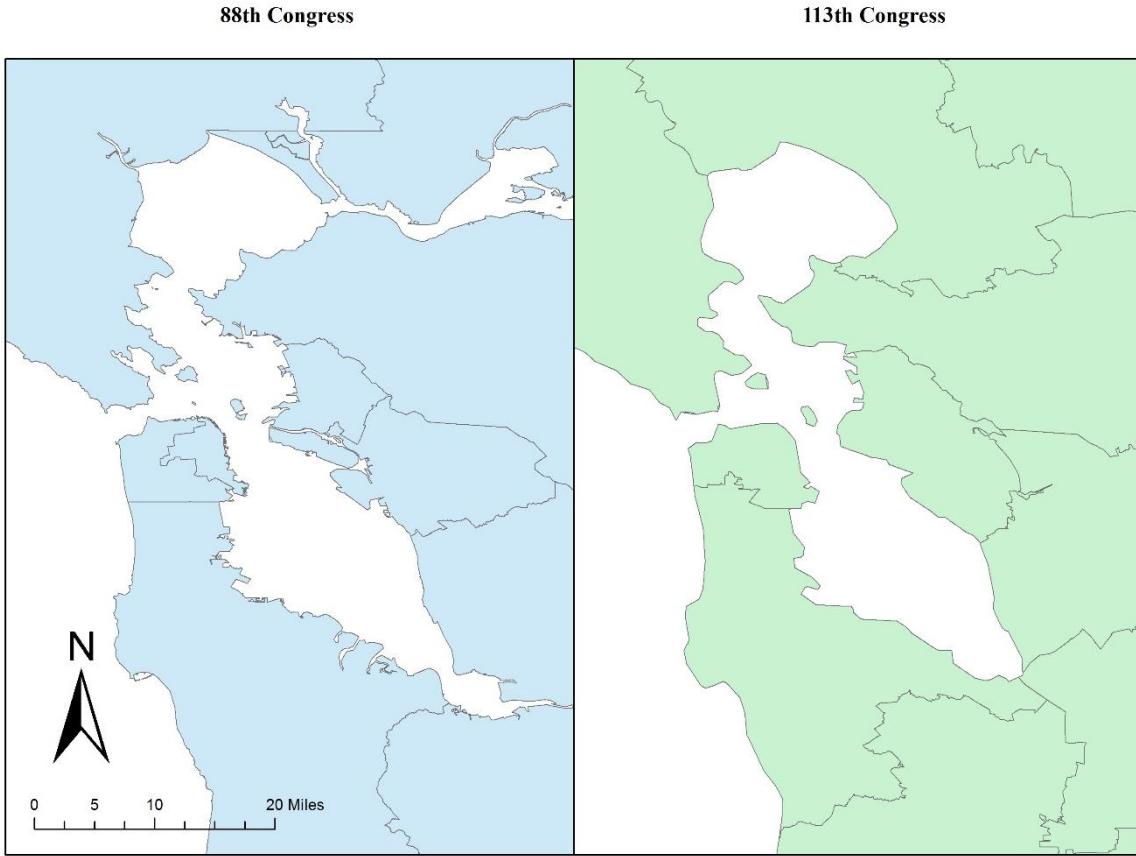


Figure 5 Boundary Discrepancies

According to Bowen (2014), the method used to measure coterminosity involves first converting all polygon features to line features. Figure 6 demonstrates this method, showing the steps taken to calculate coterminosity. A union of city and county polygons was created for each state using a 30-meter XY tolerance in order to compensate for minor discrepancies between city and county polygons. For example, if a district boundary line coincides with a county or city line, those lines should appear as one line on a map. However, the use of different mapping methods creates gaps between lines that should overlap. These gaps can be seen in Figure 7, which shows the boundary line between Arizona's Gila and Maricopa counties, missing a correct coincidence with the boundary line between Arizona's 1st and 4th districts. The XY tolerance

compensates for these gaps by creating a distance at which separate lines are assumed to be the same line. To arrive at this XY tolerance, multiple unions were performed in conjunction with tabulate intersection beginning at zero and increasing in five-meter increments. With each increment, the amount of overlap between coincident lines increased, indicating that the optimum tolerance had not yet been reached. The point at which increasing the tolerance did not result in significant increases in overlap was 30 meters.

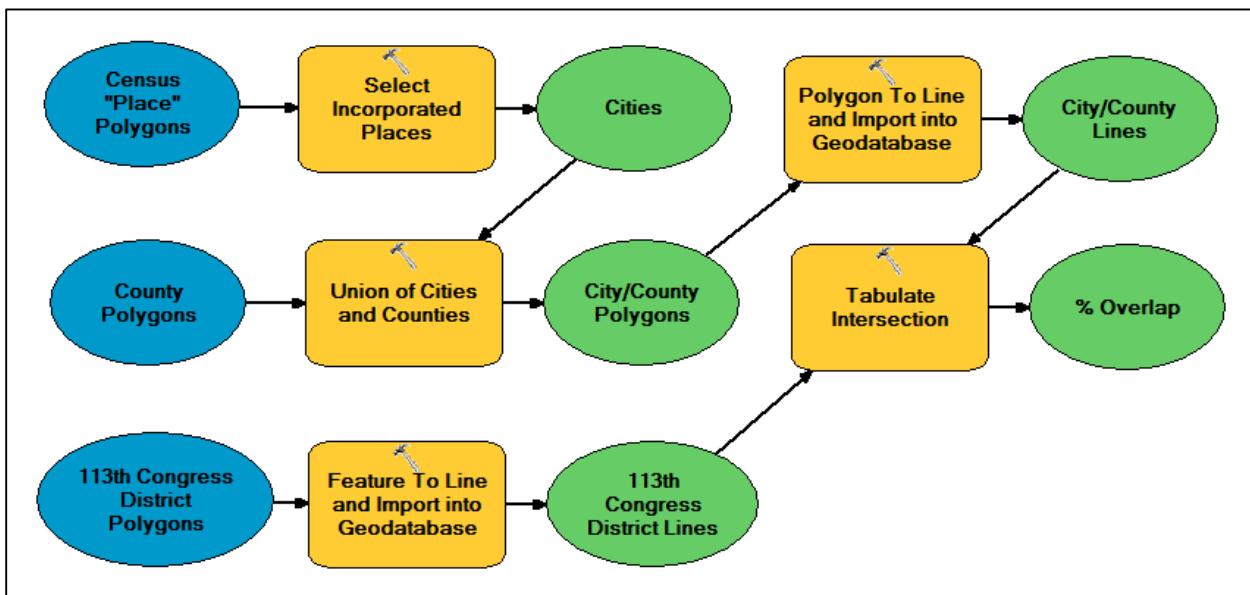


Figure 6 Coterminosity Calculation Flowchart

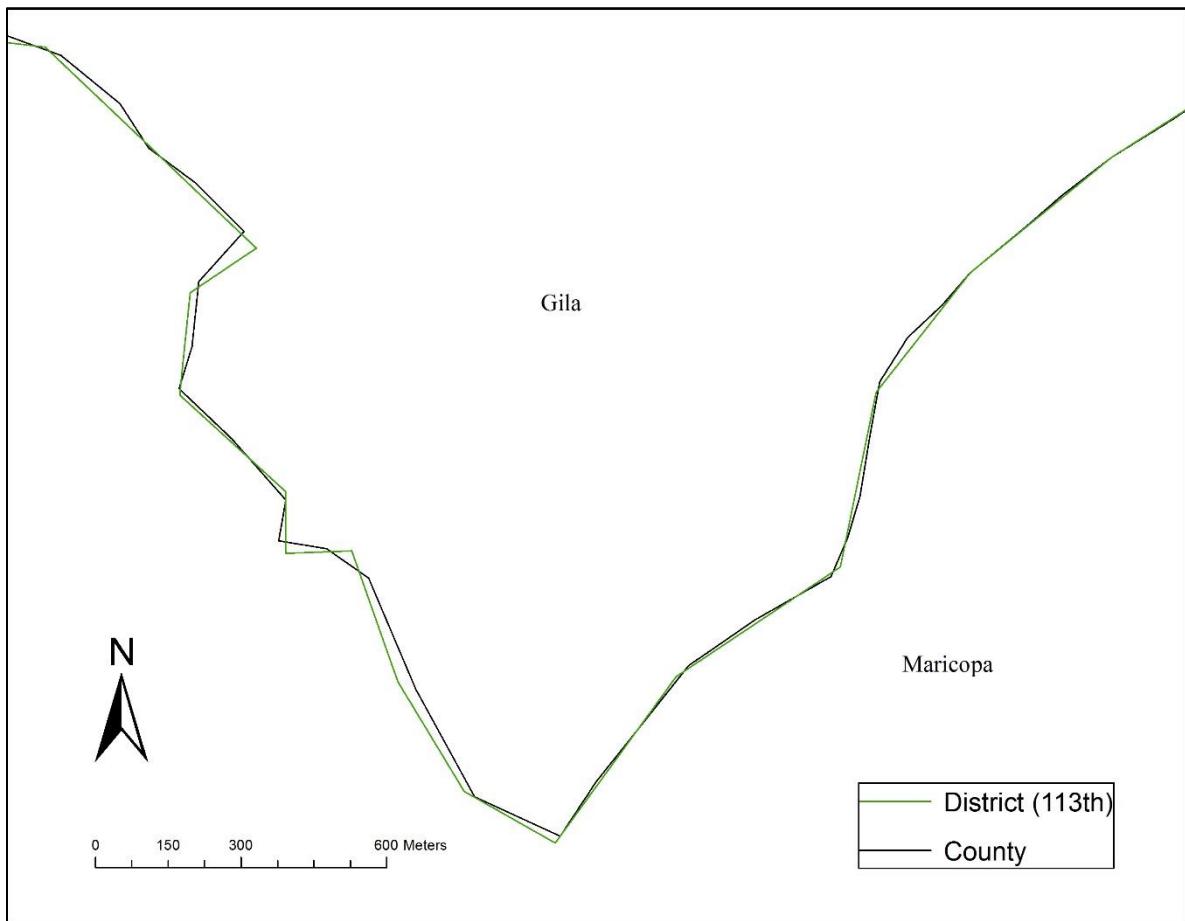


Figure 7 Illustration of the Problem of Joining Congressional District and County Lines

The union was then converted into lines using the “polygon to line” tool in the Data Management toolbox. This tool ensures that line segments are not duplicated when features that border each other, such as counties, are converted. District boundary lines, on the other hand, must maintain these duplicates because each district is its own entity and needed to be evaluated for coterminosity individually. The “feature to line” tool, also in the Data Management toolbox, accomplishes this task. Each individual feature is converted into its constituent lines. The resulting feature classes contain all city and county boundaries for each state expressed as lines. Each was then imported into a geodatabase, where the Shape\_Length field was added and calculated. Lastly, the “tabulate intersection” tool, in the Analysis toolbox, calculates how much

of one feature class intersects another feature class. Given a specific input field, the district number in this instance, tabulate intersection overlays the city/county lines with district lines, then tallies the overlap. Output for this tool is given as a percentage for each input feature, and the resulting tables were exported for analysis. Comparisons were made between district lines and city/county lines for the 113th Congress, which was the first congressional election following the results of the 2010 census.

### **3.5 Study Design and Study Period**

Analyzing district compactness and coterminosity scores over time for states with redistricting commissions required selecting a date range that included some districts drawn both before and after the states adopted their commissions. For this study, a 50-year time frame was selected in order to ensure that each state being evaluated has at least one set of districts drawn by the state legislature and one drawn by commission (Table 1). Only states with redistricting commissions were included in this time series analysis. Each set of district boundaries, drawn following the decennial census, is notated by the ordinal number of the U.S. Congress it represents: 88th Congress (1963-1964); 93rd Congress (1973-1974); 98th Congress (1983-1984); 103rd Congress (1993-1994); 108th Congress (2003-2004); and 113th Congress (2013-2014).

For additional analysis, a control group of states was also selected. Compactness data for this date range was also collected for similarly populated states without redistricting commissions (i.e., “control states”): Colorado, Indiana, Missouri, Nevada, and Texas. These states approximated the states with commissions primarily in terms of the number of districts needed, and to a lesser extent, geographic size.

Table 1 Authority to Draw Districts, by Study Area and Congress.

		88th	93rd	98th	103rd	108th	113th
Study States	Arizona	legislature	legislature	legislature	legislature	IRC	IRC
	California	legislature	legislature	legislature	legislature	legislature	IRC
	Hawaii	legislature	legislature	IRC	IRC	IRC	IRC
	Idaho	legislature	legislature	legislature	legislature	IRC	IRC
	New Jersey	legislature	legislature	legislature	legislature	IRC	IRC
	Washington	legislature	legislature	legislature	IRC	IRC	IRC
Control States	Colorado	legislature	legislature	legislature	legislature	legislature	legislature
	Indiana	legislature	legislature	legislature	legislature	legislature	legislature
	Missouri	legislature	legislature	legislature	legislature	legislature	legislature
	Nevada	legislature	legislature	legislature	legislature	legislature	legislature
	Texas	legislature	legislature	legislature	legislature	legislature	legislature

### 3.6 Hypothesis Testing

T-tests were performed for each study state comparing the pre and post IRC compactness scores. Since each state has a small total number of districts available for comparison, an additional t-test was performed using all combined pre-IRC compactness values compared to all combined post-IRC values. Outlier districts were also identified for comparison across states using the outlier labeling rule. This is done by multiplying the difference between the first and third quartiles (the interquartile range) by a factor of 2.2, then adding that value to the third quartile for an upper limit, and subtracting that value from the first quartile for a lower limit (Renze n.d.). Values greater than the upper limit and less than the lower limit are determined to be outliers. The commonly-used factor of 1.5 is suggested to be less accurate than 2.2, according to Hoaglin and Iglewicz (1987).

T-tests were also performed for the states with IRC's in comparison with the control group for compactness. To check for the need for normalization of state scores for compactness

in drawing comparisons, a Pearson's R was drawn for each state's districts versus the compactness of that state's shape overall. A positive correlation of .82 for Polsby-Popper and .85 for Reock between a state's compactness and its average district compactness was found. Therefore, in order to make state-to-state comparisons, compactness values were normalized by a simple ratio:

$$N = \frac{\text{district compactness}}{\text{state compactness}} \quad (6)$$

I also performed t-tests comparing coterminosity among states with IRCs against states without IRCs. I performed Pearson's R to find any correlation between average district compactness and average district coterminosity for the 113th Congress. The results will shed light on any difference between how IRCs and state legislatures treat existing political boundaries.

## **Chapter 4 Analysis**

Since the two compactness methods measure different things, it should not be surprising that the results of the analysis are mixed. On one normalized Reock measure of compactness, IRCs seem to result in more compact districts on average. But generally speaking, the results show that states with IRCs do not have more compact districts than their pre-commission forms. Also, when comparing states without commissions to states with commissions for the 113th Congress, the null hypothesis for compactness is confirmed for one normalized Reock measure, but rejected for one normalized Polsby-Popper measure. In contrast, with respect to coterminosity, the results are much more straightforward and lead to confirming the null hypothesis. States with IRCs do not have districts with greater coterminosity than states without IRCs for the 113th Congress.

### **4.1 Compactness**

For each individual state, the null hypothesis for both Polsby-Popper and Reock compactness measures cannot be rejected. No statistical significance was found to exist between pre-commission mean compactness and post-commission mean compactness. Table 2 shows each state's mean compactness scores and the p-values associated with their difference of means test.

The largest increase in mean Polsby-Popper compactness is 0.02 for Hawaii, indicating greater compactness for its IRC-drawn districts. The largest decrease in mean Polsby-Popper compactness is -0.03 for New Jersey, indicating less compactness for its IRC-drawn districts. New Jersey is also the state whose p-value comes the closest to significance with a value of .13.

Table 2 State Mean District Compactness with P-values

	Polsby-Popper Mean			Reock Mean		
	Pre-IRC	Post-IRC	p-value	Pre-IRC	Post-IRC	p-value
Arizona	0.31	0.32	.78	0.42	0.46	.28
California	0.21	0.21	.87	0.34	0.37	.18
Hawaii	0.07	0.09	.21	0.02	0.12	.10
Idaho	0.29	0.27	.77	0.39	0.39	.99
New Jersey	0.16	0.13	.13	0.35	0.35	.97
Washington	0.16	0.16	.95	0.40	0.37	.34

The only state to see a decrease in its post-IRC Reock mean is Washington, with a change of -0.03. Arizona and California both increase their post-IRC Reock mean, but as previously mentioned, the change is statistically insignificant.

The largest increase in mean Reock compactness goes to Hawaii with change of 0.10. A look at Hawaii's geography can explain this large upswing. For the 88th Congress, Hawaii had only one district, but the addition of a 2nd district with the 93rd Congress required the state's population to be divided among its islands. For the 93rd and 98th Congresses, Hawaii's 1st district included Honolulu, which is a portion of the island of Oahu among the large Windward Islands, plus the far-flung Leeward Islands to the west. The 2nd district was composed of the remainder of Oahu and the other Windward Islands. This setup meant that both districts would receive very low Reock scores due to the large bounding circles required to encompass them. Beginning with the 103rd Congress, the 1st district was redrawn to include only Honolulu and nearby suburbs on Oahu, earning a more reasonable Reock score, while the 2nd district included the rest of Oahu plus everything else, earning an extremely low Reock score. Hawaii's IRC drew its first districts with the 98th Congress. Therefore, the pre-IRC mean includes two decades of

very low Reock scores, while the post-IRC mean includes one decade of very low Reock scores and three decades of moderate Reock scores.

The story told by the mean compactness scores for each decade underscores the flat trend introduced by the pre-commission/post-commission comparison. Figure 8 presents a more detailed view of each state's mean district compactness. With the exception of California's volatility and Hawaii's large jump in its Reock score, there is no discernible movement in any direction over time.

## **4.2 Comparison of Normalized Compactness Scores**

For comparison across state lines using aggregated means, normalized values for all pre-IRC districts ( $n = 339$ ) and post-IRC districts ( $n = 135$ ) have been calculated using each state's overall compactness as a common denominator. This is important because according to the law of large numbers, the difference of means is a very challenging measure for a low number of observations as reflected in the intrastate comparisons across time (Renze and Weisstein n.d.).

A normalized value of 1 means the district is equally as compact as the state, less than one means the district is less compact than the state, and greater than one means the district is more compact than the state. Just as with the non-normalized measure, higher values indicate more compact districts.

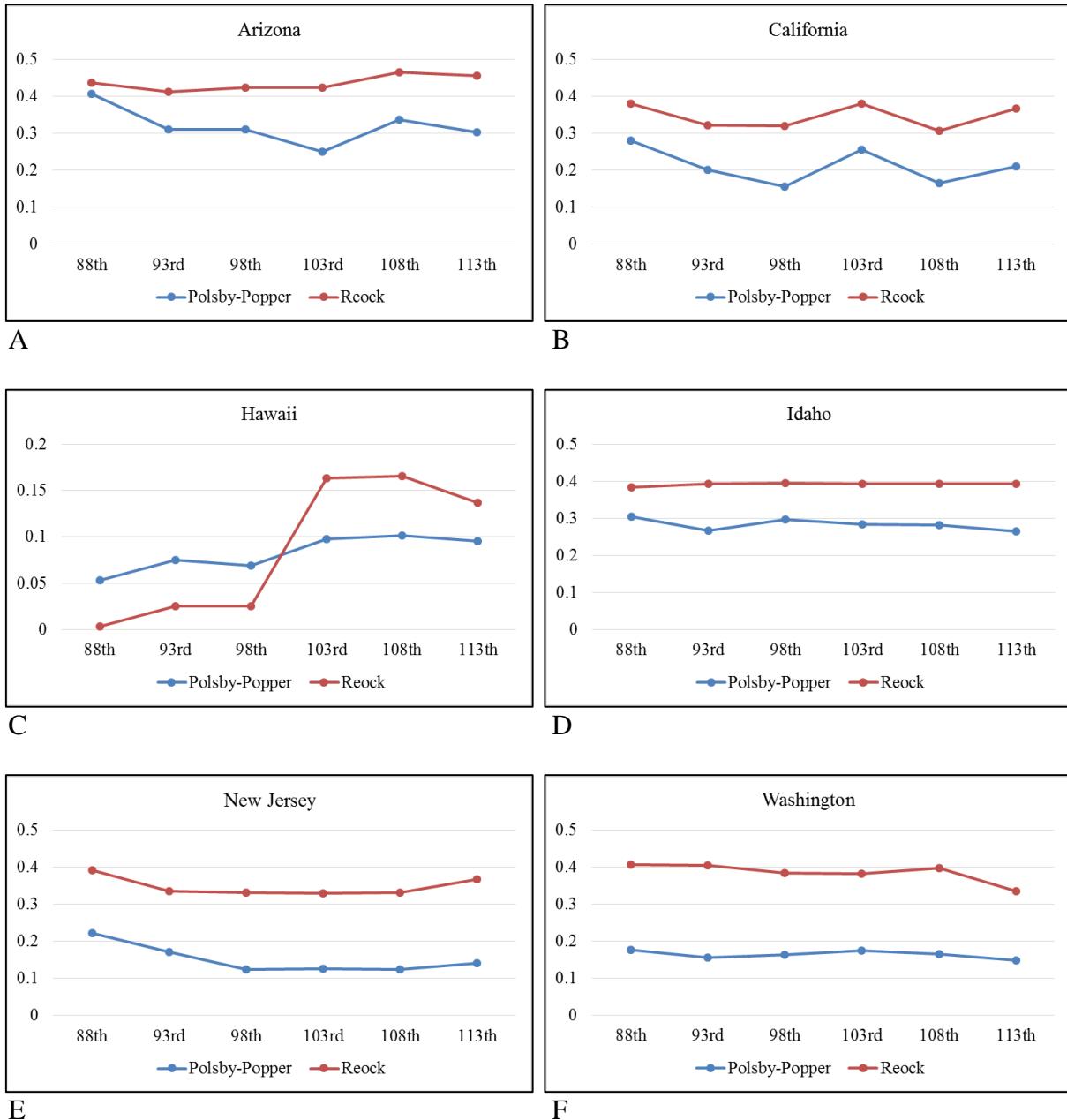


Figure 8 Mean Compactness by State and Congress

For Polsby-Popper, mean normalized compactness for all pre-IRC districts is 1.97, and for all post-IRC districts is 2.01. While this does indicate a marginal increase, with a p-value of .83, the difference is not statistically significant. However, for Reock, the pre-IRC mean for all normalized districts is 1.13, and the post-IRC mean is 3.30. With nearly a three-fold increase and

a p-value of .09, the difference should be considered significant, and the null hypothesis should be rejected in favor of commissions in aggregate.

### **4.3 Cross-State Comparisons of Compactness**

Comparing all states with IRCs against the selected states without IRCs for the 113th Congress, the compactness values lead to rejecting the null hypothesis, but not in the expected direction. Mean normalized Polsby-Popper compactness for all states with commissions is 1.8, and 2.33 for states without them. With a p-value of .09, the null hypothesis should also be rejected in favor of states without commissions. Mean normalized Reock compactness for all states with commissions is 2.08, and 0.80 for states without. With a p-value of .27, the difference is not significant.

Also worth noting is the skewness of the distribution. Skewness refers to the degree of asymmetry of a distribution (Weisstein n.d.). Normally distributed data is symmetrical, while positively skewed data has a longer right tail, and negatively skewed data has a longer left tail (Weisstein n.d.). In other words, positive skew means there are more values larger than the normal distribution predicts, while negative skew means there are more values smaller than the normal distribution predicts.

For all pre-commission districts, the skewness of the Polsby-Popper scores is 2.19, but decreases to 1.51 for all post-commission districts. The change is more striking for the Reock scores, which measure a highly skewed 13.23 for pre-commission districts, and a high, yet significantly less 6.55 for post-commission districts.

All of the results reported thus far have been generated from data with no regard for outliers. After applying the outlier labeling rule to the normalized data, I performed the same analysis to the set with the outliers removed. All outliers are more compact than their state; none

is less compact. All 35 Polsby-Popper outliers exist in New Jersey and Washington, except a single district in Texas. All 6 Reock outliers exist in Hawaii. Examples of these outliers are shown in Figures 9 through 11. These districts seem ordinary, with the exception of being far more compact than the states they belong to, even considering the strong correlation between district and state compactness. However, when taking all normalized districts into account, these outliers increase the skewness of the dataset, shown numerically in Table 3.

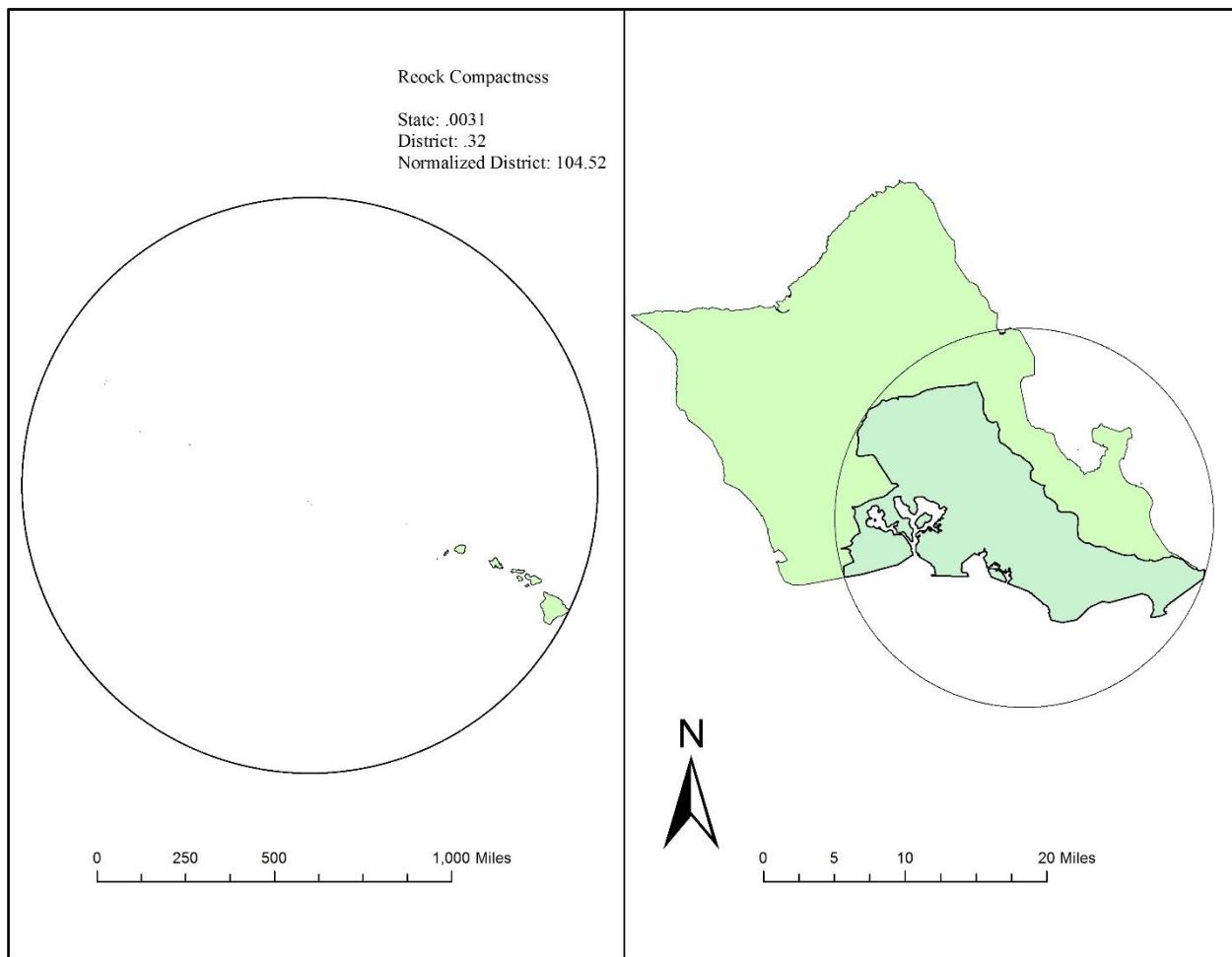


Figure 9 Normalized Reock Outlier, Hawaii 1<sup>st</sup> District, 103<sup>rd</sup> Congress

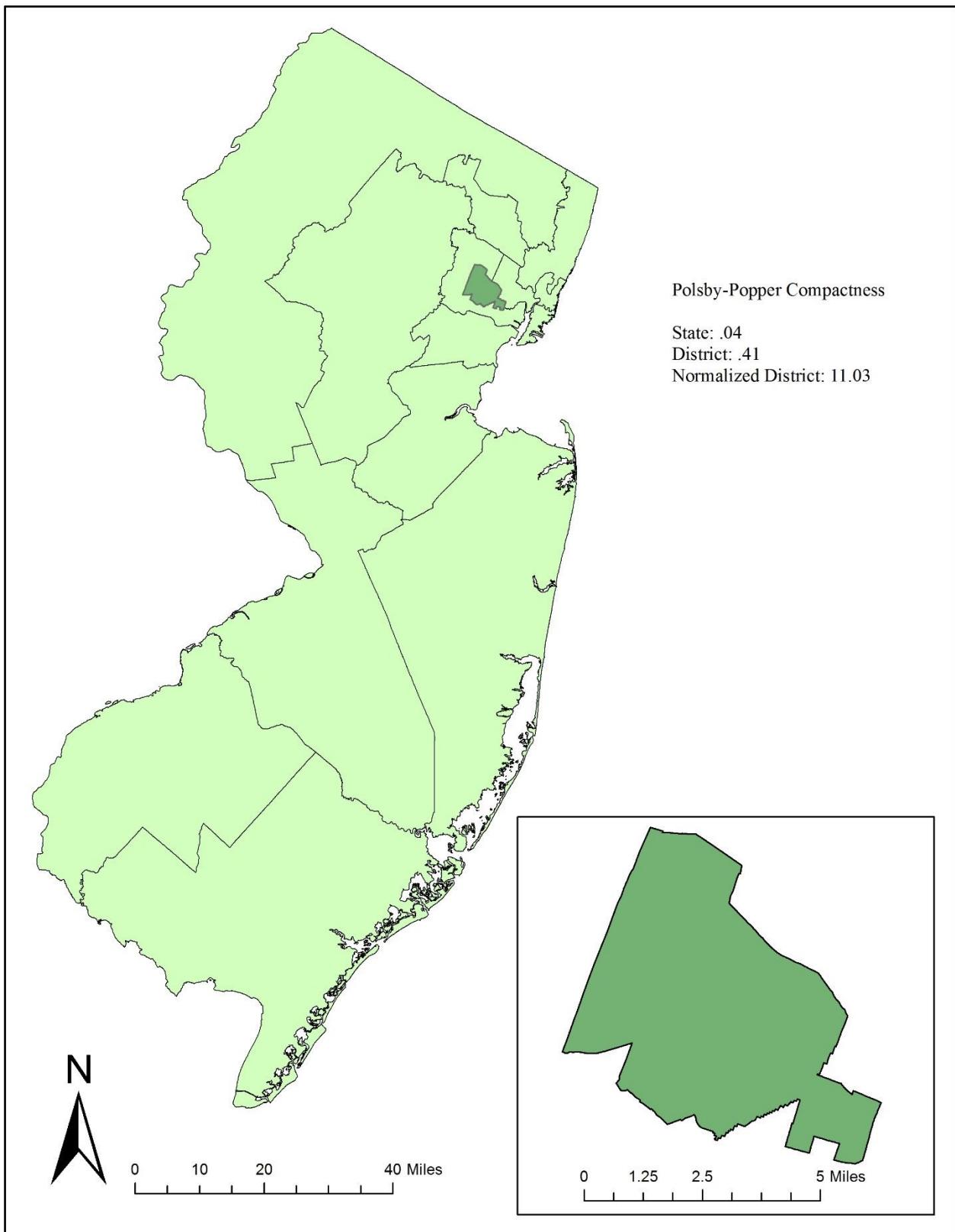


Figure 10 Normalized Polsby-Popper Outlier, New Jersey 11<sup>th</sup> District, 88<sup>th</sup> Congress

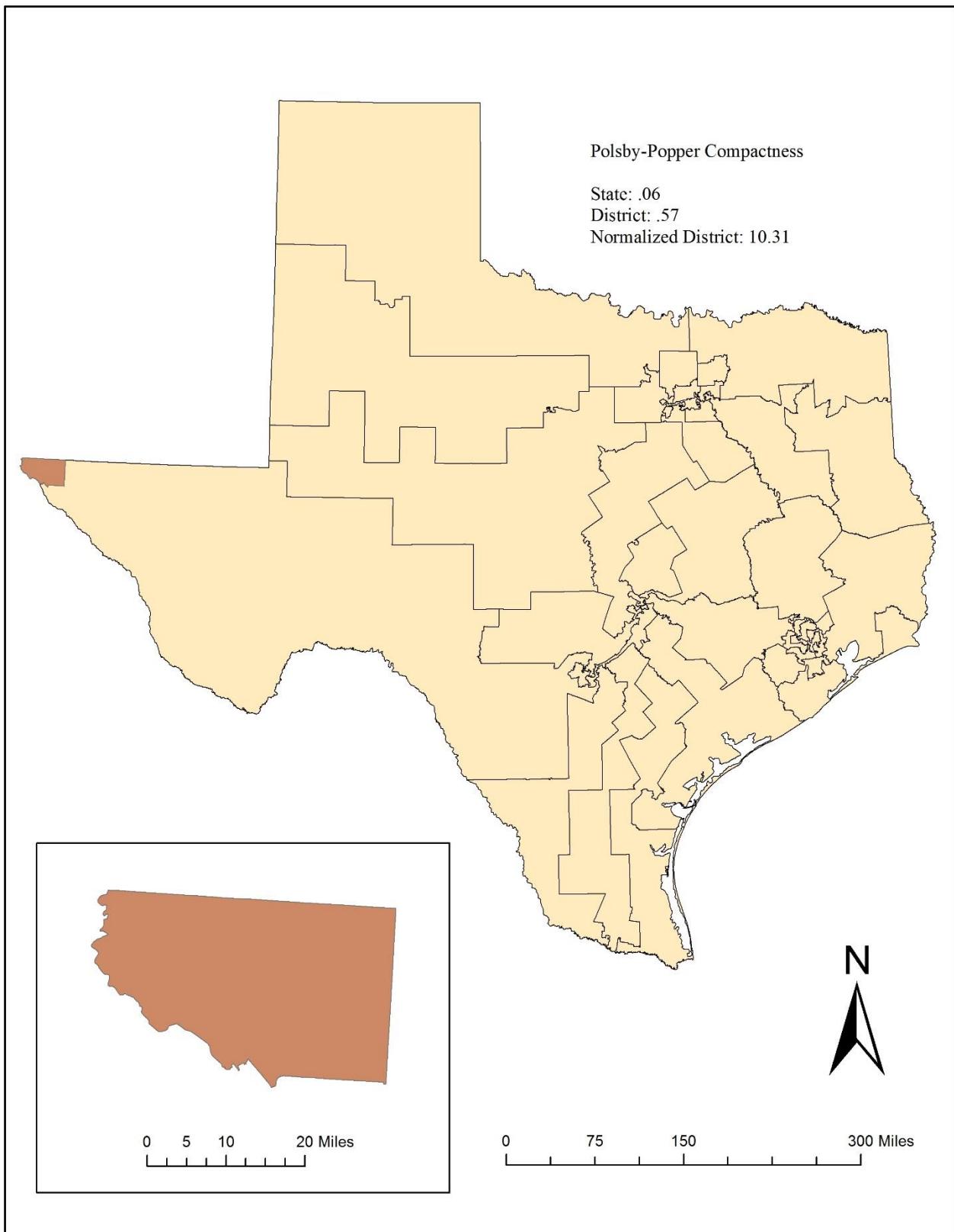


Figure 11 Normalized Polsby-Popper Outlier, Texas 16<sup>th</sup> District, 113<sup>th</sup> Congress

Table 3 Skewness Comparisons

	Skewness With Outliers		Skewness Without Outliers	
	Polsby-Popper	Reock	Polsby-Popper	Reock
All Pre-IRC Districts	2.19	13.23	1.41	0.08
All Post-IRC Districts	1.51	6.55	1.54	0.37
All Commission States, 113th Congress	1.80	9.35	1.37	0.18
All Non-Commission States, 113th Congress	1.68	0.04	1.43	0.04

With the outliers removed, the difference in mean Reock compactness remains statistically significant, but instead favors the pre-IRC districts, with a p-value of .07. The difference in mean Polsby-Popper compactness remains statistically significant, at a p-value of .01, for districts in states without commissions for the 113th Congress. However, the difference in mean Reock compactness for the same dataset is statistically significant for districts in states with commissions. Taken together with the results that include the outliers, various associations between commissions and district compactness can be discerned, however, the overall evidence does not consistently point to districts that are more compact when drawn by IRCs.

The drastic change in Hawaii's compactness based solely on the reorganization of island groupings highlights the idea that compactness, as measured in this study, is purely geometric. The geographic details of the district must be set aside, regardless of the stories they may tell. Internal distance and travel costs within districts may be more significant to constituents than the attractiveness of its borders. Balancing geometric compactness with the geographic realities that representatives and their constituents face is a challenging task for commissions. One limitation of this study is that it does not measure how this balance is achieved.

#### 4.4 Coterminosity

Additionally, this analysis fails to reject the null hypothesis for coterminosity. With a p-value of .59, no statistical significance was found between the mean district coterminosity in states with IRCs and that for states without IRCs for the 113th Congress ( $n = 91$  and 64 respectively). Table 4 shows mean district coterminosity for all states in this study, along with mean county size.

A Pearson's correlation was performed comparing mean coterminosity and mean county size. With an R-squared value of -.56, smaller mean county size is moderately linked to greater coterminosity, and vice versa. This suggests that drawing coterminous district boundaries is easier in states with small counties than for states with large counties.

Table 4 Mean Coterminosity and Mean County Size, by State

	Commission	Mean Coterminosity (%)	Mean County Size (km <sup>2</sup> )
Arizona	yes	55.63	21090
California	yes	65.07	7058
Colorado	no	83.61	4279
Idaho	yes	82.10	4919
Indiana	no	75.09	1019
Missouri	no	79.09	1570
Nevada	no	60.99	16844
New Jersey	yes	67.54	933
Texas	no	56.11	2699
Washington	yes	82.79	4484

No outliers were found in either the group of states with commissions or the states without. Skewness for distributions in each state was found to be minimal, with the exception of Missouri at -1.57.

Though the state-by-state pre/post commission compactness t-tests should stand alone as evidence against IRCs, the low number of samples in most cases, except California, inspired additional analyses to look for effects across states. These analyses uncovered effects by IRCs as a whole, both positive and negative. Though the results for coterminosity are much clearer than for compactness, the analysis is also simpler. Multiple decades of coterminosity data would increase the strength of this analysis, and help make it clearer which of these criteria redistricting bodies are more successful at achieving.

## **Chapter 5 Conclusions**

Evaluating redistricting commissions over time rather than any one particular set of districts requires datasets spanning enough pre-commission and post-commission years to be meaningful. There is still relatively little data to compare districts drawn by commissions to districts drawn by state legislatures. IRCs have existed for only two redistricting cycles in three of the six states in this study, and only one cycle in a fourth state. For this reason, among several detailed below, it is important to exercise caution when considering the results of this study. Nonetheless, it is my conclusion that IRCs are not living up to the promise they offer. There is no evidence to support the hypotheses that IRCs are associated with increases in compactness and coterminosity of congressional districts. .

### **5.1 Challenges to Drawing Compact and Coterminous Districts**

In considering the results of this study, it is important to recognize that factors essential to the redistricting process may make it very challenging to create higher levels of compactness or coterminosity when drawing districts. It is not easy even for well-intentioned authorities to draw districts that increase absolute spatial metrics of compactness or coterminosity.

Population distribution may be the most potent of these factors. Since all districts must be of equal population, any change in population for one district that is not accompanied by an equal change in all other districts must necessarily be offset by redrawing district boundaries. Additionally, the specific location of that change in population will affect how the new lines are drawn. For example, given that population equality is a constitutionally essential element of drawing districts, a district may become less compact or less coterminous through the necessary inclusion of a distant populated area that can no longer be included in its previous district.

Another factor related to the distribution of a state's population is the changing number of districts over time. With the exceptions of Hawaii and Idaho, the number of districts in each state changes throughout the study period. Depending on population distribution, adding a new district or subtracting a district from a state may change the degree of difficulty redistricting entities face in drawing compact districts. The challenges created by the addition or subtraction of districts may also be exacerbated by the shape of the state itself. It is very difficult to normalize data to smooth over all these idiosyncrasies.

Aside from compactness and coterminosity, which are often explicitly stated as goals, redistricting commissions are charged with maintaining the integrity of communities of interest, and complying with the Voting Rights Act (VRA), both of which rely on input from the public. Commissions make their proceedings open to the public, and publish preliminary maps before taking a final vote. Community leaders may, at this step in the process, choose to make their case to the commission if their interests are not met. Similarly, VRA compliance must be evaluated by minority groups who may be affected, who then may choose to file suit against the state. Over time, these communities change, as does their level of participation in the redistricting process. Of all the criteria commissions must take into account, it is possible that compactness and coterminosity may end up ranking low among priorities.

## **5.2 Districts Drawn by State Legislatures**

The hypotheses tested in this study also rest on the theory that IRCSs are the key antidote to a pervasive problem of gerrymandering by state legislatures. In fact, a complex set of factors may affect the probity of state legislature drawn districts, including the partisan balance and the media climate in a given state. In short, pre-commission districts may not have been as

gerrymandered as believed, at least not to the degree that would allow the commissions to make significant increases in compactness or coterminosity.

Another possibility is that the true effect that commissions have on district compactness and coterminosity is happening on a smaller scale than the statewide average can show. For example, the least compact district in Arizona, for all years in this study, is the 2nd District in the 108th Congress, at a Polsby-Popper value of 0.09. Arizona's average Polsby-Popper compactness for this congress is 0.33. If the 2nd District's compactness were increased to 0.27, a three-fold increase, without affecting the compactness of other districts, average compactness would increase to only 0.36 – significant to a single district, but insignificant to the average. If the impetus behind the establishment of a redistricting commission is a few egregious districts, while the remainder of the state appears normal and noncontroversial, we should not expect commissions to generate a significant increase in average statewide compactness or coterminosity.

It is possible that outliers such as these exist in the data, but finding them would require visual analysis of each district over time. When one district is split into two, in order to accommodate a new addition, determining which section is the “core” and which is “new” may not be obvious. Also, the number given to a district often changes over time, so simply tracking the number will not work. Using Crespin’s (2005) method of tracking the percentage of each district that remains from one redistricting cycle to the next doesn’t quite work either. If, say 75% of a district survives from one decade to the next, in four decades, that district could be composed of none of its original territory.

### **5.3 Future Research**

The ability to focus on a single district's boundaries over time would help to determine whether one particularly gerrymandered district is alleviated as a result of an IRC. As previously noted, such a process might involve a degree of subjectivity, but would nonetheless yield valuable information.

In order to better understand the effects of redistricting commissions, methods of analysis that focus on population distribution, similar to Belin, Fischer, and Zigler's (2011) density-variation compactness method, should be employed in conjunction with a multiple state time series analysis such as this study. This will allow the effects over time to be uncovered while controlling for population distribution. Additionally, future studies should investigate the role that population density plays in drawing compact and coterminous districts. If perhaps there exists a density at which compact and coterminous districts are easier to draw, that information might be of great interest to political reformers as well as those who seek to game the system.

Quantifying "communities of interest" remains a difficult task, especially to outside observers. Community leaders who respond to IRC's requests for public comment, however, are better suited to provide a precise geographic definition of their community. Searching these public comments for geographic information, and loading it into a GIS, would be a better alternative to a sterile proxy like homogeneity (Stephanopoulos 2012). This would allow researchers to assess how commissions accommodate the specific requests made by communities.

The desire to take power away from politically biased legislators in the redistricting process may not end until every state has its own commission. Nevertheless, we should be prepared for what happens if independent commissions fail to meet expectations. Should

reformers be satisfied with a just process, i.e., that districts will be drawn by a third party with no political stake in the outcome, or is a just result that is verifiable using objective spatial statistics required?

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